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SPECIES AND GENERA OF TERTIARY NOETINAE

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SPECIES AND GENERA OF TERTIARY NOETINAE

BY

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Shorter contributions to general geology, 1937

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By F. Stearns MacNeil

INTRODUCTION

The purpose of this paper is to treat systematically all the species and genera that are referable to the subfamily Noetinae. A redefinition of the subfamily based on the critical morphology and developmental trends of the type genus includes some forms not previously regarded as Noetinae and excludes some genera referred to this subfamily by previous authors. Emended descriptions are provided for described species and genera, for the purpose of reducing the expressions of many writers to a common terminology, and some new species and genera are described. In addition the relationships and migration of the genera involved during Tertiary time are discussed.

The synonymy and references are probably not complete, although it is hoped that all the important references are given and that the nomenclature is reasonably correct.

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CLASSIFICATION

With our increasing knowledge of the structure and phylogeny of the Pelecypoda it becomes more and more obvious that their supergeneric classification is short of satisfaction, the principal defect being that not enough groups of high ordinal rank have been recognized. I agree with Stewart [1] that an elaboration of the classification of Pelseneer is in most respects the most satisfactory and natural. The arrangement here presented was arrived at as a result of some researches in the structure and evolution of the ligament of the arcid pelecypods and will be supported more fully in a paper on ligament structure to be published soon. Under this arrangement the order Filibranchia is divided into suborders represented by the genera *Pecten, Anomia, Mytilus,* and *Arca.* The true taxodonts, of course, represented by the genera *Nucula, Nuculana,* etc.,

[1] Stewart, Ralph, Acad. Nat. Sci. Philadelphia, Special Pub. 3, p. 26, 1930.

belong to the order Protobranchia. This classification, insofar as it concerns the Noetinae, is given below:

Suborder Prionodonta:
Cyrtodontacea, Parallelodontacea, Glycymeracea, Arcacea.
Superfamily Glycymeracea:
Cucullaeidae, Glycymeridae, Naviculidae, Limopsidae, Noetidae.
Family Noetidae:
Striarcinae, Trinacriinae, Noetinae.
Subfamily Noetinae.

The subfamily Noetinae includes all the species generally referred to the genus *Noetia* and, in addition, some Eocene forms which are regarded either as prototypical or as closely related to them. These forms have vertically striated ligaments, as do all the Noetidae. The earliest members are orthogyrate or prosogyrate, but the later members are all opisthogyrate.

Their sculpture consists of well-defined secondary ribs, frequently alternating with small interstitial primary ribs. The species here included in the Noetinae are referred to eight genera and one subgenus. The genera can be divided into two well-defined supergeneric groups, an Atlantic group and a Pacific group, according to the region in which their species predominate. Although, heretofore, the majority of the species of the later Tertiary (called Neogene by European geologists) have been placed in the same genus, the geologic history of the two groups and the dissimilarity of the earlier members leaves it still to be proved that they are related at all. A new subfamily may ultimately be erected for one of them.

Several important nomenclatorial changes will be noted in this paper. *Scapularca* Cossmann is included in this subfamily but is treated as a genus, not as a subgenus of *Arcopsis*, which is referred to the Striarcinae. *Sheldonella* Maury is raised to the rank of genus and is made to include *Paranoetia* Thiele as a subgenus. *Noetiella* Thiele and Jaeckel [2] is not included but is referred to the Striarcinae. The recognition of the Peruvian Eocene and Oligocene species of *"Argina"* as belonging to the Noetinae is probably the most unexpected change set forth in this paper. *Trigonodesma* Wood is clearly a member of the Striarcinae.

GEOGRAPHIC AND STRATIGRAPHIC OCCURRENCE OF THE NOETINAE

The broader contribution of this paper is to show that the genera referable to the Noetinae are divisible into two distinct supergeneric groups. These are here called the Atlantic and Pacific groups, according to the region in which they obtain their maximum development. The Atlantic group comprises three genera and a subgenus—*Eontia*, n. gen., which has for its genotype *Arca ponderosa* Say; *Sheldonella* Maury, typified by *Noetia* (*Sheldonella*) *maoica* Maury, and its subgenus *Paranoetia* Thiele, for which the genotype is *Arca lateralis* Reeve; and the prototypical Eocene genus *Scapularca* Cossmann, for which the genotype is *Arca scapulina* Lamarck. The Pacific group consists of five genera—*Noetia* Gray, typified by *Arca reversa* Sowerby; the prototypical Eocene genus *Protonoetia*, n. gen., having for its genotype *Anadara nigeriensis* Newton; and three aberrant genera: *Noetiopsis*, n. gen., for which the genotype is *N. woodringi*, n. sp.; its terminal genus, *Arginopsis*, n. gen., for which the genotype is *Scapharca* (*Argina*) *sullanensis* Woods; and a related genus, *Arginella*, n. gen., having for its genotype *Arca* (*Argina*) *samanensis* Olsson.

ATLANTIC GROUP

The genera and species according to this classification fall into an orderly geologic and geographic arrangement.

Scapularca occurs in the Eocene of England, France, and Belgium and exhibits a series ranging from the limopsiform *S. subglobulosa* (Wood), from the Bracklesham and Bartonian, to the more extreme French forms, the carinate *S. interposita* (Deshayes), the prototype of *Eontia*, on the one hand, and the posteriorly rounded *S. scapulina* (Lamarck), the prototype of *Sheldonella*, on the other hand.

The genus *Sheldonella* is, so far as known, the smallest group of late Tertiary Noetinae. Only one species, the genotype, *Sheldonella maoica* Maury, appears to have reached America, where it occurs in the Cercado formation, of early middle Miocene age, of the Dominican Republic. It has not been found elsewhere in America and may have become extinct before the advent of *Eontia* in late Miocene time, unless, as discussed beyond, the southern species tentatively referred to *Eontia* (*E. centrota*, *E. bisulcata*, and *E. olssoni*) are to be regarded as representing a subgenus of it. The other two species for which the subgeneric name *Paranoetia* is available are Recent from the Southern Hemisphere and Indo-Pacific, *P. cafria* (Bartsch) occurring off South Africa, and *P. lateralis* (Reeve) in the Philippines.

The genus *Eontia* exhibits great diversity and contains some of the largest members of the subfamily. The last occurrence of the Noetinae in Europe and the earliest known Neogene species is *E. okeni* (Mayer), from the Aquitanian, Burdigalian, and Helvetian. *Eontia* is next known in America, where it occurs as *E. incile* (Say) in the *Chama*-bearing bed of the Yorktown formation, of upper Miocene age, of Virginia; and as *E. incile mansfieldi*, n. subsp., in the equivalent or slightly older *Ecphora* zone of the Choctawhatchee formation of Florida. One small valve of the southern group tentatively referred to *Eontia*, *E.* cf. *E. centrota*, has been reported from the Springvale Miocene of

[2] These authors made *Barbatia pectunculiformis* Dunker the type of this section, but their species *Arca* (*Noetiella*) *congoensis* is more like *Arca* (*Barbatia*) *interplicata* Grabau and King (Shells of Peitaiho: Peking Soc. Nat. History Handbook 2, p. 161, pl. 1, fig. 9, 1928) and *Arca bataviana* Martin and Wichmann (Geol. R. Mus. Leiden Samml., Ser. 1, Band 3, p. 253, pl. 13, fig. 257, 1885) than the type. In all these forms the ribs are primary and not secondary as in the Noetinae.

Trinidad by Maury. Species reported from earlier Caribbean Miocene formations belong to the genus *Noetia* and are discussed below.

In the southern province there were derived from the Springvale species *E. centrota* (Guppy), from the Pliocene of Trinidad; and two Recent species—*E. bisulcata* (Lamarck), from the Atlantic and Caribbean coasts of South America; and *E. olssoni* (Sheldon and Maury), from the Pacific coast of Panama, an Atlantic shell which somehow gained access to Pacific water.

Along the Atlantic coast of North America we find in the progeny of *E. incile* some of the most conspicuous elements in the uppermost Miocene to Recent faunas. In the upper part of the *Chama*-bearing bed of the Yorktown formation the variety *E. incile yorkensis*, n. var., occurs with typical *E. incile*. In the next higher beds, equivalent to those exposed at Yorktown, a more robust form of *E. incile* occurs. This gives rise to another varietal series in the next higher beds, the beds at Suffolk, containing as an end member *E. incile suffolkensis*, n. var.

Eontia trigintinaria (Conrad) occurs in the Duplin marl of central North Carolina; the Darlington and Maysville districts in South Carolina; in the equivalent part of the Yorktown formation of Virginia and North Carolina; and specimens from the *Cancellaria* zone of the Choctowhatchee formation of western Florida are referred to it. This form appears to have been derived from *E. incile* during middle Yorktown time, as it is distinct from the forms occurring in the beds at Suffolk, Va.

In the Miocene in the vicinity of the Chowan River in northeastern North Carolina, which may be higher than the typical Duplin, is found the form *E. carolinensis* (Conrad). In Greene County, N. C., which lies between this region and the area of the typical Duplin, a varietal series occurs which approaches *E. carolinensis* on the one hand and *E. trigintinaria* on the other. These appear to be the forms which Conrad named *Noetia filosa* and *Noetia protexta*, respectively. The former is regarded as a variety, *E. trigintinaria filosa;* the latter is placed in synonymy.

In southern North Carolina, around Lumberton and Fairmont, occurs *E. lumberensis*, n. sp., which has more the form of some Pliocene specimens from the Waccamaw formation but remains small. The upper bed at Colerain Landing, on the Chowan River, differs from the bed beneath in that it contains a varietal series which seems to foreshadow the extremely variable form found in the Pliocene Waccamaw formation of the Carolinas and the Pliocene of eastern Florida.

In the Pliocene, as in the Miocene, both very regular and very variable species are found. *Eontia limula* (Conrad), a remarkably constant species, related to *E. carolinensis*, occurs only in the Croatan sand along the Neuse River and in Onslow County, N. C., and possibly in east-central Florida near Melbourne. Another form, *E. tillensis*, n. sp., from Tilly's Lake, on the Waccamaw River, S. C., seems to represent the *E. carolinensis* or the *E. trigintinaria filosa* stock. The Waccamaw formation of North Carolina in the vicinity of the Cape Fear River contains the variable form *E. variabilis*, n. sp., which appears to be a mixture of several Miocene stocks as well as other Pliocene species. One of its varieties, *E. variabilis quadrata*, n. var., from the Walkers Bluff locality on the Cape Fear River, appears to be closely related to *E. lumberensis*. The Caloosahatchee marl of east-central Florida in the vicinity of De Land and De Leon Springs contains a form which resembles *E. variabilis* less than it resembles the form occurring in the Caloosahatchee marl of southwestern Florida. Two forms, which from their preservation occur in different beds, are found in the spoil along the Hurricane dike of Lake Okeechobee near Clewiston, Fla. One, *E. caloosana*, n. sp., a very constant form, is apparently from the lower bed. The less leached shells consist of a varietal series ranging from fairly typical *E. variabilis* to a large, rotund form, *E. variabilis clewistonensis*, n. var., which may be a hybrid of *E. variabilis* and *E. caloosana*.

In the Caloosahatchee marl of southwestern Florida, at the Alligator Creek and Shell Creek localities, another varietal series occurs which contains forms not found elsewhere. The name *Eontia platyura* (Dall) is available for this species. This form seems to be related to *E. caloosana*, but whether the *E. variabilis*-like form farther east contributed anything to it is uncertain.

Higher in the Caloosahatchee marl of southwestern Florida, near Bermont, a form indistinguishable from the De Leon Springs form is found, which may have invaded from the east at this time. The uppermost Pliocene near Murdock, Fla., contains a shell comparing almost exactly in shape with the recent *E. ponderosa* but differing somewhat in sculpture. This appears to represent a coalescence of *E. variabilis* and *E. platyura*.

During Pleistocene time this pre-*ponderosa* stock persisted on the Florida west coast. Along the Atlantic coast several distinct types are found, two of them recognized as species—one in the vicinity of Vero, in east-central Florida, called *Eontia veroensis*, n. sp., and the other north of Cape Hatteras, described as *E. palmerae*, n. sp. The former may be related to an *E. limula*-like Pliocene form from the same region; the latter is probably directly descended from *E. tillensis* or possibly *E. limula* in the north. In the intervening area, from Cape Hatteras to the vicinity of Daytona, Fla., a robust, *variabilis*-like form occurs which approaches both the northern and the southern forms. When the Florida west coast stock joined with the Atlantic stocks is not certain, but in the late Pleistocene the union appears to be complete, and in the Recent there remains the single long-ranging, remarkably constant species *E. ponderosa*. This has been obtained living from Cape Hatteras to Yucatan.

Eontia ponderosa migrated at least as far as Louisiana during Pleistocene time, very typical specimens having been obtained from a well in Plaquemines Parish at a depth of 740 feet and another well in Cameron Parish at a depth of 912–972 feet. Owing to the rapid deposition in this region, even these depths represent fairly late Pleistocene. Attention is called to the possibility of confusing young specimens of *Eontia ponderosa* from the Pleistocene of the northern Gulf region with the true *Noetia, N. gardnerae,* n. sp., specimens of which have been obtained from the upper Miocene or Pliocene near Houston, Tex., at a depth of 1,700 feet. The specimens obtained from the deep well at Galveston, Tex., at a depth of 2,552 to 2,871 feet and identified by G. D. Harris as *Arca ponderosa* var. *carolinensis* Conrad, are probably *Noetia gardnerae.* (See p. 37.)

Just what processes are involved in the history of the North American Eontias may be a debatable question, but the suggestion is strong that both geographic speciation and later hybridization have taken place. Some stocks may have become extinct, but the persistence of certain strains in later varietal series and the gradual evolution of a constant form from an almost hopeless complex strongly suggests that most of the forms remained interfertile and gradually interbred to produce hybrid series from which a true breeding species emerged.

PACIFIC GROUP

The Pacific group, for the most part, occupied geographic areas different from those of the Atlantic group. Unlike the Atlantic group, which did not reach its maximum development until Pliocene time and still survives in three seas, the Pacific group is far in the decline. Only a single, relatively restricted species survives.

This group was already a complex of five related genera in middle and upper Eocene time. Of these, three did not survive the Eocene, one culminated in the Oligocene, and the most abundant, *Noetia,* gave rise to a large number of upper Eocene to Recent species, attaining its maximum development in the middle Miocene. The genus *Noetiopsis,* n. gen., typified by *N. woodringi,* n. sp., from the middle Eocene of the Tonosi Valley, Los Santos Province, Panama, although strikingly *Noetia*-like in general appearance, appears to be the predecessor of the aberrant genus *Arginopsis,* n. gen., typified by *A. sullanensis* (Woods) from the late Eocene Saman and Talara formations of Peru. *Arginella,* n. gen., another aberrant genus, for which the genotype is *A. samanensis* (Olsson), likewise from the Saman and Talara formations, is known from two species besides the genotype—*A. puntabravoensis* (Olsson), from the middle Oligocene Mancora grits of Peru, and the end member, *A. ovalis,* n. sp., from supposed Oligocene beds of Colombia.

Protonoetia, n. gen., for which the genotype is *P. nigeriensis* (Newton), is found in beds of Lutetian age near Ameki, Nigeria. This genus is less like *Noetia* in general appearance than *Noetiopsis* is, but it is more closely related to *Noetia* in some fundamental characters and is regarded as representing the stock from which the true Noetias of the upper Eocene of the Indo-Pacific were derived.

The upper Eocene forms from the Indo-Pacific appear to be congeneric with the later American forms. Of the former are known *Noetia pondaungensis* Cotter, from Burma; *Noetia molengraffi* (Martin), from Java; and *Noetia nagaoi,* n. name, from Japan. It cannot be said with full certainty that the American Miocene to Recent species of *Noetia* were descended from these upper Eocene Indo-Pacific forms. So far only the aberrant genus *Arginella* has been found in the American Oligocene. Although the time interval was ample for the migration of *Noetia* to America, a fuller knowledge of the Pacific Oligocene is needed to show whether the genus was present previously, or, if a migrant, what course its migration took.

The oldest occurrences of *Noetia* in America are in beds generally considered to be of lower Miocene age. Unfortunately none of the species are represented by sufficient specimens to show variation to any great extent, so that the relationships of the species are not always clear. Knowledge of the stratigraphy of the regions in which they occur is still largely in the reconnaissance stage and, owing to the covering of dense vegetation in most of the areas, will probably remain so for a long time to come. It is not possible, therefore, to attempt as detailed a study of these species as was made of the North American species of *Eontia,* and little more can be done than to recognize species and varieties and to make simple comparisons with supposedly related forms.

The earliest known species are *Noetia stewarti,* n. sp., from the lower Zorritos formation and the underlying transitional beds of Peru, and two species, *N. trinitaria* (Guppy) and *N. manzanillae* Maury, from the Manzanilla beds of Trinidad. The species *N. manzanillae* is aberrant, whereas the other two are somewhat related. The diversity of these forms, as well as their separated occurrence, provides considerable ground for hope that their predecessors will be found in more than one earlier Central and South American formation.

Higher, in the middle Miocene, are found *Noetia mundonuevensis* Maury and *N. mayensis* Maury, in the Brasso beds of Trinidad. *Noetia mauryae,* n. sp., from northern Colombia is related to *N. mayensis.* The middle Zorritos of Peru contains the form *N. cholana* Spieker, of uncertain affinities. *N. ecuadoria,* n. sp., from Ecuador, appears to be related to *N. trinitaria* and to several contemporaneous and later species as well. In Colombia occur two forms, *N. atratoensis,* n. sp., and *N. colombiana,* n. sp., the former related to a variety of *N. macdonaldi,* whereas the latter appears

to be related to *N. ecuadoria* and *N. trinitaria*, on the one hand, and to typical *N. macdonaldi* Dall, on the other hand. *N. retractata* (Hanna and Israelsky) (=*N. modesta* Grzybowski) occurs in the upper Zorritos of Peru.

Noetia macdonaldi Dall occurs at several horizons in the Gatun formation of Costa Rica, and a specimen is at hand from far up the Atrato River Valley, in western Colombia. This species may not be identical in all beds along the Banana River in Costa Rica, and a subspecies, *N. macdonaldi alta*, n. subsp., is named, which resembles the Colombian species *N. atratoensis*. Another form, *N. macdonaldi truncata*, n. subsp., is recognized in northern Colombia. *N. turbacensis*, n. sp., from northern Colombia may be upper Miocene.

The upper Miocene Tumbez formation of Peru contains a gigantic form which may not be distinct from *N. magna*, n. sp., from the Mancora Tablazo beds, of Pleistocene age, of Peru.

Noetia gardnerae, n. sp., obtained from an oil well near Houston, Tex., at a depth of 1,700 feet in sediments of upper Miocene or Pliocene age, is the only species of the Pacific group to gain a foothold in the northern Gulf region. The Pliocene species *N. sheldoniana* Maury is known from the upper Pliocene of Trinidad and appears to be related to *N. gardnerae* and possibly to *N. turbacensis*. *N. reversa*, the genotype, is the only surviving species of the group and occurs along the west coast from the Gulf of California to Peru.

CHARACTERS IN WHICH THE ATLANTIC AND PACIFIC GROUPS DIFFER

It has been suggested by several writers that certain of the species referred to the genus *Noetia* were more closely related to one another than to other species. So far as I am informed, however, no one has previously suggested that these species constitute two groups of genera which have been independent of each other throughout most of Tertiary time. On the contrary, owing to the remarkable example of homeomorphy that some Pliocene and Recent species show, such a suggestion may seem ill advised to workers who are familiar with many of the species involved.

That such a condition exists, however, can be shown in several ways. First, only the more recent of the two groups, *Noetia sheldoniana*, *N. gardnerae*, *N. reversa*, and *Eontia ponderosa*, are at all liable to be confused, and the farther back their progenitors are traced the less alike they are seen to be; second, the periods of maximum development and the geographic areas in which the species are concentrated differ for the two groups; third, regardless of the great similarity which the homeomorphic species show, the groups to which they belong are characterized by certain morphologic differences, developmental tendencies, or known differences in evolution that distinguish them. These may be listed as differences in sculpture, in the nature of the postero-ventral crenulations of the inner margin, and in the distribution and evolution of the cardinal area and ligament.

DIFFERENCES IN SCULPTURE

The sculpture found in the genera of the Noetinae may take a variety of forms, but its relation to the juvenile sculpture shows that it is all of the same type. The ribs are of two kinds, primary and secondary, according to the time of their appearance in the ontogeny of individuals of most genera. Whether they have the same order in their phylogeny is unproved, but it is suggested as a hypothesis that they have, and that the primary ribs correspond to the lirate ribs of other members of the Noetidae. The primary ribs are referred to in the descriptions as the interstitial ribs, whereas the secondary ribs are the principal ribs in the adult sculpture. The primary ribs are of varying importance and may be well developed or obsolete in adults. The secondary ribs are always well developed and furnish the strong sculpture of the Noetinae. In fact, the subfamily might be defined as including Noetidae with strong secondary ribs.

Both the primary and secondary ribs vary in surface and cross section. The primary ribs are usually lirate in juveniles and beaded in adults but may remain lirate throughout. The secondary ribs may be smooth and rounded throughout but generally are beaded in juveniles. In adults they differ within the same genus, in different genera, and in different parts of the same shell. They may divide or remain single. They may tend to become more elevated or less elevated, or even submerged below the level of the interspaces with shell growth. In cross section they may range from low and broadly rounded to high and flat-topped.

In the accompanying text figure (fig. 1) are shown diagrams of the sculpture of the genera of the Noetinae in which the nealogic sculpture [3] is known. The scale is of course exaggerated, and no attempt is made to show the actual number of ribs. Likewise, an arbitrary beaded line is used to designate the primary ribs, which may be finely lirate, especially in the juvenile stages.

In *Scapularca* the sculpture consists of alternate large and small ribs. No difference is to be observed between the juvenile and adult sculpture, the ribs having their origin almost simultaneously at the end of the unsculptured nepionic stage. The shell of *Scapularca* is small, and a nealogic stage comparable in size to that of the other genera to be discussed would occupy most of the shell. It is inferred, therefore, that the nealogic stage is so short in duration as to be practically unobservable. The important fact regarding the initial sculpture of *Scapularca* is that the ribs are subequal in

[3] Jackson defined four stages in shell growth succeeding the embryonic or prodissoconch stage—the nepionic stage, or the unsculptured first stage in the formation of the true shell; the nealogic stage, or the stage of initial sculpture, which may differ considerably from the adult sculpture; the ephebolic stage, or the adult stage; and the geratologic stage, or the period of decline and irregularity.

strength at that stage and that the secondary ribs become more prominent with shell growth.

The sculpture of *Sheldonella*, following the nepionic stage, consists of well-defined nealogic and adult stages. The primary ribs are lirate in the nealogic stage and become delicately beaded in adults. The secondary ribs do not make their appearance until the end of the nealogic stage, and at that time they appear first along the umbonal ridge. Those along the umbonal ridge become divided into two equal parts in adults and, like the primary ribs, are neatly beaded. Anteriorly they may or may not be beaded, a condition which varies with individuals. It will be noted that in *Sheldonella* the primary or interstitial ribs usually persist throughout the adult stage, although in some individuals they may be obsolete medially.

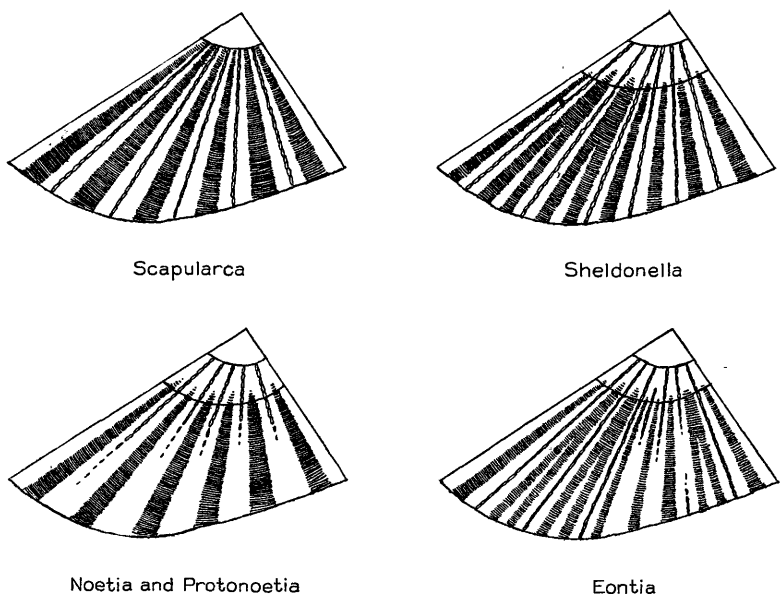

FIGURE 1.—Diagrams showing relation of adult sculpture to nealogic sculpture.

Eontia, the most important genus in the Atlantic group, exhibits the most varied sculpture in the subfamily. Like *Sheldonella* it has three well-defined stages—the unsculptured nepionic stage, the primary-ribbed nealogic stage, and the adult stage. The primary ribs are very well developed in the nealogic stage, and frequently additional primary ribs may appear, as shown medially in the diagram. With the appearance of the secondary ribs the primary ribs are transformed abruptly from coarse lirae to finely beaded interstitial threads which from then on may behave in various ways. They may increase in size throughout the life of the shell, or they may become obsolete, especially medially, or they may die out temporarily and reappear near the ventral margin.

The secondary ribs appear near the end of the nealogic stage, first along the umbonal ridge, and rapidly become larger than the primary ribs. They present considerable variation. They may be single throughout or double only in the region of the umbonal ridge, or on the medial and anterior parts of the disk as well. They may be rounded or square in cross section. They may be smooth or evenly beaded or roughened by irregular growth varices. In several respects the sculpture of *Eontia* is the most extreme in the Noetinae; the primary ribs are stronger in the nealogic stage than in other genera, the secondary ribs are more varied, and the break between the nealogic and adult stages is much more abrupt.

In the genera *Noetia* and *Protonoetia* the nealogic sculpture is very similar to that of *Sheldonella* and *Eontia*, but the primary ribs are not as strong. In a few species of *Noetia* the interstitial ribs persist to the ventral margin, but usually only in the posterior region.

In many species the primary ribs become obsolete at some time during the adult stage, so that there is really a young adult stage characterized by both primary and secondary ribs and a later adult stage having secondary ribs only. In a few species (*Noetia sheldoniana*, *N. gardnerae*) the weak primaries persist into the adult stage scarcely at all, and the regular secondaries can be traced to a very young stage.

The secondary ribs make a more gradual appearance in *Noetia* than in *Sheldonella* and *Eontia*, and therefore there is not so abrupt a break between the nealogic and adult sculpture. One outstanding difference between the Atlantic and Pacific groups is the regularity of the secondary ribs. Those of the Pacific group are never divided and are usually of the same size and spacing all over the disk and posterior slope, but in a few species—*N. reversa*, *N. colombiana*, and typical *N. macdonaldi*—those on the anterior part of the disk may be wider, lower, and broadly rounded. In the genera *Sheldonella* and *Eontia* the ribs along the umbonal ridge are always the largest and usually double or irregularly divided. Those on the medial and anterior part of the disk are smaller and may or may not be divided.

What conclusions should be drawn from the relation of the nealogic sculpture to the adult sculpture in these genera may be a matter of considerable controversy, but it is suggested that they are not interdependent, either being capable of developing independently of the other. The suggestion of independent evolution for the juvenile and adult sculpture is not an orthodox idea, but it seems that in the Atlantic group there was a change through geologic time, from a type (*Scapularca*) in which the adult sculpture was a simple magnification of the juvenile sculpture to a type (*Eontia*) in which both juvenile and adult sculptures differed in different respects from that of the geologically earlier type. This might, of course, be explained as a progressively later appearance of the secondary ribs, allowing the primary ribs in the nealogic stage greater opportunity for development.

THE LIGAMENT

Any discussion of the ligament of the arcid Pelecypoda must consider two features—(*a*) structure and (*b*) distribution on the cardinal area.

The so-called vertically striated ligament, which characterizes the Noetidae, consists of two layers—(1) a multiple elastic layer, the elements of which grow normal to the hinge line and are suspended within (2) a fibrous layer that is in contact with the shell. With shell growth the active portion of the ligament is severed, and the cardinal area of each valve retains half of the defunct ligament. The distribution of this inactive ligament thus determines the so-called ligament area, and its form, of course, varies with the structure and location of the active ligament along the hinge line. As all the Noetinae have essentially the same structure, it does not seem necessary to discuss anything but the actual distribution of the inactive ligament on the cardinal area. Before passing on, however, a few remarks should be made concerning the vertical grooves.

