American Museum
Novitates

PUBLISHED BY THE AMERICAN MUSEUM OF NATURAL HISTORY
CENTRAL PARK WEST AT 79TH STREET, NEW YORK 24, N.Y.

NUMBER 2084 MAY 24, 1962

Results of the Puritan-American Museum of Natural History Expedition to Western Mexico 15. The Littoral Balanomorph Cirripedia

By Arnold Ross[1]

INTRODUCTION

In the spring of 1957 the American Museum of Natural History undertook an expedition to western Mexico (Emerson, 1958). One of the major objectives of this expedition was the study and comparison of the past and present distribution of littoral marine invertebrate faunas. The scientific staff of the schooner "Puritan," during the course of its three-month voyage, made incidental collections of both fossil and Recent sessile barnacles. During a later "Puritan" cruise in 1959, additional collections of barnacles were made. The present paper describes the littoral balanomorph Cirripedia collected by the "Puritan" staff during these two expeditions. An attempt is also made herein to compare and to discuss both the Recent and fossil distribution, as well as the ecology, of the Balanomorpha that were collected.

The demonstrable existence of Tertiary marine connections between the tropical eastern Pacific and Caribbean-western Atlantic faunas is of

[1] Research Assistant, Department of Living Invertebrates, the American Museum of Natural History. Present address: United States Army Chemical Corps Biological Laboratories, Fort Detrick, Maryland.

considerable importance to this study, primarily because these marine continuities are strongly suggested by the Recent intertidal and near-shore cirriped fauna. Earlier investigators of cirriped zoogeography (Pilsbry, 1916; Broch, 1922) have relied on hypothetical isthmian seaways to explain the perplexing modern distribution of these invertebrates, but they have done so without the benefit of our present knowledge of the fossil record. In order to approach this problem of a somewhat ambiguous Recent distribution, it is necessary to document fully the Central American fossil and Recent barnacle faunas. In this respect it is felt that the present paper goes farther than the reports of previous investigators.

Paleontological information from Baja California and the west Mexican mainland is still scanty, so assumptions and deductions regarding the modern fauna must, at present, be based primarily on zoogeographic studies of modern species. In addition, one must consider the relationships existing between them and the same, or closely related, species living in other parts of the eastern Pacific, or of the world. Any generalizations made at this time remain provisional. A much finer interpretation of the faunistic relationships could be advanced with greater assurance and certainty if more paleontological data were available.

The "Puritan" collections of thoracic barnacles contain 17 species. All the "Puritan" specimens, including those that are figured in this paper, have been deposited in the American Museum of Natural History. Pliocene and Pleistocene collections contain six species, four of which are also represented by Recent specimens. The Recent specimens were preserved dry, and, as a result, all identifications are based wholly on shell and opercular morphology.

The format followed in this paper for each of the species treated is as follows: (1) the original citation and the eastern Pacific synonymy only; (2) a short summation of the diagnostic morphological features; (3) remarks relevant to ecology and systematics; (4) western Mexico collection data; and (5) a summary of the known Cenozoic distribution. Additional information pertaining to each marine collection locality and a general account of the 1957 expedition have been given by Emerson (1958). Hertlein and Emerson (1959), Squires (1959), and Emerson and Hertlein (1960) cite information pertaining to the fossil localities where collections were made during the 1957 and 1959 "Puritan" expeditions.

Previous Work

The Cirripedia of western Mexico are as yet relatively poorly known. Descriptive and ecological studies on the barnacle fauna from the north-

temperate eastern Pacific region are, for the most part, applicable to the littoral fauna of western Mexico. Although literature records are scanty as regards the fossil and Recent fauna south of Mazatlán, there is a large amount of distributional and systematic information concerning the fauna within the Gulf of California and on the peninsular west coast.

The earliest known reference to the barnacles of western Mexico is by Reeve (1843). In his monograph of the genus *Pollicipes* (= *Mitella*), Reeve described and illustrated several specimens of *P. elegans* Lesson (= *Mitella elegans*) collected by H. M. S. "Sulphur" on an exposed off-shore rock in the Gulf of Tehuantepec, Mexico.

Modern investigations of the Gulf and peninsular west coast fauna began with the study by Pilsbry (1916). Pilsbry's work was, in large part, limited to systematics and geographical and geological distribution. It was to a great extent a systematic report of the barnacles contained in the collections of the United States National Museum, including a monographic study of the American species.

Prior to the publication of Pilsbry's work, only three systematic studies contain references to the Cirripedia of this region. The first is that of Reeve, mentioned above. The second study is that of Darwin, appearing in 1851 and 1854. Although there is some question as to whether or not Darwin actually described any new species or "varieties" from this region, he did cite several species from west Mexican localities. No further references were made to the fauna for 51 years, until 1905, when Gruvel recorded two goose barnacles from Baja California, one of which was described as a new variety, *Lepas hilli* var. *californiensis*. However, during this time cirriped collections were made by several expeditions (see Pilsbry, 1907a, 1916; MacDonald, 1929; Henry, 1941).

The Lepadomorpha collected by the research steamer "Albatross" during the years 1891 and 1904 from the southern portion of Central America were subsequently described by MacDonald (1929). Only one species, *Lepas denticulata* Gruvel, may be considered as having been collected in west Mexican waters.

Within the last two decades the most significant and valuable contributions have been those of Cornwall (*in* Steinbeck and Ricketts, 1941) and Henry (1941, 1942, 1943, 1960). Cornwall, who identified the barnacle collections made by Steinbeck and Ricketts during their classic voyage to the Gulf of California, listed a total of 10 species or infraspecific forms, many of which had not been previously reported from this region. Ecological annotations are included with Cornwall's identifications in the phyletic catalogue which forms a part of the appendix to Steinbeck and Ricketts' "Sea of Cortez." Henry's studies have dealt primarily with

the description of new species (1941, 1943, 1960) and with the geographic distribution of the fauna (1942, 1960). In her most recent paper on the Gulf Thoracica (Henry, 1960) she summarizes much of the published information concerning the species occurring in the Gulf.

Recently, Newman (1960) and Zullo (1961a, 1961b) described new species from this region. Newman (1960) described a new ectoparasitic lepadomorph, *Octolasmis californiana*, from southern California which is also believed to occur in the vicinity of Mazatlán, Sinoloa, Mexico. Zullo (1961b) described a new coralliophilic species, *Balanus* (*Hexacreusia*) *durhami*, from the Gulf of California. This species was also recovered from late Pliocene and Pleistocene deposits in the Gulf region. *Cryptolepas murata*, described by Zullo (1961a) from late Pleistocene deposits at San Quintín Bay, Baja California, is the first known fossil representative of the genus *Cryptolepas* Dall.

There are no paleontological studies which specifically treat the Cirripedia of western Mexico. Within recent years several faunal lists of megascopic invertebrates collected at restricted localities have appeared in the literature. It is largely in these faunal compilations that many of the fossil species are cited.

Acknowledgments

Dr. William K. Emerson of the American Museum of Natural History kindly provided the author with access to his personal library and the use of many otherwise inaccessible publications in addition to identifying the mollusks. Dr. Dora Priaulx Henry of the Department of Oceanography, University of Washington, critically read the final manuscript and made several helpful suggestions which have been adopted here. The author is also deeply grateful to Dr. Meredith L. Jones, the American Museum of Natural History, for many courtesies rendered during the course of this study. Dr. Donald F. Squires, formerly of the American Museum, generously provided identifications of the stony corals.

