OLIGOCENE ARCID PELECYPODS

OF THE GENUS ANADARA [1]

ABSTRACT

This paper is the outgrowth of an attempt to determine what use might be made of the arcid pelecypod genus *Anadara, sensu stricto,* in the interregional correlation of Oligocene sedimentary deposits. Although this genus is abundantly represented in Miocene and younger strata, the list of Oligocene species is small. Nevertheless, these few species are widely distributed, occurring in North America, Europe, Africa, the Japanese Empire, and possibly in the Philippine Islands. The addition of the Oligocene records of the closely related subgenus *Scapharca* increases this distribution. Comparisons of specimens from widely separated localities fail to reveal a single identical species in Oligocene strata on different continents, indicating that identity of species of *Anadara* is not apt to be of use in interregional synchronization of Oligocene beds even though this criterion is applicable locally. This seeming lack of stratigraphical value, however, may be offset by a consideration of *Anadara* as a whole, that is, *Anadara, Scapharca, Cunearca,* and *Larkinia.* Recorded data indicate that the representatives of these subgenera made their first appearances in many parts of the world in formations called Oligocene, never occurring in older rocks. It follows as a reasonable hypothesis that in any area containing a complete marine Tertiary section, the earliest geological occurrence of *Anadara, sensu lato,* in the section may be taken as suggesting an Oligocene age for the formation in which it occurs.

Another purpose of this investigation was to discover if the representatives of *Anadara, s. s.,* would fall into groups of morphologically distinct species. Further, if such groups could be recognized, would they aid in separating

[1] Read before the Pacific Coast Section, Paleontological Society of America, Stanford University meeting, April 12, 1935; abstract published in the *Proceedings of the Geological Society of America for 1935*, p. 412, June, 1936.

Miocene from Oligocene rocks ? The result of this attempt is negative, as the Oligocene species of *Anadara* differ no more from Miocene and younger species than they do from each other.

Some of the questions concerning the Oligocene are outlined, and reasons given for including in this Series strata of Tongrian to Aquitanian age, inclusive.

A large part of the paper consists of a catalogue of the described Oligocene species of *Anadara s. s.* together with a definition and diagnosis of the restricted genus. Several species of related subgenera, notably *Scapharca*, are also included, as well as a few late Tertiary and Quaternary species of *Anadara*. The most important of these are described and many of them illustrated. Study of the younger species led to the description of the following as new : *Anadara* (*Anadara*) **bisenensis** (Recent, Japan) and *A.* (*A*). *ferruginea* subspecies **waloensis** (late Pliocene or early Pleistocene, Philippine Islands).

INTRODUCTION

We had five questions uppermost in mind at the outset of this study : (1) What are the Oligocene species of the arcid bivalve *Anadara*, *sensu stricto* ? (2) Are there any general morphological features which distinguish Oligocene from Miocene and younger species of *Anadara* ? (3) Can one adduce evidence of a faunal break between the Oligocene and Miocene by the study of this genus ? (4) What evidence is there of interregional migration of Oligocene species of *Anadara* which might justify the use of these species in long-distance synchronizations of strata ? (5) How does the Recent distribution of *Anadara. s. s.*, compare with its Oligocene and later Tertiary extent ?

Answers to these questions in the order listed above are here attempted :

(1) The number of species of *Anadara, sensu stricto,* occurring in strata known or thought to be Oligocene is small. The species, so far as we have been able to determine them, are listed in Table 1. The Oligocene age and subgeneric allocation of several of these are in doubt.

TABLE I. — **Oligocene Species of Anadara.**

SPECIES	AUTHOR	FORMATION (Stage)	LOCALITY
Anadara (Anadara ?) daitokudoensis .	Makiyama	Heirokudo	Korea
Anadara (Anadara) granosa	Linné	« Vigo Group »	Philippine Islands
Anadara (Anadara ?) guembeli . . .	Mayer	Stampian (=Rupelian)	Bavaria
Anadara (Anadara ?) intercedens . .	Wolff	Oligocene	Bavaria
Anadara (Anadara) mediaimpressa . .	Clark	San Ramon	California
Anadara (Anadara) mediaimpressa var. *submontereyana*	Clark	San Ramon	California
Anadara (Anadara ?) speyeri	Semper	Sternberg	Germany
Anadara (Anadara ?) strongi	Loel & Corey	Vaqueros	California
Anadara (Anadara) sulcicosta	Nyst	Tongrian	Belgium
Anadara (Anadara) waylandi	Cox	Pemba Series	Pemba Island, Africa
Anadara (Anadara ?) sp. A.	Schenck & Reinhart	Pleito	California
Anadara (Anadara ?) sp. B.	Schenck & Reinhart	Nye	Oregon
Anadara (?) sp. C.	Schenck & Reinhart	Eugene	Oregon

In addition, *Anadara, sensu lato,* is present in the Aquitanian of France (*aquitanica*), the Vaqueros formation of California (*santana* and *weddlei*), the Heath and Mancora formations of Peru and Ecuador (*meroensis*), the Gaj « Series » of India (*oldhamiana,* reported from the Gaj as « *Arca radiata* Sowerby »), the « Patagonian formation » of Patagonia (*camaronesia*), and from other strata that have been taken by one author or another to be either late Eocene, Oligocene, or early Miocene.

(2) As to shell characteristics which might be used in differentiating assemblages of Oligocene and Miocene or younger species of *Anadara,* we have been able to observe only one feature — the size of adult specimens — which has any value in this respect, and even this must be used with great caution. The earliest species of *Anadara, sensu lato,* are relatively small in comparison to those of Miocene-Recent age. Thus, none of the Oligocene species of *Anadara* attains a larger size than 41 mm., as far as can be seen from available specimens, with one exception, *granosa,* a specimen of which, 61 mm. long, is here illustrated (Pl. II, fig. 9) from the Philippine Vigo « group ». It is noteworthy that, although the Vigo may be Oligocene, it is generally called Miocene. In contrast to the scarcity of large Oligocene specimens are the many Miocene, Pliocene, Pleistocene, and Recent species, particularly of *Anadara, s. s., Larkinia,* and *Scapharca* which, by comparison with the Oligocene specimens, are veritable

giants. The Miocene *osmonti* commonly attains a length of more than 50 mm.; *trilineata*, the California Pliocene species, not infrequently exceeds a length of 75 mm., whereas its variety *calcarea* is 80 mm. or more in length. Some specimens of the Recent *formosa* measure 120 mm.

This increase in size is doubtless too indefinite to have exact time value, but a trend from small to large species is nevertheless an hypothesis worth testing. The presence of a giant *Anadara*, sixty or more millimeters in length, in a geologic formation of undetermined age would suggest a late Oligocene, or more likely a Miocene or younger age for that formation. The opposite situation — the presence of only small specimens of *Anadara* — would not by itself mean a pre-Miocene age, because small specimens of the genus are not uncommon in Miocene to Recent sediments.

(3) The question of whether any faunal break between Oligocene and Miocene is shown by this study of *Anadara* has been answered in part in the preceding paragraphs, in which it was stated that no general differences could be detected between Oligocene and Miocene species, except occasionally in the matter of size. Differences between the Oligocene and Miocene species are in general no greater than those existing among the several Oligocene species themselves. In fact, several cases of close similarity between Oligocene species and those in Miocene or younger strata have been noted. These are shown in Table II, which also indicates instances of close relationship between the Oligocene species themselves. In this table, only species belonging to *Anadara s. s.* and to *Scapharca* are listed.

TABLE II. — **Analogous Species of Anadara s. s. and Scapharca.**

AGE	SPECIES	ANALOGUE	AGE
Aquitanian (Oligocene) . . .	*aquitanica*	*turonica*	Helvetian (Miocene)
Vigo (Oligocene ?) to Recent .	*granosa*	*bisenensis*	Recent
Stampian (Oligocene)	*guembeli*	*speyeri*	Chattian (Oligocene)
Vicksburg (« Oligocene ») . .	*invidiosa*	*mikkula*	Chipola (Miocene)
Heath (« Upper Oligocene »).	*meroensis*	*daneyi*	Burdigalian (Miocene)
Tongrian (Oligocene)	*sulcicosta*	*mediaimpressa*	San Ramon (« Oligocene »)
		osmonti	Temblor (Miocene, in part)
Pemba Series (« Aquitanian-Burdigalian »)	*waylandi*	*dautzenbergi*	Recent
		timorensis	Pleistocene
		waloensis	Pliocene ?

(4) The question dealing with interregional migration of Oligocene species may be answered by the statement that this study has failed to show a single example of absolute specific identity between specimens occurring in the Tertiary deposits of Europe, the Americas, and Asia. This fact suggests that suffi-

cient time elapsed to permit the species to undergo various changes in migrating from one area to another. We do not place undue faith in this hypothesis; a few specimens from an unexplored area might change the conclusion completely. All we can say is that at the present state of our knowledge identity of *Anadara* species is not apt to be a reliable criterion for the correlation of Oligocene formations of the Pacific Slope of North America with those of Europe.

However, even though identity of species of *Anadara* does not appear likely to provide a means of wide correlation of Oligocene deposits, the geologic distribution of *Anadara, sensu lato,* suggests a rough basis for correlation. It has been stated already that *Anadara s. s.* did not appear until early Oligocene time. Similarly, as brought out in Table III, other representatives of *Anadara, sensu lato* — *Scapharca, Cunearca,* and *Larkinia* — made their first appearances in deposits thought to be Oligocene. The fact that *Anadara, sensu lato,* had a wide distribution during the early Tertiary, appearing for the first time in many parts of the world in formations called Oligocene by several authors, suggests this possibility : In any complete marine sequence of similar facies, the oldest formation containing *Anadara* is probably of Oligocene age.

TABLE III. — **Earliest occurrences of Species of Anadara,** sensu lato.

REGION	SPECIES	OCCURRENCE
Europe	*Anadara* (*Anadara*) *sulcicosta* (Nyst)	Tongrian, Belgium
East Africa	*Anadara* (*Anadara*) *waylandi* Cox	Pemba Series, Pemba Island
India	*Anadara* (*Scapharca ?*) *oldhamiana* (Noetling)	Gaj Series, Sind
Japanese Empire	*Anadara* (*Anadara ?*) *daitokudoensis* (Makiyama)	Heirokudo formation, Korea
East Indies	*Anadara* (*Scapharca*) *sedanensis* (Martin) (Also other species)	Rembang beds, Java
Philippine Islands	*Anadara* (*Anadara*) *granosa* (Linné)	Vigo Group, Tayabas Province
Western North America	*Anadara* (*Anadara ?*) sp. A, Schenck & Reinhart	San Emigdio formation California
Southeastern North America	*Anadara* (*Scapharca*) *invidiosa* (Casey)	Vicksburg formation, Mississippi
	Anadara (*Scapharca*) *lesueuri* (Dall)	Vicksburg formation, Mississippi
Northern South America	*Anadara* (*Scapharca ?*) *meroensis* (Olsson)	Heath formation, Peru
Southern South America	*Anadara* (*Cunearca*) *camaronesia* (von Ihering)	Lower Patagonian, Patagonia
West Indies	*Anadara* (*Scapharca ?*) *willobiana* (Cooke)	Antigua formation, Antigua Island

(5) The relation between the Tertiary and Recent distribution of *Anadara* will be made clear by a scrutiny of the accompanying map, figure 1.

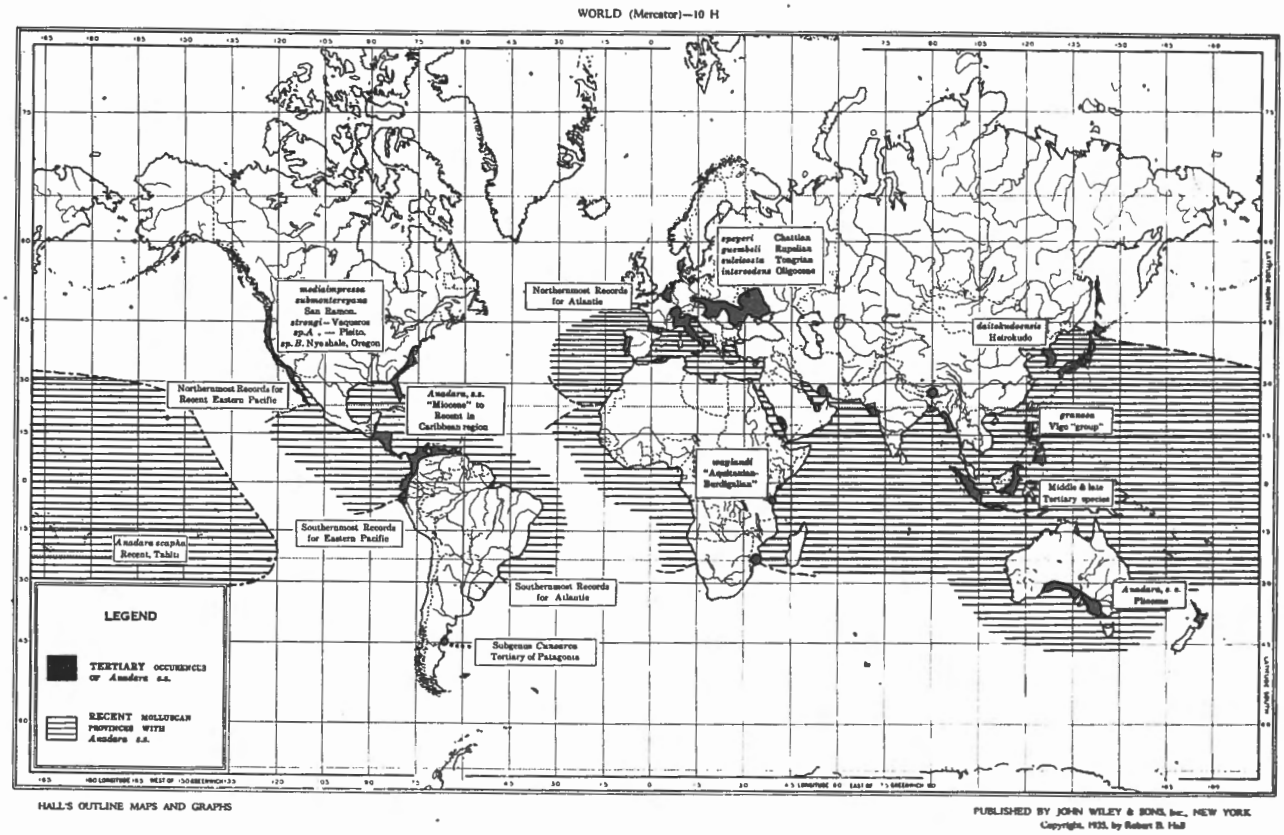

FIG. 1. — Map showing distribution of *Anadara*.

Map showing the distribution of Tertiary species of *Anadara s. s.* and the Recent molluscan provinces (after Woodward) inhabited by living species. *Anadara* does not always occur throughout an entire province. Thus, *Anadara* does not live today off the southern coast of South Australia, although it does live in the northern part of the Australian Province, which by Woodward's definition includes the ocean adjacent to the entire southern half of Australia. *Anadara s. l.* has a somewhat wider distribution in modern seas than has the typical subgenus, occurring, for example, in the Transatlantic molluscan province. The occurrences of fossils are greatly generalized because of the small scale of the map.

The oldest known species of the restricted genus *Anadara* is *sulcicosta*, from the Tongrian of Belgium. During Oligocene time *Anadara, s. s.*, lived as far north as latitude 56°, the northernmost record for the genus. Species inhabited the Miocene seas of the present-day Antillean region. Species also lived in the Miocene seas of western South America, California, Oregon, and Washington, spreading as far north as latitude 47°, and below the equator to 5° south latitude. On the Atlantic slope of North America, Miocene species ranged to about 39° 30′ north latitude. An Oligocene (or Miocene) species occurs in East Africa, in the Zanzibar Protectorate. Specimens are reported from the Miocene of the Dutch East Indies and the Philippine Islands, and perhaps from the Oli-

gocene of the latter place. A species tentatively allocated to the typical subgenus has been found in the Heirokudo formation (Oligocene ?) of Korea. Numerous authors report Miocene species from several localities in the Japanese Empire.

The closely related subgenus *Scapharca* occurs in the Aquitanian Stage of western Europe, probably in the Heath formation (« upper Oligocene ») of Peru and Ecuador, the « Oligocene » of Antigua Island, and in the Vicksburg beds of Mississippi, not to mention its many records in strata of established Miocene age. Both *Anadara, sensu stricto,* and *Scapharca* were cosmopolitan during the Miocene.

The time when *Anadara, s.s.*, spread to the Americas and Asia is precisely what we should like to determine, since that information would have a direct bearing upon the ages of certain formations in the New World. Data in hand do not warrant a categorical statement; they permit only of the postulation of this working hypothesis : species spread from the assumed European center of dispersal both eastward and westward along a Tethian route during the Oligocene epoch; during the Miocene epoch *Anadara, s.s.*, attained its maximum dispersal, later receding to its present-day distribution in the Lusitanian, West African, Caribbean, Panamic, Australian, and Indo-Pacific marine molluscan provinces. The hypothetical continental outlines ([2]) given by W. D. Matthew for the Middle Oligocene and Miocene are not inconsistent with our hypothesis.

A detailed study of a single subgenus of the marine invertebrates alone will not serve as the basis for the interregional synchronization of Tertiary formations nor for the proof or disproof of far-reaching theories. But when many genera are analyzed thoroughly and the biochron of each subgenus and genus is ascertained in each local district, then satisfactory interregional correlations may be possible.

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([2]) *Bull. Am. Mus. Nat. Hist.*, vol. 22, p. 364, 366, 1906.

L. G. Hertlein, S. Hirase, F. Hodson, Y. Otuka, K. van W. Palmer, L. M. Perry, H. A. Pilsbry, E. Quisumbing, B. Rensch, R. Rutsch, K. Sato, S. Savage, F. X. Schaffer, Pearl G. Sheldon, R. A. Stirton, Victor van Straelen, I. M. van der Vlerk, O. C. Wheeler, W. P. Woodring, and A. Wrigley.

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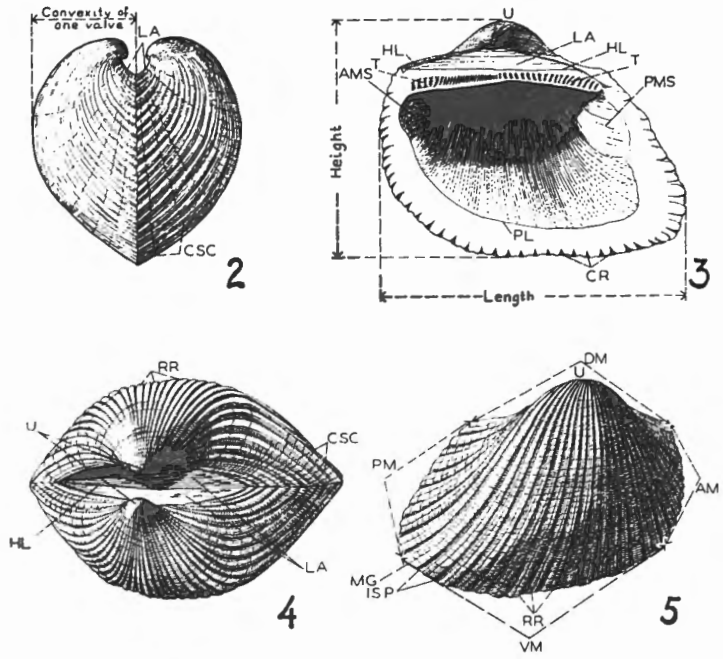
DEFINITION OF ANADARA

The originally designated type species of *Anadara* Gray, 1847, is the Recent tropical to subtropical species *Arca antiquata* Linné, 1758, the type locality of which is probably the West Indies. The type specimen has been figured by Hanley ([3]) and by Woodring ([4]), and the accompanying text figures 2, 3, 4, and 5 are based upon a representative of the species.

The name *Anadara, sensu stricto,* is applied in this paper to those species having the general morphologic characteristics of the genotype. The majority of the species are elongate and not trigonal in outline, with umbones only moderately prominent. The shell is equivalve and the sculpture of the two valves is similar, not discrepant. The following species, cited merely as examples, are among those that can be assigned with confidence to *Anadara, s. s.* : « *Arca* » *sulcicosta* Nyst, from the lower Tongrian of Belgium, and well figured by von Koenen from the Lattorfian of Germany; « *Arca* » *diluvii* Lamarck, a

([3]) HANLEY, *Ipsa Linnaei Conchylia*, pl. 4, fig. 3, 1855.

([4]) WOODRING, *Carnegie Inst. Wash., Publication* N° 366, pl. 4, figs. 1, 2, 1925.



FIGS. 2-5. — *Anadara antiquata* (LINNÉ).

Anadara antiquata (Linné); Recent, West Indies. Stanford University Paleo. Type Coll. Hypotype No. 5318 (×0.7); length, 60.9 mm.; height, 47 mm.; convexity of one valve, 20.2 mm. Fig. 2, Anterior view of attached valves; fig. 3, interior of right valve; fig. 4, dorsal view of attached valves; fig. 5, exterior view of right valve. Measurements for height and length are made along the lines shown in fig. 3.

KEY TO SYMBOLS

AM	Anterior margin.	MG	Median groove (on rib).
AMS	Anterior muscle scar.	PL	Pallial line.
CR	Crenulations on inner margin.	PM	Posterior margin.
CSC	Concentric sculpture.	PMS	Posterior muscle scar.
DM	Dorsal margin.	RR	Radial ribs.
HL	Hinge line.	T	Taxodont teeth.
ISP	Interspace between ribs.	U	Umbo.
LA	Ligamental area.	VM	Ventral margin.

common European Miocene species; *Anadara waylandi* Cox, from the Tertiary of Pemba Island; and « *Arca* » *osmonti* Dall, from the Tertiary of California.

The above definition excludes from *Anadara, sensu stricto,* those species possessing the general characteristics of « *Arca* » *incongrua* Say, the type of *Cunearca.* In the latter category are placed those forms that are distinctly inequivalve, show markedly discrepant ornamentation on the two valves, and which are usually high and short in outline.

Intermediate between typical *Cunearca* and typical *Anadara* are those species which, although having the outline of *Anadara,* are inequivalve and with

sculpture of varying degrees of discrepancy. Such species are referred to *Scapharca* (type *Arca inaequivalvis* Bruguière, 1789). Noteworthy is the fact that in *Scapharca*, as well as in *Cunearca*, the left valve is always the larger, overlapping the right. Similarly, in those two subgenera, the discrepancy in sculpture is due to the ribs of the left valve being more strongly noded or beaded than those of the right. Differences of dichotomy of the ribs on the two valves are also often present.

A few of the many species of *Scapharca* are the following : « *Arca* » *darien-sis* Brown and Pilsbry, from the Miocene of the tropical Americas; « *Arca* » *aqui-tanica* Mayer, from the Aquitanian stage of France; « *Arca* » *mirandana* H. K. Hodson, from the « Oligocene-Miocene » of Venezuela; « *Arca* » *fichteli* Deshayes, from the Miocene of Europe; « *Diluvarca* » *mikkula* Gardner, from the Miocene of Florida; and « *Arca* » *sedanensis* Martin, from the Rembang beds of Java.

The subgeneric allocation of *A. granosa* points to the difficulty of drawing sharp boundaries between *Senilia*, *Larkinia*, and *Anadara*, *sensu stricto*, if dependence is placed upon one morphologic feature alone. Separation must be made upon a combination of characters. *Senilia* (genotype *Arca senilis* Linné) may be distinguished from *Larkinia* and *Anadara*, *s. s.*, by its extremely prosogyrous beaks, its unusually small number (15 or less) of smooth, broad ribs becoming obsolete at the posterior and anterior extremities of the shell, and by its somewhat trigonal profile. *Larkinia* and *Anadara*, *s. s.*, on the other hand, sometimes are not so easily separated from each other. As a rule, specimens of the typical subgenus of *Anadara* are elongate, with the beaks anterior to the center of the shell. In *Larkinia* (type *Arca larkinii* Nelson), the length of the shell ordinarily is about equal to the height, and the beaks are centrally placed; moreover, representative specimens of the genotype show exteriorly a pronounced angulation separating the posterior slope from the central part of the shell. *Anadara granosa*, Plate II, figure 9, and Plate IV, figure 1, combines some of the characters of *Anadara*, *s. s.*, and *Larkinia*, having the general profile of the latter, but lacking the distinct angulation; the species is retained in the typical subgenus, although it is a border-line case.

Argina constitutes a biological unit readily identified by the ligamental area situated posterior to the umbones only; its anterior teeth are few in number, whereas the posterior teeth are numerous. The genotype is figured by Reeve (*Conch. Icon.*, vol. 2, *Arca*, plate 4, fig. 22, 1844).

The definition of any genus or subgenus involves consideration of two separate and distinct matters : (*a*) the evaluation of the taxonomic category, considered from the biological point of view; and (*b*) the question of nomenclature, considered from the legalistic point of view. As to whether one should treat *Argina*, *Cunearca*, *Scapharca*, *Senilia*, and *Larkinia* as subgenera of the genus *Anadara* depends to a large degree upon the systematist's professional judgment and point of view. Alleged genetic classifications of pelecypods have

been proposed that are based upon *a priori* assumptions of relative ranks of certain morphologic features; as, for example, that the hinge is of generic rank and the ornamentation of specific rank. Such classifications have been praised as « objective » because of their uniformity, despite the obvious subjective starting point. Other classifications, including the one given here, are based upon the principle of the summation of characters. The evaluation of morphologic differences and similarities, however, is complicated by questions of nomenclature. For example, Reinhart has pointed out (5) that *Senilia* and *Argina* were named earlier than *Anadara*, and that although there is no statement in the International Rules of Zoological Nomenclature to cover such a situation, the strict application of the law of priority would force *Anadara* to become a subgenus of *Senilia* or *Argina* (6). Zoological considerations, therefore, rather than legalistic, lead to the following arrangement :

FAMILY **ARCIDAE.**

SUBFAMILY **ANADARINAE** REINHART, 1935.

GENUS ANADARA GRAY, 1847.

SUBGENUS LARKINIA REINHART, 1935.

SUBGENUS CUNEARCA DALL, 1898.

SUBGENUS SCAPHARCA GRAY, 1847.

GENUS SENILIA GRAY, 1842.

GENUS ARGINA GRAY, 1842.

GENUS NEMOARCA CONRAD, 1869.

