

STUDIES ON TERTIARY AND RECENT GIANT LIMIDAE

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ABSTRACT

A new species, *Lima* (*Acesta*) *bullisi*, is described from 300 and 600 fathoms off Mobile Bay, Alabama. This represents the first reported occurrence of the subgenus *Acesta* in the western Atlantic and contiguous basins. A catalogue of the described Tertiary and Recent species of *Acesta* lists 13 known Recent species [*L. (A.) butonensis* Bartsch is considered to be a synonym of *celebensis* Bartsch], and 31 species and varieties from the Tertiary deposits of North America, Asia, New Zealand, and Europe. A new subgenus, *Plicacesta*, is proposed for the plicately ribbed *Lima smithi* Sowerby of Japan, and three Asiatic Tertiary species are also referred to it.

I. A NEW SPECIES OF *ACESTA* FROM THE GULF OF MEXICO

Mr. Harvey R. Bullis, Jr., director of the Pascagoula, Mississippi, Station of the United States Fish and Wildlife Service, recently called to my attention two, unfortunately broken, right valves of a species of *Lima* (*Acesta*). These had been obtained in a trawl made by the Fisheries M/V *Oregon* on September 24, 1955, in the Gulf of Mexico at *Oregon* station 1426, 29°17' north latitude, 87°54' west longitude, or approximately 70 miles south-southeast of the entrance to Mobile Bay, Alabama. The depth at this station was 600 fathoms, the bottom of mud.

On learning that representatives of this subgeneric group had not been reported from the western Atlantic or contiguous waters, Mr. Bullis kindly granted permission to study and describe the specimens, and thus to record the occurrence of the subgenus *Acesta* in the fauna of the Gulf of Mexico.

Family LIMIDAE

Genus LIMA Bruguière, 1797

Lima BRUGUIÈRE, 1797, Tabl. Encycl. Méth., Vers Coq., 2, p. 206.

Lima CUVIER, 1798, Tabl. Elem., p. 421.

Lima LAMARCK, 1799, Mem. Soc. d'Hist. Nat. de Paris, 1, p. 88.

Mantellum ROEDING, 1798, Mus. Bolt., p. 160.

Limaria LINK, 1807, Besch. Naturall.-Samml., Univ. Rostock, p. 157.

Radula MÖRCH, 1853, Cat. Conch. Yoldi, 2, p. 57.

Type species, by subsequent tautonymy (Lamarck, 1801) *Ostrea lima* Linnaeus, 1758 = *Lima squamosa* Lamarck, 1801; Recent, apparently world-wide in warmer waters (see discussion, below).

In 1948 the International Commission on Zoological Nomenclature and the Section on Nomenclature of the Thirteenth International Congress of Zoology adopted an amendment to Article 25 of the International Rules providing that a generic name published prior to 1931 on a legend to a plate or plates, and without further explanatory matter, was to be treated as having been published with an "indication" for the purposes of Article 25. This made available the long-used but extra-legal names first used as plate legends in the volumes of the "Tableau Encyclopédique et Méthodique . . ." prepared by Bruguière and not formally diagnosed by him prior to his death in Italy while returning from an expedition to the Near East. The sense of this provision has been embodied in the new (1961) "International Code of Zoological Nomenclature" in Article 16,a,vii, which states that an "indication" includes "the publication of a new genus- or species-group name in connection with an illustration."

This provision validated the generic name *Lima* as used by Bruguière in 1797 as the heading to plate 206 with figures of six species assigned to the genus. The species shown in figure 4 has been identified as that which had been named *Ostrea lima* by Linnaeus (1758, p. 699). Iredale (1939, p. 385) and Dodge (1952, p. 187) state, therefore, that *Ostrea lima* is the type species of *Lima* Bruguière by absolute tautonymy. However, since Bruguière cited no species by name it is not possible to fix the type by reference to the original publication alone, for the identification of the figure concerned is based on the decision of subsequent au-

thors, rather than of the author of the work in question.

Cuvier used *Lima* as a generic name in 1798, with *Lima alba* Cuvier as the sole species, but with *Ostrea lima* Linnaeus in its synonymy. There was, however, no reference to the work of Bruguière; hence, although *Lima* Cuvier is an absolute synonym of *Lima* Bruguière, its proposal cannot be held to have established the type of the Bruguière genus. Similarly, Lamarck in 1799 proposed *Lima* as a generic name, citing *Ostrea lima* as sole example, and hence type by monotypy. But here again there was no reference to earlier usages of the name in a generic sense. In 1801, Lamarck (p. 136) described the species *Lima squamosa*, and cited as illustrations of that form, Bruguière's figure 4 and the same figure in d'Argenville that had been given by Linnaeus as illustrative of his *Ostrea lima*. This combination of references served both to identify the Bruguière figure and to validate the tautonomy involved thus fixing *O. lima* Linnaeus as type of *Lima* Bruguière. Subsequently, according to Stewart (1930, 124), Latreille in 1804 designated *Ostrea lima* as type of *Lima* Bruguière.

While the original description of the species *Ostrea lima* and the cited d'Argenville figure leave little doubt as to the group of species to be included within the genus *Lima* s.s., there is a considerable degree of uncertainty as to the exact form encompassed within the specific name *Lima lima*. This uncertainty likewise results in confusion as to the geographic distribution of the typical species. Linnaeus gave the "habitat" of his species as "In O. Meridionali" a statement which is, as noted by Dodge (1952, 186), "almost completely uninformative." The confusion is, indeed, almost as old as the species itself. Chemnitz (1784, 349) lists *Ostrea lima* in the synonymy of his monomial "Radula" giving the locality as Tranquebar and the Red Sea; but Lamarck (1801, 136) located his *Lima squamosa* as from American waters. Among more recent authors, some, including Woodring (1925, 79), Grant and Gale (1931, 239), and Prashad (1932, 121) give *Lima lima* an Indo-Pacific distribution; others, including Bucquoy, Dautzenberg and Dollfus (1887, 51), Woodring (1938, 48, fig. 58a), and Iredale (1939, 384) cite it as exclusively from the Mediterranean Sea and the western Atlantic Ocean. Lamy

(1930, 101) and Abbott (1954, 170) indicate that the species is of world-wide distribution—in tropical waters according to Abbott—but with a wider range from Japan and the Mediterranean Sea on the north to the southern coasts of Australia on the south, according to Lamy. The latter, however, recognizes a number of "forme" of the species within this range.

The form, or forms, included by the various authors within this group, are all moderately large solid shells with, on the main body of the shell, about 18 to 20 strong radiating ribs covered by large, elevated scales. The submargins are marked by numerous much weaker radial riblets.

Subgenus ACESTA H. and A. Adams, 1858

Acesta H. & A. ADAMS, 1858, Genera Recent Mollusca, 2, p. 558.

Callolima BARTSCH, 1913, U. S. Natl. Mus., Proc., 45, p. 235.

Type species, by monotypy, *Lima "excavata* (Chemnitz)" = *Ostrea excavata* Fabricius; Recent, 150 to 1,450 fathoms, coast of Norway to the Azores Islands (Thiele, 1918); Greenland to Canary Islands and "à l'ouest du Soudan" (Lamy, 1930).

H. and A. Adams when erecting the subgenus *Acesta* referred to it only the species "excavata Chem." This species was variously given in Chemnitz (1784, bd. 7): as *Concha excavata* on page 267, and as *Excavata Fabricii* and *Ostrea excavata* on page 355. It was figured on plate 68, figure 654, "an den norwegischen Stranden", and is the species earlier described from the same area by J. C. Fabricius (1779, 368) as *Ostrea excavata*.

The animals referred to this subgenus have relatively large but comparatively thin shells with a cardinal area that is narrower than that of *Lima (Lima)* and is situated mainly posterior to the umbones. The anterior auricle is greatly reduced through the encroachment of the excavate lunule. The posterior position of the cardinal area results in the development of a markedly oblique ligamental pit. The ornamentation of weak, rather irregular radial ribs is more strongly developed on the anterior and posterior portions of the valves, but is fine to almost obsolete on the medial portions of the surfaces where it has an aspect suggestive of shallowly impressed, irregular grooves, rather than of true ribs.

The weak ornamentation and the strongly oblique ligamental pit serve at once to distinguish *Acesta* from *Lima* s.s.

LIMA (ACESTA) BULLISI H. E. Vokes,
new species

Plates 1, 2

The two right valves that constitute the available representatives of this species are, unfortunately, both broken. The more complete specimen has been selected as the holotype. It is broken ventrally and the surface is considerably eroded. When received it had numerous worm tube and bryozoan incrustations, and obviously had lain as a dead shell upon the bottom for a considerable period of time. The second specimen, the paratype, is broken both antero-ventrally and ventrally so that little more than one-half of the original valve remains. It is, however, much fresher than the holotype, with a relatively glossy, yellow surface to the valves and only a minimal degree of incrustation by worm tubes. The broken surfaces are relatively fresh and it is possible that the damage occurred in the trawl.

Surprisingly, as restored by growth lines, etc., both specimens are almost identical in size, and hence may be considered as indicating the normal adult size of the species. As restored the species has a height of approximately 111 millimeters, and a width of approximately 92 millimeters. The holotype has an incomplete height of 94 mm, a width, incomplete, of 89 mm, and a semi-diameter of 23.5 mm; the paratype is 105 mm high (incomplete), and has a semi-diameter of 28.3 mm. The width of 70 mm is too incomplete to be of significance. Despite the relatively large size of the specimens, the shell material is exceedingly thin, being but 0.8 mm thick on the median portion of the paratype, and 0.5 mm on the broken ventral median part of the holotype. The latter may have been thinned, however, by erosion or partial solution while lying on the sea floor.