Check List of West Mexican Cirripedia

The present collections, although somewhat small in number of species, will give an idea as to the immense interest and value of a thorough study of the Cirripedia of this region. Fossiliferous deposits have failed to yield any of the Lepadomorpha and only very few of the Balanomorpha; no species has been recovered from deposits older than Miocene age. Several of the whale barnacles and two species of *Lepas* are conspicuous by their absence from the Recent fauna. In addition, our knowledge of

the fauna inhabiting sponges, corals, gorgonians, and crustaceans is still meager. Whether the absence of any of these forms is due to a scarcity or simply to the limited exploration of the region remains to be elucidated by future investigators.

In the chronological list that follows, all the Cenozoic barnacles reported from western Mexico are cited. Those species represented in the "Puritan" collections are indicated by an asterisk, and previously recorded citations to these species in the eastern Pacific are given in the text. Those species not represented in the present collections are followed by references to the literature.

Miocene

Balanus concavus Bronn, 1831 (Beal, 1948)
Balanus aff. *B*[*alanus*] *t*[*intinnabulum*] *californicus* Pilsbry, 1916 (Hertlein and Jordan, 1927; Beal, 1948)

Pliocene

**Balanus concavus* Bronn, 1831
Balanus glyptopoma Pilsbry, 1916 (Pilsbry, 1918)
**Balanus nubilus* Darwin, 1854
Balanus tintinnabulum (Linnaeus), 1758 (Hertlein and Allison, 1959)
Balanus tintinnabulum cf. *B. tintinnabulun californicus* Pilsbry, 1916 (Jordan and Hertlein, 1926b; Beal, 1948)
Balanus tintinnabulum coccopoma Darwin, 1854 (Jordan and Hertlein, 1926b)
**Balanus durhami* Zullo, 1961 (Zullo, 1961b)
Coronula diadema (Linnaeus), 1767 (Durham, 1950; provisional identifications: Jordan and Hertlein, 1962a; Hertlein and Emerson, 1959)

Pleistocene

Balanus cf. *B. amphitrite* Darwin, 1854, var. (Hertlein and Emerson, 1956)
**Balanus concavus pacificus* Pilsbry, 1916
**Balanus trigonus* Darwin, 1854
Balanus nubilus Darwin, 1854 (Emerson and Hertlein, 1960; provisional identifications: Emerson, 1956; Emerson and Addicott, 1958; Addicott and Emerson, 1959)
Balanus aff. *B. aquila* Pilsbry, 1907 (Emerson and Addicott, 1958)
Balanus tintinnabulum (Linnaeus), 1758 (Orcutt, 1921)
**Balanus tintinnabulum* cf. *B. tintinnabulum californicus* Pilsbry, 1916
Balanus tintinnabulum peninsularis Pilsbry, 1916 (Palmer and Hertlein, 1936)
**Balanus durhami* Zullo, 1961 (Zullo, 1961b)
Tetraclita squamosa rubescens Darwin, 1854 (Emerson, 1956; provisional identification: Chace, 1956)
Tetraclita squamosa panamensis Pilsbry, 1916 (Jordan, 1936)
Tetraclita squamosa cf. *T. squamosa stalactifera* forma *confinis* Pilsbry, 1916 (Hertlein and Emerson, 1956)
Cryptolepas murata Zullo, 1961 (Zullo, 1961a)

RECENT

Balanus improvisus Darwin, 1854 (Cornwall, *in* Steinbeck and Ricketts, 1941)
**Balanus amphitrite hawaiiensis* Broch, 1922
Balanus amphitrite inexpectatus Pilsbry, 1916 (Cornwall, *in* Steinbeck and Ricketts, 1941; Henry, 1943, 1960)
**Balanus concavus pacificus* Pilsbry, 1916
Balanus concavus mexicanus Henry, 1941 (Henry, 1941, 1960)
**Balanus aquila regalis* Pilsbry, 1916
Balanus poecilus Darwin, 1854 (Henry, 1960)
**Balanus trigonus* Darwin, 1854
**Balanus eyerdami* Henry, 1960
Balanus nubilus Darwin, 1854 (Henry, 1942)
Balanus glandula Darwin, 1854 (Henry, 1942)
**Balanus durhami* Zullo, 1961 (Zullo, 1961b)
Balanus orcutti Pilsbry, 1907 (Pilsbry, 1907a)
**Balanus galeatus* (Linnaeus), 1771
Balanus tintinnabulum californicus Pilsbry, 1916 (Cornwall, *in* Steinbeck and Ricketts, 1941; Henry, 1942, 1960)
Balanus tintinnabulum peninsularis Pilsbry, 1916 (Kolosváry, 1939; Henry, 1941, 1960)
**Balanus tintinnabulum coccopoma* Darwin, 1854
Balanus psittacus (Mollina), 1782 (Henry, 1960)
Balanus nigrescens Lamarck, 1818 (Gavino, 1888)[1]
Chelonibia testudinaria (Linnaeus), 1758 (Pilsbry, 1916; Henry, 1960)
Chelonibia patula dentata Henry, 1943 (Henry, 1943, 1960)
Coronula diadema (Linnaeus), 1767 (Pilsbry, 1916)
**Chthamalus anisopoma* Pilsbry, 1916
**Chthamalus fissus* Darwin, 1854
**Tetraclita squamosa rubescens* Darwin, 1854
**Tetraclita squamosa rubescens* forma *elegans* Darwin, 1854
**Tetraclita squamosa stalactifera* (Lamarck), 1818
**Tetraclita squamosa stalactifera* forma *confinis* Pilsbry, 1916
Lepas anserifera Linnaeus, 1767 (Pilsbry, 1907c; Henry, 1960)
Lepas hilli var. *californiensis* Gruvel, 1905 (Gruvel, 1905)
Lepas denticulata Gruvel, 1900 (MacDonald, 1929)
Heteralepas quadrata (Aurivillus), 1894 (Gruvel, 1905)
Octolasmis californiana Newman, 1960 (Newman, 1960)
Mitella elegans Lesson, 1830 (Reeve, 1843; Darwin, 1851; Henry, 1960)
Mitella polymerus (Sowerby), 1833 (Henry, 1942)

The composition of the Recent cirriped fauna of western Mexico is predominantly tropical eastern Pacific in its affinities. Most of the remaining fauna is comprised of infiltrating northern, southern, and

[1] The locality "Acalpuco" (= Acapulco, Mexico), given by Gavino (1888), was based on incorrectly labeled specimens (see Steinbeck and Ricketts, 1941). Inasmuch as this species is known only from Australian waters, it does not seem advisable to consider it as a west Mexican faunal component.

cosmopolitan elements. It is of interest to note that certain elements of this fauna exhibit a distinct relationship to those of the Caribbean-western Atlantic. However, too little time apparently has elapsed since they were separated for two totally distinct faunas to have evolved on opposite sides of the existing Central American land barrier. Some of the tropical eastern Pacific species have evolved so little from their predecessors with trans-American distributions that they are almost impossible to separate, if, indeed, they are at all separable, from sibling Caribbean forms. At the present time the tropical Cirripedia of western Mexico show little or no affinity with those of the Indo-western Pacific region. There is also no indication from the fossil record that the contrary, i. e., a close faunistic relationship, has existed at any time during the Cenozoic. A combination of low hydrotemperatures and a broad expanse of deep ocean water referred to as the East Pacific Barrier (Ekman, 1953) is probably responsible for the effective isolation of the eastern and western stenothermal warm-water faunas. For members of either of these tropical faunas, migration directly across the Pacific, precluding an extension along the northern margin of the Pacific, which includes the temperate and the Arctic region, would seem to be possible only by passive dissemination on the hulls of ships or by attachment to flotsam. The temperate and cold-water faunas of western North America, species of which range southward to Baja California, share at least seven species with the Aleutian Islands, the temperate eastern Pacific, and the Japanese faunas (Hiro, 1935; Henry, 1942). It would thus appear that the temperate fauna of western North America had its origin in trans-Pacific dispersals eastward around the northern margin of the Pacific, while colonization of the west Mexican region by shallow water and intertidal barnacles was probably effected through Central American Tertiary seaways from the east.

