BULLETIN
DU
Musée royal d'Histoire naturelle de Belgique
Tome XI, n° 13.
Bruxelles, août 1935.

MEDEDEELINGEN
VAN HET
Koninklijk Natuurhistorisch Museum van België
Deel XI, nr 13.
Brussel, Augustus 1935.

CLASSIFICATION OF THE PELECYPOD FAMILY *ARCIDAE*,

by Philip W. Reinhart (Stanford, California).

Introduction.

The pelecypod family Arcidae is a large and important one, abundant and widely distributed during the Cenozoic and later Mesozoic eras. Inasmuch as more than 1300 species (1) are included within the family, its definition is obviously not a simple problem, but one on which wide differences of opinion have existed up to the present time. Classifications of the Arcidae have appeared previously, but none has attained completeness nor been entirely satisfactory in other respects. Mistakes in these earlier classifications have been found from time to time, new genera and subgenera have been described subsequently by many workers throughout the world; and, especially within recent years, nomenclatural changes have been so numerous as to cause confusion. In view of the unsatisfactory condition outlined above, my present purpose is to bring together the described subgroups of the Arcidae, make the necessary revisions in them, and attempt to arrange them in a logical sequence.

(1) This estimate is reached by a count of the specific and varietal names listed in my card catalogue, described under the generic name *Arca* or under the other genera here included in the Arcidae. This count makes no provision for homonyms, synonyms, or for species incorrectly described as « Arca ». Furthermore the catalogue cannot claim completeness. Therefore the estimate of 1300 species and varieties is not a close one, but may furnish some idea as to the abundance of the family.

This paper is the outgrowth of a study of the species of Arcidae represented on the Pacific Slope of North America. Before attempting to understand the relationships of these species with others throughout the world or to assign them to their proper taxonomic groups, it was first necessary to study these groups with the purpose of determining their validity, the relations existing between them, and their correct nomenclature. One result of this study is the classification proposed in this paper(2).

Acknowledgments.

I wish to acknowledge the cooperation of a large number of people who have aided substantially in the preparation of this paper. This work was done under the direction of Professor H. G. Schenck of Stanford University, to whom I am greatly indebted. In addition, Dr. S. W. Muller, of the same institution, assisted in many ways.

For criticism of the manuscript, as well as for other assistance, thanks are extended to Professor U. S. Grant IV, of the University of California at Los Angeles, and to Dr. John B. Reeside Jr., of the U. S. National Museum. For the loan of specimens and of necessary publications I am indebted especially to the following persons: Mrs. I. S. Oldroyd and Mr. D. L. Frizzell, of Stanford University; Dr. C. L. Camp, Dr. C. W. Merriam, Mr. W. L. Effinger, and Mr. F. Earl Turner, of the University of California; Drs. G. Dallas Hanna and Leo G. Hertlein, of the California Academy of Sciences; Mr. Clinton G. Abbott and Mr. and Mrs. Frank Stephens, of the San Diego Society of Natural History; Mr. F. B. Plummer, of the Bureau of Economic Geology of Texas; Dr. E. M. Kindle, of the Canadian Geological Survey; Mr. L. R. Cox, of the British Museum of Natural History; Mlle. H. Alimen, of the Sorbonne; Dr. M. Glibert, of the Musée royal d'Histoire naturelle at Brussels; Messrs. A. R. May and Alex Clark, of the Shell Oil Company. Finally, I am indebted to my wife, Marion E. Reinhart, for her critical assistance during the preparation of the manuscript for publication.

(2) The detailed discussion of the Pacific Slope species is as yet unpublished. It was read in part before the Pacific Coast Branch of the Paleontological Society of America, April 8, 1933, at Los Angeles, California. The abstract appears in the Proceedings of the Geological Society of America for 1933, p. 388, June, 1934.

Notwithstanding the abundant help that I have received from these many sources, I accept responsibility for the taxonomic arrangement set forth in this paper.

Relation of the Arcidae to the class Pelecypoda.

Only a few characteristics have been used as a primary basis of classification of the Pelecypoda, in the various arrangements of this class of mollusks which have been proposed. The most important of these characteristics are the following: the number and relative size of the adductor muscles, the presence or absence of siphons, the hinge, the gills, and the texture of the shell.

The two adductor muscles in the Arcidae are nearly equal in size; siphons are absent; and the pallial line, which is usually present, is entire; the hinge consists of a dorsal hinge plate provided with numerous transverse teeth—taxodont dentition of Neumayr (3); and, finally, the texture of the shell is porcellanous, though in some cases so highly polished as to seem nacreous.

The following table is a synopsis of the place occupied by the Arcidae in some of the more important classifications of the Pelecypoda.

Reference to classification.	*Position occupied by Arcidae.*
1828. Fleming, J., History of British Animals, Edinburgh, pp. 381-382.	Mollusca bivalvia. Division Asiphonida.
1835. Lamarck, J. B., Hist. Nat. des Anim. sans Vert., 2 ed., vol. 6, pp. 12-13. Also 1 ed., 1818.	Order 1. Conchifères dimyaires. Section 3. Conchifères lamellipèdes.
1849. Bronn, H. G., Handbuch einer Geschichte der Natur, Bd. 3, pp. 257-352.	II. Dimya. B. Homomya.
1851. Woodward, S. P., Manual of the Mollusca, London, p. 252.	Section A, Asiphonida.

(3) Sitzungsber. Akad. Wiss., Wien, Math.-Naturw. Klasse, Bd. 88, 1 Abt., Jahrg. 1883 (1884), pp. 385-418.

1884. Neumayr, M., Zur Morphologie des Bivalvenschlosses : Sitzungsber. Akad. Wiss., Wien, Math.-Naturw. Klasse, Bd. 88, 1 Abt., Jahrg. 1883 (1884) pp. 385-418.	Order 3, Taxodonta.
1884. Tryon, G. W., Structural and Systematic Conchology, Philadelphia, vol. 3, pp. 235, 252.	Order Asiphonida. Suborder Homomyaria.
1887. Fischer, P., Manuel de Conchyliologie, Paris, p. 923.	Order Tetrabranchia. Suborder Inappendiculata.
1892. Pelseneer, P., Introduction à l'Étude des Mollusques : Ann. Soc. Roy. Malac. Belg., vol. 27, pp. 158-200.	Order Filibranchia.
1894. Grobben, C., Zur Kenntniss der Verwandtschaftsverhältnisse und des Systems der Mollusken : Sitzungsber. Akad. Wien, Math.-Naturw. Klasse, Bd. 103, 1 Abt.	3. Ambonodonta. (1) Eutaxodonta.
1895. Dall, W. H., Tertiary Fauna of Florida: Trans. Waner Free Inst. Sci., vol. 3, pt. 3, p. 515.	Order Prionodesmacea. A. Taxodonta.
1896. Bernard, F., Le développement et la morphologie de la coquille chez les Lamellibranches: Bull. Soc. géol. de France, 3 sér., vol. 24, pp. 54-82.	Taxodontes.
1903. Ridewood, W. G., Structure of the Gills of the Lamellibranchia : Philos. Trans. Roy. Soc., B, vol. 195, pp. 185-186.	Order Eleutherorhabda. Suborder, Mytilacea.

1912. Douvillé, H., Classification des Lamellibranches : Bull. Soc. géol. de France, 4 sér., vol. 12, p. 466.	Dysodontes.
1913. Dall, W. H., *in* Zittel, K. A., Textbook of Paleontology, vol. 1 (Eastman Edition), London, p. 504.	Order Prionodesmacea. Taxodonta.

The classification of Lamarck (1818, 1835) was based primarily upon the adductor muscles, whereas that of Tryon (1884) was based upon a combination of siphons and adductor muscles. The arrangement of the hinge was the basis for the classifications of Neumayr (1884), Dall (1895 and 1913, also 1889 [4]), Bernard (1896, etc.), and Grobben (1894). The presence or absence of siphons was made the primary basis of classification by Fleming (1828) and Woodward (1851). The structure of the gills was used by P. Fischer (1887), Pelseneer (1892, etc.), Ridewood (1903), and E. L. Rice (5). H. Douvillé (1912) placed the strongest emphasis on shell texture and the arrangement of the hinge. Comparing Douvillé's classification with those of Dall and of Pelseneer, Davies (6) concluded that Douvillé's was the only one of the three which can be considered a phylogenetic arrangement.

The classifications of Dall and Pelseneer are the most commonly used at the present time, that of Dall being used especially by American paleontologists. Pelseneer's classification, though adopted by most zoologists, is not without modern critics. An arrangement paying little heed to fossils cannot be accepted as even an approximation of a phylogenetic classification.

(4) Dall, W. H., Amer. Jour. Sci., ser. 3, vol. 38, 1889, pp. 445-462.
(5) Jenaische Zs. Natw., Bd. 31, 1898, pp. 29-86.
(6) Davies, A. M., The Bases of Classification of the Lamellibranchia: Proc. Malacological Soc. London, vol. 20, pt. 6, November, 1933, pp. 322-326.

Family, generic, and specific characteristics of the Arcidae.

Characteristics of family importance.

My basis for assigning a certain number of genera to the family Arcidae, while excluding others and allocating them to different families, can be outlined by the following enumeration of important characteristics possessed by all the genera here allocated to the Arcidae and not possessed by those of other families : (1) An ark-like (boat-shaped) form, which, although varying greatly, can be traced in all of the genera here assigned to the family. (2) A straight or moderately-arched hinge with numerous taxodont teeth, arranged either vertically or obliquely (not parallel) to the hinge-line. (3) An external ligament, occupying all or only part of a well-defined ligamental (or cardinal) area. (4) Two subequal adductor muscle scars. (5) A simple pallial line, without siphonal indentation. (6) Porcellanous shell material.

The following comparison of the Arcidae with other taxodont families with which they might be and have been confused will bring out the importance of these characteristics.

Comparison of the Arcidae with related families.

Parallelodontidae : This family, including *Parallelodon* and its allies, *Cucullaria,* etc., may be distinguished from the Arcidae by the fact that the teeth are arranged mainly parallel with the hinge, not transverse to it as in the Arcidae. The Parallelodontidae have been grouped with the Arcidae by many workers in the past, and by some at the present time. That the two families are genetically allied can hardly be questioned. However, the morphologic difference mentioned above, as well as differences in geologic history (the Parallelodontidae originated in the Paleozoic, the Arcidae in the Mesozoic era), make the separation of the two families advisable. It must be admitted that in a few cases it is difficult to draw a line between the two. For example, *Pseudogrammatodon* Arkell (Geol. Mag., London, vol. 67, n° 793, 1930, p. 307), based upon the Eocene *Arca adversidentata* Deshayes, combines the hinge structure of *Parallelodon* with the form of *Barbatia.* Arkell considered his genus to be an off-shoot from *Barbatia,* which it may indeed be. However, at present, because of its hinge structure, I prefer to place *Pseudogrammatodon* in the Parallelodontidae, as it seems equally possible that it

developed from some such Cretaceous parallelodontid genus as *Nemodon* Conrad, 1869. Incidentally, the similarity between *Pseudogrammatodon* and *Porterius* Clark (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 15, n° 4, 1925, p. 79) should be mentioned. *Porterius* is based upon an Oligocene species from Grays Harbor County, Washington, « *Barbatia* » *andersoni* VanWinkle, which has the same general features as « *Arca* » *adversidentata*. Careful comparison may show that *Pseudogrammatodon* is to be considered a synonym of *Porterius*.

Limopsidae : The Limopsidae are distinguished from the Arcidae by the possession of a deep ligamental pit. Even those genera of Arcidae which possess a shallow ligamental pit (*Trigonodesma, Arcopsis)* differ from the Limopsidae by retaining a distinct, *Arca*-like ligamental area, even though the ligament occupies but a small part of this. Such an area is entirely lacking in the Limopsidae. On this criterion, *Trigonodesma* is here retained in the Arcidae, whereas *Trinacria* is referred, as has been done in the past, to the Limopsidae, although aside from this difference in the ligamental area, these two genera are fairly similar.

Glycymeridae: The rounded outline and strongly-arched hinge of this family are the main criteria, based upon the shell, for separating this family from the Arcidae. That differences of the soft parts also exist is shown by Pelseneer (*in* E. Ray Lankester, « A Treatise on Zoology », Part 5, Mollusca, p. 258, London, 1906), who states that in *Arca* the heart is situated above the rectum, whereas in « *Pectunculus* » (= *Glycymeris*) the heart is traversed by the rectum.

Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 80) placed the subfamily Noetiinae (consisting of *Noetia, Trigonarca, Halonanus* = *Trigonodesma)* in the family Glycymeridae, in which he also included the subfamily Cucullaeinae, the basis for this arrangement being shown by the following quotation: « It [*Noetia*] has only vertical striations on the ligamental area which is usually restricted posterior to the beaks. The posterior adductor muscle scar is bounded ventrally by a ridge or flange which sometimes ascends into the umbo. The posterior restriction of the ligament and the internal flange suggest relationship with *Cucullaea* which has the flange much enlarged,while *Arca, Barbatia, Anadara* and its numerous allies, *Argina, Senilia,* and *Trisidos,* all lack the flange. It seems that *Noetia* is more closely related to *Cucullaea* and *Glycymeris* than to the Arcidae.»

In view of the difference of hinge structure between *Cucullaea*

and *Glycymeris,* the above inclusion of the Cucullaeinae in the family Glycymeridae seems questionable. *Cucullaea* and related genera seem more appropriately allocated to the Parallelodontidae, where they have usually been placed in the past.

The posterior restriction of the ligament (mentioned by Stewart as suggesting a relationship between the Noetiinae and Glycymeridae) is not generally present in *Glycymeris,* nor is it very prominent in *Cucullaea,* although it is noticeable. In the Noetiinae the ligamental area is usually shorter posterior than anterior to the beaks, but this shortening is quite variable in *Noetia,* as has been outlined by Sheldon (Palaeont. Amer., vol. 1, n° 1, 1917, p. 29). This criterion does not present a strong argument for allying the Noetiinae to the Glycymeridae.

The flange or ridge bounding the posterior adductor muscle scar may indicate that the Noetiinae are related to *Cucullaea,* but it does not necessarily indicate a relationship with *Glycymeris* because such a flange is not consistently present in *Glycymeris,* and when present, is sometimes only feebly developed. Moreover, the question arises as to whether or not this flange is a character of family or subfamily rank, as in addition to its occurrence on the Noetiinae and Cucullaeinae, similar or analagous flanges are present on some genera of the Arcinae; namely *Striarca* (7), occasionally *Arca s. s.* (8), and *Microcucullaea* (9). Further, a flange bordering the anterior adductor muscle scar is present in the type species of *Parallelodon, P. rugosum* (Buckman), although it is not present on all species of *Parallelodon s. s.,* nor is it found on any species of the closely related subgenus *Grammatodon* (Arkell, Geol. Mag., London, vol. 67, n° 793, 1930, p. 302). This flange, in conclusion, is not a character of family or subfamily value.

The Noetiinae, therefore, are here retained in the Arcidae not only because the criteria cited by Stewart to justify placing this

(7) In *Striarca* a raised flange borders the inner side of both anterior and posterior adductor muscle scars.

(8) On a specimen of an undescribed species of *Arca s. s.* from Pliocene beds at Fugler Point, near Santa Maria, Santa Barbara County, California, a raised flange borders the inner side of each muscle scar. This species will be described in a later paper. Likewise, a similar raised flange borders only the posterior muscle scar of Recent specimens of *Arca tetragona* Poli (No. 341, Oldroyd Collection, Stanford University).

(9) A raised flange is present bordering each adductor muscle scar in the type species of this group.

subfamily in the Glycymeridae are not convincing, but also because of the general resemblance of *Noetia* to *Anadara* on the one hand and to *Arca s. s.* on the other.

Nuculidae : This family is distinguished from the Arcidae by having a chondrophore, no external ligament, a nacreous interior, and a different kind of taxodont dentition.

Ctenodontidae : There seems to be little possibility of confusing this family, with its oval shape, and arched hinge lacking a ligamental area, with the Arcidae.

Nuculanidae and Cyrtodontidae : The taxodont families Nuculanidae (« Ledidae ») and Cyrtodontidae are too far removed to warrant comparison with the Arcidae.

Characteristics of generic and specific importance.

The characteristics that have been found to be the most important ones in differentiating genera and subgenera are the arrangement of the hinge and teeth, character of the ligamental area, external sculpture, presence or absence of a byssal gape and of crenulations on the inner margin of the shell, general form, equivalve or inequivalve character, location of beaks and the direction in which they point, and the presence or absence of a raised flange bordering the posterior (sometimes also the anterior) adductor muscle scar, present on a few genera, notably *Trigonarca, Noetia, Trigonodesma, Striarca,* and infrequently on *Arca s. s.*

Specific characters include a totality of shell characters, the most important of these being outline, form, hinge and ligamental area, number of ribs and their ornamentation, shape of muscle scars, and denticulations on the inner margin of the shell.

Time of differentiation of the Arcidae.