In the Noetinae are found two kinds of vertical grooves. The larger grooves, to which alone attention has been called, indicate the position of the nonfibrous vertical elements. These are not attachment grooves, for the elastic layer is suspended within the fibrous layer, but areas in which the fibrous layer has become more deeply impressed in the shell to accommodate the vertical elements. The smaller and less regular vertical grooves are small cavities between the fibrous layer and the shell. These contained minute lobes of the mantle which apparently extended for a short distance up the cardinal area under the fibrous layer. Their purpose and function are unknown. These fine grooves, which are easily seen with a hand lens, have not been observed elsewhere in the Prionodonta but are found in some genera of both the Atlantic and the Pacific Noetinae. They are particularly developed in adults of *Arginopsis*, *Protonoetia*, *Noetia*, *Paranoetia*, and *Eontia*. So far they have not been observed in *Scapularca* or *Sheldonella* s. s., although many specimens of the latter have been examined. They are not well developed in the young stages of *Eontia* and frequently do not appear until the shell is well into the juvenile stage. This character, together with the well-developed secondary ribs, is further evidence that the Atlantic and Pacific groups constitute a natural subfamily, despite the dissimilarity of their earliest known members.

The ligament pattern of the Atlantic group is more nearly equilateral throughout than that of the Pacific group, in which both completely anterior and completely posterior ligaments are found. In the earliest genus of the Atlantic group, *Scapularca*, the ligament area ranges in shape from that of a nearly isosceles triangle to that of a triangle somewhat more produced posteriorly, but in all forms a considerable portion of the area at both ends is left bare. In the late Tertiary genera *Eontia* and *Sheldonella* s. s. the ligament fills the anterior portion of the area completely and in progressively later forms tends to occupy more and more of the posterior portion. This can be observed both as an evolutionary tendency and as a feature in the development of individuals, the posterior extension of the ligament being shorter in juveniles than in adults. In adults of the Recent subgenus *Paranoetia* the ligament extends from the anterior to the posterior terminus of the cardinal area. Nearly the same development occurs in the *Eontia ponderosa* group, but in this group it is aided by a secondary posterior shortening of the hinge line.

In the Pacific group *Protonoetia*, an Eocene genus, has a ligament area that fills the anterior part of its cardinal area completely and extends about half as far posteriorly as well. In the upper Eocene to Recent genus *Noetia* the ligament likewise fills the anterior part of the area but is more restricted posteriorly. *Noetia* includes a series from high-beaked forms in which the cardinal area and ligament are wider beneath the beaks, with the ligament extending a short distance posteriorly, to low-beaked forms in which the cardinal area is narrowest beneath the beaks and the ligament area is entirely anterior. Supposedly the primitive type of the Pacific Noetinae had a nearly equilateral ligament similar to that of *Scapularca* and the early genera of the Striarcinae, particularly *Breviarca*, *Arcopsis* and *Striarca*. Development from this symmetrical type produced on the one hand the type with chiefly anterior ligament, as described for *Protonoetia* and *Noetia*, and on the other hand the opposite extreme, with chiefly posterior ligament, such as is found in the genus *Noetiopsis*, in which the ligament completely fills the posterior part of the area and about half of the anterior part, just the opposite of the condition in *Protonoetia*. *Arginopsis* carries this process to the extreme in that the ligament is entirely posterior to the beaks. *Arginella*, a genus similar to *Arginopsis* in having its ligament area wholly posterior to the beaks, differs from *Arginopsis* in that the beaks are nearly central rather than anterior, and that a portion of the cardinal area anterior to the beaks is lunulelike.

The vertical ligament elements are more uniform in size and spacing in the Pacific group than in the Atlantic group, although in the strongly opisthogyrate members of both groups they tend to be stronger anteriorly. Moreover, in the Pacific group the vertical elements are distributed throughout the length of the ligament, no part being without them. In the Atlantic group considerable variety occurs. In *Scapularca* the grooves are evenly distributed anteriorly and posteriorly, but the initial groove, the one originating at the apex of the area, is stronger than the others. In juveniles of *Sheldonella* and *Eontia* equally strong grooves are added anterior to the initial groove, but the posterior part of the ligament consists of fibrous ligament only.

The South American *Eontia centrota* and *E. bisulcata* do not progress beyond this stage. Among the North American species of *Eontia* a series of forms shows all degrees of development of the vertical elements, from forms in which only one or two anterior elements are added to the initial groove (*E. incile mansfieldi*) to forms in which vertical elements are evenly distributed throughout the length of the ligament (*E. limula*).

CRENULATIONS OF THE INNER MARGIN

The nature of the posteroventral crenulations of the inner margin is a character that at first suggestion might be ignored, but I have yet to see a specimen that could not be correctly assigned to its proper group by this character alone. In the Atlantic group the crenulations are short, broad, and comparatively shallow. In the Pacific group they are deep, narrow, and round-bottomed and are two to three times as long as in Atlantic shells of the same size.

DESCRIPTIONS OF SPECIES

ATLANTIC GROUP

Genus SCAPULARCA Cossmann

Scapularca Cossmann, in Cossmann and Peyrot, Conchologie néogénique de l'Aquitaine, tome 2, livr. 1, p. 192, 1913.
Scapularca Cossmann, Catalogue illustré des coquilles fossiles de l'Éocène, app. 5, p. 100, 1913.

Type species: *Arca scapulina* Lamarck.

Shell ranging in shape from sublimopsiform to modioliform or carinate arciform. Beaks straight or slightly prosogyrate, moderately high to low. Ligament area ranging from nearly symmetrical in the more limopsiform species to more elongate posteriorly in the modioliform species. The anterior part of the area is never completely covered with ligament, as in the later opisthogyrate genera. Sculpture consists of larger ribs alternating with smaller, beaded ribs which may be reduced to mere beaded lirae. Teeth of variable number—as few as 9 in the shorter species, as many as 20 in the longer species.

Although recognized here for the first time, there seems to be little to dispute the thesis that this genus is the forerunner of the later genera *Eontia* and *Sheldonella* and that they are already foreshadowed in its extreme species. *Scapularca* differs from them, however, in its small size, the restriction of its ligament anteriorly, and the almost simultaneous appearance of the primary and secondary ribs in the nealogic sculpture. The subequilateral ligament area in *Scapularca* shows its relation to earlier members of the Noetidae, but it differs from them in the possession of secondary ribs.

EOCENE SPECIES

Scapularca subglobulosa (Wood) MacNeil

Plate 1, figures 1–4

Arca globulosa? Wood, Pal. Soc. Mon., p. 84, pl. 15, figs. 9a, 9b, 1864 (*subglobulosa* proposed in text).

Shell obliquely limopsiform, somewhat globular or gibbous; beaks moderately low, just anterior of central; ribs alternately large and small, the larger nearly smooth, the smaller distinctly beaded; ligament confined to a small triangular central part of the area beneath the umbo; teeth divided into two rows, four anteriorly and five posteriorly, the posterior teeth much inclined. (Emended description.)

Length 3 millimeters, height 2+ millimeters.

This species, with its nearly equilateral cardinal area, median beaks, and central ligament, most nearly approximates the hypothetical ancestor for the Atlantic Noetinae. Its typical noetine sculpture, however, still isolates it from any of the other groups of early Tertiary Noetidae.

Distribution: Bracklesham and Bartonian, England.
Type locality: Highcliff, Barton, England.

Scapularca globulosa (Deshayes) Cossmann

Arca globulosa Deshayes, Coquilles fossiles des environs de Paris, tome 1, p. 209, pl. 33, figs. 4, 5, 6, 1829; Animaux sans vertèbres dans le bassin de Paris, tome 1, p. 893, 1860.
Arca (*Anadara*) *globulosa.* Cossmann, Catalogue illustré des coquilles fossiles de l'Éocène, fasc. 2, p. 141, 1887.
Arca (*Anadara*) *globulosa.* Cossmann and Pissarro, Iconographie des coquilles fossiles de l'Éocène de Paris, vol. 1, pl. 36, fig. 110–46, 1904.
Fossularca (*Scapularca*) *globulosa.* Cossmann, Catalogue illustré des coquilles fossiles de l'Éocène, app. 5, p. 101, 1913.
Trigonodesma (*Scapularca*) *globulosa.* Glibert, Mus. Roy. histoire nat. Belgique Mém. 53, p. 123, 1933.

Shell subrhomboidal, inflated, higher posteriorly than anteriorly; broadly rounded posteroventrally, more angulate anteroventrally; beaks moderately high, situated just posterior to the anterior quarter of the shell; ribs alternately large and small, the larger smooth except for growth lines, the smaller scarcely more than beaded lirae; umbonal ridge broadly rounded; ligament area triangular, the posterior side about twice as long as the anterior; teeth often obsolete directly beneath the beak, the posterior ones inclined, about 8 anteriorly, about 12 posteriorly. (Emended description.)

This species differs from *S. subglobulosa* in its longer hinge line and more arciform shape. The interstitial ribs are not as much developed.

Distribution: Lutetian and Bartonian of France and Belgium.

Scapularca interposita (Deshayes) Cossmann

Plate 1, figures 5, 6

Arca interposita Deshayes, Animaux sans vertèbres dans le bassin de Paris, tome 1, p. 892, pl. 67, figs. 11–13, 1860.
Arca (*Anadara*) *globulosa* var. *interposita.* Cossmann and Pissarro, Iconographie des coquilles fossiles de l'Éocène de Paris, vol. 1, pl. 36, fig. 110–46–1, 1904.
Fossularca (*Scapularca*) *interposita.* Cossmann, Catalogue illustré des coquilles fossiles de l'Éocène, app. 5, p. 101, 1913.

Shell subrhomboidal, inflated, the posterior margin longer than the anterior, somewhat angulate both posteroventrally and anteroventrally; beaks high, located at the anterior quarter of the shell or just

posterior to it; ribs alternately large and small, the larger marked by growth varices, the smaller somewhat beaded; umbonal ridge rounded but well defined; ligament area longer posteriorly, about twice as long as anterior in young specimens, about four times as long in adults; teeth usually continuous, vertical centrally, inclined terminally, about 7 to 9 anteriorly, about 12 to 15 posteriorly. (Emended description.)

Figured specimen (U.S.N.M. 496506), length 6.5 millimeters, height 4.5 millimeters, convexity 1.5 millimeters.

This species differs from *S. globulosa* in being about twice as large and in having a more carinate umbonal ridge and accentuated sculpture. It may be only a variety of *S. globulosa*, but a decision cannot be made from the few specimens at hand. The interesting features of this shell are its tendency to form a carinate umbonal ridge and the increasing extension of the ligament toward the posterior with shell growth. It differs from *S. scapulina*, in which the umbonal ridge is broad and rounded.

Distribution: Lutetian and Bartonian, France.

Scapularca scapulina (Lamarck) Cossmann

Plate 1, figures 7, 8

Arca scapulina Lamarck, Mus. histoire nat. Annales, vol. 6, p. 221, 1805; vol. 9, pl. 18, fig. 10, a, b.
Deshayes, Coquilles fossiles des environs de Paris, tome 1, p. 216, pl. 33, figs. 9, 10, 11, 1829; Animaux sans vertèbres dans le bassin de Paris, tome 1, p. 898, 1860.
Arca (*Anadara*) *scapulina*. Cossmann, Catalogue illustré des coquilles fossiles de l'Éocène, fasc. 2, p. 142, 1887.
Arca (*Anadara*) *miliacea* Cossmann, idem, p. 141.
Arca (*Anadara*) *scapulina*. Cossmann and Pissarro, Iconographie des coquilles fossiles de l'Éocène de Paris, vol. 1, pl. 36, fig. 110–48, 1904.
Arca (*Anadara*) *miliacea*. Cossmann and Pissarro, idem, fig. 110–47.
Arca scapulina. Lamy, Jour. conchyliologie, vol. 52, p. 138, 1904.
Fossularca (*Scapularca*) *scapulina*. Cossmann, Catalogue illustré des coquilles fossiles de l'Éocène, app. 5, p. 100, 1913.
Fossularca (*Scapularca*) *miliacea*. Cossmann, idem, p. 101.
Trigonodesma (*Scapularca*) *scapulina*. Glibert, Mus. roy. histoire nat. Belgique Mém. 78, p. 27, 1936.

Shell modioliform, inflated along the umbonal rostrum; beaks moderately low, situated at about the anterior fifth of the shell; ribs alternately large and small, the larger nearly smooth posteriorly but somewhat granular centrally, the smaller ribs well developed and beaded; both large and small ribs stronger posteriorly; ligament area much longer posteriorly than anteriorly but less so in younger stages; teeth crowded and more vertical anteriorly, more separated and inclined posteriorly, often obsolete along the central part of the hinge line, 6 to 7 anteriorly, 8 to 12 posteriorly. (Emended description.)

Figured specimen (U.S.N.M. 496505), length 6.5 millimeters, height 5 millimeters, convexity 2 millimeters.

This species is readily distinguished from the other species of *Scapularca* by its modioliform shape. *S. subglobulosa* most nearly approaches it in the perfection of its sculpture.

"Arca" miliacea Cossmann, "de la forme d'un grain de millet", is almost too small to be an adult specimen. Juvenile specimens of *S. scapulina* are less elongate than adults and conform to the description of this species.

Diversification within the genus *Scapularca* appears to have proceeded in two directions from the subovate form—to the carinate arciform type of *S. interposita* on the one hand, and to the modioliform *S. scapulina* with its rounded umbonal region on the other hand. The similarity of the former to *Eontia* and of the latter to *Sheldonella* suggests that these two late Tertiary genera were already foreshadowed among the species of *Scapularca*.

Lamy appears to be the only author to have called attention to the similarity of *Arca scapulina* and Recent Indian Ocean species of *Paranoetia*. He compared Lamarck's type with specimens from the Persian Gulf identified by Fischer as *Arca venusta* Dunker and other specimens of the same species from Madagascar and Zanzibar. The species Lamy had in mind is here treated as *Sheldonella* (*Paranoetia*) *cafria* (Bartsch).

Distribution: Lutetian and Bartonian, France.

Genus SHELDONELLA Maury

Noetia (*Sheldonella*) Maury, Bull. Am. Paleontology, vol. 5, no. 29, p. 166, 1917.

Type species: *Noetia* (*Sheldonella*) *maoica* Maury.

Miss Maury proposed the "new section *Sheldonella* to contain thin, small, trigonal Noetias without the angular umbonal ridge."

Aside from the species of *Scapularca* with rounded umbonal areas, only three species of Atlantic Noetinae have been described which conform to this definition, and two of them appear to be at least subgenerically removed from the type. *Sheldonella maoica* occurs in the lower middle Miocene of the Dominican Republic. The other two species, for which the subgeneric name *Paranoetia* Thiele is available, are Recent from the Southern Hemisphere—*Arca lateralis* Reeve, the type of *Paranoetia*, from the Philippines; and *Barbatia cafria* Bartsch, from South Africa.

All these forms have a very neat sculpture. The ribs along the inflated umbonal region are precisely divided and beaded. The interstitial ribs remain well developed posteriorly but may, in some individuals, become obsolete medially. I recognize *Sheldonella* as a genus distinct from *Eontia* because of my belief that they are derived from different species of the prototypical genus, *Scapularca*. The rounded umbonal region might not, in itself, be considered sufficient reason for treating the three species mentioned as constituting a separate genus, but none of them appears to be very closely related to any of the species of *Eontia*. Adults of some species of *Eontia* have rounded umbonal

areas, but the juvenile shells are carinate, so that shells of the same size are not likely to be confused.

The genotype of *Sheldonella* possesses a secondary ridge on the posterior slope, called the anal ridge. This ridge is not present in the subgenus *Paranoetia* and is found only as an occasional individual variation in adults of a few of the North American species of *Eontia*, but it is constant and strongly developed in the three southern species referred to *Eontia*—*E. centrota*, *E. bisulcata*, and *E. olssoni*. Thus, though these species are referred to *Eontia* on the basis of the angulate umbonal ridge, they also agree with *Sheldonella* in possessing an anal ridge, and it may be that they really constitute a subgenus of *Sheldonella*. In that event the nature of the umbonal ridge would prove to be inconsistent as a generic character. Unless the group of *E. centrota-bisulcata* can be definitely proved to be derived from *Sheldonella*, however, it seems best to refer this group to *Eontia*.

MIOCENE SPECIES

Sheldonella maoica Maury

Plate 1, figures 13, 14

Noetia (*Sheldonella*) *maoica* Maury, Bull. Am. Paleontology, vol. 5, no. 29, p. 166, pl. 30, figs. 17, 18, 1917.

Arca cuneolus Pilsbry and Johnson, Acad. Nat. Sci. Philadelphia Proc., 1917, p. 191.

Arca maoica. Pilsbry, Acad. Nat. Sci. Philadelphia Proc., 1921, p. 407, text fig. 36.

Shell subpteriiform or modioliform, posterior large and high, anterior small, shell sulcated and margin constricted just anterior of the umbonal region; beaks moderately high and opisthogyrate, situated just anterior of the anterior third of the shell; umbonal region very large and inflated; posterior slope larger than the portion anterior to the ridge in some specimens; anal ridge usually well developed; ribs 33 to 38, averaging about 35, alternating with small interstitial ribs, large ribs double posteriorly, both large and interstitial ribs beaded by growth varices; ligament area filling the anterior part of the cardinal area completely and extending about an equal distance posteriorly, a broad strip of the area devoid of ligament posteriorly; teeth vertical and very small centrally, inclined terminally. (Emended description.)

Holotype (in Paleontological Research Institution, Ithaca, N. Y.), length 12 millimeters, height 6 millimeters, convexity 4 millimeters; figured topotype (U.S.N.M. 496507).

This species is unique because of its much-inflated umbonal ridge. It differs from *Scapularca* in having a different ligament pattern and in being larger, with a more alate hinge line and more inflated ridge.

This is the only species with a rounded umbonal ridge and modioliform shape known from America. It occurs in deposits of early middle Miocene age, whereas the carinate type does not make its appearance until the upper Miocene. The carinate type is known from the Aquitanian, Burdigalian, and Helvetian, and the inference is strong that we need not look to this early American form for the ancestor of *Eontia*. Furthermore, *Eontia incile mansfieldi*, nearest to *Sheldonella maoica* both stratigraphically and geographically, is the most unlike it of all the species of *Eontia*.

The structure referred to in the description as the anal ridge appears fairly high on the posterior slope and, although weakly developed in some specimens, is usually quite distinct. Three species that are referred to the genus *Eontia* on the basis of the carinate umbonal ridge—*E. centrota*, *E. bisulcata*, and *E. olssoni*—also have the anal ridge, and it may be that the affinities of this small group are really with *Sheldonella* rather than with *Eontia*.

Distribution: Lower middle Miocene, Cercado formation, Dominican Republic.

Type locality: Cercado de Mao, Provincia de Santiago, Dominican Republic. Topotypes, U.S.G.S. 8525.

Subgenus PARANOETIA Thiele

Paranoetia Thiele, Handbuch der systematischen Weichtierkunde, 3. Teil, p. 793, 1934.

Type species: *Arca lateralis* Reeve.

This subgenus was proposed as a subgenus of *Noetia* but in my arrangement falls nearest to the genus *Sheldonella* and is accordingly made a subgenus of it. It might be the opinion of some that *Paranoetia* is entitled to stand as an independent genus. If the present arrangement is correct, the genotype species, *Sheldonella maoica*, is probably aberrant to the stock which produced *Paranoetia*.

The species of *Paranoetia* do not have the anal ridge.

RECENT SPECIES

Sheldonella (Paranoetia) lateralis (Reeve) MacNeil

Plate 1, figures 21, 22

Arca lateralis Reeve, Conchologia iconica, vol. 2, *Arca*, sp. 115, pl. 17, fig. 115, 1844.

Barbatia venusta Dunker, Novitates conchologicae, Mollusca marina, p. 91, pl. 31, fig. 1, 1870.

Arca (*Barbatia*) *venusta*. Kobelt, Conchylien-Cabinet von Martini u. Chemnitz, *Arca*, p. 189, pl. 46, fig. 6, 1891.

Arca (*Barbatia*) *lateralis*. Kobelt, idem, p. 192, pl. 46, fig. 12 (Reeve's figure).

Arca venusta. Hedley, Linnean Soc. N. S. Wales, vol. 30, p. 545, 1905.

Arca (*Noetia*) *lateralis*. Lamy, Jour. conchyliologie, vol. 55, p. 303 (in part), 1907.

Shell subrhomboidal, considerably narrower anteriorly than posteriorly; beaks moderately high, relatively higher in adults, situated at about the anterior third of the hinge line; umbonal region broadly rounded; ribs 33 to 36, averaging about 34, alternating large and small, the larger double posteriorly, both large and small ribs conspicuously beaded by growth varices; ligament almost completely covering the cardinal area

in adults, but more restricted posteriorly in juveniles; teeth vertical centrally, inclined terminally, somewhat L-shaped anteriorly. (Emended description.)

Figured specimen (U.S.N.M. 248983), length 16 millimeters, height 12 millimeters, convexity 5 millimeters; a larger, worn specimen, length 31 millimeters, height 23 millimeters, convexity 10 millimeters.

This species compares somewhat with *Sheldonella maoica*, but is a much larger species and less constricted anteriorly. In addition, its ligament covers more of the cardinal area. Like *S. maoica*, which appears to have been strongly byssated, *P. lateralis* apparently attaches to objects by means of a byssus, and two adults of this species are distorted and worn in spots, indicating that some individuals, at least, are rock nestlers.

The identification of *Barbatia venusta* Dunker as *Arca lateralis* Reeve rather than *Barbatia cafria* Bartsch is based on the number of ribs (38) given in the description. It thus compares with *A. lateralis*, of which the number of ribs on specimens in the U. S. National Museum ranges from 33 to 36, rather than with *B. cafria*, which has about 30 or 31. It may be that Dunker counted both parts of the bifid ribs on the posterior ridge separately or included the interstitial ribs in the count, which would give a larger number. If this is so it may prove that *B. venusta* is the east African species and not the Indo-Pacific species, in which case the synonomy here given would need revision.

The two species were treated together by Lamy as *A. lateralis* but the dimensions and locality records which he gives, including unpublished museum records and personal communications, makes them easily delimitable into a small west Indian Ocean species and a larger Indo-Pacific species.

Distribution: Recent, Ceylon, East Indies, Australia, Philippine Islands, and China Sea.

Type locality: Philippine Islands.

Other occurrences: Galle, Ceylon (a specimen from this locality is the largest on record, having a length of 42 millimeters), Penang, Malacca Straight (Calcutta Museum); Gulf of Carpentaria, Queensland (Hedley); Manila Bay, Amoy, Formosa Strait (U. S. National Museum).

Sheldonella (Paranoetia) cafria (Bartsch) MacNeil

Plate 1, figures 17, 18

Arca venusta. Fischer, Jour. conchyliologie, vol. 39, p. 228, 1891.
Arca (Noetia) lateralis. Lamy, Jour. conchyliologie, vol. 55, p. 303 (in part), 1907.
Barbatia cafria Bartsch, U. S. Nat. Mus. Bull. 91, p. 183, pl. 38, figs. 1, 5, 1915.

Shell subrhomboidal, somewhat narrower anteriorly than posteriorly, both anterior and posterior ends about equally rounded; beaks moderately high, situated at about the anterior third of the shell; umbonal region very broadly rounded; ribs about 30 or 31, alternating with smaller, interstitial ribs, the larger ribs double posteriorly, smaller ribs conspicuously beaded by growth varices; ligament covering nearly the entire cardinal area; teeth vertical centrally, inclined terminally. (Emended description.)

Holotype (U.S.N.M. 249849), length 14.2 millimeters, height 8.5 millimeters, double convexity 8.6 millimeters.

This species has a simpler outline than *P. lateralis*, the hinge line being shorter and the dorsal extremities more rounded. The medial sulcus is less pronounced, and the anterior end of the shell is comparatively larger. Of a number of specimens at hand all approximate 14 millimeters in length, showing that it is a smaller species than *P. lateralis*.

Distribution: Recent, west Indian Ocean from South Africa to the Persian Gulf and India.

Type locality: Port Alfred, South Africa.

Other occurrences: Durban, Natal (Amsterdam Museum); Madagascar (?), Zanzibar (Paris Museum); Aden (Jousseaume); Persian Gulf (Fischer); Goa (U. S. National Museum).

Genus EONTIA MacNeil, n. gen.

Type species: *Arca ponderosa* Say.

The separation of the *Arca ponderosa* group from the *Noetia reversa* group necessitates the proposal of a new generic name for the former. *Eontia*, an anagram of *Noetia*, is proposed.

Although related to the genus *Sheldonella*, *Eontia* differs from it in being less modioliform, with a better-defined, often carinate umbonal ridge. The sculpture is coarser and less regular, and there is a greater break between the nealogic and adult sculpture. The characteristics of sculpture that distinguish *Eontia* from the Pacific genus, *Noetia*, are fully described on pages 2–8.

The genus *Eontia* is predominantly American. Only one species is known to occur elsewhere—*Eontia oleni*, in the lower Miocene of France. This species not only occurs at a lower stratigraphic horizon than any of the American forms but is properly located to support my hypothesis that the genus is descended from the European Eocene genus *Scapularca*. Two sections of *Eontia* appear to exist in America—one the Caribbean and South American group of *E. centrota, bisulcata*, and *olssoni*, and the other the North American group of *E. incile* and *ponderosa*. The first group is characterized by a well-developed anal ridge recalling *Sheldonella maoica*, and possibly its affinities are with *Sheldonella*. Because of their carinate umbonal ridge, however, these species are tentatively referred to *Eontia*.

A study of this group involves investigation of the migration of stocks and the development of geographic species and subspecies. Several varietal series are known, the end members of which are represented by purer strains elsewhere or at lower horizons. The question arises whether such conditions represent speciation or interbreeding. I believe that at least some preexisting species or varieties have intermingled to produce varietal series from which emerged a single,

more uniformly breeding species. In other words, so far as this group is concerned, hybridization is regarded as a factor that tends to limit diversification.

The North American group is represented in the collection of the United States National Museum by many specimens from numerous localities of each horizon at which the series occurs, and it is hoped that my interpretation of these forms will prove to be of value in correlating the stages of the upper Miocene and Pliocene of the Atlantic Coastal Plain.

EUROPEAN SPECIES

MIOCENE SPECIES

Eontia okeni (Mayer) MacNeil

Plate 1, figures 9, 10

Arca okeni Mayer, Jour. conchyliologie, vol. 6, p. 185, pl. 14, figs. 7, 8, 1857.

Dollfus and Dautzenberg, Soc. géol. France Mém., Paléontologie, vol. 20, Mém. 27, p. 337, pl. 27, figs. 19–27, 1913.

Arca (*Anadara*) *okeni*. Cossmann and Peyrot, Conchologie néogénique de l'Aquitaine, tome 2, livr. 1, p. 162, pl. 9, figs. 5, 6, 1913.

Shell subrhomboidal, rounded anteriorly, produced posteroventrally; beaks high, situated between the center and the anterior third of the hinge line; umbonal region carinate; ribs alternately large and small, the larger often double posteriorly, ribs beaded by growth varices; cardinal area wide; ligament filling the anterior part of the area completely and extending almost an equal distance posteriorly, leaving a wide strip of the area bare posteriorly; teeth small and vertical or nearly obsolete centrally, inclined terminally, the posterior row slightly longer than the anterior row. (Emended description.)

Length 20 millimeters, height 13 millimeters, convexity 6.5 millimeters.

The vertical ligament elements in this species appear to be confined to the portion of the ligament anterior to the beaks. It thus differs in ligamental characters from *Scapularca interposita*, in which the ligament is more restricted anteriorly and the vertical elements are more evenly distributed, although occasionally specimens of that species are found in which the posterior grooves are very weak.

As all the species vary considerably, it is difficult to say which of the first American species most nearly resembles this European form, although perhaps specimens of *E. centrota* can be selected that appear more like it in shape. None of the published figures of the species show any indication of the anal ridge, however, and it may be that the resemblance of *E. okeni* to *E. centrota* and *E. bisulcata* is homeomorphic. Probably *E. incile* is its nearest American relative.

Distribution: Lower Miocene, Aquitanian and Burdigalian of Aquitaine; middle Miocene, Helvetian of Touraine, France.

SOUTH AMERICAN SPECIES

PLIOCENE SPECIES

Eontia centrota (Guppy) MacNeil

Plate 1, figures 11, 12

Arca centrota Guppy, Sci. Assoc. Trinidad Proc., p. 175, 1867 (Harris reprint, Bull. Am. Paleontology, vol. 8, no. 35, p. 54, 1921); Geol. Mag., London, new ser., vol. 1, pl. 18, fig. 23, 1874 (this plate was prepared for the 1867 paper but was not issued with it.)

Arca (*Noetia*) *centrota*. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 617, 1898.

Maury, Bull. Am. Paleontology, vol. 10, no. 42, p. 38, pl. 8, figs. 10, 12, 1925.