Between approximately 23° and 33° north latitude, the transition zone between the tropical and temperate faunal divisions of the eastern Pacific (Emerson, 1956), certain constituents of the cirriped fauna drop out or enter the biota. Emerson has defined this "Transition faunal province" as extending from Point Conception, California, on the north, to Cape San Lucas, Baja California, on the south. The faunal changes occurring along the outer coast of Baja California are neither so abrupt nor so regular as to justify drawing definite boundaries. However, the distribution of the west Mexican cirriped fauna is, for the most part, consistent with Emerson's (1956) boundaries of this province, although certain of the eurythermic tropical species extend beyond its northern limit. On the basis of the existing literature (see Henry, 1942) and the present collections, it is obvious that two overlapping barnacle faunas are present in

this zone, namely, the south-ranging temperate and the north-ranging tropical. It should be mentioned in this connection that the intermixing of faunal components is also evident in late Cenozoic assemblages occurring on the west coast of Baja California. The discontinuous distribution of tropical and temperate cirriped faunas, during Recent times, along the Pacific side of Baja California could, perhaps, be explained in part by the variability in hydrotemperatures owing to the localized upwelling of cold water.

Paleontological studies (see below) have shown that four species, *Balanus concavus concavus*, *B. glyptopoma*, *B. trigonus*, and *Tetraclita squamosa stalactifera*, are common to both western Atlantic and eastern Pacific late Cenozoic deposits. The last two species, as well as the following six species, are also common to the Recent faunas of both of these regions: *Balanus amphitrite hawaiiensis*, *B. amphitrite inexpectatus*, *B. improvisus*, *B. concavus pacificus*, *B. galeatus*, and *Catophragmus imbricatus*. Of these six species, three, *Balanus galeatus*, *B. concavus pacificus*, and *Catophragmus imbricatus*, are of somewhat restricted distribution, and the remaining species are rather widely distributed in tropical and warm-temperate seas. Three of the above species, i. e., *Balanus amphitrite hawaiiensis*, *B. amphitrite inexpectatus*, and *B. concavus pacificus*, may owe their Recent widespread distribution to passive migrations on the hulls of ships.

Of the 27 Recent species, subspecies, and infrasubspecific forms of Balanomorpha cited above, the following nine, as far as is known, are endemic to the coastal waters of western Mexico: *Balanus concavus mexicanus*, *B. eyerdami*, *B. durhami*, *B. orcutti*, *B. tintinnabulum peninsularis*, *Chelonibia patula dentata*, *Chthamalus anisopoma*, *Tetraclita squamosa stalactifera*, and *T. squamosa stalactifera* forma *confinis*. The following five species have their northern limits in Californian waters: *Balanus tintinnabulum californicus*, *B. galeatus*, *Chthamalus fissus*, *Tetraclita squamosa rubescens*, and *T. squamosa rubescens* forma *elegans*. *Balanus aquila regalis*, *B. amphitrite inexpectatus*, *B. tintinnabulum coccopoma*, *B. poecilus*, and *B. psittacus* range southward into the Panamanian or Peruvian faunal province. *Balanus concavus pacificus* has its southern limit in Peruvian waters and its northern limit in Californian waters, and two of the temperate sessile species, *B. nubilus* and *B. glandula*, have southern limits in west Mexican waters. The remaining five species are widely distributed, and some may even be considered cosmopolitan in distribution.

Approximately one-fourth of the Recent Balanomorpha (29.6%) are common to both the eastern Pacific and western Atlantic regions. One-third of the fauna are endemic, and of these endemic species, 22.2 per cent are restricted to the Gulf of California. Eighteen and one-half

per cent of the fauna range northward into California; 18.5 per cent are cosmopolitan in distribution; 18.5 per cent extend southward into the Panamanian or Peruvian faunal zone; 7.4 per cent range southward into western Mexico from Alaskan waters; and 3.7 per cent range from California to Peru. These distributional data provide strong evidence that the cirriped fauna of western Mexico has developed through the invasion of this area by species from two major sources, a smaller number coming in from the southern and northern eastern Pacific, and the majority probably entering from the Caribbean-western Atlantic. With these species as a basis, new species have developed at various localities along the distribution routes. Some of these, developed long since, have become rather widely distributed along the eastern Pacific coast, while others, seemingly of more recent origin, are still restricted to a limited range.

SYSTEMATIC DESCRIPTIONS

SUBCLASS CIRRIPEDIA BURMEISTER, 1834

ORDER THORACICA DARWIN, 1854

SUBORDER BALANOMORPHA PILSBRY, 1916

FAMILY BALANIDAE GRAY, 1825

SUBFAMILY BALANINAE DARWIN, 1854

GENUS *BALANUS* DA COSTA, 1778

SUBGENUS *MEGABALANUS* HOEK, 1913

Balanus tintinnabulum coccopoma Darwin, 1854

Balanus tintinnabulum var. *coccopoma* DARWIN, 1854, A monograph on the sub-class Cirripedia, p. 196, pl. 1, fig. d, pl. 2, figs. 1f, 1l, 1o.

Balanus tintinnabulum coccopoma, PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 68, pl. 16, figs. 1, 1a, 2, 2a.

Balanus tintinnabulum forma *coccopoma*, BROCH, 1922, Vidensk. Meddel. Dansk Naturhist. For. Kjøbenhavn, vol. 73, p. 310.

Balanus tintinnabulum coccopoma, JORDAN AND HERTLEIN, 1926, Proc. California Acad. Sci., ser. 4, vol. 15, p. 420.

Balanus tintinnabulum coccopoma, HENRY, 1941, Proc. New England Zool. Club, vol. 18, p. 102.

Balanus tintinnabulum coccopoma, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 120, fig. 3, pl. 4, figs. 8–9.

The juvenile specimens, which comprise the present collections, have either convexly conic or nearly cylindrical shells. The parietes are smooth and roseate-red. The broad radii are vinaceous purple and are deeply striated or transversely grooved from the base to the apex. The orifice is rather large and is usually ovate. Although the circumference of the orifice is worn, the radii have horizontal summits whereas the summits of

the alae are sub-horizontal. Both the sheath and inner lamina are white. The sheath is moderately short, with a shallow, narrow space beneath the depending free margin. Basally the inner lamina is strongly ribbed. Numerous incomplete septa are present on the internal surface of the outer lamina.