The following is a list of the genera and subgenera of Arcidae, arranged in the order of their first appearance in the geologic column, so far as data available to me indicate :

TRIASSIC : *Barbatia, sensu lato?*

JURASSIC : *Eonavicula, Barbatia, s. l.,* (definitely present).

CRETACEOUS : *Cucullaearca, Plagiarca, Arcopsis* (Danian), *Acar* (Danian), *Striarca, Nemoarca, Trigonarca.*

EOCENE : *Arca, sensu stricto, Barbatia, sensu stricto, Obliquarca, Scapularca, Trisidos, Argina, Noetia, Trigonodesma.*

OLIGOCENE (10) : *Bathyarca, Anadara, sensu stricto, Cunearca, Scapharca.*

MIOCENE (11) : *Calloarca, Granoarca, Larkinia.*

PLIOCENE : *Arcoptera, Soldania.*

PLEISTOCENE : No first appearances recorded.

RECENT : *Litharca, Pugilarca, Bentharca, Microcucullaea, Scaphula, Noetiella, Paranoetia.*

« TERTIARY » (PROBABLY LATE TERTIARY) : *Senilia, Sheldonella.*

This tabulation indicates that the family possibly originated in the Triassic, species of *Barbatia* having been reported from Triassic strata. Two groups of the family were definitely present during Jurassic time : *Eonavicula* and *Barbatia, s. l.* During the Cretaceous seven new groups, and in the Eocene, eight new groups appeared, these being followed by only four new ones in the Oligocene, three in the Miocene, and two in the Pliocene. No new groups are known to have originated during Pleistocene time, but in the Recent fauna there are seven which are not yet definitely reported as fossils.

Classification of the Arcidae followed in this paper.

The following classification is based upon both a study of the literature and an examination of specimens of hundreds of species, including the type species of the various groups dealt with except in the few cases where these were not available. Shell characters alone have been used in my arrangement of the arcids. Since there are many reasons for believing that the shell is at least as reliable as the soft parts for classificatory purposes, my failure to consider soft parts is not of overwhelming importance.

It will be noted that the following list does not include the Jurassic-Cretaceous genus *Isoarca* Münster, 1842 (type species :

(10) The Tongrian stage of Belgium and its equivalents are taken as lower Oligocene.

(11) If some formations now synchronized with the Aquitanian stage are taken as upper Oligocene, then *Larkinia* appears first in the Oligocene.

I. decussata Münster), which, although it was listed as a subgenus of *Arca* by Dall (*in* Zittel, Textbook of Paleontology, Eastman Edition, 1927, p. 443), does not appear to have much in common with the Arcidae. The systematic position of this genus is somewhat uncertain. It was placed as a subgenus of *Cucullaea* by Fischer (Man. de Conch., 1887, p. 977); Stoliczka, although placing *Isoarca* in the Arcinae, pointed out its pearly shell and lack of a true ligamental area, suggesting that it might better be classed in the family Nuculidae (Pal. Indica, vol. 3, 1871, pp. 338-339). The resemblance of *Isoarca* and the upper Carboniferous genus *Carbonarca* Meek and Worthen, 1870 (monotypic species: *C. gibbosa* Meek and Worthen), has been pointed out by Arkell (Geol. Mag. London, vol. 67, n° 794, 1930, p. 350).

In conclusion, the following summary includes two new systematic names: the subgenus *Larkinia* and the subfamily *Anadarinae*.

Divisions of the family Arcidae as recognized in this paper.

Perhaps some systematists will oppose this arrangement on the grounds that either too many or too few genera are recognized. Opinions as to the proper delimitation of genera and of subgenera are so varied that disagreement cannot be avoided. By many, though not by all, workers in the past the name *Arca* has been used in a much broader sense than here, one of the reasons often cited for this usage being that most of the groups of the arcids intergrade at their peripheries, and consequently cannot be separated generically. Intergradation unquestionably exists, but this condition has been overemphasized. Even in cases where intergradation between groups can be shown, this fact does not necessarily mean that these groups must therefore belong to the same genus; for if we accept the doctrine of evolution, it follows that any two closely related genera, broadly or narrowly defined, must be connected by intermediate forms. The delimitation of genera is therefore of necessity arbitrary. In the following classification only those categories are recognized as genera which seem sufficiently distinct to warrant this rank, while the lesser units are treated as subgenera, and unnecessary names

are suppressed as synonyms. In brief, I have attempted to recognize a sufficient number of genera so that precision of nomenclature is possible, but at the same time without retaining a confusingly large number of generic names.

Several groups are recognized here to which, so far as I know, only one or two species can be definitely assigned (especially *Litharca, Arcoptera, Pugilarca, Nemoarca, Paranoetia, Sheldonella, Noetiella*). Although evaluation of the taxonomic rank of such groups, naturally, is questionable, it is better to recognize them at present until more is known about them than to place them haphazardly in the synonymy of some other better-known group. When more species have been found which belong to these questionable groups, then it will be possible to reach some justifiable conclusion as to their relationships and taxonomic rank.

In the following part a thorough treatment of each taxonomic group has not been attempted, but sufficient information has been included to enable the reader, by referring to the works cited, to gain a fairly adequate knowledge of each group. Systematic names proposed before the year 1758, or proposed by authors who did not apply the principles of binary nomenclature, are not included in the following discussion because they are not accepted under the International Rules of Zoological Nomenclature (Articles 25B and 26), and their insertion would seem to cause more confusion than benefit.

Family ARCIDAE (*Auctores, partim*).

Shell consisting of two valves, equally inflated; equivalve or slightly inequivalve. Shell usually longer than high; umbones ordinarily placed anterior to center of shell. Sculpture consisting of radial ribs crossed by concentric lines or bands; radial sculpture absent in some groups. Texture of shell porcellanous. Ventral margin gaping for the passage of a byssus in the subfamily Arcinae; in the Anadarinae and usually in the Noetiinae, however, ventral margin is closed. Periostracum of horny material, usually covered with hairs, but in some cases smooth, lacking hairs. Ligament external, occupying a ligamental area which, in most genera, extends both anterior and posterior to the umbones, forming a notch, deeply entrenched between them. Hinge straight or gently arched; teeth numerous, usually either perpendicular to the hinge or set obliquely so as to converge ventrally. Two adductor muscle scars, subequal in size; pallial line

simple, lacking a sinus. Type genus: *Arca* Linné, based upon *A. noae* Linné.

Geologic range: Jurassic (possibly Triassic) to Recent.

Subfamily ARCINAE (*Auctores, partim*).

Ventral margin generally with opening for passage of byssus; sculpture consisting of radial ribs crossed by concentric growth lines; ribs sometimes noded, often irregular in size and spacing; surface of shell usually irregular; when viewed from anterior end, with both valves joined, ligamental area appears narrow and V-shaped (as in *Barbatia*) to very wide and quite flat (as in *Arca s. s.*); hinge straight or gently arched. Inner margin of shell usually smooth; beaks not opisthogyrate, but pointing forward, upward, or inward. Type genus: *Arca* Linné, based upon *A. noae* Linné.

Geologic range: Jurassic (possibly Triassic) to Recent.

Genus ARCA Linné, 1758.

Subgenus ARCA *s. s.*

Pl. I, figs. a, a'.

Arca Linné (12), Syst. Nat., ed. 10, 1758, p. 693; type species: *Arca noae* Linné *(loc. cit.)*, Recent, from the Mediterranean Sea. Figured by Bucquoy, Dautzenberg, and Dollfus (Mollusques Marins du Roussillon, vol.2, Pelecypoda, Fascicule 5, 1891, pl. 30, figs. 1-5).

Navicula Blainville, Dict. Sci. Nat., vol. 34, 1825, p. 319; type species (by monotypy): *Arca noae* Linné, 1758.

Not *Navicula* Bory de Saint-Vincent, Dict. Hist. Nat. Paris, vol. 2, 1822, p. 128 (a diatom); type species (by original designation): *Vibrio tripunctatus* Müller.

Byssoarca Swainson, Zoological Illustrations, ser. 2, vol. 3, 1832-1833, pl. 118; type species: *Arca noae* Linné, 1758; type by

(12) *Arcacites* Schlotheim (Die Petrefactenkunde auf ihrem jetzigen Standpunkte durch die Beschreibung seiner Sammlung versteinerter und fossiler Ueberreste des Thier- und Pflanzenreichs der Vorwelt erläutert, 1820, p. 201) is a synonym of *Arca* in the broad, Linnean sense. The suffix *ites* was added by Schlotheim to the generic name of each genus dealt with by him.

subsequent designation of Herrmannsen, Ind. Generum Malacozoorum, vol. 1, 1846, p. 149.

Cibota (Browne) Mörch, Catalogus Conchyliorum quae reliquit D. Alphonso d'Aguirra & Gadea Comes de Yoldi, Fasc. 2, 1853, p. 39.

Thyas M. E. Gray, Figures of Molluscous Animals, vol. 5, 1857, p. 24 (13).

Not *Thyas* J. Huebner, Samml. exotische Schmett. II, Tab. (203), exact date of publication unknown; between 1806-1834. Not *Thyas* Koch *in* Panzer, Deutschl. Crust. Ins., Heft 5, 1837, tab. 18.

Shifting of opinion as to what species should be accepted as the genotype of *Arca* has resulted in a great deal of confusion concerning the typical subgenus, as has been outlined by Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, pp. 83-86). As Stewart notes, since 1847 *Arca noae* Linné has been accepted almost universally as the type species, following the designation of Gray (Proc. Zool. Soc. London, 1847, p. 197). This same species had previously been designated the type of *Arca* by Schmidt (Versuch. Conch.-Samml., 1818, pp. 65, 178) but this designation seems to have been overlooked by most systematists before Stewart. At any rate, Gray's designation, as mentioned above, was almost universally accepted.

Within the last few years, however, there has been brought to light the fact that two other species had been designated the type of *Arca* previous to 1847, one of these even before Schmidt's designation of 1818: (1) Cox (Paleont. Zanzibar, 1927, p. 93) pointed out that Children had designated *A. tortuosa* Linné the type of *Arca* in 1823; and (2) in 1930, Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, p. 83) disclosed the fact that *A. anti-*

(13) *Thyas* is listed by Gray under the subclass Siphonophora (« Mantle leaves connected, with two siphonal openings behind »). *Thyas radula* is the only species cited; the reference to the illustration given is « pl. 358, fig. 4 ». The explanation of plates gives for pl. 358, fig. 4, the following : « Arca Gaimardi. Deshayes, Algeria, t. 123, f. 9. » The illustration itself shows what is evidently an *Arca s. s.* The citation to the illustration of *Thyas* is therefore evidently a mistake, and one is left in doubt as to the correct interpretation of *Thyas*. Fortunately the name is preoccupied and can be dropped as a homonym.

quata Linné had been designated the type species by Schumacher in 1817 (Essai Nouv. Syst. Test., p. 172).

Inasmuch as Schumacher's designation of *A. antiquata* antedates Schmidt's of *A. noae* by one year, *A. antiquata* was accepted as the typical species of *Arca* by Stewart and by Grant and Gale (San Diego Soc. Nat. Hist., Mem. vol. 1, 1931, p. 137), although Stewart was reluctant at the change, suggesting that *A. noae* should be arbitrarily accepted as type by the International Commission on Zoological Nomenclature.

From this review, we see that lately three different groups have successively been called the typical subgenus of *Arca* : (1) the group accepted as *Arca s. s.* in this paper, having *Arca noae* Linné as type species; (2) *Trisidos*, the type species of which is *A. tortuosa* Linné; and (3) *Anadara*, with *Arca antiquata* Linné as type species.

In view of this complicated history, and of the reluctance of many workers to abandon *Arca noae* as the type of *Arca*, it is desirable to submit this case to the International Commission on Zoological Nomenclature so that an opinion from this body may definitely settle the question. I have therefore presented the case to Dr. C. W. Stiles, Chairman of the Commission, recommending that *Arca noae* be established as the type species, and he has assured me that the question will receive consideration as soon as possible.

Until an opinion from the Commission is available, the nomenclature used in this paper is subject to a possible change, as the Commission may vote in favor of retaining *Arca antiquata* as the type species. I do not, however, think this possibility very strong, for the following reasons: First, I have stated the case to a number of prominent paleontologists throughout the world, several of whom are on the International Commission, and with one exception these persons have expressed an opinion in favor of *Arca noae* as type species. Second, Schumacher's designation of *Arca antiquata* is questionable. Schumacher says (Essai Nouv. Syst. Test., 1817, p. 172) : « Pour le type du genre j'ai donné la fig. 2, Pl. XIX, de la charnière de l'*Arca antiquata* Lin. qu'on trouve figurée dans Chemn. 7, pag. 201. Tab. 55, fig. 548. » It is a debatable question whether Schumacher was here designating a type species or merely illustrating a type of hinge structure.

For these reasons, probably *Arca noae* will be accepted by the International Commission as the type species of *Arca*, as has been done in this paper. However, in the event that *A. antiquata*

should be accepted as the type, the following changes in nomenclature will have to be made: (1) the group called *Anadara* in this paper will become *Arca s. s.;* and (2) the group here called *Arca s. s.* will be called *Navicula*, a name which appears to be preoccupied by a diatom genus (14), as stated by Hanna (Nautilus, vol. 45, n° 4, 1932, pp. 118-120).

Arca s. s., in the sense that *A. noae* is the type species, has been common in Europe and North America since the Eocene; and at least one European Cretaceous species may be definitely assigned to it — *Arca dupiniana* d'Orbigny from the Lower Greensand (Arkell, Geol. Mag., London, vol. 67, n° 793, 1930, pl. 16, fig. 2). My recognition of *Arca s. s.* in the type Tejon formation, Eocene, of California, is important in that it records the earliest occurrence of this genus in western North America; it had previously not been known here in beds older than Oligocene, where it is represented by *A. washingtoniana* Dickerson (Proc. Calif. Acad. Sci., 4 ser., vol. 7, n° 6, 1917, p. 166, pl. 27, figs. 2 a-b), from southwestern Washington.

Arca is represented also in the Oligocene of Europe, for example by *Arca sandbergeri* Deshayes, var. *crassistria* von Koenen (Abh. zur geol. Specialkarte von Preuss. und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1081-1084, pl. 72, figs. 1-4) ; also by *Arca conformis* von Koenen (*op. cit.,* pp. 1084-1086, pl. 72, figs. 5-7) from the lower and middle Oligocene of Germany. Miocene and later occurrences are wide-spread and abundant. At the present time *Arca s. s.* is world-wide in distribution, in tropical and warm seas.

(14) With regard to the diatom genus *Navicula*, Dr. G. D. Hanna has shown me a photographic reproduction of Saint-Vincent's original diagnosis of that genus, which is as follows (Dict. Hist. Nat. Paris, vol. 2, 1822, p. 128):

« III. Navicule, *Navicula*, N (V. pl. de ce Dict., Bacillariées, fig. 3). Ce nom est emprunté de la forme des Animalcules auxquelles nous l'appliquons, et dont le corps ressemble à une navette de tisserand; ce corps linéaire, comprimé, au moins sur un côté, est aminci aux deux extrémités. Le *Vibrio tripunctatus* de Müller est le type de ce genre, dans lequel rentre l'*Echinella acuta* de Lyngbye, et l'Animalcule que Gaillon, observateur exact de Dieppe, a reconnu être la cause de ce qu'il appelle Viridité des Huîtres. V. ce mot. »

Whether the diatom *Navicula* was proposed in a zoological or botanical sense depends upon the use of the word « animalcule », which in the early 19th century was used in either sense. Whether the diatom genus preoccupies the molluscan one, therefore, is a question which would have to be decided by the International Commission.

Subgenus LITHARCA Gray, 1842.

Litharca Gray, Syn. Cont. British Mus., ed. 44, 1842, p. 81 (genus without species) ; type species: *Byssoarca lithodomus* Sowerby (Proc. Zool. Soc. London, pt. 1, 1833, pp. 16-17), a Recent species from the coast of Ecuador. Type by subsequent designation of Gray, Proc. Zool. Soc. London, 1847, p. 197.

Arca lithodomus, the only species allocated to this subgenus, was considered by Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 615) to be probably based upon a deformed specimen of « *Arca* » *candida* Gmelin. On this same assumption, Gardner (U. S. Geol. Survey Prof. Paper 142-A, 1926, p. 26) rejected *Litharca* as a synonym of *Plagiarca* Conrad, a subgenus of *Barbatia*. However, Maury (Science, vol. 54, n° 1404, 1921, pp. 516-517) had previously brought out the fact that *Arca lithodomus* is a valid species, and later (Palaeont. Amer., vol. 1, n° 4, 1922, pp. 7-8, pl. 1, figs. 1, 3) assigned it to *Litharca*, where it belongs.

Although known from only one species, *Litharca* probably should be retained as a separate subgenus, as it is distinct from *Arca s. s.*, and indeed even resembles *Noetia* somewhat in general form, as Maury noted. However, Maury's description and illustrations (1922) show that *A. lithodomus* belongs to *Arca s. s.* and not to *Noetia*.

Subgenus ARCOPTERA Heilprin, 1887.