The International Commission on Zoological Nomenclature has ruled upon the question of the type genus of a family (7). The opinion states that the oldest included generic name need not be taken as the type for the family name. No ruling, however, is yet available as to the genotype of *Arca*, although the case was submitted to the Commission in 1932 (8). We accept *Arca noae* Linné as the genotype of *Arca*, for reasons given by Reinhart (1935), instead of *Arca antiquata* Linné, which, according to some authorities, should be considered the genotype. We believe it likely that *noae* will be accepted ultimately by the

(5) REINHART, *Bull. Mus. Roy. Nat. Hist. Belgique*, t. XI, N° 13 (August 1935), p. 54.

(6) For a similar situation, consult the paper by Schenck and Frizzell. (*Am. Jour. Sci.*, vol. 31 [June 1936], p. 464-466.)

(7) Opinions rendered by the International Commission on Zoological Nomenclature, Opinions 124 to 133. (*Smithsonian Miscellaneous Collections*, vol. 73, N° 8 [October 28, 1936], p. 41-44.)

(8) Our latest request for action was addressed to Captain Francis Hemming, Secretary of the Commission, on January 19, 1937.

Commission as the genotype of *Arca*; the possibility nevertheless exists that *antiquata* may be accepted instead. In that case, *Anadara* would become an exact synonym of *Arca*, and all of the species referred to *Anadara* in this paper would have to be called *Arca*.

Evaded here is the controversial subject of the evaluation of rank of the units treated in this paper. For example, many specialists condemn the subgeneric category on the grounds that it does not express satisfactory genetic relationships and leads to nomenclatural tangles (9). *Senilia* was treated by Reinhart (*op. cit.*, p. 42) as a subgenus; it is here evaluated as a genus. After careful deliberation, we feel that the above scheme for the evaluation of the subdivisions of the Anadarinae is the most satisfactory arrangement possible at the present time. The value of the arrangement is that commonly-employed names may continue to refer to the accustomed biological entities.

The time ranges of these units are as follows :

Anadara, sensu stricto	Early Tongrian to Recent.
Larkinia	Oligocene (Vaqueros) to Recent.
Cunearca	Oligocene to Recent.
Scapharca	Oligocene to Recent.
Senilia	Tertiary (?) (10) to Recent.
Argina	Late Eocene to Recent.
Nemoarca	Cretaceous.

DIAGNOSIS OF ANADARA, SENSU STRICTO

Shell equivalve, commonly inflated, heavy, elongate-oval in outline; umbones anterior to center of shell; beaks prosogyrous, pointing inward; length of adult shells usually 20 to 75 millimeters, rarely 120 mm.; external sculpture of regular, strong, radial ribs, which are plain, beaded, or grooved; interspaces often squarely excavated; concentric sculpture usually stronger on interspaces than on ribs; sculpture of two valves similar, both as to number of ribs and degree and kind of ornamentation; most species possess from about 20 to 40 radial ribs; when attached, two valves close tightly, lacking a byssal gape; ligament external, occupying practically all of the trough-shaped ligamental area between beaks, and extending the length of dorsal margin, both anterior and posterior to beaks; surface of ligamental area usually grooved by chevron-shaped

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(9) SCHENCK, HUBERT, G., The Subgenus as a taxonomic category. (*Geol. Soc. Am., Proc. for 1936* [*1937*].)

(10) DREGER, *Verhand. der k. k. geol. Reichsanstalt*, Jahr. 1895, N° 4, p. 129-130. *Senilia senilis* (Linné), the genotype, is reported from a deposit at St. Paul de Loanda, Angola (West Africa), the age of which is thought by Dreger to be Miocene, Pliocene, or « Diluvial ».

or, more rarely, by straight, longitudinal lines; hinge straight or slightly arched, extending nearly entire length of dorsal margin; hinge teeth numerous, fairly strong and regular, larger at extremities than at center of hinge; teeth more or less perpendicular to hinge line near beaks, but somewhat oblique near extremities of hinge, so as to converge ventrally; two adductor muscle scars, subequal in size, the posterior one commonly larger and more quadrangular than anterior; pallial line simple, in some species indistinctly developed; inner ventral margin crenulate, the crenulations corresponding to radial ribs on surface; shell porcellaneous; periostracum of horny material usually covered with « hairs ». Distribution : cosmopolitan, in warm, shallow water; marine. Time range : Tongrian (early Oligocene) to Recent. Genotype : « *Arca* » *antiquata* Linné.

CRITERIA OF SPECIFIC IMPORTANCE

All of the morphological features of the shell must be taken into account in the identification of species. Of these features, the following are considered the most important, the nomenclature employed being explained in text figures 2-5 :

(*a*) *Form* — size, shape, convexity, and thickness of shell. For example, even a casual inspection of *granosa* (Pl. IV, fig. 1), with a large, ovate, heavy shell bearing high, full umbones centrally placed, at once suffices to distinguish this species from *sulcicosta* (Pl. 1, fig. 3), which is relatively elongate and thin-shelled, and has low, moderately sharp umbones located anteriorly.

(*b*) *Sculpture* — number, size, shape, and ornamentation of radial ribs; shape, relative width, and depth of interspaces; concentric sculpture. These features, shown on most of the accompanying plates, are illustrated in detail for several species on Pl. V. Figs. 2 and 3, for example, clearly show the marked difference in radial and concentric sculpture between *antiquata* and *hankeyana*, two species which superficially resemble each other in form. Again, comparison of fig. 5 with figs. 4*c* and 6, on the same plate, brings out the fact that the radial ribs of *waloensis* are narrower in proportion to the interspaces than those of *timorensis* or *ferruginea*. The number of ribs, although varying somewhat within a species, is an important specific criterion, which can be used even on poorly preserved specimens. It is useful in dealing with young shells as well as with adults, as the number of ribs seems not to change with age. Thus, the table showing the dimensions and number of ribs of *bisenensis*, under the discussion of that species, shows that the number of ribs on a specimen 2.8 mm. long is the same as on shells in the neighborhood of 50 mm. long.

(*c*) *Ligamental area* — relative width, shape; type of ligamental grooves and their arrangement. On Pl. VI are shown the ligamental areas of several

species, in which differences in relative widths are striking, as between figs. 6 and 7. Various different arrangements of the ligamental grooves, or « chevrons » are there illustrated. Figs. 7 and 8 show species having a large number of closely-spaced « chevrons », whereas in fig. 3, *antiquata* is shown to have no true « chevrons », but only a groove bounding the outer side of the ligamental area, which is striated with fine, horizontal growth lines lying parallel with the hinge. Such horizontal growth lines are also commonly developed in species bearing « chevrons », and may be discerned in figs. 1, 2, 5, and 7 of Pl. VI. As is pointed out in the discussion of *Anadara turonica*, the arrangement of the ligamental grooves is the chief means of distinguishing this species (Pl. VI, fig. 2) from *aquitanica* (Pl. VI, fig. 1), and is likewise important in separating both of these species from *diluvii* (Pl. VI, fig. 6).

(*d*) *Hinge* — degree of arching; size, shape, inclination, and number of taxodont teeth ([11]). Fig. 7 of Pl. VI shows the hinge of *fichteli*, in which no arching can be observed, the hinge being nearly straight. Some of the others, however, show a definite though slight arch, caused by a thinning of the hinge plate at the center, as in *osmonti* (fig. 8). Fig. 6 shows a specimen of *diluvii*, in which the teeth are longer, and the hinge wider than on *speyeri* (fig. 5). Similarly, the teeth of *granosa* (Pl. IV, fig. 1*b*) are relatively long, in contrast to most species. Pl. VI, figs. 5 and 8 (*speyeri* and *osmonti*), show a hinge in which the posterior five or six teeth lie at an angle of about 45 degrees to the hinge line, while the anterior teeth slope the other way, although less strongly. The two series of teeth thus converge ventrally. Such convergence is greater on some species than on others; for example, *fichteli* (fig. 7) shows little convergence.

(*e*) *Adductor muscle scars* — size, shape, degree of prominence. Variation in muscle scars is an aid in specific determination. In *granosa* (Pl. IV, fig. 1*b*) these scars are well developed and conspicuous, although in the related species *bisenensis* (Pl. IV, figs. 2 *a-b*) they are indistinct.

(*f*) *Pallial line* — The two last-named species illustrate the difference in development of the pallial line between two related species; in *granosa*, the pallial line is well developed, but in *bisenensis* it is scarcely visible.

(*g*) *Crenulations on inner margin of shell* — A comparison of *hankeyana* and *granosa* (Pl. III, fig. 4*a* and Pl. IV, fig. 1*b*) illustrates the variation of these crenulations. In most species, they do not extend inside the pallial line, although in *bisenensis* (Pl. IV, figs. 2*a-b*) some extend dorsally almost as far as the umbo.

([11]) The number of teeth is a criterion of specific value only on adult shells, as the number increases with growth.

Some features, such as color, periostracum, and soft parts, available to the zoologist, cannot be observed by the paleontologist, and are therefore omitted from this list. In no case is any one feature sufficient for the identification of a species, but, on the contrary, a summation of characters is always necessary.

DEFINITION OF OLIGOCENE

The term Oligocene is employed in this paper to include, in ascending order, the following Stages ([12]) : Tongrian, Rupelian, Chattian, and Aquitanian (each with its type locality in western Europe), and their synonyms and correlatives. As is well known, the upper and lower boundaries of the Oligocene Series, in Europe and elsewhere, are and will continue to be the subject of disagreement among stratigraphers and paleontologists, some affirming that the Oligocene should be restricted to include only the Rupelian and Chattian Stages and assigning the Tongrian Stage to the upper Eocene, others maintaining that the Aquitanian Stage is referable to the Miocene Series. A few authorities even advocate the abandonment of the term Oligocene entirely. Those who defend its existence take the Oligocene Series to be a thickness of strata deposited during a given interval of time. Hence, the Series is a time-stratigraphic unit whose definition depends equally upon rocks and upon time ([13]). This means that paleontologic criteria are of prime importance in the delimiting of the Oligocene Series.

The problem of the Oligocene, which cannot be treated fully here, may be summarized as falling into two main categories : (*a*) the constitution of the Oligocene Series at its type area in Europe, and (*b*) the correlation of sedimentary deposits in different parts of the world with the beds at the type area. The solution must rest upon detailed stratigraphic studies, the recognition of facies, the diastrophic record, and above all, in our opinion, upon comprehensive paleobiologic investigations. Which kind of evidence adduced by investigators will meet with general acceptance is difficult to predict. Thus, whether Matthew's ([14]) view that the first appearance of *Anchitherium* in the Burdigalian should mark the lower limit of the Miocene will meet with general approbation of all specialists dealing with the Mollusca, one cannot say. Certainly, however,

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([12]) SCHENCK, HUBERT, G. and MULLER, SIEMON, W., *Stratigraphic Terminology*, an unpublished paper presented before the Cordilleran Section, Geological Society of America, Pasadena meeting, 1936, contains the suggestion that when the words Stage, Series, Group, etc., are used in a restricted stratigraphic sense they should be capitalized. GREGORY and BARRETT, *General Stratigraphy* (1931, p. 18), make a similar suggestion.

([13]) SCHENCK and KLEINPELL, *Bull. Am. Assoc. Pet. Geol.*, vol. 20, N° 2, p. 215-217, 1936.

([14]) MATTHEW, *Quart. Rev. Biol.*, vol. 1, N° 2, fig. 25, p. 167, 1926; consult also Viret. (*Ann. Univ. Lyon*, n. s. I, Sci., Med., fasc. 47, p. 291-299, 1929.)

such biological studies as his place the paleontological criteria in better perspective than do purely faunistic studies of limited formations in isolated localities. The evaluation of paleontological evidence, in short, is best made by comprehensive reviews of individual taxonomic units.

Even granting the completion of numerous comprehensive paleobiological and stratigraphical investigations, the delimitation of the Oligocene Series, as well as many others, will have to be arbitrary. Consider as a related problem the question of where to place the boundary between the Recent and Pleistocene in Europe, the Sahara desert, the Philippine Islands, California, and Greenland. The criteria relied upon will vary both with the locality and with the scientist. At some locality or localities, the transition from one Series to another Series, if not already known, is certain to be discovered. The establishment of arbitrary limits, therefore, is as satisfactory a means of defining the Oligocene Series as any yet employed.

It is proposed here as a consequence of this argument to delimit the Oligocene Series in a purely arbitrary manner. The lower limit of the Series is set at the base of the Tongrian Stage at its type area in Belgium, these lower beds including, among others, the lower Tongrian marine sands exposed at Vliermael. Among the several reasons for including the Tongrian Stage in the Oligocene Series is that it was so allocated by Beyrich ([15]) in his original definition of the Oligocene. The upper limit of the Oligocene Series is placed at the top of the Aquitanian Stage ([16]) at its type area in the Aquitaine basin of France.

Some stratigraphers oppose the allocation of the Aquitanian to the Oligocene but place it, instead, in the Miocene. They emphasize the close relationship between the Aquitanian and Burdigalian marine molluscan assemblages in the Aquitaine basin and point out that the Aquitanian Age marks the beginning of a great transgression. In support of an Oligocene age for the Aquitanian, however, it may be pointed out that : (1) the faunas of all Stages are related to those of adjacent Stages of the same facies and in the same district; (2) transgressions are not satisfactory means for delimiting geological time: (3) the type Aquitanian Stage — as a time-stratigraphic unit — does not have its lower limit defined satisfactorily by paleontological criteria; (4) many species of Aquitanian invertebrates are closely related to older species; and (5) the Aquitanian mammals are Oligocene. On consideration of these points we are of the opinion that there are more reasons for than against taking the Aquitanian Stage as a division of the Oligocene Series.

The solution of the second class of problems — that of the synchronization of deposits in different parts of the world with beds at the type areas of the various Oligocene Stages — is likewise difficult. The correlatives of the Ton-

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([15]) BEYRICH, *K. preuss. Akad. Wiss.* Berlin, Monatsber., November 1854, p. 664-666. See translation in Wilmarth. (*U. S. Geol. Survey Bull.*, 769, p. 53-54, 1925.)

([16]) SCHENCK, *Bull. Am. Assoc. Pet. Geol.*, vol. 19, N° 4, p. 521-536, April 1935; *Soc. Géol. France, C. R. S. des séances*, fasc. 10, p. 143-144, May 1935.

grian, Rupelian, Chattian, and Aquitanian are set forth in a concise way by Julia Gardner ([17]) and these synchronizations are as satisfactory as many. We accept as possible correlatives of the Aquitanian Stage the lower Gaj « series » of India, the Rembang beds of Java ([18]), and the « Vigo Group » of the Philippine Islands. The Vaqueros formation of California may be of Aquitanian age or even somewhat older. It is because of the unsettled nature of many synchronizations that this paper contains discussions of species which later may prove to be characteristic of Series other than the Oligocene.

Also dealt with are some Miocene and younger species that are related to those coming from the Oligocene and supposed Oligocene beds. The justification for this, if justification be needed, is that such treatment should aid in evaluating the morphological differences of such species of *Anadara* as may be used in synchronizing widely-separated geological formations.

LIST OF SPECIES EXAMINED

We have examined specimens of the eighty-six species, subspecies, « varieties », and « mutations » tabulated here under their original name-combinations. So far as can be determined, this list includes all of the species of *Anadara* described from Oligocene formations and many from Miocene beds, as well as several Pliocene and younger species studied for comparison with the older ones and for the determination of essential facts of distribution. The study of these specimens, therefore, forms the basis for this report. The subgeneric allocations were made for the most part upon the specimens in hand. Sometimes the identifications of the specimens could not be checked, and dependence was placed upon the name-label accompanying the fossils. In those cases, consequently, opinion regarding the subgenus of the species is tentative.

EXPLANATION OF SYMBOLS AND CONVENTIONS USED.

Boldface type	**Anadara, sensu stricto.**
*	Discussed (figured) in text.
**	Discussed (figured) in text and believed to be from the Oligocene, or from beds called Oligocene.
!	Assigned to *Scapharca*.
!!	Assigned to *Cunearca*.
?	Interrogation points added after any of these symbols in case of doubt.

([17]) GARDNER, JULIA, Table I in Vaughan. (*Bull. Geol. Soc. Am.*, vol. 35, p. 677-742, 1924.)

([18]) UMBGROVE, *Fourth Pacific Sci. Congress*. Batavia-Bandoeng, Java, May-June 1929, p. 4-7, 1929.

! *Arca abdita* Makiyama.
Arca americana « Gray » Wood (Genus *Argina*).
• *Arca* **antiquata** Linné.
••! *Arca aquitanica* Mayer.
! *Arca* (*Scapharca*) *biformis* Martin.
• *Anadara* (*Anadara*) **bisenensis** Schenck and Reinhart, n. sp.
! *Arca breislacki* Basterot.
!!? *Arca burnesi* d'Archiac and Haime.
Arca campechensis « Gmelin » (Genus *Argina*).
!! *Arca cardiiformis* Basterot.
Arca (*Scapharca*) **copiosa** Pilsbry and Johnson.
! *Arca cornea* Reeve.
•• *Arca* (*Anadara*) **daitokudoensis** Makiyama.
?! *Arca* (*Anadara*) *daneyi* Cossmann and Peyrot.
! *Arca dariensis* Brown and Pilsbry.
! *Arca delicatula* Casey (synonym of *A. invidiosa*).
Arca (*Scapharca*) **devexa** Pilsbry and Johnson.
Arca **devincta** Conrad.
Arca **diluvii** Lamarck.
! *Arca muldensis* var. *elongata* Schaffer.
Arca **ferruginea** Reeve.
• *Arca* (*Anadara*) *ferruginea* **timorensis** Koperberg.
• *Anadara* (*Anadara*) *ferruginea* subsp. **waloensis** Schenck and Reinhart, n. subsp.
! *Arca fichteli* Deshayes.
Arca **formosa** Sowerby.
!! *Arca* (*Scapharca*) *gendinganensis* Martin.
! *Arca girondica* Mayer.
•• *Arca* **granosa** Linné.
Arca granosa **teschi** Koperberg.
•• *Arca* **guembeli** Mayer.
• *Arca* **hankeyana** Reeve.
! *Arca helvetica* Mayer.
!!? *Arca hispida* Philippi.
! *Arca* (*Scapharca*) *hulshofi* Martin.
! *Arca inaequilateralis* Guppy.
! *Arca inaequivalvis* Bruguière.
!! *Arca incongrua* Say.
•• *Arca* **intercedens** Wolff.
Arca (*Scapharca*) **intumulata** Pilsbry and Johnson.
••! *Arca invidiosa* Casey.
! *Arca* (*Anadara*) *junghuhni* Martin.
!! *Arca larkhanaensis* d'Archiac & Haime.
Arca **latesulcata** Nyst.
! *Scapharca* (*Scapharca*) *lesueuri* Dall.
•• *Arca* (*Scapharca*) **mediaimpressa** Clark.
! *Arca* (*Scapharca*) *menengtengana* Martin.
•! *Arca* (*Scapharca*) *meroensis* Olsson.
! *Diluvarca* (*Diluvarca*) *mikkula* Gardner.
! *Arca* (*Scapharca*) *mirandana* H. K. Hodson.
!! *Arca* (*Scapharca*) *multiformis* Martin.
Arca ninohensis Otuka (Subgenus *Larkinia*).
! *Arca* (*Anadara*) *nodosa* Martin.
Arca (*Anadara*) **ogawai** Makiyama.
• *Arca* **osmonti** Dall.
Arca peethensis d'Archiac and Haime.
!? *Barbatia* (*Diluvarca*) *perplura* Woodring.
Arca pexata Say (Genus *Argina*).
!! *Arca pilula* Reeve.
!! *Arca pomponiana* Pilsbry and Johnson.
! *Arca preangerensis* Martin.
•! « *Arca radiata* » Sowerby.
!! *Arca rhombea* Born.
Arca rhomboidella Lea (Genus *Plagiarca*).
!! *Arca* (*Scapharca*) *salladilloensis* H. K. Hodson.
!! *Arca* (*Anadara*) *santaclarana* Loel and Corey.
Arca (*Anadara*) *santana* Loel and Corey (Subgenus *Larkinia*).
Arca santana weddlei Loel and Corey (Subgenus *Larkinia*).
Arca **secticostata** Reeve.
! *Arca* (*Scapharca*) *sedanensis* Martin.
•• *Arca* **speyeri** Semper.
••? *Arca* (*Barbatia*) **strongi** Loel and Corey.
•• *Arca* (*Scapharca*) **submontereyana** Clark.
! *Arca subrostrata* Conrad.
•• *Arca* **sulcicosta** Nyst.
Arca (*Anadara*) **tambacana** Martin.
!! *Arca* (*Cunearca*) *thalia* Olsson.
Arca **trapezia** Deshayes.
•! *Arca turonica* Dujardin.
•• *Anadara* **waylandi** Cox.
!! *Arca websteri* Pilsbry.
!! *Arca* (*Scapharca*) *weeksi* H. K. Hodson.
!! *Arca* (*Scapharca*) *wiedenmayeri* H. K. Hodson.
••! *Scapharca willobiana* Cooke.
! *Barbatia* (*Diluvarca*) *wordoni* Woodring.
!! *Arca* (*Scapharca*) *zuliana* H. K. Hodson.
!! *Arca zuliana* var. *maracaibensis* H. K. Hodson.

REPOSITORIES OF SPECIMENS EXAMINED

Name	Address	Abbreviation
British Museum (Natural History).	London, England.	Brit. Mus.
Bureau of Science.	Manila, P. I.	Phil. Bur. Sci.
California Academy of Sciences.	San Francisco, California.	C. A. S.
Eidgenössisch Technische Hochschule.	Zürich, Switzerland.	
Fred Baker Collection.	Point Loma, California.	
Geological Institute, Kyoto Imperial University.	Kyoto, Japan.	Geol. Inst., Kyoto Imp. Univ.
Geologisch Instituut, Universiteit van Amsterdam.	Amsterdam, The Netherlands.	Geol. Inst. Univ. Amsterdam.
Mecklenburgische Geologische Landesanstalt.	Rostock, Germany.	
Musée royal d'Histoire naturelle de Belgique.	Brussels, Belgium.	Mus. roy. Hist. nat. Belg.
Museum of Paleontology (Invertebrates), University of California.	Berkeley, California.	Univ. Calif. Mus. Invert. Paleo.
Naturhistorisches Museum.	Basel, Switzerland.	
Oldroyd Collection.	Stanford University, California.	Oldroyd Coll.
Paleontological Research Institute.	Ithaca, New York.	Paleo. Res. Inst.
Philadelphia Academy of Sciences.	Philadelphia, Pennsylvania.	
Rijksmuseum van Geologie en Mineralogie.	Leiden, The Netherlands.	Rijks Geol.-Min. Mus.
Royal School of Mines.	London, England.	
Sammlung für Paläontologie und Historische Geologie.	Munich, Germany.	
Schenck Collection.	Stanford University, California.	Schenck Coll.
Sedgwick Museum.	Cambridge, England.	
Shell Oil Company.	Bakersfield, California.	
Stanford University Paleontological Type Collection.	Stanford University, California.	Stanford Univ. Paleo. type coll.
United States National Museum.	Washington, D. C.	U. S. Nat. Mus.

OLIGOCENE SPECIES OF ANADARA, *s. s.*

SPECIES FROM EUROPE

Anadara (Anadara) sulcicosta (Nyst), 1836.

Pl. I, fig. 3; pl. II, fig. 1.

1836. *Arca sulcicosta* Nyst, Rech. coq. foss. de Housselt et Kleyn-Spauwn., p. 10, N° 26, pl. 1, fig. 26. « Housselt et Vliermael. »

1839. *Arca sulcicosta*. Dumont, Bull. Acad. roy. Sci. et Belles-Lettres, Bruxelles, t. VI, 2e partie, année 1839, N° 11, p. 473. Tongrian : Grimmertingen, Hasselt, and Lethen, Belgium.

1845. *Arca sulcicosta* Nyst, Mém. cour. des Sav. Étrangers, Acad. roy. de Bruxelles, t. 17, p. 257-258, pl. 18, figs. 9*a*, *b*.

1848. *Arca sulcicosta* Nyst, Mém. Acad. roy. Belg., t. 22. Tableau synoptique... des Arcacées, p. 70-71. Tertiary : Vliermael, Hasselt and Lethen, province of Limbourg, Belgium.

1864. *A. duplicata* Sow. (*partim*), von Koenen, Quart. Jour. Geol. Soc. London, Proc. Dec. 2, 1863, vol. 20, p. 100. Not *Arca duplicata* Sowerby, 1824, a synonym of *A. appendiculata* Sowerby, 1821.

1886. *Arca appendiculata* J. Sow., Vincent, Ann. Soc. roy. Malac. Belg., t. 21, p. 13. Not *Arca appendiculata* J. Sowerby, Miner. Conch., vol. 3, p. 135, pl. 276, fig. 3, 1821; a *Barbatia* from the Barton beds, Eocene, of England.

1893. *Arca sulcicosta* Nyst, von Koenen, Abh. d. geol. Landesanstalt, Bd. X, Heft 5, p. 1097-1100, pl. LXX, fig. 1*a*, 1*b*, 2*a*, 2*b*, 2*c*. Lower Oligocene : Lattorf, Atzendorf, Unseburg, Wolmirsleben, Osterweddingen, Lethen, Hasselt, Vliermael, Brockenhurst.

1893.?, *Arca sulcicosta* var. *camerata* von Koenen, *supra cit.*, p. 1099-1100, pl. 70, figs. 3-4.

1902.?, *Arca appendiculata*. Maury, Bull. Amer. Palaeont., vol. 3, N° 15, p. 327, Magdeburg sands : Germany; p. 391, Tongrian : Belgium.

1912. *A. sulcicosta* Nyst, Cossmann and Peyrot, Actes Soc. Linn. Bordeaux, t. 66, p. 282. Differentiated from *daneyi*, an Aquitanian species.

1936. *Anadara* (*Anadara*) *sulcicosta* (Nyst), Schenck and Reinhart, Geol. Soc. Am., Proc. for 1935 (June 1936), p. 412.

Not *Arca sulcicosta* Gabb, Paleontology of California, vol. 2, pt. 1, p. 31, pl. 9, figs. 53. 53*a*, 1866. (Renamed *A. schizotoma* Dall, 1898.)

Type material. — Holotype unknown. Lectotype (here selected) N° 1, paratypes N°s 2-5, hypotypes N°s 112, 142, Mus. roy. Hist. nat. Belg.

Type locality. — « Sables de Vliermael », lower Tongrian, at Vliermael, Province of Limbourg, Belgium. Fig. 6 is a sketch map showing the general geology of this district.