As compared to other described species of *Acesta* the present form is of but moderate size, and is somewhat more ovate and equilateral in outline, but, due to the reduction of the anterior auricle, much more inequilateral than species referred to other subgenera of *Lima*. The umbones are low, eroded, and situated near the anterior end of the relatively short and straight hinge line. The strongly curved ligamental pit varies in size, its greatest width being approximately one-third the total length of the hinge line of the paratype, and but slightly more than one-quarter that length in the holotype; in both specimens the hinge line is 32 mm. long. An elongate and excavate lunular area lies below the beaks, its surface finely radiately sculptured and delimited from the rest of the valve area by the strongest radial riblet present on the entire surface of the shell. The antero-

dorsal slope of the valve is oblique, straight to slightly concave, proportionately short; the anterior, ventral and posterior margins are broadly and regularly rounded, the posterior straightening to the short, straight dorsal margin. The junction of the posterior and dorsal margins is moderately to strongly angulate. Exterior sculpture is that characteristic of the subgenus, with numerous radial ribs, very fine along the medial portion of the valve surface, nearly obsolete on the umbo, but becoming coarser toward the margins, especially anteriorly and posteriorly. The first three or four ribs posterior to the lunule are the strongest on the entire valve, other areas with 8 or 9 irregularly developed, rather wavy ribs per centimeter. The ribs increase in number mainly through bifurcation with the development of a median groove on the surface; but occasional increase by intercalation may be observed. On the holotype there is a tendency for the ribbing on the posterior and postero-ventral slope to have each eighth or ninth rib broader, but not higher than the others, and hence the stronger rib does not become a pronounced surface feature.

The interior of the valve is white, with the inner margins apparently smooth (although they may be slightly worn on both specimens.) The adductor impression is relatively small, situated rather high in the valve and at approximately the posterior third of the valve width.

Lima (Acesta) bullisi, new species, differs from *L. (A.) excavata* (Fabricius), the type of the subgenus, and the only other species of the group yet reported from within the Atlantic basin waters, in having a shell that is proportionately much broader in comparison with its height, and in the more equilateral and less deeply impressed lunule. The radial ornamentation, though finer, is more strongly developed and the ribs much more numerous.

Among the Pacific Ocean species from American waters, the new species differs from *L. (A.) mori* Hertlein (1952, 378-80, pl. 20, figs. 12, 13) from Mulberry Seamount off California, in its much sharper, less inflated umbone and proportionately more elongate, less rotund shell outline. *L. (A.) agassizii* Dall (1902, 16; 1908, 407, pl. 16, fig. 1) from the Gulf of Panama, has a proportionately higher shell with an almost straight anterior end, and, so far as can be judged from Dall's figure, has broader and apparently more strongly developed radial ribbing.

While the present manuscript was in the hands of the editor a complete, but unfortunately pathologic, specimen was received from Mr. Bullis. This had been trawled on

August 26, 1962, at Oregon Station 3741, depth 300-340 fathoms, at 29°10' North latitude and 88°01.5' West longitude, about 75 miles due south of the entrance to Mobile Bay. Information as to bottom temperature and bottom sediment type are not available.

The specimen, which was alive when taken, had suffered serious damage to the shell and mantle in the region of the lunule at a time when the animal was approximately half grown. This has resulted in a strong in-bending of the lunular area and the development of an open gape in this region (see plate 2, fig. 2). The shell material is thickened and rather rugose and the lunule projects into the main shell cavity in an abnormal manner (pl. 2, fig. 3). Because of this damage the incomplete original specimen is retained as holotype to typify the species despite its worn and broken condition, since it better illustrates the normal form of the shell than does the present distorted specimen.

The height of the shell is 96.8 mm, the width 92.6 mm, and the paired valves have a diameter of 51.5 mm. It is, therefore, slightly wider than the holotype but the height is approximately 18 mm less than the restored height indicated by the original specimens. This apparent difference seems to be due, in part at least, to the injury suffered by the shell, since the width is a little increased by a slight "pouting" of the anterior margin immediately adjacent to the damaged lunular area. Growth lines suggest that the relative height-width proportions were more nearly in accord with those of the holotype during stages of development prior to the injury.

The ornamentation of the valves agrees in all details with that exhibited by the original specimens except in the region immediately adjacent to the lunular area. Here the ornamentation of the younger stages of development is normal in all respects, but that formed after the injury shows radial ribbing that is somewhat stronger and more thread-like with unusually widened interspaces. The hinge area agrees with the previous specimens in all respects and, in addition shows a thin band of lamellar ligament occupying the cardinal margins on each side of the impressed ligamental pit; the latter appears to contain only fibrous ligament. The inner margins of the valve are smooth with the shell thinned to the degree that it is translucent at the immediate edge. The adductor scar is somewhat larger and very slightly impressed, in contrast to that on the uninjured specimens where it is not impressed and rather difficult to distinguish.

II. A CATALOGUE OF THE DESCRIBED RECENT AND TERTIARY SPECIES OF *ACESTA*

During the course of the investigations preparatory to the description of *Lima (Acesta) bullisi* a considerable amount of information was accumulated concerning previously described species of the subgenus, Recent and fossil. No catalogue of these forms has been published. Thiele (1918) discussed the then known Recent species, and Woodring (1938, 14) gave a table of the dredging records available to him. More recently Oyama (1943) discussed (in Japanese) and figured the known Tertiary and Recent species from eastern Asia. It was decided, therefore, to supplement the information available and to prepare a catalogue of the described Recent and Tertiary species referable to the subgenus *Acesta*. This is a result of a canvass of the literature and it is quite possible that some species, especially in the fossil record, have been overlooked; however, it is believed that the following list is essentially complete so far as the described species are concerned, but no attempt has been made to recover all distributional records for these forms and the information here given must be considered as being representative, but not definitive in this respect.

RECENT SPECIES

1. Atlantic Basin Area

LIMA (*ACESTA*) EXCAVATA (Fabricius)

Ostrea excavata FABRICIUS, 1779, Reise Norwegen, p. 386.

Lima excavata (Gmelin). LAMARCK, 1819, Anim. s. vert., 6, p. 158.

Radula (Acesta) excavata (Chemnitz). H. & A. ADAMS, 1858, Gen. Recent Mollusca, 2, p. 558.

Lima (Mantellum) excavata (Fabricius). JEFFREYS, 1879, Zool. Soc., London, Proc., p. 564.

Lima (Acesta) excavata (Chemnitz). PHILIPPI, 1900, Zeitsch. Deutsch. Geol. Gesellsch., 52, p. 630, pl. 24, fig. 5.

Lima (Acesta) excavata (Fabricius). THIELE, 1918, Syst. Conchylien-Cab., (N.F.), 7 (2a), Fam. Limidae, p. 19, pl. 1, fig. 4; pl. 3, fig. 13.

PLATE 1

Figs. 1-4. *Lima (Acesta) bullisi* H. E. Vokes, n. sp. (X1). Exterior and hinge views of the holotype, USNM 639045 (figs. 1, 2) and of the paratype USNM 639046 (figs. 3, 4). Figure 3 shows the outline of the valve as restored from the two specimens.