Arcoptera Heilprin, Trans. Wagner Free Inst. Sci., vol. 1, 1887, p. 98 ; type species (by monotypy) : *Arca aviculaeformis* Heilprin (*op. cit.*, pp. 98-99, pl. 13, figs. 32-32a) from the Caloosahatchie formation, Pliocene, of Florida. This species was renamed *Arca wagneriana* Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 619), as Heilprin's name was preoccupied by Nyst (Tabl. Synopt. Arcacées, Mém. Acad. Roy. Sci. Belgique, t. 22, 1848, p. 12).

Not *Arcoptera* Bittner, Abh. Geol. Reichs., Wien, Bd. 18, Heft 1, 1895, p. 126 ; type species (by monotypy) : *A. elegantula* Bittner (*op. cit.*, pp. 126-127), from the Triassic of the Alps. Renamed *Elegantarca* by Tomlin, Proc. Malac. Soc. London, vol. 19, pt. 1, 1930, p. 23.

Although *Arcoptera* does not differ greatly from *Arca s. s.*, I nevertheless consider it sufficiently distinct to retain it as a subgenus of *Arca* instead of reducing it to synonymy, as was done by Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 614). The attenuated extremities of *Arcoptera* are distinctive; and a further difference is that the ligamental area is not flat, as in *Arca s. s.*, but V-shaped when viewed from the anterior end of the shell, with both valves joined. *Arcoptera* is known only from the one species.

Subgenus EONAVICULA Arkell, 1929.

Eonavicula Arkell, British Corallian Lamellibranchia, pt. 1, Palaeont. Soc., vol. 81, 1929, p. 36; type species (by original designation) : *Arca quadrisulcata* Sowerby (Mineral Conch. of Gt. Britain, vol. 5, 1825, p. 115, pl. 473, fig. 1) from the Corallian (Jurassic) of England.

In addition to the type species, Arkell included in *Eonavicula* such Cretaceous species as *Arca carteroni* d'Orbigny, figured by Woods (Monograph of Cretaceous Lamellibranchia, pt. 1, Palaeont. Soc., vol. 53, 1899, pl. 6, figs. 4, 5), differentiating these species from « *Navicula* » (= *Arca s. s.*) by the greater inclination (and consequently smaller number) of the teeth of *Eonavicula*. The separation of these Mesozoic species is often a difficult one to make, as some Tertiary species that unquestionably belong to *Arca s. s.* also have inclined teeth (15), and, as Arkell noted, some Cretaceous species, as *A. carteroni* d'Orbigny, are gradational between *Eonavicula* and « *Navicula* ». Specimens of *Arca quadrisulcata* (N^os^ 47526 and 23374, British Museum of Natural History), placed at my disposal by L. R. Cox, appear externally very similar to *Arca s. s.* The hinge is not exposed in these specimens. One difference, however, is noticeable : in *A. quadrisulcata* the ligamental area (unfortunately not well preserved in my specimens) is considerably narrower than in typical *Arca*. This distinction may be added to the criterion of highly inclined teeth in differentiating *Eonavicula* from *Arca s. s.*

(15) For example: *Arca washingtoniana* Dickerson (Proc. Calif. Acad. Sci., 4 ser., vol. 7, n° 6, p. 166, pl. 27, fig. 2) from the Oligocene of Washington and Oregon; *Arca tetragona* Poli, as figured by Woods (Crag Mollusca, pt. 2, Bivalves; Palaeont. Soc., vol. 4, 1850, pl. 10, figs. 1a-d), from the Pliocene of England. Other examples are mentioned by Arkell, *op. cit.*, p. 344.

The development of *Arca s. s.* (« *Navicula* ») from *Eonavicula* as well as the possible ancestry of *Eonavicula* have been ably discussed by Arkell (Geol. Mag., London, vol. 67, n° 794, 1930, pp. 342-352). He suggests that three species figured by King (16) from the Permian Magnesian Limestone are closely related to *Eonavicula,* although the dentition of these species is not clearly known.

Genus BARBATIA Gray, 1842.

Subgenus Barbatia *s. s.*

Pl. I, figs. b, b'.

Barbatia Gray, Synopsis of the Contents of the British Museum. ed. 44, 1842, p. 81; type species: *Arca barbata* Linné (Syst. Nat., ed. 10, 1758, p. 693), Recent, from the Mediterranean Sea; type by subsequent designation of Gray (Proc. Zool. Soc. London, 1847, p. 197). Figured by Bucquoy, Dautzenberg, and Dollfus (Mollusques Marins du Roussillon, vol. 2, Pelecypoda, Fascicule 5, 1891, pl. 32, figs. 1-5).

?*Savignyarca* Jousseaume, Le Naturaliste, 13e ann., 1891, p. 222; type species: *Savignyarca savignyarca* Jousseaume, *loc. cit.*, Recent, from the Gulf of Aden (16a).

Savignyarca savignyarca was placed by Lamy (Jour. de Conch., vol. 55, n° 1, 1907, p. 71) as a synonym of *Arca obliquata* Gray. Judging from Reeve's figure of this species (Conch. Icon., vol. 2, 1844, *Arca,* pl. 12, fig. 80), *obliquata* seems to be a *Barbatia,* and *Savignyarca* is therefore tentatively regarded as a synonym of *Barbatia* (17), as it was by Thiele (Handbuch der Systematischen Weichtierkunde, 3 Teil, Jena, 1934, p. 792).

(16) « *Byssoarca* » *tumida*, « *B.* » *striata*, and « *B.* » *Kingiana*. King, Mon. Permian Foss. England: Palaeont. Soc., 1850, pp. 172-173, pl. 15, figs. 1-12.

(16a) By typographical error, spelled « *Savignyarca savignyrarca* » by Jousseaume.

(17) Reeve's figure, however, does not show the hinge. The hinge of a Tertiary species from Java called *Arca obliquata* Gray has been illustrated by Martin (Foss. von Java: Samml. Geol. Reichs Mus. Leiden, Bd. 1, 2 Abt., Heft 2, 1910, pl. 51, figs. 81 a-b). This species strongly suggests *Obliquarca*, and if correctly identified indicates the possibility that a study of authentic specimens of *Savignyarca savignyarca* may show that the name *Obliquarca* must be replaced by the earlier-named *Savignyarca*. Such specimens have not yet been available to me.

Barbatia, sensu lato, is present in Jurassic beds of Europe, from which several species have been described. Of these, *Barbatia gracilicostata* (Favre) (Mém. Soc. Physique et d'Hist. Nat. de Genève, vol. 37, fasc. 4, 1913, pp. 404-405, pl. 18, figs. 4-6), from the lower Portlandian of France, is at least closely related to *Barbatia* and probably should be classified in this genus, although it may belong to a distinct subgenus. Arkell (Geol. Mag., London, vol. 67, n° 794, 1930, p. 349) points out a species of *Barbatia* from the Lower Lias, *B. pulla* (Terquem) (Mém. Soc. Géol. France, 2 sér., vol. 5, 1855, p. 307, pl. 21, figs. 1a-b). He also refers to Triassic occurrences of *Barbatia* but mentions no species. Although such species may be assigned to *Barbatia*, I have not seen any and am therefore unable to offer any opinion.

It is doubtful if any of the Cretaceous species of *Barbatia* belong to the typical subgenus, although they may be closely related. *Barbatia fractura* Wade (U. S. Geol. Survey Prof. Paper 137, 1926, p. 46, pl. 10, figs. 9-11), from the Upper Cretaceous of Tennessee, belongs to the subgenus *Cucullaearca* Conrad.

In the Eocene, species appeared which are unhesitatingly assigned to *Barbatia s. s.;* for example, *B. rigaulti* (Deshayes) from the Bartonian, lower upper Eocene, of the Paris Basin (Cossmann and Pissarro, Icon. Compl. des Coq. Foss. de l'Éoc. des Env. de Paris, vol. 1, 1904-1906, pl. 36, fig. 110-37).

There appear to be few records of *Barbatia* from Oligocene beds, but the Miocene to Recent occurrences are plentiful; at present the genus is widely distributed in all of the warm and temperate seas, and in number of described species it is exceeded only by *Anadara.*

Lissarca Smith (Transit of Venus Exp., Zoology, Mollusca, 1877, p. 19), which was thought by Dall to be related to *Barbatia,* has been placed in the Limopsidae by Suter (Man. New Zealand Moll., 1913, p. 854), where it probably belongs. The type species of *Lissarca* is « *Arca* » *(Lissarca) rubro-fusca* Smith (*op. cit.*, p. 19, pl. 9, fig. 17), a Recent species from Kerguelen Island. The original description of this genus has been inaccessible to me, and I have seen no specimens of the type species. Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 616) grouped *Lissarca* as a section of *Barbatia;* Lamy (Jour. de Conch., vol. 55, n° 1, 1907, p. 9) placed *Lissarca* as a subgenus of *Arca,* but followed Dall in recognizing its relation to *Barbatia;* Lamy observed that it is distinguished from *Barbatia* by the sub-

terminal position of the beaks and the absence of radial sculpture. Only a few species have been assigned to *Lissarca*. Recent species have been reported from the Shetland Islands, New Zealand, Kerguelen Islands, and Tasmania. *Lissarca* has also been reported from the Tertiary of Victoria (18) and of New Zealand (19).

Subgenus SOLDANIA de Stefani and Pantanelli, 1878.

Soldania de Stefani and Pantanelli, Bull. Soc. Mal. Ital., vol. 4, 1878, p. 38; type species (by monotypy) : *Arca mytiloides* Brocchi (Conchiologia Fossile Subapennina, vol. 2, 1814, pp. 477-478, pl. 11, figs. 1 a-b) from the Pliocene of Italy.

This subgenus, characterized by its obsolete radial sculpture and by the extremely wide, edentulous gap in the hinge, has been reported, to my knowledge, only from the Pliocene of Europe. On a specimen in the Stanford University paleontological type collection (n° 5332) the posterior teeth are granular and quite irregular whereas the front teeth, although small, are fairly regular.

Subgenus CALLOARCA Gray, 1857.

Pl. I, figs. c, c'.

Calloarca Gray, Ann. Mag. Nat. Hist., 2 ser., vol. 19, 1857, p. 369; type species (by monotypy) : *Byssoarca alternata* Sowerby (Proc. Zool. Soc. London, pt. 1, 1833, p. 17), Recent, from western Colombia.

« *Byssoarca* » *alternata* has been well figured in exterior view by Maury (Palaeont. Amer., vol. 1, n° 4, 1922, pl. 2, fig. 11). The hinge of this species is similar to that of *Barbatia (Calloarca) leonensis* Mansfield (Florida State Geol. Survey, Bull. 8, 1932, pp. 42-43, pl. 5, figs. 1, 3, 5) from the Miocene of Florida. Examination of specimens of « *Byssoarca* » *alternata* has convinced me that *Calloarca* should be retained as a subgenus of

(18) *Lissarca cincturata* Chapman and Crespin, Rec. Geol. Survey Victoria, vol. 5, pt. 1, 1928, p. 97.

(19) *Lissarca fossilis* Marwick, Trans. Proc. New Zealand Inst., vol. 58, 1928, pp. 442, 496, figs. 24, 25.

Barbatia and not reduced to a synonym of *Acar* as was done by Gardner (U. S. Geol. Survey Prof. Paper 142-A, 1926, p. 26), because, as Mansfield has pointed out (*op. cit.*, p. 43), « *B* » *alternata* has a different type of sculpture from *Acar*, and an edentulous gap in the hinge. It also lacks the elevated muscle scars of *Acar*.

In addition to « *B* » *alternata*, the type species, and *Barbatia leonensis* Mansfield, *Calloarca* includes *Barbatia* «(*Cucullaria*)» *taeniata* Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 631, pl. 25, figs. 1, 1a) from the Pliocene of Florida, and *Barbatia (Calloarca) phalacra* Dall (*op. cit.*, p. 626, pl. 33, fig. 3) from the Chipola formation, Miocene, of Florida. « *Byssoarca* » *lurida* Sowerby (Proc. Zool. Soc. London, pt. 1, 1833, p. 19), a Recent species originally described from Ecuador, belongs to *Calloarca*, although it resembles the type less than the other species mentioned.

The name *Calloarca* was used incorrectly by Dall (1898) and by several subsequent workers to refer to species which actually belong to the subgenus *Cucullaearca* Conrad; some details of this usage are given under the discussion of *Cucullaearca*.

Calloarca resembles *Acar* Gray in that the ligamental area is wide in front and tapers to a point in the rear; a further resemblance is that the ligamental area is mainly, though not entirely, confined to the posterior of the beaks. However, *Calloarca* differs from *Acar*, as stated, by lacking reticulate sculpture and elevated muscle scars and by the edentulous gap in the hinge.

Subgenus ACAR Gray, 1857 (20).

Pl. II, figs. f, f'.

Acar Gray, Ann. Mag. Nat. Hist., ser. 2, vol. 19, 1857, p. 369; type species : *Arca gradata* Broderip and Sowerby (Zool. Jour., London, vol. 4, 1829, p. 365), Recent, from the west coast of Mexico; type by subsequent designation of Woodring (Carn. Inst. Washington, Pub. 366, 1925, p. 36). Figured by

(20) *Daphnoderma* (Poli) Mörch (Catalogus Conchyliorum quae reliquit D. Alphonso d'Aguirra & Gadea Comes de Yoldi, Fasc. 2, 1853, p. 40) antedates *Acar* Gray, and may have to replace it. Inasmuch as I have not seen Poli's work, this question is here left open. Mörch includes two species in *Daphnoderma: Arca domingensis* Lamarck and *A. angulata* Meuschen, both of which belong to the group called *Acar*.

Bartsch (Proc. U. S. Nat. Mus., vol. 80, Art. 9, 1931, pl. 1, five top figures).

Acar has existed from Danian (Upper Cretaceous or Paleocene) to the present time; today it is world-wide in distribution, in warm seas. Apparently the oldest reported species is *Barbatia (Acar) forchhammeri* (Lundgren), which is listed from the Danian of Faxe, Denmark (Ravn, Mém. de l'Acad. Roy. des Sci. et des Lettres de Danemark, Sect. des Sci., 9 sér., t. 5, n° 2, 1933, pp. 12-13). Another early species is « *Arca* » *(Acar) lamellosa* Deshayes (Cossmann and Pissarro, Icon. Compl. des Coq. Foss. de l'Éoc. des Env. de Paris, vol. 1, 1904-1906, pl. 35, figs. 110-5), from the Thanetian, Lutetian, and Bartonian of the Paris Basin. *Acar* was also living in southeastern United States during later Eocene, as Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 629) reports *Barbatia (Acar) reticulata* (Gmelin) from the Jacksonian Eocene at Jackson, Mississippi. In the Oligocene *Acar* is represented by « *Arca* » *lamellosa* Deshayes, var.? (von Koenen, Abh. zur geol. Specialkarte von Preuss. und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1086-1088, pl. 72, figs. 8-10) from Germany. This subgenus is also present in the so-called Oligocene of Washington, where an undescribed species is found in the Gries Ranch beds. The Miocene, Pliocene, and Pleistocene occurrences of this subgenus are fairly common, corresponding in general with its present distribution.

Bartsch may be correct in his proposal (Proc. U. S. Nat. Mus., vol. 80, Art. 9, 1931, p. 1) to elevate *Acar* to generic rank; but for the present, in order to emphasize its similarity to *Barbatia*, it is retained here as a subgenus of *Barbatia*.

Acar is distinguished by its reticulate sculpture, compact, quadrate form, raised muscle scars, and by its ligament being mainly restricted to the posterior of the umbones, resembling *Obliquarca* in this last respect.

Subgenus OBLIQUARCA Sacco, 1898.

Pl. II, figs. d, d'.

Obliquarca Sacco, I Molluschi dei Terreni Terziarii del Piemonte e della Liguria, pt. 26, 1898, p. 16; type species (by original designation): *Arca modioliformis* Deshayes (Descrip. des Coq. Foss. de Paris, vol. 1, 1831, p. 214, pl. 32, figs. 5, 6) from the Eocene of the Paris Basin.

« *Arca* » *modioliformis* was figured by Cossmann and Pissarro (Icon. Compl. des Coq. Foss. de l'Éoc. des Env. de Paris, vol. 1, 1904-1906, pl. 36, figs. 110-38). These figures, together with the description of Deshayes (Anim. sans Vert., Bas. Paris, vol. 1. 1860, pp. 896-897), show that the most striking feature about the species is that the ligamental area is restricted to the part of the dorsal margin posterior to the umbo. This feature has been observed also on specimens of this species in the Schenck Collection, Stanford University (n° 857). The ligamental grooves, which are clearly visible on the posterior part of the dorsal margin, stop on reaching the umbo, and the anterior dorsal margin is perfectly smooth and flat. In this respect *Obliquarca* is similar to *Porterius* Clark (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 15, n° 4, 1925, p. 79) which differs, however, in that the posterior teeth of *Porterius* are arranged horizontally, whereas those of *Obliquarca* are set obliquely, as in *Barbatia*.