Shell subrhomboidal, wider posteriorly than anteriorly, somewhat produced and angulate posteroventrally; more modioliform in young stages; beaks moderately high, situated just posterior to the anterior third of the hinge line; umbonal ridge carinate but not much inflated; anal ridge well developed; ribs about 34, alternating with small interstitial ribs, the larger ribs frequently double posteriorly, both large and small ribs beaded by growth varices; ligament extending about as far posteriorly as anteriorly, leaving a wide strip of the area bare posteriorly; vertical ligament elements weak or absent posterior to the beaks; teeth small and vertical centrally, inclined terminally, the posterior row about twice as long as the anterior row. (Emended description.)

Lectotype (U.S.N.M. 496508), length 26 millimeters, height 16 millimeters, convexity 7 millimeters; paratypes (U.S.N.M. 115682).

Many specimens of this species are shorter and higher than the specimen from Guppy's type lot figured here. As in *E. okeni*, the vertical ligament elements are weak or absent posteriorly, but *E. centrota* differs from that species in being more elongate along the hinge line and less produced posteroventrally, in having a less elevated umbonal ridge but a well-developed anal ridge and more anterior beaks. The shell is less inflated, and the umbones do not appear to be as high.

The anal ridge on the posterior slope, which this species, *E. bisulcata*, and *E. olssoni* possess distinguishes them from the North American species of *Eontia*, and it may be that they are not as closely related to the North American species as the carinate umbonal ridge would indicate. The anal ridge is also found in *Sheldonella maoica*, and it remains for a fuller knowledge of the ancestry of *E. centrota* to show whether the South American group is related to the North American group or should be treated as a subgenus of *Sheldonella*.

Distribution: Upper Miocene, Springvale formation, Trinidad (Maury); Pliocene, Matura Bay deposits, eastern Trinidad.

Type locality: Matura Bay, Trinidad.

RECENT SPECIES

Eontia bisulcata (Lamarck) MacNeil

Plates 1, figures 15, 16

Arca bisulcata Lamarck, Animaux sans Vertèbres, vol. 6, p. 45, 1819.

Arca (Byssoarca) martinii Recluz, Jour. conchyliologie, vol. 3, p. 409, pl. 12, figs. 3–5, 1852.

Arca martinii. Dunker, Novitates conchologicae, Mollusca marina, p. 133, pl. 45, figs. 1–4, 1870.

Arca centrota Guppy, Sci. Assoc. Trinidad Proc., vol. 2, pl. 3, figs. 4a, 4b, 1873 (Harris reprint, Bull. Am. Paleontology, vol. 8, no. 35, pl. 1, figs. 4a, 4b, 1921); Annals and Mag. Nat. History, 4th ser., vol. 15, p. 51, pl. 7, figs. 4a, 4b, 1875 (except for the addition of a few lines, this paper is a reprint of the 1873 paper).

Arca (Noetia?) martinii. Kobelt, Conchylien-Cabinet von Martini u. Chemnitz, *Arca*, p. 60, pl. 17, figs. 7, 8, 1891.

Arca (Noetia) martinii. Von Ihering, Jour. conchyliologie, vol. 43, p. 214, 1895.

Arca bisulcata. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 617, 1898.

Arca (Noetia) martini. Lamy, Jour. conchyliologie, vol. 55, p. 301, 1907.

Shell subrhomboidal, rounded anteriorly, angulate posteroventrally; beaks high, situated between the middle and anterior third of the hinge line; umbonal region carinate and inflated; anal ridge well developed; ribs about 33 or 34, alternating with small interstitial ribs, the large ribs wider but not showing any great tendency to be doubled posteriorly; both large and small ribs beaded by growth varices; ligament not as long posteriorly as anteriorly, leaving a wide area bare posteriorly, vertical elements coarse anteriorly but absent posterior to the beaks; teeth small and vertical centrally, inclined posteriorly, inclined or L-shaped anteriorly; the posterior row slightly longer. (Emended description.)

Figured specimen (U.S.N.M. 496509), length 23 millimeters, height 15 millimeters, convexity 7.5 millimeters; an eroded, larger specimen, length 30 millimeters, height 19.5 millimeters, convexity 10.5 millimeters.

This species with its high beaks and short hinge line has more the aspect of *E. okeni* than the more elongate specimens of *E. centrota.* It differs from *E. okeni,* however, in having a well-developed anal ridge. It has much coarser vertical ligament elements than *E. centrota,* is more inflated, and the ribs do not have as great a tendency to divide posteriorly. Future collections may show that these two species pass insensibly into one another.

Lamy expressed doubt concerning the suggestion of Dunker, Kobelt, and Dall that *Arca martinii* and *A. bisulcata* were the same species, but his reason that a specimen of another species in the collection of Defrance was labeled "*Arca bisulcata* var." in the hand of Lamarck does not prove his point. Rather, it seems to indicate that Lamarck recognized the specimen in Defrance's cabinet as different from his species.

Distribution: Recent, Caribbean and Atlantic coasts of South America from Colombia to Uruguay.

Eontia olssoni (Sheldon and Maury) MacNeil

Plate 1, figures 19, 20

Arca sp. indet. *a,* Adams, Lyceum Nat. History New York Annals, vol. 5, p. 488, 1852.

Carpenter, Zool. Soc. London Proc., p. 364, 1863.

Noetia olssoni Sheldon and Maury, Paleontographica americana, vol. 1, no. 4, p. 10, pl. 1, figs. 6, 9, 1922.

Shell subrhomboidal, as high anteriorly as posteriorly, anterior rounded, posteroventral margin angulate; beaks of about medium height, situated at about the center of the hinge line; umbonal ridge carinate; anal ridge well developed; posterior slope deeply sulcated between the two ridges, especially in young shells; ribs alternately large and small with a slight tendency for the larger ribs to become double posteriorly, ribs delicately beaded by growth varices; ligament nearly as long posteriorly as anteriorly; teeth small and vertical centrally, inclined terminally, rows subequal in length. (Emended description.)

Holotype (in Paleontological Research Institution, Ithaca, N. Y.), length 19 millimeters, height 11 millimeters, convexity 5 millimeters.

This species occurring in the Pacific is clearly a member of the *E. centrota-bisulcata* group but differs from the Recent Caribbean species in being longer posteriorly and in having more central beaks and nearly equal rows of teeth. Its vertical ligament grooves are finer, the posterior slope is more sulcated between the umbonal and anal ridges, and the ribs are finer and more delicately beaded.

A study of the Pacific genus *Noetia* and Central and South American faunas as a whole strongly suggests that there has been no free passage between the Pacific and Caribbean since Miocene time, so that the separation of this species from the Caribbean stock is probably not of very late date. It is easily distinguished from *E. bisulcata,* and it is not likely to be merely an introduced form of that species. This species should be compared with the Springvale Miocene form from Trinidad. If these two forms are related, the genus should be present in some of the upper Miocene or Pliocene beds of northern South America or Central America.

Distribution: Recent, Pacific coast of Panama, Negritos and Salinas, Peru (Olsson).

Type locality: Bucaru, Los Santos Province, Panama.

NORTH AMERICAN SPECIES

MIOCENE SPECIES

Eontia incile (Say) MacNeil

Plate 1, figures 25–28, 30, 31

Arca incile Say, Acad. Nat. Sci. Philadelphia Jour., 1st ser., vol. 4, p. 139, pl. 10, fig. 3, 1824.

Conrad, Fossils of the Tertiary formations, p. 16, pl. 2, fig. 1, 1832; Fossils of the medial Tertiary, p. 56, pl. 29, fig. 5, 1840.

Arca (Noetia) incile. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 632 (in part), 1898.

Sheldon, Paleontographica americana, vol. 1, no. 1, p. 25 (in part), pl. 5, figs. 18–25, 1916.

Shell subrhomboidal and elongate, anterior rounded, posterior usually emarginate, angulate posteroventrally; hinge line of variable length, sometimes greater and sometimes less than the middle length of the shell; beaks high, situated at about the anterior quarter or fifth of the hinge line; umbonal ridge sharply rounded and moderately inflated; posterior slope with a median sulcus which is more pronounced the longer the hinge line; ribs about 27, alternating with small interstitial ribs which may be obsolete in some specimens, the larger ribs tending to be double or irregularly divided posteriorly; ribs slightly beaded or roughened by growth varices, more beaded in young stages; ligament extending posteriorly about as far to twice as far as anteriorly, leaving a large part of the area bare posteriorly; vertical ligament elements absent posteriorly in young specimens but appearing weakly and irregularly posterior to the beaks in specimens about half grown; teeth numerous and mostly vertical, the terminal teeth inclined, anterior and posterior rows practically continuous, about four-fifths of the teeth posterior to the beaks. (Emended description.)

Figured specimens: *Chama*-bearing bed (U.S.N.M. 496510), length 22 millimeters, height 17.5 millimeters, convexity 8.5 millimeters; bed *a* (U.S.N.M. 496512), length 31 millimeters, height 20 millimeters, convexity 10 millimeters; bed *c* or *Crepidula* bed (U.S.N.M. 496513), length 36.5 millimeters, height 25.5 millimeters, convexity 12 millimeters; *Crepidula* bed at Bellefield (U.S.N.M. 496517), length 39.5 millimeters, height 23 millimeters, convexity 11 millimeters; bed *f* (U.S.N.M. 496511), length 45.5 millimeters, height 27 millimeters, convexity 13.5 millimeters.

The development of the posterior ligament elements in this species and its progeny is in contrast to the great rarity or absence of these structures in the *E. centrota-bisulcata* group. Specimens of *E. incile* can be selected which approach *E. centrota* in shape but lack the anal ridge. In both *E. centrota* and the European species *E. okeni* the hinge line is always shorter than the greatest length of the shell, whereas in *E. incile* it is commonly equal to the greatest length and frequently is the region of the greatest length. The sculpture of *E. incile* is more irregular than that of *E. centrota*, and the ribs are less beaded. *E. centrota* is usually less inflated, and the young stages are more modioliform.

The specimen figured by Say, which he believed to have come from Maryland, is the short, inflated, long-hinged type found in the lower part of zone 2 of the Yorktown formation, the *Chama*-bearing bed at Grove Wharf and King's Mill Wharf on the James River, and in all probability Say's specimen came from there. This form grades into larger, longer, and less inflated specimens. In the upper part of the *Chama*-bearing bed the more rotund variety, *E. incile yorkensis*, n. var., is found as the end member of a varietal series.

In the lowest bed at Yorktown, the *Turritella*-bearing bed or bed *a*, which is probably equivalent to the next higher bed above the *Chama*-bearing bed, is found a medium-sized form which is similar to the more elongate type of the *Chama*-bearing bed but which, on the average, has more central beaks than specimens from either the underlying or overlying beds. The short type is rare, and the variety *yorkensis* has not been found. In the next overlying zone, bed *b*, the genus appears to be absent, at least at Yorktown, although considerable search was made for specimens.

The middle and upper beds at Yorktown, the *Crepidula*-bearing bed, or bed *c*, and higher, contain a form which averages considerably larger than those in the *Turritella*- and *Chama*-bearing beds, and some specimens approach the Duplin species *E. trigintinaria* in size. Considerable variation is displayed by this form from bed *c*, but it consists mostly of irregularity of shape and does not constitute a well-defined varietal series as in the *Chama*-bearing bed. Most individuals from bed *c* are more elongate and have more anterior beaks than the forms in bed *a* and thus compare less with the Duplin species *E. trigintinaria* than specimens from bed *a* in this respect. It may be that these robust forms should be considered a subspecies, but no definition except size and irregularity seems possible, and for the time being they will be left in *E. incile*, s. s. It may be pointed out, however, that on the basis of varieties and size any collection containing a number of specimens can usually be assigned to its correct horizon.

A condition occurring in this species, the cause of which has not been determined, although it may be due to muscle parasites, is that of the raised or swollen muscle scars, especially anteriorly. Occasional specimens showing this condition are found in the *Chama*-bearing bed, and also in *E. trigintinaria* from the Carolinas, but if caused by parasites, it reached epidemic proportions at certain localities in the middle part of the Yorktown formation of Virginia. Specimens from the *Crepidula*-bearing bed at Yorktown, in a well 1 mile east of Wareham, Gloucester County, and at Bellefield, just below Felgates Creek on the York River, are unaffected. In the continuous layer, bed *f*, immediately overlying the fragmental zone at Yorktown, and in what is probably the same zone at the site of the colonial limekiln below Indian Field Creek, above Yorktown, every specimen has greatly swollen and deformed muscle scars. They are also found in specimens from Rushmere Wharf, on the James River; from a locality 2 miles below City Point, on the James River; from Petersburg; and from the Dismal Swamp.

Whether this condition is of any lateral extent and represents the same stratum throughout is uncertain. If the present zoning of the Yorktown formation[4] is correct, it occurs at a lower horizon along the James River than along the York River, and I conclude for the present, therefore, that this is a diseased condition and not a genetic character.

[4] Mansfield, W. C., 16th Internat. Geol. Congress Guidebook 5, Chesapeake Bay region, p. 32, 1932, and unpublished notes.

Dall and the Maryland Geological Survey reported *E. incile* in the Burns and Harris collection from the Choptank formation at Jones Wharf, Md. This was evidently an error, as the specimens of this species in the Burns and Harris collection in the United States National Museum are recorded in the locality catalog as having come from Virginia and are like specimens from Rushmere Wharf in form and preservation. No collections from Maryland have contained any specimens of *Eontia*, to my knowledge.

Distribution: Upper Miocene, zone 2, Yorktown formation, Virginia.

Type locality: Unknown, but the specimen figured by Say appears to be the type found in the *Chama*-bearing bed, the basal bed of zone 2.

Occurrence: This species occurs abundantly at localities too numerous to mention along the York River from a point below Yorktown to a point above Felgates Creek; in Gloucester County; along the James River from a point below Smithfield to City Point; at Petersburg; and in southern Virginia at Sycamore Church on the Nottoway River, Southampton County, U. S. G. S. 10216. It occurs with the variety *E. incile yorkensis* in the *Chama*-bearing bed in the York-James Peninsula, at Dinwiddie, and near Powcan, in King and Queen County, and with *E. incile suffolkensis* in the upper part of the Yorktown formation north of Smithfield, at Chuckatuck and Suffolk.

Eontia incile mansfieldi MacNeil, n. subsp.

Plate 1, figures 23, 24

Arca (*Noetia*) *incile*. Mansfield, Florida Geol. Survey Bull. 8, p. 45, pl. 6, 1932.

Shell subrhomboidal and elongate, anterior rounded, posterior strongly emarginate, angulate anterodorsally, alate posterodorsally, angulate posteroventrally; beaks moderately high, situated at about the anterior fifth of the hinge line; umbonal ridge carinate and narrowly inflated; posterior slope deeply sulcated; ribs about 27; interstitial ribs small or absent, ribs beaded in young stages; ligament extending about as far posteriorly as anteriorly, but leaving a wide strip of the area bare posteriorly, vertical ligament elements rare or absent posterior to the beaks; teeth numerous and mostly vertical, the posterior teeth slightly inclined, the anterior teeth L-shaped, anterior and posterior rows continuous, about four-fifths of the teeth posterior to the beaks.

Holotype (U.S.N.M. 371122), length 25.5 millimeters, height 15.5 millimeters, convexity 7.5 millimeters.

This species is well characterized by its alate posterior and pronounced sulcus. The figured holotype is the largest specimen known of this species but does not appear to be a full-grown adult. Occasional specimens of *E. incile* from Virginia and more commonly of *E. trigintinaria* from the Carolinas are found with a subalate posterior, but never so pronounced nor of the constant character of the Florida subspecies.

If the present correlation of the *Ecphora* zone of the Choctawhatchee formation of Florida with zone 1 of the Yorktown formation is correct, *E. incile mansfieldi* is the earliest American occurrence of *Eontia*, the northern form making its appearance at the base of the *Chama*-bearing bed, the lowest horizon of zone 2 of the Yorktown formation. The possibility remains, however, that the *Ecphora* zone is equivalent to some part of zone 2 of the Yorktown formation.

Distribution: Upper Miocene, *Ecphora* zone, Choctawhatchee formation, Florida.

Type locality: Jackson Bluff, Ocklocknee River, Leon County, Fla., U.S.G.S. 3423.

Eontia incile yorkensis MacNeil, n. var.[6]

Plate 1, figures 34–36.

Arca (*Noetia*) *incile*. Dall, Wagner Free Inst. Sci. Trans. vol. 3, pt. 4, p. 632 (in part), 1898.

Sheldon, Paleontographica americana, vol. 1, no. 1, p. 25 (in part), 1916.

Shell subrhomboidal to subovate, not much inflated, anterior rounded, posterior straight or broadly rounded, posteroventral margin rounded, not angulate; beaks high, situated at about the anterior third of the hinge line; umbonal ridge rounded and not well defined in adults; posterior slope narrow and moderately steep, sometimes with a shallow depression; ribs 26 to 30, averaging about 28, alternating with weak interstitial ribs, tending to be slightly double posteriorly; ribs slightly beaded in young stages; ligament over twice as long posteriorly as anteriorly, leaving a small strip of the area bare posteriorly, vertical elements appearing when the shell is about one-third grown; teeth numerous and mostly vertical, the posterior teeth slightly inclined and the anterior teeth tending to be L-shaped, anterior and posterior rows continuous.

Holotype (U.S.N.M. 496515), length 29.5 millimeters, height 23.5 millimeters, convexity 9.5 millimeters. Paratype (U.S.N.M. 496518).

Eontia incile yorkensis differs from the typical form in being less inflated, higher, and more rounded, with a broadly rounded ridge in adults. It has a more equilateral cardinal area than typical *E. incile* and a relatively larger ligament area. As in that species, the posterior ligament elements do not appear until the shell is one-third or more grown and remain weaker than the anterior ones throughout.

The variety has not been found in the lowest part of the *Chama*-bearing bed in the York-James Peninsula, but in the upper part of the *Chama*-bearing bed it occurs as the end member of a varietal series which grades into typical *E. incile*. In this area the variety is outnumbered by the more typical specimens, but farther north, at a locality about half a mile southwest of Powcan, King and Queen County, which is the northernmost outlier of the Yorktown formation known, it greatly outnumbers the typical form.

Distribution: Upper Miocene, upper part of the *Chama*-bearing bed, zone 2 of the Yorktown formation, Virginia.

[6] In this paper subspecific forms geographically or stratigraphically isolated from the typical form are made subspecies, whereas extreme forms that grade into the typical form in the same bed are made varieties.

Type locality: Upper part of the *Chama*-bearing bed exposed in the fourth tributary on the south of Queen Creek, about 300 to 400 feet south of the Yorktown-Williamsburg Parkway about 1½ miles east of Williamsburg, York County, Va., U.S.G.S. 13817.

Other occurrences: Paratype, Dinwiddie, Dinwiddie County, U.S.G.S. 1623; about half a mile southwest of Powcan, King and Queen County, U.S.G.S. 8205; on the headwater of a branch of Garnett Creek, about 1 mile southwest of Miller's Tavern, King and Queen County, U.S.G.S. 8206.

Eontia incile suffolkensis MacNeil, n. var.

Plate 1, figure 29

Occurring with more or less typical specimens of *E. incile* in the upper part of the Yorktown formation of southern Virginia, the beds at Suffolk and their nearby equivalents, are occasional specimens of a variety which at first glance appears quite distinct. It is distinguished by its very sharp umbonal ridge and deep sulcus on the posterior slope. The hinge line is long, so that the shell is angulate both anterodorsally and posterodorsally. The beaks are high and strongly opisthogyrate, causing the posterior part of the cardinal area to appear very broad. The ribs are high and very well defined, perhaps more so anteriorly than in the typical form.

Holotype (U.S.N.M. 496514), length 36 millimeters, height 24 millimeters, convexity 13.5 millimeters.

The beds at Suffolk have been correlated with the Duplin marl of North Carolina, but the species of *Eontia* in them are quite distinct. This may be due primarily to a difference in faunal provinces, but the existence of beds equivalent to the Duplin marl near Franklin, Va., indicates that the Duplin marl may be mostly younger as well. If anything, the young of the Duplin species more nearly resemble the middle Yorktown forms, particularly those occurring in the *Turritella* bed, or bed *a*, at Yorktown, than forms from the beds at Suffolk, and it may be that the two stocks became separated at that time and developed independently thereafter.

There is no evidence that the upper Yorktown stock in Virginia contributed anything to the Pliocene forms, and the supposition is that the latter were descended from Miocene forms farther south and that the Virginia stock became extinct, possibly owing to a sudden cooling of the water in their province. The *Yoldia* bed that occupies the uppermost position in the shallow trough a few miles upstream from Yorktown carries a distinctly cold-water fauna and contains no Eontias. This bed is probably the cold-water equivalent of *Eontia*-bearing beds farther south.

Distribution: Upper Miocene, upper part of the Yorktown formation; the beds at Suffolk and their equivalents and possibly next underlying beds, Virginia.

Type locality: Highest bed at Rock Wharf, 4 miles north of Smithfield, Isle of Wight County, Va., U.S.G.S. 10207.

Other occurrences: One mile east of Chuckatuck, Nansemond County, U.S.G.S. 13826; Suffolk, Nansemond County, U.S.G.S. 10201.

Eontia trigintinaria (Conrad) MacNeil

Plate 1, figures 32, 33, 37, 38; plate 2, figures 3, 4

Arca incile. Tuomey and Holmes, Pleiocene fossils of South Carolina, p. 35, pl. 14, figs. 6, 7, 1857.
Emmons, North Carolina Geol. Survey Rept., p. 284, 1858.
Anomolocardia trigintinaria Conrad, Acad. Nat. Sci. Philadelphia Proc., vol. 14, pp. 289, 580, 1862.
Noetia protexta Conrad, Kerr's Geol. Rept. North Carolina, app. A, p. 19, pl. 3, fig. 5, 1875.

Shell subrhomboidal, moderately elongate, anterior rounded, posterior margin emarginate or nearly straight, angulate posteroventrally; beaks moderately high, situated at about the anterior third of the hinge line; umbonal ridge bluntly carinate, moderately inflated; posterior slope wide, somewhat sulcated; medial sulcus sometimes weak; ribs 28 to 33, averaging about 31, large and usually alternating with smaller interstitial ribs, especially posteriorly; larger ribs double posteriorly and tending to divide anteriorly in full-grown adults, beaded in young stages; posterior part of ligament about one and a half times as long as anterior part but relatively shorter in young shells, leaving a wide strip of the area bare posteriorly; vertical elements appearing posteriorly when about one-third grown and about evenly distributed along the length of the ligament in adults, the posterior grooves remaining mostly vertical, weaker than the anterior ones; teeth numerous and the terminal ones inclined, those at the anterior end tending to be L-shaped. (Emended description.)

Holotype in Philadelphia Academy of Natural Sciences. Figured specimen from South Carolina (U.S.N.M. 496583), length 52 millimeters, height 38 millimeters, convexity 16 millimeters; specimen from Florida (U.S.N.M. 496521), length 34 millimeters, height 21 millimeters, convexity 10 millimeters.

This form appears to initiate the subdivision of the anterior ribs, which in the foregoing forms remained undivided. It is considerably larger and relatively higher, and the beaks are more central and less opisthogyrate than in *E. incile*.

Eontia trigintinaria probably represents a geographic subspecies derived from typical *E. incile*. The transition between *E. incile* and *E. trigintinaria* is not sharp, and specimens from the lowest bed, bed *a*, at Yorktown and young specimens from the Duplin marl in Duplin County, N. C., cannot always be identified with certainty. This has already been discussed with reference to *E. incile suffolkensis* (p. 16). Full-grown specimens of *E. trigintinaria* from the Carolinas are readily distinguishable from specimens from the Yorktown of Virginia, however.

The *Cancellaria* zone of the Choctawhatchee formation of western Florida contains a form that is tentatively referred to *Eontia trigintinaria* because of the position of its beaks (pl. 1, figs. 32, 33), but it may warrant a subspecific name. No specimens have been

thus far collected which approach the Carolina form in size, so that this form might be compared quite as justifiably with specimens of *E. incile* from bed *a* at Yorktown. The remainder of the fauna indicates a later age for the *Cancellaria* zone, however, so that this zone probably represents a faunal province in which the Eontias did not keep pace in evolution with those of provinces farther north. This alternative is plausible in view of the Florida Pliocene species discussed on page 20.

Noetia protexta Conrad is probably the end member of the varietal series which occurs in Greene County, N. C. (pl. 2, figs. 3, 4), and is placed in synonymy with *E. trigintinaria*, from which it cannot be distinguished.

Distribution: Upper Miocene, Duplin marl of North and South Carolina, and the Yorktown formation of North Carolina and Virginia; *Cancellaria* zone, Choctawhatchee formation, western Florida.

Type locality: "South Carolina."

Occurrence: The Biggs farm, 3 miles west of Franklin, Southampton County, Va., and many localities in the Carolinas, some of the most important of which are Natural Well, 2 miles southwest of Magnolia, Duplin County, N. C., U.S.G.S. 2279, 2280, 13827; Rock Landing, Neuse River, 16 miles above New Bern, Craven County, N. C., U.S.G.S. 10898; Shell Branch near Darlington Courthouse, Darlington, S. C., U.S.G.S. 2024; Davis Landing, Pee Dee River, 6¾ miles northwest of the mouth of Lynches River, Florence County, S. C., U.S.G.S. 5302; Muldrow estate, 0.7 mile northeast of Brick Church on Black River Road 5 miles southeast of Mayesville, Sumter County, S. C., U.S.G.S. 4000. At Sullivan's marl pits, 8 miles east of Snow Hill, Greene County, N. C., U.S.G.S. 2298, and at Darlington Courthouse it occurs with the variety *E. trigintinaria filosa*. In Florida forms referred to this species occur at the borrow pit, Jackson Bluff, Ochlockonee River, Leon County, U.S.G.S. 11732; and 1 mile west of Holland post office, Leon County, U.S.G.S. 4993.

Eontia trigintinaria filosa (Conrad) MacNeil

Plate 2, figures 1, 2

Noetia filosa Conrad, Kerr's Geol. Rept. North Carolina, app. A, p. 20, pl. 4, fig. 3, 1875.

Arca (Noetia) limula var. *filosa*. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 632, 1898.

Sheldon, Paleontographica americana, vol. 1, no. 1, p. 27 (in part), 1916.

Shell subrhomboidal, inflated, medially depressed, varying from moderately elongate to medium length, rounded anteriorly, emarginate to nearly straight posteriorly, bluntly angulate posteroventrally; breaks high, situated between the anterior third and center of the hinge line; umbonal ridge carinate in younger stages, more rounded in adults; posterior slope sulcated, varying from moderately expanded to moderately steep; ribs 29 to 35, averaging about 32, usually alternating with smaller interstitial ribs, larger ribs double posteriorly and tending to be double anteriorly in adults, beaded in younger stages; ligament about twice as long posteriorly as anteriorly in adults but less produced posteriorly in juveniles, leaving a moderately wide strip of the area bare posteriorly, vertical ligament elements appearing posteriorly when about one-third grown, evenly distributed but weaker than the anterior grooves in adults; teeth nearly vertical centrally, inclined terminally. (Emended description.)

Figured specimen (neotype) (U.S.N.M. 496516), length 45 millimeters, height 33.5 millimeters, convexity 14.5 millimeters. The specimen figured by Conrad is a juvenile.

In Greene County, N. C., a varietal series is found which compares with *E. trigintinaria* on the one hand and approaches a more northern form, *E. carolinensis* (Conrad), on the other hand. Conrad gave no locality for his species *Noetia protexta* and *Noetia filosa*, and the types have probably been lost, but they conform perfectly to the extremes of this series and presumably came from this region. As all subsequent references to this form have been based on Dall's interpretation of it, it seems desirable to designate one of the specimens which Dall had before him as neotype and accept its locality as the type locality.

Dall considered *E. filosa* a variety of the Pliocene species *E. limula*, and Miss Sheldon expanded it to include all the Pliocene forms except the Florida variety, *E. limula platyura* (Dall). The dissimilarity between *filosa* and the Pliocene species, as well as its gradation into a typical Miocene species, leads me to regard *filosa* as little more than an extreme variety of *E. trigintinaria*. Although the name *filosa* is retained as indicating a variety, there does not appear to be any good reason for perpetuating all the names which Conrad applied to this series, especially as the *Noetia protexta* end is not definitely separable from *E. trigintinaria*. *E. trigintinaria* occurs abundantly at the type locality and is known elsewhere only at Darlington, S. C., where it is apparently rare.

Distribution: Upper Miocene, upper beds of the Yorktown formation in Greene County, N. C.

Type locality: Sullivan's marl pits, 8 miles east of Snow Hill, Greene County, N. C., U.S.G.S. 2298.

Other occurrences: Shell Branch near Darlington courthouse, Darlington, S. C., U.S.G.S. 2024.

Eontia carolinensis (Conrad) MacNeil

Plate 2, figures 5, 6

Noetia ponderosa Say var. *carolinensis* Conrad, Acad. Nat. Sci Philadelphia Proc., vol. 14, p. 290, 1862; *Noetia (Arca) carolinensis*, p. 580 [not *Arca carolinensis* Wagner, 1847].