E. van den Broeck pointed out in the description of the Bilsen sheet (1883) that the Tongrian is a transgressive formation, with a conglomerate (Tg1a) at the base, followed by 2-3 meters of sands, succeeded, in turn, by fossiliferous argillaceous sands (Tg1c) about 12-15 meters thick. Above these sands is a quartzose sand, finely stratified, having a maximum thickness of 8 meters. These beds, totalling some 80 feet in thickness, comprise the lower Tongrian at its type area, although nearby a total thickness of nearly 250 feet is reported. The lower Tongrian grades upwards into homogeneous greenish sands (Tg2a) of the lower part of the upper or « fluvio-marine » Tongrian. The middle part of the upper Tongrian is the « Argile de Henis » (Tg2b), composed chiefly of sandy clays and fine sands. The uppermost part (Tg2c), classically exposed at Vieux-Joncs, is made up of clays with *Cyrena semistriata* Deshayes, etc. The upper, or non-marine, Tongrian locally has a maximum thickness of about 50 feet. The Tongrian thus totals about 130 feet in thickness at its type area.

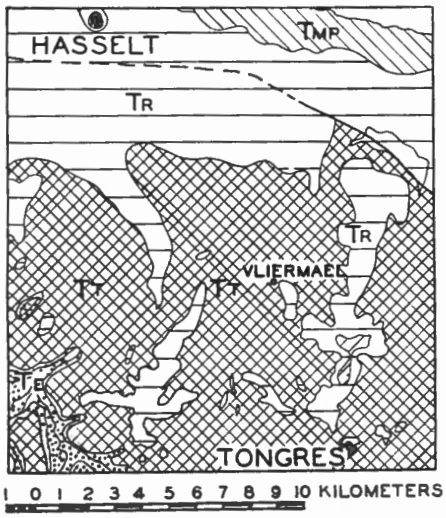

FIG. 6. — Map showing type locality of *Anadara sulcicosta*.

Map showing the type locality of *Anadara sulcicosta* (Nyst), modified from « La carte géologique de la Belgique, troisième état », 1900.
TE = Eocene; TT = Tongrian (lower Oligocene); TR = Rupelian (middle Oligocene); TMP = Bolderian (upper Miocene).

The stratigraphic relations between the Rupelian and upper Tongrian are well shown in several localities in this region. The basal Rupelian is marine. The lower Rupelian (R1) consists of the « Sables du Limbourg » with *Glycymeris obovatus*, and the upper (R2) is the« Argile du Rupel ». R1a is a pebble bed, R1b is the « Sables de Berg », quartzose sands up to about 8 meters thick. R1c is sandy clay, with numerous specimens of *Nucula*, aggregating about 10 meters in thickness. R1d consists of 4 meters of sands. R2a is gravel about

1 meter thick, R2c is 2 meters of clay. The total thickness of the Rupelian in Belgium is about 450 feet ([19]).

The Eocene beds underlying the Tongrian in this area are not uppermost Eocene (Bartonian), hence the Tongrian Stage at its type locality cannot be said to have a stratigraphic base. However, superposition is convincing evidence that the type Tongrian is lower and older than the typical Rupelian.

MATERIAL EXAMINED. — The type specimens cited above; one topotype, Schenck Coll. N° 856. Numerous specimens in the Natural History Museum, Brussels, from the « Sables de Vliermael » and from the lower Tongrian at Lethen, Broek, Hasselt, Smeermaas, and Neerrepen, Province of Limbourg, Belgium.

DESCRIPTION OF LECTOTYPE AND PARATYPES. — Shell of medium size for genus, equivalve, inequilateral, trapezoidal in outline; anterior margin evenly rounded, ventral margin nearly straight and parallel to hinge, posterior margin sharply rounded below and straight above; dorsal margin interrupted by fairly prominent umbones located anterior to center of shell; medial sulcus extending from tip of beaks to center of ventral margin, but pronounced only in vicinity of umbones; no byssal gape; radial ribs 23 to 30 in number, crossed by inconspicuous growth lines; the ribs begin to dichotomize when the shell attains a height of about 6.5 mm., becoming distinctly twinned at the ventral margin; width of such « double » ribs is up to 1.8 mm.; right and left valves equally sculptured; ligamental area moderately wide, bearing 3 ± irregularly chevron-shaped ligamental grooves; hinge straight, bearing many small taxodont teeth perpendicular to the hinge line except at the extremities, where they become oblique; muscle scars subequal; interior of shell vertically striated inside of pallial line; inner margin of shell strongly crenulate, but crenulations less strong at intersection of medial sulcus with ventral margin; pallial line rather weak.

DIMENSIONS. — The lectotype and paratypes have the following dimensions :

TABLE IV. — **Dimensions of types of sulcicosta.**

	Type specimen in Musée Royal.	Length in mm.	Height in mm.	Convexity of one valve in mm.	Number of radial ribs.	Ratio of height to length in percent (*).
Lectotype	No. 1	33.8	20.8	8.9	29	62
Paratypes	No. 2	37.5	21.3	—	28	57
	No. 3	25.2	14.9	5.7	27	59
	No. 4	20.0	12.9	—	28	62
	No. 5	7.3	4.8	1.8	23	62

(*) The ratio here expressed may vary from about 1 to 5 %, depending upon the person who makes the measurements.

([19]) FOURMARIER, *Ann. Soc. géol. Belg.* Année 1933-1934, p. 173, 1934, gives the maximum thickness of the Tongrian as 80 meters, of the Rupelian 146 meters.

Lectotype N° 1 is illustrated by figures 3 *d*, *e*, and *f* of Plate I. The specimen shown on Plate I, figures 3 *a*, *b*, and *c* is Hypotype N° 112 from Grimmertingen; its dimensions are : length 21.6 mm.; height, 13.4 mm., convexity (both valves), 12 mm., measurements by M. Glibert. The specimen figured on plate II, fig. 1, is a right valve (from Neerrepen) 1.9 mm. in length; it is Hypotype N° 142 of the same museum.

In the collections in the Natural History Museum in Brussels are numerous specimens from the lower Tongrian sands of nearby localities in the province of Limbourg. The dimensions of these fossils are given in the accompanying Table V.

TABLE V (*). — **Dimensions of Anadara sulcicosta.**

LOCALITY.	Specimen.	Length in mm.	Height in mm.	Convexity (1 valve).	Convexity (2 valves).	Number radial ribs.	Ratio H. to L. in percent.	Serial number.
Grimmertingen	1	5.0	3.0			28	60	1
Grimmertingen	2	5.3	3.1	1.3		26	58	2
Lethen	1	12.1	7.8	3.2		25	64	3
Lethen	2	12.7	8.2	3.3		28	65	4
Broek	1	14.6	8.4	3.6		26	58	5
Grimmertingen	3	16.1	10.4		7.7	26	65	6
Grimmertingen	4	16.6	10.5	3.8		26	63	7
Grimmertingen	5	20.4	13.6	5.4		27	67	8
Hoesselt	1	21.2	13.5			26	64	9
Grimmertingen	6	21.7	14.4		11.6	24	66	10
Smeermaas	1	22.0	13.5	5.6		25	61	11
Broek	2	22.2	14.3			27	64	12
Hoesselt	2	24.0	14 1	5.2		28	69	13
Lethen	3	25.4	15.9	6.0		27	63	14
Lethen	4	25.7	16.5	7.4		28	64	15
Lethen	5	25.8	16.4	7.0		28	64	16
Grimmertingen	7	27.6	16.6		14.4	28	60	17
Grimmertingen	8	28.1	16.6		17.0	25	59	18
Grimmertingen	9	28.2	17.4	7.6		26	62	19
Lethen	6	28.2	17.6	7.7		29	62	20
Broek	3	28.6	17.7			28	62	21
Grimmertingen	10	28.7	16.0	6.4		25	66	22
Hoesselt	3	30.0	18.0	7.9		30	60	23
Grimmertingen	11	30.7	18.6	9.0		26	61	24
Smeermaas	2	31.2	19.4	7.2		29	62	25
Broek	4	31.8	18.5			27	58	26
Broek	5	32.2	17.9			28	56	27
Lethen	7	32.2	21.2	8.9		28	66	28
Grimmertingen	12	32.3	19.7	8.9		25	61	29
Lethen	8	33.3	20.0	8.3		28	60	30

(*) Measurements and counts by H. G. Schenck.

TABLE V. — **Dimensions of Anadara sulcicosta** (*continued*).

LOCALITY.	Specimen.	Length in mm.	Height in mm.	Convexity (1 valve).	Convexity (2 valves).	Number radial ribs.	Ratio H. to L. in percent.	Serial number.
Grimmertingen	13	34.1	20.5		17.8	29	60	31
Hoesselt	4	34.6	20 8	9.6		28	60	32
Broek	6	36.3	21.8			30	60	33
Hoesselt	5	37.1	22.7	9.9		28	61	34
Hoesselt	6	37.6	22.1	10.1		27	59	35
Broek	7	40.0	23.3			27	58	36
Broek	8	40.6	23.4			29	58	37
Grimmertingen	14	41.3	24.2	10.4		26	59	38

DIAGNOSIS OF THE ADDITIONAL MATERIAL FROM BELGIUM. — The specimens listed in Table V and some from Neerrepen furnish the basis for the following remarks : The anterior series of teeth (especially in specimens smaller than 3 mm. in length) is short and somewhat irregular, with the hinge widened anteriorly, in this respect having an *Argina*-like arrangement; the ligament, however, is amphidetic — not confined to the posterior of the beak as in *Argina*. The teeth of these small specimens are highly inclined in the posterior series, lying at an angle of about 45° to the hinge line, but are more nearly vertical in the anterior series. On shells which are about 12 mm. in length, the hinge is that of the adult. The ribs are entire and have a beaded appearance on shells 4± mm. in length, and the medial sulcus at this stage is pronounced to the extent that it forms an indentation of the ventral margin. Although the number of ribs, regardless of the size of the specimen, ranges from 23-30, one-third of 42 shells measured have 28 ribs. The ligamental area is moderately wide; a single valve 33.0 mm. long, for example, has an area 3.0 mm. wide, measured directly under the beaks.

COMPARISONS AND SUBGENERIC ALLOCATION. — *Arca sulcicosta* var. *camerata* von Koenen (1893, p. 1099-1100, pl. LXX, figs. 3-4) is of doubtful validity. Considering its smaller size, as compared with *sulcicosta*, the distinctions cited by the German authority are probably of little significance.

Several species of *Anadara* other than *sulcicosta* have an incipient or well-developed medial sulcus and have other general features in common. Among these are *speyeri* (Semper), *diluvii* (Lamarck), *mediaimpressa* (Clark), *invidiosa* (Casey), *daneyi* (Cossmann & Peyrot), and *aquitanica* (Mayer). Only *sulcicosta* and *invidiosa*, however, have the medial sulcus extending from the beaks to the ventral margin, whereas on the other species named, this depression is con-

fined to the umbonal region. Since *invidiosa* has discrepant sculpture and is therefore a *Scapharca*, it can be separated readily from *sulcicosta*.

A. sulcicosta need not be confused with *Barbatia intumescens* Slodkewitsch ([20]), described from the Charkov Stage of the Oligocene on the Omelnik River, southern Russia. This bivalve was described as a variety of « *Barbatia sulcicosta* Nyst », but it is not congeneric with Nyst's species.

The Belgian species, *sulcicosta*, was placed by Vincent and at one time by von Koenen in synonymy with Sowerby's « *Arca* » *appendiculata* and *duplicata*, both from the upper Eocene of Barton, England. Von Koenen (1893) recognized the mistake of his earlier determination and separated *sulcicosta* from *appendiculata*, but additional discussion is pertinent.

Concerning Sowerby's species, Wood ([21]) considered *duplicata* Sowerby to be a variety of the earlier-named species *appendiculata*. The type of *duplicata* was « sent from Hordwell by several friends » ([22]) to Sowerby, and the type of *appendiculata* is from Barton, adjoining localities. Both are from the Barton beds ([23]). The holotype, in the British Museum of Natural History, has the following dimensions, according to Cox : length, 16.8 mm., height 11.8 mm., convexity (single valve), 3.9 mm. An examination of a number of topotypes shows that it is not possible to maintain even a varietal distinction between *duplicata* and *appendiculata* (the latter name to be retained).

These fossils, moreover, are not *Anadara*, but *Barbatia*. The topotypes from Barton have many fine, narrow radial ribs that are undivided on the small shells and in the early stages of the larger ones, but the ribs are divided on the more mature specimens. The ligamental area, which is present on both sides of the beaks, is up to about 2.5 mm. wide, as measured under the beaks. The teeth converge ventrally and are small at the center of the hinge. The inner margin of the shell is smooth on the larger specimens; the byssal gape is small. The fossils exhibit no posterior enlargement in outline, as in the case of *Cucullaearca*. Wood's figures give one a good idea of *appendiculata*, but the larger topotypes do not show such a dentate inner ventral margin as do his figures. With the specimens from Barton placed alongside of those from near Tongrès, it is easy to distinguish *sulcicosta* from *appendiculata* : by ornamentation, profile, character of inner ventral margin, and other features.

([20]) SLODKEWITSCH, *Trans. Geol. and Prospecting Service of U. S. S. R.*, fasc. 89, p. 55, pl. 1, fig. 2. Moscow, 1932.

([21]) WOOD, *A Monograph of the Eocene Bivalves of England*, vol. 1, p. 79, pl. 14, figs. 3*a-f*. (Paleont. Soc. London), August 1864.

([22]) SOWERBY, *Miner. Conch.*, vol. 5, p. 116, pl. 474, fig. 1, 1824.

([23]) Letter to H. G. SCHENCK by L. R. COX, dated October 30, 1933.

The Tongrian species has also been confused with *Anadara diluvii* (Lamarck) ([24]), but the two species can be distinguished by the fact that *diluvii* lacks the conspicuous medial sulcus and divided ribs characteristic of *sulcicosta*.

The description given above, the illustrations, and the remarks just completed should serve to support the allocation of *sulcicosta* to the typical subgenus of *Anadara*.

Anadara (Anadara ?) speyeri (Semper), 1861.

Pl. I, figs 4, 5; pl. VI, fig. 5.

1861. *Arca speyeri* Semper, Beiträge zur Kenntnis der Tertiärformation, 4 Teil, Katalog einer Sammlung Petrefakten der Sternberger Gesteins, Archiv des Vereins der Freunde der Naturgeschichte in Mecklenburg, Bd. 15, p. 323. Sternberg sandstone : Germany.

1907.?, *Arca speyeri* Semper, Ravn, Mém. Acad. roy. Sci., Let. de Danemark, 7e sér., Sect. des Sciences, t. 3, N° 2, p. 262. Tertiary : Jutland.

Type material. — Holotype, unknown.

Topotypes and Hypotypes : Mecklenburgische Geologische Landesanstalt, in Rostock.

Hypotypes : Stanford Univ. paleo. type coll. N° 5957; Schenck coll., N°s 916a, 916b.

Type locality. — Sternberg, near Mecklenburg, Germany. Sternberg sandstone, called upper Oligocene (Chattian) by Kayser ([25]). However, O. H. Schindewolf informs us ([26]) that the Sternberg sandstone consists of blocks in glacial till and does not outcrop in place as a formation.

Original description. — The original description reads, after listing a number of specimens incorrectly identified as « *Arca diluvii* » but that are actually *speyeri*, as follows :

« Von den vorliegenden Schalen ist keine ganz erhalten, aller aber beweisen deutlich ihre Verschiedenheit von der, meistens *A. diluvii* genannten Art (*Arca antiquata* Brocchi *nec.* L.) die vom Wirbel ausstrahlenden Rippen sind bei dieser nie durch eine Längsfurche getheilt, bei allen gut erhaltenen Exemplaren der *A. speyeri* aber sind sie es stets. An einer kleineren, gut erhalten Schale der *A. speyeri*, deren Inneres aber verdeckt ist, zähle ich 29 Rippen, die nur in der Mitte der Schale ebenso breit wie ihre Zwischenräume sind, vorne und hinten aber sehr viel breiter. Die Rippen sind platt und wenig erhaben und die vorderen stets gefurcht. Der vordere Muskeleindruck ist bei beiden Arten ähn-

([24]) See Favre, *Catalogue illustré de la Collection Lamarck*, 1 part, *Fossiles*, *Conch. dimyaires*, pl. 30, figs. 192-199, 1918.

([25]) Kayser, *Lehrbuch der geologischen Formationskunde*, 1924, p. 290.

([26]) Letter dated February 15, 1936.

lich; der hintere aber ist an der oligocänen Art viel schwächer und von anderer Form

» Der von d'Orbigny gegebene Name (27) ist vollständig sinnlos und umfasst ausser der vorliegenden oligocänen mindestens noch eine miocäne Art. So habe ich geglaubt, der norddeutschen oligocänen Art, deren Selbständigkeit auch Deshayes anerkannt hat, einer neuen Namen geben zu dürfen und bitte Herrn Dr. Speyer die Widmung derselben anzunehmen.

» Mein grösstes vollständig erhaltenes Exemplar des Sternberger Gesteins ist 16 Mm. lang und 13 Mm. hoch, doch kommen noch bedeutend grössere Exemplare vor. »

DESCRIPTION OF MATERIAL EXAMINED. — Professor F. Schuh submitted to us, through Professor Otto Wilckens, a suite of unattached valves from Sternberg, the type locality of the species. The specimens may be described as follows :

Small to medium in size, perhaps equivalved, moderately inflated, inequilateral; beaks prominent, prosogyrate, situated anterior to center of shell; distinct, shallow umbonal depression present at tip of beak on every specimen examined (34 in all), from smallest to largest, extending ventrally for only 1 to 2 millimeters; outline of shell rhombic; anterior margin rounded, ventral margin slightly rounded to straight; posterior margin slightly rounded to truncate; sculpture of 26 to 28 radial ribs (28) crossed by less prominent concentric growth lines; some specimens show a weak groove in the middle of the ribs, and some left valves have faintly beaded appearance usually not present on right valves; this discrepancy in sculpture is slight (29); ligamental area narrow, nearly flat; a few chevron-shaped grooves present on one large specimen, superimposed upon longitudinal growth lines; teeth fairly regular, proportional in number to size of shell, there being about 50 on a specimen 21.5 mm. long, and only 26 on one 11 mm. long; on mature specimens, teeth in central third of hinge small and perpendicular to hinge line, but at extremities of hinge, teeth are longer, and converge ventrally, this convergence being far more pronounced on young specimens than on adults; inner margin of shell strongly crenulated; inside the indistinct pallial line, crenulations continue, in some of the small, thin valves, as radial grooves which reflect the external ribbing; interior of shell

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(27) *Arca subdiluvii* D'ORBIGNY (*Prodrome*, 1852, *3*, p. 123), placed (in part) by Semper in the synonymy of *A. speyeri*.

(28) Semper gives 29 as the number of ribs on the holotype, and we have counted 30 on one shell (Schenck coll. N° 916) from Rosental, Germany.

(29) The largest valve in the lot agrees in appearance with an unfigured specimen (N° 916, Schenck coll.) of this species of equal size from the Chattian of Rosental, Rhineland. On the specimens from Rosental illustrated on plate I, figs. 5*b*, 5*e*, the discrepancy of sculpture is clearly marked, all but the posterior ribs being beaded on the left valve, whereas on the right, only the anterior ribs are beaded.

not well preserved on adult specimens examined; adductor muscle scars indistinct; shell evidently tightly closed, without a byssal gape.

DIMENSIONS. — Measurements (in millimeters) of the Mecklenburg Institute specimens from Sternberg are given in the accompanying Table VI.

TABLE VI. — **Dimensions of Anadara speyeri.**

SPECIMEN.	Right or left valve.	Length in mm.	Height in mm.	Convexity (one valve).	Number of radial ribs.	Ratio of height to length in percent.
1	Right	7.7	5.4	2.0	27	70.1
2	Right	8.5	6.2	2.3	28	72.9
3	Right	8.2	5.7	2.0	27	69.5
4	Right	9.8	6.5	2.6	27	66.3
5	Left	9.3	7.0	2.7	28	75.2
6	Left	10.0	7.8	3.0	26	78.0
7	Left	10.5	8.1	3.0	26	77.1
8	Left	11.0	7.7	2.8	26	70.0
9	Left	10.5	8.1	3.2	26	77.1
10	Left	14.3	12.0±			83.2
11	Right	14.6	9.6±			65.7
12	Left	21.5	16.4	5.2	28	76.2

SUBGENERIC ALLOCATION. — Until we have examined a specimen of this species with the valves in the attached position, we cannot decide whether it is inequivalved or not, and hence cannot be sure that it is not referable to *Scapharca*. The slight but distinct discrepancy in sculpture of the right and left valves described above suggests that the species may belong to *Scapharca*. It is excluded from *Cunearca* because it lacks the typically elevated profile of that subgenus. We tentatively favor *Anadara s. s.* as the subgenus for *speyeri*.

COMPARISONS. — *Anadara speyeri* has much in common with *A.* (*Scapharca*) *aquitanica* (Mayer), the chief differences determined by an examination of the material available being the following : *aquitanica* has a slightly more pronounced ridge extending from the umbones to the posterior ventral margin and the ribs of this species do not dichotomize, whereas on *speyeri* on both right and left valves of mature specimens (especially on the anterior half of shell) the ribs are dichotomous. Furthermore, *aquitanica* is definitely inequivalved. *A. turonica* (Dujardin) is so closely related to *aquitanica* that comparison with *speyeri* is not necessary.

A. speyeri also closely resembles *A.* (*Scapharca* ?) *daneyi* (Cossmann and Peyrot), from southern France. The latter species, however, has a continuously convex ventral margin, whereas on *speyeri* the ventral margin is straight

throughout a part of its course. *A. daneyi* may also prove to be consistently slightly more elongate and more compressed than either *speyeri* or *aquitanica*. For a comparison of *speyeri* with its close relative, *A.* (*Anadara* ?) *guembeli* (Mayer), see the description of that species (page 32) and figures on plate II.

The hinge of a specimen of *speyeri* is illustrated in figure 5, plate VI. The anterior part of the ligamental area is bevelled smooth, whereas the posterior is bounded by a « cliff ». The contrast between this and *antiquata*, shown in fig. 3 of the same plate, is striking. Figure 4 (*daneyi*) and fig. 6 (*diluvii*) show the same bevelling, as do *fichteli* (fig. 7) and *osmonti* (fig. 8). The last two differ from the others shown on plate VI by the extreme width of the ligamental area and in having a larger number of « chevrons ».

Anadara (Anadara ?) guembeli (Mayer), 1868.

Pl. II, fig. 6.

1868. *Arca Guembeli* Mayer, Vierteljahrsschrift d. Naturf. Gesell. in Zürich, Dreizehnter Jahrgang, p. 33, 87 (separate pagination, p. 14, 69), Upper Bavaria.

1897. Not *Arca Guembeli* Mayer-Eymar, Wolff, Palaeontographica, Bd. 43, 5-6 Lief., p. 238, pl. 21, figs. 13, 14. Oligocene : Schlierach bei Meisbach. (Probably immature *A. intercedens* Wolff).

Type material. — Syntypes, Lot N° C-1063, Museum of Geology of the Eidgenössisch Technische Hochschule at Zürich, Switzerland. Professor A. Jeannet informs us (letter dated July 7, 1936) that it was upon this lot that Mayer based

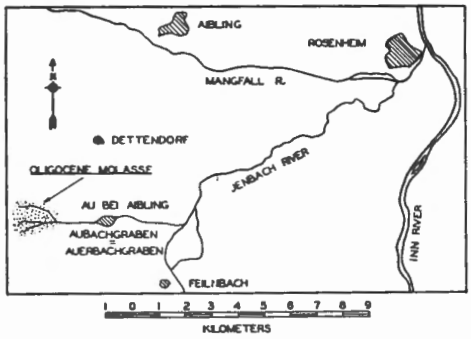

Fig. 7. — Map showing type locality of *Anadara guembeli*.

Sketch map of the area southwest of Rosenheim, west of the Chiemsee in Bavaria, showing the Oligocene molasse carrying *Anadara guembeli* (Mayer). This is the type locality of the species.

his original description. These specimens were collected by Mayer himself from Aubachgraben. Inasmuch as, again according to Jeannet (letter dated October 28, 1935), Mayer did not select a type specimen, we hereby designate as

lectotype the specimen figured on plate II, fig. 6, one of the original syntypes from Aubachgraben. This specimen, along with the others of Lot N° C-1063, is deposited in the same Museum of Geology at Zürich.

TYPE LOCALITY. — Aubachgraben (= Auerbachgraben), Upper Bavaria. « Marnes à Cyrènes ..... partie moyenne de l'Étage aquitanien » (= Stampian, *fide* R. Rutsch, letter dated July 1, 1935). This locality is shown in figure 7, a sketch map of the area southwest of Rosenheim supplied to us by Professor Jeannet.

ORIGINAL DESCRIPTION. — « A. testa ovata, transversa, paulum ventricosa, inaequilaterali; costis 24, intersticiis paulo latioribus, planulatis, sulco humili bipartitis, fere laevigatis; lateribus attenuatis, rotundatis; antico breviore; umbonibus tumidus, recurvis; area mediocri, sublanceolata, sulcata; dentibus numerosis, satis tenuibus. — Long. 20, lat. 14 millim. »

Although Mayer did not figure this shell, he stated (*supra cit.*, p. 87) that « la forme ovale de cette petite espèce, sa légère compression et ses côtes peu nombreuses, un peu espacées, bipartites et à peu près lisses la distinguent de l'*A. turonica* avec laquelle elle a le plus de rapports. »

MATERIAL EXAMINED. — Several specimens from Aubachgraben, and from the « Aquitanian » of Meisbach and Franenried in Leizachtal, Bavaria.

NOTES ON MATERIAL EXAMINED. — The lectotype, a left valve, has 24 radial ribs, slightly beaded in the umbonal region. On the anterior half of the shell, the ribs become dichotomous toward the ventral margin. A slight, but distinct, umbonal sulcus, similar to that on *Anadara speyeri*, is present. The hinge is typically anadarid, very similar to that of *speyeri*. The dimensions are the following : Length, 18.6 mm.; height, 14.5 mm.; convexity, 6.4 mm.

Specimens from Leizachtal, Bavaria; the largest has the following dimensions : length, 14.0 mm.; height, 11.5 mm.; convexity of one valve, 5.8 mm. As nearly as can be estimated, the number of ribs is about 25, and on one shell, the ribs are slightly bipartite.