Obliquarca is well represented in the Eocene by several species in addition to the type; for example, the following: *Barbatia marceauxi* (Deshayes), *B. striatularis* (Deshayes), *B. distans* (Deshayes) (21) from the Paris Basin, and by *B. morsei* Gabb from the Domengine formation, Eocene, of California. *Obliquarca* is also probably represented in the Oligocene of north Germany, as « *Arca* » *decussata* Nyst (von Koenen, Abh. zur geol. Specialkarte von Preuss. und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1104-1107, pl. 70, figs. 11-14) appears to be close to *Obliquarca*, although it may belong to *Porterius*. Von Koenen's fig. 14b, showing a small specimen, especially resembles *Porterius*.

Obliquarca was recognized in the Miocene of Jamaica by Woodring (Carn. Inst. Washington, Pub. 366, 1925, pp. 38-40), who described three species from Bowden. Although these species belong to *Obliquarca*, they differ from the type by lacking the central nearly edentulous gap in the hinge.

That *Obliquarca* or at least a closely related group is present in the Recent fauna is shown by specimens in the Oldroyd Collection, Stanford University (n° 360, labelled « *Arca barbata* Linné »), from Key West, Florida. The hinge on these Recent specimens is similar to that of *Barbatia modioliformis* (Deshayes), and the ligament is present only posterior to the umbones. *B. modioliformis* differs mainly by having its umbones

(21) These species are figured by Cossmann and Pissarro, *op. cit.*, pl. 36.

placed slightly more anteriorly than are those of the Recent species. Sheldon (Palaeont. Amer., vol. 1, n° 1, 1917, pl. 2, figs. 5-7) has figured the same species as « *Arca barbata* Linné », her figure 7 showing the arrangement of the ligament. Although I do not know the name of this species, it is clearly not *Barbatia barbata* (Linné). It is probably a variety of *Barbatia fusca* (Bruguière) (Dict. Ency. Méth., 1, 1792, p. 102, n° 10).

In addition, *Barbatia alfredensis* Bartsch (U. S. Nat. Mus. Bull. 91, 1915, p. 182, pl. 46, figs. 9, 10), a Recent species from South Africa, seems to be related to *Obliquarca*. Judging from Bartsch's fig. 10, the ligament is confined to the posterior of the beaks, and this species resembles *Obliquarca* in other respects, except that the beaks are not placed so far anteriorly as in the type species.

Subgenus CUCULLAEARCA Conrad, 1865.

Pl. II, fig. e.

Cucullaearca Conrad, Amer. Jour. Conch., vol. 1, 1865, p. 11; type species: *Byssoarca lima* Conrad (Proc. Acad. Nat. Sci. Philadelphia, vol. 3, 1847, p. 295; Jour., 2 ser., vol. 1, pt. 2, 1848, p. 125, pl. 13, fig. 23) from the Oligocene of Vicksburg, Mississippi; type by subsequent designation (Stoliczka, Palaeont. Indica, vol. 3, 1871, p. 340).

« *Lithoarca* Gray ». Mörch, Catalogus Conchyliorum quae reliquit D. Alphonso d'Aguirra & Gadea, Comes de Yoldi, Fasc. 2, 1853, p. 40; several species listed, including *Arca velata* Sowerby. (Not *Litharca* Gray, 1842.)

Polynema Conrad, *in* Kerr, « Geology of North Carolina », vol. 1, 1875, App. A, p. 4; type species (by monotypy): *Barbatia lintea* Conrad (Kerr, 1875, App. A, p. 4, pl. 1, fig. 12) from the upper Cretaceous of Snow Hill, Green County, North Carolina.

Not *Polynema* Haliday, Entom. Mag., vol. 1, n° 3, App., 1833, p. 269.

« *Calloarca* Gray ». Dall, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, pp. 615, 623; called the « Group of *Arca candida* Gmelin ». (Not *Calloarca* Gray, 1857).

« *Plagiarca* Conrad ». Gardner, U. S. Geol. Survey Prof. Paper 142-A, 1926, p. 26 (in part). (Not *Plagiarca* Conrad, 1875).

Dall (1898, p. 624) considered « *Byssoarca* » *lima* Conrad, the type species of *Cucullaearca,* to be a synonym of the Eocene « *Arca* » *cuculloides* Conrad, which has been figured by Sheldon (Palaeont. Amer., vol. 1, n° 1, 1917, pl. 2, figs. 8-12) ; I have compared Sheldon's figures with the original figure of « *Arca* » *lima,* and whether the two are conspecific or not, they are very similar.

Stoliczka (Palaeont. Indica, vol. 3, 1871, p. 340) pointed out the similarity of *Cucullaearca* to *Barbatia* of the *B. velata* type, but did not see the distinction from true *Barbatia. Cucullaearca*, however, comprises a clearly recognizable group, characterized by a large byssal gape, a wide, grooved ligamental area which usually separates the anterior teeth widely from the posterior ones, a widened posterior end, and a fairly heavy shell. Although Dall recognized this group as distinct from *Barbatia s. s.,* he incorrectly referred to it under the name « *Calloarca* — the group of *Arca candida* Gmelin ». Actually, however, « *Arca* » *candida* belongs to *Cucullaearca,* not to *Calloarca,* the type species of which is *Byssoarca alternata* Sowerby, 1833. This misconception as to the type species of *Calloarca* has been the cause of the erroneous suppression of *Cucullaearca* and the incorrect use of the name *Calloarca.* It is thus seen that *Cucullaearca* includes most of the species called *Calloarca* by Dall (1898) and Maury (Palaeont. Amer., vol. 1, n° 4, 1922, pp. 13-18).

Polynema Conrad is based upon *Barbatia lintea* Conrad, which has been well figured by Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, pl. 21, figs. 6-10). His figs. 7 and 8 show a mature specimen which does not differ in important respects from the type species of *Cucullaearca,* and I consequently see no basis for recognizing *Polynema* as distinct. Furthermore, the name *Polynema* is preoccupied.

Cucullaearca is represented in the upper Cretaceous by several species, including *Barbatia fractura* Wade (U. S. Geol. Survey Prof. Paper 137, 1926, p. 46, pl. 10, figs. 9-11) from the Ripley formation of Coon Creek, Tennessee. It is represented in the Eocene by numerous species, such as *Barbatia cliffensis* Hanna (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 16, n° 8, 1927, p. 272, pl. 26, figs. 1-6) from the upper middle Eocene of California ; and *Barbatia morlieri* (Deshayes) (Cossmann and Pissarro, Icon. Compl. des Coq. Foss. de l'Éoc. des Env. de Paris, vol. 1, 1904-1906, pl. 35, fig. 110-8) from the upper Eocene of the Paris Basin. *Cucullaearca* occurs in the Oligocene, as in addition

to the type species, « *Byssoarca* » *lima* from the Vicksburgian Oligocene, it includes « *Arca* » *rustica* von Koenen (Abh. zur geol. Specialkarte von Preuss. und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1088-1090, pl. 71, figs. 1-3) from the lower Oligocene of Lattorf, Germany. This species was renamed *Arca kokeni* by von Koenen (*op. cit.*, Bd. 10, Heft 7, 1894, pp. 1416-1417).

At the present time *Cucullaearca* is widely distributed in warm seas, a characteristic example being *Barbatia velata* (Sowerby) (Proc. Zool. Soc. London, pt. 1, 1833, p. 18), a Recent species originally described from the Lord Hood and Chain Islands, north of Australia.

Subgenus GRANOARCA Conrad, 1862.

Granoarca Conrad, Proc. Acad. Nat. Sci. Philadelphia, vol. 14, 1862, p. 290; type species (by monotypy) : *Arca propatula* Conrad (Proc. Acad. Nat. Sci. Philadelphia, vol. 1, 1843, p. 323; figured by Conrad, « Fossils of the medial Tertiary of the United States », 1845, pl. 32, fig. 1) from the upper Miocene of Virginia.

Pectinatarca Sacco, I Molluschi dei Terreni Terziarii del Piemonte e della Liguria, pt. 26, 1898, p. 26; type species (by original designation) : *Arca pectinata* Brocchi (Conchiologia Fossile Subapennina, vol. 2, 1814, pp. 476-477, pl. 10, figs. 15 a-b) from the Pliocene of Italy; also figured by Sacco, *op. cit.*, pl. 5, figs. 22-25.

Because of its *Barbatia*-like form and byssal gape — which, although slight, is nevertheless present — *Granoarca* has in the past always been grouped as a subdivision of *Barbatia* (22) where it appears to belong, although in dentition, external sculpture, and thickness of shell it is similar to *Anadara*, as shown by plesiotypes 5354-5356 in the Stanford University paleontological type collection. No matter with which group it is classified, *Granoarca* seems to represent, as stated by Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 628), an intermediate form between *Barbatia* and *Anadara*.

(22) Conrad, Proc. Acad. Nat. Sci. Philadelphia, vol. 14, 1862, p. 290. Dall, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 615. Sheldon, Palaeont. Amer., vol. 1, n° 1, 1917, p. 18 (*Arca propatula* is there placed in the subgenus *Barbatia*). Mansfield, Florida State Geol. Survey, Bull. 8, 1932, pp. 43-44.

Mansfield includes in *Granoarca, Barbatia (Granoarca) propatula,* var. *busana* Harris (Mansfield, Florida State Geol. Survey, Bull. 8, 1932, p. 44, pl. 3, figs. 2, 4, 6) from the upper Miocene of Florida, and *Arca campyla* Dall (*op. cit.,* pp. 644-645, pl. 31, figs. 3-4; pl. 32, fig. 22) from the Pliocene of Florida, but the last species does not seem very close to the type.

Pectinatarca Sacco has for its type species « *Arca* » *pectinata* Brocchi from the Pliocene of Italy. Through the courtesy of L. R. Cox a specimen of this species has been available to me. Judging from this specimen as well as from the figures of Sacco and Brocchi, there can be little doubt that « *Arca* » *pectinata* belongs to the same group as *Barbatia (Granoarca) propatula;* the Italian species is similar in form and ornamentation, and has the small byssal gape characteristic of *Granoarca,* although Cossmann and Peyrot (Conch. néogénique de l'Aquitaine, vol. 2, 1912, p. 141) state, in regard to this last point : « vraisemblablement pas de byssus à cause de la régularité de la coquille ». However, the byssal gape of *Barbatia propatula* is also difficult to detect, and the shell likewise appears fairly regular. A careful examination leaves little doubt as to the presence of a byssal gape on both *B. propatula* and *B. pectinata.*

Subgenus PUGILARCA Marwick, 1928.

Pugilarca Marwick, Trans. Proc. New Zealand Inst., vol. 58, 1928, p. 441; type species (by original designation) : *Barbatia barneaformis* Marwick (*op. cit.,* pp. 441, 494, figs. 2, 3) from the Tertiary of Chatham Islands, Australia.

Although proposed as a subgenus of *Barbatia, Pugilarca* appears to be closer to *Acar,* resembling it in general form, sculpture, and character of ligamental area. The hinge of *Pugilarca* differs in lacking central teeth, whereas in *Acar* there is usually little, if any, interruption in the dentition. Marwick's mention (p. 441) of the smooth valve-margins of *Pugilarca* carries very little weight, however, because in some specimens of *Barbatia (Acar) gradata* (Broderip and Sowerby) the valve-margins are also smooth, not crenulated. One point of uncertainty is the adductor muscle scars. Marwick does not state whether or not *Barbatia barneaformis* has the raised muscle scars which characterize *Acar,* and his figures do not settle this question.

Subgenus PLAGIARCA Conrad, 1875.

Plagiarca Conrad *in* Kerr, « Geology of North Carolina », vol. 1, 1875, App. A., p. 4; type species (by monotypy) : *Barbatia carolinensis* Conrad *(op. cit.,* App. A., p. 4, pl. 1, fig. 11) from the Ripley formation, upper Cretaceous, North Carolina.

The type species of this subgenus has been well illustrated by Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, pl. 22, figs. 1-6). *Plagiarca* seems to be close to *Barbatia s. s.* but has heavier radial ribs, in this respect approaching *Anadara*. « *Arca* » *rhomboidella* Lea (23) and « *A.* » *vaughani* Casey, as figured by Sheldon (Palaeont. Amer., vol. 1, n° 1, 1917, pl. 7, figs. 7, 8, 11), from the Claiborne Eocene of Alabama, somewhat resemble *Plagiarca* and appear to belong to this subgenus, as does the upper Cretaceous species *Arca mcnairyensis* Wade (U. S. Geol. Survey Prof. Paper 137, 1926, p. 46, pl. 10, figs. 3, 6). *Plagiarca* thus appears to range from Upper Cretaceous to Upper Eocene.

Gardner (U. S. Geol. Survey Prof. Paper 142-A, 1926, p. 26), due to a misconception, regarded *Plagiarca* as being equivalent to *Litharca* Gray, as I have stated under the discussion of *Litharca*. *Barbatia marylandica* Conrad and *B. phalacra* Dall, of the Floridan Miocene, cannot be included in *Plagiarca* as was done by Gardner (*loc. cit.*). *B. marylandica* belongs to *Cucullaearca* Conrad, and *B. phalacra* to *Calloarca* Gray.

Genus ARCOPSIS von Koenen, 1885.

Subgenus Arcopsis *s. s.*

Pl. III, figs. g, g'.

Arcopsis von Koenen, Abh. König. Gesel. der Wiss., Göttingen, Physikal. Classe, 32 Band, 2 Theil, 1885, p. 86; type species (here designated) : *Arca limopsis* von Koenen (24) *(op. cit.,*

(23) Represented in Stanford University paleontological collection by topotype 5311.

(24) Von Koenen evidently proposed *Arcopsis* for his new species, *Arca limopsis*, but he did not designate a type. His inclusion of *Arca lactea* Linné in *Arcopsis* makes the present type designation necessary.

pp. 85-86, pl. 4, figs. 12 a-e) from the Paleocene of Copenhagen.

Fossularca Cossmann, Cat. Ill. des Coq. Foss. de l'Éoc. des Env. de Paris, Ann. Soc. Roy. Malac. Belgique, 4 sér., vol. 2, 1887, p. 138; type species (by original designation) : *Arca quadrilatera* Lamarck (Ann. Mus. Hist. Nat. Paris, vol. 6, 1805, p. 221; figured in vol. 9, 1807, pl. 19, figs. 1 a-b) (25) from the upper Eocene of the Paris Basin.

It is unfortunate that the well-known name *Fossularca* must be replaced by *Arcopsis* which, due probably to the obscure way in which it was proposed, has been almost entirely overlooked. Vincent, however (Mém. du Mus. Roy. d'Hist. Nat. de Belgique, Mém. 46, 1930, p. 71), has shown *Arcopsis* to have priority. A comparison of the type species of *Arcopsis* with that of *Fossularca* leaves no doubt that this conclusion is correct.

Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, p. 109) suggested that *Fossularca* was probably to be considered a synonym of *Striarca* Conrad, this suggestion being based upon a certain similarity between the type species of *Striarca* and « *Fossularca* » *adamsi* (Smith), which he mistakenly regarded as the type of *Fossularca*. However, « *Fossularca* » *adamsi* (which has been well figured by Gardner, U. S. Geol. Survey Prof. Paper 142-A, 1926, pl. 5, figs. 1-4), although superficially similar, nevertheless appears to me distinct from the type species of *Striarca*. « *F.* » *adamsi* possesses the small, triangular ligamental pit and the dentition interrupted in the center, characteristic of *Arcopsis* (= « *Fossularca* »), and should therefore be retained in the genus *Arcopsis*. In *Striarca* the ligamental area is comparatively large and transversely striated.

The oldest occurrence of *Arcopsis* seems to be that reported by Ravn who described two species from the Danian of Faxe, Denmark; at least one of these species, « *Barbatia* » *(Arcopsis) brünnichi* Ravn, is a true *Arcopsis* (Ravn, Mém. de l'Acad. des Sci. et des Lettres de Danemark, Sect. des Sci., 9 sér., t. 5, n° 2, 1933, pp. 13-14, pl. 1, figs. 3 a-b, 4 a-b). For reasons given in an earlier paper this author assigns the Danian to the Upper Cretaceous, rather than to the Eocene (Ravn, Mus. de Minéral. et Géol. de l'Univ. de Copenhague, Communications géol., n° 5,

(25) The explanation of plate 19 appears on p. 238, incorrectly labelled « Dix-septième planche ».

1925). If this assignment proves to be correct, the geologic range of *Arcopsis* is Upper Cretaceous to Recent.

Arcopsis is known most abundantly from the Eocene, being recognized in the United States, France, and New Zealand (26) ; it is also present in the Oligocene of Germany (27). The later species of *Arcopsis* include *Arcopsis adamsi* (Smith) which has existed in the West Indies and southeastern United States from Miocene to Recent, and *Arcopsis solida* (Sowerby) (Proc. Zool. Soc. London, pt. 1, 1833, p. 18) from tropical wes ern America.

Ovalarca Woodring (Carn. Inst. Washington, Pub. 366, 1925, p. 52), the type species of which is « *Arca* » *ovalina* Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 630., pl. 32, fig. 18), from the Miocene of Bowden, Jamaica, was proposed as a subgenus of *Fossularca; Ovalarca,* however, seems more properly to belong to the family Limopsidae.