Arca carolinensis Heilprin, Acad. Nat. Sci. Philadelphia Proc., vol. 33, p. 450,1881.

Arca (Noetia) limula var. *filosa*. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 632, 1898.

Sheldon, Paleontographica americana, vol. 1, no. 1, p. 27 (in part), 1916.

Shell subrhomboidal or subtrigonal, inflated, varying from moderately elongate to medium length, rounded anteriorly, slightly emarginate to broadly rounded posteriorly, bluntly angulate to rounded postero-ventrally; beaks high, situated between the anterior third and center of the hinge line; umbonal ridge carinate in younger stages, more rounded in adults; posterior slope varying from expanded to moderately so, rarely sulcated; ribs 31 to 36, averaging about 33, usually alternating with smaller interstitial ribs, larger ribs double posteriorly and tending to be double anteriorly in adults, ribs beaded in younger stages; ligament occupying nearly the entire cardinal area in adults but leaving a wider strip of the area bare posteriorly in juveniles, vertical ligament elements appearing irregularly posteriorly when about one-quarter or one-third grown but stronger and evenly distributed in adults; teeth nearly vertical centrally, inclined terminally.

Lectotype in Philadelphia Academy of Natural Sciences. The largest of the three cotypes is here so designated. Figured specimen (U.S.N.M. 496519), length 48 millimeters, height 40 millimeters, convexity 17.5 millimeters.

This species, found in the uppermost Miocene in the vicinity of the Chowan River, differs from *E. trigintinaria filosa* in being larger, averaging one or two more ribs, rarely, if ever, having the minimum number found in *filosa*, and in being rounded posteriorly. The sulcus on the posterior slope and emarginate posterior always found in *filosa* are almost never found in *E. carolinensis*. Furthermore, *E. carolinensis* exhibits very little variation in the lower part of the bluffs along the Chowan River or at Tar Ferry on Wicocon Creek.

In the uppermost bed at Colerain Landing, however, some variations occur, consisting principally of a more quadrate form and greater subdivision of the anterior ribs, which forecasts some of the North Carolina Pliocene forms. This may represent an intermingling with *E. lumberensis*, the next species to be described.

There can be but little doubt that *E. carolinensis* is closely related to *E. trigintinaria filosa*, but whether the latter represents the production of *E. carolinensis* from *E. trigintinaria* or is a hybrid of two distinct strains is still uncertain. The rounded umbonal region and full ligament of *E. carolinensis* recalls, to a certain extent, the Yorktown form *E. incile yorkensis*, and it may be that the latter was perpetuated, but there is no record of the persistence of this strain above the horizon of the upper *Chama*-bearing bed.

Distribution: Upper Miocene, uppermost part of the Yorktown formation in the vicinity of the Chowan River, N. C.

Type locality: If Conrad's locality, "Dauphin County, N. C.", is a mistake for Duplin County, it is an error, as this form is not found in Duplin County. The middle bed at Colerain Landing, Bertie County, N. C. (U.S.G.S. 13829), might be regarded as the type locality.

Other occurrences: Half a mile below Mount Gould Landing, Bertie County, N. C., U.S.G.S. 11999; Tar Landing Ferry, Wicocon Creek, 1 mile north of Harrellsville, Hertford County, N. C., U.S.G.S. 13830.

Eontia lumberensis MacNeil, n. sp.

Plate 2, figures 7, 8

Shell subrhomboidal, thickened, moderately elongate and inflated, rounded anteriorly, subemarginate or straight posteriorly, angulate posteroventrally; beaks moderately high, situated just anterior of the center of the hinge line; umbonal ridge carinate; posterior slope flat or somewhat sulcated, moderately steep; ribs 30 to 33, averaging 31, alternating with small interstitial ribs, especially posteriorly, the larger ribs double or irregularly divided posteriorly and tending to become double anteriorly; ribs beaded in young stages; ligament about as long or slightly longer posteriorly than anteriorly, vertical elements absent posteriorly but appearing when about one-third grown; a moderately wide strip of the area left bare posteriorly; teeth vertical centrally, inclined posteriorly, L-shaped anteriorly.

Holotype (U.S.N.M. 496520), length 39 millimeters, height 28 millimeters, convexity 13 millimeters.

This species differs from *E. trigintinaria* in being relatively shorter and higher and in having more central beaks and a more equilateral ligament area. It more closely resembles the Pliocene forms, particularly *E. variabilis*, than any other Miocene species, and the young of *E. variabilis* cannot be separated from it with certainty. All the largest specimens are of about the same size, however, and the shells are thickened, more so than is common in shells of the same size in other species. *E. lumberensis*, therefore, is probably a smaller shell than the Pliocene forms which it most resembles. Were it not for the fact that *E. lumberensis* is associated with an undoubted Miocene fauna it would most certainly be regarded as a Pliocene species.

Distribution: Upper Miocene, upper part of the Duplin marl in the vicinity of Lumberton and Fairmont, Robeson County, N. C.

Type locality: 4 miles southeast of Lumberton, Robeson County, N. C., U.S.G.S. 11824.

Other occurrences: 2¼ miles east of Fairmort, U. S. G. S. 11832; 2 miles east of Fairmont, U.S.G.S. 13828a; road cut just north of bridge over Lumber River, 2 miles southeast of Lumberton, U.S.G.S. 13828.

Correlation of uppermost Miocene Eontia-bearing beds in the Carolinas and Virginia

<table>
<tr><th></th><th>South Carolina</th><th colspan="4">North Carolina</th><th>Virginia</th></tr>
<tr><th></th><th></th><th>Southern</th><th>South central</th><th colspan="2">North central</th><th>Northern</th><th></th></tr>
<tr><td rowspan="3">Duplin marl</td><td>?</td><td>Beds around Lumberton.[a]</td><td rowspan="3"></td><td rowspan="3">Yorktown formation</td><td></td><td>Beds in the vicinity of the Chowan River.[b]</td><td rowspan="3"></td></tr>
<tr><td rowspan="2">Beds in the vicinity of Darlington and Mayesville.[c]</td><td rowspan="2"></td><td>Highest beds in Greene County.[d]</td><td>?</td></tr>
<tr><td>Beds in Duplin and Sampson Counties.[e]</td><td>Beds in Pitt, Greene, and Craven Counties.[e]</td><td></td><td>Beds near Franklin.[e]
?</td></tr>
<tr><td></td><td></td><td></td><td>?</td><td>?</td><td>Beds at Suffolk.[f]</td></tr>
</table>

[a] Carries *E. lumberensis.*
[b] Carries *E. carolinensis.*
[c] Carries *E. trigintinaria.* Variety *filosa* at Darlington.
[d] Carries *E. trigintinaria* and variety *filosa.*
[e] Carry *E. trigintinaria.*
[f] Carries *E. incile* and variety *suffolkensis.*

The lowest questioned beds in central and northern North Carolina may be mostly older than those at Suffolk.

PLIOCENE SPECIES

Eontia limula (Conrad) MacNeil

Plate 2, figure 9

Arca limula Conrad, Fossils of the Tertiary formations, pl. 15, pl. 1, fig. 1, 1832; Fossils of the medial Tertiary, p. 60, pl. 31, fig. 3, 1845.

Noetia (*Arca*) *limula.* Conrad, Acad. Nat. Sci. Philadelphia Proc., vol. 14, p. 580, 1862.

Arca (*Noetia*) *limula.* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 631 (in part), 1898.

Arca (*Noetia*) *limula* var. *filosa.* Sheldon, Palaeontographica americana, vol. 1, no. 1, p. 26 (in part), pl. 5, fig. 26, 1916.

Shell subrhomboidal and elongate, rounded anteriorly, posteroventral region produced and subangulate in young shells, but rounded in adults; beaks high and situated at about the center of the hinge line but at about the anterior third of the shell; umbonal ridge carinate and moderately inflated in juveniles but becoming broadly rounded in adults; ribs 29 to 33, averaging about 31, usually alternating with small interstitial threads; ribs usually double all around, the posterior ribs so much so that a small riblet may appear in the furrow between the two parts; ribs in juveniles single and beaded anteriorly; ligament area nearly symmetrical and covering the cardinal area except for a narrow strip posteriorly, vertical ligament elements appearing posteriorly when about one-quarter grown; teeth small and vertical centrally, inclined posteriorly and often L-shaped anteriorly, the posterior row slightly longer. (Emended description.)

Figured specimen (topotype?) (U.S.N.M., 496522), length 76 millimeters, height 52 millimeters, convexity 21.5 millimeters.

This species is considerably larger and more produced posteriorly than the uppermost Miocene form, *E. carolinensis.* The ribs are fewer and become double at a much earlier stage in shell growth. The vertical ligament elements appear posterior to the beaks at an earlier age and in adults are distributed along the entire length of the ligament.

Eontia limula is a remarkably constant species, showing little or no variation. Its occurrence is restricted to the Croatan sand of northeastern North Carolina. It differs from *E. variabilis,* the form occurring in the Waccamaw formation, in both form and variability, the nature of which is discussed under that species. *Eontia limula* is probably directly descended from *E. carolinensis.*

The Croatan sand of United States Geological Survey usage is of Pliocene age. Dall's original material from the "Croatan beds" is a mixture of Pliocene and Pleistocene and was probably collected along the river for a distance of several miles. No Pliocene is exposed in the bluffs of the Neuse River nearest Croatan itself, so that the type section for the Croatan sand cannot be recognized there. Perhaps the best section of the Pliocene in this region is exposed on the property of Mr. Hastings on the right bank of the Neuse River 2 miles below James City, Craven County, N. C., and this might be regarded as the type section of the Croatan sand. This is probably the exact spot from which a number of species described by Conrad as from "New Berne" were obtained. Of the specimens figured by Miss Sheldon as from the "Croatan beds" only one, that shown on her plate 5, figure 26, is the typical Pliocene species *E. limula.* All the others are from the Pleistocene and are discussed under the species *E. palmerae,* n. sp., described below.

Distribution: Pliocene; Croatan sand, Craven and Onslow Counties, N. C.

Type locality: "New Berne, N. C." Conrad's locality is probably the bluff on the property of Mr. Hastings, 2 miles below James City, Craven County, N. C., U.S.G.S. 13812.

Other occurrences: Brices Creek about 1½ miles west of Croatan station, Craven County, N. C.; marl pits on the farm of Jackson Jones on the north side of Grants Creek on the old road from Jacksonville to Maysville, about 5 miles west of Silverdale, Onslow County, N. C., U.S.G.S. 11996.

Doubtful identifications: Some specimens found near Melbourne, Fla., resemble this species and are discussed under *E. variabilis*.

Eontia tillensis MacNeil, n. sp.

Plate 2, figure 10

Shell subrhomboidal, moderately inflated, medium to moderately elongate, rounded anteriorly, usually broadly rounded posteriorly but occasionally slightly emarginate, more sharply rounded posteroventrally; valves thin; beaks moderately high, situated at about the center of the hinge line; umbonal ridge well defined in young stages but rounded in adults; medial sulcus usually present but not well defined; posterior slope varying from slightly sulcate to broadly rounded; ribs 29 to 32, averaging about 31, double or irregularly divided posteriorly, usually double anteriorly; ligament usually longer anteriorly than posteriorly, a moderately wide strip of the area left bare posteriorly, vertical elements weak or absent posteriorly in young stages but usually well developed in full-grown adults; teeth vertical centrally, inclined posteriorly, L-shaped anteriorly.

Holotype (U.S.N.M. 496527), length 54 millimeters, height 45 millimeters, convexity 19.5 millimeters.

This species differs from *E. limula* in being considerably shorter and more inflated, with a less developed medial sulcus and a more sharply rounded posteroventral margin. *Eontia tillensis* resembles the Miocene form *E. carolinensis*, more so than *E. limula*. Some specimens are emarginate posteriorly, suggesting relationship with *E. trigintinaria filosa*, and the species may be descended from that form.

Eontia tillensis is typically developed in northeastern South Carolina, being known from Tillys Lake and the Intracoastal Waterway 3 miles west-southwest of Little River. At Tillys Lake it occurs with individuals resembling *E. variabilis*, but so far no specimens referable to *E. tillensis* have been seen from the region of the Cape Fear River in North Carolina, where *E. variabilis* predominates. *E. tillensis* may represent one of the purer strains that contributed to the *E. variabilis* complex, but it also appears to be related to the Pleistocene *E. palmerae*, n. sp., so that although it may intergrade with *E. variabilis* at some localities, it seems best not to consider it a variety of that species.

Distribution: Pliocene, Waccamaw formation, northeastern South Carolina.

Type locality: Tillys Lake, Waccamaw River, Horry County, S. C., U.S.G.S. 4400.

Other occurrences: Intracoastal Waterway 3 miles west-southwest of Little River, Horry County, S. C., U.S.G.S. 13377. The Pleistocene species is present in great numbers at this locality, but only one specimen with the Pliocene limestone matrix adhering was obtained from the dump.

Eontia caloosana MacNeil, n. sp.

Plate 3, figure 4

Shell subrhomboidal and elongate, usually broadly rounded anteriorly and posteriorly, sharply rounded posteroventrally, inflated between the medial sulcus and the ridge; beaks moderately high, situated at about the anterior third of the hinge line; hinge line long, making the shell subangulate at both ends; umbonal ridge moderately well defined; posterior slope expanded; ribs 31 to 39, averaging about 34, double posteriorly, but rarely so anteriorly, interstitial ribs usually well developed and stronger anteriorly; anterior ribs tending to be less elevated in adults; ligament about one-half to twice as long posteriorly, leaving a wide strip of the area bare posteriorly; vertical ligament elements appearing posteriorly when about one-third grown and well developed thereafter; teeth vertical centrally, inclined posteriorly, L-shaped anteriorly.

Holotype (U. S. N. M. 496531), length 57 millimeters, height 42 millimeters, convexity 18 millimeters.

Eontia caloosana is not particularly varied in shape, but the number of ribs shows a considerable range, the maximum being greater than in any other species of the Atlantic group. It differs from *E. limula* in being smaller, with a much longer hinge line and more anterior beaks. The ligament is considerably longer posteriorly, and the anterior ribs rarely show any tendency to divide. The shell is more angulate at the dorsal extremities.

Certain features of this species, such as its long hinge line, distinguish it from other Pliocene types. It may be that *E. caloosana* was isolated in development from *E. trigintinaria* at the southern extent of its range, possibly from the form occurring in the *Cancellaria* zone of the Choctawhatchee formation.

This species is believed to occur at a lower horizon than *E. variabilis clewistonensis* from the same area.

Distribution: Pliocene, Caloosahatchee marl near Clewiston, Fla.

Type locality: 6 miles northwest of Clewiston, Hendry County, Fla., U.S.G.S. 13834.

Eontia variabilis MacNeil, n. sp.

Plate 2, figures 12–16

Arca (*Noetia*) *limula*. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 631 (in part), 1898.

Arca (*Noetia*) *limula* var. *filosa*. Sheldon, Paleontographica americana, v. 1, no. 1, p. 26 (in part), pl. 6, figs. 1, 2, 1916.

Shell subrhomboidal, moderately elongate to elongate, rounded anteriorly, angulate to sharply rounded posteroventrally; medial sulcus present in longer individuals; beaks high, situated just anterior of the center of the hinge line but in longer individuals being more nearly at the anterior third of the shell; umbonal ridge well defined, often carinate but more commonly sharply rounded; posterior slope rarely sulcated; ribs 28 to 33,

averaging about 31, double or irregularly divided posteriorly, single and rounded to double anteriorly; interstitial ribs frequently absent medially; ribs somewhat beaded in young stages; ligament about as long posteriorly as anteriorly, leaving a moderately wide strip of the area bare posteriorly; posterior vertical elements variable in strength and time of appearance, but generally well developed in adults; teeth vertical centrally, inclined posteriorly, L-shaped anteriorly.

Holotype (U.S.N.M. 496524), length 67 millimeters, height 49 millimeters, convexity 23.5 millimeters. Paratype (U.S.N.M. 496525), length 55 millimeters, height 37.5 millimeters, convexity 14.5 millimeters; paratypes (U.S.N.M. 496578, 496579).

In striking contrast to *E. limula*, *E. variabilis* is is marked by great irregularity in form. The umbonal ridge is never so broad and perfectly rounded, tending more often to be subcarinate, and the shell is less elongate posteriorly and relatively higher in most individuals. *E. variabilis* is found in typical form along the Cape Fear River in North Carolina, but varieties that appear quite distinct are met at the extremities of its range in this region. At Walkers Bluff, the locality farthest inland at which it has been found, a form having a sharp umbonal ridge and long hinge line occurs which resembles the Miocene form *E. trigintinaria*. A short, subquadrate type from this locality is named as a variety, *E. variabilis quadrata*, and resembles the Miocene species *E. lumberensis*.

Farther east, at Neills Eddy Landing, near Acme, and at Wilmington,[7] a larger, less carinate form occurs, some specimens of which approach *E. limula* but are easily separated from it on the basis of irregularity. A specimen near the middle of this varietal series is taken to represent typical *E. variabilis*, which is probably a hybrid of the more western stock and *E. limula* and possibly *E. tillensis*, although no typical specimens of either of these species have been found in this region.

E. variabilis differs from *E. tillensis* in being less inflated, with a less rounded umbonal ridge and a thicker shell. The doubling of the anterior ribs is less uniform and advanced. *E. variabilis* has a shorter hinge line than *E. caloosana*, giving the shell a less angulate appearance at the dorsal extremities. It is considerably less elongate posteriorly and broader anteriorly, with more central beaks and a shorter ligament.

Fairly typical specimens of *E. variabilis* have been dredged from Pliocene deposits in the Brunswick River at Brunswick, Ga. The Caloosahatchee marl of east-central Florida around De Land and De Leon Springs contains a varietal series that more nearly conforms with that of typical *E. variabilis* in North Carolina but may be of somewhat different composition. Some individuals in this series appear to be dwarfs and are characterized by short shells, high umbonal ridges, and very little inflated anteriors, resembling *E. platyura* from southwestern Florida. Although a large collection is at hand, certain common varieties of typical *E. platyura* appear to be absent. Specimens which can be matched perfectly with specimens from North Carolina have been obtained near Clewiston, Fla., at a horizon that is probably above that of *E. caloosana*.

Some specimens dredged from a canal near Melbourne, Fla., approach specimens of *E. limula* from Onslow County, N. C., more closely than any known specimens of *E. variabilis* from the Cape Fear region of North Carolina. This might be taken as evidence that while *E. limula* contributed to the *E. variabilis* complex in North Carolina and was smothered up by it in that region, it migrated as a less contaminated strain to Florida and participated in the *E. variabilis* flux in that region as well.

It appears certain that *E. variabilis* is a hybrid species. Its varieties include Miocene as well as true-breeding Pliocene types, and at some localities there is clear evidence of hybrid vigor. An inescapable fact is that from a large number of homogeneous species, varietal series, and local varieties there has evolved the consistent, long-ranging Recent species *E. ponderosa*. It is improbable, and the evidence is unsupporting, that *E. ponderosa* represents only a single surviving strain of this complex, and I therefore conclude from the role that *E. variabilis* must have played in the process that *E. variabilis* is polyphyletic but should be considered a unit, inasmuch as it represents the bringing together of related but diverse forms. (See p. 25.)

Distribution: Pliocene, Waccamaw formation of North Carolina and South Carolina (?); Pliocene of Brunswick, Ga.; Caloosahatchee marl of east-central Florida.

Type locality: Neills Eddy Landing, 5 miles northeast of Acme, Columbus County, N. C., U.S.G.S. 4276.

Other occurrences: Paratype, Walkers Bluff, 18 miles east-southeast of Elizabethtown, Bladen County, N. C., U.S.G.S. 11817; North shore of Lake Waccamaw, Columbus County, N. C., U.S.G.S. 13379; paratypes, Wilmington, N. C., U.S. G.S. 6104, 2295. Upper Pliocene horizon 6 miles northwest of Clewiston, Hendry County, Fla., U.S.G.S. 13834.

Doubtful identifications: 3¾ miles west of Melbourne, Brevard County, Fla., U.S.G.S. 11140; Fellsmere, St. Lucie County, Fla. These specimens appear to be closely related to *E. limula*. Half a mile south of De Land, Volusia County, Fla.; just south of the airport at De Leon Springs, Volusia County, Fla., U.S.G.S. 13832. A specimen obtained from a marl pit 1 mile north of Bermont, Charlotte County, Fla., U.S.G.S. 13835, is discussed under *E. platyura*.

Eontia variabilis quadrata MacNeil, n. var.

Plate 2, figure 11

This form is the end member of the varietal series occurring at the Walkers Bluff locality on the Cape Fear River, N. C., and grades into the typical form through the long-hinged, carinate type figured as a

[7] The abundantly fossiliferous marl encountered in building and sewer construction in Wilmington, N. C., was considered by Dall to be of Miocene age. W. C. Mansfield recently reidentified this material to verify conclusions reached by me as to its Pliocene age, and reported that at least some of the material appears to be undoubtedly Pliocene (Jour. Paleontology, vol. 10, no. 7, p. 668, 1936). Very typical specimens of *Eontia variabilis* indicate that the Pliocene beds underlying Wilmington are to be referred to the Waccamaw formation.

paratype (pl. 2, fig. 15). Occasional specimens referable to it are found farther east, but at the type locality it may constitute as many as a fifth of the individuals. It resembles the Miocene species *E. lumberensis*.

This variety is characterized by its short posterior end and carinate umbonal ridge. The shell is angulate posteroventrally, and the posterior margin is nearly straight. The disk is inflated without a medial sulcus. The number of ribs varies from 25 to 31, averaging 28 or 29, so that it has fewer ribs than is typical for the species.

Holotype (U.S.N.M. 496523), length 51.5 millimeters, height 43 millimeters, convexity 19.5 millimeters.

Distribution: Pliocene, Waccamaw formation, North Carolina.

Type locality: Walkers Bluff, Cape Fear River, 18 miles east-southeast of Elizabethtown, Bladen County, N. C., U.S.G.S. 11817.

Eontia variabilis clewistonensis MacNeil, n. var.

Plate 3, figure 5.

Shell subquadrate to subovate, inflated, rounded anteriorly and ventrally, straight to broadly rounded posteriorly; beaks moderately high, situated at about the center of the hinge line; umbonal ridge well defined in young stages but of less prominence than the inflated medial area in adults; posterior slope broad and nearly flat, but in some specimens an anal ridge is developed; ribs 29 to 35, averaging about 33, double posteriorly but usually single and rounded anteriorly; interstitial ribs usually well developed, heavier anteriorly; ligament of about equal length anteriorly and posteriorly but in very large shells somewhat longer posteriorly, filling the cardinal area except for a strip of decreasing width posteriorly; vertical elements weak or absent posteriorly until about one-third or half grown but well developed thereafter; teeth vertical centrally, inclined posteriorly, L-shaped anteriorly.

Holotype (U.S.N.M. 496532), length 51.5 millimeters, height 47 millimeters, convexity 20 millimeters.

Eontia variabilis clewistonensis is characterized by its rotund outline, inflated disk and broadly rounded posteroventral margin. It is the end member of a varietal series that grades into more elongate, subrhomboidal individuals of *E. variabilis*.

The beds at the type locality of this variety are not exposed, the material having been thrown out by the dredge in the construction of the hurricane dike on the south shore of Lake Okeechobee. Specimens of *Eontia* from this locality appear to have come from two beds, to judge from their form and preservation. The more elongate form described as *E. caloosana* has its shells bleached and opaque, whereas the shells of the *E. variabilis* type are gray and glassy and are supposedly from a higher bed. This variety may be a hybrid of *E. variabilis* and *E. caloosana*.

Distribution: Pliocene, Caloosahatchee marl, south-central Florida.

Type locality: Six miles northwest of Clewiston, Hendry County, Fla., U.S.G.S. 13834.

Eontia platyura (Dall) MacNeil

Plate 3, figures 1–3

Arca (*Noetia*) *limula* var. *platyura* Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 632, 1898.

Sheldon, Palaeontographica americana, vol. 1, no. 1, p. 26, 1916.

Shell subrhomboidal, rounded anteriorly, often angulate anterodorsally, broadly rounded to slightly emarginate posteriorly, sharply rounded to angulate posteroventrally; posterodorsal region rounded to subalate, sometimes forming an angle of nearly 90°; beaks high, situated between the center and anterior third of the hinge line; umbonal ridge sharply rounded and moderately inflated; posterior slope expanded to moderately steep; medial sulcus weak; ribs 29 to 33, averaging about 31, usually alternating with small interstitial riblets; ribs double posteriorly but variable in this respect anteriorly, beaded in young stages, anterior ribs frequently tending to be less elevated or level with the interspaces in adults; ligament usually shorter posteriorly than anteriorly except in very large individuals, leaving a wide strip of the cardinal area bare posteriorly; posterior vertical ligament elements weak and irregular in shells one-third to one-half grown, but well developed thereafter; teeth vertical centrally, inclined posteriorly, L-shaped anteriorly, the posterior row slightly longer. (Emended description.)

Lectotype (U.S.N.M. 496529), length 46 millimeters, height 36 millimeters, convexity 15 millimeters. Paratype (U.S.N.M. 496528), length 55.5 millimeters, height 43 millimeters, convexity 17.5 millimeters. Paratype (U.S.N.M. 496530), length 64.5 millimeters, height 45 millimeters, convexity 18 millimeters.

The specimens on which Dall based the "variety" *platyura* are extreme or even abnormal shells, but the name is available for the varietal series which occurs in the Caloosahatchee marl of southwestern Florida. It is much shorter than *E. caloosana* from localities farther east and has a more carinate and less inflated umbonal ridge. The anterodorsal region of *E. platyura* tends to be more angulate than in *E. variabilis*, giving the shell the effect of being higher anteriorly, with a more nearly horizontal border and a more nearly vertical posterior margin, especially when viewed from the inside. The shell of *E. platyura* tends to be little inflated anteriorly, sloping evenly from the umbonal ridge to the anterior margin, and the anterior ribs show a strong tendency to become less elevated with shell growth.

None of the adult varieties of *E. platyura* particularly resemble any of the varieties of *E. variabilis* or *E. caloosana* farther east, but the younger stages of the typical form—that is, specimens comparing with the lectotype—are very similar to the young stages of *E. caloosana*, and the two are probably related. The varieties of *E. variabilis* resemble Miocene forms from the Carolinas, whereas the varieties of *E. platyura* have no known Miocene equivalents and appear to be the

result of Pliocene variation. It is probable that *E. caloosana* and *E. platyura* are typically southern species, not related to *E. variabilis* except through ancestral upper Miocene forms. There is evidence that at some later time in the Pliocene, however, the *E. variabilis* stock invaded southwestern Florida and merged with *E. platyura* to produce a pre-*ponderosa* stock. At one of the upper Pliocene localities near Bermont, Fla., a form is found which resembles *E. variabilis* more than it resembles *E. platyura*, at the Alligator Creek and Shell Creek horizons. At a horizon penetrated in a ditch 1.6 miles northwest of Murdock, which probably represents the uppermost Pliocene of Florida, the Myakka River stage, a short, subtrigonal form which is hardly distinguishable in shape from typical *E. ponderosa* was found.

The genetic composition of the Pliocene forms is not as simple as the treatment of former authors would indicate, but unfortunately the data are still not entirely at hand. It appears that the ancestry of all the Pliocene forms may be traced, either directly or through some uppermost Miocene species, to *E. trigintinaria*, or to its southernmost representative in the Choctawhatchee formation. Some species appear to be monophyletic (*E. limula, E. caloosana*), whereas others appear to be composed of several Miocene stocks as well as strains of other Pliocene species (*E. variabilis*). The more variable species, *E. variabilis* and *E. platyura*, produced a large number of varieties; indeed, each locality has furnished some particular type that is rare or unduplicated at others, such as the extreme form from Prairie Creek (pl. 3, fig. 3). Nothing of value seems to be gained from naming any but the most characteristic of these forms, however, especially as their differences appear to have been ironed out later on. Until their phylogeny is perfectly known, the last word on their nomenclature cannot be pronounced, but for the present the arrangement adopted here seems to be the most satisfactory.

Distribution: Pliocene, Caloosahatchee marl of southwestern Florida.

Type locality: West bank of Alligator Creek, just north of Acline, Charlotte County, Fla., U.S.G.S. 13833.

Other occurrences: Near the head of Prairie Creek, a tributary of Shell Creek, Charlotte County, Fla., U.S.G.S. 3300.

PLEISTOCENE SPECIES

Eontia palmerae MacNeil, n. sp.

Plate 3, figures 7, 8

Shell subrhomboidal, medium elongate, rounded anteriorly, sharply rounded posteroventrally and moderately produced; beaks moderately high, situated just posterior of center; umbonal ridge sharply rounded; posterior slope moderately steep; medial sulcus weak or absent; ribs 29 to 32, averaging about 30, double or irregularly divided both anteriorly and posteriorly, interstitial ribs sometimes fairly strong medially; ligament shorter posteriorly than anteriorly, leaving a strip of the area of moderate length bare posteriorly, vertical elements appearing posteriorly when about one-third or half grown; teeth vertical centrally, inclined posteriorly, L-shaped anteriorly.