SUBGENERIC ALLOCATION. — The preservation of our specimens is not good enough to allow us to assign this species unquestionably to *Anadara s. s.*

COMPARISONS. — A comparison of our figures of *guembeli* with those of *speyeri* from Sternberg, Germany (Plate I, fig. 4), clearly demonstrates the close relationship of the two species; in fact, the main reason for differentiating them is that *guembeli* has fewer ribs (23-25, usually 23-24) than *speyeri* (26-30, usually 26-28). Finally, the umbones of *guembeli* are slightly more inflated than those of *speyeri*.

Anadara (Anadara ?) intercedens (Wolff), 1897.

1897. *Arca intercedens* Wolff, Palaeontographica, Bd. 43, 5-6 Lief., p. 237-238, pl. 21, figs. 15-17. Oligocene : Bavaria.

1897.?, *Arca güembeli* Mayer-Eymar, Wolff, *op. cit.*, p. 238, pl. 21, figs. 13, 14. (Not *Arca guembeli* Mayer).

Type material. — Type specimens in Sammlung für Paläontologie und historische Geologie in Munich.

Type locality. — « Upper » Oligocene of Hochberg, Thalberggraben bei Siegsdorf, in Bavaria, southeast of Munich. Also present at the type locality are *Glycymeris latiradiatus* Sandberger, *Turritella sandbergeri* Mayer, and other species often referred to as Upper Oligocene. A. M. Davies (1935, p. 168) believes that the assemblage may be Aquitanian.

Notes on type specimens. — The type specimens were examined by Schenck in April, 1934. The radial ribs are flat-topped, not sulcate. They attain a width of 1.5 mm., and are separated by interspaces of equal width. Dimensions are given in the accompanying Table VII.

TABLE VII. — **Dimensions of Anadara intercedens.**

SPECIMEN No.	Length in mm.	Height in mm.	Convexity in mm. (one valve).	Number of radial ribs.
1	28.7	22.5		27
2	30.9	24.4		26±
3	33.3	23.5		26
4	31+	26.4	12	25

The proximity of the type locality of *intercedens* to that of *guembeli* — both in the « Bassin molassique » — suggests that Wolff's species may be a synonym. However, specimens examined during this investigation show certain morphological differences, notably, in the character of the ribs. Lacking a series of specimens for comparison, we hesitate to pass judgment on the validity of *intercedens*.

SPECIES FROM AFRICA.

Anadara (Anadara) waylandi Cox, 1927.

1927. *Anadara waylandi* Cox, Report Palaeont. Zanzibar Protectorate, p. 34-35, pl. 8, figs. 5-7. Pemba Island, Africa.

TYPE MATERIAL. — (Figured specimens) : Holotype, N° L43703; paratypes, N°s L43704 and L43705; (unfigured specimens) : paratypes N°s L43706 to L43714, Brit. Mus. Paratypes : N° 2215, Schenck Coll.

TYPE LOCALITY. — Pemba Island, Africa. Pemba Series, « Aquitanian-Burdigalian ».

MATERIAL EXAMINED. — Through the courtesy of L. R. Cox, we have examined a number of perfectly preserved valves of this species. Because of the possibility that the Pemba Series may prove to be upper Oligocene, this species is here recorded for the sake of completeness. The original characterization and illustrations of the species are adequate.

COMPARISONS. — *Anadara dautzenbergi* (Lamy) ([30]), described from New Caledonia, is close to *waylandi* Cox and to our new subspecies, *waloensis*, described on page 47. *A. dautzenbergi* has 23 granulose ribs, each one being distinctly grooved, a character which supports the slight differences in profile in separating the species.

SPECIES FROM THE PACIFIC SLOPE OF NORTH AMERICA.

Anadara (Anadara) mediaimpressa (CLARK), 1918.

Pl. I, fig. 1.

1918. *Arca* (*Scapharca*) *mediaimpressa* CLARK, Univ. Calif. Pub. Bull. Dept. Geol., vol. 11, N° 2, checklist, p. 80, p. 96, 127-128, pl. 7, figs. 7, 8; pl. 16, figs. 5-7. San Ramon formation (« Oligocene »). Near town of Walnut Creek, Contra Costa County, California.

1921.?, *Arca* cf. *A. mediaimpressa* Clark, GARDNER *in* DARTON, Jour. Geol., vol. 29, N° 8, p. 732. Vaqueros? formation (lower Miocene or upper Oligocene) : Arroyo de la Purisima, Baja California.

1929. *Arca mediaimpressa* CLARK, Stratigraphy and Faunal Horizons of the Coast Ranges of California. Berkeley, California, p. 17, pl. 16, figs. 5, 11. Typical species of San Ramon formation, central California.

([30]) LAMY, *Jour. de Conchyliologie*, vol. 55, N° 3 (1907), p. 232, pl. 3, figs. 9-11.

1935. *Anadara mediaimpressa* (Clark), REINHART, Bull. Mus. roy. Hist. nat. Belg., t. XI, N° 13, p. 40, footnote. Referred to *Anadara*, *s. s.*

1936. *Anadara* (*Anadara*) *mediaimpressa* (Clark), SCHENCK and REINHART, Geol. Soc. Am., Proc. for 1935 (June 1936), p. 412.

TYPE MATERIAL. — Holotype, N° 11174; paratypes, N°s 11172, 11189, Univ. Calif. Mus. Invert. Paleo. Topotypes : N° 32439, Univ. Calif.; N° 520, Schenck Coll. Hypotypes, N°s 5301 and 5302, Stanford Univ. Paleo. type Coll.

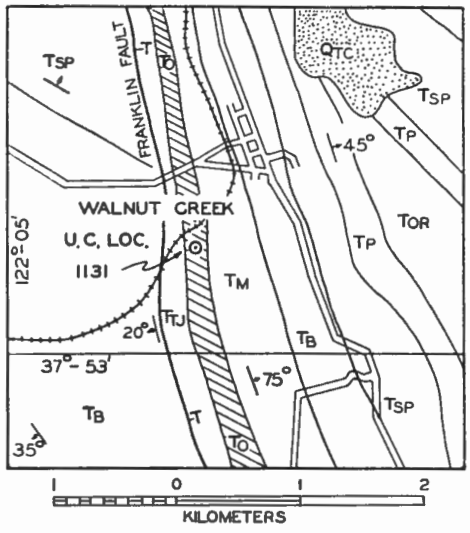

FIG. 8. — Map showing type locality of *Anadara mediaimpressa*.

Map showing type locality (1131) of *Anadara mediaimpressa* (CLARK). TTJ, « Tejon » formation (Eocene); TO, San Ramon formation, type locality; TM, « Monterey » formation (Miocene); TB, Briones sandstone; TSP, San Pablo formation; TP, Pinole tuff; TOR, Orinda formation; QTC, Quaternary.
(After LAWSON, *S. F. Bay Folio*, U. S. G. S., and B. L. CLARK, *Univ. Calif. Publ., Bull. Dept. Geol.*, vol. 11, plate 4.)

TYPE LOCALITY. — University of California locality 1131, one-half mile southwest of the town of Walnut Creek, Contra Costa County, California; San Ramon formation, upper part of « San Lorenzo Series », Oligocene, according to Clark (1918, p. 80). Figure 8 is a map adapted from Clark's report, which in turn was adapted from the geological map in the San Francisco Bay Folio by A. C. Lawson. The type locality of the species and the relation of the San Ramon to adjacent formations are shown. Local stratigraphic evidence does not prove that the San Ramon is older than the *Turritella inezana* zone; that presumption is based upon the molluscan faunule, but even the fossils do not allow a precise synchronization of the San Ramon with other formations in California.

SUMMARY OF DISTRIBUTION. — In addition to its occurrence in the San Ramon formation at its type locality, this species is present in « Miocene » strata in at least two localities in California. Stanford University hypotypes N°s 5301 and 5302, from the Temblor formation of the Pozo quadrangle, San Luis Obispo County, California ([31]), appear to belong to *mediaimpressa*. Although not perfectly preserved, these specimens, when compared with the holotype and paratypes, resemble them closely.

Another specimen of *mediaimpressa* is in the paleontologic collection of the Shell Oil Company at Bakersfield, California, from Shell C° locality L. C. N° 2 ([32]), from the lower 35 feet of a silt of supposed Miocene age. This silt, which is exposed in the vicinity of Round Mountain and elsewhere near Bakersfield, has not yet received a formal published name. The age of the silt is thought by R. M. Kleinpell ([33]) to range from the Saucesion through the Luisian Stages, as defined by Kleinpell (1934).

The occurrence of a species referred to *mediaimpressa* in the « Miocene » of Lower California, reported by Gardner in Darton (1921), is interesting, but we have not seen specimens from this locality.

DESCRIPTION OF TYPE SPECIMENS. — Medium size, equivalve, moderately inflated, inequilateral, elongately oval in outline; umbones prominent, situated anterior to center of shell, beaks pointing inward, prosogyrate; slight umbonal depression extends from tip of beak halfway to ventral margin; sharply concave area on posterior dorsal slope; sculpture of 27 to 29 radial ribs crossed by concentric growth lines; ribs flat-topped, beaded on anterior half of shell (well shown on topotype N° 32439), separated by flat interspaces about as wide as ribs; ribs and interspaces crossed by closely-spaced concentric growth lines; medial groove present on ribs near ventral margin, becoming distinct at distance of 10 to 15 mm. from umbo; medial grooves not present on holotype, which is too small a specimen for these grooves to have developed; on Univ. Calif. topotype N° 32439, a relatively large individual, an additional groove is present near ventral margin, on each side of medial groove; ligamental area, preserved on paratype N° 11172 (Pl. I, fig. 1 *b*), long, nearly flat, rather narrow, wider in front of than behind beaks, bearing three chevron-shaped grooves, only the posterior halves of which are well preserved; hinge exposed only on holotype, gently arched, shorter anteriorly than posteriorly, wider at extremities

([31]) Hypotype N° 5301, from the northeast corner of Section 15, Township 28 South, Range 15 East; Hypotype N° 5302, from the center of the southwest ¼ section 29, Township 28 South, Range 15 East, M. D. M., in bed of Indian Creek, near road intersection.

([32]) Kern County, California, 2200 feet west and 2100 feet south of the northeast corner of Section 32, Township 28 South, Range 29 east, M. D. B. and M. Collector, L. M. Clark.

([33]) Personal communication.

than in medial area; teeth strong, regular, vertical at center, converging ventrally at extremities of hinge; inner margin of shell crenulated; interior not entirely exposed.

Dimensions. — The dimensions of the type specimens are shown on the accompanying Table VIII.

TABLE VIII. — **Dimensions of Anadara mediaimpressa.**

SPECIMEN.	Right or left valve.	Length in mm.	Height in mm.	Convexity in mm.	Number of radial ribs.	Ratio of height to length in percent.
Univ. Calif. Mus. Invert. Paleo.						
Holotype 11174	Right	14.8	11.8	4.7	29	79
Paratype 11172	Both	21.6	17.6	14.7	27	81
Topotype 32439	Left	32.0	24+	9.5	28	
Stanford Univ. Paleo. Type Coll.						
Hypotype 5301	Both	30 0	24.0	20.8	27	80
Hypotype 5302	Left	33.0	26.0	11±	27	79
Schenck Coll.						
Topotype 520-A	Left	16.0	11.7	5.2	28	73

Comparisons. — This species resembles *Anadara osmonti* (Dall) ([34]) from the Temblor formation, « Miocene », of California. This comparison is based upon a small number of specimens of *mediaimpressa* and a large number of probable topotypes of *osmonti* ([35]) ranging in length from 20 to 54 mm. and exhibiting considerable variation in outline and convexity. The similarity between the San Ramon and Temblor specimens is so great as to suggest the possibility that one rather than two species is present, but the meager representatives of *mediaimpressa* do not warrant making a definite decision as to specific identity.

([34]) *Arca osmonti* Dall, *U. S. Geol. Survey Prof. Paper* 59, 1909, p. 110; new name for species figured (as *Arca microdonta* Conrad) by Osmont, *Univ. Calif. Pub. Bull. Dept. Geol.*, vol. 4, N° 4, pl. 8, figs. 1, 2, 1905.

([35]) Schenck Coll. 2082; Wagonwheel Mountain, Kern C°, California; most northerly hill in Sec. 36, T. 25 S., R. 19 E., M. D. M., Temblor sandstone; collector : Donald Birch.

Anadara (Anadara) mediaimpressa, var. **submontereyana** (CLARK), 1918.

1918. *Arca* (*Scapharca*) *submontereyana* CLARK, Univ. Calif. Pub. Bull. Dept. Geol., vol. 11, N° 2, checklist, p. 80, p. 96, 128-129, pl. 16, fig. 2. San Ramon formation : central California.

1935. *Anadara mediaimpressa* var. *submontereyana* (Clark), REINHART, Bull. Mus. roy. Hist. nat. Belg., t. XI, N° 13, p. 40, footnote. Referred to *Anadara s. s.*

TYPE MATERIAL. — Holotype, N° 11186; paratype, N° 11186A, Univ. Calif. Mus. Invert. Paleo.

TYPE LOCALITY. — Univ. Calif. locality 52, « 1 ¼ miles south of town of Walnut Creek, near top of first ridge west of Walnut Creek; elevation 350 feet »; Contra Costa County, California. San Ramon formation, « Oligocene ».

COMMENTS ON TYPE SPECIMENS. — The type specimens are so poorly preserved that the status of *submontereyana* is in doubt. Well preserved material may show *submontereyana* to be a synonym of *mediaimpressa.*

Anadara (Anadara ?) strongi (LOEL and COREY), 1932.

1932. *Arca* (*Barbatia*) *strongi* LOEL and COREY, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 22, N° 3, p. 183, pl. 7, fig. 11.

TYPE MATERIAL. — Cotypes, N° 31762, Univ. Calif. Mus. Invert. Pal., loc. A-527. Paratype, N° 110, Schenck Coll.

TYPE LOCALITY. — On spur, west side of big bend of Laguna Canyon, about 2.5 miles North of Laguna Beach, Orange County, California. « Vaqueros-Temblor transition zone. »

DISCUSSION. — This species is based upon unsatisfactory material and its subgenus, therefore, cannot be determined. The species, however, is definitely *Anadara, sensu lato,* not a *Barbatia.* Loel and Corey treat this as a Miocene species, but because subsequent work may show that it is better considered Oligocene, we record this bivalve here for the sake of completeness.

Other poorly-preserved specimens of *Anadara* (Schenck Coll. 290) perhaps referable to this species were collected by Schenck from the Vaqueros formation on upper Kings Creek, Santa Cruz county, California, Section 6, T. 9 S., R. 2 W., M. D. M., about two miles by road upstream from the main highway, in south-dipping beds. L. Forrest collected specimens on Kings Creek from the same stratigraphic position — 1500 feet above the base of the Vaqueros — but in north-dipping beds, and associated with *Pecten* (*Pecten*) *sanctaecruzensis* Arnold. These fossils fall in the Zemorrian Stage of the Pacific Slope Tertiary.

Anadara (Anadara ?) sp. A.

1923. *Arca* sp. WAGNER and SCHILLING, Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 14, N° 6, p. 248.

SPECIMEN. — N° 30195, Univ. Calif. Mus. Invert. Paleo.

LOCALITY. — Univ. Calif. locality 3218, east center of the southwest quarter, Section 21, Township 10 North, Range 21 West, S. B. B. & M., Kern County, California; bluffs on east side of Pleitito Creek, three-fourths mile north of Rock Springs, Pleito formation ([36]), « Oligocene » of California geologists. This formation was included in the « San Lorenzo formation » of Hoots ([37]).

DESCRIPTION. — An imperfectly preserved interior mold of an elongate left valve; length, 18.7 mm., height, 8.4 mm.; number of radial ribs, *ca.* 25; beaks situated 5 mm. posterior from rounded anterior extremity.

SUBGENERIC ALLOCATION. — Preservation prevents a definite assertion that this specimen falls in the typical subgenus rather than in *Scapharca*.

POSSIBLE OCCURRENCE IN SAN EMIGDIO FORMATION. — Wagner and Schilling (*op. cit.*, p. 244) record an « *Arca* » from University of California locality 3231, San Emigdio formation. This record is based upon a broken impression lacking both beaks and hinge. The ribs are those of an *Anadara*, and are sulcate as in *A. mediaimpressa*.

SIGNIFICANCE. — The importance of these records is that they show the presence of *Anadara*, *sensu lato*, in beds older than the *Turritella inezana* zone. Thus, the oldest specimens of *Anadara* from the Pacific Slope of North America are from the Refugian Stage, or « Oligocene », as that term is used currently.

Anadara (Anadara ?) sp. B.

SPECIMEN. — N° 31504, Univ. Calif. Mus. Invert. Paleo.

LOCALITY. — Univ. Calif. locality 10023, northwest quarter of Section 10, Township 11 south, Range 11 west, Lincoln County, Oregon; on railroad between Yaquina and Newport, Yaquina Bay; lower part of the Nye shale, upper Oligocene or lower Miocene. The stratigraphic relations of this formation and the geographic position of locality 10023 are dealt with by Schenck (Univ. Calif. Pub. Bull. Dept. Geol. Sci., vol. 18, N° 1, p. 23, fig. 7, 1928), who collected the specimen.

([36]) Consult WAGNER and SCHILLING, *supra cit.*, p. 235-276.

([37]) HOOTS, *U. S. Geol. Survey Bull.*, 812-D, 1930.

DESCRIPTION. — An interior mold of a right valve having the following dimensions : length 35 mm., height 26.5 mm., convexity 5.5 mm. Number of ribs : 22. Shell ovate in outline; umbo rather pointed, situated toward anterior end.

This specimen is illustrated and discussed in more detail in a paper by Reinhart now in preparation.

Anadara (?), sp. C.

SPECIMEN. — N° 2127, Schenck Coll.

LOCALITY. — University of Oregon locality N° 80, Lane County, Oregon, Eugene quadrangle, about one-half mile west of B. M. 447, on S. P. Railroad; massive sandstone of the Eugene formation of Refugian — « Oligocene » — age; associated with *Aturia angustata* (Conrad), *Epitonium condoni* Dall, etc. The locality is shown in the paper by Schenck (Univ. Calif. Publ. Bull. Dept. Geol. Sci., vol. 18, N° 1, 1928), who collected the poorly preserved specimen.

DESCRIPTION. — Shell small, quadrangular, equivalve, inequilateral, inflated; anterior dorsal margin short, rounded; anterior extremity broadly rounded; ventral margin almost straight; posterior extremity rounded, though slightly truncated dorsally; posterior dorsal margin gently sloping; cardinal area narrow; umbones anterior to middle of shell; surface sculptured by about 26 low, rounded ribs separated by shallow interspaces about twice the width of the ribs. Dimensions : length, 14 mm., height, 10.8 mm., convexity of both valves, 9.8 mm.

GENERIC ALLOCATION. — The hinge is not visible, hence we cannot be sure that the specimen belongs to the Arcidae. However, its general profile and character of ribbing suggests that it may belong to *Anadara*. Dr. A. Myra Keen examined the fossil carefully and reported (verbal communication) that it could not be a cardiid.

ANADARA IN THE TERTIARY OF JAPAN, PHILIPPINE ISLANDS, AND THE DUTCH EAST INDIES

INTRODUCTION. — A survey of the arcid pelecypods from the Japanese Empire, the Philippine Islands, and Netherland Indies discloses the presence of a number of species of *Anadara, sensu lato*, in the Cenozoic rocks of that area. Thus, « *Arca* » *tambacana* Martin, 1910, from the Upper Miocene and Pliocene of Java, is *Anadara, sensu stricto*, whereas « *Arca* » *sedanensis* Martin, from the Rembang beds of Java, as well as several other species named by Martin, belongs to *Scapharca*. « *Arca* » *rhombea* Born, of which we have seen specimens from

the Pliocene and Quaternary of Java, is a *Cunearca*. Similarly, we have seen a number of specimens, under one name or another, from the Philippines and Japan, and these are referable to *Anadara, sensu lato*. Hence, the presence in this region of numerous species of *Anadara*, including some belonging to the typical subgenus, is established; however, in our attempts to isolate the Oligocene species of *Anadara, s. s.*, we are confronted by extreme uncertainty regarding the age of the beds, in European terminology, in which these species occur.

Japanese Empire. — A survey of the literature and correspondence with K. Hatai and J. Makiyama disclosed no record of *Anadara, sensu stricto*, in beds known to be older than late Oligocene. Specimens of *A. daitokudoensis* from the Heirokudo formation, northern Korea, are believed to belong to the typical subgenus; the age of the formation is treated tentatively as Aquitanian. The several species of *Anadara* from the Miocene and younger formations of the Japanese Empire need not be discussed at this time.

Philippine Islands. — Specimens of *Anadara* are present in the « Vigo Group » of the Philippine Islands. Dickerson ([38]) figured as « *Arca ferruginea* Reeve » a specimen from the « Vigo Group » of the Bondoc Peninsula, Tayabas Province, Island of Luzon. The same author ([39]) figured « *Arca granosa* Linné » from the same « group », together with *ferruginea*, and perpetuated the inherited view that the Vigo is Miocene. « *Arca* » *cornea* Reeve and « *Arca* » *tenebrica* Reeve have also been recorded from this « group », but the first-named is *Scapharca* and the latter is a *Barbatia*.

Too little is known of the detailed stratigraphy and paleontology of the « Vigo Group » to permit us to enter into a discussion of the relative merits of the Oligocene and Miocene age assignments of this « Group ». Those who favor its Miocene age may quote Smith ([40]), who followed Douvillé, who, in turn, followed his belief that the Aquitanian Stage is Miocene. Those who favor an Oligocene age for the « Vigo Group » may quote as their authority the recent paper by Faustino ([41]). Perhaps before much more following is done, local stratigraphers will define in a satisfactory manner just what is meant by the « Vigo Group ». It is employed in the literature as a lithogenetic term — a formation or several formations, or cartographic units — and as a time-stratigraphic term, a Series.

([38]) Dickerson, R. E. *in* Smith, *Geology and Mineral Resources of the Philippine Islands*, 1924, pl. 9, fig. 3.

([39]) Dickerson, *Philippine Jour. Sci.*, vol. 18, N° 1, January 1921, p. 11.

([40]) Smith, *Spec. Publ. Bernice P. Bishop Museum*, N° 7, 1921, p. 770-774.

([41]) Faustino, *Philippine Jour. Sci.*, vol. 35, N° 7, February 1928, p. 125.

NETHERLAND INDIES. — « *Arca* » *sedanensis* Martin and « *Arca* » *hulshofi* Martin, from the Rembang beds of Java, are both *Scapharca* ([42]). We have not seen any specimen from those beds that can be assigned with certainty to *Anadara, sensu stricto*. Upper Miocene, Pliocene, and Pleistocene specimens, on the other hand, definitely fall in the typical subgenus.

Anadara (Anadara ?) daitokudoensis (MAKIYAMA), 1926.

1926. *Arca* (*Anadara*) *daitokudoensis* MAKIYAMA, Mem. Coll. Sci. Kyoto Imp. Univ., Ser. B., vol. 2, N° 3, p. 153-154, pl. 12, figs. 10, 14, 15. Heirokudo formation : Korea.

1936. *Anadara daitokudoensis* MAKIYAMA, Mem. Coll. Sci. Kyoto Imp. Univ., Ser. B., vol. 11, N° 4, Art. 8, p. 197, 205. Heiroku stage : Daitokudo and Nenseki; Uetuki series.

TYPE MATERIAL. — Holotype in Geol. Inst. Kyoto Imp. Univ. Topotypes N° 1905, Schenck Coll.

TYPE LOCALITY. — Daitokudo, Meisen-gun, North Kankyo-do, Korea; Heirokudo formation.

MATERIAL EXAMINED. — Through the courteous cooperation of S. Nomura and K. Hatai, we have before us two topotypes of this species. The specimens suggest that the species is *Anadara, sensu stricto*.

DISCUSSION. — Makiyama (1936) reported this species associated with *Batillaria* and *Vicarya callosa* Jenkins. The latter species is often taken as Aquitanian. Makiyama (1926) believed that the Heirokudo formation is Upper Eocene. We believe that one might hold, in the light of the new finds, that the formation is Upper Oligocene.

Anadara (Anadara) granosa (LINNÉ), 1758.

Pl. II, fig. 9; pl. IV, fig. 1.

1758. *Arca granosa* LINNÉ, Systema Naturae, 10 Ed., p. 694. « Habitat in O. Europae meridionalis. »

1855. *Arca granosa* Linné, HANLEY, Ipsa Linnaei Conchylia, p. 95-96.

1907. *Arca granosa* Linné, LAMY, Jour. Conchyliologie, vol. 55, N° 3, p. 210-214.

1922. *Arca granosa* Linnaeus, DICKERSON, Philip. Jour. Sci., vol. 20, N° 2, p. 203, pl. 6, fig. 4. « Vigo Group » : Bondoc Peninsula, P. I.

1932. *Arca granosa* Linné, DOLLFUS and DAUTZENBERG, Jour. Conchy., vol. LXXVI, p. 293.

TYPE MATERIAL. — Linnean Society Collection, London.

TYPE LOCALITY. — Uncertain; probably Indo-Pacific.

([42]) The Rembang beds have been correlated with the Aquitanian; consult KAYSER, *Geologische Formationskunde*, II, 6 u. 7 Auflage, p. 373, 1924.

MATERIAL EXAMINED. — Recent specimens (N° 368, Oldroyd Coll.). One specimen, (fig. 9, pl. II), from the Vigo « group » of the Bondoc Peninsula, Tayabas Province, and several fossils from Wright, Samar, all from the Philippine Islands. One topotype of *A. teschi* Koperberg (Schenck Coll. 2039).

DIAGNOSIS. — The following is the original description of the species :

« A. testa subcordata sulcis muricatis, natibus recurvis, margine crenato. »

Hanley (1855, p. 95-96), made the following statements :

« This species first appeared in the tenth edition of the *Systema*, with references to figures in Columna, Bonanni, Gualtier, and Argenville. The two former engravings are so ill executed as to be almost irrecognizable. The first represents a crowdedly grooved fossil; the second a mere interior, which, intended possibly for *A. diluvii* (judging, at least, from the Italian locality) was probably only quoted from being cited for this species by Gualtier. Both the latter are decidedly meant for the *Arca granosa* of modern conchology, of which the characters are in accordance with the postulates of the diagnosis. The erroneous locality was derived from the statement of Bonanni, the reference to whose work is correctly expunged in the copy of the younger Linné, who has substituted « List. t. 242, f. 79 ». The *Arca granosa* (Chemn. Conch. Cab., vol. vii, pl. 56, f. 557) is still present in the collection (as indicated in the list) and alone of the shells therein contained agrees with the combined pictorial and descriptive definition.