Subgenus SCAPULARCA Cossmann and Peyrot, 1912.

Scapularca Cossmann and Peyrot, Conch. néogénique de l'Aquitaine, vol. 2, 1912, p. 192; type species (by original designation) : *Arca scapulina* Lamarck (Ann. Mus. Hist. Nat. Paris, vol. 6, 1805, p. 221; figured in vol. 9, 1807, pl. 18, figs. 10 a-b) (28) from the upper Eocene of the Paris Basin.

This subgenus includes several species from the Eocene of France, but I have not seen it reported from elsewhere. *Scapularca* resembles *Arcopsis* in dentition and ligamental area, but differs in being more inequilateral in shape and in possessing stronger radial ribs. Specimens of *Arcopsis (Scapularca) globosa* (Deshayes), n^{os} 854 and 862 in the Schenck collection at Stanford University, show, on both valves, a small raised flange bordering each muscle scar, just behind the anterior scar and in front of the posterior scar. Similar flanges are likewise present

(26) « *Fossularca* » *januaria* Marwick (Trans. Proc. New Zealand Inst., vol. 56, 1926, pp. 310-311, pl. 72, figs. 1, 5) from the Waiarekan stage of the Oamaru Series, the age of which is stated to be either upper Eocene or Oligocene.

(27) « *Fossularca* » *pretiosa* (Deshayes) (von Koenen, Abh. zur geol. Specialkarte von Preuss. und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1109-1111, pl. 73, figs. 1-3).

(28) The explanation of plate 18 appears on pp. 237-238, incorrectly labelled « Seizième planche ».

on three species of *Arcopsis s. s.* in the Stanford University collections, but do not seem to be developed on the type species. *Scapularca* was considered a subgenus of *Trigonodesma* (one of the Noetiinae) by Glibert (Mus. Roy. d'Hist. Nat. de Belgique, Mém. 53, 1933, p. 123). Because of its closer resemblance to *Arcopsis* in many respects, however, *Scapularca* is here retained under *Arcopsis*.

Arcopsis scapulina and other species of *Scapularca* were called *Anadara* by Cossmann and Pissarro (Icon. Compl. des Coq. Foss. de l'Éoc. des Env. de Paris, vol. 1, 1904-1906, pl. 36, figs. 110-45 to 110-48).

Genus STRIARCA Conrad, 1862.

Striarca Conrad, Proc. Acad. Nat. Sci. Philadelphia, vol. 14, 1862, p. 290; type species (by monotypy): *Arca centenaria* Say (Jour. Acad. Nat. Sci. Philadelphia, vol. 4, pt. 1, 1824, p. 138-139, pl. 10, fig. 2) from the Miocene of eastern United States.

Breviarca Conrad, Proc. Acad. Nat. Sci. Philadelphia, 1872, p. 55; type species: *Trigonarca saffordi* (Gabb) Conrad *(op. cit.*, pl. 2, fig. 3); type by subsequent designation, Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 86, footnote). Ripley formation, upper Cretaceous, Hardeman County, Tennessee.

Galactella Cossmann and Peyrot, Conch. néogénique de l'Aquitaine, Tome 2, 1912, p. 192; type species (by original designation): *Arca lactea* Linné (Syst. Nat., ed. 10, 1758, p. 694), a Recent species, the type locality of which is the Mediterranean Sea. Figured by Bucquoy, Dautzenberg, and Dollfus (Mollusques Marins du Roussillon, tome 2, Pelecypoda, Fascicule 5, 1891, pl. 37, figs. 1-5).

The type species of *Breviarca* has been well figured by Wade (U. S. Geol. Survey Prof. Paper 137, 1926, pl. 10, fig. 14, pl. 11, figs. 1, 2). The similarity between *Striarca* and *Breviarca* was pointed out by Gardner *in* Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, p.109). A comparison of « *Arca* » *centenaria* and « *Trigonarca* » *saffordi* leads me also to the conclusion that these two species are congeneric, as they were considered by Stephenson.

A comparison of « *Fossularca (Galactella)*» *lactea* (Linné) (29) (the type species of *Galactella*) with *Striarca centenaria* shows such a striking similarity between the two that *Galactella,* which had been proposed as a subgenus of *Fossularca,* is here regarded as a synonym of *Striarca,* which it more closely resembles.

In addition to its distinctive form, *Striarca* is characterized by a raised flange bordering the inner side of both the anterior and posterior adductor muscle scars. Its geologic range seems to be Upper Cretaceous to Recent.

Genus BATHYARCA Kobelt, 1891.

Subgenus Bathyarca *s. s.*

Pl. III, fig. h.

Bathyarca Kobelt, Systematisches Conchylien-Cabinet von Martini und Chemnitz, vol. 8, pt. 2, 1891, Die Gattung Arca L., pp. 213-214; type species (by original designation) : *Arca pectunculoides* Scacchi (Not. Conch. foss. Gravina *in* Ann. Civ. due Sisil., vol. 7, 1833, p. 82), a Recent species widespread in European seas. Figured by Kobelt (Conch. Cab., *Arca,* 1891, pl. 49, figs. 8, 9).

The synonymy and distribution of *Bathyarca pectunculoides* (Scacchi) are given by Lamy (Jour. de Conch., vol. 55, n° 3, 1907, pp. 278-281). This species has been reported from European waters, from the Mediterranean to as far north as Norway, often living in deep water. Other species which have been referred to *Bathyarca* are given by Verrill and Bush (Proc. U. S. Nat. Mus., vol. 20, n° 1139, 1898, pp. 842-843) ; these increase the distribution of this genus to world-wide extent, but a critical study of these species would be necessary in order to determine how many actually should be grouped as *Bathyarca*. For example, « *Arca* » *glacialis* Gray (Parry's First Voyage, Supp. to App., 1824, p. 244), though related, can hardly be a typical *Bathyarca* as it differs in important respects from *B. pectunculoides.*

Although Dall reported this genus from the Eocene (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 619) he did not mention any species, and I have not found a definite record of *Bathyarca* from strata older than Oligocene. *Bathyarca* is repre-

(29) Syst. Nat., ed. 10, 1758, p. 694. Specimens of this species are in the Oldroyd Collection, Stanford University, n° 355.

sented in the lower Oligocene of Germany by « *Arca* » *saxonica* von Koenen (Abh. zur geol. Specialkarte von Preuss. und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1107-1109, pl. 73, figs. 9-12). In addition, *Bathyarca hendersoni* (Dall) (*op. cit.*, p. 653, pl. 33, fig. 9), which was also figured by Woodring (Carn. Inst. Washington, Pub. 366, 1925, pl. 6, figs. 1-3), from the Miocene of Bowden, Jamaica, appears to be a true *Bathyarca*.

Subgenus BENTHARCA Verrill and Bush, 1898.

Bentharca Verrill and Bush, Proc. U. S. Nat. Mus., vol. 20, n° 1139, 1898, p. 842, footnote; type species (by original designation) : *Macrodon asperula* Dall (Bull. Mus. Comp. Zool., Harvard College, vol. 9, 1881, pp. 120-121; *op. cit.*, vol. 12, 1885-1886, pp. 244-245, pl. 8, figs. 4, 4a), a Recent species from the Gulf of Mexico.

Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 616) considered *Bentharca* to be inseparable from *Cucullaria* Conrad (type species: « *Arca* » *heterodonta* Deshayes). Verrill and Bush (*op. cit.*, p. 842) associated their new genus with « *Arca* » *adversidentata* Deshayes from the Eocene of the Paris Basin, which *Bentharca* does indeed resemble in hinge structure although not in other respects.

Bentharca appears clearly to be related to *Bathyarca*, differing in being more inequilateral, and in having horizontal posterior teeth and short, transverse anterior ones. The type species is from the Gulf of Mexico and the West Indies, living in deep water (1000 to 1500 fathoms). « *Arca (Macrodon)* » *dalli* Smith (Rep. H. M. S. Challenger, Zool., vol. 13, 1885, p. 269, pl. 17, figs. 10-10b), from a depth of 50 fathoms, off Kobé, Japan, may belong to *Bentharca* (30), but it is not very similar to the type species. I have not seen *Bentharca* reported as a fossil.

(30) This species was recently assigned to *Pseudogrammatodon* Arkell (Geol. Mag., London, vol. 67, n° 793, 1930, p. 307), the type species of which is the Eocene *Arca adversidentata* Deshayes. This assignment, however, appears questionable.

Subgenus MICROCUCULLAEA Iredale, 1929.

Microcucullaea Iredale, Rec. Australian Mus. Sydney, vol. 17, 1929, p. 159; type species (by original designation) : *Bathyarca perversidens* Hedley (Australian Mus. Mem. 4, vol. 1, pt. 5, 1902, p. 298, text fig. 45), Recent, from New South Wales.

Topotypes n° 1505, Oldroyd Collection at Stanford University, show the small flanges, one just in front of the posterior muscle scar and one behind the anterior scar, which separate this group from *Bathyarca* and which probably are the basis for Iredale's conjecture (*loc. cit.*) that *Microcucullaea* is a dwarfed relative of *Cucullaea*. This conjecture is extremely interesting, but for the present, due to its close resemblance to *Bathyarca, Microcucullaea* is placed as a subgenus of *Bathyarca.*

Only two species of *Microcucullaea* are definitely known to me: the type and *B. (M.) adelaideana* (Iredale) *(loc. cit.),* both from southern Australia. Depths reported for these species range from 40 to 100 fathoms. Marwick (Geol. Survey New Zealand, Pal. Bull. 13, 1931, pp. 56-57, pl. 3, figs. 36-37) describes two species (*Microcucullaea pectinata* and *M. crenulifera*) from the Tertiary of New Zealand, but inasmuch as the hinge and interior of his specimens are not preserved, it appears impossible to refer them with any certainty to *Microcucullaea,* although they seem to belong to the genus *Bathyarca.*

Genus TRISIDOS Bolten, 1798.

Trisidos Bolten, Museum Boltenianum, 1798, p. 175; type species (by monotypy) : *Arca tortuosa* Linné (Syst. Nat., ed. 10, 1758, p. 693), a Recent species living in the Indo-Pacific region. Figured by Reeve (Conch. Icon., vol. 2, 1844, *Arca,* pl. 13, fig. 86).

Trisis Oken, Lehrbuch d. Naturgesch., 3 Teil., Zoologie, 1 Abt., Fleischlose Thiere, Leipzig, 1815, p. 236 (*fide* Herrmannsen, Ind. Generum Malacozoorum, vol. 2, 1847, p. 604) ; type species: *Arca tortuosa* Linné, 1758.

Parallelepipedum (Klein) Mörch, Catalogus Conchyliorum quae reliquit D. Alphonso d'Aguirra & Gadea Comes de Yoldi, Fasc. 2, 1853, p. 40. Several species listed, including *Arca semitorta* Lamarck.

Arca tortuosa was designated the type species of *Arca* by Children in 1823 (Lamarck's Genera of Shells, p. 46), as was noticed by Cox (Paleont. Zanzibar, 1927, p. 93). This peculiarly twisted species of *Arca* was accordingly considered the type of the genus until 1930 when Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, p. 83) pointed out that in 1817 *Arca antiquata* Linné had been designated the type of *Arca* by Schumacher (Essai Nouv. Syst. Test., 1817, p. 172), and that in 1818 *Arca noae* had been so designated by Schmidt (Versuch. Conch.-Samml., 1818, pp. 65, 178), both of these designations antedating that of Children.

Trisidos has been reported from the upper Eocene of Egypt(31) and from the « Nummulitic group » of India (32). It has also been reported from the Oligocene of Italy (33) and Hungary (34), and from the Miocene of southern France (35) and Burma (36).

An outline of some of the fossil species of *Trisidos* is given by Sacco (1898, p. 27; see footnote 33 for reference). The Recent species of *Trisidos* are restricted to the Red Sea, the Indian Ocean, and the China Sea.

A useful paper on *Trisidos* is the recent one by Makiyama (Venus, vol. 2, n° 6, 1931, pp. 269-277), in which he describes a new species, « *Arca* » *kiyonoi*, and summarizes a good deal of information on *Trisidos*. Examination of Stanford University paratype n° 5548 of this new species shows it to be fairly close to the type of the genus *Trisidos*. It should be mentioned that Makiyama followed Children's designation of *Arca tortuosa* as

(31) *Arca (Parallelepipedum) fajumensis* Oppenheim, Palaeontographica, vol. 30, Abt. 3, 1906, pp. 212-214.

(32) D'Archiac and Haime, Anim. Foss. du Groupe Nummulitique de l'Inde, 1853, p. 263.

(33) *Arca (Parallelepipedum) isseli* Rov., Stefanini, Atti dell'Accademia Scientifica Veneto-Trentino-Istriana, anno VIII (1915), p. 9, pl. 5, fig. 3 (an inadequate illustration of a poorly-preserved specimen).

Parallelepipedum kurracheense, var. *italica* Sacco (I Molluschi dei Terreni Terziarii del Piemonte e della Liguria, pt. 26, 1898, p. 27, pl. 6, fig. 6), from the Tongrian, is a true *Trisidos*.

(34) *Parallelepipedum schafarziki* Ferenc and Horusitzky, Földrazi Közlemények, Budapest, 57, 1927, pp. 63, 144.

(35) Davies reports (Proc. Geologists' Assn., vol. 40, 1929, p. 322) that a « *Parallelepipedum* » was described by Myer-Eymar from the Vindobonian (middle Miocene) of southern France.

(36) *Parallelepipedum protortuosum* Noetling, Mem. Geol. Survey India, Palaeont. Indica, n. s., vol. 13, 1901, p. 152.

type of *Arca*, and therefore incorrectly considered *Trisidos* a synonym of *Arca s. s.*

Genus SCAPHULA Benson, 1834.

Scaphula Benson, Zool. Jour., London, vol. 5, 1834, pp. 464-465; type species: *Scaphula celox* Benson (Jour. Asiat. Soc. Bengal, vol. 5, 1836, p. 750), a Recent species living in the Jumna River, Burma; type by subsequent designation (Benson, 1836, p. 750). Figured by Blanford (Jour. Asiat. Soc. Bengal, vol. 36, 1867, pl. 3, figs. 14, 15).

The few known species of this unusual little genus inhabit the rivers of Burma, Siam, and India. *Scaphula* seems not to be restricted to fresh water, however, as Stoliczka (Palaeont. Indica, vol. 3, 1871, p. 333) says: « Scaphula, which is generally quoted as a mere fresh-water inhabitant, seems quite as common, if not more common, in the brackish waters of the delta of the Irawadi, as where it occurs in the Ganges near Monghyr, (see Blanford, Jour. As. Soc., Bengal, XXXVI, pt. II, p. 70). »

Apparently no *Scaphula* has ever been identified with certainty as a fossil, although a few fossil species such as the two mentioned below have been assigned to this genus.

« *Barbatia (Scaphula?)* » *austeni* (Forbes) (Woods, Monograph of Cretaceous Lamellibranchia, pt. 1, Palaeont. Soc., vol. 53, 1899, pp. 37-38, pl. 7, figs. 1-3), from the Cretaceous of England, has radial striations and a well-developed ligamental area which distinguish it from *Scaphula*, although it somewhat resembles this genus in form. Judging from a specimen of this species from Atherfield, England (N° L. 16283, British Museum of Natural History), loaned by L. R. Cox, it appears to be an unusually high, strongly carinated species of *Eonavicula*.

« *Arca (Scaphula)* » *convergidens* Gerhardt (Neues Jahrb. für Min., B. Bd., vol. 11, 1897, p. 98, pl. 2, figs. 5 a-c) from the Cretaceous of northern South America, appears to resemble *Cucullaea*, rather than *Scaphula*.

Subfamily ANADARINAE Reinhart, n. subfam.

Ventral margin closed, byssal gape lacking; sculpture consisting of large, regular radial ribs, sculptured with grooves or nodes in most species; surface of shell regularly rounded; liga-

mental area narrow to moderately wide, flat to widely V-shaped when viewed in cross section (with both valves joined); hinge straight or gently arched; teeth regularly diminishing in size from extremities to center, but usually not completely lacking in the center. Inner margin of shell crenulated; beaks never opisthogyrate, pointing either inward or forward. Type genus: *Anadara* Gray, based upon *Arca antiquata* Linné.

Geologic range: Cretaceous to Recent.

Genus ANADARA Gray, 1847.

Subgenus ANADARA *s. s.*

Pl. III, figs. i, i'.

Anadara Gray, Proc. Zool. Soc. London, 1847, p. 198; type species (by original designation): *Arca antiquata* Linné (Syst. Nat., ed. 10, 1758, p. 694). Recent; type locality, « western America » (probably West Indies). Holotype figured by Woodring (Carn. Inst. Washington, Pub. 366, 1925, pl. 4, figs. 1, 2).

Rasia Gray, Ann. Mag. Nat. Hist., ser. 2, vol. 19, 1857, p. 371; type species: *Arca formosa* Sowerby (Proc. Zool. Soc. London, pt. 1, 1833, p. 20), designated by Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 86). Recent, from Gulf of Tehuantepec, Mexico.