Holotype (U.S.N.M. 496533), length 59 millimeters, height 45 millimeters, convexity 20 millimeters.

This Pleistocene form has usually been identified as *E. ponderosa* but differs from it in being more elongate, with ribs more doubled and with little tendency for them to be flat-topped. The beaks are relatively lower and the umbonal ridge less carinate. The shell is thinner, and there is also a tendency for the medial area to be flattened or weakly sulcate.

Eontia palmerae is typically developed north of Cape Hatteras and became less distinct during Pleistocene time, owing first, apparently, to interbreeding with the relict *variabilis* stock farther south, and later to what probably represents a warm interglacial or postglacial stage, an invasion of the robust southern stock as far north as Marthas Vineyard and Nantucket, a northern record for the genus.

Eontia palmerae appears to be related to *E. tillensis* and possibly to *E. limula*. Thin-shelled specimens from deposits of probably not very late Pleistocene age at Heislerville, Cumberland County, N. J. (pl. 3, fig. 8), are similar to the holotype of *E. tillensis* from Tillys Lake, S. C. Dall considered the Heislerville fauna to be Pliocene. At Wailes Bluff on the Potomac River, St. Marys County, Md., typical *E. palmerae* occurs as a heavier but still moderately thin-shelled, true-breeding species. The region farther south, from Cape Hatteras to the Florida east coast, exhibits a varied, robust, thick-shelled form that is believed to identify it as the region in which the *E. variabilis* stock survived. This form is tentatively referred to *E. ponderosa* but is not regarded as typical.

In the late Pleistocene the robust, *ponderosa*-like form migrated as far north as Marthas Vineyard and Nantucket. That these heavy, subquadrate shells are not very old is evidenced by their slight amount of leaching. This northern advance was followed by a retreat, and at the present time no living shells, as shown by adhering periostracum, can be found north of Cape Hatteras. The collection in the United States National Museum contains one small specimen, supposedly taken living off Marthas Vineyard, but so far this record has not been verified. Dr. Horace G. Richards, of the New Jersey State Museum, who has been checking the Pleistocene and Recent ranges of Atlantic coast Mollusca, concurs in this statement. The Marine Biological Laboratory at Woods Hole, Mass., has not obtained a single living specimen in all its dredgings for the last 40 years.

Distribution: Early and middle Pleistocene north of Cape Hatteras.

Type locality: Wailes Bluff, near Cornfield Harbor, Potomac River, St. Marys County, Md.; U.S.G.S. 10902.

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Other occurrences: Heislerville, Cumberland County, N. J., U.S.G.S. 2110; Dismal Swamp Canal, about 3½ miles south of the Virginia-North Carolina line, Camden County, N. C., U.S.G.S. 11995.

Doubtful identifications: Variable forms which may be hybrids of *E. palmerae* and a relict *E. variabilis* stock occur in the Pleistocene along the Neuse River near Croatan, Craven County, N. C., U.S.G.S. 10893, and along the Intracoastal Waterway between the Little River and Myrtle Beach, Horry County, S. C., U.S.G.S. 13424, 13425, and are referred to *E. ponderosa*.

Eontia veroensis MacNeil, n. sp.

Plate 3, figure 6

Shell subovate and inflated, moderately elongate, rounded anteriorly, more sharply rounded and produced posteroventrally; beaks moderately high, situated at about the center of the hinge line; umbones not very high; umbonal ridge rounded and moderately sharp; posterior slope moderately steep; medial sulcus rarely, if ever, noticeable; ribs averaging about 32 or 33, double or irregularly divided along the umbonal ridge and anteriorly as well in some specimens, interstitial ribs present posteriorly and to a lesser extent anteriorly, but usually obsolete medially, larger ribs tending to be flat-topped; ligament shorter posteriorly than anteriorly, leaving a narrow strip of the area bare posteriorly, vertical elements appearing posteriorly when about one-quarter grown; teeth vertical centrally, inclined posteriorly, L-shaped anteriorly.

Holotype (U.S.N.M. 496580), length 52 millimeters, height 35 millimeters, convexity 17 millimeters.

This species occurs in a restricted area in the vicinity of Vero, St. Lucie County, Fla. It is smaller, is somewhat more elongate and inflated, and has several more ribs than the more robust form farther north. *E. veroensis* appears to be connected by intermediate forms with the *E. limula*-like form occurring in the Pliocene near Melbourne and Fellsmere, in Brevard and St. Lucie Counties, but is smaller and more inflated and lacks the medial sulcus. *E. veroensis* is probably not very late Pleistocene and represents an uncontaminated strain.

Distribution: Lower (?) Pleistocene, St. Lucie County, Fla.

Type locality: Vero, St. Lucie County, Fla., U.S.G.S. 7853.

RECENT SPECIES

Eontia ponderosa (Say) MacNeil

Plate 3, figures 9–12

Arca ponderosa Say, Acad. Nat. Sci. Philadelphia Jour., 1st ser., vol. 2, p. 267, 1822.

Arca contraria Reeve, Conchologia iconica, *Arca* no. 55, 1844.

Arca elegans Philippi, Zeitschr. Malacozoologie, p. 92, 1847; Abbildungen und Beschreibungen Conchylien, vol. 3, p. 86, *Arca* tab. 5, fig. 5, 1849 [not *Arca elegans* Perry, 1811; Roemer, 1836; D'Orbigny, 1844; Wood, 1846, or De Koninck].

Noetia contraria. Dunker, Novitates conchologicae, Mollusca marina, p. 122, p. 40, figs. 4, 5, 1870.

Arca (Noetia) contraria. Kobelt, Conchylien-Cabinet von Martini und Chemnitz, *Arca*, p. 23, pl. 7, figs. 4, 5, pl. 8, figs. 3, 4, 1891.

Arca (Noetia) ponderosa. Kobelt, idem, p. 123, pl. 32, figs. 1, 2, 1891.

Arca (Scapharca?) elegans. Kobelt, idem, p. 184, pl. 45, figs. 5, 6, 1891.

Arca (Noetia) ponderosa. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 633, 1898.

Sheldon, Palaeontographica americana, vol. 1, no. 1, p. 28, pl. 6, figs. 6–10, 1916.

Lamy, Jour. conchyliologie, vol. 55, p. 299, 1907.

Shell obliquely trigonal or subrhomboidal, short; anterior rounded, posteroventral margin bluntly angulate and moderately produced; hinge line short posteriorly; beaks high, situated just posterior to the center of the hinge line; umbonal ridge carinate; posterior slope steep; ribs 25 to 30, averaging about 2?, double or irregularly divided posteriorly, frequently double anteriorly but when remaining single usually flat-topped, beaded in very young stages; interstitial riblets usually present posteriorly; ligament longer anteriorly than posteriorly, leaving a moderately narrow strip of the area bare posteriorly; teeth small and vertical centrally, inclined posteriorly, L-shaped anteriorly, anterior and posterior rows subequal in length. (Emended description.)

Figured specimens: Murdock form (U.S.N.M. 496534), length 47 millimeters, height 39 millimeters, convexity 18 millimeters. Pleistocene form, from Bradenton, Fla. (U.S.N.M. 496535), length 44 millimeters, height 37.5 millimeters, convexity 17.5 millimeters. Recent, Florida (U.S.N.M. B1055), length 67.5 millimeters, height 58 millimeters, convexity 27.5 millimeters.

Considerable has already been said concerning this well-known species under its related forms. The living species is quite constant in form, and nowhere throughout its long range does it show any consistent local variation. During the Pleistocene epoch, however, several local varieties as well as two Atlantic coast forms regarded as separate species existed, all of which contributed to typical *E. ponderosa*. This condition makes it difficult to decide the limits to which the specific name should be applied, inasmuch as none but the most recent of the Pleistocene forms can be regarded as representing the sum total genetic composition of the Recent species. Possibly all the early Pleistocene varieties should be recognized, but until the stages of the Pleistocene of the Atlantic and Gulf Coastal Plains are worked out in more detail, it seems better to designate them as local forms of *E. ponderosa*.

The form occurring in beds believed to be Pliocene, because of the occurrence of *Conus adversarius* Conrad, near Murdock, Fla., is indistinguishable from the Recent form in shape and is referred to *E. ponderosa*. The possibility exists, however, that these beds are Pleistocene. Elsewhere along the Florida west coast undoubted Pleistocene beds carry a medium-sized shell which, although somewhat variable, is predominantly of the short, *E. ponderosa* type. The species is less variable in Pleistocene beds in Louisiana.

Along the Atlantic coast two Pleistocene species have been recognized, one in the north, *E. palmerae* and the

other in the south, *E. veroensis*. In addition, a relict of the *E. variabilis* stock existed in the intervening area that gradually absorbed the *E. palmerae* stock and migrated as far north as Nantucket. This vigorous southern stock was probably supplemented by the more quadrate *pre-ponderosa* stock from the Florida west coast during this time, resulting in complete absorption of *E. veroensis* and finally in the homogeneous, long-ranging Recent species.

A specimen that undoubtedly belongs to this species is in the Japanese collection in the United States National Museum, supposedly from the Ryukyu Islands. It was acquired along with other specimens from the United States Fish Commission. I am inclined to doubt the correctness of this label, but it is not impossible that this species has been introduced in Japanese waters, just as many Japanese species have been introduced into California waters along with the spat of the edible Japanese oyster.

Distribution: Upper Pliocene (?) of western Florida, Pleistocene and Recent.

Range: Upper Pleistocene, Nantucket to Louisiana and west (?); Recent, Cape Hatteras to Yucatan.

Louisiana well records: All the known Pleistocene specimens from Louisiana were obtained from wells. Specimens are in the United States National Museum from a well in lower Plaque-mines Parish at a depth of 740 feet, and from Cameron Parish at a depth of 912 to 972 feet. Miss Maury[8] lists other records as follows: "Grand Chenier, New Orleans pumping station no. 7, New Orleans artesian well of 1856 at 480 and 560 feet (Hilgard), Lake Borgne borings; Knapp's wells, Terrebonne Parish, no. 2, at 1,519–1,542, 1,632–1,726, 1,719–1,842, no. 3 at 670, 1,579–1,618, 1,700, Crowley well no. 4, Jennings, at 1,663–1,670 feet." The rapid accumulation of sediments in the region of the Mississippi Delta makes it probable that all these depths are within Pleistocene strata. Care should be exercised in the future in delimiting the stratigraphic and geographic ranges of *Eontia ponderosa* and *Noetia gardnerae* in the northern Gulf region.

In the accompanying diagram (fig. 2) are shown the supposed relationships of the North American species of *Eontia*. The general plan of the evolution of these organisms does not appear to be one of continual branching out, but rather one in which the tendency to diversification is limited by hybridization. Once long-ranging species appear to have been broken up, by whatever process, into various geographic species and subspecies, some of which persisted in isolated regions practically unchanged. There is evidence that later two or more of these true-breeding species were brought together and produced an extremely heterogeneous series of forms, individuals of which can be selected that recall either or any of the contributing species and all stages in between. From this hybrid series there emerged not further modifications of the original species but a single, less variable form, unlike any of the earlier species. This emergent probably does not represent the sum total genetic composition of all the parent species, nor a simple linear descendant of one of them, but rather a partial recombination of the characters of all of them. Other recombinations of the same parentage did not survive. Thus, whatever extinction takes place during the process of hybrid synthesis, it does not appear to be a wholesale extinction of any of the contributory strains but rather of unsuited phenotypes resulting from the union. The emergent thus traces its ancestry not to any one of the original strains but to all of them, and its family tree takes the form of two or more species converging to produce a single species.

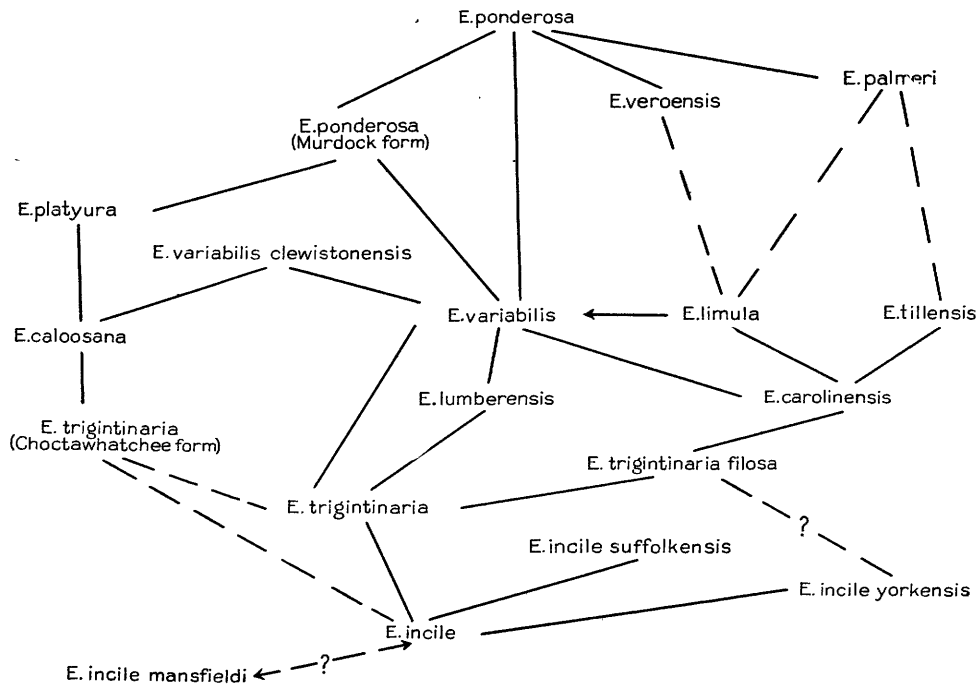


FIGURE 2.—Diagram showing supposed relationships of North American species of *Eontia*.

PACIFIC GROUP

Genus PROTONOETIA MacNeil, n. gen.

Type species: *Anadara nigeriensis* Newton.

Shell subquadrate, inflated, subangulate posteroventrally; hinge line long, beaks nearly central and orthogyrate; umbonal ridge subcarinate; sculpture consisting of regular ribs of about equal size all over the disk and posterior slope, and interstitial ribs in young stages which may persist into the adult stage; interstitial ribs lirate in nealogic stage, beaded later; principal ribs beaded in nealogic stage, smooth in adults; ligament extending both anteriorly and posteriorly, covering the entire anterior part of the cardinal area; teeth short and vertical centrally, inclined and tending to be L-shaped terminally.

[8] Maury, C. J., Bull. Am. Paleontology, vol. 8, no. 34, p. 15, 1920.

This genus exhibits a combination of characters which distinguishes it from all others and yet has single characters which definitely link it with other genera. Its ligament entirely fills the anterior part of the area, as in *Noetia*, but the posterior portion of the ligament is more produced, and the hinge line is longer than in any known species of that genus. In addition the beaks are orthogyrate and just anterior of the center, rather than opisthogyrate and well into the posterior half of the hinge line, or terminal as in *Noetia*.

The sculpture of the young stages shows the primary and secondary ribs characteristic of the Noetinae. Adults of *Protonoetia* do not particularly resemble any species of Striarcinae but rather bear a superficial resemblance in shape to some Miocene to Recent species of *Arca*, which led the author of the type species to refer it to Gray's genus *Anadara*. *Protonoetia* is intermediate in hinge, beak, and ligament characters between *Noetia* and early members of the Noetidae. *Protonoetia* represents in ligament evolution from its hypothetical ancestor a step comparable to that between *Eontia* and *Sheldonella* and the genus *Scapularca* in that the anterior part of the cardinal area is completely covered with ligament.

EOCENE SPECIES

Protonoetia nigeriensis (Newton) MacNeil

Plate 4, figures 1–3

Anadara nigeriensis Newton, Geol. Survey Nigeria Bull. 3, p. 70, pl. 8, figs. 4–7, 1922.

Shell subquadrate, inflated, broadly rounded anteriorly, straighter posteriorly, sharply rounded or subangulate posteroventrally; hinge line long, making the shell subangulate at its dorsal extremities; beaks low, orthogyrate, situated just anterior of the center of the hinge line; umbonal ridge subcarinate; ribs 25 to 32, averaging 27 or 28, rounded posteriorly, slightly wider and flatter anteriorly, interstitial ribs frequently persisting into the adult stage on the posterior slope and in the anterodorsal region; ligament about twice as long anteriorly as posteriorly, covering the entire anterior part of the cardinal area; teeth short and vertical centrally, inclined and tending to be L-shaped terminally, anterior and posterior rows subequal in length. (Emended description.)

Lectotype, refigured (pl. 4, fig. 2), in British Museum. Topotype (U.S.N.M. 496536), length 29 millimeters, height 25 millimeters, convexity 11.5 millimeters. Newton's largest specimen, length 42 millimeters, height 35 millimeters, double convexity 32 millimeters.

Little need be said concerning this species except that it represents a genus which is regarded as prototypical to *Noetia*. Not enough is known to say whether it is or is not in the direct line.

Distribution: Eocene, upper Lutetian of Nigeria.

Type locality: Ameki, Omobialla district, southern Nigeria.

Genus NOETIOPSIS MacNeil, n. gen.

Type species: *Noetiopsis woodringi*, n. sp.

Shell subrhomboidal or subtrigonal, rounded anteriorly, sharply rounded and produced posteroventrally; hinge line moderately short; beaks prosogyrate, situated well anterior of the center of the hinge line; umbonal ridge subcarinate; sculpture consisting of many regular ribs of about equal size; interstitial ribs may be present in adults on the posterior slope; ligament well produced posteriorly and anteriorly, completely covering the posterior part of the cardinal area; teeth arranged in an arc, vertical and shorter centrally, inclined posteriorly, tending to be L-shaped anteriorly, the posterior row slightly longer.

Noetiopsis differs from *Protonoetia* principally in the position and orientation of the beaks and in the part of the cardinal area covered by the ligament. In *Noetiopsis* the beaks are prosogyrate and well into the anterior half of the hinge line. The ligament completely fills the posterior part of the area and leaves only a narrow strip uncovered anteriorly. It thus differs from *Protonoetia*, in which the beaks are about central and orthogyrate and the ligament fills the anterior part of the area, leaving much of the posterior part bare. Juveniles of *Noetiopsis* have a longer hinge line and more expanded posterior slope, comparing more closely with *Protonoetia* than adults. It is possible that in future discoveries the length of the hinge line may not be found to contrast as much as in the species now known.

Noetiopsis bears a striking resemblance to *Noetia*, principally because of its short hinge line and truncate posterior slope. If *Protonoetia* had a hinge line comparable in length to that of adults of *Noetiopsis* it would be even more *Noetia*-like owing to its beak and ligament characters. *Noetiopsis* approaches more closely the genus *Arginopsis*, described below, occurring in the upper Eocene of Peru.

EOCENE SPECIES

Noetiopsis woodringi MacNeil, n. sp.

Plate 4, figures 4–8

Shell subrhomboidal or subtrigonal, inflated, rounded anteriorly, sharply rounded and produced posteroventrally; hinge line moderately short; beaks prosogyrate and of medium height, situated at about the anterior third of the hinge line; umbones full; umbonal ridge subcarinate; ribs 30 to 33, usually 31 or 32, of about equal size all over the disk and posterior slope, the posterior ribs rounded, the anterior ribs flatter; tending to be more in relief in young and middle adult stages; interstitial ribs sometimes persisting on the posterior slope; ligament about twice as long posteriorly as anteriorly, completely covering the posterior part of the cardinal area, leaving a narrow strip bare anteriorly; teeth arranged in an arc, vertical and shorter

centrally where they are cut off by the cardinal area, inclined posteriorly, tending to be L-shaped anteriorly, the posterior row somewhat longer.

Holotype (U.S.N.M. 496537). Paratype (U.S.N.M. 496538). Figured topotype, the largest specimen seen (in Axel Olsson collection, Gloversville, N. Y.), length 33 millimeters, height 27 millimeters, double convexity 26 millimeters.

This species is very constant in the number of ribs, most specimens differing by only one rib. It thus differs from *Protonoetia nigeriensis*, in which the number ranges from 25 to 32. The maximum number of ribs in *P. nigeriensis*, however, is the normal number for *N. woodringi*. The shorter hinge line makes the demarcation of the cardinal area from the anterodorsal part of the disk less distinct, and the growth lines in that region pass onto the cardinal area with little interruption, except that they pass from a rounded to a flat surface.

Noetiopsis woodringi is a very conspicuous element in the fauna in which it occurs and, like all the upper Eocene Pacific Noetinae, has the aspect of Miocene or later arcid shells. This species may be the direct ancestor of the genus *Arginopsis*.

Distribution: Middle Eocene, Tonosi River, Panama.

Type locality: Bucaru, Port of Tonosi, Los Santos Province, Panama, U.S.G.S. 8414 (Axel Olsson collection); U.S.G.S. 6586a (Donald MacDonald collection).

Genus ARGINOPSIS MacNeil, n. gen.[9]

Type species: *Scapharca* (*Argina*) *sullanensis* Woods.

Shell subovate or rounded, inflated, all margins of about the same rotundity; beaks low, strongly prosogyrate, situated at the anterior end of the hinge line; hinge line moderately long; umbonal ridge rounded but distinct; sculpture consisting of many very regular ribs which tend to become low and flat-topped ventrally; interstitial ribs sometimes present posteriorly; ligament wholly posterior to the beaks, filling that part of the cardinal area completely; only a very short part of the cardinal area anterior to the beaks, and that sharply rounded and nearly atrophied; teeth vertical centrally, the anterior row inclined with the teeth, tending to be L-shaped, the posterior row long and extending away from the hinge line on an arcuate or more abruptly curved cardinal plate.

Arginopsis represents the opposite extreme in orientation to *Noetia* and is regarded as an aberrant genus. In *Arginopsis* the beaks are strongly prosogyrate, the ligament posterior, and the umbonal ridge rounded. In *Noetia* the beaks are opisthogyrate, the ligament anterior, and the umbonal ridge usually carinate, owing to twisting. These two genera illustrate remarkably well the way in which the entire aspect of a shell can be altered by a change in the position and orientation of the beaks.

This genus is closely related to *Noetiopsis* and probably was derived from it, although the genotype species may not form a linear series. It is not expected that many species of these two genera will be discovered, as one is regarded as a transitional and the other a terminal genus, both of relatively short geologic range.

Arginopsis cannot be regarded as ancestral to the Pliocene to Recent genus *Lunarca* (=*Argina*), a relationship which has been almost universally accepted, because of its perfectly developed vertical ligament elements.

EOCENE SPECIES

Arginopsis sullanensis (Woods) MacNeil

Plate 4, figures 9–11

Scapharca (*Argina*) *sullanensis* Woods, in Bosworth, Geology and paleontology of northwest Peru, p. 62, pl. 1, fig. 5, 1922.

Shell suborbicular and much inflated, anterior, posterior, and ventral margins about equally curved; beaks strongly prosogyrate and low, situated at about the anterior terminus of the hinge line; umbones moderately full; hinge line of moderate length; ribs about 40, smooth and tending to be flat-topped anteriorly, rounded posteriorly, becoming less elevated in full-grown adults; interstitial ribs present on the posterior slope; ligament area narrow and partly obscured by the overhanging margins, completely covering the part of the cardinal area posterior to the beaks; cardinal area very short anteriorly, with the border not well defined; teeth small centrally, somewhat crowded anteriorly, the hinge plate swinging ventrally at the posterior end of the hinge line to form a short row of nearly horizontal teeth. (Emended description.)

Holotype in British Museum. Figured specimen (U.S.N.M. 496539), length 34 millimeters, height 31 millimeters, double convexity 27 millimeters.

This species is remarkable for the number of its ribs, which exceeds that of any other known forms of Pacific Noetinae except some species of *Noetia*, from which it differs greatly in orientation. The known species of the genus *Arginella* have about 15 less ribs. The extremely prosogyrate beaks, narrow ligament area, and rotund outline give this species a striking resemblance to the Pliocene to Recent species *Lunarca pexata* (Say) and led its author to refer it to that group.

Distribution: Upper Eocene, Talara and Saman formations, Peru.

Type locality: Ten miles west-northwest of Sullana, Peru.

Figured specimens: Hacienda Saman, south escarpment of mesa, 30 to 40 feet below top, at mouth of Rio Chira, 3 miles inland from the ocean, Piura Department, Paita district, Peru, U.S.G.S. 5556.

[9] *Arginopsis* and *Arginella* take their names from the familiar name *Argina*, although they are not related to that group, and it might furthermore be pointed out that *Argina* is not available for Mollusca, because it is preoccupied in Lepidoptera by *Argina* Hubner, 1816. The valid name for *Arca pexata* Say is probably *Lunarca* Gray.

Genus ARGINELLA MacNeil, n. gen.

Type species: *Arca (Argina) samanensis* Olsson.

Shell subrhomboidal to subovate, rounded anteriorly, more sharply rounded posteroventrally, often subangulate anterodorsally; beaks moderately low to very low, prosogyrate, situated at or near the anterior end of the hinge line; hinge line short to medium length; umbones high, narrow to moderately full; umbonal ridge conspicuous but rounded; sculpture consisting of very regular but comparatively few ribs that tend to become less elevated ventrally; interstitial ribs usually present on the posterior slope; ligament wholly or almost wholly posterior to the beaks, filling that part of the cardinal area completely; cardinal area narrow, the part anterior to the beaks plane or concave, forming a lunular area, to more rounded and indistinct; teeth numerous, small and vertical centrally, longer and inclined terminally, swinging away from the hinge line on a narrow, arcuate cardinal plate posteriorly, the short anterior row beginning beneath the beaks, offset from and diagonal to the posterior row.

The species included in this genus form a more or less linear series showing the transition of the anterior part of the cardinal area from a lunulelike area to a shorter, convex area which passes insensibly into the anterior part of the disk. Its ultimate form thus compares with *Arginopsis* in this respect, but it differs from that genus in being smaller, having less prosogyrate and more central beaks, a shorter hinge line and ligament area, and a more arcuate cardinal plate. The species of *Arginella* all have about 15 less ribs than the monotype of *Arginopsis*.

The developmental process that produced *Arginopsis* was an initial gyration and shifting of the beaks nearly to the anterior end of the cardinal area, resulting in a long posterior ligament area. In *Arginella* the beaks were not shifted as far anteriorly, with the result that the anterior end of the cardinal area became lunular and then indistinct, whereas the posterior ligament area was comparatively short.

Noetiopsis differs from *Arginella* in being larger, with more ribs, and in having a wider cardinal area with about a third of the ligament anterior to the beaks. The hinge line coincides with the cardinal area throughout, whereas in *Arginella* the lunular anterior part is diagonal to the hinge line.

The genera *Protonoetia*, *Noetiopsis*, *Arginopsis*, and *Arginella* are all closely related. At the present time it is not possible to make positive statements regarding their phylogeny, or to say in which direction evolution proceeded. It is believed, however, that the ancestral form was intermediate between *Protonoetia* and *Noetiopsis* and that three subsequent groups were developed —the *Protonoetia-Noetia* group, the *Noetiopsis-Arginopsis* group, and *Arginella*.

No interstitial ribs have been observed in any specimens of *Arginella* thus far observed, although in some specimens the sculpture is well preserved down to about the beginning of the adult stage. It remains to be seen on specimens with the nealogic sculpture preserved whether or not the primary ribs are present in that stage.

EOCENE SPECIES

Arginella samanensis (Olsson) MacNeil

Plate 4, figures 12, 13

Arca (Argina) samanensis Olsson, Bull. Am. Paleontology, vol. 15, no. 57, p. 5, pl. 1, figs. 4, 5, 1929.

Shell subrhomboidal, varying in inflation, rounded anteriorly, ventral margin sometimes contracted, sharply rounded posteroventrally, often subangulate anterodorsally; beaks strongly prosogyrate and moderately low, situated at about the anterior end of the hinge line; hinge line of medium length; umbones moderately narrow; ribs about 25, rounded posteriorly, flatter anteriorly, becoming less elevated or level with the interspaces in adults; interstitial ribs present on the posterior slope; ligament area moderately narrow and posteriorly obscured by the overhanging margins, posterior to the beaks except for a very small anterior extension, completely filling the posterior part of the cardinal area; the cardinal area anterior to the ligament out of the plane of the ligament area, forming a plane or concave lunular area; teeth small and vertical centrally, inclined terminally, the posterior row long and arcuate, swinging away from the hinge line on a curved or arcuate cardinal plate, anterior row about half as long, diagonal to and offset from the hinge line. (Emended description.)

Holotype in Paleontological Research Institution, Ithaca, N. Y.; figured specimen (topotype?) (U.S.N.M. 496540), length 23 millimeters, height 20.5 millimeters, double convexity 16 millimeters. A shorter and more inflated specimen, length 24 millimeters, height 23 millimeters, double convexity 19.5 millimeters.