» Although Gualtier and Argenville alone are cited in the Museum Ulricae, the « altera testa minor » of that work leads us to infer that some inequivalve species must have been the original of that description. »

The Linnean types of this species are illustrated on Plate IV, figure 1. We hereby designate the right valve shown in figs. 1 *b*, *c*, and *d* as the lectotype of this species. The measurements of the Linnean shells are given in Table IX.

TABLE IX. — **Dimensions of Linnean specimens of Anadara granosa.**

SPECIMEN.	Length in mm.	Height in mm.	Convexity in mm.	Number of ribs (*).	Ratio of height to length in percent.
Lectotype	48.0	38.0	16.0	22	79
Paratype	37.5	31.0	17.0	21	83

(*) « This includes marginal ribs », stated R. Winckworth (letter dated October 26, 1936), who made the measurements given above. These marginal ribs, two in number, were not included in our counts made on other Recent shells.

THE VIGO SPECIMEN. — The specimen figured on pl. II, fig. 9, is from Locality F-15, Bahay River, Bondoc Peninsula, Tayabas Province, probably identical with or near the locality and geological formation (Vigo) from which Dickerson's figured specimen was obtained. This left valve measures, in millimeters: length, 61.3; height, 51.1; convexity, 25.2; number of ribs, 17. This valve has been compared with the figure given by Chemnitz (pl. 56, fig. 557), said by Lamy to be the true *granosa*. It has also been compared with Recent specimens from the Philippines, which likewise agree with the figure in Chemnitz. It thus seems certain that the Vigo specimen is correctly identified.

SUBGENERIC ALLOCATION. — The difficulty of making an unquestionable allocation of *granosa* to the typical subgenus of *Anadara* is referred to on a previous page (p. 12).

COMPARISONS. — *A. granosa* resembles *bisenensis*, described on page 44, where the differences separating the species are pointed out. Although *Anadara ferruginea* and its relatives (*waloensis*, *timorensis*, *dautzenbergi*, and *waylandi*) are somewhat similar to *granosa*, these are more elongate, proportionally less inflated, and never grow to such a large size as *granosa*, adults of which attain a length of at least 75 millimeters. Furthermore, the heavy transverse bars on the ribs of *granosa* — prominent on adult shells, and even distinctly noticeable on young specimens — are characteristic. The subspecies *teschi* Koperberg (1931) is of doubtful validity.

DISTRIBUTION. — In addition to the Vigo record of *A. granosa* in the Philippine Islands, this species likewise occurs in the Pliocene of Australia ([43]) and the Pleistocene of Timor. Boettger (1908) gives a range of Miocene to Recent for the species. The Recent localities given by Lamy show that the species is widespread in the Indo-Pacific marine molluscan province.

Anadara (Anadara) bisenensis SCHENCK & REINHART, n. sp.

Pl. IV, fig. 2; pl. V, fig. 1.

Arca granosa (*partim*) of authors, NON Linné.

TYPE MATERIAL. — Holotype N° 6026, Stanford Univ. Paleo. Type Coll.; paratype N° 894, Oldroyd Coll.; hypotypes N°s 6018-6025, incl., Stanford Univ. Paleo. Type Coll.

TYPE LOCALITY. — Bisen, on the Inland Sea, Okayama prefecture, Japan; Recent.

([43]) Letter from J. Marwick, March 4, 1935.

DESCRIPTION. — Shell moderately large for subgenus; inflated; in profile, anterior margin curving evenly into ventral margin, posterior margin straight in its upper half; dorsal margin straight, interrupted by umbones placed at anterior third of shell; beaks prosogyrate; shell equivalved. Sculpture consisting of 16 to 17 radial ribs (17 on holotype) of which the anterior 10 or 11 are strongly noded, the posterior ribs plain and smooth; sculpture similar on the two valves; concentric lines of growth traverse ribs and interspaces alike; ligamental area broad and flat, bearing one or more chevron-like grooves on each valve; ligament extends on both sides of beaks, covering nearly all of ligamental area; hinge nearly straight, teeth regular, smaller and more closely-spaced at center than at extremities of hinge; crenulations on inner margins of shell pronounced, extending faintly up to umbones; pallial line and muscle scars indistinct.

We have at our disposal a large growth-series of known age; that is, with reference to date of hatching from eggs. A number of these are figured on plates IV & V and their dimensions and ages given in the accompanying Table X.

These specimens show a gradual elongation in outline with increase in size, the shells 60 days old being nearly equilateral. The ribs of these young specimens are nearly plain, with but traces of incipient nodes. From an age of 90 days onward, the shells show distinctly noded ribs. The number of ribs is the same (16-17) on all specimens, from the youngest to the oldest. The shell at six months shows all of the characteristics of the adult.

DIMENSIONS. — The dimensions of the holotype and hypotypes of this new species are given in Table X.

TABLE X. — **Dimensions of Stanford University types of Anadara bisenensis.**

SPECIMEN.	Length in mm.	Height in mm.	Convexity in mm. (both valves).	Number of ribs.	Age.
Hypotype No. 6018 . .	2.8	2.3	1.8	17	60 days
Hypotype No. 6019 . .	4.6	3.6	2.9	17	90 days
Hypotype No. 6020 . .	11.7	8.8	6.9	16	6 months
Hypotype No. 6021 . .	21.8	17.2	14.3	17	1 year
Hypotype No. 6022 . .	26.7	21.8	18.8	17	2 years
Hypotype No. 6023 . .	35.1	25.2	21.0	17	3 years
Paratype No. 894 . . .	42.0	31.8	24.0	16	
Holotype No. 6026 . . .	47.4	36.3	30.3	17	
Hypotype No. 6024 . .	49.1	39 3	29.8	17	5 years
Hypotype No. 6025 . .	56.3	44.8	39.8	16	

COMPARISONS. — The new species differs from *granosa* as follows :

(1) *A. bisenensis* has generally 16-18 ribs, in contrast to the 17-20 ribs on *granosa*.

(2) The profiles of the two are dissimilar, *bisenensis* being more elongate.

(3) The umbones of *bisenensis* are not as broad as those of *granosa*.

The new species agrees with the specimen figured as *granosa* by Matsumoto (1930), but the contrast between his subfossil and the true *granosa* will be apparent by contrasting his figure 2, plate XL with plate 56, fig. 557, of Chemnitz. Because of this confusion of identification, one cannot rely upon such a list of occurrences as that by Nomura (1933), as it is likely that most of his records of *granosa* refer to the biologic unit here given a new specific name. Furthermore, the biometrical study by Oinomikado ([44]) is probably of *bisenensis*.

A. bisenensis is related to « *Arca* » *nodifera* Martens ([45]), described as a Recent shell with 21 nodose ribs. A specimen from Japan identified as *nodifera* is figured by Otuka ([46]).

That *bisenensis* is not confined to the Japonic province but occurs also in the Indo-Pacific is proved by a specimen of this species in the Fred Baker collection. One individual (valves attached) comes from the largest of the Luchu (« Loochoo ») Islands, latitude *ca.* 26° 30′ N.

Anadara (Anadara) hankeyana (REEVE), 1844.

Pl. III, figs 3, 4; pl. V, fig. 3.

1844. *Arca Hankeyana* REEVE, Conch. Icon., vol. 2, pl. 10, fig. 68.

1907. *Arca* (*Anadara*) *antiquata* (Linné) var. *Hankeyana* Reeve, LAMY, Jour. Conchyliologie, t. 55, 3° trimestre, p. 201, 206-207. Red Sea; New Caledonia.

TYPE MATERIAL. — Holotype unknown; not in Brit. Mus., *fide* G. C. Robson, letter dated July 10, 1936. Hypotype (pl. III, figs. 3), Phil. Bur. Sci. Hypotype (and topotype), N° 6056, Stanford Univ. Paleo. type Coll. Two valves (Schenck Coll. N° 2040), Pleistocene of Timor.

TYPE LOCALITY. — Harbor of Mozambique, Recent.

COMPARISONS. — The fossil specimen figured on plate III is from the Tertiary of Batan Island, Province of Albay, Philippine Islands; the exact geologic age of the beds carrying the specimen is unsettled. This shell is among those from the Philippines that has been masquerading under the name « *Arca* » *antiquata*

([44]) OINOMIKADO, *The Venus*, vol. 6, N° 3, p. 135-145, 1936.

([45]) MARTENS, *Proc. Zool. Soc. London*, Part XXVIII, p. 17, 1860.

([46]) OTUKA, *The Venus*, vol. 6, N° 3, 1936, figs. 3 and 4.

Linné, a species which has its type locality in the West Indies. The Philippine fossil has three longitudinal grooves on each rib, whereas *antiquata* has only one on each. Since this shell agrees in outline, sculpture, and proportions with the topotypes of *hankeyana*, as our figure 3, plate III, and figure 4, plate III, clearly demonstrate, we think that its identification is correct.

DIMENSIONS. — The dimensions of the specimens here figured are shown in Table XI.

TABLE XI. — **Dimensions of hypotypes of Anadara hankeyana.**

SPECIMEN.	Length in mm.	Height in mm.	Convexity in mm. (one valve).	Right or left valve.	Number of ribs.
Phil. Bur. Sci. . . .	51.7	40.9	17.8	Right	33
Stanford Univ. Paleo. type coll. No. 6056. .	70.8	52.2	23.1	Right	37

DISTRIBUTION. — In addition to its Tertiary record, we have before us several Recent shells of this species from various indefinitely-described localities in the Philippine Islands. These shells have been going under the name « *Arca antiquata* Linnaeus », and it is likely that this name in Faustino's list ([47]) refers to *hankeyana* rather than to the West Indian species. Today *hankeyana* seems to be restricted to the Indo-Pacific marine molluscan province.

Anadara (Anadara) ferruginea (REEVE), **waloensis** SCHENCK & REINHART, new subspecies.

Pl. III, fig. 1; pl. V, fig. 5.

TYPE MATERIAL. — Holotype (left valve); paratype (right valve); paratype (valves attached); and eight paratypes, Phil. Bur. Sci.

TYPE LOCALITY. — On the bank of a small stream about one mile due east of the village of Waloe, Province of Agusan, on the Island of Mindanao, Philippine Islands; probably late Pliocene or early Pleistocene. Graham Moody, collector; his locality N° 315. Geologic and geographic information shown in figure 9 were generously made available by Dr. J. O. Nomland, Standard Oil Company of California.

DESCRIPTION AND COMPARISONS. — Although this subspecies is similar in general appearance to typical *ferruginea*, a topotype of which is here illustrated (pl. III, fig. 2), *waloensis* differs in several respects. On eight well-preserved spe-

([47]) FAUSTINO, *Monograph 25, Phil. Bur. Sci.*, p. 19, 1928.

cimens of the new subspecies the number of flat-topped ribs varies from 19 to 22, with 21 being the most common number. Typical *ferruginea*, in contrast, carries 24 to 27 ribs, the original description by Reeve giving 27. These ribs, furthermore, are more strongly noded and more highly elevated on the subspecies than on *ferruginea*. Like typical *ferruginea*, the new subspecies is equivalved, and both valves are similarly sculptured.

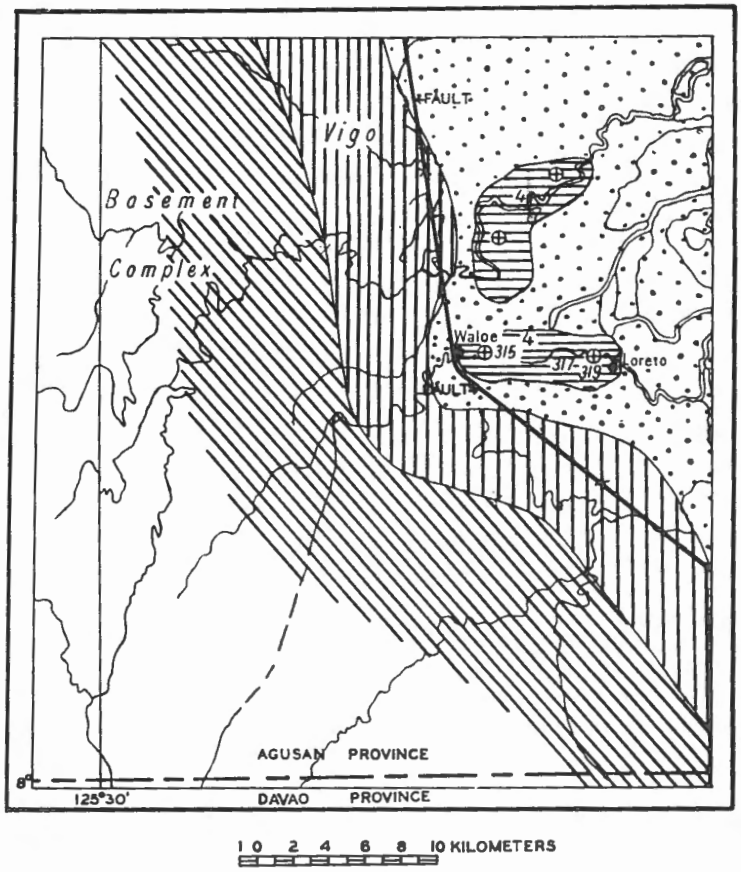

FIG. 9. — Map showing type locality of *Anadara waloensis*.

Type locality (315) of *Anadara waloensis*; near Waloe, Agusan Province, Philippine Islands. The vertical ruling indicates the distribution of Vigo beds; the horizontal ruling (as from Waloe to Loreto), No. 4 on the map, refers to strata of late Pliocene to early Pleistocene age; these beds, as shown by the cross-in-circle symbol, are horizontal. Post-Pliocene and stream deposits are indicated by coarse stippling. Geology by Graham Moody.

The new subspecies is closely related to « *Arca* » *ferruginea timorensis* Koperberg (Jaarb.-Mijnw. Ned.-Ost. Ind., 1930, p. 17), a topotype of which is here figured on plate V, figure 4. This fossil (N° A - 9776, Geol. Inst. Univ. Amsterdam) from the Pleistocene between Ae Lomea and Atamboea.

Dutch Timor, is a shell 36.7 mm. long, but the posterior end is incomplete. The larger of the 25 ribs are sulcate, flat-topped, and measure 2 mm. in width; the interspaces are only slightly narrower. The smaller ribs at the anterior and posterior extremities of the shell are not as pronouncedly sulcate. In summary, although in size, shape, and general ornamentation, *waloensis* and *timorensis* are similar, the former has fewer ribs.

The locality from which *timorensis* was described is loc. 3 (Koperberg, *op. cit.*, p. 155), also discussed by Burck (1920, p. 51, map N° 1), who gives, on p. 51, the following (translated into English by H. A. Brouwer, letter dated September 24, 1936) : « Between Atamboea and Aé Tali, near the crossing of the river Talaoe, well developed young Tertiary clays were found with many fossils. On the return trip the expedition made a small collection of these fossils. »

R. E. Dickerson ([48]) figured a specimen identified as *ferruginea* from the « Vigo » group of Tayabas Province, Bondoc Peninsula ([49]). This specimen is similar to *waloensis* in having noded ribs, but the number of ribs of the Vigo specimen is greater. A comparison of Dickerson's figure with our fig. 2, plate III, a topotype of *ferruginea*, will demonstrate the difference between the Vigo and Recent species. The ribs of the Recent specimen are but slightly noded, the interspaces are wide in comparison with the fossil, and a difference in outline is apparent, even allowing for the poorer preservation of the fossil.

The similarity of *waloensis* to *dautzenbergi* Lamy (*Jour. de Conch.*, vol. 55, p. 32, pl. 3, figs. 9-11, 1907) is noticeable. The furrowed ribs of *dautzenbergi* will separate this New Caledonian species from the Philippine fossil.

A related species is *Anadara waylandi* Cox (1927), described from the « Lower Miocene » of Pemba Island, Africa, and compared to *ferruginea* (Reeve). The original description states that the ribs number about 21, a count which corresponds to the number on *waloensis*, but the Philippine shells are not as elongate as the African fossils; the ventral margin is straighter and the umbones of *waylandi* are less sharply pointed. In spite of these slight differences, the similarity between the fossils is so marked as to prove close relationship. Future investigations may show the biogeographical significance of this relationship.

Dimensions. — The holotype of *waloensis* measures in millimeters : length, 36.9; height 26.6; convexity, 12.7. Paratype (right valve) : length, 38.2; height 28.0; convexity, 12.5. Paratype (valves attached) : length, 17.8; height, 14.0; convexity, 10.6.

([48]) In Smith, *Geology and Mineral Resources of the Philippine Islands*, pl. 9, fig. 3, 1923.

([49]) For locality data and list of fossils, consult Dickerson, *Phil. Jour. Sci.*, vol. 18, N° 1, p. 7, 1921.

SIGNIFICANCE. — Specimens belonging to the gens of *ferruginea* are now allocated by professional conchologists to at least five biological subdivisions of the genus *Anadara*; *ferruginea* and *dautzenbergi* (Recent); *timorensis* (Pleistocene); *waloensis* (Pliocene or Pleistocene); and *waylandi* (Oligocene or Miocene). The specimens from the « Vigo Group » of the Philippine Islands, once identified as *ferruginea*, are held to be distinct from the typical species. Unless one objects to restricted species, the hypothesis that the rate of evolution is slower in tropic than in temperate waters is not supported by this gens of arcid pelecypods, since a species once considered to have a long time range is in reality composed of several units of probably different biochrons.

MISCELLANEOUS TERTIARY SPECIES OF ANADARA, *s. l.*

SPECIES FROM EUROPE.

Anadara (Scapharca) turonica (DUJARDIN), 1837.

Pl. II, fig. 4; pl. VI, fig. 2.

1837. *Arca turonica* DUJARDIN, Mém. Soc. géol. France, t. 2, pt. 2, p. 267, pl. 18, fig. 16. Miocene : Touraine, France.

1898. *Arca turonica* Dujardin, SACCO, I Moll. dei Ter. terziarii del Piemonte e della Liguria des. d. Dott. Federico Sacco, Pt. 26, p. 24.

1900. *Arca Turonica* Dujardin, SCHAFFER, Jahrb. d. k. k. Geol. Reich. Wien, Bd. 49 (1899), p. 146.

1906. *Arca* (*Anadara*) *turonica* Dujardin, DOLLFUS, Assoc. franç. pour l'Avancement des Sci., C. R., Congrès de Lyon, p. 309. Upper Miocene : Beaulieu (Mayenne).

1914. *Arca* (*Anadara*) *turoniensis* Dujardin, FAVRE, Cat. illustré de la Coll. Lamarck, Conch. dimyaires foss., Mus. d'Hist. nat. de Genève, 3e livraison, pl. 30, figs. 192, 193, 194, explanation of pl. 31. Vindobonian : Touraine.

1932. *Arca* (*Anadara*) *Turoniensis* (Dujardin), CHIESA, Boll. Soc. Geol. Ital., vol. 51, fasc. 1, p. 174-177. Upper Miocene : Algeria.

TYPE MATERIAL. — Holotype : unknown to the writers. Hypotypes N° 5963, Stanford Univ. Paleo. type Coll.; N° 1935, Schenck Coll.

TYPE LOCALITY. — « Dépôts marins supérieurs ou faluns », Miocene (lower Helvetian) of Touraine, France. A. Peyrot states (letter dated March 10, 1936) : « Le type de *A. turoniensis* a été pris dans l'Helvétien infr. (Helvétien I de Mayer, base du 2e étage méditerranéen de Suess). »

MATERIAL EXAMINED. — Three valves from the Miocene of Touraine, France (Mus. roy. Hist. nat. Belg., coll. de Malzinne). Two valves from the Tortonian, Miocene, of Lapugy, Hungary (Schenck Coll. N° 1506). Three valves from the Tortonian of Vösbau, Vienna Basin, Austria (Schenck Coll. N° 1507). Nine valves from Pontlevoy, « Faluns de la Touraine », and therefore topotypes of

turonica (Schenck Coll. N° 1897). Five valves from the Miocene of Touraine (Indre et Loire), France, namely : from Manthelan (Schenck Coll. N° 1935); from Ste. Catherine de Kerbois (Schenck Coll. N° 1934 and Stanford Univ. Paleo. type coll. 5963); from Ferrière l'Arcon (Schenck Coll. N° 1936); from Louans (Schenck Coll. N° 1937).

SUBGENERIC ALLOCATION. — Slightly discrepant sculpture on the two valves of this species indicates that it belongs to *Scapharca,* a suggestion which is strongly borne out by its close relationship to *aquitanica,* which is definitely a *Scapharca* (see p. 52). We have not seen specimens of *turonica* with the valves in the attached position.

VARIETIES. — A number of varieties of *turonica* have been described, the validity of which we have not had an opportunity to check. These are the following : *precompressa, subalata,* and *taurangulosa* Sacco ([50]): *albanensis* Dollfus ([51]); and *gjaurtapensis* Grigorovic-Berezovskij ([52]), a *nomen nudum.*

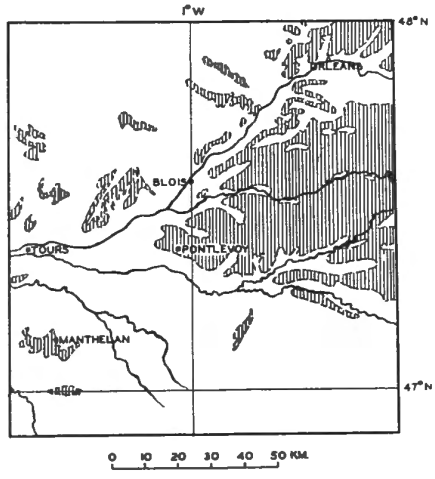

FIG. 10. — Map showing type locality of *Anadara turonica.*

Sketch map showing the type area of *Anadara* (*Scapharca*) *turonica* (DUJARDIN), after « Carte géologique de la France » (1905).
The vertical ruling indicates the general distribution of Miocene deposits.

COMPARISONS. — The relationship between this species and *speyeri* is brought out by our illustrations.

The similarity between *Anadara turonica* and *aquitanica* has been for years the cause of difficulty in separating these two species. *A. aquitanica* is some-

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([50]) SACCO, *supra cit.*, p. 24-25.

([51]) DOLLFUS, *Jour. Conchy. Paris*, vol. 70, 1926, p. 112. Pliocene of Albania.

([52]) GRIGOROVIC-BEREZOVSKIJ, *Trav. Mus. Géol. Leningrad*, vol. I, p. 64, 1927. Tchokrak Stage, Upper Tertiary of Daghestan.

times listed as a variety or « mutant » of *turonica*. The following observations give our basis for separation. The profile of *aquitanica* is variable, but there is a suggestion that *turonica* is proportionally longer than *aquitanica*, on some specimens of which the height equals two-thirds of the length. Furthermore, the ventral margin of *turonica* is commonly straighter than that of *aquitanica*. The most reliable means of distinction, however, is the arrangement of the ligamental grooves, as shown in Plate VI. The anterior groove, on *turonica*, forms the outer boundary of the anterior part of the ligamental area, while the posterior groove lies some distance within this outer boundary. In *aquitanica*, the ligamental area is not delimited by a groove either anteriorly or posteriorly. Aside from these differences, the two species are similar in appearance and carry the same number of ribs (32 on most specimens).

Anadara turonica has also been confused with *diluvii* (Lamarck). For example, the specimen of *diluvii* shown in fig. 5, Plate II, from the Tortonian (Miocene) of Saubrigues (Landes), France, is among those which have been misidentified as *turonica*. As A. Peyrot has said ([53]), *turonica* has a more distinctly trapezoidal shape, and is further distinguished by differences in the ligamental area, as shown by a comparison of figures 2 and 6, plate VI. In *diluvii* the posterior ligamental groove (instead of the anterior groove, as in *turonica*) forms the outer boundary of the ligamental area, while the anterior part of this area is not bounded by a groove.

DISTRIBUTION. — This species is reported from the Miocene of France, Spain, Italy, Austria, Hungary, Portugal, Corsica, and elsewhere in southern Europe.

Anadara (Scapharca) aquitanica (MAYER), 1861.

Pl. II, figs 2, 7; pl. VI, fig. 1.

1861. *Arca aquitanica* MAYER, Jour. Conch., 3 sér., t. 1, vol. IX, p. 362-363. Aquitanian : Saint-Avit, France.

1923. *Arca aquitanica* ASTRE, Bull. Soc. Hist. nat. Toulouse, vol. 51, p. 466-471.

TYPE MATERIAL. — Holotype, unknown to the writers. Hypotypes here illustrated : N°s 5953, 5961, 5964, 5965, Stanford Univ. Paleo. type coll.

TYPE LOCALITY. — Tertiary (Aquitanian) of Saint-Avit ([54]), near Mont-de-Marsan (Landes), France. Notes on the geology of this area have been published by Degrange-Touzin (1912).

([53]) In a letter to H. G. Schenck, dated January 29, 1936.

([54]) By typographical error called « Saint-Toit » by Mayer. We are indebted to Dr. Louis Castex for calling our attention to this error.

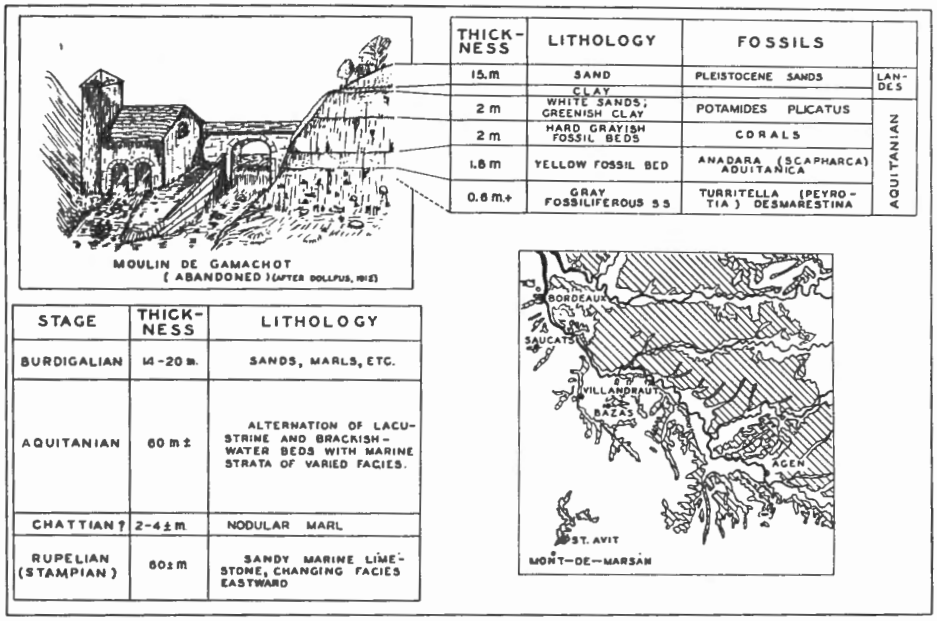

FIG. 11. — Map showing type locality of *Anadara aquitanica*.