Anomalocardia (Klein) Mörch, Catalogus Conchyliorum quae reliquit D. Alphonso d'Aguirra & Gadea Comes de Yoldi. Fasc. 2, Acephala, etc., 1853, p. 41. Type species (by monotypy): *Arca granosa* Linné (Syst. Nat., ed. 10, 1758, p. 694).

Anomalocardia (Klein, 1753) H. & A. Adams, Genera of Recent Moll., vol. 2, 1858, pp. 535-536; type species not designated; *Arca antiquata* Linné cited as an example.

Not *Anomalocardia* Schumacher, Essai Nouv. Syst. Test., 1817, p. 134; type species: *Anomalocardia rugosa* Schumacher (= *Venus flexuosa* Linné).

Diluvarca Woodring, Carn. Inst. Washington, Pub. 366, 1925, p. 40; type species (by original designation): *Arca diluvii* Lamarck (Ann. Mus. Hist. Nat. Paris, vol. 6, 1805, p. 219). Recent, from the Mediterranean Sea.

Anomalocardia Mörch is not subgenerically distinguishable from *Anadara*. *Rasia* was noticed by Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 86) for the first time, apparently, since it was proposed. It may later prove desirable to recognize this group, but at present it seems to differ from *Anadara* by specific — not by subgeneric — distinctions.

Diluvarca has been discussed at length by Grant and Gale (San Diego Soc. Nat. Hist., Mem. vol. 1, 1931, pp. 137-138) who correctly considered it a synonym of *Anadara*, not a subgenus of *Barbatia* as it was first used by Woodring (1925). In 1928 Woodring (Carn. Inst. Washington, Pub. 385, p. 18, footnote) had arrived at the same conclusion later reached by Grant and Gale regarding *Diluvarca*, recognizing that it should be suppressed as a synonym of *Anadara*. *Arca diluviii* Lamarck, the type species of *Diluvarca*, has been figured by Bucquoy, Dautzenberg, and Dollfus (Mollusques Marins du Roussillon, vol. 2, Pelecypoda, Fascicule 5, 1891, pl. 31, figs. 13-17).

The range of *Anadara s. s.* is Oligocene (37) to Recent. This group has been, since the Miocene, one of the most abundant of the Arcidae, occurring in all the warm seas of the world. Its detailed record in the Oligocene is not clear, due to the uncertainty of the Oligocene-Miocene boundary in most parts of the world, but it is represented in the Oligocene of Europe (38) and in the socalled Oligocene of North (39) and South America. «*Arca*»

(37) Von Ihering has described a species of *Anadara* (« *Arca* » *camaronesia*) from Patagonia, occurring in beds which he assigned to the lower Eocene (Ann. Museo Nacional de Buenos Aires, ser. 3, vol. 7, 1907, p. 238, text figs. 9 a-b). The age of the « Patagonian formation » has long been in dispute, but it is now generally regarded as Oligocene or Miocene (Davies, « Tertiary Faunas », 1934, pp. 184-185).

(38) « *Arca* » *sulcicosta* Nyst (von Koenen, Abh. zur geol. Specialkarte von Preuss. und den Thüringischen Staaten, Bd. 10, Heft 5. König. Preuss. geol. Landes., Berlin, 1893, pp. 1097-1100, pl. 70, figs. 1 a-b, 2 a-c) from the Oligocene of Lattorf, Germany, is a true *Anadara;* also « *Arca* » *sulcicosta*, var. *camerata* von Koenen (*op. cit.*, pp. 1097-1100, pl. 70, figs. 3 a-c, 4 a-c) from the same locality. A topotype of « *A.* » *sulcicosta* is in the Schenck collection at Stanford University (n° 856).

(39) *Anadara mediaimpressa* and *A. mediaimpressa*, var. *submontereyana* (Clark) (Univ. Calif. Pub. Bull. Dept. Geol., vol. 11, n° 2, 1918, pp. 127-129) occur in the San Ramon formation assigned by Clark to the Oligocene. These clearly belong to *Anadara*, but their Oligocene age has recently been questioned by Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, pp. 19-20) who considers the San Ramon to be probably Miocene in age.

granulosa Deshayes was referred to *Anadara* by Cossmann and Pissarro (Icon. Compl. des Coq. Foss. de l'Éoc. des Env. de Paris, vol. 1, 1904-1906, pl. 36, figs. 110-45). This species, from the Lutetian, Eocene, of the Paris Basin, is represented by specimens in the Schenck collection at Stanford University (n° 865). Examination of these specimens shows that « *Arca* » *granulosa* is a small, somewhat elongate species of *Argina*, shown both by the arrangement of the teeth, and by the ligament, which is narrow and confined to the posterior of the beaks.

My reasons for not accepting *Arca antiquata* as the type species of *Arca s. s.*, as has recently been done (40), are given under the discussion of *Arca s. s.* See Addendum, p. 54.

Subgenus LARKINIA Reinhart, n. subgen.

Pl. IV, fig. 1.

Type species: *Anadara larkinii* (Nelson) (Olsson, Bull. Amer. Paleo., vol. 19, 1932, pp. 75-76, pl. 2, figs. 1, 4, 5) from the Tumbez formation, Miocene, of Peru.

This subgenus is proposed as a substitute for the incorrect use of the name *Senilia* as recently applied to several South American species (41), and as applied previously to *Anadara grandis* (Broderip and Sowerby). *A. grandis* was placed in *Senilia* by Lamy (Jour. de Conch., vol. 55, n° 3, 1907, p. 262) as well as by some subsequent workers; and indeed this species does somewhat resemble « *Arca* » *senilis* Linné, the type of *Senilia*, although it lacks the extremely prosogyrate beaks of *Senilia* and differs in other respects. However, if *A. grandis* were considered a *Senilia*, it would be necessary also to include the closely related species *A. multicostata* (Sowerby) and its variety *camuloensis* (Osmont) (Univ. Calif. Pub. Bull. Dept. Geol., vol. 4, n° 4, 1905, p. 98.

(40) Thiele, J., Handbuch der Systematischen Weichtierkunde, 3 Teil, Jena, 1934, p. 793.

Grant, U. S., and Gale, H. R., San Diego Soc. Nat. Hist., Mem. vol. 1, 1931, p. 137.

(41) « *Arca (Senilia)* » *chiriquiensis* var. *toroensis* Spieker, « *A. (S.)* » *chiriquiensis obesiformis* Grzybowski, « *A. (S.)* » *zorritosensis* Woods, « *A. (S.)* » *garitensis* Olsson, and « *A. (S.)* » *larkinii* Nelson (see Olsson, Bull. Amer. Paleo., vol. 19, 1932, pp. 71-76, pls. 1 and 2). « *Arca* » *septifera* Grzybowski, which Olsson (*op. cit.*, p. 73) refers to *Senilia*, is a *Cunearca*.

pl. 10, figs. 6, 6a; pl. 11, figs. 6 b-c), both of which are more closely related to *Anadara s. s.* than to *Senilia*.

It is seen, then, that *Larkinia* is intermediate between *Anadara s. s.* and *Senilia*. However, it is separated more sharply from *Senilia* than from *Anadara s. s.*, into which it merges gradually.

In addition to the species mentioned, *Larkinia* includes *Anadara santana* and its variety *weddlei*, both of Loel and Corey (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 22, n° 3, 1932, p. 185, pl. 8, figs. 1-4), from the Vaqueros formation, lower Miocene? of California.

Larkinia differs from *Anadara s. s.* in having a somewhat high, trigonal form; prominent, highly-elevated umbones; exceptionally long crenulations on the inner margin of the shell; and a wide hinge, bearing long teeth which have a tendency to diverge at the center of the hinge, whereas in *Anadara s. s.* the central teeth are usually either vertical or convergent ventrally. *Senilia* differs from *Larkinia* by possessing extremely prosogyrate beaks, an abnormally small number of very wide radial ribs, and a more trigonal form.

Anadara larkinii is represented in the Schenck Collection, Stanford University (n° 680), as are most of the other species here referred to *Larkinia*.

Subgenus SENILIA Gray, 1842.

Senilia Gray, Syn. Cont. British Mus., ed. 44, 1842, p. 81 (genus without species); type species : *Arca senilis* Linné (Syst. Nat., ed. 10, 1758, p. 694), a west African (42) species inhabiting brackish water. Type by subsequent designation of Gray, Proc. Zool. Soc. London, 1847, p. 198. Figured by Reeve (Conch. Icon., vol. 2, *Arca*, 1844, pl. 7, fig. 45).

In addition to the type species, *Senilia* includes « *Arca* » *subnitens* Recluz (Jour. de Conch., vol. 2, 1851, p. 363, pl. 10,

(42) Although Linné cites Jamaica as the type locality of *A. senilis*, its presence in the West Indies has not been confirmed (Lamy, Jour. de Conch., vol. 55, n° 3, 1907, p. 262). So far as known, *A. senilis* lives only in western Africa. It has been reported from the Tertiary by Dreger (« Vorkommen der *Senilia senilis* Linn. als Fossil », Verh. geol. Reichsanst., 1895, pp. 129-130).

figs. 3, 4), Recent, from the west coast of Africa. This species is similar to *A. senilis* but seems to be a distinct species.

Olsson (Bull. Amer. Paleo., vol. 19, 1932, pp. 71-76, pls. 1 and 2) has included in *Senilia* several species from the Peruvian Miocene which are distinct from this subgenus, as has been stated above. The type of *Senilia* is characterized by its high, trigonal form, extremely prosogyrate beaks, small number of ribs, and by an oblique break in the dentition just under the umbo (43). Although these Peruvian Miocene species resemble *Senilia* in shape, they lack the other characteristics, and it is therefore necessary to keep them separate; they are accordingly included in the new subgenus *Larkinia* Reinhart.

Subgenus ARGINA Gray, 1842 (44).

Pl. IV, fig. m.

Argina Gray, Syn. Cont. British Mus., ed. 44, 1842, p. 81 (genus without species); type species : *Arca pexata* Say (Jour. Acad. Nat. Sci. Philadelphia, vol. 2, 1821, p. 268), Recent, from the Atlantic coast of North America; type by subsequent designation of Stoliczka (Palaeont. Indica, vol. 3, 1871, p. 339). Figured by Reeve (Conch. Icon., vol. 2, 1844, *Arca*, pl. 4, fig. 22).

? *Lunarca* Gray, Ann. Mag. Nat. Hist., ser. 2, vol. 19, 1857, p. 372; type species (by monotypy) : *L. costata* Gray *(loc. cit.)*, Recent, from the Atlantic coast of North America.

Gray's description of *Lunarca* shows that it was known only from the single type specimen of *L. costata*. Due to this scarcity of material Gray was suspicious of the validity of his new group and suggested that *L. costata* might be « only a monstrosity of *Argina pexata* ». In regard to this point, the illustrations of *L. costata* given by Adams (Genera of Recent Moll., vol. 3, 1858. pl. 125, figs. 8, 8a) so strongly resemble *Argina* in all details ex-

(43) This last feature is not shown in Reeve's figure of *A. senilis* (Conch. Icon., 1844, *Arca*, pl. 7, fig. 45) but is present in every specimen of a large collection of this species in the Oldroyd Collection, n° 373, Stanford University.

(44) *Argina* was more fully described by Gray in 1857 (Ann. Mag. Nat. Hist. ser. 2, vol. 19, p. 372). In this publication several species are mentioned: *Arca pexata*, *A. campechensis*, etc.

cept the anterior teeth that Gray's suggestion appears to be highly probable, and *Lunarca* is accordingly here questionably placed as a synonym of *Argina*.

Argina is known from Eocene to Recent; it has been described from the Eocene of Peru by Olsson (45) and Woods (46), and is also represented in the Eocene of the Paris Basin by « *Arca* » *granulosa* Deshayes, as previously stated. *Argina* is also apparently represented in the so-called Oligocene of Peru by « *Arca* » *(Argina) puntabravoensis* Olsson (Bull. Amer. Paleo., vol. 17, n° 63, 1931, pp. 134-135, pl. 2, figs. 1, 4) although inasmuch as the hinge is unknown its subgeneric assignment is uncertain. At the present time *Argina* is for the most part confined to tropical America, in both the Atlantic and Pacific Oceans, although one species, « *Arca* » *(Argina) canalicostata* Lamy (Jour. de Conch., vol. 55, n° 3, 1907, p. 297, pl. 3, figs. 1-3), lives off the coast of eastern Africa, and another, « *Arca* » *(Argina) indica* Gmelin (*in* Linné, Syst. Nat., ed. 13, t. 1, pt. 6, 1790, p. 3312), was originally reported from the Indian Ocean, but its occurrence there is questioned by Lamy (*op. cit.*, p. 296).

Subgenus CUNEARCA Dall, 1898.

Pl. III, figs. j, j'.

Cunearca Dall, Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 618; type species: *Arca incongrua* Say (Jour. Acad. Nat. Sci. Philadelphia, vol. 2, pt. 2, 1822, pp. 268-269) (47), a Recent species from southeastern United States. Figured by Sheldon (Palaeont. Amer., vol. 1, n° 1, 1917, pl. 14. figs. 4-7).

Imparilarca Iredale, Mem. Queensland Museum, vol. 9, pt. 3, 1929, p. 263; type species (by original designation): *I. hubbardi* Iredale (*op. cit.*, p. 263, pl. 30, figs. 1, 2), a Recent species from Queensland, Australia.

(45) « *Arca* » *(Argina) samanensis* Olsson, Bull. Amer. Paleo., vol. 15, n° 57, 1929, p. 71, pl. 1, figs. 4, 5.

(46) « *Scapharca* » *(Argina) sullanensis* Woods *in* Bosworth, « Geology and Palaeontology of North-west Peru », 1922, pp. 62-63, pl. 1, figs. 5 a-b.

(47) Although Dall obviously intended this species as type of *Cunearca*, he did not so designate it. However, *Arca incongrua* was named as type species in 1907 by Lamy (Jour. Conch., vol. 55, n° 1, p. 6).

Iredale's description and figures of *Imparilarca* show it to be a synonym of *Cunearca*. *Imparilarca hubbardi* is described as inequivalve and with discrepant sculpture, the ribs on the left valve being nodose while those on the right are mostly smooth. These features are characteristic of *Cunearca* and show, together with Iredale's illustrations, which unfortunately do not show the hinge, that *Imparilarca hubbardi* is a *Cunearca*. The same conclusion was reached by Thiele (Handbuch der Systematischen Weichtierkunde, 3 Teil, Jena, 1934, p. 793).

The earliest occurrence of this subgenus of which I have a record is in the Vicksburgian Oligocene of Mississippi, where it is represented by « *Scapharca* » *lesueuri* Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4, 1898, p. 643; Sheldon, Palaeont. Amer., vol. 1, n° 1, 1917, pp. 32-33, pl. 7, figs. 12-16). This species unquestionably belongs to *Cunearca*, as it is inequivalve, and has the discrepant sculpture, elevated beaks, and somewhat trigonal form which characterize this subgenus.

« *Arca* » *filicata* Guppy (Quart. Jour. Geol. Soc. London, vol. 22, 1866, p. 583, pl. 26, fig. 5) has been correctly assigned by Sheldon to *Cunearca*. This species is found in the Manzanillo beds of Trinidad which were correlated by Maury (Jour. Acad. Nat. Sci. Philadelphia, 2 ser., vol. 15, pt. 2, 1912, pp. 35, 45) with the Oligocene Vicksburg group. Woodring, however (Carn. Inst. Washington, Pub. 385, 1928, table opp. p. 41), later placed the Manzanillo beds in the lower middle Miocene.

Other Miocene and Oligocene occurrences of *Cunearca* in North and South America and Europe are fairly common (48), but records of its Pliocene and especially of its Pleistocene occurrences are rare. At the present time *Cunearca* is widely distributed in warm seas.

Under the discussion of *Scapharca* is mentioned the close relationship of *Scapharca* with *Cunearca* and *Anadara*; the criteria for distinguishing these three groups are there pointed out.

(48) For example: « *Arca* » *santaclarana* Loel and Corey (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 22, n° 3, p. 184, pl. 7, figs. 8-10) from the Vaqueros formation, Miocene?, of California; « *Arca* » *pomponiana* Pilsbry and Johnson (Proc. Acad. Nat. Sci. Philadelphia, vol. 69, 1917, p. 190) from beds called Oligocene, Santo Domingo; « *Arca* » *salladilloensis* H. K. Hodson (F. Hodson, H. K. Hodson, and Harris, Bull. Amer. Paleo., vol. 13, n° 49, 1927, p. 8, pl. 5, figs. 1, 3) from the « Oligocene-Miocene » beds of Venezuela; « *Arca* » *cardiiformis* Basterot (represented by specimens (n° 457) in the Schenck collection, Stanford University, from the Upper Aquitanian of Mérignac, France). Many other species could be cited.

Subgenus SCAPHARCA Gray, 1847.

Pl. IV, fig. k.