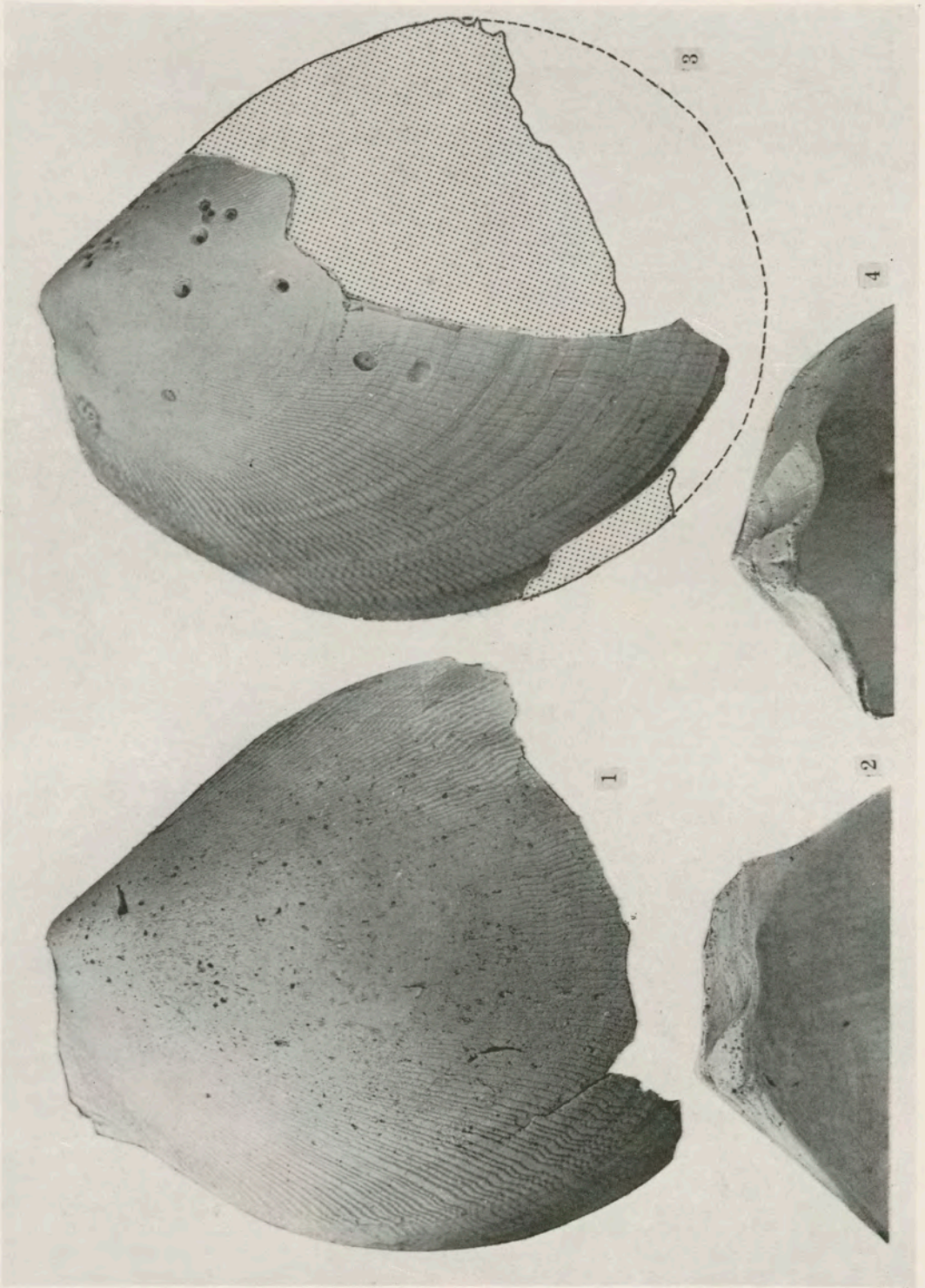


PLATE 1

Range: This species, the type of the subgenus, was described as "an den norwegischen Stranden" (see Chemnitz, 1784, 7, pl. 68, fig. 654), but subsequent authors have indicated a greater depth range. Lamy (1930, 188) states: "Cette espèce, presque littorale dans les mers du Nord (Norvège), a été signalée aux Açores et près de Ténérife à des profondeurs dépassant 2,000 metres." Later he adds, for the north, records from Iceland and Greenland, and at the south, "dragages de 'Talisman' (1883) à l'ouest du Soudan." Other northern records are given by MacAndrew (1857, 112) who states that it occurs from "North Drontheim to Finmark" in 50 to 150 fathoms. Dall (1902, 16) records it from "Norway (150-300 fms.)". Thiele (1918, 20) gives the range as from Norway to the Azores in 150 to 1450 fathoms.

Size: The largest specimen reported (Smith, 1899, 251) is 170 mm in height and 125 mm in width. Dall (1902, 16) lists a specimen "Alt. 100; Lat. 106; diam. 55 mm." while MacAndrew (1857, 112) reported "one specimen, living, 5½ by 4¼ in." [ca. 140 X 108 mm]. Bartsch's record (1913, 236): "Alt. 170, lat. 125, diam. 55 . . .", although credited to Dall, 1902, appears to be a combination of the measurements of Smith and Dall cited above.

Ecologic Information: MacAndrew (1857, 112) reports that this species "adheres by a small byssus" to stones on the sea bottom, and Jeffreys (1879, 564-5) states: "Herr Friele informs me . . . that *excavata* attaches itself by a strong byssus to rocks close to the shore." I have found no records suggesting this byssiferous attachment for other species of *Acesta*.

Little temperature information is available for stations from which this species has been taken. Available hydrographic data suggest possible temperatures of approximately 43.5° F. for 150 fathoms off Norway, and of approximately 37.5° F. for 1450 fathoms off the Azores. Shallower water temperatures in the northern seas would be lower than the 150 fathom figure, and the 43.5° temperature may be an upper limit for the species. It is apparent that *L. excavata* furnishes another example of those species whose depth distribution is a function of temperature control.

LIMA (ACESTA) BULLISI H. E. Vokes

Information concerning this species, now known from 300 to 600 fathoms, is given

above, in the introduction to the paper and the description of the species.

2. Eastern Pacific Ocean

LIMA (ACESTA) AGASSIZII Dall

Lima agassizii DALL, Nautilus, 16, (2), p. 16.

Lima (Acesta) agassizii DALL, 1908, Harvard Coll., Bull. Mus. Comp. Zool., 43 (6), p. 407, pl. 16, fig. 1.

Range: The single known right valve representing this species was dredged from 322 fathoms in the Gulf of Panama.

Size: "Alt. 97; lat. 78; diam. 30 mm." (Dall, 1902).

Ecologic Information: Bottom, green mud (Woodring, 1938, 14); bottom temperature 47° F. (Dall, 1908).

LIMA (ACESTA) MORI Hertlein

Lima (Acesta) mori HERTLEIN, 1952, Calif. Acad. Sci., Proc., (4) 27, 379, pl. 20, figs. 12, 13.

Range: The holotype right valve and a fragment of a left valve, presumably the opposite valve of the type, were dredged from the Mulberry Seamount, Lat. 37°26.5' N., Long. 123°28.7' W., off San Mateo County, California, in 690 to 800 fathoms. Other specimens have not been recorded.

Size: "Dimensions (ventral margin incomplete); height, 61.8 mm; length, 55 mm; convexity (one valve), 15.8 mm; length of hinge, 15.5 mm; length of anterior umbonal ridge, 23 mm." (Hertlein, 1952).

Ecologic information: The dredge indicated a bottom of rock and shells. No temperature data have been given for this Mulberry dredging, but "Albatross" stations in the general vicinity (dredging station 3104, 37°23' N., 123°08' W., depth 391 fathoms, bottom temperature 40.8° F., and hydrographic station 2163, 37°48.5' N., 123°30.3' W., depth 900 fathoms, bottom temperature 36.8° F.) suggest bottom temperatures of about 38° F. at the *Lima* locality.

LIMA (ACESTA) PATAGONICA Dall

Lima goliath Sowerby. SMITH, 1885, Voy. H.M.S. "Challenger", Zool., 13, p. 290 [part].

Lima patagonica DALL, 1902, Nautilus, 16, (2), p. 16 [non *L. patagonica* von Iher-

PLATE 2

Figs. 1-4. *Lima (Acesta) bullisi* H. E. Vokes, n. sp. (X1). Exterior and hinge views of the left valve of the pathologic hypotype, USNM 639047 (figs. 1, 3), and a dorsal view of the paired valves of the same specimen (fig. 2). Note the great distortion of the lunular area resulting from the injury during growth. Fig. 4 is a dorsal view of the holotype, USNM 639045, for comparison.

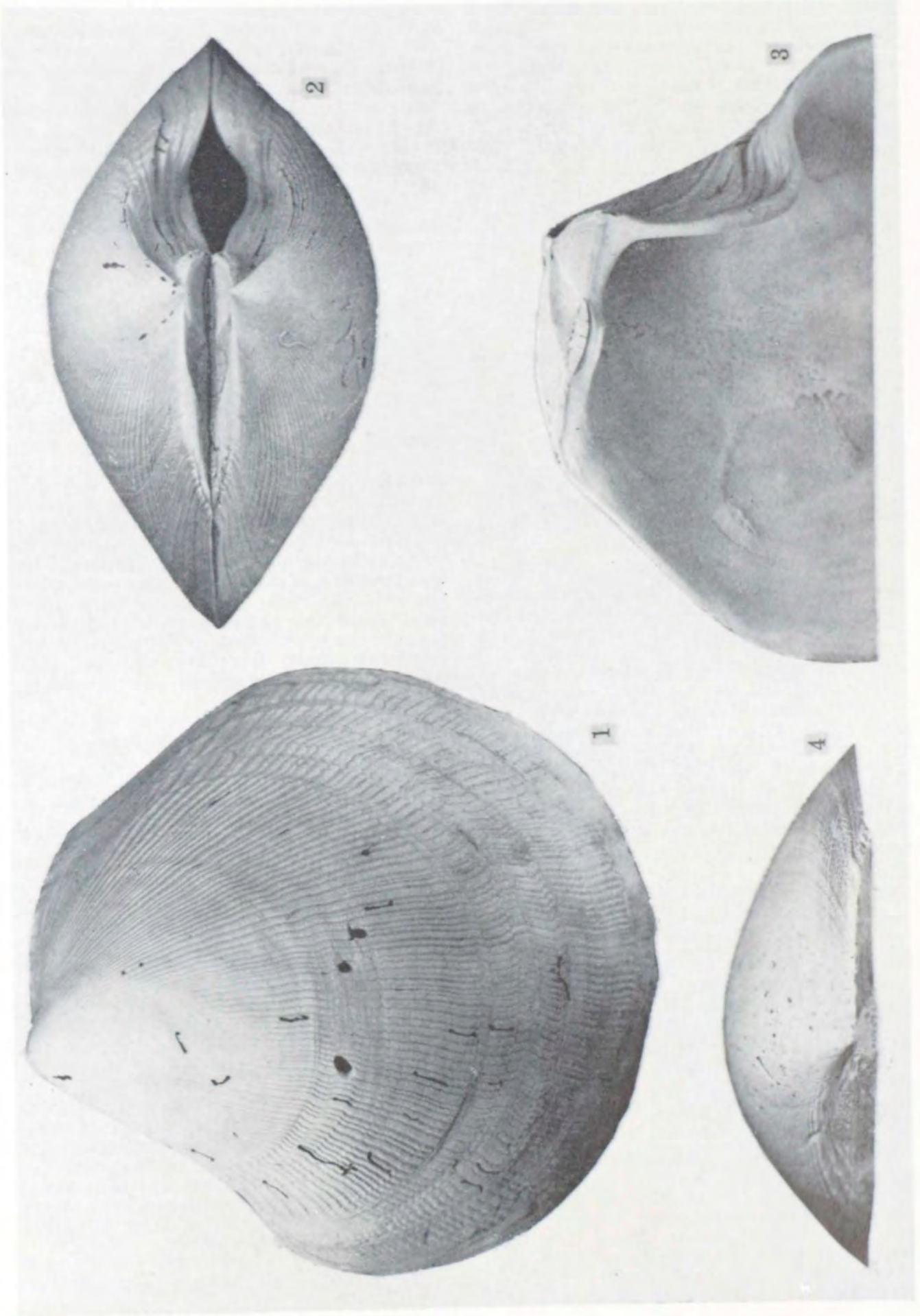


PLATE 2

ing, 1907, Anales Mus. Nac. de Buenos Aires, p. 262, pl. 9, fig. 60].