Type locality (St. Avit) of *Anadara* (*Scapharca*) *aquitanica* (MAYER), the occurrence of specimens at the Moulin de Gamachot, and a summary of the Rupelian-Burdigalian stratigraphic succession in the Aquitaine basin, southern France.

Dr. Louis Castex (letter dated March 8, 1937) informs us that the figure by Dollfus (*Bull. Soc. géol. France*, 4 sér., t. 12, p. 486, 1912) is not accurate as the mill is now in ruins. Since the mill's appearance will change from year to year, we reproduce the original figure instead of a new drawing, such as Dr. Castex so carefully prepared for us. Dr. Castex also pointed out that the « Zone of *Anadara aquitanica* » extends from the lower part of the exposed section up to and including the beds with corals. Below the gray fossiliferous sandstone is a hard sandstone, also assigned to the Aquitanian.

The column shown in the lower left of our figure 11 gives in summary form the essential facts of stratigraphic succession in the Aquitaine basin, insofar as the Aquitanian Stage is concerned. The column shown in the upper right of figure 11 represents only a part of the Aquitanian Stage.

ORIGINAL DESCRIPTION. — « Coquille oblongue, transverse, trapézoïdale, un peu inéquilatérale, médiocrement enflée, couverte d'environ 30 côtes étroites et déprimées, séparées par des sillons étroits, légèrement crénelées du côté antérieur, lisses du côté opposé. Côté antérieur le plus court, assez large et souvent presque droit, postérieur tronqué obliquement, palléal presque droit. Crochets assez élevés, peu obliques. Aire cardinale peu allongée. Charnière légèrement arquée. Long. 25, lat. 19 mm. »

MATERIAL EXAMINED. — We have had for study 183 separate valves and three specimens with valves attached from the lower Aquitanian of Moulin de Gamachot, near Villandraut, southern France (Schenck Coll. N°s 79 and 911; and Stanford Univ. Paleo. type Coll. N°s 5953, 5961, 5964, and 5965); six valves from the upper Aquitanian Stage of Moulin de Fortir, Aquitaine basin (Schenck Coll. N° 460); six valves (topotypes) from Saint-Avit (Landes), France (Schenck Coll. N° 1898), and 4 valves from the Aquitanian of Meynot, Dax (Landes), France (Schenck Coll. 2086).

NOTES ON MATERIAL EXAMINED. — The specimens figured here on plate II, figs. 2 *a* and *b*, plate II, fig. 7, and plate VI, fig. 1, are from the lower Aquitanian Stage of Moulin de Gamachot (fig. 11) near Villandraut, southeast of Bordeaux, France, collected by F. Daguin, L. Castex, and H. G. Schenck in 1934 ([55]). The dimensions of these specimens are given in Table XII.

TABLE XII. — **Dimensions of Stanford University Hypotypes of Anadara aquitanica.**

TYPE No.	Valve.	Length in mm.	Height in mm.	Convexity in mm.	Number of ribs.
5953	Right	32.6	23.9	11.9	29
5961	Both	20.7	16.8	14.3	31
5964	Left	30 5	23.5	11.2	30
5965	Right	32.1	25.7	12.8	31

Specimens of *aquitanica* from the Moulin de Gamachot, ranging in length from 10 to 35 millimeters, have from 30 to 35 radial ribs, the statistical reconnaissance suggesting that 32 ribs is the most frequently recurring number. Rarely does a specimen bear fewer than 29 ribs. Small valves (*e. g.*, 8 mm. in length) have 28 to 30 ribs and show clearly an umbonal depression, a feature visible but not conspicuous on adult shells. The numerous specimens of *aquitanica* show that the profile is variable.

The hinge and ligamental area of a specimen of *aquitanica* are shown on plate VI, fig. 1. The question of how much reliance is to be placed upon the number of « chevrons » in the ligamental area in separating species would have to be answered by a biometrical survey. It may be of some significance, however, to record the fact that in the case of *aquitanica* the greatest number, not counting the grooves delimiting the area, seems to be six, three to four being the more common number. Such a criterion would aid in separating *aquitanica* from *fichteli* and *osmonti*, for example.

([55]) For locality, consult map, Plate B, *Actes de la Société Linnéenne de Bordeaux*, t. LXIII; for species see t. LXVIII, pl. 8, figs. 12-16. Consult also DOLLFUS, *Bull. Géol. Soc. France*, 4e sér., t. XII, p. 486, 1912.

SUBGENERIC ALLOCATION. — The numerous specimens at our disposal prove that this species belongs to the subgenus *Scapharca*. The specimens with the valves in the attached position show clearly that the left valves are larger than the right (see Plate II, fig. 7). Moreover, the sculpture of the two valves of single individuals is slightly discrepant.

COMPARISONS. — For comparisons, see the discussion of *Anadara turonica*, on page 51.

ANADARA, *sensu lato*, FROM INDIA.

Anadara (Scapharca ?) oldhamiana (NOETLING), 1901.

1840. *Arca radiata* J. de C. SOWERBY, Trans. Geol. Soc. London, ser. 2, vol. 5, explanation of plate 25, fig. 12. « Tertiary formations of Cutch » : Soomrow, India.

1901. *Arca* (*Anomalocardia*) *oldhamiana* NOETLING, Pal. Indica, n. s., vol. 1, p. 143, pl. 6, figs. 3*a-b*; zone of *Pholas orientalis*, Miocene : Thayetmyo, Burma.

1928. *Arca radiata* J. de C. Sowerby, VREDENBURG, Mem. Geol. Surv. India, vol. 50, part 2, p. 414. Upper Gaj (Miocene) : Sind and Kachh.

NOT *Arca radiata* J. S. SCHROETER, Archiv. Zool., vol. III (1), 1802, p. 130-131.

NOT *Arca radiata* FISCHER, Mus. Demid., III, 1807, p. 267 (NOT seen).

NOT *Arca radiata* MÜNSTER *in* G. A. GOLDFUSS, Petref. German., II (6), 1837, p. 143.

NOT *Arca radiata* REEVE, Conch. Icon., II, *Arca*, N° 40, February 1844. (=*Arca radians* Deshayes, Traité élém. Conch., p. 350, 1839-1857. New name for *A. radiata* Reeve.)

Arca radiata Sowerby, several times an absolute homonym, and *oldhamiana* Noetling, from the Burmese Miocene, are claimed by Vredenburg to be conspecific. If he is correct, the latter name should be applied to the species. The following information is supplied to us by L. R. Cox ([56]) :

« The type of *A. radiata* is in our collection here (Geol. Soc. Coll. reg. N° 10021) and is a somewhat eroded cast. It came from Soomrow (Cutch) and unfortunately we have no topotypes. I have looked at the specimens from Sind which were sent to you on loan previously as *A. radiata*, but their preservation and that of the type is so poor that I am very uncertain of their specific identity, and I think that it would be unsafe to base your conception of the species on them. They probably belong to *A. hybrida* d'Archiac and Haime *non* Sowerby, which Vredenburg says is identical with *A. radiata*, but have fewer ribs than its (*A. radiata's*) holotype and are more inflated. »

([56]) Letter dated December 28, 1935.

ANADARA, *sensu lato*, FROM THE TROPICAL AMERICAS.

Anadara (Scapharca ?) meroensis (OLSSON), 1931.

Pl. II, fig. 8.

1931. *Arca (Scapharca) meroensis* OLSSON, Bull. Amer. Paleo., vol. 17, N° 63, p. 135-136, pl. 2, figs. 2, 3, 5, 6. Heath formation : Peru and Ecuador.

TYPE MATERIAL. — Pal. Res. Inst., Holotype N° 1942; paratypes 1938, 1939, 1941. Hypotype N° 5962, Stanford Univ. Paleo. type coll.

TYPE LOCALITY. — Heath formation (base of Heath shales, « upper Oligocene »), Caleto Mero, Peru. Text figure 12 shows the type area of the species.

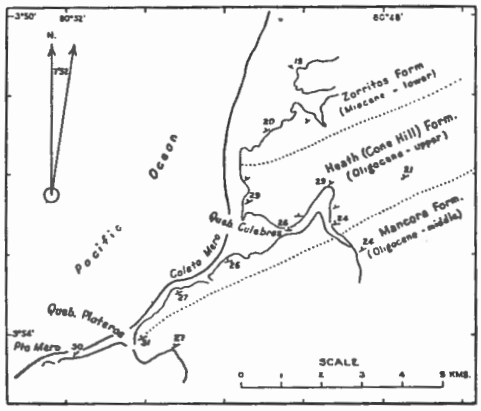

FIG. 12. — Map showing type locality of *Anadara meroensis*.
Map showing type area of *Anadara (Scapharca ?) meroensis* (OLSSON). The succession shown is (lowest) Mancora formation, Heath formation and (uppermost) Zorritos formation. Map prepared by and published through the courtesy of the Geological Department of the International Petroleum Company.

NOTES ON MATERIAL EXAMINED. — Through the courtesy of A. A. Olsson, we have examined eight specimens of this species from Posorja, Ecuador, and eleven fairly well preserved specimens from the type locality, Caleto Mero, Peru. Several of the better preserved individuals show a distinct umbonal sulcus. The ribs, ranging in number from 28 to 33, show longitudinal grooves, and, on some of the left valves, distinct nodes in the umbonal region. Preservation is too poor to show whether or not nodes are also present on the right valve. The shell appears to be equivalved, although this surmise is based on crushed material.

SUBGENERIC ALLOCATION. — This species probably is a *Scapharca*, but the specimens are not well enough preserved to allow us to assign it to that subgenus except questionably.

COMPARISONS. — This South American so-called upper Oligocene species has a striking resemblance to *Anadara* (*Scapharca* ?) *daneyi* (Cossmann and Peyrot), described from the lower Burdigalian (lower Miocene) of the Aquitaine Basin, southern France. These two species are so similar in profile and ornamentation that it would be interesting to know how many other species, if any, from the Heath shale are likewise related to those from the Burdigalian.

The similarity between *meroensis* and *mediaimpressa* from California, although considerable, is less striking. The two species differ in profile, and moreover the umbonal depression is more pronounced in the Californian species.

Anadara (Scapharca ?) willobiana (COOKE), 1919.

1919. *Scapharca willobiana* COOKE, Carnegie Institute Pub., N° 291, p. 127, pl. 5, figs. 11*a-b*. Oligocene : Antigua, West Indies.

TYPE MATERIAL. — Holotype, U. S. Nat. Mus. Catalogue N° 167040. Plastotype, Schenck Coll., N° 927.

TYPE LOCALITY. — Oligocene of Antigua Island, West Indies.

Judging from plaster casts, the holotype is a fairly well preserved specimen having both valves joined. The sculpture on the two valves seems to be slightly discrepant. Moreover, *willobiana* is somewhat thinner in form than typical *Anadara*, being a small, compressed species. Whether it is equivalve or not cannot be determined definitely from the casts.

Anadara (Cunearca) camaronesia (VON IHERING), 1907.

1907. *Arca camaronesia* VON IHERING, An. Mus. de Buenos Aires, ser. 3, vol. 7, p. 238-239, text figs. 9*a-b*. Lower Patagonian : Patagonia.

TYPE MATERIAL. — Museu Paulista, Universidade de Sao Paulo, Brazil.

TYPE LOCALITY. — Camarones, Patagonia. Von Ihering called the formation yielding this species Eocene. There is, however, considerable doubt as to the age of the lower Patagonian, and inasmuch as Reinhart's ([57]) study has shown that *Cunearca* is unknown in beds of undoubted Eocene age, it may well be that the Lower Patagonian is Oligocene or younger.

ORIGINAL DESCRIPTION. — The original description of this species was based upon « nombreuses valves, toutes de petite taille » and the figured specimens (specimen ?) measured 9.5 mm. in length; height, 8.0 mm., and convexity, 5 mm.; number of radial ribs, 23-24.

([57]) REINHART, *Mus. roy. Hist. nat. Belg.*, t. 11, N° 13, p. 45, 1935.

MATERIAL EXAMINED. — Cotype N° 6913, Museu Paulista. This specimen was placed at our disposal by F. Lange de Morretes, to whom we express our thanks.

DESCRIPTION OF COTYPE N° 6913. — Shell (left valve) small, probably immature; elongate-oval in profile, inflated; umbo prominent, beak prosogyrate, indented with sharp medial sulcus which extends only a short distance ventrally; sculpture of 23 rounded radial ribs, strongly noded except on posterior slope; nodes observed only near ventral and anterior margins; ribs on central and umbonal regions badly worn; interspaces concave, about same width as ribs; concentric growth lines cross interspaces and ribs; ligamental area flat and wide in front, tapering posteriorly; area with longitudinal growth lines and part of one ligamental groove, just behind beak, poorly preserved; posterior half of ligamental area strongly indented from rest of shell, separated from it by a sharp, overhanging « cliff » with groove at base; no « cliff » bounds anterior half of ligament; hinge slightly arched, bearing 26 teeth which converge ventrally; pallial line distinct; inner margin of shell with deep crenulations, a few posterior ones extending upward toward umbo, inside of pallial line; adductor muscle scars distinct, the posterior one considerably the larger.

DIMENSIONS (IN MM.) OF COTYPE N° 6913. — Length, 7.6; height, 6.3; convexity (left valve), 3.0.

COMPARISONS. — Von Ihering compared this species with *Anadara* (*Cunearca*) *chemnitzi* (Philippi). A comparison of *camaronesia* with *Anadara* (*Cunearca*) *incongrua* (Say), the genotype of *Cunearca*, shows a strong general similarity, although the ligamental area is set off both anteriorly and posteriorly by a sharp « cliff » in *incongrua*, but only posteriorly in *camaronesia*.

SUBGENERIC ALLOCATION. — Because of its resemblance to the genotype of *Cunearca*, we feel that *camaronesia* is to be referred to *Cunearca*, despite the fact that we have examined only one valve of a small, probably immature individual.

ANADARA, *sensu lato*, FROM SOUTHEASTERN UNITED STATES.

Anadara (Scapharca) invidiosa (CASEY), 1903.

Pl. I, fig. 2.

1903. *Arca invidiosa* CASEY, Acad. Nat. Sci. Philadelphia, Proc. for 1903, p. 264 (NOT figured).

1903. *Arca delicatula* CASEY, *op. cit.*, p. 265 (NOT figured).

1917. *Arca invidiosa* Casey, SHELDON, Palaeont. Amer., vol. 1, N° 1, p. 31. Original description reprinted; referred to subgenus *Scapharca*.

1917. *Arca delicatula* Casey, SHELDON, *op. cit.*, vol. 1, N° 1, p. 32, Ithaca, New York. Original description reprinted; referred to subgenus *Scapharca*.

1936. *Anadara* (*Anadara*) *delicatula* (Casey), SCHENCK and REINHART, Geol. Soc. Am., Proc. for 1935 (June 1936), p. 412.

TYPE MATERIAL. — Proterotypes unknown to the writers. Topotypes (of *invidiosa*), Cat. N° 2633, U. S. Nat. Mus.; topotypes (of *delicatula*), Cat. N° 13287, U. S. Nat. Mus. and N° 10320, Univ. Calif. Mus. Invert. Paleo.

TYPE LOCALITY. — (of *invidiosa*), Red Bluff formation, lower Oligocene, Mississippi; (of *delicatula*), « Lower Vicksburgian limestone », lower Oligocene, Mississippi.

Cooke ([58]) presents a correlation of the Red Bluff clay of Mississippi with the Mariana limestone of Alabama. This limestone, characterized by the presence of *Lepidocyclina mantelli* (Morton), has been correlated ([59]) with the Sannoisian of western Europe. Notes on the Vicksburg Group were published recently by Howe (1933) and Mornhinveg and Garrett (1935).

DESCRIPTION OF TOPOTYPES OF INVIDIOSA. — The following notes are based upon two detached, well-preserved valves, one left, one right (not from same individual), Cat. N° 2633, U. S. Nat. Mus. These shells are from Carson's Creek, Wayne C°, Mississippi, Red Bluff formation.

Shell elongate, with rather prominent medial sulcus extending from beak to anterior third of ventral margin; ribs 28 in number; on *left valve* : the six ribs within medial sulcus area fairly thin; the five ribs just anterior to and the two ribs just posterior to this sulcus dichotomize, the dichotomizing apparently having started when shell was 2/3 its present size; anterior and posterior ribs plain and rounded, much wider than interspaces; ribs within sulcus area only *ca.* 1/3 as wide as interspaces; on *right valve* : about 6 ribs within sulcus area, with interspaces 3 to 4 times as wide as ribs; just anterior to sulcus, 4 ribs are dichotomous, the dichotomizing starting when shell was *ca.* 3/4 its present size; posterior to sulcus, ribs do not dichotomize, are wider than interspaces, rounded and plain; on left valve, a distinct trace of beading, which is not present on right; teeth of right valve numerous, small, granular; anterior 9 teeth larger than granular medial ones; slightly converging; the posterior 9 or 10 teeth likewise larger than medial ones, and converging ventrally; ligamental area narrow, nearly flat; numerous wavy ligamental grooves, especially on larger left valve; beaks slightly prosogyrate; pallial line and muscle scars indistinct; interior of shell furrowed in harmony with external ribbing; inner margin of shell crenulated; apparently no byssal gape.

([58]) COOKE, *Bull. Am. Assoc. Pet. Geol.*, vol. 19, N° 18, p. 1171, 1935.

([59]) VAUGHAN, *Bull. Geol. Soc. Am.*, vol. 35, Table 3, 1934.

Dimensions of U. S. Nat. Mus. specimens Cat. N° 2633 are given in Table XIII.

NOTES ON U. S. NATIONAL MUSEUM TOPOTYPES OF DELICATULA. — Cat. N° 13287 : two detached valves, one right, one left (not from the same individual); preservation good; locality, « Lower bed, Vicksburg, Miss. » (This is the type locality of *delicatula*). These specimens may be described as follows :

Same shape and proportions as *invidiosa*, but smaller; elongate beaks located anterior to center; prominent medial sulcus extends from tip of beak to ventral margin, striking this margin anterior to center of shell; ribs 25 to 27 in number; on *left valve* : all ribs definitely beaded except those on posterior slope, which are plain; no dichotomizing in any ribs; about 4 ribs in medial sulcus area are narrower than interspaces; anterior ribs about as wide as interspaces, posterior ribs wider; on *right valve* : no trace of beading or dichotomizing : about 6 ribs in region of sulcus very fine, but anterior and posterior ribs about as wide as interspaces; posterior ribs (on posterior slope) wider than interspaces; anterior series of teeth only one-half as long as posterior series; all teeth small; granular at and near center of hinge; anterior teeth somewhat converging; posterior teeth strongly converging ventrally (*ca.* 45°); ligamental area very narrow, nearly flat, bearing faint longitudinal growth lines; beaks prosogyrate; pallial line and muscle scars indistinct; interior of shell : right valve faintly grooved internally in harmony with external ribbing; left valve distinctly grooved internally, these grooves joining the crenulations at shell margin without interruption; shell material of both valves thin.

Dimensions of U. S. N. M. specimens, Cat. N° 13287, are given in Table XIII.

NOTES ON UNIVERSITY OF CALIFORNIA TOPOTYPES OF DELICATULA. — Seven fairly well preserved valves of this species are available to us (University of California topotypes A. 1050/10320, collected by F. E. Turner). One of these specimens is shown in figs. 2 *a-c*, plate I. The number of ribs varies from 24 to about 30, as shown in the following Table XIII.

TABLE XIII. — **Dimensions of Anadara invidiosa.**

SPECIMEN.	Length in mm.	Height in mm.	Convexity in mm.	Right or left valve.	Number of radial ribs.	Ratio of height to length in percent.
U. S. Nat. Mus. Cat. No. 2633 (topotypes of *invidiosa*).	9.7	5.2	2.5	Right	28	51.5
	10.7	7.1	3.0	Left	28	66.4
U. S. Nat. Mus. Cat. No. 13287 (topotypes of *delicatula*).	6.4	3.4	1.4	Right	27	53.1
	7.5	3.7	1.4	Left	25	49.3

TABLE XIII. — **Dimensions of Anadara invidiosa** (*continued*).

SPECIMEN.	Length in mm.	Height in mm.	Convexity in mm.	Right or left valve.	Number of radial ribs.	Ratio of height to length in percent.
Univ. Calif. Mus. Invert.	3.7	2.0	0.9	Left	27	54.1
Paleo. No. A. 1050/10320	4.2	2.3	1.0	Right	30±	54.8
(topotypes of *delicatula*).	5+ (*)	2.5	1.0	Right	28	50.0
	5.2	3.0	1.2	Right	25	57.7
	5.6	3.0	1.2	Right	25	53.6
	6.2	3.2	1.4	Left	28	43.8
	7 (*)				24	

(*) Refers to broken specimen.

REASONS FOR SYNONYMIZING INVIDIOSA AND DELICATULA. — These names were applied to specimens of different size, *invidiosa* being the larger. The smaller forms (*delicatula*) lack the dichotomous ribs present on the anterior half of the larger forms (*invidiosa*). However, the ribs of *invidiosa* do not begin to dichotomize until the shell attains a size greater than that of the topotypes of *delicatula*. The crowding of the concentric growth rings at the ventral margin of the specimens of *invidiosa* suggests maturity, whereas the specimens of *delicatula* seem to be the shells of immature animals. Because *invidiosa* and *delicatula* are so similar in all other respects, it is reasonable to consider them conspecific, and to adopt the name having page preference.

COMPARISON. — The above-mentioned resemblance of this species to « *Diluvarca* » *mikkula* Gardner (U. S. Geol. Survey Prof. Paper 142A, 1926, p. 29, pl. 5, figs. 8, 9), from the Chipola formation, « lower Miocene », of Florida, is a striking one. « *Diluvarca* » *mikkula* differs from *delicatula* by having a shallower medial sulcus and fewer ribs [23]; *mikkula* is described as slightly inequivalved and therefore likewise probably belongs to *Scapharca*.

SYSTEMATIC POSITION OF INVIDIOSA. — Our reason for placing *invidiosa* (and its synonym, *delicatula*) in *Scapharca* is the discrepancy of sculpture of the left and right valves. The obliquity of the teeth, such as shown in figure 2*b*, plate I (of a topotype of *delicatula*), seems to mark, as it does in *sulcicosta* Nyst and other species, merely an immature stage. For example, we have before us a large series of specimens of *sulcicosta* from very small ones (fig. 1, pl. II) to the larger adults, and it is evident from a study of this series that the teeth of the very small shells are oblique and become progressively less oblique as the shell approaches maturity. Finally, although we have not had a specimen of *invidiosa* with the valves in the attached position and hence cannot determine whether the species is inequivalve, nevertheless we assign it to *Scapharca* not

only because of the discrepant sculpture, mentioned above, but also because of the marked resemblance of this species to *Anadara* (*Scapharca*) *mikkula* (Gardner).

EOCENE SPECIES INCORRECTLY ASSIGNED TO ANADARA.

In view of the statement made at the outset of this paper that *Anadara* does not occur in beds older than Tongrian, the assignment by various authors of several Eocene arcid species to *Anadara* must be considered here. The following is a catalogue of these species, showing what we believe to be their correct disposition.

Argina granulosa (Deshayes), 1824.

1824. *Arca granulosa* Deshayes, Description des Coquilles des environs de Paris, t. 1, p. 208-209, pl. XXXII, fig. 17, 18. Eocène : Parnes, Château-Rouge, Ully-Saint-George, France.

1904-1906. *Arca* (*Anadara*) *granulosa* Desh., Cossmann and Pissarro, Icon. Com. des Coquilles fos. de l'Éocène des environs de Paris, t. 1, pl. 36, figs. 110-45, Lutetian : Paris Basin.

Reinhart has pointed out (1935, p. 41) that this species is an *Argina*. The ligament is narrow and confined to the posterior of the beaks; the anterior series of teeth is short and irregular; the posterior series is long. The type locality of the species is Parnes, but L. Morellet (written communication, December 12, 1936) states that he has never found specimens there.

Scapularca scapulina (Lamarck), 1805.

1805. *Arca scapulina* Lamarck, Ann. Mus. Hist. Nat. Paris, vol. 6, p. 221, June 1805. Lutetian (Eocene) : Grignon, France.

1904-1906. *Arca* (*Anadara*) *scapulina* Lamarck, Cossmann and Pissarro, Icon. Com. Coq. foss. de l'Éocène des environs de Paris, t. 1, pl. 36, figs. 110-48. Lutetian : Paris Basin.

1935. *Arcopsis* (*Scapularca*) *scapulina*. Reinhart, Bull. Mus. roy. Hist. nat. Belg., t. XI, N° 13, p. 32-33, Aug. 1935.

1936. *Trigonodesma* (*Scapularca*) *scapulina* Lamarck, Glibert, Mém. Mus. roy. Hist. nat. Belg., N° 78, p. 27-28, fig. 15, Nov. 30, 1936. Wemmel sands (Upper Eocene) : Belgium. Lutetian, Auversian, and Bartonian : France.

Material examined. — Topotypes, N°s 1930 and 2265, Schenck Coll., from the Lutetian (Eocene) of Grignon, France.

Discussion. — The specimens show the strong symmetry of the hinge, as is well brought out by Glibert's (1936) illustrations. The striations shown in his

figure are, we believe, due to preservation and are not to be interpreted as a transversely striated ligamental area, such as occurs in *Striarca*.

This species, the genotype of *Scapularca* Cossmann and Peyrot, is widespread in the Lutetian deposits. L. Morellet (written communication, Dec. 12, 1936) states that Bartonian specimens are rare, though often occurring as reworked material.

Scapularca globulosa (Deshayes), 1824.

1824. *Arca globulosa* Deshayes, Description des Coquilles des environs de Paris, t. 1, p. 209-210, pl. XXXIII, figs. 4-6. Éocène : « Guise-Lamothe près Compiègne », France.