OCCURRENCE: Station 36, southeastern side of San Juanito Island, Tres Marías Group, 0-0.5 fathoms, on *Pseudochama corrugata* (Broderip). Station 75, off southeast side of Isabel Island, 0.5–3.5 fathoms. Station 83, Olas Altas Bay, Mazatlán, Sinoloa, 3.5 fathoms.

DISTRIBUTION: This subspecies ranges from Mazatlán, Mexico, to Panama (Pilsbry, 1916; Broch, 1922). Nilsson-Cantell (1931) recorded the occurrence of this subspecies, as an "accidental immigrant," in the port of Le Havre, France. Subsequent workers have failed to note its occurrence, and thus it does not appear to have been permanently established.

Jordan and Hertlein (1926b) reported this subspecies from Pliocene deposits at Turtle Bay, Baja California.

Balanus tintinnabulum cf. *B. tintinnabulum californicus* Pilsbry, 1916

Balanus tintinnabulum californicus PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 65, pl. 14, figs. 1–3, pl. 15, fig. 4.

Balanus tintinnabulum forma *californica* [*sic*], BROCH, 1922, Vidensk. Meddel. Dansk Naturhist. For. Kjøbenhavn, vol. 73, p. 333.

Balanus tintinnabulum californicus, JOHNSON AND SNOOK, 1927, Seashore animals of the Pacific coast, p. 264, figs. 213, 217, 218.

Balanus tintinnabulum californicus, COE, 1932, Bull. Scripps Inst. Oceanogr., tech. ser., vol. 3, p. 63, pl. 1, figs. 1–12, pl. 2, figs. 13–18, pl. 6, figs. 54–65a.

Balanus tintinnabulum californicus, RASMUSSEN, *in* Shelford *et al.*, 1935, Ecol. Monogr., vol. 5, p. 306.

Balanus tintinnabulum californicus, HEWATT, 1937, Amer. Midland Nat., vol. 18, p. 187.

Balanus tintinnabulum californicus, COE AND ALLEN, 1937, Bull. Scripps Inst. Oceanogr., tech. ser., vol. 4, p. 126.

Balanus tintinnabulum californicus, WILLETT, 1937, Trans. San Diego Soc. Nat. Hist., vol. 8, p. 383.

Balanus tintinnabulum californicus, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 118, fig. 2, pl. 4, figs. 10–12.

Balanus tintinnabulum californicus, HENRY, 1943, Proc. U. S. Natl. Mus., vol. 93, p. 367.

B[*alanus*] *tinntinnabulum* [*sic*] *californicus*, GRAHAM AND GAY, 1945, Ecology, vol. 26, p. 382.

Balanus tintinnabulum californicus, HEWATT, 1946, Ecol. Monogr., vol. 16, p. 194.

Balanus tintinnabulum californicus, BRUFF, 1946, Univ. California Publ. Geol., vol. 27, p. 234.

Balanus tintinnabulum californicus, CORNWALL, 1951, Wasmann Jour. Biol., vol. 9, p. 324, pl. 3, figs. D, E.

Balanus tintinnabulum californicus, CORNWALL, 1956, Jour. Paleont., vol. 30, p. 647, fig. 1e.

Balanus tintinnabulum californicus, ALEEM, 1957, Hydrobiologica, vol. 11, p. 51, fig. 5.

Balanus tintinnabulum, BOOLOOTIAN, 1958, Bull. Southern California Acad. Sci., vol. 57, p. 91, pl. 29.

B[alanus] tintinnabulum californicus, CORNWALL, 1959, Canadian Jour. Zool., vol. 37, p. 405, pl. 1, fig. 11.

Balanus tintinnabulum californicus, KANAKOFF AND EMERSON, 1959, Los Angeles County Mus., Contrib. Sci., no. 31, p. 20.

Balanus tintinnabulum californicus, HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 138.

Six juvenile and five larger specimens, which have grown on one another, are probably referable to this subspecies. A more definite identification is not possible owing to the absence of opercular valves. The compartments still show some traces of the roseate-red coloring. Although poorly preserved, fine striae are still noticeable on the parietes. The radii are transversely striated and, on some specimens, these striations are present from the base to the apex. The orifice, although worn, is angularly ovate. The porous basis is greatly deepened in all the larger specimens.

REMARKS: This subspecies is generally not known to occur at any great depth. The data suggest that it is limited to sub-tidal habitats, but that it probably does not occur below 1 fathom (Coe, 1932; Rasmussen, *in* Shelford *et. al.*, 1935; Coe and Allen, 1937; Hewatt, 1937, 1946). Aleem (1957), however, recorded its occurrence on test panels submerged at a depth of approximately 7 fathoms off the coast of La Jolla, California. In those areas that are washed by waves, *B. tintinnabulum californicus* is likely to be found slightly above the sub-tidal zone (Rasmussen, *in* Shelford *et al.*, 1935).

The Pleistocene deposits from which these specimens were collected probably represent a shallow-water, near-shore facies. This is indicated by the presence of the intertidal barnacle *Tetraclita*, upon which these specimens were growing.

Coe (1932) and Coe and Allen (1937) have found that the critical temperature below which the spawning of *B. tintinnabulum californicus* is inhibited is approximately 16° C. Normally the reproductive season lasts from April to December, but spawning may be induced during unseasonably warm periods in February and March (Coe, 1932; Coe and Allen, 1937; Aleem, 1957). Under these conditions, "Two complete generations

may thus occur in one calendar year" (Coe, 1932, p. 63). The presence of several juveniles, which have settled upon the larger specimens, would suggest a paleohydroclimate of 16° C. or higher prior to the time of deposition.

OCCURRENCE: Pleistocene: F-6, east side of Magdalena Island, ½ mile north of Puerto Magdalena, on *Tetraclita* sp.

DISTRIBUTION: The Recent distribution of this subspecies is San Francisco, California, to Guaymas, Mexico (Henry, 1960).

Willett (1937) recorded this subspecies from a Pleistocene locality in the Baldwin Hills area, Los Angeles County, California. Bruff (1946) and Kanakoff and Emerson (1959) cite Pleistocene occurrences for this subspecies in the Newport Bay area, southern California. Additional late Cenozoic localities, for specimens probably referable to this subspecies, are given by Jordan and Hertlein (1926b), Hertlein and Jordan (1927), Hertlein (1931), Beal (1948), Emerson and Addicott (1953, 1958), Emerson (1956), and Addicott and Emerson (1959). These localities range through the southernmost portion of California and the northern half of Baja California. The literature, in addition to the "Puritan" record, suggests a shorter and more northern range during the late Cenozoic than at the present time.

SUBGENUS *BALANUS* DA COSTA, 1778

Balanus amphitrite hawaiiensis Broch, 1922

Figures 1–5

Balanus amphitrite forma *hawaiiensis* BROCH, 1922, Vidensk. Meddel. Dansk Naturhist. For. Kjøbenhavn, vol. 73, p. 314, figs. 56, 57a-e.

Balanus amphitrite herzi ROGERS, 1949, Pomona College Jour. Ent. Zool., vol. 43, p. 28, pl. 1, figs. 6, 12–15.