Scapharca Gray, Proc. Zool. Soc. London, 1847, p. 198; type species (by original designation) : *Arca inaequivalvis* Bruguière (Encycl. Méth., Hist. Nat. Vers., vol. 1, 1789, pp. 106-107), Recent; type locality : Tranquebar, southeastern India.

Cara Gray, Ann. Mag. Nat. Hist., ser. 2, vol. 19, 1857, p. 371; type species: *Arca aviculoides* Reeve (Conch. Icon., 1844, *Arca,* pl. 10, fig. 63), designated by Stewart (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 86). Recent, from Santa Elena, Ecuador. Renamed *Arca aviculaeformis* Nyst.

In the description of *Arca inaequivalvis,* Bruguière refers to « Martini, Conchyl. tom. 7, pag. 210, tab. 156, fig. 552 ». (« Tab. 156 » is an error for tab. 56). The specimen figured by Martini (Martini and Chemnitz, Conch. Cab.), from Tranquebar, Indian Ocean, is therefore the type of this species. Martini's illustration is poor; the species has been somewhat better figured by Reeve (Conch. Icon., vol. 2, *Arca,* 1844, pl. 8, fig. 54).

Scapharca is intermediate between *Anadara s. s.* and *Cunearca,* but is more closely allied to the latter. All three groups intergrade considerably, and for correct subgeneric allocation, well preserved specimens are often necessary. *Anadara* is equivalved, with the two valves similarly sculptured, comparatively heavy-shelled, and typically elongate. *Cunearca* and *Scapharca*, in contrast, are inequivalved, discrepantly sculptured, usually (although not always) thin-shelled, typically rather high in outline, with prominent beaks. The distinction between *Scapharca* and *Cunearca* lies in the degree of discrepancy of sculpture. In *Cunearca,* the left valve usually bears prominent nodes which are not conspicuously developed on the right. Other discrepancies in sculpture also sometimes exist. In *Scapharca,* on the other hand, the sculpture is nearly, sometimes entirely, similar on the two valves. A slight discrepancy in sculpture exists in the type species, judging from specimens in the Oldroyd Collection (n° 1948), Stanford University. Finally, *Cunearca* is generally higher and more trigonal in outline than *Scapharca.*

The geologic range of *Scapharca* is Oligocene to Recent. In Oligocene deposits it is represented by a few species, among them

Arca mirandana H. K. Hodson (F. and H. K. Hodson and Harris, Bull. Amer. Paleont., vol. 13, n° 49, 1927, p. 11, pl. 5, figs. 12-13) from Venezuela.

The Miocene occurrences are numerous and world-wide, a few examples being the following: *Arca dariensis* Brown and Pilsbry (Proc. Acad. Nat. Sci. Philadelphia, vol. 63, 1911, pp. 362-363, pl. 22, fig. 11), from the Gatun formation of Panama; *Scapharca hypomela* Dall (Trans. Wagner Free Inst. Sci., vol. 3, pt. 4. 1898, p. 648, pl. 33, fig. 1), from the Miocene of Florida; *Arca daneyi* Cossmann and Pissarro (Bordeaux Actes Soc. Linn., vol. 66, 1912, pp. 280-282), originally described from the Aquitanian of France. Specimens of this species from the lower Burdigalian, Miocene, are in the Schenck collection (n° 458), Stanford University.

Pliocene to Recent occurrences of *Scapharca* are likewise very common and widely distributed. Included among the Recent species are several from the Pacific coast of North and Central America, among them *Arca labiosa* Sowerby, *A. cepoides* Reeve. *A. obesa* Sowerby. These species are illustrated and discussed by Maury (Palaeont. Amer., vol. 1, n° 4, 1922, pp. 23-31, pl. 3).

Genus NEMOARCA Conrad, 1869.

Nemoarca Conrad, Amer. Jour. Conch., vol. 5, pt. 2, 1869, p. 97; type species (by monotypy): *Nemoarca cretacea* Conrad (*op. cit.*, p. 97, pl. 9, fig. 21) from the Cretaceous of Haddonfield, New Jersey. Conrad's figure is poor; this species has been figured more clearly by Whitfield (Geol. Survey New Jersey, Palaeontology, vol. 1, 1886, pl. 12, figs. 8-10).

Nemoarca has been recognized only in the Cretaceous, being represented so far as I am aware solely by the type species. It appears to belong to the Anadarinae, but is quite distinct from any of the Cenozoic members of that subfamily.

Subfamily NOETIINAE Stewart, 1930.

Ventral margin closed, byssal gape usually lacking; sculpture consisting either of radial ribs, or concentric bands, or both; surface of shell regularly rounded; ligamental area narrow to moderately wide, flat to V-shaped in cross-section (with both valves joined); hinge gently to strongly arched; teeth regular,

converging ventrally, in most cases not dying out completely in the center. Inner margin either crenulated or smooth; beaks opisthogyrate; outline of shell trigonal. Posterior muscle scar typically bordered in front by a raised flange. Type genus: *Noetia* Gray, based upon *Noetia triangularis* Gray (= *Arca reversa* (Gray MS) Sowerby).

Geologic range: Cretaceous to Recent.

Genus NOETIA Gray, 1857.

Subgenus NOETIA *s. s.*

Pl. V, fig. n.

Noetia Gray, Ann. Mag. Nat. Hist., 2 ser., vol. 19, 1857, p. 371; type species (by monotypy): *Noetia triangularis* Gray *(loc. cit.)*, Recent, locality not stated.

L. R. Cox very kindly compared the holotype of *Noetia triangularis,* in the British Museum of Natural History, with specimens of *N. reversa* (Gray MS) (Sowerby) (Proc. Zool. Soc. London, 1833, pt. 1, p. 20). This comparison showed *triangularis* to be a synonym of *N. reversa.* Photographs of *triangularis* furnished me by Mr. Cox lead to the same conclusion. Stewart was therefore incorrect (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 80) in assuming that *N. triangularis* is a synonym of « *Arca* » *ponderosa* Say. *Noetia reversa* has been figured by Maury (Palaeont. Amer., vol. 1, n° 4, 1922, pl. 1, figs. 7, 11).

As Stewart observed (*op. cit.,* p. 81), *Noetia s. s.* seems to be restricted to American waters in the Recent fauna, although at least one of the foreign species mentioned by Lamy (Jour. de Conch., vol. 55, n° 3, 1907, pp. 300-305) belongs to the subgenus *Paranoetia* Thiele: for example, « *Arca* » *lateralis* Reeve (Conch. Icon., vol. 2, 1844, *Arca,* pl. 17, fig. 115) from the Philippines. In addition, « *Barbatia* » *cafria* Bartsch (U. S. Nat. Mus. Bull. 91, 1915, p. 183, pl. 38, figs. 1, 5) from South Africa is close to *Noetia,* and it may likewise belong to the subgenus *Paranoetia.*

The distribution of the fossil species of *Noetia* has been discussed by Stewart (*op. cit.,* p. 81) and Woodring (Carn. Inst. Washington, Pub. 385, 1928, p. 101). As these authors state, *Noetia* is not known in Europe in beds older than Aquitanian (Miocene?). Beginning with the Miocene, it is fairly common in

America, but, as stated, is represented in Europe by only one species, *Noetia okeni* (Mayer) (Jour. de Conch., vol. 6, 1857, p. 185, pl. 14, figs. 7, 8) from the Aquitanian. Topotypes of this species in the Schenck collection, Stanford University (n° 859), show it to be a true *Noetia*. *Noetia* is represented in the Eocene of the East Indies (49) and of the Indian region (50) ; and in addition a variety has been described from upper Eocene beds of Kyûshû, Japan, as *Arca (Noetia) pondaungensis* Cotter, var. *transversa* Nagao (51) (Sci. Rep. Tôhoku Imp. Univ., geol. ser. 2, vol. 12, n° 1, 1928, pp. 26-27, pl. 6, figs. 8-10), which appears to be a *Noetia*.

Subgenus NOETIELLA Thiele and Jaeckel, 1931.

Noetiella Thiele and Jaeckel, Muscheln der deutschen Tiefsee-Expedition : Wissenschaftlich Ergebnisse der Deutschen Tiefsee-Expedition, Bd. 21, Heft 1, 1931, Jena, p. 173 ; type species (by original designation) : *Barbatia pectunculiformis* Dunker (Novitates Conchologicae, 1870, pp. 88-89, pl. 28, figs. 4-6), Recent, from Borneo.

I have not had the opportunity of seeing the type species of *Noetiella*. The suggestion was made by Stewart that it might be related to *Halonanus* (Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 79). In addition to the type, the following species is assigned to *Noetiella* by its authors : *Arca (Noetiella) congoensis* Thiele and Jaeckel (*op. cit.*, p. 176, pl. 1, fig. 11) from the mouth of the Congo.

Subgenus PARANOETIA Thiele, 1934.

Paranoetia Thiele, Handbuch der Systematischen Weichtierkunde, 3 Teil, Jena, 1934, p. 793 ; type species (by mono-

(49) « *Arca (Anadara)* » *molengraaffii* Martin (Samml. Geol. Reichs-Mus. Leiden, n. ser., vol. 2, n° 5, 1916, p. 184, pl. 7, figs. 191, a, 192, a) from the upper Eocene of Java.

(50) *Noetia pondaungensis* Cotter (Palaeont. Indica, n. ser., vol. 7, n° 2, 1923, p. 20, pl. 7, figs. 1-2) from the Eocene of Burma.

(51) Inasmuch as the specific name *transversa* has been preoccupied in the genus *Arca* since 1822 (*Arca transversa* Say, Jour. Acad. Nat. Sci. Philadelphia, vol. 2, pt. 2, pp. 269-270), Nagao's varietal name is a homonym. I have notified Professor Nagao of this fact, and he will soon rename his variety.

typy) : *Arca lateralis* Reeve (Conch. Icon., vol. 2, 1844, *Arca*, pl. 17, fig. 115), Recent, from the Philippine Islands.

Arca lateralis, the type species of *Paranoetia*, is similar in general form to the type of *Sheldonella*, mentioned below, but apparently lacks a byssal notch.

Subgenus SHELDONELLA Maury, 1917.

Sheldonella Maury, Bull. Amer. Paleo., vol. 5, n° 29, pt. 1, 1917, p. 330 ; type species (by monotypy) : *Noetia (Sheldonella) maoica* Maury (*op. cit.*, pp. 330-331, pl. 30, figs. 17-18) from the Tertiary of the Dominican Republic, West Indies.

The type species of *Sheldonella* differs from typical *Noetia* by lacking the usual sharp umbonal ridge, and notably by the presence of the well-developed byssal notch described by Maury and shown in her illustrations. In true *Noetia* no byssal notch is present. Because of this notch the relation of *Sheldonella* to *Noetia* seems uncertain, but inasmuch as the two are similar in most other respects, *Sheldonella* seems best placed as a subgenus of *Noetia*. I know of no species other than the type which can be confidently assigned to *Sheldonella*.

Genus TRIGONARCA Conrad, 1862.

Pl. V, fig. o.

Trigonarca Conrad, Proc. Acad. Nat. Sci. Philadelphia, vol. 14, 1862, p. 289 ; type species (by monotypy) : *Cucullaea maconensis* Conrad (Jour. Acad. Nat. Sci. Philadelphia, 2 ser., vol. 4, pt. 3, 1860, p. 281, pl. 47, fig. 20), Ripley formation, upper Cretaceous, of Macon County, Alabama.

A good description of *Trigonarca* and illustrations of the type species are given by Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, pp. 96-98, pl. 15, figs. 1-3). *Trigonarca* forms a distinctive, widely-distributed group limited to the Cretaceous (52), appearing to be most abundant in the Upper

(52) Gillet (Mém. Soc. Géol. de France, n. sér., Mém. n° 3, 1924, p. 18) mentions an unnamed species of *Trigonarca* in the Lias, but sufficient information is not given concerning it ; I must therefore question its occurrence for the time being.

Cretaceous. This genus has been reported from the Cretaceous of North America (Stephenson, 1923; Packard, Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 13, n° 10, 1922, pp. 418-419) ; from southern India (Stoliczka, Palaeont. Indica, Cretaceous Fauna of S. India, vol. 3, 1871, pp. 352-355) ; from England (Woods, Monograph of Cretaceous Lamellibranchia, pt. 1, Palaeont. Soc., vol. 53, 1899, p. 47) ; from South Africa (Rennie, Ann. S. African Mus., vol. 28, pt. 2, 1930, p. 169 (53) ; and from Italy (Greco, Palaeont. Italica, vol. 24, 1918, pp. 28-30). Several of the other occurrences reported are either incorrect or uncertain; for example, « *Arca (Trigonarca)* » *ferlinii* Greco (Palaeont. Italica, vol. 23, 1917, pp. 128-129, pl. 16, fig. 7) and « *A. (T.)* » *rosellinii* Greco (*op. cit.*, pp. 150-151, pl. 17, fig. 13) from the Cretaceous of Egypt do not belong to *Trigonarca*. And the status of *Trigonarca? obsoleta* Yabe and Nagao (Sci. Rep. Tôhoku Imp. Univ., 2 ser., vol. 9, n° 2, 1926, pp. 43-44, pl. 12, fig. 24), from the Cretaceous of Japan, is very doubtful, as it is based upon a poorly-preserved specimen.

Protarca Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, pp. 103-104) was considered by Stephenson to be intermediate between *Trigonarca* and *Glycymeris*. This seems to be the case, but I believe *Protarca* to be more nearly related to *Glycymeris*. The type species of *Protarca*, designated by Stephenson, is *P. obliqua* Stephenson (*op. cit.*, pp. 104-105, pl. 19, figs. 1-3), from the Upper Cretaceous of Snow Hill, North Carolina. A plastotype is in the Stanford University paleontological type collection.

Genus TRIGONODESMA Wood, 1864.

Pl. V, figs. p, p'.

Trigonodesma Wood, Monograph of the Eocene Bivalves of England, Mem. Palaeont. Soc., 1864, p. 86; type species : *Arca lissa* Bayan (Études faites dans la collection de l'École des Mines sur des fossiles nouveaux ou mal connus, t. 2. 1873, p. 130) = *A. laevigata* Caillat (Desc. de quelq. Coq. Nouv., 1834, p. 4, pl. 2, fig. 7) ; not *A. laevigata* Spengler *in* Chemnitz, 1784. Type by subsequent designation of Winck-

(53) *Trigonarca elongata* Rennie (1930) is a homonym of *T. elongata* Stephenson (North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, pp. 100-101, pl. 18, figs. 1-4) and should be renamed.

worth, Journ. of Conch., vol. 20, n° 1, 1934, p. 10. Upper Eocene of France and England.

? *Halonanus* Stewart, Acad. Nat. Sci. Philadelphia, Special Pub. 3, 1930, p. 78; type species (by original designation) : *Noetia pulchra* Gabb (Jour. Acad. Nat. Sci. Philadelphia, 2 ser., vol. 4, pt. 4, 1860, p. 388, pl. 67, fig. 55), from the Claiborne group, Upper Eocène, of Texas.

The type species of *Trigonodesma* was figured, as *Arca laevigata* Caillat, by Wood *(op. cit.,* pl. 15, figs. 8 a-c). Wood noted that this species is slightly inequivalved, with the right valve larger than the left; he also observed that the ligament occupies a small, triangular pit beneath the umbones. According to Glibert (Mus. Roy. d'Hist. Nat. de Belgique, Mém. 53, 1933, p. 122) the ornamentation of the two valves is somewhat dissimilar, the left valve being ornamented only with concentric growth lines, while the right has radial striations as well. This observation has been partly verified by an examination made by me of a series of eleven well-preserved specimens of this species from Barton, England (N° 72521 in the Geological Department of the British Museum of Natural History). This discrepancy of ornamentation, however, does not seem to be a constant character, as two left valves were noted in which the radial striations are more prominent than the concentric ones. My observations on this point may be summarized as follows: radial and concentric striations are present on both valves; in most cases, though not in all, the radial sculpture predominates on the right valve and concentric sculpture on the left. The posterior muscle scar is bordered on its anterior side by a slightly-elevated flange, but no flange could be detected bordering the anterior scar.

Halonanus Stewart, based upon « *Noetia* » *pulchra* Gabb, differs slightly from *Trigonodesma* and is therefore only questionably considered a synonym of that genus. The hinge of « *Noetia* » *pulchra* is definitely arched, and the central interruption in the teeth is not so pronounced as in *Trigonodesma*. *Trigonodesma* has only a slightly arched hinge; it also has a more prominent anterior dorsal margin than « *N.* » *pulchra*. However, an attempt to separate *Halonanus* from *Trigonodesma* has failed to disclose any satisfactory criteria for a generic separation, as in other respects, including the elevated posterior flange, the two are similar. The differences therefore appear to be specific rather than generic, although this point is debatable.