1904-1906. *Arca* (*Anadara*) *globulosa* Desh., Cossmann and Pissarro, Icon. Com. des Coquilles fos. de l'Éocène des environs de Paris, t. 1, pl. 36, figs. 110-46. Lutetian, Bartonian : Paris Basin.

1933. *Trigonodesma* (*Scapularca*) *globulosa* Deshayes, Glibert, Mém. 53, Mus. roy. Hist. nat. Belg., p. 123, fig. 18, 1933. Bruxellian : Belgium.

Material examined. — N° 862 and 1931, Schenck Coll., from the Cuisian of Liancourt, and Cuise, France.

Discussion. — The topotypes from the Cuisian are closely related to *A. scapulina*, the genotype of *Scapularca*. Morellet informs us that *globulosa* occurs in the Lutetian, as well as the Cuisian, and questionably in the Bartonian. The Sparnacian occurrence reported by Cossmann seems to be in doubt.

Although in hinge and ligamental area *Scapularca* resembles *Trigonodesma* fully as much as *Arcopsis*, *Scapularca* does not possess opisthogyrate beaks nor a sharp posterior carina — features which distinguish *Trigonodesma*.

Scapularca globulosa var. **interposita** (Deshayes), 1860.

1860. *Arca interposita* Deshayes, Description des animaux sans vertèbres découverts dans le bassin de Paris, t. 1, p. 892, pl. LXVII, figs. 11-13 (*fide* Glibert, Mém. 53, Mus. roy. Hist. nat. Belg., p. 123, 1933).

1904-1906. *Arca* (*Anadara*) *globulosa* var. *interposita* Desh., Cossmann and Pissarro, Icon. Com. des Coquilles de l'Éocène des environs de Paris, t. 1, pl. 36, figs. 110-46'. Cuisian : Hérouval, Paris Basin.

L. Morellet (written communication, Dec. 12, 1936) states that this variety is known only from its type locality, Hérouval. Glibert (1933) considers *interposita* a synonym of *globulosa*.

Scapularca miliacea (Cossmann), 1887.

1887. *Anadara miliacea* Cossmann, Soc. roy. Malacologique de Belgique, Mém., Ann. Soc. roy. Mal. Belg., t. 22 (4e sér., t. II), année 1887, p. 137-138, pl. VI, figs. 19-21. Eocène : Parnes, France.

1904-1906. *Arca* (*Anadara*) *miliacea* Coss., Cossmann and Pissarro, Icon. Com. des Coquilles fos. de l'Eocène des environs de Paris, t. 1, pl. 36, figs. 110-47. Lutetian : Paris Basin.

The figures of Cossmann and Pissarro show that this species is not an *Anadara*. These figures seem to be copies of the protographs.

Noetia molengraaffi (Martin), 1914.

1914. *Arca* (*Anadara*) *molengraaffi* Martin, Samml. Geol. Reichs Mus. Leiden, N. F., Bd. 2, Heft 4, p. 184, pl. 7, figs. 191-192. Eocene : Java.

1930. *Noetia molengraaffi* (Martin), Stewart, Acad. Nat. Sci. Philadelphia, Special Pub., N° 3, p. 81, 1930.

An examination of specimens from the Eocene of Nanggulan, Java, verifies Stewart's allocation of this species to *Noetia*.

Noetia nigeriensis (Newton), 1922.

1922. *Anadara nigeriensis* Newton, Geol. Survey Nigeria, Bull. N° 2, p. 70-71, pl. 8, figs. 4-7. Eocene : Nigeria.

Material examined. — A. G. Brighton loaned us four valves of this species from the « Upper Lutetian » Eocene of Ameki, Omabialla District, Nigeria, N°s C5169, C5170, C5171, and C5172, Sedgwick Museum. L. R. Cox donated two valves (Schenck Coll., N° 2216).

Generic allocation. — Examination of these specimens leads us to assign this species to *Noetia* as was done tentatively by Stewart (1930, p. 81) and more recently by A. M. Davies (1935, p. 172), who expressed the belief that it appears to be the ancestral species of *Noetia*.

This species resembles *Noetia* in the following respects : the beaks are opisthogyrate, although only slightly so; the ligament is transversely striated and is situated mainly anterior to the beaks; the shell is high and inflated, and possesses a distinct angulation extending from the beak to the posterior ventral margin. *Noetia nigeriensis*, unlike typical *Noetia*, does not possess a distinct flange bordering the posterior adductor muscle scar, except on one specimen (C5172), on which a small flange is present.

SPECIES OF DOUBTFUL SYSTEMATIC POSITION.

Sacco ([60]) assigned to *Anadara* the species « *Arca* » *peethensis, eogassinensis,* and *interposita,* and stated that they are Eocene. As for « *Arca* » *peethensis* d'Archiac, Noetling ([61]) reports it from the Miocene of Burma; and Vredenburg ([62]) lists it from the Upper Gaj of « Kachh and Sind ». We have seen British Museum specimens N° 56065-9 from the Gaj of Sind; they are inflated, high, and strongly carinate. Preservation is too poor to warrant subgeneric identification. *A. eogassinensis,* judging from Sacco's figure, is not *Anadara, sensu stricto.* By *interposita* Sacco might have been referring to *Scapularca globulosa* var. *interposita* (Deshayes).

([60]) SACCO, F., *I. Moll. Ter. terz. del Piemonte*, Parte XXVI, p. 25, 1898.

([61]) NOETLING, *Mem. Geol. Surv. India, Pal. Indica*, n. s., vol. 1, N° 3, p. 150-151, pl. 7, figs. 9*a-e*, 1901.

([62]) VREDENBURG, *Mem. Geol. Surv. India*, vol. 50, pt. 2, p. 414, 1928.

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PLATE I

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FIG. 1. — *Anadara* (*Anadara*) *mediaimpressa* (Clark).

Types from type locality of San Ramon formation, Contra Costa County, California, Univ. Calif. locality 1131. Specimens deposited in Museum of Paleontology, University of California, Berkeley, Calif. Figs. *a*, *b*, *c*, Univ. Calif. Paratype 11172, length 21.6 mm. (×2). Fig. *d*, Univ. Calif. Holotype 11174, interior of young specimen, right valve, length 14.8 mm. (×2).

FIG. 2. — *Anadara* (*Scapharca*) *invidiosa* (Casey).

Topotype of *Arca delicatula* Casey, a synonym of *invidiosa*, from the Vicksburg formation of Vicksburg, Mississippi. Figured specimen deposited in Museum of Paleontology, University of California, Berkeley, Calif., locality A-1050; No. 10320. Left valve, length 6.2 mm. (×8.5).

FIG. 3. — *Anadara* (*Anadara*) *sulcicosta* (Nyst).

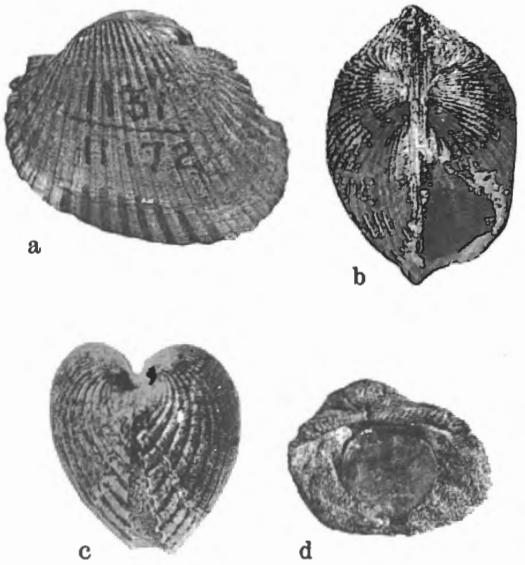
Lectotype and topotypes from the lower Tongrian, Province of Limbourg, Belgium; deposited in Musée royal d'Histoire naturelle de Belgique, Brussels. Figs *a*, *b*, *c*, Hypotype, No. 112, both valves attached, length 21.6 mm. (×2). Figs *d*, *e*, *f*, Lectotype, No. 1, M. R. H. N., left valve, length 33.8 mm. (×2), from « Sables de Vliermael ».

FIG. 4. — *Anadara* (*Anadara*?) *speyeri* (Semper).

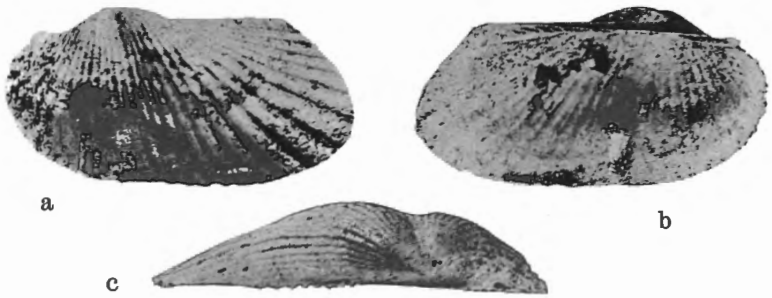
Topotype from Sternberg sandstone, Chattian, Sternberg (near Mecklenburg), Germany; deposited in Mecklenburgische Geologische Landesanstalt in Rostock. Left valve, length 21.5 mm. (×3).

FIG. 5. — *Anadara* (*Anadara*?) *speyeri* (Semper).

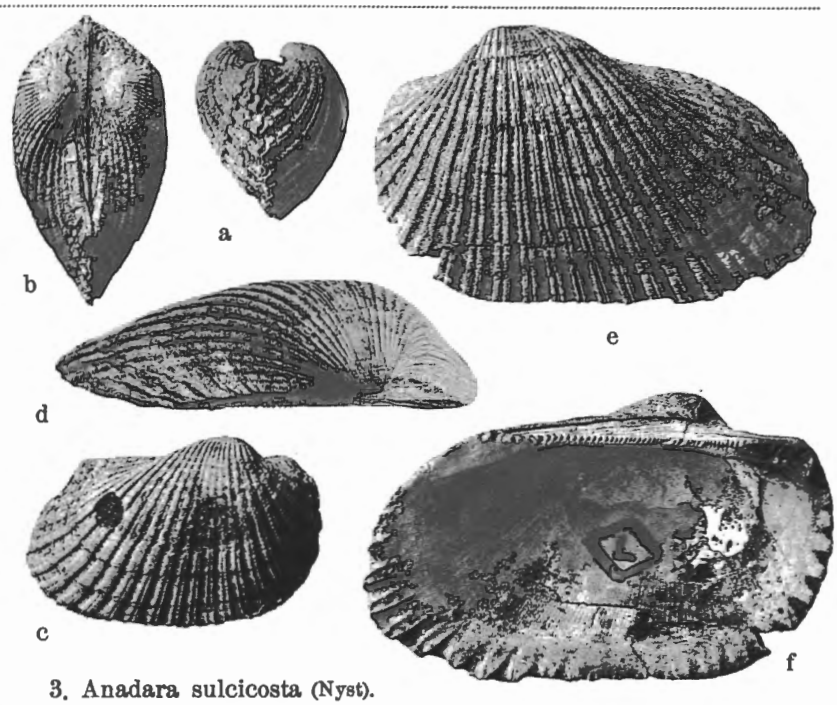
Hypotypes from the Chattian of a boring at Rosental, Rhineland, Germany. (Wegberg sheet of the Preussischen Spezialkarte, collected by W. Wunstorf.) Figs *a*, *e*, left valve, No. 916-*b*, Schenck Collection; length 17.3 mm. (×2.9); note beaded ribs. Figs. *c*, *d*, right valve, No. 5957, Stanford Univ. Paleo. type coll.; length 33.5 mm. (×1.5). Fig. *b*, right valve, No. 916-*a*, Schenck Collection; length 15.5 mm. (×2.8); note plain ribs.



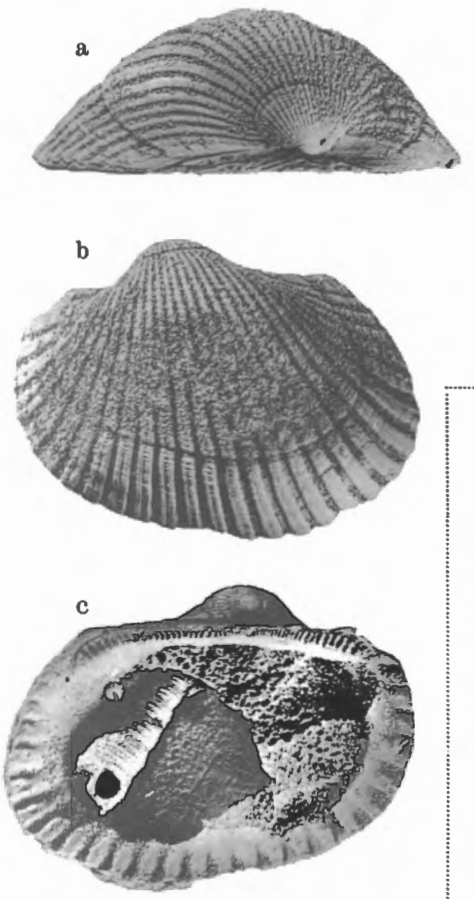
1. Anadara mediaimpressa (Clark).



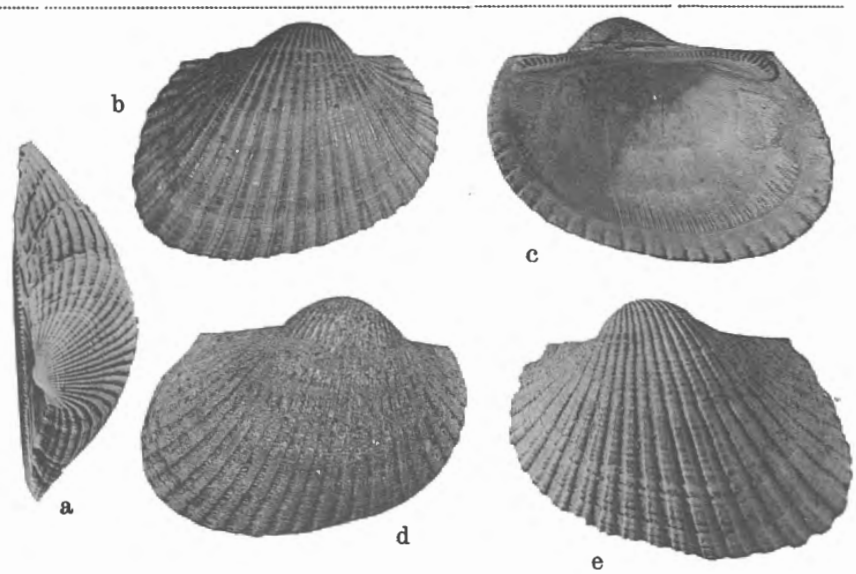
2. Anadara invidiosa (Casey).



3. Anadara sulcicosta (Nyst).



4. Anadara speyeri (Semper).



5. Anadara speyeri (Semper).

H. G. SCHENCK and P. W. REINHART. — Oligocene Anadara.

Phototypie A. Dohmen, Bruxelles.

PLATE II

EXPLANATION OF PLATE II

FIG. 1. — *Anadara* (*Anadara*) *sulcicosta* (Nyst).

Hypotype No. 142 from lower Tongrian (Tg. 1), Neerrepen, Belgium, Coll. de Looz. Deposited in Musée royal d'Histoire naturelle de Belgique, Brussels. Right valve, length 1.9 mm. (×20); juv. Note oblique teeth.

FIG. 2. — *Anadara* (*Scapharca*) *aquitanica* (Mayer).

Hypotypes from lower Aquitanian, Moulin de Gamachot, southeast of Bordeaux, France. Fig. *a*, left valve, Hypotype No. 5964, deposited in Stanford Univ. Paleo. type coll.; length 30.5 mm. (×1.5); note beaded ribs. Fig. *b*, right valve, Hypotype No 5965, deposited in Stanford Univ. Paleo. type coll.; length 32.1 mm. (×1.5); note smooth ribs.

FIG. 3. — *Anadara* (*Scapharca* ?) *daneyi* (Cossmann and Peyrot).

Hypotype from lower Burdigalian of Merignac, France. No. 5959 deposited in Stanford Univ. Paleo. type coll. Exterior of left valve, length, 24.0 mm. (×2).

FIG. 4. — *Anadara* (*Scapharca* ?) *turonica* (Dujardin).

Hypotypes from Miocene of Touraine, France. Fig. *a*, exterior of right valve, copied from Favre (1914, pl. 30, fig. 193*a*). Fig. *b*, Hypotype, No. 5963, deposited in Stanford Univ. Paleo. type coll., from Sainte-Catherine-de-Kerbois (Indre-et-Loire). Exterior of left valve, length 36.2 mm. (×1.8).

FIG. 5. — *Anadara* (*Anadara*) *diluvii* (Lamarck).

Hypotype from Tortonian of Saubrigues, France. No. 5960 deposited in Stanford Univ. Paleo. type coll. Exterior of left valve, length 18.8 mm. (×3).

FIG. 6. — *Anadara* (*Anadara* ?) *guembeli* (Mayer).

Lectotype from Oligocene molasse, Aubachgraben, Bavaria. No. C-1063, deposited in Museum of Geology, Eidgenössich Technische Hochschule at Zürich, Switzerland. Fig. *a*, exterior; fig. *b*, dorsal view; fig. *c*, interior of left valve, length 18.6 mm. (×3).

FIG. 7. — *Anadara* (*Scapharca*) *aquitanica* (Mayer).

Hypotype from Aquitanian of Moulin de Gamachot (Gironde), France. No. 5961, deposited in Stanford Univ. Paleo. type coll. Exterior of right valve showing overlap of left valve; length 20.7 mm. (×2).

FIG. 8. — *Anadara* (*Scapharca* ?) *meroensis* (Olsson).

Hypotype from Heath formation, Oligocene, of Caleto Mero, Peru, No. 5962, deposited in Stanford Univ. Paleo. type coll. Exterior of left valve, length 17.0 mm. (×3).

FIG. 9. — *Anadara* (*Anadara*) *granosa* (Linné).

Hypotype from the « Vigo Group », Locality F-15, Bahay River, Tayabas Province, P. I.; deposited in Bureau of Science, Manila, P. I. Left valve, length 61.3 mm. (×1).

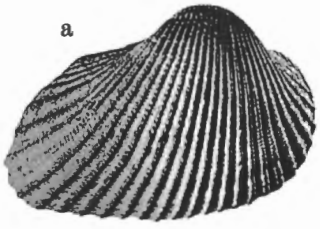
1. Anadara sulcicosta (Nyst).

a

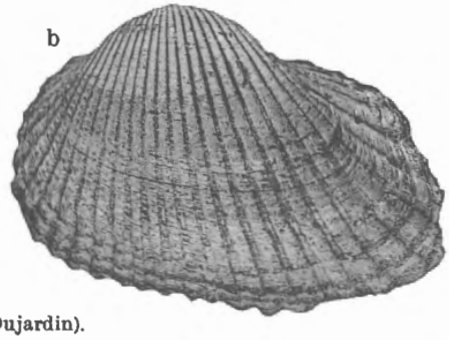
b

2. Anadara aquitanica (Mayer).

3. Anadara daneyi (Cossm. et Peyr.).



a



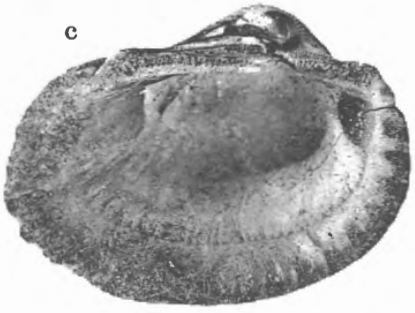
b

4. Anadara turonica (Dujardin).

5. Anadara diluvii (Lamarck).

a

b

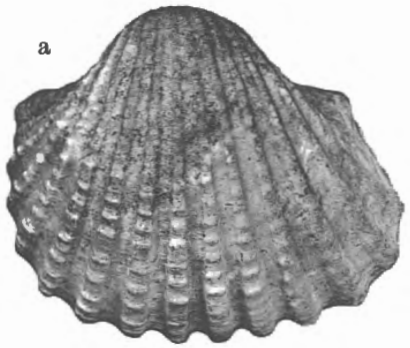


c

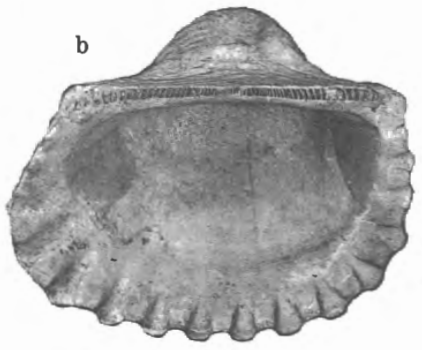
6. Anadara guembeli (Mayer).

7. Anadara aquitanica (Mayer).

8. Anadara mercœnsis (Olsson).



a



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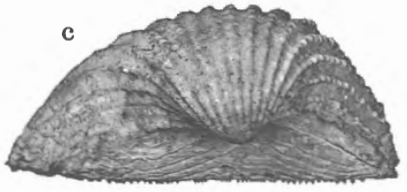


c

9. Anadara granosa (Linné).

H. G. SCHENCK and P. W. REINHART. — Oligocene Anadara.

Phototypie A. Dohmen, Bruxelles.

PLATE III

EXPLANATION OF PLATE III

FIG. 1. — *Anadara* (*Anadara*) *ferruginea waloensis* Schenck and Reinhart n. subsp.

Types from near village of Waloe, province of Agusan, Island of Mindanao, P. I.: Pliocene or Pleistocene; deposited in Bureau of Science, Manila, P. I. Figs. *a*, *b*, *e*, Paratype, right valve, length 38.2 mm. (×1.6). Figs. *c*, *d*, Holotype, left valve, length 36.9 mm. (×1.8). Figs. *f*, *g*, Paratype, valves attached, length 17.8 mm. (×2). Convexity (both valves) 10.6 mm. (×2).

FIG. 2. — *Anadara* (*Anadara*) *ferruginea* (Reeve).

Topotype and Hypotype, a Recent shell from Manila, P. I., deposited in Stanford Univ. Paleo. type coll., No. 6057. Left valve, length 44 mm. (×1.4); height 30.9 mm., convexity 13.9 mm., number of ribs 25.

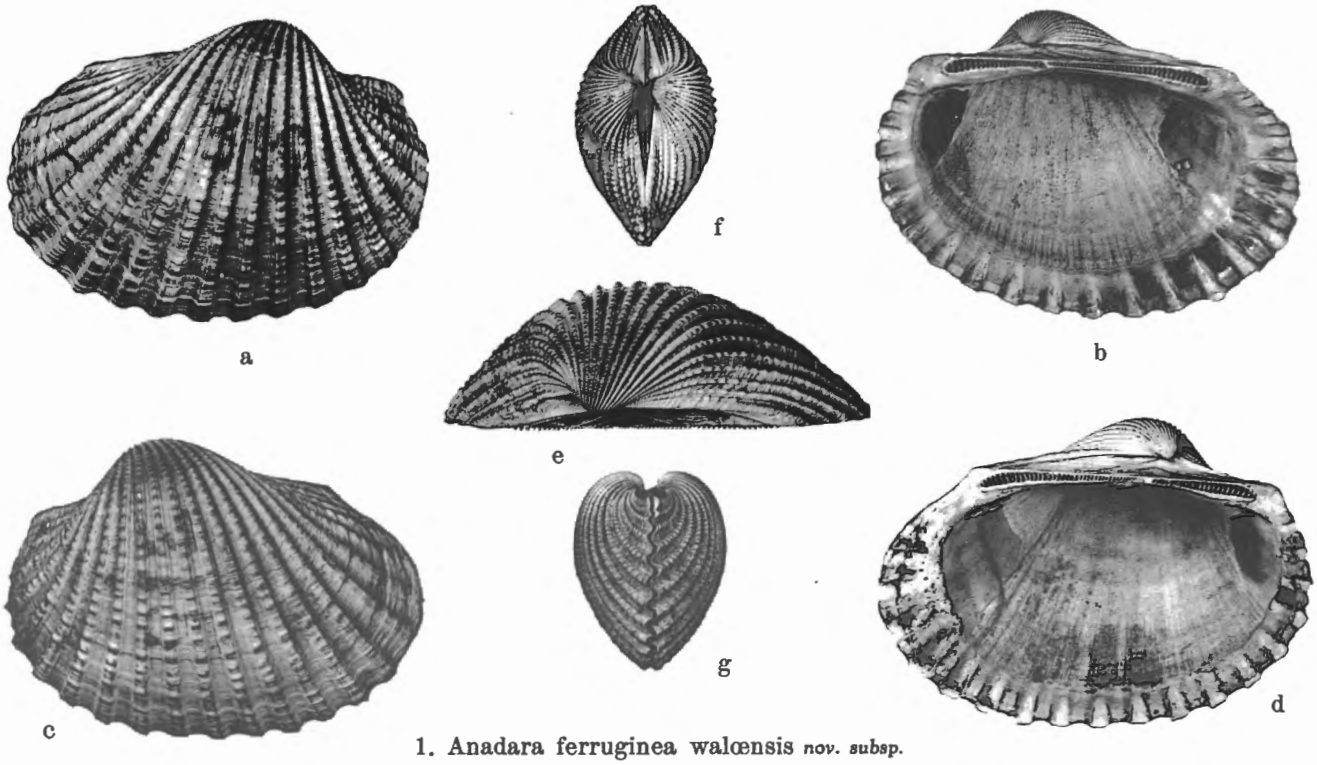
FIG. 3. — *Anadara* (*Anadara*) *hankeyana* (Reeve).

Hypotype from Tertiary, Batan Island, P. I., deposited in Bureau of Science, Manila, P. I. Right valve, length 51.7 mm. (×1).

FIG. 4. — *Anadara* (*Anadara*) *hankeyana* (Reeve).

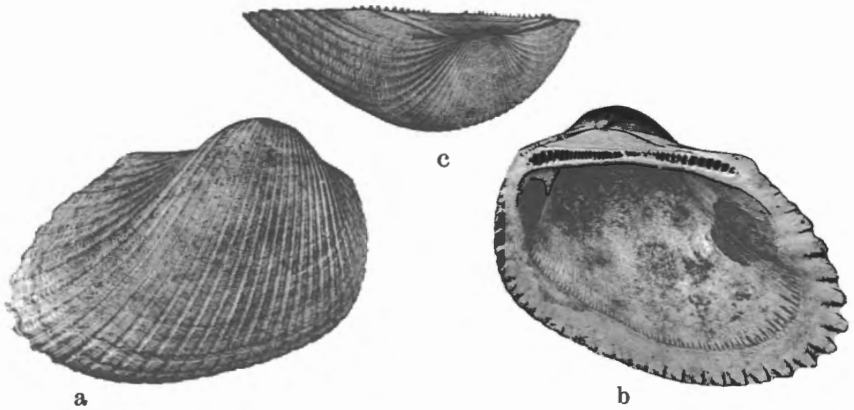
Topotypes from Mozambique; Recent; deposited in Stanford Univ. Paleo. type coll. No. 6056. Right valve, length 70.8 mm. (×1).