Lima (Acesta) patagonica DALL, 1908, Harvard Coll., Bull. Mus. Comp. Zool., **43**, (6), p. 407.

Range: Dall in his original description of this species recorded it as from the "West coast of Patagonia (245-481 fms.)". The 245 fathoms record is apparently from Smith's report of a specimen, determined as *Lima goliath* Sowerby, taken by the "Challenger" at that depth. Later, in 1908, Dall gave the species as from two "Albatross" localities at 348 and 449 fathoms, respectively, and Woodring, (1938, 14) records an additional specimen from 258 fathoms. I have not found the record upon which Dall based his report of 481 fathoms as the greatest depth.

Size: In the original description of this as yet unfigured species Dall gave dimensions as follows: "Alt. 100; Lat. 72; diam. 31 mm.". This constitutes the only published set of measurements for the species, although Smith (1885, 290) indicates that the "Challenger" specimen was somewhat less than two inches high.

Ecologic information: According to Woodring (1938, 14) the bottom sediment at all "Albatross" stations from which Dall's original specimens were secured was "blue mud", and Smith (1885, 24) indicates the same type of bottom at "Challenger" station 311 from which the specimen reported as "*goliath*" was obtained. Bottom temperatures at the stations from which this species has been obtained range from 46° F. ("Challenger", Stn. 311, 245 fms.) to 50° F. ("Albatross" Stn. 2781, 348 fms.); at "Albatross" Stn. 2785, 449 fms., the deepest confirmed record for the species, the temperature was 47° F.

3. Western Pacific Ocean

LIMA (ACESTA) BARTSCHI Thiele

Lima (Callolima) smithi BARTSCH, 1913, U. S. Natl. Mus., Proc., **45**, p. 236, pls. 12, 13. [non *Lima smithi* Sowerby, 1888]

Lima (Acesta) bartschi THIELE, 1918, Syst. Conchylien-Cab., (N.F.), **7**, (2a), Fam. Limidae, p. 20, pl. 5, fig. 1; pl. 8, fig. 7. [nom. nov.]

Lima hughii BARTSCH, 1923, Nautilus, **37**, p. 69-70. [nom. nov.]

Range: Bartsch in describing this species reported its occurrence at five dredging stations in the western part of the Philippine Archipelago from north of Mindanao northward to off southeastern Luzon. "It was dredged at depths varying from 281 to 508, or at an average of 401 fathoms." (Bartsch, 1913, 236.)

Size: "The type, which is the largest specimen, measures: alt. 175 mm, lat. 118

mm, diameter 48 mm." (Bartsch, 1913, 236.)

Ecologic information: The species occurs on finely sandy, green to gray mud bottoms. Temperature information for three of the five "Albatross" stations is as follows: off Malavatuau Isl. (13°48.5' N.; 120°28'40" E.—the most northern occurrence) 280 fathoms, temp. 46.8° F.; Jolo Sea, south of Cagayan Isl., in 505 fathoms, temp. 49.8° F.; off Balicasag Isl., in southern end of the Bohol Strait, (type locality) in 432 fathoms, temp. 53.3° F. The average temperature is thus about 50° F.

Notes: Oyama (1943, 49, 50) considers that *L. bartschi* is a synonym of *L. philippinensis* Bartsch. Judging from Bartsch's original illustrations, *L. bartschi* is proportionately wider and the postero-ventral margin more obliquely sloping than it is in *philippinensis*. This is more apparent from the illustrations than it is from the comparative dimensions of the two type specimens. Both are of approximately the same height. *Bartschi* is said to be 118 mm wide and this figure is confirmed by measurements of the illustration, but *philippinensis*, which is said to be 111 mm wide, measures on the illustrations only approximately 101 mm in width. This latter figure agrees better with the visual difference between the two specimens. Otherwise, the two forms are strikingly similar in details of ornamentation, hinge structure, etc., and it is possible that larger collections will confirm their identity.

LIMA (ACESTA) BORNEENSIS Bartsch

Lima (Callolima?) borneensis BARTSCH, 1913, U. S. Natl. Mus., Proc., **45**, p. 239, pl. 20, figs. 1, 2.

Lima (Acesta) borneensis Bartsch. THIELE, 1918, Conchylien-Cab., (N.F.) **7**, (2a), Fam. Limidae, p. 25, pl. 7, figs. 8, 9.

Range: The single immature valve upon which this species is based was dredged in 305 fathoms off Silungen Island off the west coast of Borneo.

Size: "The shell measures: alt. 39.2 mm, lat. 33 mm; diameter of the single valve 8 mm." (Bartsch, 1913, 239)

Ecologic information: "Green mud bottom; bottom temperature 43.2°." (Bartsch, 1913, 239)

Note: Though based upon an immature specimen, the wide dorsal area with an umbonal angle between the anterior dorsal and the dorsal margin of almost 140° is sufficient to distinguish it from all other presently described species.

LIMA (ACESTA) CELEBENSIS Bartsch

Lima weberi PELSENEER, 1911, Lamelli-branchiata, "Siboga" Exped., (Anat.), p. 33-35. [nomen nudum]

Lima (Acesta) celebensis BARTSCH, 1913, U. S. Natl. Mus., Proc., 45, p. 240, pl. 18 (2 figs.), pl. 19 (2 figs.); PRASHAD, 1932, Lamellibranchiata, "Siboga" Exped., (Systematic Part, 2), p. 127, pl. 4, figs. 1-6.

?, *Lima (Acesta) butonensis* BARTSCH, 1913, U. S. Natl. Mus., Proc., 45, p. 240, pl. 20, figs. 3, 4.

Range: All dredging records of *L. celebensis* are for areas between 5°29' and 7°36' South latitude in the Flores and Banda Seas of the East Indian Archipelago. Bartsch's type came from the Buton Strait, southeast of Celebes, on the north side of the Flores Sea (519 fathoms), while Prashad records it from north of Sumbawa and Lombok Islands in the southwestern part of that sea, as well as northwest of Great Kei Island near the eastern end of the Banda Sea. His depth records range from 487 meters (266 faths.), off Great Kei Isl., to 794 meters (434 faths.), north of Sumbawa Isl.

Size: The type specimen is badly broken and much worn. The height was 159 mm, but other dimensions cannot be determined. The largest specimen recorded by Prashad (1932, 127), from "Siboga" station 316, north of Lombok Isl., 294 fathoms, shows the following dimensions: height 156 mm; width 92 mm; diameter (paired valves) 52 mm.

Ecologic information: No temperature records are available for stations from which *Lima (Acesta) celebensis* has been identified. However, the record for Albatross station 5648, from which the type of *L. butonensis* was obtained in 559 fathoms, is given (U. S. Bur. of Fisheries Doc. 741, 1910) as 59.2° F. This is only a few miles away, and 40 fathoms deeper than the type station (Albatross 5647) for *L. celebensis*. Presumably the bottom temperatures at the two stations were not greatly different.

Bottom sediment at both Albatross stations was green mud. At the Siboga station north of Lombok, where the largest specimen in their collections was obtained, the bottom was of fine, dark brown sandy mud (Tydeman in Weber, 1902, App., 16); for the two stations north of Sumbawa, the bottom is reported to have been "fine sandy mud" and "fine grey mud, with some radiolariae and diatoms". At the easternmost station, off Great Kei Island, in the Banda Sea the bottom was "coral sand and dead coral" (Tydeman in Weber, 14).

Remarks: *Lima (Acesta) butonensis* Bartsch was described from a small broken right valve, 26.8 mm high, 22 mm wide and with a diameter of 5.5 mm. It clearly represents an immature individual and there is a most suggestive similarity between Bartsch's original figures and those given

by Prashad (1932, pl. 4, figs. 1, 2) of even more immature specimens of *L. celebensis*. In view of this similarity and of the fact that Bartsch's types of the two species are only a few miles apart in Buton Strait and of less than 40 fathoms difference in depth it seems almost certain that *butonensis* represents an immature specimen of *L. celebensis*.

According to Prashad, the forms referred to by Pelseener in his report on the anatomy of the Lamellibranchiata collected by the Siboga under the name *Lima weberi* represent this species. There was, fortunately, no specific anatomical description of *weberi* by Pelseener and his name is a *nomen nudum* and can be disregarded.

LIMA (ACESTA) GOLIATH G. B. SOWERBY,
Jun.

Lima goliath SOWERBY, 1883, Zool. Soc., London, Proc., 1883, p. 30, pl. 7, fig. 3; DALL, 1902, Nautilus, 16, (2), p. 16. (belongs to "Section *Acesta*").

Lima (Acesta) goliath SOWERBY, BARTSCH, 1913, U. S. Natl. Mus., Proc., 45, p. 236; THIELE, 1918, Syst. Conchylien-Cab., (N.F.), 7, (2a), Fam. Limidae, p. 22, pl. 4, figs. 4, 5; OYAMA, 1943, Conch. Asiatica, 1 (1), Fam. Limidae, p. 39, pl. 3, figs. 1a, b; pl. 14, fig. 8.

Range: Sowerby's description gave only "Japan" as the locality for this species. More recently Kuroda and Habe (1952, 22) indicate the range as between 35° and 40° N. lat. on the Pacific side of the Island of Honshu, and between 35° and 42° N. lat. on the Japan Sea. Included within these limits are the more or less north-south trending eastern side of Honshu from Sagami Bay northward, and most of the western side of that island plus the southernmost part of Hokkaido in the Japan Sea. With respect to depth distribution Yamamoto and Habe (1958, 17) state: "This is apparently a deep water species, . . . the bathymetric records of the collected shells, though not alive, ranging from 30 m to 1417 m." [=16 to 775 fathoms]. The latter depth is the Challenger record of a specimen from 34°58' N., and 139°29' E., in Sagami Bay. There is, however, some evidence suggesting temperature controls of the depth distribution of this species, as there is for *L. excavata* (see above). Nomura and Hatai (1936, 254) report that in the Tugaru Strait between Honshu and Hokkaido the species occurs between 90 and 123 meters [49 to 67 fthms.] while between Sado Island and the Oga Peninsula, approximately four and a half degrees of latitude to the south, the range was (1936, 260) 117 to 338 meters [64 to 185 fthms.]