Trigonodesma includes « *Arca* » *hornii* Gabb (54) (Pal. Calif., vol. 1, 1864, p. 194, pl. 30, fig. 263) and « *A.* » *hornii,* subsp. *elusa* Clark and Woodford (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 17, n° 2, 1927, p. 87, pl. 14, fig. 6) from the Eocene of California, and a number of other Eocene species from the eastern United States, which are listed by Stewart : « *Noetia* » *pulchra* Gabb (type of *Halonanus),* « *Trinacria* » *decisa* (Conrad), « *T.* » *perplana* (Conrad), « *T.* » *declivis* (Conrad), and « *T.* » *ellipsis* Lea (55). To these may be added « *Trigonocoelia* » *ledoides* Meyer (Alabama Geol. Survey, Bull. 1, 1886, p. 79, pl. 1, fig. 20) from the Eocene of Claiborne, Alabama. Stewart also questionably included (in *Halonanus*) « *Trinacria* » *baudoni* Mayer (Cossmann and Pissarro, Icon. Compl. des Coq. Foss. de l'Eocène des Env. de Paris, vol. 1, 1904-1906, pl. 34, fig. 107-9) from the Eocene of the Paris Basin.

Trigonodesma resembles *Noetia* and *Trigonarca* in having a trigonal form and opisthogyrate beaks, but differs from both in having the ligament placed in a small shallow pit between the umbones, resembling *Arcopsis* in this respect. However, because of its trigonal form and generally opisthogyrate beaks, *Trigonodesma* is here placed in the Noetiinae. It is apparently confined to the Eocene.

As stated under the discussion of « Family, generic, and specific characteristics of the Arcidae », *Trigonodesma* is similar in form to the type species of *Trinacria* Mayer, 1868, of the family Limopsidae (« *Trigonocoelia* » *crassa* Deshayes, Anim. sans vert. bas. Paris, vol. 1, 1860, p. 841, pl. 65, figs. 1-4 ; upper Eocene — « Sables moyens » — of the Paris Basin). The difference of hinge structure which distinguishes *Trinacria* from *Trigonodesma* has already been discussed earlier in this paper, and will not be repeated. The general similarity in form between *Trigonodesma* and *Trinacria,* and the relatively small differences which separate them, indicate that these two genera are on the border line of the families Arcidae and Limopsidae, respectively.

(54) It should be mentioned that « *Arca* » *hornii* and its subspecies *elusa* are more closely related to the type species of *Trigonodesma* from Europe than to the type species of *Halonanus* from southeastern United States.

(55) These species are discussed and figured by Harris, Bull. Amer. Paleo., vol. 6, n° 31, 1919, pp. 41-44, pls. 18-19.

ADDENDUM.

Although *Senilia* and *Argina* were named earlier than *Anadara,* they are treated in this paper as subgenera of *Anadara.* Even though it is not customary for subgeneric names to antedate generic ones, there is nothing in the International Rules of Zoological Nomenclature to prevent such an action. On the other hand, this action is made advisable in this case because of the following considerations: (1) the wide-spread use of the name *Anadara* as a genus, in contrast to the much less common use of *Senilia* and *Argina;* (2) the unsatisfactory manner in which *Senilia* and *Argina* (as well as all other genera in Gray's 1842 Synopsis) were proposed, causing Iredale to favor rejecting all of the names proposed in this work (Iredale, Proc. Mal. Soc. London, vol. 10, 1913, p. 301). Should some later ruling by the International Commission make it necessary for generic names to antedate subgeneric names, it would be preferable to elevate *Argina* and *Senilia* to generic rank, in order to avoid reducing *Anadara* to a subgenus of either.

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A complete list of the papers cited in the foregoing text would be desirable here, but inasmuch as its length would make its publication prohibitive, the list has been shortened so as to include only those works referred to most frequently.

Bibliographic citations in the text are abbreviated, in most cases, in accordance with the form suggested by Wood (Suggestions to Authors: U. S. Geological Survey Admin. Pub., 3 ed., 1916, pp. 24-28), and in citing publications not listed by Wood I have attempted to make the references as clear as possible.

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EXPLANATION OF PLATES

a, a'. *Arca (Arca) noae* Linné (type of *Arca*). Plesiotype n° 5297, Stanford University paleo. type coll., Recent, from Mediterranean Sea. a, interior of right valve; a', anterior view, outline, showing wide, flat ligamental area. Length 69 mm.

b, b'. *Barbatia (Barbatia) barbata* (Linné) (type of *Barbatia s. s.*). Plesiotype n° 1115, Oldroyd Collection, Stanford University, Recent from Roussillon, Mediterranean Sea. b, interior of left valve; b' anterior view, outline. Length 63 mm.

c, c'. *Barbatia (Calloarca) alternata* (Sowerby) (type of *Calloarca*). Plesiotype n° 3483, University of California at Los Angeles type coll., Recent, from western Mexico. c, interior of right valve; c', dorsal view of the same. Length, *ca.* 38 mm.

d, d'. *Barbatia (Obliquarca) marceauxi* (Deshayes). Plesiotype n° 5299, Stanford University paleo. type coll., upper Eocene of Hermonville, Paris Basin. d, interior of right valve; d' oblique dorsal view, showing ligament to be restricted to the posterior of the umbo. Length 18 mm. This is not the type species of *Obliquarca*, but is is a closely related species, having the same general characteristics.

e. *Barbatia (Cucullaearca) cuculloides* (Conrad). Sketched from Aldrich, Alabama Mus. Nat. Hist., Mus. Paper 12, 1931, pl. 6, fig. 1A. Upper Eocene of Claiborne, Alabama. Interior of right valve. Length 61 mm. *B. lima* (Conrad), the type species of *Cucullaearca*, is usually considered a synonym of *cuculloides*.

f, f'. *Barbatia (Acar) gradata* (Broderip and Sowerby) (type of *Acar*). Sketched from Bartsch, Proc. U. S. Nat. Mus., vol. 80, Art. 9, 1931, pl. 1, top figures. Recent, from Mazatlan, western Mexico. f, interior of left valve showing prominent muscle scars; f', dorsal view of both valves together showing shape of ligamental area and its location mainly posterior to umbones. Length 41 mm.

g, g'. *Arcopsis (Arcopsis) quadrilatera* (Lamarck) (type of *Fossularca*, here placed in the synonymy of *Arcopsis*). Plesiotype n° 5295, Stanford University paleo. type coll., Bartonian, Eocene, of Le Fayel, Oise, Paris Basin. g, interior of left valve; g', dorsal view showing location of shallow ligamental pit. Length 7 mm.

h. *Bathyarca (Bathyarca) pectunculoides* (Scacchi) (type of *Bathyarca).* Sketched from Sheldon, Palaeont. Amer., vol. 1, n° 1, 1917, pl. 16, fig. 11. Recent, from Finmark, Sweden. Interior of left valve. Length *ca.* 11 mm.

i, i'. *Anadara (Anadara) antiquata* (Linné) (type of *Anadara s. s.*). Plesiotype n° 5298, Stanford University paleo. type coll., Recent, from Philippine Islands. i, interior of left valve; i', anterior view, outline. Length 58.5 mm.

j, j'. *Anadara (Cunearca) incongrua* (Say) (type of *Cunearca).* Plesiotype n° 5296, Stanford University paleo. type coll., Recent, from Florida. j, interior of left valve; j', anterior view, outline, showing posterior extension of shell. Length 57 mm.

k. *Anadara (Scapharca) inaequivalvis* (Bruguière) (type of *Scapharca).* Plesiotype n° 1948, Oldroyd Collection, Stanford University. Recent, from Awaji, Japan. Left valve. Length 76 mm.

l. *Anadara (Larkinia) larkinii* (Nelson) (type species of *Larkinia*). Sketched from Olsson, Bull. Amer. Paleo., vol. 19, n° 68, 1932, pl. 2, fig. 4. Tumbes formation, Miocene, of Que. Tucillal, Zorritos district, Peru.

m. *Anadara (Argina) pexata* (Say) (type of *Argina*). Sketched from Sheldon, Palaeont. Amer., vol. 1, n° 1, 1917, pl. 15, fig. 13. Recent, from southeastern United States. Interior of right valve. Length 55 mm.

n. *Noetia (Noetia) triangularis* Gray (type of *Noetia*). Holotype, British Mus. Nat. Hist. Recent, locality unknown. Interior of right valve. Length, *ca.* 35 mm. This species is a synonym of *N. reversa* (Gray MS) (Sowerby), a tropical American species living in both the Atlantic and Pacific Oceans.

o. *Trigonarca maconensis* (Conrad) (type of *Trigonarca*). Sketched from Stephenson, North Carolina Geol. and Econ. Survey, vol. 5, pt. 1, 1923, pl. 15, fig. 1. Cretaceous. Interior of right valve. Length, *ca.* 97 mm.

p, p'. *Trigonodesma lissa* Bayan (type of *Trigonodesma).* Sketched from Glibert (Mus. Roy. d'Hist. Nat. de Belgique, Mém. n° 53, 1933, p. 122, text fig. 17). Eocene, from Neder-Ockerzeel, Belgium. p, interior of right valve; p', exterior of same valve. Length 2.5 mm.

Distinguishing characteristics of the genera and subgenera of Arcidae represented on the Pacific slope of North America from Cretaceous to Recent time.

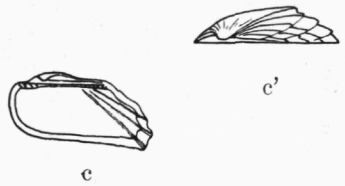
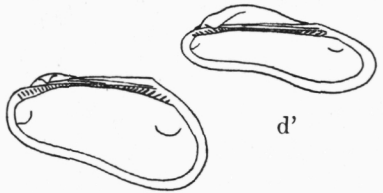
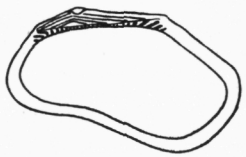
Genera and subgenera		Distinguishing characteristics
ARCA s. s.	 a a'	*Surface ornamentation:* numerous radial ribs, resembling those of *Barbatia.* Surface of shell irregular. *Ligamental area:* extremely wide and almost flat. *Teeth:* numerous fine, regular teeth, perpendicular to hinge or converging ventrally; hinge very long, narrow, and straight. *Inner margin of shell:* smooth. Large byssal gape.
BARBATIA s. s.	 b b'	*Surface ornamentation:* many fine, narrow, radial ribs; irregular concentric lines; surface of shell irregular. *Ligamental area:* narrow; V-shaped in cross section, with both valves joined. *Teeth:* converging ventrally; reduced to very small size at center of hinge. *Inner margin of shell:* smooth. Small byssal gape.
CALLOARCA	 c c'	*Surface ornamentation:* radial ribs, very large on posterior slope and only sligthly less so at anterior end; less prominent medially. *Ligamental area :* as in *Acar;* narrow, ligament present posterior to beaks. *Teeth:* small, converging strongly at extremities. *Inner margin of shell:* smooth. Small byssal gape. Differs from *Acar* by lacking the reticulate sculpture and prominently elevated muscle scars of that subgenus.

PLATE II.

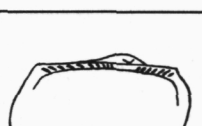
OBLIQUARCA	 d d'	*Surface ornamentation:* fine radial ribs. *Ligamental area:* narrow, present only posterior to umbones. *Teeth:* converging ventrally; small at center of hinge. *Inner margin of shell:* smooth. Distinguished from *Barbatia s. s.* by the arrangement of its ligamental area.
CUCULLAEARCA	 e	*Surface ornamentation:* same as *Barbatia s. s.* — fine radial ribs. *Ligamental area:* wide; V-shaped in cross section, with both valves joined. *Teeth:* Large at extremities of hinge, converging ventrally; small and granular at center. *Inner margin of shell:* smooth. Large byssal gape. Distinguished from *Barbatia s. s.* by large ligamental area, large byssal gape, and posterior enlargement in outline.
ACAR	 f f'	*Surface ornamentation:* reticulate sculpture; surface of shell irregular, deformed in appearance. *Ligamental area:* narrow; present only posterior to umbones. *Teeth:* converging ventrally; small and granular, especially at center of hinge. *Inner margin of shell:* smooth or crenulated. Small byssal gape. *Muscle scars:* elevated, conspicuous.

ARCOPSIS

g g'

Surface ornamentation: fine radial ribs.
Ligamental area: narrow; ligament confined to small, shallow pit between umbones.
Teeth: regular, converging ventrally; edentulous gap at center of hinge.
Inner margin of shell: smooth.

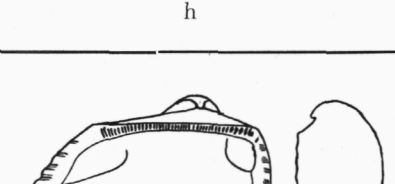
BATHYARCA



h

Surface ornamentation: fine radial and concentric lines.
Ligamental area: very narrow.
Teeth: converging ventrally, with an edentulous gap at center of hinge.
Inner margin of shell: smooth; small byssal gape.
Shell very small and fragile; right valve smaller than the left.

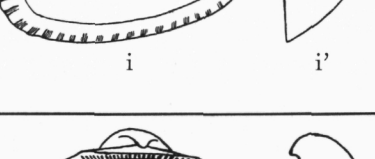
ANADARA s. s.



i i'

Surface ornamentation: large radial ribs, grooved or noded on most species. Both valves equally sculptured.
Ligamental area: moderately wide, usually V-shaped in cross section, with both valves joined. Commonly sculptured with chevron-shaped grooves.
Teeth: regular, arranged perpendiculary to hinge line; in most cases converging ventrally at extremities of hinge.
Inner margin of shell: crenulated; no byssal gape. Shell commonly heavy, equivalved.

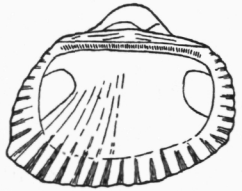
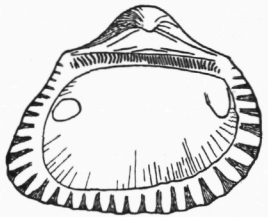
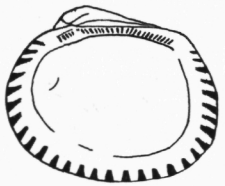
CUNEARCA

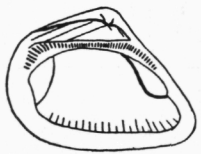


j j'

Similar to *Anadara s. s.* except for the following points: Left valve always larger than right; left valve with noded ribs; right valve with ribs plain or only slightly noded; other discrepancies in sculpture between the two valves sometimes present. Shell high and short in outline, with elevated beaks. Valves typically thin-shelled.

PLATE IV.

SCAPHARCA	 k	Intermediate between *Cunearca and Anadara s.s.* Inequivalved, with the left valve larger than the right. Sculpture either similar on the two valves or slightly discrepant (never strongly discrepant as in *Cunearca).* Valves typically thin-shelled.
LARKINIA	 l	*Surface ornamentation :* large radial ribs, noded or smooth. *Shape:* high and somewhat trigonal, with strongly elevated beaks. *Ligamental area:* large, with ligamental grooves tending to be chevron-shaped. *Teeth:* very long; converging ventrally at extremities of hinge, but diverging near the center. *Inner margin of shell:* deeply grooved with long crenulations. No byssal gape. Shell equivalved. Shell very thick and heavy.
ARGINA	 m	*Surface ornamentation:* large radial ribs. *Ligamental area:* narrow; confined to posterior of beaks. *Teeth:* anterior teeth few in number and irregular; posterior teeth numerous. *Inner margin of shell:* crenulated. No byssal gape. Differs from *Anadara s. s.* only in the arrangement of the teeth and ligamental area.

NOETIA	 n	*Surface ornamentation:* fairly prominent radial ribs. *Shape:* trigonal in outline. Beaks opisthogyrate. *Ligamental area :* moderately wide; located chiefly (in the type species entirely) anterior to the beaks. *Teeth:* converging ventrally; hinge somewhat arched. *Inner margin of shell:* crenulated; no byssal gape. *Muscle scars :* posterior scar bordered, on its anterior side, by an elevated flange
TRIGONARCA	 o	*Surface ornamentation:* concentric lines only. *Shape:* trigonal in outline. Beaks opisthogyrate. *Ligamental area :* wide; longer in front of beaks than behind. *Teeth :* strong and regular; converging at extremities. Hinge arched. *Inner margin of shell:* smooth. No byssal gape. *Muscle scars:* prominent; posterior scar bordered, on its anterior side, by an elevated flange.
TRIGONODESMA	 p  p'	*Surface ornamentation :* concentric lines, and (particularly on right valve) radial striations. *Shape :* trigonal in outline; beaks opisthogyrate; shell very small. *Ligamental area :* small; ligament restricted to small shallow pit beneath umbones, in type species. *Teeth :* small and fairly regular; hinge straight to slightly arched. *Inner margin of shell:* smooth; no byssal gape. *Muscle scars:* posterior scar bordered by elevated flange.

INDEX

Listed below are the generic, subgeneric, specific, and subspecific names mentioned in the text. Subspecific and varietal names are listed with the specific name omitted: for example, *Anadara santana*, var. *weddlei* appears in the index as « *weddlei*, *Anadara* ». Numbers in italics indicate the page or pages on which the principal discussion of each genus and subgenus is to be found (thus, *23-24*). In many cases, names occur several times on one page, as well as in footnotes.

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