See also Plate V, fig. 3.

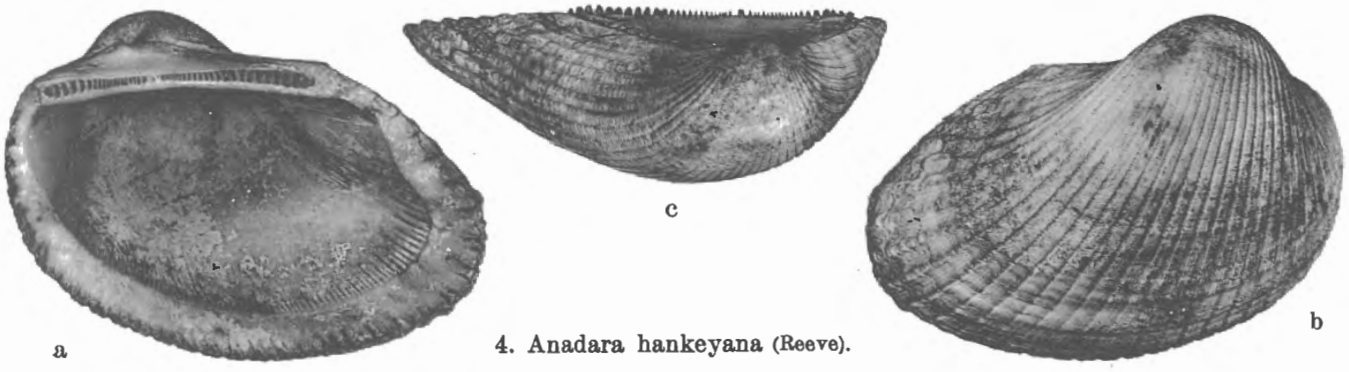


1. Anadara ferruginea walœnsis *nov. subsp.*

2. Anadara ferruginea (Reeve).



3. Anadara hankeyana (Reeve).



4. Anadara hankeyana (Reeve).

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PLATE IV

EXPLANATION OF PLATE IV

FIG. 1. — *Anadara* (*Anadara*) *granosa* (Linné).

Recent; exact locality unknown; probably Indo-Pacific marine molluscan province. Type specimens in the Linnean Society collection, Burlington House, London. Figs. *b*, *c*, *d*, Lectotype; right valve; 48 mm. in length (×2). Figs. *a*, *e*, Paratype; left valve; length 37.5 mm. (×2).

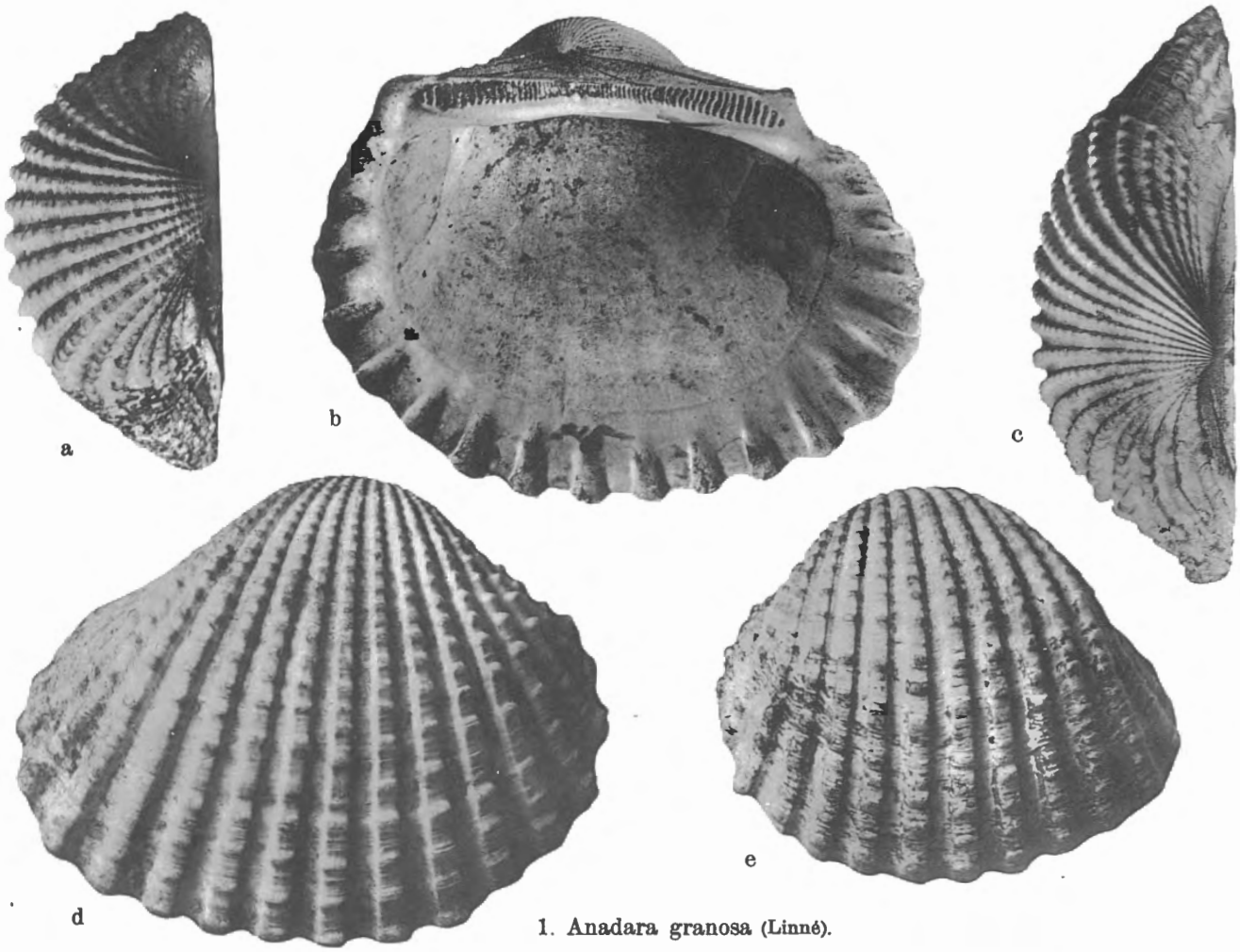
See also Plate II, fig. 9.

FIG. 2. — *Anadara* (*Anadara*) *bisenensis* Schenck and Reinhart n. sp.

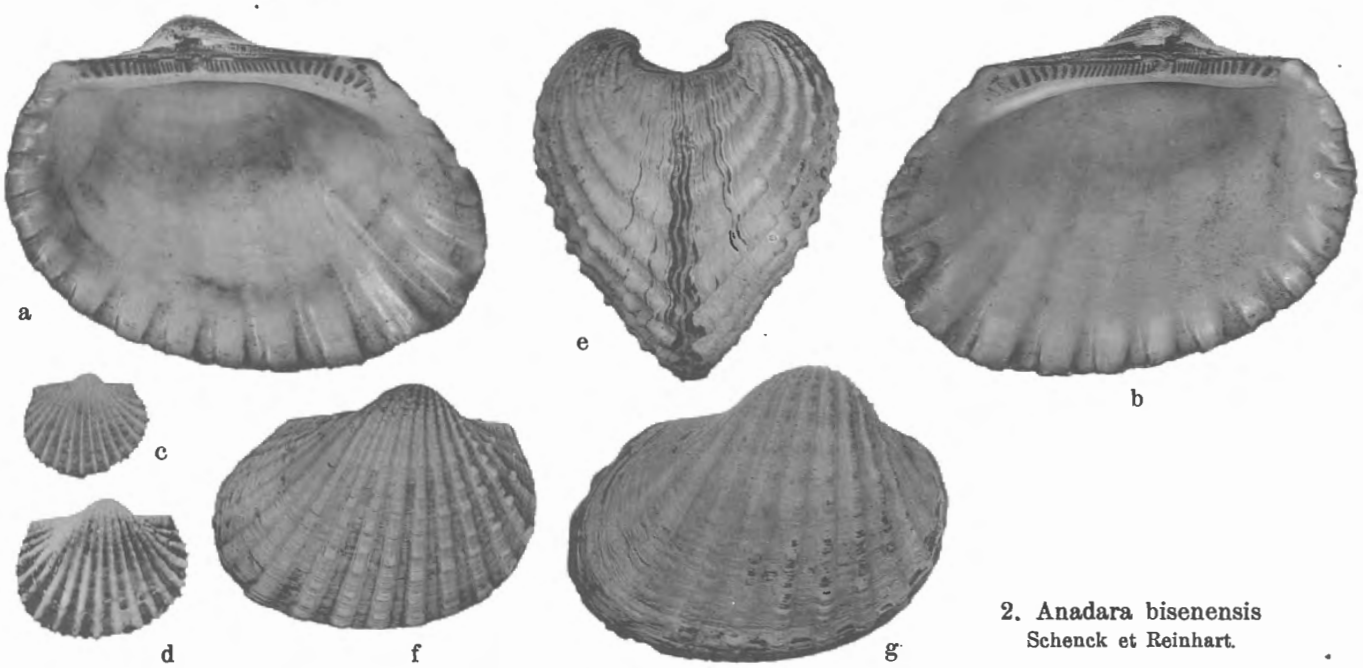
The Holotype is from Bisen, Japan; Recent. The Hypotypes are from Japan, exact locality unknown. The figured specimens are in the Stanford Univ. Paleo. type coll. Figs. *a*, *b*, *e*, Holotype (two valves), No. 6026; length 47.4 mm. (×1.5). Fig. *c*, Hypotype, No. 6018, length 2.8 mm. (×6). Fig. *f*, Hypotype, No. 6024, length 49.1 mm. (×1). Fig. *d*, Hypotype, No. 6019, length 4.6 mm. (×5). Fig. *g*, Hypotype, No. 6025, length 56.3 mm. (×1).

See table X, page 45 for ages of shells.

Additional specimens are figured on Plate V.



1. Anadara granosa (Linné).



2. Anadara bisenensis
Schenck et Reinhart.

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Phototypie A. Dohmen, Bruxelles

PLATE V

EXPLANATION OF PLATE V

FIG. 1. — *Anadara* (*Anadara*) *bisenensis* Schenck and Reinhart n. sp.

Holotype and hypotypes from Japan; Recent; specimens deposited in Stanford Univ. Paleo. type coll. Figs. *a*, *c*, *d*, Holotype (two valves), No. 6026, length 47.4 mm. (×1.5); fig. *b*, Hypotype, No. 6022, length 26.7 mm. (×2); fig. *e*, Hypotype, No. 6020, length 11.7 mm. (×4); fig. *f*, Hypotype, No. 6023, length 53.1 mm. (×1); fig. *g*, Hypotype, No. 6021, length 21.8 mm. (×2).

FIG. 2. — *Anadara* (*Anadara*) *antiquata* (Linné).

Hypotype from West Indies, Recent; deposited in Stanford Univ. Paleo. type coll. No. 5318. Detail of sculpture on ventral part of right valve.

See also text figures 2-5 and plate VI, fig. 3. Interspaces 1.0 mm. wide (×2.5).

FIG. 3. — *Anadara* (*Anadara*) *hankeyana* (Reeve).

Fig. *a*, Hypotype from Mozambique, Recent; deposited in Stanford Univ. Paleo. type coll., No. 6056. Detail of sculpture of ventral part of right valve; interspaces 0.6 mm. wide (×3). This specimen is a topotype of the species.

See also Plate III, fig. 4.

Fig. *b*, Hypotype from Tertiary, Batan Island, P. I.; deposited in Philippine Bureau of Science, No. 224. Detail of sculpture of anterior ventral part of right valve; interspaces 0.6 mm. wide (×3).

See also plate III, fig. 3.

FIG. 4. — *Anadara* (*Anadara*) *ferruginea timorensis* Koperberg.

Lectotype from the Pleistocene, Dutch Timor, deposited in Geologisch Instituut, Universiteit van Amsterdam, No. A-9776. Figs. *a*, *b*, exterior and dorsal views of specimen 36.7 mm. in length (×1.7). Fig. *c*, detail of ornamentation of ventral part of left valve; interspaces 1.5 mm. wide (×2.6).

FIG. 5. — *Anadara* (*Anadara*) *ferruginea waloensis* Schenck and Reinhart n. subsp.

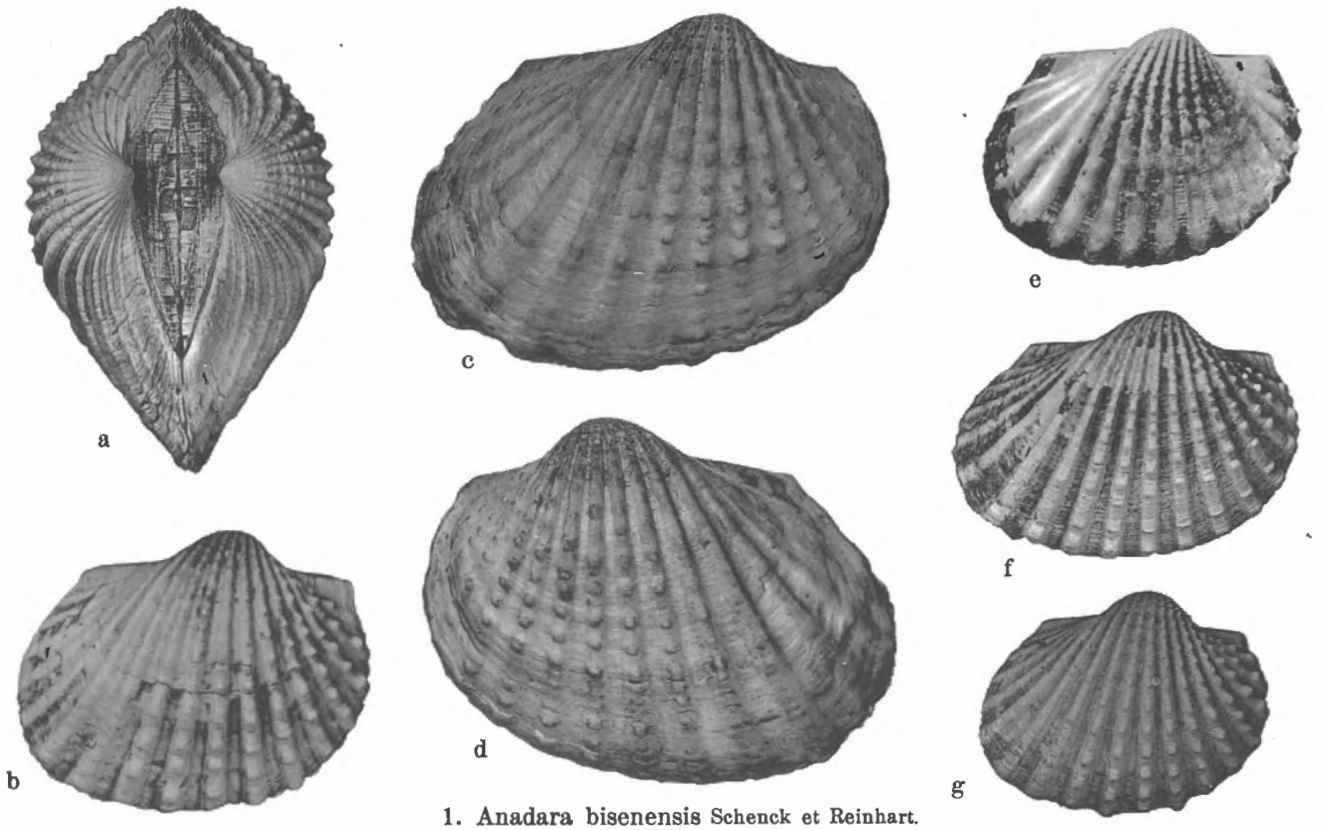
Holotype from the Pliocene or Pleistocene of the Province of Agusan, Mindanao, P. I., deposited in Philippine Bureau of Science, Manila. Detail of ornamentation of ventral part of the holotype of the subspecies, a left valve; interspaces 1.6 mm. wide (×4).

See also Plate III, fig. 1.

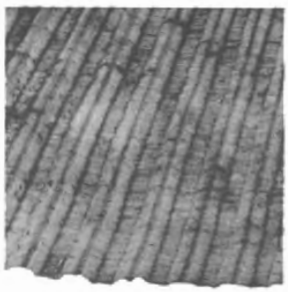
FIG. 6. — *Anadara* (*Anadara*) *ferruginea* (Reeve).

Hypotype from Manila, P. I., Recent; deposited in Stanford Univ. Paleo. type coll., No. 6057. Detail of ornamentation of ventral part of left valve; interspaces 1.2 mm. wide (×3).

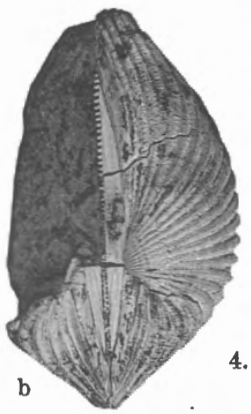
See also Plate III, fig. 2.

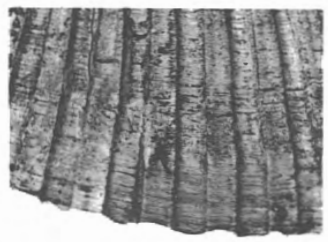


1. Anadara bisenensis Schenck et Reinhart.

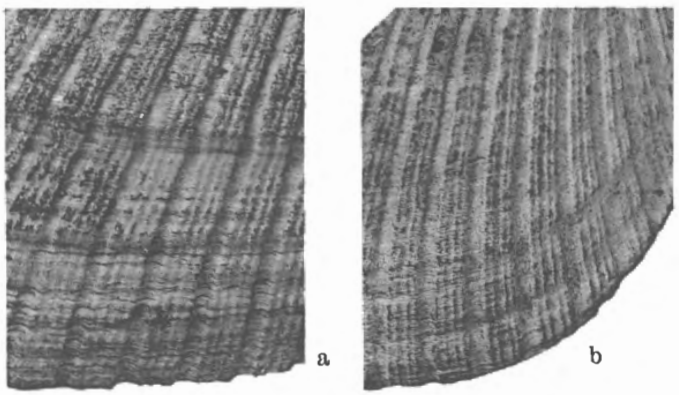


2. Anadara antiquata (Linné).

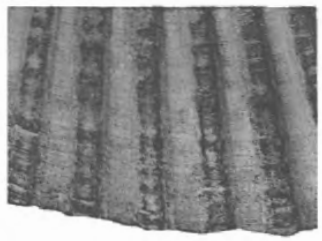




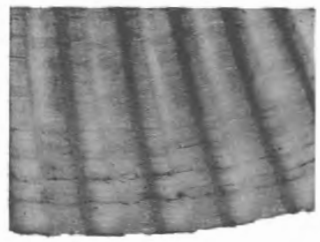
4. Anadara timorensis Koperberg.



3. Anadara hankeyana (Reeve).



5. Anadara walœnsis Schenck et Reinhart.



6. Anadara ferruginea (Reeve).

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PLATE VI

EXPLANATION OF PLATE VI

FIG. 1. — *Anadara* (*Scapharca*) *aquitanica* (Mayer).

Hypotype from lower Aquitanian, Moulin de Gamachot (Gironde), France. Deposited in Stanford Univ. Paleo. type coll., No. 5953. Hinge of right valve; length of entire valve 32.6 mm. (×2.9).

FIG. 2. — *Anadara* (*Scapharca*) *turonica* (Dujardin).

Hypotype from the Helvetian, Manthelan, near Tours (Indre-et-Loire), France, deposited in Schenck coll., No. 1935. Hinge of right valve; length of entire valve 42.3 mm. (×2.2).

FIG. 3. — *Anadara* (*Anadara*) *antiquata* (Linné).

Hypotype from West Indies, Recent; deposited in Stanford Univ. Paleo. type coll., No. 5318. Hinge of right valve; length of entire valve 60.3 mm. (×1.8).

FIG. 4. — *Anadara* (*Scapharca*?) *daneyi* (Cossmann and Peyrot).

Hypotype from lower Burdigalian, Merignac, Pontic, Aquitaine Basin, France; deposited in Stanford Univ. Paleo. type coll., No. 5958. Hinge of right valve; length of entire valve 20.5 mm. (×5.2).

FIG. 5. — *Anadara* (*Anadara*?) *speyeri* (Semper).

Hypotype from Chattian, Rosental, Rhineland, Germany; deposited in Stanford Univ. Paleo. type coll., No. 5957. Hinge of right valve; length of entire valve 33.5 mm (×3).

FIG. 6. — *Anadara* (*Anadara*) *diluvii* (Lamarck).

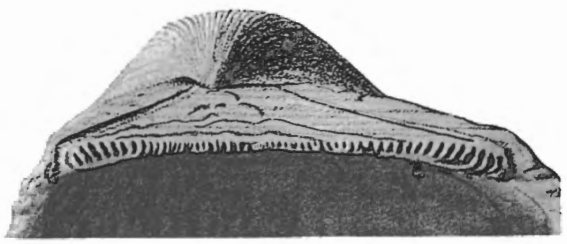
Hypotype from Tortonian, Enzesfeld, Austria; deposited in Stanford Univ. Paleo. type coll., No. 5954. Hinge of right valve; length of entire valve 31.3 mm. (×3.2).

FIG. 7. — *Anadara* (*Scapharca*) *fichteli* (Deshayes) var.

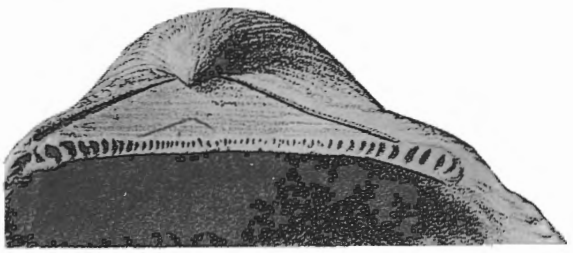
Hypotype from Tortonian, Ritzing, in Burgenland, Austria, deposited in Stanford Univ. Paleo. type coll., No. 5956. Hinge of right valve; length of entire valve 39.3 mm. (×2.7).

FIG. 8. — *Anadara* (*Anadara*) *osmonti* (Dall).

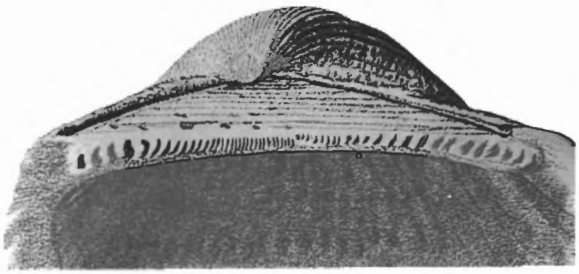
Hypotype from Temblor formation (« Miocene »), Barker's Ranch, Section 34, Township 28 South, Range 29 East, M. D. M., Kern County, California; deposited in Stanford Univ. Paleo. type coll., No. 5955. Hinge of right valve; length of entire valve 44.8 mm. (×2.3).



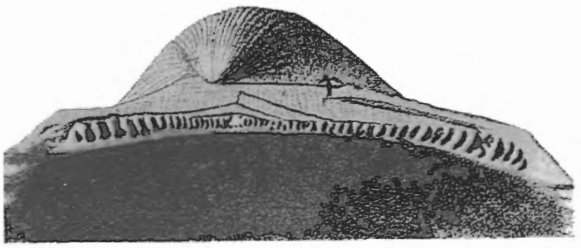
1. Anadara (Scapharca) aquitanica (Mayer).



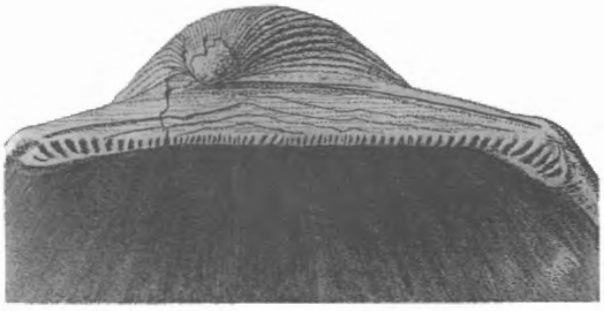
2. Anadara (Scapharca) turonica (Dujardin).



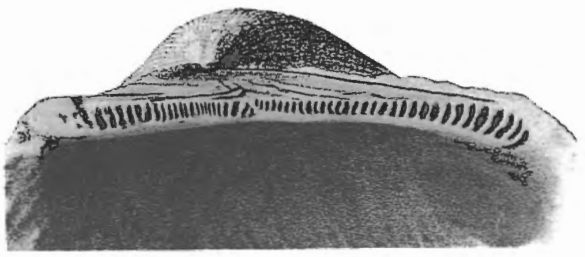
3. Anadara (Anadara) antiquata (Linné).



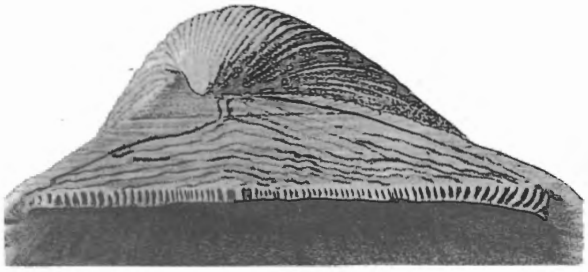
4. Anadara (Scapharca?) daneyi (Cossm. et Peyr.).



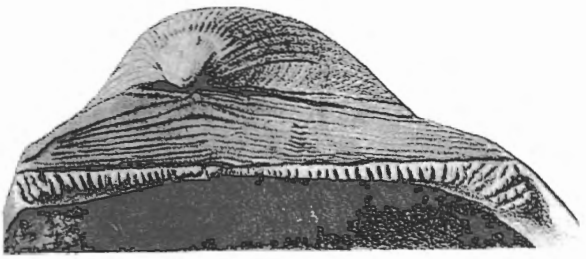
5. Anadara (Anadara?) speyeri (Semper).



6. Anadara (Anadara) diluvii (Lamarck).



7. Anadara (Scapharca) fichteli (Deshayes).



8. Anadara (Anadara) osmonti (Dall).

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