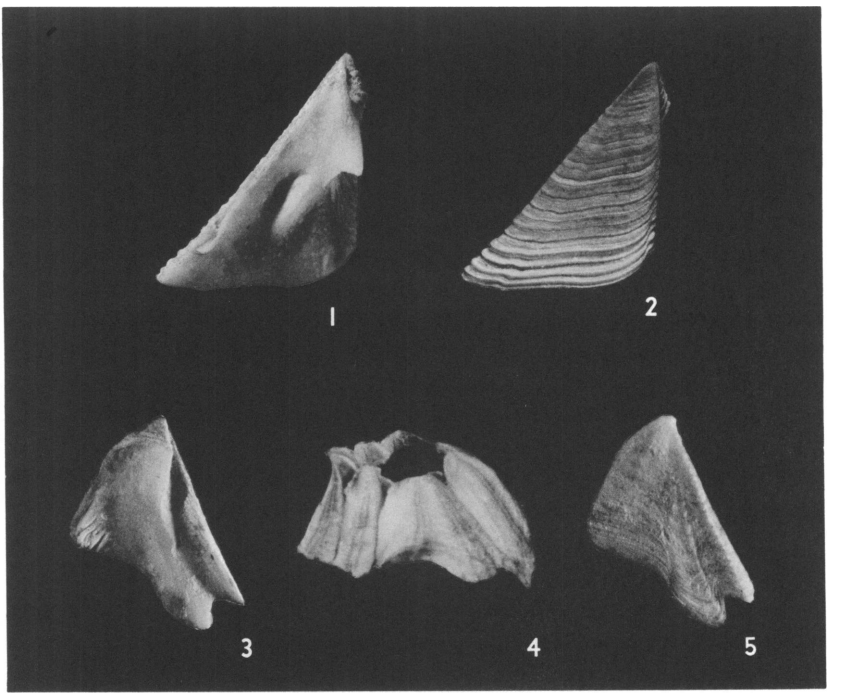
Balanus amphitrite franciscanus ROGERS, 1949, Pomona College Jour. Ent. Zool., vol. 43, p. 29, pl. 1, figs. 1, 5, 7, 16–19.

Balanus amphitrite hawaiiensis, HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 142.

The shell (fig. 4) is low, conic, white, and striped with narrow lavender or violet bands. The orifice is moderately large, sub-trigonal, and slightly toothed. The apex of the rostrum is recurved. The sheath is moderately long and mottled with lavender and white. Basally the white inner lamina is strongly ribbed. Numerous incomplete septa are present only on the inner surface of the outer lamina. Transverse septa occur only in the upper portion of the parietal tubes.

Externally the triangular scutum (fig. 2) is sculptured with low, weakly developed growth lines. The tergal half of the valve is violet. The articular

ridge is high, slightly reflexed, and distally produced into a point (fig. 1). This ridge continues downward and bounds the lateral depressor muscle pit. The articular furrow is broad and deep. The adductor ridge is thick, short, and erect; the muscle pit is elongate-oval. The pit for the insertion of the lateral muscle is small and shallow.



FIGS. 1–5. *Balanus amphitrite hawaiiensis* Broch, San Carlos Bay, Sonora, hypotype, A.M.N.H. No. 11867. 1. Internal view of scutum. × 8.6. 2. External view of scutum. × 8.6. 3. Internal view of tergum. × 8.6. 4. Lateral view of shell. × 4. 5. External view of tergum. × 8.6. Photograph by the American Museum of Natural History.

The tergum (figs. 3, 5) is rather wide and is tinted with alternating bands of violet and white. The distal end of the long and broad spur is obliquely rounded. Externally the valve is almost flat, and the growth lines are feebly developed. On the inner surface the valve is tinted violet on the upper one-half. The articular ridge is high, and the articular furrow is broad and deep. The five crests for the tergal depressor muscle are short and strongly developed; they project below the basal margin of the valve.

REMARKS: *Balanus amphitrite hawaiiensis* usually occurs below the low-tide level. Unpublished observations made by the author on the east and west coasts of Florida have shown this subspecies is found most commonly between mean sea level and 0.5–1 fathom. At Cedar Keys, Sea Horse Key, and Naples, on the west coast of Florida, this subspecies appears as a common fouling organism in competition with *B. amphitrite niveus*, *B. eburneus*, or *B. improvisus*. Rare occurrences of this subspecies were noted at Fernandina Beach, Jacksonville Beach, St. Augustine, and Flagler Beach, on the east coast of Florida.

In temperate waters, such as on the California coast, this subspecies is generally restricted to quiet bays or enclosed harbors (Utinomi, 1960). All the sites investigated on the east coast of Florida are unprotected, open-sea habitats. As noted by Utinomi, this type of habitat is not conducive to the establishment of large populations of *B. amphitrite hawaiiensis*.

Balanus amphitrite hawaiiensis is a euryhaline barnacle, having a salinity tolerance range of 16–30 parts per thousand (Utinomi, 1960), which is within the range of salinities recorded by the author at Sea Horse Key and Cedar Keys, Florida (unpublished data). In the Suez Canal, where this subspecies has been found, salinities as high as 50 parts per thousand may be encountered.

OCCURRENCE: Station 153, San Carlos Bay, Sonora, intertidal, on *Tetraclita squamosa stalactifera* forma *confinis* Pilsbry.

DISTRIBUTION: This subspecies was originally described from the Hawaiian Islands (Broch, 1922). In a recent synthesis of data it was brought out that it now has a nearly world-wide distribution in tropical and temperate seas (Utinomi, 1960). Utinomi (1960) believes that its native habitat is probably the Hawaiian Islands, and that from this archipelago it has spread to other regions of the world. On the basis of the information presented, there is no strong support for this view. The fact that it has spread so rapidly and so far precludes any chances of determining its original habitat.

In the eastern Pacific this subspecies was previously known from only four localities. In California it has been recorded from San Diego, Salton Sea, and San Francisco (Utinomi, 1960). In western Mexico it has been recorded from the vicinity of Guaymas (Henry, 1960).

Balanus concavus concavus Bronn, 1831

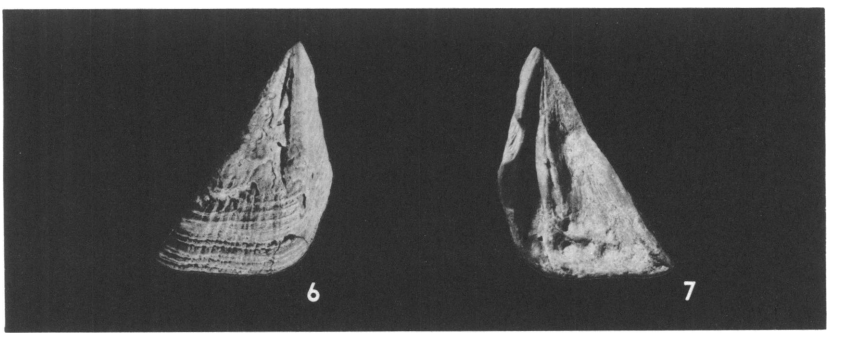
Figures 6, 7

Balanus concavus BRONN, 1831, Italiens Tertiär gebilde und deren organische einschlüsse, p. 127 (original citation not seen).

Balanus concavus, ARNOLD, 1907, Proc. U. S. Natl. Mus., vol. 32, p. 543, pl. 45, figs. 5, 5a.