This species occurs with *Arginopsis sullanensis*, but the two do not intergrade, a fact which supports the morphologic reasons for placing them in different genera. It differs from *Arginopsis sullanensis* in being smaller and subrhomboidal rather than suborbicular and in having about 15 less ribs, less prosogyrate and more posterior beaks, narrower umbones, a more sharply rounded umbonal ridge, and a lunulelike development of the anterior part of the cardinal area. This and the other species of *Arginella* have fewer ribs than either *Noetiopsis woodringi* or *Arginopsis sullanensis*, the number being about the minimum number found in *Protonoetia nigeriensis*.

The lunular area is a striking feature of this species and is probably better developed in it than in the Oligocene species. It dips to the anterior out of the plane of the ligament area, and when the valves are open there is a gape between its opposing margins, so that, while morphologically a part of the cardinal area,

its edges no longer form a part of the hinge line. Rotation of the beaks to the anterior was not as complete as in *Arginopsis* and is compensated for by a degeneration of the anterior part of the cardinal area.

Distribution: Upper Eocene, Talara and Saman formations, Peru.

Type locality: Casa Saman, Peru (Olsson).

Other occurrences: Lagunitas and Talara (Olsson).

Figured specimens (topotypes?), Hacienda Saman, south escarpment of mesa, 30 to 40 feet below top, at mouth of Rio Chira, 3 miles inland from ocean, Piura Department, Paita district, Peru, U.S.G.S. 5556.

OLIGOCENE SPECIES

Arginella puntabravoensis (Olsson) MacNeil

Plate 4, figure 14

Arca (*Argina*) *puntabravoensis* Olsson, Bull. Am. Paleontology, vol. 17, no. 63, p. 38, pl. 2, figs. 1, 4, 1931.

Shell subrhomboidal, inflated, bluntly angulate anterodorsally, sharply rounded and often produced posteroventrally, ventral margin contracted; beaks prosogyrate; umbones moderately full; ribs regular, about 22 to 23, tending to be flat-topped or even concave ventrally; ligament area narrow and posterior to the beaks; cardinal area forming a lunular area anteriorly; teeth not visible on any of the specimens examined. (Emended description.)

Holotype in Paleontological Research Institution, Ithaca, N. Y. Olsson gives the following measurements for two specimens: Length 22 millimeters, height 19 millimeters, convexity 6 millimeters; length 20.5 millimeters, height 18 millimeters, convexity 8 millimeters.

This species is much like the more inflated and angulated variants of *A. samanensis* and differs from them principally in being more inflated; with fuller and higher umbones and a more contracted ventral margin. This is the only one of the known aberrant species which is not present in my collection, so that it is not compared with related species in very great detail. The type was examined at an early stage in the preparation of this paper, before the critical characters of the other species had been recognized.

Distribution: Middle Oligocene, Mancora formation, Punta Bravo grits of Punta Bravo, Peru (Olsson).

Arginella ovalis MacNeil, n. sp.

Plate 4, figures 15, 16

Shell subovate, inflated, rounded anteriorly and posteriorly, broadly rounded ventrally, more sharply rounded posteroventrally and anterodorsally; beaks very low, prosogyrate, situated at the anterior end of the hinge line; hinge line short; umbones high and moderately full; umbonal ridge rounded but well defined; ribs 23 to 25, very regular and rounded, less elevated ventrally; interstitial ribs usually present on the posterior slope; interspaces neatly sculptured by raised growth varices; ligament very narrow and wholly posterior to the beaks, partly obscured by overhanging margins; anterior part of cardinal area somewhat lunular but not well defined; teeth very numerous, small and vertical centrally, longer and inclined posteriorly, swinging away from the hinge line on a long, narrow cardinal plate, anterior row beginning beneath the beaks, offset from and diagonal to those along the hinge line.

Holotype (U.S.N.M. 496541), length 18.5 millimeters, height 17.5 millimeters, convexity 5 millimeters. Paratype (U.S.N.M. 496542).

This is the smallest of the three species referred to the genus *Arginella*. It differs from the other two species in being more rounded, without any contraction of the ventral margin, and with broader and fuller umbones. The ligament area is smaller, and the lunular area is more indistinct in adults, although in young shells the anterodorsal region is more angulate and the lunular area less rounded. Only about a third of the teeth of this species are along the hinge line, the entire anterior row and the posterior half of the posterior row being situated on a cardinal plate diverging from it.

Distribution: Oligocene(?), Colombia.

Type locality: Between Arroyo Mancamajon and Ovejas, Bolivar Department, Colombia, U.S.G.S. 11482.

Genus NOETIA Gray

Type species: *Arca reversa* Sowerby.

Shells ranging in shape from subrhomboidal to subtrigonal, usually produced or angulate posteroventrally; beaks opisthogyrate, varying from just posterior of the center of the hinge line and high to very posterior and low; cardinal area wide or very narrow posteriorly according to the position and height of the beaks; umbonal ridge well defined, usually carinate; sculpture consisting of rounded or flat-topped ribs, more in relief dorsally, becoming less elevated or even lower than the interspaces ventrally; ribs usually of equal size all over, but larger anteriorly in some species; interstitial ribs frequently present, especially posteriorly; inner margin deeply crenulated by ribs posteroventrally; ligament area covering the entire anterior part of the cardinal area, extending a very short distance posteriorly in high-beaked species; teeth arranged in a broad arc, vertical centrally, inclined posteriorly, L-shaped anteriorly, the anterior and posterior rows subequal in length in species with more central beaks, the anterior row longer in species with posterior beaks. (Emended description.)

Although *Noetia* forms a recognizably compact genus, it can be seen from the descriptions that the species are rather variable. It can be distinguished from all other genera of the Pacific group by its beaks, which, while showing all stages in a series, are always

posterior of the center and opisthogyrate. *Noetia* differs from the Atlantic genus *Eontia*, with which it has usually been combined, in having decidedly more regular sculpture, the ribs smoother and never divided, and the interstitial ribs but weakly developed; deeper and longer posteroventral crenulations of the inner margin; and a more anteriorly restricted ligament area, the posterior extension never being as long as in *Eontia*.

Noetia has a range from the upper Eocene to Recent, three species being known from the upper Eocene of the Indo-Pacific and the rest from the lower Miocene to Recent of America. While the Pacific Noetinae are represented in the Eocene and Oligocene of America by the genera *Noetiopsis*, *Arginopsis*, and *Arginella*, there is reason to regard these as aberrant genera, and the American species of *Noetia* as derived from the Indo-Pacific stock.

Most of the American species are of middle or upper Miocene age and lived in Pacific waters, or in waters having free intercourse with or recently separated from Pacific waters. These species are distributed in Peru, Ecuador, Colombia, Panama, Costa Rica, Venezuela, and Trinidad. The genus survived the reseparation of the Caribbean and Pacific, one species being known from the upper Miocene or Pliocene of Texas, and another from the upper Pliocene of Trinidad, but it apparently became extinct after late Pliocene time in the Gulf and Caribbean region. The only Recent species lives in the Pacific from the Gulf of California to Peru.

INDO-PACIFIC SPECIES

EOCENE SPECIES

Noetia molengraffi (Martin) MacNeil

Plate 4, figures 22, 23

Arca (*Anadara*) *molengraffi* Martin, Geol. R. Mus. Leiden Samml., new ser., vol. 2, p. 184, pl. 7, fig. 191–2, 1915.

Shell subrhomboidal, moderately inflated, anterior rounded, posteroventral margin sharply rounded and somewhat produced; beaks of about medium height, situated at about the anterior fifth of the hinge line; umbones moderately high and full; umbonal ridge sharply rounded; ligament mostly anterior, extending only a short distance posteriorly; ribs small and regular, about 38 to 40, rounded posteriorly, flatter anteriorly, less in relief ventrally; teeth vertical centrally, L-shaped anteriorly, inclined posteriorly, the posterior row short and diagonal to the anterior row. (Emended description.)

Lectotype (in Rijksmuseum van Geologie en Mineralogie, Leiden), length 42 millimeters, height 36 millimeters.

The accompanying figures are the first published photographs of this species and show the details of the hinge and sculpture better than the original drawings. The ribs are very regular and comparatively small for *Noetia*. The beaks, although well toward the posterior end of the hinge line, are high, so that the area is as wide beneath the beaks as it is more anteriorly.

Distribution: Upper Eocene, Nanggulan, Java.

Noetia pondaungensis Cotter

Plate 4, figures 17, 18

Arca (*Noetia*) *pondaungensis* Cotter, Paleontologia indica, new ser., vol. 7, no. 2, p. 20, pl. 5, figs. 1, 2, 1923.

Shell subrhomboidal, inflated, anterior rounded, posteroventral margin produced and angulate; beaks high, near the posterior end of the hinge line; umbones high and narrow; umbonal ridge angulate; posterior slope steep; ligament area moderately wide and mostly anterior to the beaks; ribs about 35, flat-topped anteriorly, rounded posteriorly and becoming submerged below the level of the interspaces in adults; teeth vertical centrally, inclined terminally, the anterior row much the longer. (Emended description.)

Holotype (in Geological Survey of India, Calcutta), length 44 millimeters, height 34 millimeters, convexity 15 millimeters.

This species has a more pointed posteroventral margin, a more angulate umbonal ridge, higher beaks, and a wider cardinal area than the Javanese species. The ribs are less numerous and wider in this species than in *N. molengraffi* and become distinctly submerged in adults. Cotter did not describe this condition in exactly these words but stated that "both ribs and furrows are crossed by fine, wavy lines of growth which [ventrally] curve downward on the ribs and upward in the furrows", the opposite of the condition with elevated ribs.

It is interesting to note that although the ribs in all the species of Pacific Noetinae tend to become less elevated in adults, actual submergence of them below the level of the interspaces is attained in only a few species, the most outstanding of which are the Panama Eocene form *Noetiopsis woodringi*, the Burmese Eocene species *Noetia pondaungensis*, and the Trinidad Miocene species *N. manzanillae* and *N. mundonuevensis*.

Distribution: Upper Eocene, Pondaung sandstones, Burma.

Noetia nagaoi MacNeil, n. name

Plate 4, figures 19–21

Arca (*Noetia*) *pondaungensis* Cotter var. *transversa* Nagao, Tohoku Univ. Sci. Rept., ser. 2, Geology, vol. 12, no. 1, p. 26, 27, pl. 6, figs. 8, 9, 1928.

Shell subrhomboidal, moderately inflated, elongate and sharply rounded anteriorly, angulate posteroventrally; beaks moderately high and near the posterior third of the hinge line; umbonal ridge sharp; posterior slope flattened; ribs about 40, apparently wider than the interspaces; ligament area wide and mostly anterior, but well extended posteriorly as well; teeth vertical

centrally, inclined terminally, but not well exhibited in the type. (Emended description.)

Holotype (Institute of Geology and Paleontology, Sendai, Japan, no. 36012), length 57 millimeters, height 37 millimeters.

The elongate anterior end and angulate posterodorsal margin shown in the figure may be due to crushing, for, as Nagao states, "the shell is somewhat variable in shape, usually being as high as long." From the figures it appears to differ from the Burmese and Javanese species in being larger and in having more central beaks and a greater posterior extension of the ligament. In this respect it appears to be the most extreme of the known species of *Noetia* and approaches the genus *Protonoetia*.

The photographs here used were kindly furnished by Professor Nagao. As the name *transversa* is preoccupied in *Arca*, Professor Nagao suggested that I take the opportunity to rename his homonym. I take great pleasure, therefore, in naming this species in honor of its discoverer.

Distribution: Upper Eocene, Doshi beds, Asakura coal field, Province of Chikuzen, Japan.

AMERICAN SPECIES

MIOCENE SPECIES

Noetia stewarti MacNeil, n. sp.

Plate 5, figures 1, 2

Arca (Noetia) retractata. Olsson, Bull. Am. Paleontology, vol. 19, no. 68, p. 76, pl. 4, fig. 8 [not fig. 2], 1932.

Shell subrhomboidal or subtrigonal, inflated, anterior rounded, angulate and produced posteroventrally; beaks high and situated just behind the posterior third of the hinge line; umbones high and narrow; umbonal ridge sharp; posterior slope steep; ribs about 42, narrow and of about equal width over the entire disk, more rounded on the posterior slope; ligament mostly anterior to the beaks but extending posteriorly a short distance, a wide strip of the area bare behind the beaks; cardinal area wider posteriorly; teeth nearly vertical centrally, L-shaped anteriorly, not preserved on the type posteriorly.

Holotype in Paleontological Research Institution, Ithaca, N. Y. A topotype loaned to me by Mr. Olsson measures, length 33 millimeters, height 29.5 millimeters, convexity 13 millimeters. The convexity is probably greater owing to crushing of the specimen.

This form was united with the upper Zorritos species *N. retractata* by Olsson but differs from that species in having narrower and more numerous ribs, higher beaks and umbones, a shorter disk, a wider ligament area, and a shorter hinge line posteriorly. In *N. retractata* the posterior row of teeth and dorsal margin are more nearly horizontal. *Noetia stewarti* is related to *N. trinitaria* in beak and ligament characters but differs from it in being larger and heavier and in being less produced posteroventrally. *Noetia ecuadoria*, n. sp., is very similar in general form but is smaller, with a broader disk and lower and more posterior beaks.

It will be noted that *N. stewarti* and *N. trinitaria* have high beaks, with the cardinal area and ligament wider posteriorly, thus comparing with the upper Eocene Indo-Pacific forms in this respect rather than with later American forms, in which the beaks are lower and more posterior, making the area narrower posteriorly.

The exact age relationship of the lower Zorritos of Peru and the Manzanilla beds of Trinidad is not settled, but it is very probable that some specimens furnished to me by Mr. Olsson from the "transitional beds between the Heath shales and the lower Zorritos" of Peru are the oldest specimens of *Noetia* thus far obtained from the Americas.

Distribution: Lower Miocene, lower Zorritos sandstone and underlying transitional beds between it and the Heath shales, Peru.

Type locality: Quebrada Boca Pan at Zapotal, just south of Vacura, Province of Tumbez, Peru.

Other occurrences: Quebrada La Cruz, north of Mal Paso and about 4 miles inland, Peru.

Noetia trinitaria (Guppy) Dall

Plate 5, figures 5, 6

Arca trinitaria Guppy, Geol. Soc. London Quart. Jour., vol. 22, p. 583, pl. 26, figs. 3a, 3b, 1866.

Arca (Noetia) trinitaria. Dall, Wagner Free Inst. Sci. Trans., vol. 3, pt. 4, p. 617, 658, 1898.

Sheldon, Paleontographica americana, vol. 1, no. 1, p. 29, pl. 7, figs. 1, 2, 1916.

Maury, Bull. Am. Paleontology, vol. 10, no. 42, p. 35, pl. 3, figs. 1, 3, 4, 1925.

Shell subtrigonal, inflated, rounded anteriorly, very much produced posteroventrally; beaks high and situated at about the posterior third of the hinge line; umbones high and narrow; umbonal ridge sharp, curving outward; posterior slope very steep; ligament mostly anterior to the beaks, wider directly beneath the beaks; cardinal area wider posterior to the beaks, where a moderately wide strip is uncovered by ligament; ribs about 40, becoming flat-topped and about level with the interspaces ventrally; teeth vertical centrally, inclined or L-shaped terminally, the anterior row slightly longer. (Emended description.)

Lectotype (U.S.N.M. 496543), length 26 millimeters, height 21.5 millimeters, convexity 11 millimeters.

Noetia trinitaria compares with *N. stewarti* in its high beaks, wide cardinal area, and rib texture. It has a sharper ridge and more produced posteroventral margin, however, being one of the most extreme of the known species in this respect, and is considerably smaller than *N. stewarti*. Both of these species are probably related to *N. ecuadoria*, described below.

Distribution: Lower Miocene, Manzanilla formation, Trinidad.

Type locality: Northwest side of Manzanilla Point, Trinidad.

Noetia manzanillae Maury

Plate 5, figures 3, 4

Arca (Noetia) manzanillae Maury, Bull. Am. Paleontology, vol. 10, no. 42, p. 41, pl. 8, figs. 13, 19, 1925.

Shell suboval or subtrigonal, much inflated, anterior short and rounded, posterior rounded from the posterior end of the ligament to the ventral margin, without any angulation posterodorsally, posteroventral margin more sharply rounded and slightly produced; beaks moderately high and divergent, situated at the posterior end of the hinge line, which is about central with respect to the shell as a whole; umbones high and moderately narrow; umbonal ridge rounded, not angular; ribs about 30, slightly narrower than the interspaces and becoming level with the interspaces or submerged ventrally; ligament entirely anterior to the beaks, not occupying any of the curved region posteriorly; teeth not well known. (Emended description.)

Holotype (in Paleontological Research Institution, Ithaca, N. Y.), length 10 millimeters, height 12 millimeters, convexity 6 millimeters.

This is the smallest known species of the genus and does not appear to be particularly related to any of its contemporaries. Miss Maury suggested that *N. manzanillae* might be entitled to subgeneric recognition, similar to that accorded to *Sheldonella*, because of its rounded umbonal ridge. In outline and convexity it is quite rotund, and the rounded posterior slope and posterodorsal margin are extreme for the genus. The types, although small, appear to be full-grown adults, inasmuch as the ribs become submerged, a condition which, though occurring in other species, has not been found in shells of this size.

Distribution: Lower Miocene, Manzanilla formation, Trinidad.

Type locality: North of Manzanilla Point, northeastern coast of Trinidad.

Noetia mundonuevensis Maury

Plate 5, figures 7–9

Arca (Noetia) mundonuevensis Maury, Bull. Am. Paleontology, vol. 10, no. 42, p. 36, pl. 5, figs. 5, 7, 1925.

Shell subtrigonal, inflated, anterior broadly rounded, posterior margin nearly straight, posteroventral margin sharply rounded but not produced; beaks high, situated at about the posterior end of the hinge line; umbones high and moderately narrow; umbonal ridge sharply rounded; ribs about 30, flat-topped dorsally but becoming level or submerged ventrally, considerably so in the region of the umbonal ridge; ligament wholly anterior to the beaks, not constricted posteriorly; teeth nearly vertical centrally, L-shaped anteriorly, the posterior row oblique and the teeth inclined. (Emended description.)

Lectotype (in Paleontological Research Institution, Ithaca, N. Y.), length 40 millimeters, height 41 millimeters, convexity 19 millimeters. Paratype, length 27 millimeters, height 31 millimeters, convexity 14 millimeters. Figured topotype (in Museum of Geology, Cornell University, Ithaca, N. Y., no. 38635), if uncrushed, would measure about, length 31 millimeters, height 40 millimeters, convexity 15 millimeters.

This species has the high beaks and wide cardinal area characteristic of the early species of *Noetia*, as well as a very great submergence of the ribs along the posterior part of the disk and umbonal ridge. It is well characterized by its relatively greater height than length and its high, narrow umbones. The submerged ribs, which coincide with the crenulations of the inner margin, form such deep indentations along the posteroventral margin in some specimens that the thick interspaces form toothlike, interlocking projections between the two valves.

The specimen figured is from the type lot and, although somewhat crushed, is better preserved internally than either of the figured cotypes. An enlargement of one of these to show the submergence of the ribs is reproduced on plate 5, figure 7. This specimen is here designated as lectotype of the species.

Distribution: Lower middle Miocene, Brasso beds, Trinidad.

Type locality: Near the junction of the Mayo and Couva main roads, west-central Trinidad.

Noetia cholana Spieker

Plate 5, figures 21–23

Arca (Noetia) cholana Spieker, Johns Hopkins Univ. Studies in Geology, no. 3, p. 95, pl. 5, figs. 2, 3, 1922.

Shell subrhomboidal or somewhat egg-shaped, elongate, not much inflated, anterior rounded, posterior broadly produced and somewhat angulate; beaks low, situated near the posterior end of the area, but nearly central with respect to the shell, owing to the elongate posterior; umbones low and broad; umbonal ridge moderately carinate, curving outward so that the posterior angle is comparatively high; ribs about 35, slightly wider than the interspaces, tending to become flat-topped, nearly level with the interspaces ventrally; interstitial ribs developed all around in some specimens, absent anteriorly in others; ligament anterior to the beaks; a narrow strip of cardinal area posterior to the beaks but devoid of ligament; teeth vertical centrally, L-shaped anteriorly, inclined posteriorly, the posterior row being nearly as long as the anterior row, and less oblique to the hinge line than in most other species, owing to the more horizontal dorsal margin. (Emended description.)

Holotype (in Museum of Geology, Johns Hopkins University, Baltimore, Md.), length 34± millimeters, height 26± millimeters, convexity 10± millimeters. A less perfect specimen is larger.

The relationship of *N. cholana* to other species of *Noetia* is not clear. It does not appear to be particularly related to the lower Zorritos form *N. stewarti*, which is short and inflated, with high beaks, whereas

N. cholana is elongate, very little inflated, and with low beaks. It may prove to be related to *N. retractata*, which it more resembles in hinge and beak characters, although that species is much heavier and subquadrate rather than light and egg-shaped. The types of *N. cholana* are not well preserved, so that until better topotypes can be studied, its true relationships cannot be satisfactorily determined.

Distribution: Lower middle Miocene, middle Zorritos, Variegated beds, Quebrada Tucillal, Zorritos, Peru.

Noetia retractata (Hanna and Israelsky) Olsson

Plate 5, figures 14, 15; plate 6, figures 5, 6

Arca (Noetia) modesta Grzybowski, Neues Jahrb., Beilage Band 12, p. 635, pl. 18, fig. 4, 1899 [not *modesta* Weinkel, 1863].
Arca retractata Hanna and Israelsky, California Acad. Sci. Proc., 4th ser., vol. 14, p. 61, 1925.
Arca (Noetia) retractata. Olsson, Bull. Am. Paleontology, vol. 19, no. 68, p. 76, pl. 4, fig. 2 [not fig. 8], 1932.

Shell subrhomboidal or subquadrate, inflated, high and rounded anteriorly, angulate posteroventrally; beaks moderately low, situated at about the posterior quarter or fifth of the hinge line; umbones moderately high and of medium breadth; umbonal ridge sharp and curving outward; posterior slope steep but frequently expanded at the margin; hinge line moderately long; ribs 35 or 36, wider than the interspaces and of about equal width all over the disk, very flat or even concave on the disk, more rounded on the posterior slope, less in relief ventrally; ligament almost wholly anterior; cardinal area produced a short distance behind the beaks but uncovered by ligament except for a small wedge under the beaks; teeth vertical centrally, L-shaped anteriorly, inclined posteriorly, the posterior row about two-thirds as long as the anterior row and gradually swinging away from the hinge line on a moderately broad plate. (Emended description.)

Holotype in Geological Institute of the Jagiellonian University, Krakow, Poland. Topotype (Axel Olsson collection, Gloversville, N. Y.), length 40 millimeters, height 33 millimeters, double convexity 28 millimeters.

Noetia retractata is well characterized by its subquadrate outline, relatively long hinge line, and flat or concave ribs. It has been stated that *N. retractata* and *N. macdonaldi* would prove to merge into each other, but there is no evidence of this in any of the specimens examined. The ribs of *N. macdonaldi* are low and broadly rounded, with the anterior ribs frequently wider than the posterior ribs, and the interspaces very narrow and shallow. In *N. retractata* the ribs are flat or even concave, equisized, with the interspaces about half as wide and well defined. The umbones of *N. retractata* are lower and broader, the posteroventral margin less produced, the beaks less opisthogyrate, the break between the cardinal area and the adjoining part of the posterior slope less abrupt, and the posterodorsal margin more horizontal, with the posterior row of teeth less divergent from the hinge line. In addition, *N. retractata* probably does not attain the size of *N. macdonaldi*.

Specimens furnished to me by Mr. Olsson from the upper Zorritos sandstone about 1 mile east of Punta Picos, Province of Tumbez, Peru (pl. 5, fig. 20), although not well preserved, appear to be more nearly related to *N. ecuadoria* than to *N. retractata* and are referred to that species. It may be that these two species are connected by a series of intermediate forms. The relation of *N. ecuadoria* to *N. macdonaldi* is discussed below, and if *N. macdonaldi* and *N. retractata* are related it may be through this intermediate species.

Grzybowski described this species as having 30 ribs, but the photographs of the type obtained from the University of Krakow show this statement to be an error.

Distribution: Lower middle Miocene, upper Zorritos sandstone, Zorritos and Punta Picos, Peru.

Type locality: Zorritos.

Figured topotypes from a locality just southwest of Zorritos, Province of Tumbez, Peru.

Noetia ecuadoria MacNeil, n. sp.

Plate 5, figures 12, 13, 20

Shell subrhomboidal, moderately inflated, rounded anteriorly, sharply angulate posteroventrally, posterior margin nearly straight; beaks moderately low, situated at about the posterior fourth or fifth of the hinge line; umbones moderately high and of medium breadth; umbonal ridge carinate and curving outward; posterior slope steep; ribs about 35, slightly wider than the interspaces, tending to be flat-topped and level with the interspaces in adults, especially on the central and posterior part of the disk; interstitial ribs well developed on the ridge and posterior slope; ligament mostly anterior, extending a very short distance posteriorly, narrower beneath the beaks than centrally; cardinal area extending a short distance posteriorly but mostly devoid of ligament; teeth inclined to the posterior, L-shaped anteriorly, the posterior row oblique to the hinge line and about three-quarters as long as the anterior row.

Holotype (in Axel Olsson collection, Gloversville, N. Y.), length 34 millimeters, height 27.5 millimeters, convexity 12.5 millimeters.

This species appears to be related to and possibly descended from *N. trinitaria* or *N. stewarti*. It is intermediate in size between them and similar to *N. trinitaria* in the sharpness of the ridge and elongation of the posteroventral margin and in the anterior thickening of the shell. It differs from these two species in being broader across the disk, with lower umbones, more posterior beaks, and a narrower cardinal area posteriorly.

Noetia ecuadoria is probably closely related to *N. macdonaldi* on the other hand, although *N. colombiana*, next described, appears to be as closely related to that species

in some respects. The possibility of an intergradation between *N. ecuadoria* and *N. retractata* in the upper Zorritos has already been mentioned. *N. ecuadoria* may prove to be a key species which through interbreeding or direct evolution contributed to more than one contemporaneous or later species.

Distribution: Lower middle Miocene, Ecuador.

Type locality: Cueva de Angostura, Rio Santiago, Province of Esmeraldas, northern Ecuador.

Other occurrences: Miocene of Daule, Ecuador, near Estacada, Rio de la Balsa, Province of Guayas, Ecuador.

Doubtful identifications: Upper Zorritos formation, 1 mile east of Punta Picos, Province of Tumbez, Peru.

Noetia colombiana MacNeil, n. sp.

Plate 5, figures 10, 11

Shell subrhomboidal, moderately inflated, sometimes with a shallow medial sulcus, high and rounded anteriorly, angulate and considerably produced posteroventrally, posterior margin nearly straight; beaks low, situated at the posterior end of the hinge line; umbones low and full; umbonal ridge moderately sharp and curving strongly outward; posterior slope moderately expanded; hinge line of medium length; ribs about 32, ranging from 31 to 33, wider than the interspaces, low and rounded, becoming less elevated ventrally, those on the anterior part of the disk wider, sometimes much wider, than elsewhere; ligament wholly anterior, wider anterior to the beaks; a very narrow bare strip of the cardinal area posterior to the beaks; teeth inclined centrally and posteriorly, L-shaped anteriorly, the posterior row about half as long as the anterior row and oblique to the hinge line.

Holotype (U.S.N.M. 496544), length 31 millimeters, height 25.5 millimeters, convexity 12 millimeters.

This species, with its much-produced posteroventral region, has much the shape and size of *N. ecuadoria* but has lower and more posterior beaks, a shorter cardinal area posteriorly, and a tendency for the anterior ribs to be wider and lacks the anterior thickening of the shell. In beak and rib characters it approaches typical *N. macdonaldi*, but that form also has a much thickened anterior and is considerably larger and heavier. Thus *N. ecuadoria* has the thickened anterior and *N. colombiana* has the wide anterior ribs, both of which characterize the larger species *N. macdonaldi* and *N. reversa*, and when workable collections are obtained it will probably prove that both of these species contributed to the *N. macdonaldi-reversa* series.

Distribution: Middle Miocene, northern Colombia.

Type locality: Base of the Juan de Acosta, between Saco and Juan de Acosta, Atlantico Department, Colombia, U.S.G.S. 11360.

Other occurrences: Between Piojo and Saco, half a mile south of Saco, Atlantico Department, Colombia, U.S.G.S. 11333.

Noetia mayensis Maury

Plate 5, figures 16, 17

Arca (*Noetia*) *mayensis* Maury, Bull. Am. Paleontology, vol. 10, no. 42, p. 40, pl. 5, fig. 2, 1925.