Size: Sowerby recorded the dimensions of his type specimen as "Long. 150, lat. 110

mill." The largest Recent specimen that I have found reported in the literature is that figured by Hirase (Taki Ed., 1951, pl. 16, fig. 4) which is reported as being 176 mm high, 124 mm wide, and 53 mm in diameter.

Ecologic Information: The Challenger specimen was reported as having been dredged from a green mud bottom with the bottom temperature being 37.6° F.

LIMA (ACESTA) PHILIPPINENSIS Bartsch

Lima (*Callolima*) *philippinensis* BARTSCH, 1913, U. S. Natl. Mus., Proc., 45, p. 237, pls. 14, 15.

Lima (*Acesta*) *philippinensis* Bartsch. THIELE, 1918, Syst. Conchylien-Cab., (N.F.), 7 (2a), Fam. Limidae, p. 24, pl. 7, fig. 1; pl. 8, fig. 3.

Range: *Lima* (*Acesta*) *philippinensis* appears to have been based upon a single, rather well preserved left valve dredged at "Albatross" Stn. 5373, off the outer Tayabas Light on the south coast of Luzon between the Island of Marinduque and the Batangas Coast. The depth was 190 fathoms, according to Bartsch, who adds: "sounding not made but taken from chart". Woodring (1938, 14) notes that the label on the specimen reads 338 fathoms, and this same depth is given for the dredging station by the United States Bureau of Fisheries in their "Document 741" (1910).

Size: According to Bartsch the type measures: "alt. 177 mm, lat. 111 mm; diameter 37 mm", but, as noted above in the discussion of *Lima bartschi*, the width is more probably 101 mm.

Ecologic Information: The bottom sediment at the type locality was gray mud. Bottom temperature according to "Document 741" was 51.8° F.

LIMA (ACESTA) RATHBUNI Bartsch

Lima crocea PELSENEER, 1911, Lamelli-branchiata, "Siboga" Exped. (Anat.), pp. 33, 34 [*nomen nudum*].

Lima (*Callolima*) *rathbuni* BARTSCH, 1913, U. S. Natl. Mus., Proc., 45, p. 237, pls. 15, 16.

Lima (*Acesta*) *rathbuni* Bartsch. THIELE, 1918, Syst. Conchylien-Cab., (N.F.), 7 (2a), Fam. Limidae, p. 23, pl. 6, fig. 1, pl. 8, fig. 1; PRASHAD, 1932, Lamelli-branchiata, "Siboga" Exped., (Systematic Part 2), p. 127.

?, *Lima dalli* PLATT, 1949, Natl. Geographic Mag., 96, (1), color plate, p. 71, fig. 11.

Range: This appears to be the most widely distributed species of *Acesta* in the tropical western Pacific Ocean. Bartsch recorded it from a number of localities ranging from north of Jolo in the Sulu Archipelago (lat. 6°02'55" North), northward

to the southern coast of Luzon off Outer Tayabas Light, at 13°49' North. Prashad reports specimens dredged by the "Siboga" Expedition off the Kei Islands Group in the Banda Sea at 5°26' to 5°40' South latitude. Bartsch records the depth ranges in the Philippine area as being "from 161 to 226 fathoms, or an average of 194 fathoms", while Prashad records the species from 310 and 397 meters [169.5 and 217 fthms.] or within the depth range recorded for the Philippine specimens.

Size: Bartsch states that the largest specimen obtained by the "Albatross" measures: "alt. 208 mm, lat. 156 mm; diameter 59 mm." This is the largest Recent specimen of *Acesta* for which I have found any record. The type, from 186 fathoms off Jolo Light measures: "alt. 182 mm, lat. 135 mm; diameter 52 mm." The larger of the two specimens secured by the "Siboga" measured 156 mm in height, 119 mm in width, and had a diameter of 51 mm.

Ecologic Information: Four of the eight localities recorded by Bartsch for this species had a bottom sediment of green mud. The two localities reported by Prashad had, according to Tydeman in Weber (1902, App., 14), greenish gray mud and gray mud bottoms. Of the remaining four localities, one had fine coral sand, one was *Globigerina* ooze, a third was *Globigerina* and sand, and the fourth had shell and coral bottom. Bottom temperatures ranged from 52.4° F. to 54.3° F. for five stations in the Mindanao Sea between Mindanao and Bohol, and to 57.4° F. for 161 fathoms off Jolo Light in the Sulu Archipelago.

Remarks: According to Prashad the forms referred to by Pelseener under the specific name *Lima crocea* represent this species. Fortunately, Pelseener only listed *crocea* along with other forms as exhibiting certain anatomical characters and did not give any specific description by which the form could be distinguished. Hence his name is a *nomen nudum* and can be disregarded.

The beautiful pair of valves figured by Platt in the National Geographic Magazine under the name *Lima dalli* and said to come from the Philippines, appear to represent this species. I have been unable to find any description of an *Acesta*-type *Lima* bearing this specific name.

4. Indian Ocean Species

LIMA (ACESTA) INDICA Smith

Lima indica SMITH, 1899, Ann. & Mag. Nat. Hist., (7) 4, p. 251; ALCOCK, 1907, Illustr. Zool. "Investigator", Moll., pl. 13, figs. 4, 4a.

Range: This species was described from two possibly somewhat immature specimens

dredged from 430 fathoms off the Travancore coast, near the southwestern end of the Indian peninsula.

Size: The larger specimen had a length of 75 mm; a width of 61 mm, and was 34 mm in diameter. The smaller specimen was 51 mm in length; other dimensions are not given.

Ecologic Information: Bottom sediment at the type locality was gray mud; temperature data are not available.

LIMA (ACESTA) NIASENSIS Thiele

Lima (Acesta) niasensis THIELE, 1918, Syst. Conchylien-Cab., (N.F.), 7 (2a), Fam. Limidae, p. 23, pl. 3, fig. 3; pl. 4, fig. 12.

Range: This species was described from the "Nias-sud-Kanal". According to Thiele and Jaekel (1931, 166) the type was dredged in 370 fathoms off the south coast of the Island of Nias, southwest of Sumatra.

Size: The dimensions of the holotype are: height 137 mm; width 101 mm, diameter 47 mm.

Ecologic Information: Not given.

A survey of the available dredging records for the stations from which species of *Acesta* have been recovered indicate that the genus has a depth range from 16 fathoms (shallowest report for *goliath*) to 1450 fathoms (*excavata*); the average of all available record is 336.4 fathoms. The average bottom temperature for all stations from which data were available is 48.4° F. This figure is somewhat high due to the fact that *L. rathbuni* Bartsch, the largest species, appears also to be a warmer water species than the rest, the average for 6 stations for that species being 54.3° F.; without this species the average temperature for all other species is 45.7° F.

That the species of *Acesta* prefer a mud, or fine sand and mud, bottom is well evidenced by the fact that records of bottom sediment for 24 of the localities report "mud" either green, gray, or blue in color. "Green mud" is specified for 13 of these stations, while "gray mud" occurs six times and "blue mud" twice; 3 stations do not report a specific color. There is one record of a *Globigerina* bottom, presumably an ooze, and one of a *Globigerina* and sand. Four stations report sand, or "fine sand"; one "shell and coral"; one "rock, shell", and one record of "stones".

RECENT SPECIES INCORRECTLY REFERRED TO ACESTA

Woodring (1938, p. 14) has noted that the thick-shelled *Lima* "*(Acesta)*" *diomedae* Dall (1908, p. 407, pl. 7, fig. 2) off a rocky bottom in 385 fathoms near the Galapagos Islands, and *Lima* "*(Acesta)*" *verdensis* Bartsch (1913, p. 239, pl. 20, figs. 5, 6) from green mud and sand in 394 fathoms off Sombbrero Island in the Philippines, "apparently do not belong to this group of thin-shelled species." It may be that it will prove necessary to establish a new subgenus to accommodate them.

"*Acesta*" *iwaotakii* Habe (1961, pp. 419, 429, text figs. 3, 4) lacks the oblique ligamental pit of *Acesta*, and is sculptured by divaricate radial ribbing unlike that characteristic of the subgenus. It was compared by Habe with *Lima albimacoma* Dall from the Caribbean Sea, a species that is generally referred to *Ctenoides* Mörch, 1853.

TERTIARY SPECIES

As would be expected the deepwater habitat of species of *Acesta* makes them of relatively rare occurrence in the Tertiary fossil record, and the known fossil species all are from tectonically active areas where deeper water deposits have been elevated by faulting. One species is known from the Caribbean region; eleven from the circum-Pacific area including western North America, Japan, the Celebes, and New Zealand; and fourteen species and varieties have been named from the northern portion of the Tertiary Tethyan sea along the Alpine-Carpathian fore-deeps.

1. Caribbean Region

LIMA (ACESTA) GOAJIRA Olsson and Richards

Lima (Acesta) goajira OLSSON and RICHARDS, 1961, Acad. Nat. Sci., Philad., Notulae Nat., no. 350, p. 6, pl. 1, fig. 1.

The type of this species was obtained from limestones of probable upper Oligocene age ten kilometers SSE of Guatchari on the Goajira Peninsula of northeastern Colombia. A second specimen, apparently referable to this species, is in the collections of Dr. Olsson from a locality in Costa Rica. Both are characterized by smooth surface of the valve with fine radial riblets present only near the extreme dorsal margin.