Balanus concavus, ARNOLD, 1908, Smithsonian Misc. Coll., vol. 50, p. 424.
Balanus concavus, NOMLAND, 1917, Univ. California Publ. Geol., vol. 10, p. 213.
Balanus concavus, NOMLAND, 1917, Univ. California Publ. Geol., vol. 10, p. 301.
Balanus concavus, WATERFALL, 1929, Univ. California. Publ. Geol. Sci., vol. 18, check list.
Balanus concavus, DELONG, 1941, Trans. San Diego Soc. Nat. Hist., vol. 9, p. 243.
Balanus concavus, BEAL, 1948, Mem. Geol. Soc. Amer., no. 31, p. 64.
Balanus concavus, WEAVER, 1949, Mem. Geol. Soc. Amer., no. 35, p. 104.
Balanus concavus, EMERSON AND HERTLEIN, 1960, Amer. Mus. Novitates, no. 2004, p. 7.

One specimen, a right scutum (figs. 6, 7) referable to this species, was identified by Ira E. Cornwall of British Columbia before the collections were submitted to the present author (see Emerson and Hertlein, 1960).



FIGS. 6, 7. *Balanus concavus concavus* Bronn, Punta Rosalía, Baja California, hypotype, A.M.N.H. No. 11866. 6. External view of scutum. × 1.5. 7. Internal view of scutum. × 1.5. Photograph by the American Museum of Natural History.

The specimen measures 21 mm. in length and 17.5 mm. in width. The articular ridge of the valve is short and moderately reflexed. The adductor ridge is short and high. The pit for the adductor muscle is ovate and moderately deep. A long ridge bounds the adductor muscle pit, which is deep and long. The pit extends from the basal margin about two-thirds or less of the length of the valve. Externally the valve surface is eroded in the upper portion, while the lower portion is characteristically strongly latticed.

OCCURRENCE: Pliocene: Punta Rosalía, Baja California, latitude 28° 40′ N., longitude 114° 16′ W., August 1, 1959.

DISTRIBUTION: According to Pilsbry (1916) *Balanus concavus concavus* was first described from Pliocene deposits in the Andona Valley, near Asti, Piemonte, Italy. In Italy this species ranges from Oligocene to

Pleistocene (de Alessandri, 1906). In the eastern Pacific the stratigraphic biozone of this circumtropical species is probably lower or middle Miocene to middle or upper Pliocene. *Balanus concavus concavus* has been reported from several horizons in Europe (Darwin, 1854; de Alessandri, 1906; Kolosváry, 1955, 1959, 1960), northern Africa (Davadie-Suadeau, 1952), South America (Nilsson-Cantell, 1939), and North America.

Many authors have probably failed to distinguish between the nominate subspecies and *B. concavus pacificus*. Instead they have listed *B. concavus, sensu lato*, with the understanding that subsequent workers would probably realize which taxonomic unit they were citing. Until a thorough examination can be made of the specimens recorded as *B. concavus, sensu stricto*, or *B. concavus pacificus*, it does not seem advisable at this time to cite any of the eastern Pacific geological records for either of these taxonomic units.

Balanus concavus pacificus Pilsbry, 1916

Balanus concavus, DARWIN, 1854, (in part), A monograph on the sub-class Cirripedia, p. 235, pl. 4, figs. 4a, 4b, 4c.

Balanus concavus, ARNOLD, 1903, Mem. California Acad. Sci., vol. 3, p. 344.

Balanus concavus, PILSBRY, 1907, Bull. U. S. Bur. Fish., vol. 26, p. 199.

Balanus concavus, PILSBRY, 1909, Proc. U. S. Natl. Mus., vol. 37, p. 67.

Balanus concavus pacificus PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 104, fig. 25, pl. 23, figs. 1–1d.

Balanus concavus pacificus, ORCUTT, 1921, West. Amer. Sci., vol. 19, p. 24.

Balanus concavus pacificus, GILTAY, 1934, Bull. Mus. Roy. d'Hist. Nat. Belgique, vol. 10, p. 1, figs. 1–4.

Balanus concavus pacificus, HERTLEIN, 1934, Bull. Southern California Acad. Sci., vol. 33, p. 61.

Balanus concavus, CORNWALL, *in* Steinbeck and Ricketts, 1941, Sea of Cortez, p. 432.

Balanus concavus pacificus, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 104, pl. 2, figs. 1–4.

Balanus concavus, HENRY, 1943, Proc. U. S. Natl. Mus., vol. 93, p. 367.

Balanus concavus pacificus, CORNWALL, 1951, Wasmann Jour. Biol., vol. 9, p. 328, pl. 4, figs. D, E.

Balanus concavus pacificus, KOLOSVÁRY, 1955, Acta Biol. Szeged, new ser., vol. 1, p. 185.

Balanus concavus pacificus, CORNWALL, 1956, Jour. Paleont., vol. 30, p. 647, fig. 1g.

B[alanus] concavus pacificus, CORNWALL, 1958, Canadian Jour. Zool., vol. 36, p. 84, figs. 47, 48.

B[alanus] concavus pacificus, CORNWALL, 1959, Canadian Jour. Zool., vol. 37, p. 406, pl. 3, fig. 20.

Balanus concavus pacificus, HENRY, *in* Ray, D. E. (ed.), 1959, Marine boring and fouling organisms, p. 200, pl. 2, figs. 1–6.

Balanus concavus pacificus, HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 146.

The shell is conic or convexly conic, with a diamond-shaped or ovate orifice. The parietes are smooth, but on one specimen they are moderately folded at the base. The radii are broad, with the summits forming angles of 45 degrees or less with the base. The interior surface of the compartments is ribbed. Transverse septa are lacking, but the parietal tubes are filled near the apices.

The opercular valves are tinted vinaceous both inside and outside near the apices. The triangular scutum has low, prominent, growth ridges and longitudinal striae. The valve appears to be strongly latticed under low magnification. The adductor ridge is high, long, undercut, and it terminates near the basal margin. A small, thin, infolded ridge bounds the depression for the lateral depressor muscle. There is a second ridge, more or less parallel to the depressor muscle ridge, but it is lower and extends upward between the adductor and articular ridges.

The tergum is broad and triangular. It has an almost closed external longitudinal furrow. The spur is long and narrow and is separated from the basiscutal angle by its own width or less. Crests for the depressor muscle are low and numerous.

OCCURRENCE: *Recent:* Station 17, off Red Point, Magdalena Island, 22 fathoms, on *Hanetia anomala* Reeve. Station 22, north of Puerto Magdalena, Magdalena Island, intertidal, on *Turbo fluctuosus* Wood. Southwest of entrance to Scammons Lagoon, Baja California, latitude 27° 58′ N., longitude 114° 23′ W., 11.5 fathoms, coarse sand and broken shell bottom, July 28, 1959, on *Bursa californica* Hinds. *Pleistocene:* F-5, east side of Magdalena Island, just south of Puerto Magdalena.

DISTRIBUTION: The type locality for *B. concavus pacificus* is San Diego, California. Pilsbry (1916) recorded the modern range to be from California to Peru.