Shell subrhomboidal and elongate, inflated, anterior rounded, posterior less sharply rounded and broadly produced, posteroventral margin angulate but not projecting; beaks low, situated at about the posterior quarter or fifth of the hinge line but about centrally with respect to the shell, owing to the elongate posterior; umbones low and broad; umbonal ridge moderately carinate; posterior slope expanded; ribs about 36, rounded and roughened by growth lines; interstitial ribs developed posteriorly; ligament wholly anterior to the beaks, narrower posteriorly owing to the low beaks; a moderate-sized portion of the cardinal area existing posterior to the beaks but uncovered by ligament; teeth vertical centrally, somewhat L-shaped anteriorly, smaller and sharper posteriorly, the posterior row about three-quarters as long as the anterior row and at first continuous with it but more posteriorly gently swinging away.

Holotype (in Paleontological Research Institution, Ithaca, N. Y.), length 27 millimeters, height 17 millimeters, convexity 9 millimeters.

If the hinge of this species were not visible, it might be mistaken for a member of the Atlantic group, because of its elongate shape and roughened sculpture. The hinge line is not produced posteriorly, and the ligament is extremely short posterior to the beaks, however. *N. mayensis* is probably closely related to *N. mauryae*, n. sp., from Colombia, but the relationship of these two to other species is not clear. *N. cholana* is similar in its broad, elongate posterior and nearly horizontal posterior row of teeth and may or may not be related.

Distribution: Lower middle Miocene, Brasso beds Trinidad.

Type locality: Near junction of Mayo and Couva main roads, west-central Trinidad.

Noetia mauryae MacNeil, n. sp.

Plate 5, figures 18, 19

Shell subrhomboidal and elongate, inflated, rounded anteriorly, produced posteroventrally, posterior margin arcuate; beaks low, situated at nearly the posterior end of the hinge line; umbones low, moderately broad and inflated; umbonal ridge carinate, curving slightly outward; posterior slope moderately expanded; hinge line of medium length; ribs about 34, of about the same width as the interspaces, low and rounded or with a slight tendency to be flat-topped ventrally; interstitial ribs well developed posteriorly; ligament wholly anterior to the beaks, wider anteriorly; a narrow strip of

the cardinal area bare posteriorly; teeth inclined centrally and posteriorly, L-shaped anteriorly, the posterior row about two-thirds as long as the anterior row and moderately divergent, following the arcuate posterodorsal margin.

Holotype (U.S.N.M. 496545), length 29.5 millimeters, height 23.5 millimeters, convexity 11.5 millimeters.

Noetia mauryae is probably very closely related to the Trinidad species *N. mayensis*, from which it differs in being higher and having smoother ribs. The shells of these two species are comparatively thin, without any anterior thickening, thus differing from the majority of species of *Noetia* in this respect. *N. colombiana*, which likewise is unthickened anteriorly, is not very closely related, however. Both *N. mayensis* and *N. mauryae* have well-rounded posterior margins, and the posterior row of teeth is more nearly in line with the hinge line than in most other species, although *N. cholana* is likewise characterized by this condition.

Distribution: Middle Miocene, upper Saco, northern Colombia.

Type locality: "Lookout" point on road just north of Tubará, slightly below the formation exposed in Tubará and above the Piojo limestone, Atlantico Department, Colombia, U.S.G.S. 11251.

Other occurrences: Road from Tubará to Los Perdices, 300 feet southeast of "lookout" point north of Tubará, Atlantico Department, Colombia, U.S.G.S. 11346.

Noetia atratoensis MacNeil, n. sp.

Plate 5, figures 24, 25

Shell subtrigonal, short, much inflated, anterior rounded, angulate and produced posteroventrally, posterior margin nearly straight; beaks of medium height, divergent, strongly opisthogyrate and recurving over the cardinal area, situated at nearly the posterior end of the hinge line; umbones moderately narrow but very high and inflated, accounting for over a third of the height of the shell; umbonal ridge sharp and curving outward, forming the most inflated part of the disk; posterior slope very steep; hinge line moderately short; ribs about 30, wider than the interspaces in adults, becoming flat and level with the interspaces ventrally, especially centrally; interstitial ribs fairly well developed posteriorly; ligament anterior except for a narrow posterior wedge; a very narrow strip of the cardinal area left bare posteriorly; teeth vertical or slightly inclined centrally, L-shaped anteriorly, long and inclined posteriorly, the posterior row diverging sharply from the hinge line.

Holotype (U.S.N.M. 496546), length 23 millimeters, height 21.5 millimeters, convexity 12.5 millimeters.

This interesting little species is characterized by its extremely high and inflated umbones. The large posterior teeth on the type may be somewhat abnormal. In shape and sculpture this species most closely resembles *N. macdonaldi alta*, described below, but it is much smaller and less opisthogyrate and has a relatively longer hinge line. The umbones of *N. atratoensis* account for about a third of its height. This species has only about 30 ribs, which represents about the minimum number for *Noetia*.

Distribution: Middle Miocene, Atrato River district, Colombia.

Type locality: Quebrada Limon, Atrato River district, Antioquia Department, Colombia, U.S.G.S. 11570.

Other occurrences: Quebrada Mata Perro, U.S.G.S. 11556; Quebrada Mata Tigre, U.S.G.S. 11558, Atrato River district, Antioquia Department, Colombia.

Noetia macdonaldi Dall

Plate 6, figures 10–13

Arca (Noetia) macdonaldi Dall, Smithsonian Misc. Coll., vol. 59, no. 2, p. 9, 1912; U. S. Nat. Mus. Proc., vol. 66, p. 5, pl. 17, fig. 9, 1925.

Arca (Noetia) macdonaldi subreversa Olsson, Bull. Am. Paleontology, vol. 9, no. 39, pt. 2, p. 194, pl. 25, figs. 6, 7, 1922.

Shell subtrigonal, inflated, anterior high and rounded posterior margin nearly straight, posteroventral margin sharply angulate and produced; beaks low and situated at about the posterior end of the hinge line; umbones moderately high and of medium breadth; umbonal ridge curving outward, sharply carinate; posterior slope flattened and steep; ribs 38 to 39, rounded and higher and about as wide as the interspaces posteriorly, but much broader and lower on the anterior part of the disk, becoming less elevated and flatter ventrally; ligament wholly anterior to the beaks, higher at the center of the hinge line owing to the low beaks; a very narrow strip of bare cardinal area posterior to the beaks; teeth inclined centrally, becoming L-shaped anteriorly, inclined posteriorly, the posterior row about half as long, ventrally offset from and diagonal to the hinge line. (Emended description.)

Holotype (U.S.N.M. 214344), length 56 millimeters, height 44 millimeters, convexity 22.5 millimeters.

An error has crept into the literature concerning this species owing to the fact that the hinge was never figured. Specimens from the Banana River and nearby in Costa Rica are varied and may form a uniformly graded series, but at present not enough specimens are at hand to say definitely whether or not this is so. Two extremes can be selected which appear to be quite distinct—one with high beaks, narrow umbones, and a much produced posteroventral margin, and the other with low beaks, broader umbones, and a more expanded posterior slope, giving the shell a less produced appearance posteroventrally. In addition the ribs in the low-beaked form are more rounded and less uniform in size, ranging from equisized all over the disk to broad, rounded, and much wider anteriorly than posteriorly. The relationship of these forms is not clear. It is probable that the width of the anterior ribs in the low-beaked forms is a matter of individual variation, as it is in the species *N. colombiana*, this character not being of the fixed nature that it is in the Recent species *N. reversa*.

Olsson believed that the high-beaked type was the typical form and gave the subspecific name *subreversa* to the low-beaked form. Actually, Dall's type has low beaks and wide anterior ribs, so that the name *subreversa* is a synonym. The high-beaked form is here given the subspecific name *alta*.

The holotype of *N. macdonaldi* came from the lowest bed along the Banana River and is noteworthy in being by far the largest specimen in the MacDonald collection. Large numbers of smaller specimens from successively higher beds seem to indicate that there is a decrease in the number of ribs from the lower to the upper part of the section, although this must be proved by rib counts on shells of the same size. The type has 39 to 40 ribs, whereas specimens from successively higher beds gradually decrease to an average of about 32.

In addition, the holotype is the only specimen from the type locality which shows a good development of the wide anterior ribs, although this character is one which is not conspicuous until the shell is about half or two-thirds grown, so that the smaller specimens do not show much in this respect. A specimen somewhat larger than the holotype from a locality 40 miles north-northwest of Quibdo, in the Atrato River Valley, western Colombia, has wide ribs and narrow interspaces on the central and anterior part of the disk. There is reason for considering the species with wide anterior ribs to be closely related, and if they are, *N. colombiana*, *N. macdonaldi*, and *N. reversa* form a more or less natural group. These are the only species in which this character has been observed, and in *N. colombiana*, and probably in *N. macdonaldi*, it appears to be a matter of individual variation, but in *N. reversa* it is constant. *Noetia ecuadoria* is closely related to *N. macdonaldi* and might easily be confused with it. The beaks of *N. ecuadoria* are more central and less opisthogyrate, the ribs are narrower and less rounded, and the posteroventral margin is usually more produced.

Specimens from Colombia which have been previously identified as *N. macdonaldi* are not exactly typical, and it is thought desirable to recognize one of them by name. Whether this is really a subspecies of *N. macdonaldi* remains to be proved, but for the time being it is so regarded. The specimen from the locality 40 miles north-northwest of Quibdo is the most typical specimen of *N. macdonaldi* seen from Colombia. Its hinge is identical with that of the type, but the shell differs in being more elongate, with a less carinate umbonal ridge. Whether this is a matter of individual variation or is peculiar to specimens more than several hundred miles distant from the type locality remains to be seen.

Distribution: Upper middle Miocene, Gatun formation and its equivalents in Costa Rica, Panama, and Colombia.

Type locality: About a quarter of a mile south of the Banana River and about 5½ miles inland from the Caribbean (supposedly low in the fossiliferous beds that crop out in this region), Costa Rica, U.S.G.S. 5882*m*.

Other occurrences: At numerous localities along the Banana River east of the type locality (supposedly from progressively higher beds), Costa Rica, U.S.G.S. 5882*n–a*; 2 miles east of Juan de Acosta, Atlantico Department, Colombia, U.S.G.S. 11321; Rio Tagachi, 18 miles west of its junction with Rio Atrato and 40 miles north-northwest of Quibdo, Antioquia Department, Colombia, U.S.G.S. 11560. Another specimen is labeled "coastal traverse, 2½ miles west of Rio San Juan, Antioquia Department", U.S.G.S. 11659. According to all available maps the Rio San Juan does not enter Antioquia Department, but if the specimen is from somewhere along the Rio San Juan it is the southernmost locality at which I have been able to identify this species.

Noetia macdonaldi alta MacNeil, n. subsp.

Plate 6, figures 1, 2, 8, 9

Arca (*Noetia*) *macdonaldi*. Olsson, Bull. Am. Paleontology, vol. 9, no. 39, pt. 2, p. 194, pl. 25, figs. 4, 5, 1922.

This subspecies has an aspect quite different from that of the typical form, being much shorter, with higher beaks and narrower and higher umbones, a wider cardinal area posteriorly, and a much steeper and less expanded posterior slope. The ribs are about as wide as the interspaces, are rounded and well defined in the young stages, but become wider, flat, and low, being about level with the interspaces, in adults. There is some variety in the length of the hinge line in this form and also some variety in the angulation and extent to which the posteroventral region is produced.

Holotype in Paleontological Research Institution, Ithaca, N. Y. Figured specimen (U.S.N.M. 496548), length 30 millimeters, height 29 millimeters, convexity 15.5 millimeters. A larger specimen (U.S.N.M. 496549), length 36+millimeters, height 35+millimeters, convexity 20.5 millimeters.

The relationship of this subspecies to the typical form is not clear, and it seems to be more related to some Colombian forms than to the holotype and paratypes of *N. macdonaldi* from the Banana River. *Noetia atratoensis* from western Colombia is closely related but considerably smaller, with a longer hinge line and higher umbones. It resembles in size and shape another subspecies from Colombia, *N. macdonaldi truncata*, more than the typical form but differs from that subspecies in having wider and much less elevated ribs.

Type locality: "Hill No. 3", Banana River, Costa Rica (Olsson).

Other occurrences: Rio Bananito, about 3½ to 4 miles from the Caribbean (supposedly equivalent to some of the upper fossiliferous beds along the Banana River), Costa Rica, U.S.G.S. 5883c; mouth of Cumbre Creek, Estrella River, El Porvenir station, Costa Rica, U.S.G.S. 8056.

Noetia macdonaldi truncata MacNeil, n. var.

Plate 6, figures 3, 4

This variety from Colombia differs from the typical form in being much shorter, with higher beaks, narrower umbones, and a more rounded umbonal ridge. The

ribs are very regular and comparatively narrow, being about as wide as the interspaces, rounded, and relatively high. The interstitial ribs are fairly well developed.

The beaks are not as high as in *N. macdonaldi alta*, the posteroventral margin is not as produced, and the posterior slope is not as steep. The ribs of *N. macdonaldi truncata* are narrower and higher than in *N. macdonaldi alta*.

Holotype (U.S.N. M. 496550), length 28 millimeters, height 27 millimeters, double convexity 25.5 millimeters. The paratype is less perfect but larger (U.S.N.M. 496582).

Distribution: Middle Miocene, Colombia.

Type locality: Near San Andreas, Bolivar Department, Colombia, U.S.G.S. 10151.

Other occurrences: Quebrada Pajuil, west of Sinu River, Bolivar Department, Colombia, U.S.G.S. 11628.

Noetia turbacensis MacNeil, n. sp.

Plate 6, figures 14, 15

Shell subrhomboidal, thick, inflated, rounded anteriorly, more broadly rounded posteriorly; posteroventral margin sharply rounded and moderately produced; beaks low, situated at about the posterior fifth or sixth of the hinge line; umbones low and broad; umbonal ridge sharp but not curving outward, forming the most inflated part of the shell; posterior slope of moderate expansion; ribs about 37, slightly wider than the interspaces and very regular in size and spacing all over, rounded posteriorly, flatter and less elevated on the disk; interstitial ribs well developed posteriorly; ligament wholly anterior to the beaks, narrow throughout but slightly higher at the center, owing to the low beaks; cardinal area extending a short distance posteriorly but uncovered by ligament; teeth inclined and crowded centrally, L-shaped anteriorly, inclined posteriorly, the posterior row about three-fourths as long as the anterior row and slightly oblique to the hinge line.

Holotype (U.S.N.M. 496551), length 21.5 millimeters, height 18.5 millimeters, convexity 9.5 millimeters.

This species is characterized by its small, subquadrate form, considerable inflation, and very thick shell. The shell is much thicker than in any other species of this size, and the thickening is uniform rather than just anteriorly, as in many other species. The ribs are very uniform and smooth in appearance.

Distribution: Upper (?) Miocene, Colombia.

Type locality: Shale in creek bed just below dam, one-eighth of a mile northeast of mud volcanoes, Turbaco, Bolivar Department, Colombia, U.S.G.S. 8084.

MIOCENE OR PLIOCENE SPECIES

Noetia gardnerae MacNeil, n. sp.

Plate 6, figures 16, 17

Shell subrhomboidal, thickened, moderately inflated, anterior rounded, posterior straight or slightly emarginate, sharply rounded but not produced posteroventrally, less sharply rounded posterodorsally; beaks very low, situated at about the posterior fifth of the cardinal area but just anterior of center with respect to the shell, owing to the extended posterior; umbones moderately low and not very full; umbonal ridge sharply rounded, curving gently outward; hinge line of medium length; ribs about 36 to 38, smooth, rounded, and very regular, of about the same width as the interspaces; interstitial ribs present posteriorly; ligament wholly anterior to the beaks, narrow, but wider centrally than beneath the beaks; a moderate portion of the cardinal area posterior to the beaks but devoid of ligament; teeth small and vertical centrally, L-shaped anteriorly, inclined posteriorly, the posterior and anterior rows subequal in length, and the posterior row almost horizontal and in line with the anterior row, owing to the high, elongate posterodorsal margin.

Holotype (U.S.G.S. 496552), length 12.5 ± millimeters, height 10 ± millimeters, convexity 4 millimeters.

This species is closely related to *N. sheldoniana*, from which it differs in being somewhat longer, with a thicker shell and a tendency to emargination posteriorly. The hinge is heavier, a condition which can usually be correlated with the thickness of the shell.

Noetia gardnerae is of interest because of the fact that it is the only true *Noetia* to obtain a foothold in the northern Gulf region, the type having been obtained from an oil well near Houston, Tex., at a depth of 1,700 feet in sediments of very late Miocene or early Pliocene age.

Especial attention is called to the possibility of confusing this species with young specimens of *Eontia ponderosa* that have been obtained from wells in Louisiana at depths of nearly 2,000 feet. Owing to the much more rapid sinking in this region, however, these beds are probably fairly late Pleistocene.

Distribution: Upper Miocene or Pliocene, Texas.

Type locality: From an oil well near Houston, Tex., at a depth of 1,700 feet.

Doubtful identifications: Specimens obtained at a depth of 2,552 to 2,871 feet, from the deep well at Galveston, Tex., in sediments believed to be of upper Miocene age, were identified by Harris[10] as *Arca ponderosa* var. *carolinensis* Conrad. The specimens used for comparison came from Natural Well, North Carolina, which are here referred to *Eontia trigintinaria* (Conrad). It is not impossible that the form of *E. trigintinaria* occurring in the *Cancellaria* zone of the Choctawhatchee formation of western Florida ranged as far west as Galveston, but it is more likely that the Galveston form is a *Noetia*. This conclusion should, of course, be verified.

PLIOCENE SPECIES

Noetia sheldoniana Maury

Plate 6, figures 18, 19

Arca (Noetia) sheldoniana Maury, Acad. Nat. Sci. Philadelphia Jour., 2d ser., vol. 15, p. 43, pl. 8, figs. 10, 11, 1912; Bull. Am. Paleontology, vol. 10, no. 42, p. 39, pl. 8, fig. 11, 1925.

[10] Harris, G. D., Texas Geol. Survey 4th Ann. Rept., pp. 93, 94, 118, 1902; Bull. Am. Paleontology, vol. 1, no. 3, p. 6, 1895.

Shell subrhomboidal, thin, moderately inflated, anterior rounded, posterior straight and vertical, sharply rounded posteroventrally and less sharply posterodorsally; beaks low, situated near the posterior end of the hinge line but nearly centrally with respect to the shell; umbones low, moderately broad; umbonal ridge sharply rounded, curving gently outward; hinge line of medium length; ribs about 38, smooth, rounded, and very regular, of about the same width as the interspaces; ligament wholly anterior to the beaks, narrow but wider centrally than under the beaks; cardinal area extending a short distance posteriorly but bare; interstitial ribs present posteriorly; teeth small and nearly vertical centrally, L-shaped anteriorly, inclined posteriorly, the posterior row about three-fourths as long as the anterior row and diverging at a narrow angle from the hinge line. (Emended description.)

Holotype (in Museum of Geology, Cornell University, Ithaca, N. Y., no. 38296), length 15 millimeters, height 13.5 millimeters, convexity 6 millimeters.

This species is probably the most perfect homeomorph of the Atlantic shell *Eontia ponderosa*, the adults of which it almost perfectly simulates in shape. Shells of this size, however, are quite distinct, juveniles of *E. ponderosa* being more elongate. *Noetia sheldoniana* has about 38 ribs, as opposed to 25 to 28 for *Eontia ponderosa*, and the usual characteristics which distinguish the Pacific group can be noted—the considerably shorter posterior portion of the ligament and the deeper and longer posteroventral crenulations of the inner margin.

Noetia sheldoniana is probably related to *N. turbacensis*, which it resembles somewhat in shape, but it has a much thinner shell. It is also related to the new species from Texas, *N. gardneri*, just described.

Noetia sheldoniana and *N. gardnerae* are the last known species of *Noetia* in the Gulf and Caribbean region, and they represent the extinction of a branch of the genus which gained access to this region in middle or late Miocene time. The difference between these species and the *Noetia reversa* stock and the absence of the latter from the Caribbean region druing the Pliocene epoch lend strong support to the theory that there has been no free passage between the Pacific and Caribbean since Miocene time.

Distribution: Upper(?) Pliocene, Trinidad.

Type locality: Along shore 1,000 feet west of Brighton pier, in black asphaltic marl, Trinidad.

PLEISTOCENE SPECIES

Noetia magna MacNeil, n. sp.

Plate 6, figures 20, 21

Arca (Noetia) reversa. Grzybowski, Neues Jahrb., Beilage-Band 12, p. 134, pl. 17, figs. 1, 1a, 1899.

The form from Paita which Grzybowski referred to *Noetia reversa* is much like it in shape but differs in size, being about twice as large, and in having more ribs, 40 to 42, as compared with 35 for *N. reversa*. Photographs of Grzybowski's specimen show it to have more elevated ribs, with less tendency to widen on the anterior part of the disk, although this might be a matter of individual variation. It compares with *N. reversa* in having strongly opisthogyrate, low, and very posterior beaks, these being at or even behind the posterior end of the cardinal area, the two species being extremes in this respect.

A *Noetia* figured by Olsson [11] as *Arca (Noetia) reversa*, subsp., compares with Grzybowski's specimen in size and for the time being might be referred to the new species, although Olsson states that Grzybowski's specimen is from the Mancora Tablazo beds, of Pleistocene age, whereas his specimen from the mouth of Quebrada Tucillal is supposedly from the Tumbez formation, of late Miocene age.

Grzybowski's specimen measures over 80 millimeters in length, and Olsson gives lengths of 80 and 83 millimeters for two specimens of his form, whereas he reports the largest specimen of *N. reversa* seen by him to be 45 millimeters. The average runs less than that, the largest specimen in the U. S. National Museum being only 40 millimeters. Such a length makes *N. magna* the largest shell in the Noetinae, the Recent *Eontia ponderosa* of the Atlantic group rarely attaining a greater length than 65 millimeters.

Holotype (in Geological Institute of the Jagiellonian University, Krakow, Poland), length 80 millimeters, height 72 millimeters, convexity 37 millimeters. The margins are eroded, so that only approximate measurements can be made.

Distribution: Pleistocene(?), Peru.

Type locality: Mancora Tablazo beds, Paita, Peru.

Doubtful identifications: Upper Miocene, Tumbez formation, Quebrada Tucillal, Tumbez, Peru (Olsson).

RECENT SPECIES

Noetia reversa (Sowerby) H. and A. Adams

Plate 6, figures 7, 22, 23

Arca reversa Sowerby, Zool. Soc. London Proc., vol. 1, p. 20, 1833.

Arca hemicardium Koch, in Philippi, Abbildungen und Beschreibungen Conchylien, vol. 1, p. 43, *Arca*, Tafel 1, fig. 1, 1849.

Arca reversa. Carpenter, Catalog of the Reigen collection of Mazatlan mollusks, p. 136, 1857.

Noetia triangularis Gray, Annals and Mag. Nat. History, 2d ser., vol. 19, p. 371, 1857.

Noetia reversa. H. and A. Adams, Genera of Recent Mollusca, vol. 2, p. 536, v. 3, pl. 125, figs. 1, 1a, 1858.

Arca (Noetia) reversa. Lamy, Jour. conchyliologie, vol. 55, p. 298, 1907.

Dall, U. S. Nat. Mus. Proc., vol. 37, p. 253, 1910.

Maury, Paleontographica americana, vol. 1, no. 4, p. 9, pl. 1, figs. 7, 11, 1922.

[11] Olsson, Axel, Bull. Am. Paleontology, vol. 19, no. 68, p. 77, pl. 3, fig. 1, 1932.

Shell subrhomboidal or trigonal, moderately inflated, rounded anteriorly, posterior margin nearly straight, sharply rounded and produced posteroventrally; beaks low and situated at the posterior end of the cardinal area, or even behind it; umbones low and moderately broad; umbonal ridge subcarinate and curving gently outward; posterior slope flat and steep; ribs about 35, higher and narrower posteriorly, much wider than the interspaces and about level with them on the anterior part of the disk in adults; ligament entirely anterior to the beaks, completely covering the cardinal area, which likewise is entirely anterior to the beaks; teeth inclined centrally, L-shaped anteriorly, inclined posteriorly, the posterior row short and ventrally offset from the anterior row and sharply diverging from it. (Emended description.)

Figured specimen (U.S.N.M. 101954), length 40 millimeters, height 33 millimeters, convexity 16 millimeters.

This is the sole surviving species of the large genus *Noetia*, but despite its rather limited occurrence it is probably as well known as any other species in the Recent fauna because of the attention focused upon it by early systematists. It is not as large as some of its nearest relatives, particularly *N. magna* and *N. macdonaldi*. It appears to be less variable than *N. macdonaldi*, especially in the width and low elevation of the ribs on the anterior part of the disk. It shares with *N. magna* the distinction of having the most posterior beaks in the genus.

Noetia triangularis Gray, the type of *Noetia*, has been variously interpreted as *Arca reversa* Sowerby and *Arca ponderosa* Say, a distinction which did not particularly matter until it became evident, as shown in this paper, that the two species represent groups of long-standing independence. The photographs of *N. triangularis*, forwarded to me by Dr. Philip W. Reinhart, who obtained them from Dr. L. R. Cox, of the British Museum, show beyond doubt that *N. triangularis* is a synonym of *Arca reversa*.

Distribution: Pleistocene (?) and Recent, Gulf of California to Peru.

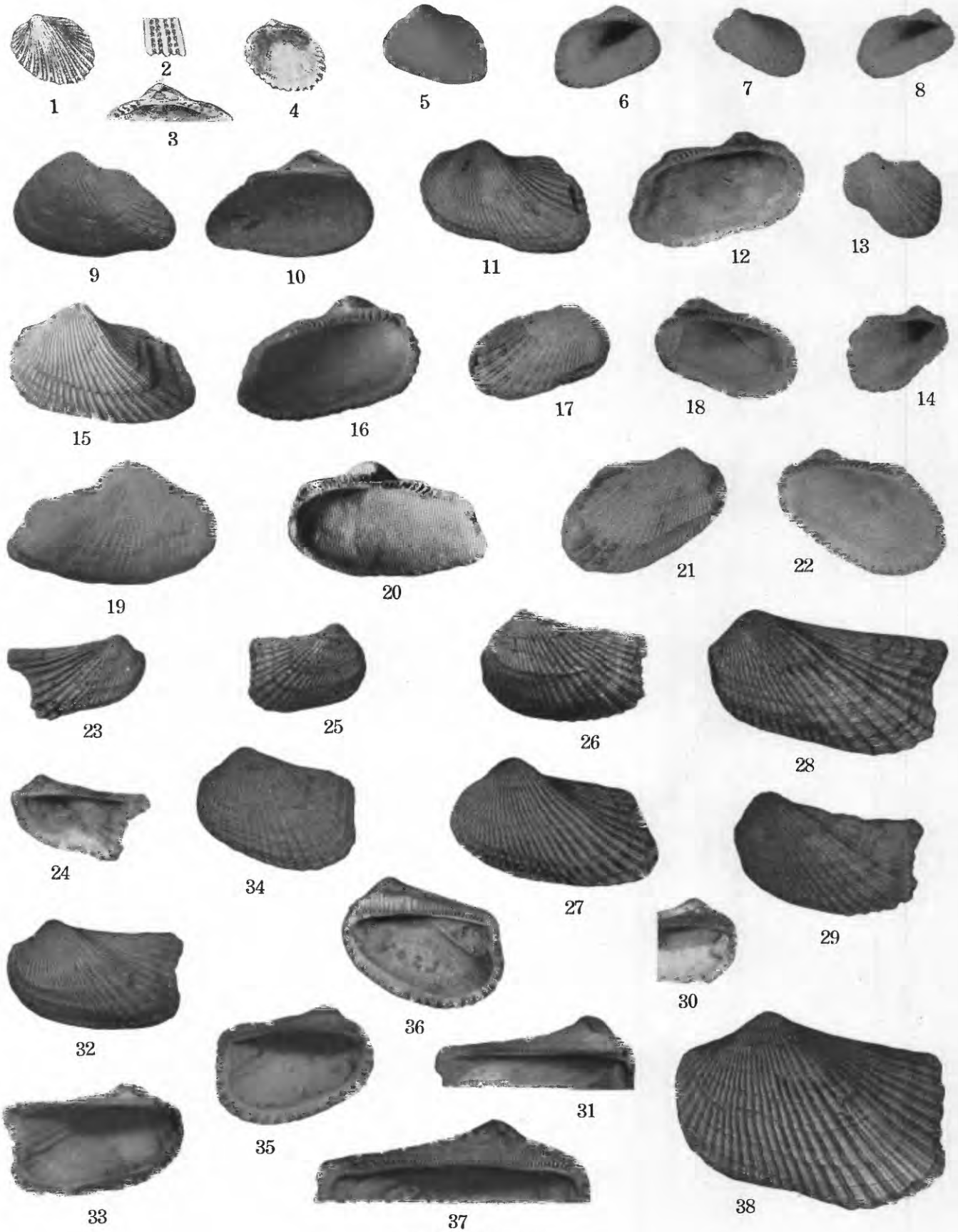
ADDENDA

Arca delgada Lowe (San Diego Soc. Nat. Hist. Trans., vol. 8, no. 6, p. 16, pl. 1, fig. 2, 1935), from Manzanillo, Colima, Mexico, may be an *Eontia* related to *E. centrota*, but as the hinge is not figured it is impossible to say.