2. Western North America

LIMA (ACESTA) OREGONENSIS Clark

Lima (Plagiostoma) oregonensis CLARK, 1925, California Univ., Dept. Geol. Sci., Bull., 15 (4), p. 84, pl. 14, figs. 3, 4.

Lima oregonensis Clark. WEAVER, 1943, Washington Univ. [Seattle] Publ. Geol., 5, p. 99, pl. 22, figs. 2, 6.

Lima (Acesta) oregonensis Clark. MOORE and VOKES, 1953, U. S. Geol. Survey, Prof. Paper 223-E, pp. 115, 118.

This species appears to be diagnostic of the upper member of the Keasey Formation in northwestern Oregon (see Moore and Vokes, 1953). The strata referred to this member are believed by the present writer to be of lower Oligocene age. Weaver (1943, p. 99) reports that *Lima oregonensis* also occurs "in the Keasey formation near Holcomb in southwestern Washington and in lower Oligocene strata on the south side of Bremerton Inlet." These latter specimens are said to be proportionately higher than those from the type locality.

The type specimens were relatively immature individuals, Clark citing the holotype as: "Length about 63 mm; height about 66 mm." Larger specimens collected by the writer are now in the United States National Museum. The largest, an incomplete cast, has a height of 107 mm, a width of 98 mm, and a diameter (left valve only) of approximately 24 mm; the total height probably did not exceed 115 mm. As suggested by the above dimensions this species has an almost orbicular outline with the height and width closely approximate. In addition to the coarser radial ornamentation near the anterior and posterior margins there are fine incised radial lines present on the mid-area of the valve in the umbonal region; these are absent over the smooth, polished surface ventral to the umbones.

LIMA (ACESTA) ROBERTSAE Durham

Lima robertsae DURHAM, 1944, California Univ., Dept. Geol. Sci., Bull., 27 (5), p. 139, pl. 13, fig. 10.

Described from the "*Echinophoria rex* zone" of the upper Oligocene, Blakeley Formation of Kitsap County, Washington, *Lima robertsae* is distinguished by the possession of "about nine well-defined rounded radial ribs with slightly narrower interspaces, situated on the anterior third of the shell." A few indistinct ribs "may occasionally be seen" on the posterior part of the valves; otherwise the shell is smooth.

LIMA (ACESTA) TWINENSIS Durham

Lima twinensis DURHAM, 1944, California Univ., Dept. Geol. Sci., Bull., 27 (5), p. 139, pl. 13, fig. 11.

Lima twinensis was described from the "*Echinophoria apta* zone", uppermost Oligocene or lower Miocene, of the Twin Rivers Formation in Clallam County, Washington. It is also reported by Durham as occurring in the "*E. rex* zone", upper Oligocene, in

the Blakeley Formation in Kitsap County, Washington. It is similar to *Lima oregonensis* Clark in shape and general proportions, but differs in details of ornamentation. Durham thought it more tumid than the Keasey species, but Oregon specimens of comparable size show the same degree of inflation as *twinensis*.

LIMA (ACESTA) HAMLINI Dall

Lima hamlini DALL, 1900, Nautilus, 14, pp. 15, 16; DALL, 1925, U. S. Natl. Mus., Proc., 66, art. 17, p. 18, pl. 29, fig. 6.

Lima (Acesta) hamlini Dall. WOODRING, 1938, U. S. Geol. Survey, Prof. Paper 190, p. 47, pl. 8, figs. 5, 7, 10, 11.

Woodring has given a full discussion of this species from the Pliocene, Repetto Formation of the Los Angeles Basin area in southern California. He also reports a single small crushed right valve from deposits of upper Miocene age. On the basis of available information he concludes (1938, p. 17) that "the fossils of deep-water facies suggest that during Repetto time the Los Angeles Basin sea had depths of 300 to 600 fathoms (roughly 2,000 to 4,000 feet)."

3. Western Pacific: Japan

LIMA (ACESTA) KUMASOANA Nagao

Lima amaxensis Yokoyama *kumasoana* NAGAO, 1928, Tohoku Imp. Univ., Sci. Repts., (2) Geol., 9 (3), p. 104, pl. 20, figs. 31, 31a, 32.

Lima (Acesta) kumasoana Nagao. OYAMA, 1943, Conch. Asiatica, 1 (1), Fam. Limidae, p. 43, pl. 3, fig. 2; pl. 5, fig. 3.

Judging from the published illustrations the valve surfaces in this species are rather completely covered by irregularly developed surficial radial ribbing similar to that exhibited by *L. (Acesta) celebensis* Bartsch (1913, p. 240, pls. 18, 19), and quite different from the plicated ribbing that marks *Lima (Plicacesta) amaxensis* Yokoyama (1911, p. 15, pl. 3, fig. 2).

The lectotype, selected by Hatai and Nisiyama (1952, p. 71), is from the Sakasegawa Formation, upper Eocene of Kyushu, Japan.

?, LIMA (ACESTA) NISHIYAMAI (Yokoyama)

Perna nishiyamai YOKOYAMA, 1911, Coll. Sci., Univ. Tokyo, Jour., 27, art. 20, p. 7, pl. 1, figs. 1a, 1b.

Lima eocenica NAGAO, 1928, Tohoku Imp. Univ., Sci. Repts., (2) Geol., 9 (3), p. 105, pl. 21, figs. 1-3. [non *Lima miocenica* var. *eocenica* Rovasenda, 1892]

Lima (Acesta) nishiyamai (Yokoyama). OYAMA, 1943, Conch. Asiatica, 1 (1), Fam. Limidae, p. 40, pl. 3, figs. 3, 4; pl. 4, fig. 1; pl. 14, fig. 9.

Perna ? *nishiyamai* Yokoyama. MAKIYAMA, 1957, Palaeont. Soc. Japan, Spec. Paper 3 (1), pl. 1, figs. 1a, 1b.

The systematic position of this upper Eocene species from the Island of Kyushu is uncertain. Hatai and Nisiyama (1952, pp. 72, 73, 124) accept, apparently without question, Oyama's assignment of *Perna nishiyamai* Yokoyama to *Lima* (*Acesta*), and also the synonymizing with it of Nagao's *Lima eocenica*. More recently however, Makiyama while refiguring the Yokoyama types makes reference to the assignment to *Lima* (*Acesta*), but without comment, and at the same time refers it to "*Perna* ?".

Published illustrations are inconclusive, although, if the dashed line restoration of the outline of the holotype given by Yokoyama, and reprinted both by Oyama and Makiyama, is correct, the straight posterior dorsal margin is much longer in proportion to the other dimensions of the valves than is characteristic of most species of *Acesta*, and at the same time is more like that found in "*Perna*" (= *Isognomon*).

It may also be observed that there is little other than upper Eocene age to suggest that the crushed and fragmentary specimens upon which Nagao based his *Lima eocenica* are conspecific with "*Perna*" *nishiyamai*.

LIMA (ACESTA) NAGAOI Oyama

Lima goliath Smith [Sowerby]. YOKOYAMA, 1927, Fac. Sci., Imp. Univ. Tokyo, Jour., (2) 2 (4), p. 188, pl. 50, fig. 1.

Lima sp.; cfr *goliath* Sm. [Sowerby]. NAGAO, 1928, Tohoku Imp. Univ., Sci. Repts., (2) Geol., 12 (1), p. 40, pl. 6, figs. 17-19.

Lima (*Acesta*) *nagaoi* OYAMA, 1951, Mineral. & Geol., 4 (1-2), p. 56.

Lima (*Acesta*) cf. *goliath* Sowerby. HATAI and NISIYAMA, 1952, Tohoku Univ. Sci. Repts., (2) Geol., Spec. vol. 3, p. 72.

Lima nagaoi, from the Oligocene deposits of Nagasaki Prefecture, Kyushu, was distinguished from the typical *L. goliath* by its greater width in proportion to its height. The holotype is the specimen figured by Yokoyama in 1927, (republished by Makiyama 1959, pl. 61, fig. 1 as "*Lima* (*Acesta*) aff. *goliath* Sowerby"). A comparison of this figure with the original illustration of *goliath* appears to justify the separation of *nagaoi*, but the ornamentation, etc., is so similar as to suggest that it may be ancestral to *goliath* which has been reported from the upper Miocene and the Pliocene as well as from the Recent in Japan.

LIMA (ACESTA) J-SUZUKII Takeda

Lima (*Acesta*) *j-suzukii* TAKEDA, 1953, Hokkaido Assoc. Coal Mining Technol., Studies in Coal Geol., 3, p. 75, pl. 13, figs. 1-4.

The holotype of this elongate-ovate species from the upper Oligocene Poronai Formation of the Island of Hokkaido is the largest Tertiary *Acesta* reported from the Japanese archipelago. Its dimensions are: height 180 mm, width 90 mm, diameter, paired valves, 43 mm.

LIMA (ACESTA) YAGENENSIS Otuka

Lima goliath Sowerby. YOKOYAMA, 1925, Fac. Sci., Imp. Univ. Tokyo, Jour., (2) 1 (3), p. 123, pl. 14, fig. 11; YOKOYAMA, 1925, Coll. Sci., Imp. Univ. Tokyo, Jour., 45 (5), p. 26, pl. 3, figs. 1, 4.

Lima (*Acesta*) *goliath yagenensis* OTUKA, 1939, Geol. Soc., Japan, Jour., 44, no. 544, p. 27.

Lima (*Acesta*) *yagenensis* Otuka. OYAMA, 1943, Conch. Asiatica, 1 (1), Fam. Limidae, p. 42, pl. 4, fig. 2; pl. 5, fig. 4.

The illustrations of Yokoyama, cited above, show that this species which has been reported from the upper Oligocene and the lower and middle Miocene of Honshu differs from the typical forms of *Lima goliath* in having a greater amount of antero-ventral obliquity in the shell together with an apparently more inflated, and hence more pronounced, umbonal area.