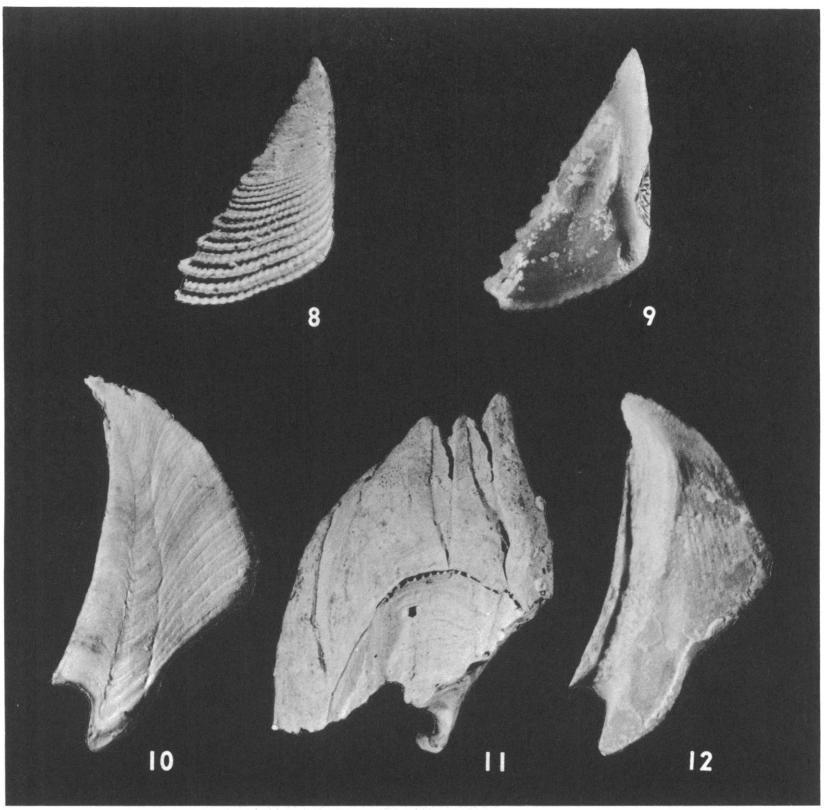
Specimens of this species have been found on *Dosinia elegans* Conrad collected on Shell Key near the entrance to Tampa Bay, Florida (unpublished record). This subspecies was not recorded in the Gulf of Mexico by Henry (1954), so it may have been introduced recently.

Balanus eyerdami Henry, 1960

Figures 8–12

Balanus eyerdami HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 139, pl. 1, figs. a–b, pl. 2, figs. b, e–g, pl. 3, figs. a–h, pl. 4, figs. a–e.

The shell (fig. 11) is conic to cylindrical, with the color varying from roseate-red, in juvenile specimens, to purple-red or reddish lavender in



FIGS. 8–12. *Balanus eyerdami* Henry, San Diego Island, hypotype, A.M.N.H. No. 11862 (figs. 8–10, 12); Tiburón Island, hypotype, A.M.N.H. No. 11860 (fig. 11). 8. External view of scutum. × 8.6. 9. Internal view of scutum. × 8.6. 10. External view of tergum. × 12.5. 11. Lateral view of shell. × 1.5. 12 Internal view of tergum. × 12.5. Photograph by the American Museum of Natural History.

larger specimens. Although the parietes are smooth, they have a wavy appearance which may be due to variations of the color intensity. Concentric growth lines are noticeable under low magnification. The orifice is rather large, trigonal, and deeply toothed. The radii are moderately broad, transversely striate, glossy, rather deeply sunken, and not permeated with pores. The summits of the radii are crenulated. The oblique summits form an angle greater than 60 degrees with a horizontal. The summits of the alae are also oblique and approach an angle of 60 degrees. The sutural margins of the compartments are strongly septate from the

base to the apex, and the lower side of each septum is denticulate. The sheath is moderately long, with wide-spaced, coarse, growth striae. The inner lamina and sheath are the same color as the parietes in juvenile specimens, but in larger forms the inner lamina may be white. Near the base of the shell the inner lamina is strongly ribbed; the ribs correspond with the wall septa. The parietal pores are large and square, with transverse septa present from the base to the apex; these septa are closely spaced and very numerous. The calcareous basis is thin, white, smooth, and permeated by small ovate pores which are also crossed by septa.

The following description of the opercular valves is based on a juvenile specimen. Between the apex and base the scutum (fig. 8) is concave. Its color is the same as that of the shell, and it is about one-half as wide as high. The exterior surface is sculptured with moderately high, serrate, growth ridges and longitudinal striae, which produces a cancellated appearance. Each growth ridge bears a row of short bristles. The articular ridge is low, reflexed, and about two-thirds of the length of the valve (fig. 9). The ridge for the insertion of the adductor muscle is erect, thick, and moderately short. The ridge extends to about one-third of the distance from the basal margin. The basal margin of the valve is crenulated, and it is not cut off at the basitergal angle.

The tergum (figs. 10, 12) is almost flat. The external growth lines are feebly developed. The longitudinal furrow is open and shallow. The articular ridge is low, and it is not reflexed. Crests for the depressor muscle are long and weak.

OCCURRENCE: Station 120, off southwestern side of San Diego Island, 25–40 fathoms, on *Arca pacifica* (Sowerby). Station 162, off Red Bluff, south side of Tiburón Island, 40 fathoms, on *Arca pacifica* (Sowerby).

DISTRIBUTION: This species was previously known only from the type locality, Guaymas, Mexico (Henry, 1960). The two localities at which it was dredged during the "Puritan" expedition extend its range farther northward in the Gulf of California.

Balanus aquila regalis Pilsbry, 1916

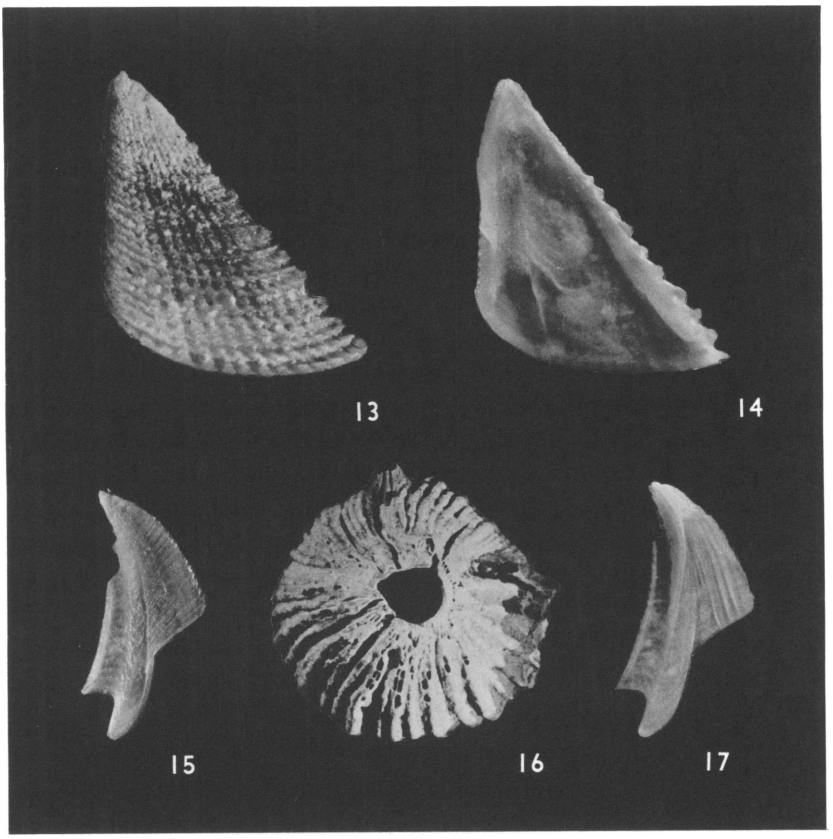
Figures 13–17

Balanus regalis PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 108, pl. 21, figs. 4, 4a.