PLATES 1–6

PLATE 1

FIGURES 1–4. *Scapularca subglobulosa* (Wood), × 5, Bartonian, Highcliff, Barton, England. (After Wood.)
FIGURES 5, 6. *Scapularca interposita* (Deshayes), × 3, lower Lutetian, Herouval, Seine-et-Oise, France, U.S.N.M. 496506.
FIGURES 7, 8. *Scapularca scapulina* (Lamarck), × 3, Lutetian, Villiers, Seine-et-Oise, France, U.S.N.M. 496505.
FIGURES 9, 10. *Eontia okeni* (Mayer), × 1½, Aquitanian, Merignac (Lorient), France. (After Cossmann and Peyrot.)
FIGURES 11, 12. *Eontia centrota* (Guppy), × 1¼, lectotype, Pliocene, Matura Bay deposits, eastern Trinidad, U.S.N.M. 496508.
FIGURES 13, 14. *Sheldonella maoica* (Maury), × 1½, lower middle Miocene, Cercado formation, 3 miles above Cercado de Mao, Santiago Province, Dominican Republic, U.S.N.M. 496507.
FIGURES 15, 16. *Eontia bisulcata* (Lamarck), × 1½, Recent, Miranda district, State of Falcon, Venezuela, U.S.N.M. 496509.
FIGURES 17, 18. *Sheldonella* (*Paranoetia*) *cafria* (Bartsch), × 1½, topotype, Recent, Port Alfred, South Africa, U.S.N.M. 249849.
FIGURES 19, 20. *Eontia olssoni* (Sheldon and Maury), × 2, holotype, Recent, Bucaru, Los Santos Province, Panama.
FIGURES 21, 22. *Sheldonella* (*Paranoetia*) *lateralis* (Reeve), × 1½, Recent, Manila Bay, Philippine Islands, U.S.N.M. 248983.
FIGURES 23, 24. *Eontia incile mansfieldi* MacNeil, n. subsp., × 1, holotype, upper Miocene, *Ecphora* zone, Choctawhatchee formation, Jackson Bluff, Leon County, Fla., U.S.N.M. 371122.
FIGURES 25–28, 30, 31. *Eontia incile* (Say), × 1, upper Miocene, zone 2, Yorktown formation, Virginia: 25, *Chama*-bearing bed, about 1½ miles east of Williamsburg, U. S. N. M. 496510; 26, bed *a*, 1½ miles below Yorktown, U.S.N.M. 496512; 27, bed *c*, Bellefield, just below Felgates Creek about 4½ miles above Yorktown, U.S.N.M. 496517; 28, bed *f*, Colonial limekiln, about 3 miles above Yorktown, U.S.N.M. 496511; 30, interior, showing raised muscle scars, bed *f*, half a mile below Yorktown; 31, hinge, bed *c*, 1 mile below Yorktown.
FIGURE 29. *Eontia incile suffolkensis* MacNeil, n. var., × 1, holotype, upper Miocene, Yorktown formation, upper bed at Rock Wharf, 4 miles N. of Smithfield, Va., U.S.N.M. 496514.
FIGURES 32, 33. *Eontia trigintinaria* (Conrad) subsp.(?), × 1, upper Miocene, *Cancellaria* zone, Choctawhatchee formation, borrow pit, Jackson Bluff, Leon County, Fla., U.S.N.M. 496521.
FIGURES 34–36. *Eontia incile yorkensis* MacNeil, n. var., × 1: 34, 35, holotype, upper Miocene, Yorktown formation, upper part of *Chama*-bearing bed, about 1½ miles east of Williamsburg, Va., U.S.N.M. 496515; 36, paratype, Dinwiddie, Va., U.S.N.M. 496518.
FIGURES 37, 38. *Eontia trigintinaria* (Conrad), × 1, upper Miocene, Duplin marl, Darlington Court House, Darlington, S. C., U.S.N.M. 496583.



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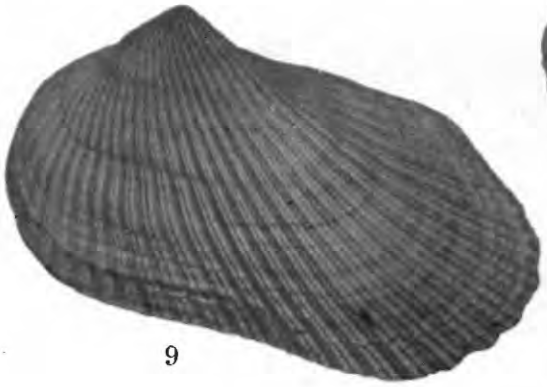
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TERTIARY NOETINAE.

PLATE 2

FIGURES 1, 2. *Eontia trigintinaria filosa* (Conrad), × 1, neotype, upper Miocene, Yorktown formation, Sullivan's marl pits, 8 miles east of Snow Hill, Greene County, N. C., U.S.N.M. 496516.

FIGURES 3, 4. *Eontia trigintinaria* (Conrad), × 1, upper Miocene, Duplin marl, Sullivan's marl pits, 8 miles east of Snow Hill, Greene County, N. C., U.S.N.M. 497009.

FIGURES 5, 6. *Eontia carolinensis* (Conrad), × 1, upper Miocene, uppermost part of Yorktown formation, middle bed at Colerain Landing, Chowan River, Bertie County, N. C., U.S.N.M. 496519.

FIGURES 7, 8. *Eontia lumberensis* MacNeil, n. sp., × 1, holotype, upper Miocene, upper part of Duplin marl, 2½ miles east of Fairmont, Robeson County, N. C., U.S.N.M. 496520.

FIGURE 9. *Eontia limula* (Conrad), × 1, topotype (?), Pliocene, Croatan sand, 2 miles below James City, Craven County, N. C., U.S.N.M. 496522.

FIGURE 10. *Eontia tillensis* MacNeil, n. sp., × 1, holotype, Pliocene, Waccamaw formation, Tillys Lake, Waccamaw River, Horry County, S. C., U.S.N.M., 496527.

FIGURE 11. *Eontia variabilis quadrata* MacNeil, n. var., slightly reduced, holotype, Pliocene, Waccamaw formation, Walkers Bluff, Cape Fear River, 18 miles east-southeast of Elizabethtown, N. C., U.S.N.M. 496523.

FIGURES 12–15. *Eontia variabilis* MacNeil, n. sp., × 1, Pliocene, Waccamaw formation: 12, holotype, Neills Eddy Landing, 5 miles northeast of Acme, Columbus County, N. C., U.S.N.M. 496524; 13, 14, paratypes, Wilmington, N. C., U.S.N.M. 496578, 496579; 15, paratype, Walkers Bluff, Cape Fear River, 18 miles east-southeast of Elizabethtown, N. C., U.S.N.M. 496525.

FIGURE 16. *Eontia* cf. *E. variabilis* MacNeil, n. sp., × 1, Pliocene, Caloosahatchee marl, marl pit south of Airport, De Leon Springs, Volusia County, Fla., U.S.N.M. 496526.

PLATE 3

FIGURES 1, 2. *Eontia platyura* (Dall), × 1, Pliocene, Caloosahatchee marl, Alligator Creek, just north of Acline, Charlotte County, Fla.: 1, lectotype, U.S.N.M. 496529; 2, paratype, U.S.N.M. 496528.

FIGURE 3. *Eontia playtura* (Dall) var., × 1, Pliocene, Caloosahatchee marl, near head of Prairie Creek, a tributary of Shell Creek, Charlotte County, Fla., U.S.N.M. 496530.

FIGURE 4. *Eontia caloosana* MacNeil, n. sp., × 1, holotype, Pliocene, Caloosahatchee marl, 6 miles northwest of Clewiston, Hendry County, Fla., U.S.N.M. 496531.

FIGURE 5. *Eontia variabilis clewistonensis* MacNeil, n. var., × 1, holotype, Pliocene, Caloosahatchee marl, upper bed, 6 miles northwest of Clewiston, Hendry County, Fla., U.S.N.M. 496532.

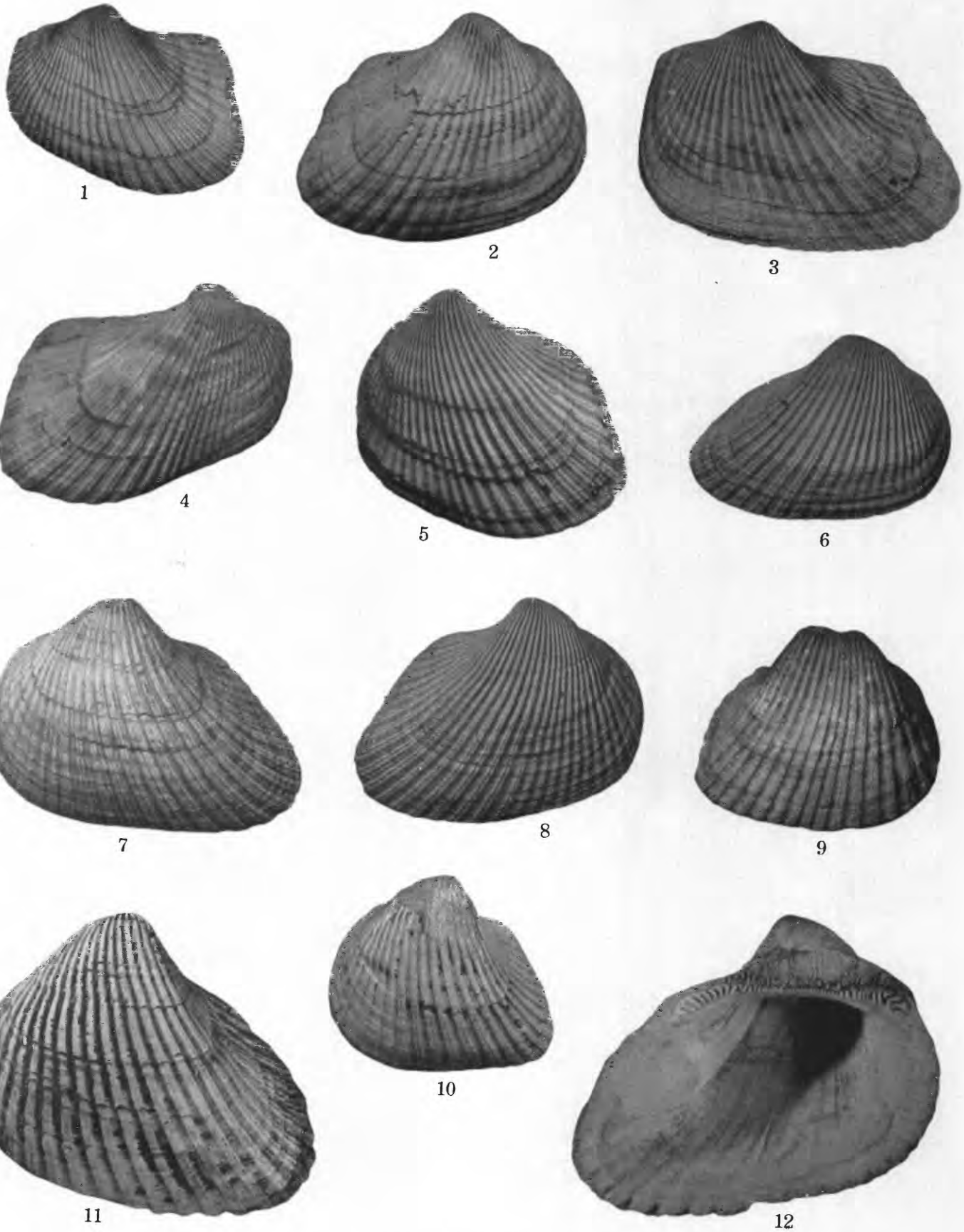
FIGURE 6. *Eontia veroensis* MacNeil, n. sp., × 1, holotype, Pleistocene, Vero, St. Lucie County, Fla., U.S.N.M. 496580.

FIGURES 7, 8. *Eontia palmeri* MacNeil, n. sp., × 1, Pleistocene; 7, holotype, Wailes Bluff, near Cornfield Harbor, Potomac River, St. Marys County, Md., U.S.N.M. 496533; 8, Heislerville, Cumberland County, N. J., U.S.N.M. 496581.

FIGURE 9. *Eontia ponderosa* (Say) (Murdock form), × 1, Pliocene (?), 1.6 miles northwest of Murdock, Charlotte County, Fla., U.S.N.M. 496534.

FIGURE 10. *Eontia ponderosa* (Say), × 1, Pleistocene, Bradenton, Manatee County, Fla., U.S.N.M. 496535.

FIGURES 11, 12. *Eontia ponderosa* (Say), × 1, Recent, Florida, U.S.N.M. B1055.



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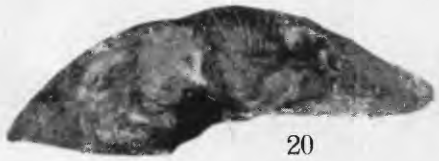
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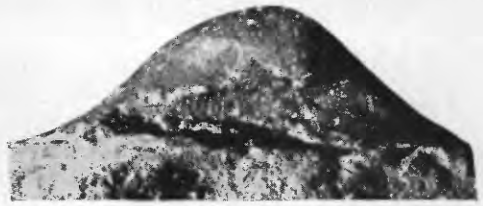
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TERTIARY NOETINAE.

PLATE 4

FIGURES 1–3. *Protonoetia nigeriensis* (Newton), × 1, middle Eocene, Ameki, Omobialla district, southern Nigeria: 1, 3, topotype, U.S.N.M. 496536; 2, lectotype, British Museum.

FIGURES 4–8. *Noetiopsis woodringi* MacNeil, n. sp., × 1, middle Eocene, near mouth of the Tonosi River, Los Santos Province, Panama: 4, topotype, Axel Olsson collection, Gloversville, N. Y.; 5, 6, paratype, U.S.N.M. 496538; 7, 8, holotype, U.S.N.M. 496537.

FIGURES 9–11. *Arginopsis sullanensis* (Woods), × 1, upper Eocene, Hacienda Saman, Rio Chira, Piura Department, Paita district, Peru, U.S.N.M. 496539.

FIGURES 12, 13. *Arginella samanensis* (Olsson), × 1½, topotype (?), upper Eocene, Hacienda Saman, Rio Chira, Piura Department, Paita district, Peru, U.S.N.M. 496540.

FIGURE 14. *Arginella puntabravoensis* (Olsson), × 1½, holotype (after Olsson), Oligocene, Mancora formation, Punta Bravo grits of Punta Bravo, Peru.

FIGURES 15, 16. *Arginella ovalis* MacNeil, n. sp., × 3, Oligocene (?), between Arroyo Mancamajon and Ovejas, Bolivar Department, Colombia: 15, holotype, U.S.N.M. 496541; 16, paratype, U.S.N.M. 496542.

FIGURES 17, 18. *Noetia pondaungensis* Cotter, × 1, holotype, upper Eocene, Pondaung sandstones, Burma. (After Cotter.)

FIGURES 19–21. *Noetia nagaoi* MacNeil, n. name, fig. 19, slightly reduced; fig. 20, × 1; fig. 21, enlarged, holotype, upper Eocene, Doshi beds, Asakura coal field, Chikuzen Province, Japan.

FIGURES 22, 23. *Noetia molengraffi* (Martin), × 1, lectotype (fig. 22 is printed in reverse), upper Eocene, Nanggulan, Java.

PLATE 5

FIGURES 1, 2. *Noetia stewarti* MacNeil, n. sp., × 1½, holotype, lower Miocene, transitional beds between Heath shales and lower Zorritos sandstone, Quebrada Boca Pan, at Zapotal, just south of Vacura, Tumbez Province, Peru.

FIGURES 3, 4. *Noetia manzanillae* Maury, × 1½, holotype, lower Miocene, Manzanilla formation, north of Manzanilla Point, northeast coast of Trinidad.

FIGURES 5, 6. *Noetia trinitaria* (Guppy), × 1, lectotype, lower Miocene, Manzanilla formation, northwest side of Manzanilla Point, Trinidad, U.S.N.M. 496543.

FIGURES 7–9. *Noetia mundonuevensis* Maury, lower middle Miocene, Brasso beds, near the junction of Mayo and Couva main roads, west-central Trinidad: 7, lectotype, × 1½; 8, 9, topotype, × 1.

FIGURES 10, 11. *Noetia colombiana* MacNeil, n. sp., × 1½, holotype, middle Miocene, base of Juan de Acosta, between Saco and Juan de Acosta, Atlantico Department, Colombia, U.S.N.M. 496544.

FIGURES 12, 13. *Noetia ecuadoria* MacNeil, n. sp., × 1, holotype, lower middle Miocene, Cueva de Angostura, Rio Santiago, Esmeraldas Province, northern Ecuador (Axel Olsson collection).

FIGURES 14, 15. *Noetia retractata* (Hanna and Israelsky), × 1, topotypes, lower middle Miocene, upper Zorritos sandstone, just southwest of Zorritos, Peru (Axel Olsson collection).

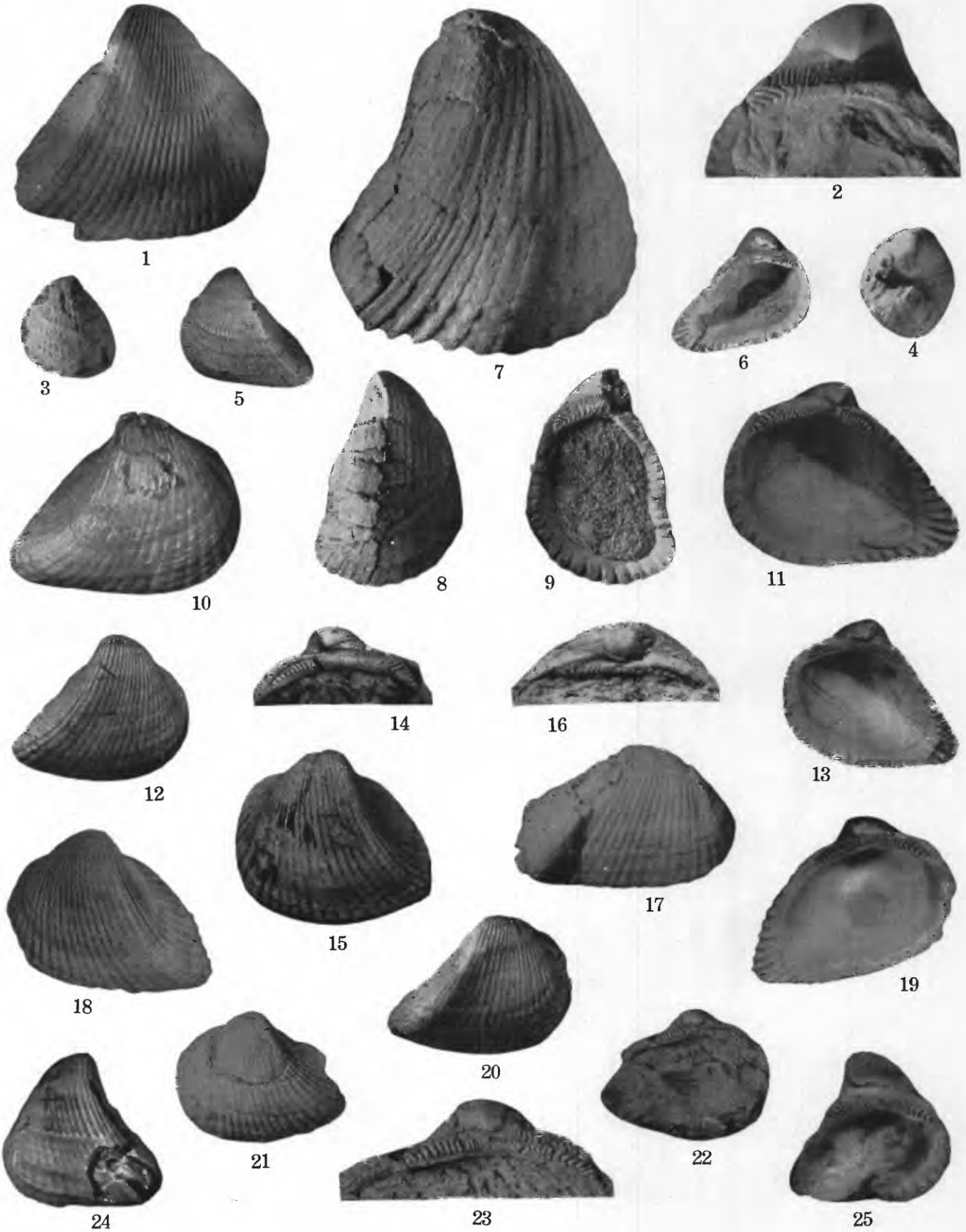
FIGURES 16, 17. *Noetia mayensis* Maury, × 1½, holotype, lower middle Miocene, Brasso beds, near junction of Mayo and Couva main roads, west-central Trinidad.

FIGURES 18, 19. *Noetia mauryae* MacNeil, n. sp., × 1½, holotype, middle Miocene, upper Saco, "lookout" point on road just north of Tubará, Atlantico Department, Colombia, U.S.N.M. 496545.

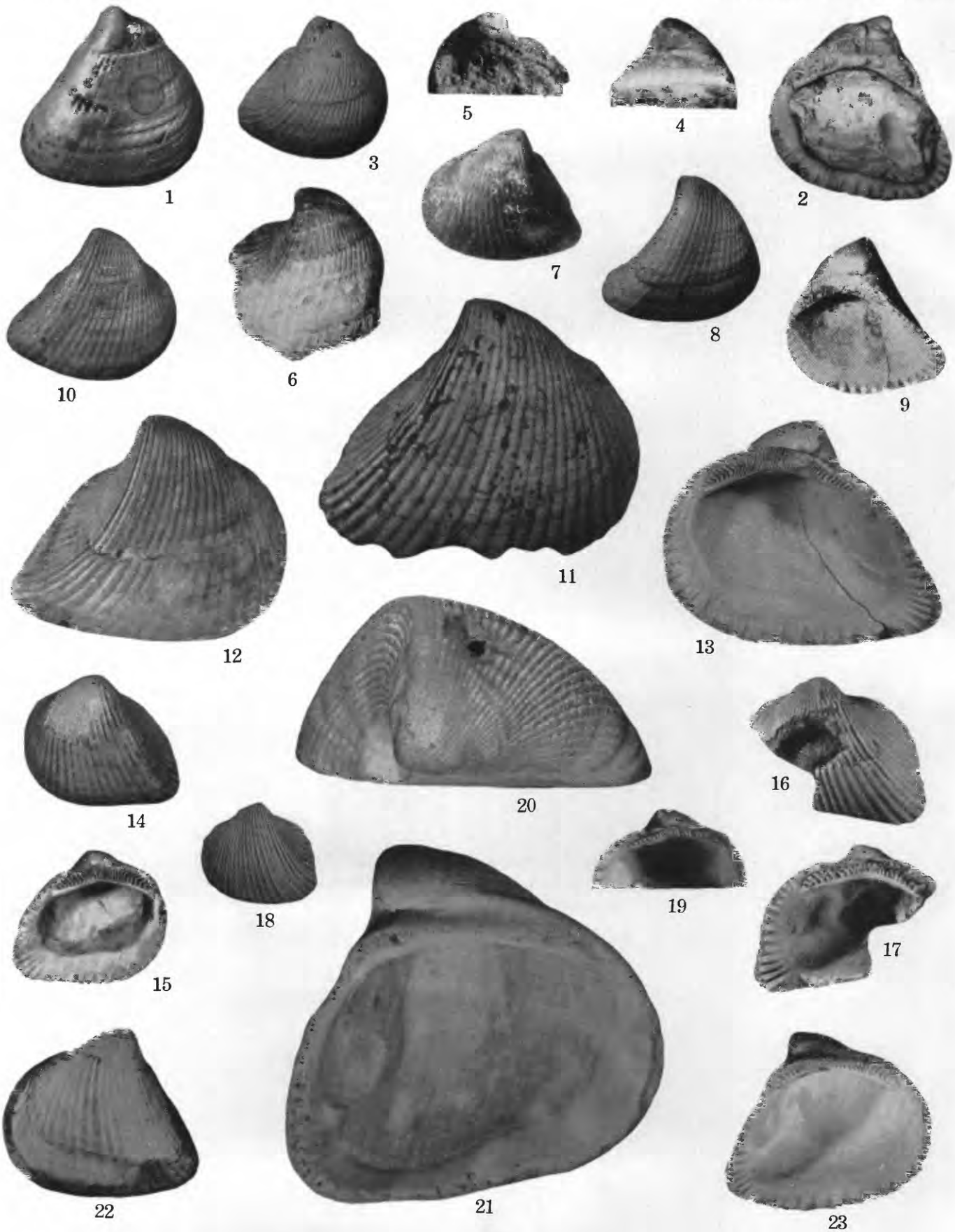
FIGURE 20. *Noetia ecuadoria* (?) MacNeil, n. sp., × 1, lower middle Miocene, upper Zorritos formation, 1 mile east of Punta Picos, Tumbez Province, Peru (Axel Olsson collection).

FIGURES 21–23. *Noetia cholana* Spieker, holotype, lower middle Miocene, middle Zorritos formation, variegated beds, Quebrada Tucillal, Zorritos, Peru: 21, 22, × 1; 23, × 2.

FIGURES 24, 25. *Noetia atratoensis* MacNeil, n. sp., × 1½, holotype, middle Miocene, Quebrada Limon, Antioquia Department, Atrato River district, Colombia, U.S.N.M. 496546.



TERTIARY NOETINAE.



TERTIARY NOETINAE.

PLATE 6

FIGURES 1, 2. *Noetia macdonaldi alta* MacNeil, n. subsp., × 1, middle Miocene, Gatun formation, Rio Bananito, 3½–4 miles from Caribbean Sea, Costa Rica, U.S.N.M. 496549.

FIGURES 3, 4. *Noetia macdonaldi truncata* MacNeil, n. subsp., × 1, middle Miocene, near San Andreas, Bolivar Department, Colombia: 3, holotype, U.S.N.M. 496550; 4, paratype, U.S.N.M. 496582.

FIGURES 5, 6. *Noetia retractata* (Hanna and Israelsky), × 1, holotype, Zorritos, Peru. This is the type of *Arca modesta* Grzybowski, in the Jagiellonian University, Krakow, Poland.

FIGURE 7. *Noetia triangularis* Gray (=*N. reversa* (Sowerby)). The holotype of the species on which the genus *Noetia* was based. British Museum.

FIGURES 8, 9. *Noetia macdonaldi alta* MacNeil, n. subsp., middle Miocene, Gatun formation, Costa Rica: 8, × 1, paratype, Cumbre Creek, Estrella River, U.S.N.M. 496548; 9, slightly reduced, holotype, "Hill No. 3", Banana River.

FIGURES 10, 12, 13. *Noetia macdonaldi* Dall, × 1, upper middle Miocene, Gatun formation, about a quarter of a mile south of the Banana River and about 5½ miles from the Caribbean Sea, Costa Rica: 10, young topotype; 12, 13, holotype, U. S. N. M. 214344.

FIGURE 11. *Noetia macdonaldi* Dall, × 1, Rio Tagachi, 18 miles west of its junction with Rio Atrato and about 40 miles northwest of Quibdo, Antioquia Department, Colombia, U.S.N.M. 496547.

FIGURES 14, 15. *Noetia turbacensis* MacNeil, n. sp., × 1½, holotype, upper (?) Miocene, one-eighth mile northeast of mud volcanoes, Turbaco, Bolivar Department, Colombia, U.S.N.M. 496551.

FIGURES 16, 17. *Noetia gardnerae* MacNeil, n. sp., × 3, holotype, upper Miocene or Pliocene, from an oil well near Houston, Tex., at a depth of 1,700 feet, U.S.N.M. 496552.

FIGURES 18, 19. *Noetia sheldoniana* Maury, holotype, upper Pliocene, 1,000 feet west of Brighton Pier, Trinidad: 18, × 1½; 19, × 2. Museum of Geology, Cornell University, no. 38296.

FIGURES 20, 21. *Noetia magna* MacNeil, n. sp., × 1, holotype, Pleistocene, Mancora Tablazo beds, Paita, Peru. Jagiellonian University, Krakow, Poland.

FIGURES 22, 23. *Noetia reversa* (Sowerby), × 1, Recent, Guayamas, Gulf of California, U.S.N.M. 101954.

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