LIMA (ACESTA) OMORII Aoki

Lima (*Acesta*) *omorii* AOKI, 1956, Palaeont. Soc. Japan, Tran. & Proc., (N.S.), no. 22, art. 287, p. 189, pl. 29, figs. 1a, 1b, text fig. 2 (7).

Lima omorii, from the Miocene of Honshu, is strikingly orbicular in outline, is almost smooth except for weak radial ribbing near the lateral margins, and is rather more inflated than most species of the subgenus.

LIMA (ACESTA) GOLIATH Sowerby

As noted above (see *Lima nagaoi*, supra), *Lima goliath* the representative of the subgenus *Acesta* in the Recent faunas of the Japanese seas, has been reported from deposits as old as the Oligocene. The older occurrences are now referred to other species, but there are records of the true *goliath* from the upper Miocene and the Pliocene to substantiate its geologic antiquity.

4. Western Pacific: Celebes

LIMA (ACESTA) FULGURANS Martin

Lima fulgurans MARTIN, 1933, Leid. Geol. Med., 6, p. 14, pl. 1, fig. 1.

Lima (*Acesta*) *fulgurans* Martin. OYAMA, 1943, Conch. Asiatica, 1 (1), p. 51, text fig. 12.

Because of the absence of Recent species in the fauna, Martin assigned an Oligocene age to *Lima fulgurans* and associated forms

from the Sampolakosa beds as exposed in the asphalt quarries at Waisiu on the Island of Buton in the Celebes. More recently, Beets (in Van Bemmelen, 1949, p. 421) has concluded that the results of studies of the corals, diatoms, foraminifera, as well as of more complete molluscan collections, indicate that the fauna is "certainly younger Upper Miocene and possibly Lower Pliocene" in age and that Martin was misled by the unusual deep-water aspect of the fauna represented.

In size, shape, and so far as can be determined from the original illustration, in character and strength of the radial ornamentation, this species is strikingly similar to *L. (Acesta) celebensis* Bartsch (1913, p. 240, pls. 18, 19) the type of which had been dredged from nearby in the Buton Straits.

5. Western Pacific: New Zealand

LIMA (ACESTA) LEVITESTA Finlay

Lima laevigata HUTTON, 1873, Catal. Tert. Moll. New Zeal., p. 33. [non *Lima laevigata* McCoy, 1844]

Lima levitesta FINLAY, 1926, New Zeal. Inst., Trans., 57, p. 527 (new name pro *laevigata* Hutton).

Callolima levitesta (Finlay). MARWICK, 1943, Royal Soc. New Zeal., Trans., 73 (3), p. 182.

This relatively smooth-shelled species was described from the Milburn Limestone, middle Oligocene, of Otago, New Zealand.

LIMA (ACESTA) REGIA Suter

Lima (Plagiostoma) regia SUTER, 1917, New Zeal. Geol. Survey, Palaeont. Bull. 5, p. 70, pl. 9, fig. 1.

Callolima regia (Suter). MARWICK, 1943, Royal Soc. New Zeal., Trans., 73 (3), p. 182.

This gigantic species (holotype height 200 mm, width 175 mm, semidiameter 15 mm) appears to represent the largest known *Acesta*. The height of the holotype is exceeded by that of the largest specimen of the Recent *rathbuni* Bartsch (1913, p. 238) which is 208 mm high, but that form has a width of but 156 mm. Marwick reports a single valve from "Isis bed, Campbell's Beach, Allday Bay" that measures "190 mm X 155 mm X 45 mm" and suggests that the diameter of the type specimen has been affected by post-depositional compaction.

Suter gave a Miocene age for his type from Seal Rock near Brighton, New Zealand; Marwick (1943, p. 190) gives the age of the Isis bed as "Waitakian Stage, Upper Oligocene."

LIMA (ACESTA) IMITATA Suter

Lima imitata SUTER, 1917, New Zeal. Geol. Survey, Palaeont. Bull. 5, p. 70.

Lima (Acesta ?) imitata SUTER, 1917, New Zeal. Geol. Survey, Palaeont. Bull., 5, pl. 8, fig. 1.

Callolima imitata (Suter). MARWICK, 1943, Royal Soc. New Zeal., Trans., 73 (3), p. 182.

In describing his *Lima imitata* Suter noted that it bore "close resemblance" to *Callolima* and *Acesta* "neither of which, however, has been recorded in the fossil stage." He further compared his species with *L. (Acesta) celebensis* Bartsch and *L. ("Callolima") philippinensis* Bartsch, concluding that the shape of the valve and the sculpture suggested the reference of *imitata* to "one of these sections, more especially *Acesta*."

Suter gave a Miocene age for the species.

LIMA (ACESTA) sp. (Marwick)

Callolima sp. MARWICK, 1931, New Zeal. Geol. Survey, Palaeont. Bull. 13, p. 65, fig. 65.

A relatively small, possibly somewhat immature specimen of *Acesta* has been reported by Marwick (as *Callolima*) from the Ihungia Series of the upper Oligocene, Gisborne District, New Zealand.

6. Europe: Italy

LIMA (ACESTA) EOCENICA Rovasenda

Lima miocenica var. *eocenica* ROVASENDA, 1892, I fossili di Gassino, pp. 9, 10.

Lima (Acesta) eocenica (Rovasenda). SACCO, 1898, I Moll. terr. Terziarii Piemonte e Liguria, (25), p. 21, pl. 6, fig. 2.

Lima eocenica Rovasenda is an exceedingly orbicular species that was thought both by Sacco (1898, p. 21) and by Philippi (1900, p. 631) to be, together with the Miocene *L. (Acesta) postclypeiformis* Sacco, descendants of the Cenomanian, Cretaceous, *clypeiformis* d'Orbigny, a similarly orbicular species that appears to have a small anterior ear. These authors believed that the *clypeiformis* - *eocenica* - *postclypeiformis* series represented an evolutionary line distinct from that which produced the *miocenica* - *excavata* series, derived by Sacco from *Lima undata* Deshayes and *orbignyana* Matheron of the European Cretaceous.

Lima eocenica is reported as rare in the "Calcere de Gassino" in strata correlated with the Bartonian, upper Eocene.

LIMA (ACESTA) POSTCLYPEIFORMIS Sacco

Acesta postclypeiformis SACCO, 1898, I. Moll. terr. Terziarii Piemonte e Liguria, (25), p. 21, pl. 6, fig. 3.

Although this orbicular species from the Aquitanian of Italy is said to be "90 X 90 mm", the original figure suggests that the type is slightly higher than wide.

LIMA (ACESTA) MIOCENICA Sismonda

Lima gigantea BELLARDI, 1839, Soc. geol. France, Bull., **10**, p. 31. [non *Lima gigantea* Gray, 1825, Ann. Phil., **25**, 139]

Lima miocenica SISMONDA, 1842, Syn. meth. Anim. invert. coll. Com. st. Mart. della Motta, p. 22; MICHELOTTI, 1847, Naturk. Verh. Hollandische Maatsch. Wetens. Te Haarlem, **3** (2), p. 12.

Lima (Acesta) miocenica (Sismond.). SACCO, 1898, I Moll. terr. Terziarii Piemonte e Liguria, (25), p. 19, pl. 5, figs. 23-27.

Acesta miocenica ranges, in its typical form, according to Sacco, from the Tongrian to the Helvetian (Oligocene-middle Miocene) in Italy. The form from the Vienna Basin referred to this species by Hoernes (1867, p. 385, pl. 54, figs. 3a, b) has been distinguished as a variety by Sacco (see below). Other described "varieties" range from the upper Eocene to the Helvetian, Miocene.

LIMA (ACESTA) MIOCENICA Sismonda
EOGASSINENSIS Sacco

Lima miocenica Sismonda. ROVASENDA, 1892, I fossili di Gassino, p. 9.

Lima (Acesta) miocenica var. *eogassinensis* SACCO, 1898, I Moll. terr. Terziarii Piemonte e Liguria, (25), p. 20, pl. 5, fig. 29.

Described from marls associated with limestone at Gassino, Italy, and reported by Sacco as being "frequente". The strata are correlated with the Bartonian, upper Eocene.

LIMA (ACESTA) MIOCENICA Sismonda
STRICTA Sacco

Lima (Acesta) miocenica var. *stricta* SACCO, 1898, I Moll. terr. Terziarii Piemonte e Liguria, (25), p. 19, pl. 5, fig. 28 [non 22, as stated, p. 19]

An unusually narrow and elongate form of *miocenica*, which in turn is to be recognized by its elongate-ovate outline as contrasted with the orbicular form of *eocenica* and *postclypeiformis*. The variety *stricta* was described from the Helvetian, Miocene, strata at Rosignano Monferrato, Italy, where it was said to be of "poco frequente" occurrence.

LIMA (ACESTA) INOCERAMOIDES Sismonda
MS in Sacco

"*Lima (Acesta) inoceramoides* (Sismond.). (*Lima inoceramoides* Sismd. in litt.)" SACCO, 1898, I Moll. terr. Terziarii Piemonte e Liguria, (25), p. 20, pl. 6, fig. 1.

This Italian Oligocene species is somewhat more broadly ovate than the typical representatives of the *miocenica*-group. It is described as concentrically subsquamose, with radial ribbing only near the margins.

LIMA (ACESTA) CRASSICOSTA Seguenza

Lima crassicosta SEGUENZA, 1877, Soc. Malac. Ital., Bull., 1877.

Acesta crassicosta (Segu.). SACCO, 1898, I Moll. terr. Terziarii Piemonte e Liguria, (25), p. 21.

A Pliocene species characterized by somewhat stronger radial ornamentation than that of *excavata*, which was described by Seguenza as from "sedimenti pliocenici depositatisi a grandi profundita."

7. Europe: Vienna Basin

LIMA (ACESTA) MIOCENICA Sismonda
COLLIGENS Sacco

Lima miocenica Sismonda. HOERNES, 1867, Abhandl. d. K.-K. geol. Reichsanstalt, Wien, **4**, p. 385, pl. 54, figs. 3a, b.

Lima miocenica var. *colligens* SACCO, 1898, I Moll. terr. Terziarii Piemonte e Liguria, (25), p. 19.

Sacco distinguished this Miocene form from Ruditz, Austria, as a separate variety because the surface of the valve was completely striated and lacked the median smooth area of *miocenica miocenica*.

8. Europe: Hungary

A rather thick series of marls and clays of apparent rather deep-water deposition marks the upper Eocene and Oligocene deposits near Budapest, Hungary. *Acestas* appear to occur at different stratigraphic levels throughout the entire 300 to 500 meters of sediment present. Three species had been described from these beds prior to work of Nozsky (1939). The latter relegated two of these to positions as "varieties" of *miocenica*, while adding three additional "varieties". Unfortunately Nozsky's illustrations are too poor to permit certain conclusions as to the validity of these "varieties" but it seems probable that all of Nozsky's new forms might well be better considered as distinct from the typical Italian form of *miocenica*.

LIMA (ACESTA) HAERINGENSIS Dreger

Lima haeringensis DREGER, 1903, Jahrb. K.-K. geol. Reichsanstalt, Wien, **53**, p. 257, pl. 11, fig. 1.

Lima miocenica var. *haeringensis* Dreger. NOZSKY, 1939, Ann. Mus. nat. Hungarici, **32**, pars Min. Geol. et Palaeont., pp. 42, 113.

An almost smooth, elongated upper Eocene or lowermost Oligocene species.

LIMA (ACESTA) MITTERERI Dreger

Lima mittereri DREGER, 1903, Jahrb. K.-K. geol. Reichsanstalt, Wien, **53**, p. 258, pl. 9, figs. 6, 8.

A large, elongate-ovate species, somewhat more anteriorly oblique than *haeringensis*, and readily distinguished from it by the irregular radial ribbing that covers the surface of the valve. Apparently collected from the same geologic horizon as *haeringensis*.

LIMA (ACESTA) SZABOI Hofmann

Lima szaboi HOFMANN, 1873, Hung. geol. Anstalt, Mitt. a Jahrb., (2) 3, p. 199, pl. 14, fig. 3; GAÁL, 1918, Ann. Mus. nat. Hungarici, 16, p. 258, fig. 5.

Lima (Acesta) miocenica Sism. var. *szaboi* Hofm. NOZSKY, 1939, Ann. Mus. nat. Hungarici, 32, pars Min. Geol. et Palaeont., pp. 41, 112.

Described as lower Oligocene, but now thought to be of upper Eocene age, this form was considered as ancestral to *L. miocenica* by Gaál; a conclusion which was accepted by Nozsky, who at the same time, reduced it to the rank of a "variety" of *miocenica*.

LIMA (ACESTA) MIOCENICA Sismonda HANTKENI Nozsky

Lima (Acesta) miocenica Sism. var. *hantkeni* NOZSKY, 1939, Ann. Mus. nat. Hungarici, 32, pars Min. Geol. et Palaeont., pp. 41, 111, pl. 2, fig. 7.

The illustration of this Rupellian, Oligocene, species is apparently based upon a shaded drawing and it is not possible to judge whether or not the specimen has been in any way crushed or distorted in fossilization. If it has not been altered it represents the most anteriorly elongated form to be referred to *Acesta*, and is clearly to be separated from *miocenica*. If it be measured in conventional style, with the dorsal margin parallel to the dorsal margin of the posterior auricle, the height is approximately 103 mm and the width of the valve 118 mm. These figures contrast with those given by Sacco (1898, p. 19) for typical forms of *miocenica*: "Alt. 20-165 mm; Lat. 13-125 mm."

LIMA (ACESTA) MIOCENICA Sismonda MARGINATOSTRIATA Nozsky

Lima (Acesta) miocenica Sism. var. *marginatostriata* NOZSKY, 1939, Ann. Mus. nat. Hungarici, 32, pars Min. Geol. et Palaeont., pp. 43, 113, pl. 2, fig. 16.

A broadly orbicular Oligocene species, this "variety of *miocenica*" seems to the writer to be more probably related to the *eocenica-postclypeiformis* series of the Italian authors than it is to *miocenica*.

LIMA (ACESTA) MIOCENICA Sismonda HOFMANNI Nozsky

Lima (Acesta) miocenica Sism. var. *hofmanni* NOZSKY, 1939, Ann. Mus. nat. Hun-

garici, 32, pars Min. Geol. et Palaeont., pp. 43, 113, pl. 2, fig. 25.

Nozsky compared this "skulpturierter Steinkern" with *Lima (Acesta) postclypeiformis* Sacco and it resembles that species (as well as *inoceramoides* Sacco) in being ornamented by concentric undulations. The illustration suggests that the cast is badly broken and incomplete; but if a restoration be made on the basis of the trend of the undulations, it would seem that this form is even more broadly orbicular than *postclypeiformis*, and like the "variety" *marginatostriata* of Nozsky, would be more accurately referred to the *eocenica-postclypeiformis* sequence.

III. PLICACESTA, A NEW SUBGENUS OF LIMA

PLICACESTA H. E. Vokes, new subgenus

Type species, *Lima smithi* Sowerby 1888.

Typical forms of *Lima (Acesta)* are characterized by the possession of a posteriorly situated cardinal area with a markedly oblique ligamental pit, a very thin shell, and an ornamentation of weak, irregular radial ribs that are, essentially, inscribed on the surface of the valve by shallowly impressed grooves rather than by the more conventional type of interspaces. This radial ribbing is stronger toward the valve margins than on the central portion of its surface. The Recent species *Lima smithi* Sowerby, and certain fossil species in the Japanese Tertiary faunas, while possessing a cardinal area with a ligamental pit similar to that of *Acesta*, differ in the strong radial ribbing that plicates the relatively thin shell, rather than being exclusively a surficial feature, and is almost as strongly evident on the interior of the valve as it is on the exterior. Characteristically, also, the radial ornament is more strongly developed on the median portion of the valve than it is near the lateral margins.

LIMA (PLICACESTA) SMITHI Sowerby

Lima smithi SOWERBY, 1888, Zool. Soc. London, Proc. for 1888, p. 207, pl. 11, fig. 12.

Lima (Acesta) smithi Sowerby. THIELE, 1918, Conchylien-Cab., (N.F.) 7 (2a), Fam. Limidae, p. 21, pl. 4, figs. 1, 2; OYAMA, 1943, Conch. Asiatica, 1 (1), Fam. Limidae, p. 45, pl. 4, figs. 3a, b; pl. 14, fig. 11.

Acesta smithi (Sowerby), HABE, 1958, Seto. Mar. Biol. Lab., Publ. 6 (3), p. 270.

Lima smithi was originally described by Sowerby as "Resembling in form *L. excavata*, but very decidedly ribbed. The auricles, cardinal area, and anterior lunule are much the same as in . . . *L. goliath*, but that species is smooth, excepting at the side, and not so inflated."

Habe reports the species in the collections of the "Sôyô-maru" at depths ranging from 115 to 669 meters, and indicates the geographic range as "Honshu (south to Suruga Bay and Wakasa Bay)". Suruga Bay is located at 35° N. lat. on the eastern side of Honshu, and Wakasa Bay near 36° on the Japan Sea. *Lima smithi* has not been reported as a fossil so far as I have been able to determine from the literature.

LIMA (PLICACESTA) AMAXENSIS Yokoyama

Lima amaxensis YOKOYAMA, 1911, Coll. Sci., Univ. Tokyo, Jour., 27, art. 20, p. 15, pl. 3, fig. 2; NAGAO, 1928, Tohoku Imp. Univ., Sci. Repts., (2) Geol., 9 (3), p. 104, pl. 20, fig. 35.

Lima (Acesta) amaxensis Yokoyama. OYAMA, 1943, Conch. Asiatica, 1 (1), Fam. Limidae, p. 43, pl. 5, fig. 1.

Lima amaxensis is very like *Lima smithi* in the pattern of its ornamentation, but differs in being wider in proportion to the height of the valve, and hence has a more orbicular appearance. It was described from the Itchôda (or Icchôda) Formation of the upper Eocene at the Miike coal field, Kumamoto Prefecture, Kyushu, Japan.

LIMA (PLICACESTA) SAMESHIMAI Oyama and Mizuno

Lima (Acesta) sameshimai OYAMA and MIZUNO, 1958, Geol. Survey Japan, Bull., 9 (9), p. 10, pl. 1, figs. 11, 12.

This species from the "Lower ?" Oligocene of central Honshu, Japan, has a relatively narrow and high shell that is somewhat more produced anteriorly than is *L. smithi*, and is particularly marked by the fact that the rounded radial ribs are separated by broad round-bottomed interspaces that are as wide as the ribs. Judging from the illustrations the ribbing tends to become almost obsolete toward the valve margins.

LIMA (PLICACESTA?) PROTOSQUAMOSA Noetling

Lima protosquamosa NOETLING, 1901, Palaeont. Indica (n.s.), 1 (3), p. 114, pl. 3, figs. 10, 10a.

Lima (Acesta) protosquamosa Noetling. OYAMA, 1943, Conch. Asiatica, 1 (1), Fam. Limidae, p. 44, pl. 5, fig. 5; pl. 14, fig. 10.

This small species from Singu, Burma, has been referred by Oyama to *Lima (Acesta)*. The illustrations are not clear as to the nature of the ligamental area, and are equivocal as to whether the species is better referred to *Lima (Lima)* or to *L. (Plicacesta)*; it clearly is not an *Acesta*.

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