? *Balanus concavus regalis*, KOLOSVÁRY, 1940, Paleont. Zeitschr., vol. 22, p. 106, pl. 1, figs. d, e, f.

B[alanus] regalis, CORNWALL, *in* Steinbeck and Ricketts, 1941, Sea of Cortez, p. 430.

Balanus aquila, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 100, pl. 1, figs. 1–3, 7.



FIGS. 13–17. *Balanus aquila regalis* Pilsbry, Hughes Point, Magdalena Island, hypotype, A.M.N.H. No. 11868. 13. External view of scutum. × 16. 14. Internal view of scutum. × 16. 15. External view of tergum. × 12. 16. Apical view of shell; rostrum oriented towards left of page. × 1. 17. Internal view of tergum. × 12. Photograph by the American Museum of Natural History.

? *Balanus concavus regalis*, KOLOSVÁRY, 1942, Zool. Anz., vol. 137, p. 139, figs. 1–4.

Balanus regalis, HENRY, 1943, Proc. U. S. Natl. Mus., vol. 93, p. 368.

Balanus regalis, CORNWALL, 1959, Canadian Jour. Zool., vol. 37, p. 403, pl. 2, figs. 12, 13.

Balanus aquila regalis, HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 144.

The walls form a cone strongly bent towards the rostrum. Juvenile specimens, with a rostro-carinal diameter of less than 4 mm., do not show

this rostrad flexure. The shell is Vandyke red clouded with white. Young specimens are covered with a light brown or buff-colored cuticle which bears numerous short bristles; this cuticle does not persist to the adult stage. The parietes are moderately ribbed, with deep folds at the base. Linear sutures closely unite the compartments. On larger specimens the sutures are straight, deep, narrow clefts which are easily seen. Juvenile specimens, on the other hand, appear to lack all traces of radii and sutures. The orifice is ovate; the periphery is usually abraded and the parietal tubes exposed. Transverse septa are present in the parietal tubes from the base to the apex.

The following description of the opercular valves is based on a juvenile specimen. The scutum (figs. 13, 14) is triangular, and its basal margin is not cut off at the basitergal angle. Externally the valve is ornamented by high growth ridges and equidistant longitudinal striae. The articular ridge is slightly reflexed, evenly rounded basally, and separated from the adductor ridge. The adductor ridge is high, moderately long, and it extends to a little less than one-third of the distance from the basal margin. A ridge, below the adductor ridge, bounds the pit for the lateral depressor muscle. Basally the occludent margin is folded inward to form a narrow, incomplete tube.

The tergum (figs. 15, 17) is elongate-triangular, and it is sculptured with fine, smooth, growth ridges. Each growth ridge bears a single row of short bristles, similar to those of the scutum. The external longitudinal furrow is open throughout its length; the furrow lips are not folded in. The spur is moderately long, narrow, obliquely truncated distally, and separated from the basiscutal angle by less than its own width. It forms an angle of approximately 90 degrees with the basiscutal margin. The articular ridge is rather high, and the furrow is moderately deep and narrow. Crests for the tergal depressor muscle are well developed, long, and are spaced almost equidistantly.

REMARKS: Although Kolosváry (1940, 1942) referred this species to *Balanus concavus, sensu lato*, Henry (1960) believes that it is the Panamic representative of the north temperate species *B. aquila, sensu stricto*. It is distinguished from the nominate subspecies, *B. aquila aquila*, by the color; the more finely ribbed walls; the narrower radii; the wider scutum, of which the tergal margin is longer; the shorter and weaker adductor ridge; and the wider tergum. Cornwall (1960) has shown that the interlaminate figures of *B. aquila aquila* and *B. aquila regalis* are similar, although there are some minor differences.

Owing to the rarity of this subspecies, little is known about its ecology. The abraded condition of the orifice and compartments and the lack of

a cuticle on larger specimens suggest an affinity for biotopes accompanied by wave or tidal scouring.

OCCURRENCE: Station 11, south side of Hughes Point, Magdalena Island, intertidal, on *Thais biserialis* (Blainville).

DISTRIBUTION: Although originally described from Point Abreojas, on the west coast of Baja California (Pilsbry, 1916), this subspecies has since been cited from Santa María Bay (Cornwall, 1959), San Antonio del Mar (Cornwall, 1960; Henry, 1960), San Quintin, Rosario, and Guaymas, Mexico (Henry, 1960). Kolosváry reported this species from the coast of Mollendo, Peru (1940), and Valparaiso, Chile (1942).

Balanus trigonus Darwin, 1854

Balanus trigonus DARWIN, 1854, A monograph on the sub-class Cirripedia, p. 223, pl. 3, figs. 7a–7f.

Balanus trigonus, PILSBRY, 1909, Proc. U. S. Natl. Mus., vol. 37, p. 70.

Balanus trigonus, PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 111, fig. 28d, pl. 26, figs. 13–13e.

Balanus trigonus, CORNWALL, *in* Steinbeck and Ricketts, 1941, Sea of Cortez, p. 431, pl. 14, fig. 2.

Balanus trigonus, HENRY, 1941, Proc. New England Zool. Club, vol. 18, p. 104, pl. 16, figs. 15, 17.

B[alanus] trigonus, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 127.

Balanus trigonus, HENRY, 1943, Proc. U. S. Natl. Mus., vol. 93, p. 369.

Balanus trigonus, CORNWALL, 1958, Canadian Jour. Zool., vol. 36, p. 81, figs. 29, 30.

Balanus trigonus, HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 139.

The walls form a low cone. Although the orifice is characteristically trigonal, it often assumes a pentagonal shape. Weak ribs or striae ornament the parietes. The radii are broad, transversely striate, glossy, and possess sub-horizontal summits. The inner lamina is weakly to strongly ribbed. Towards the apex the parietal tubes are filled, whereas the lower portion has transverse septa.

The external surface of the scutum is ornamented with prominent growth ridges and from one to six rows of small longitudinal pits. Specimens without a pitted surface are rare. The internal surface of both valves is covered with a dark purple chitinous membrane. The articular ridge of the scutum is long and slightly reflexed. There is a rather short adductor ridge which is not united with the articular ridge. The pit for the lateral depressor muscle is very deep and narrow.

The tergum is almost flat, and it is wider, but shorter, than the scutum. Obscure or low growth ridges sculpture the external surface of the valve.

The spur is short, and its width generally exceeds one-third of that of the basal margin. The depressor muscle crests are numerous, low, and sharp.

REMARKS: On the basis of the present collections *B. trigonus* appears to be one of the most ubiquitous faunal elements. It was found on mollusks, octocorals, and stony corals, as well as inanimate objects. This species has also been found on decapod crustaceans (Steinbeck and Ricketts, 1941), and embedded "*Acasta*-like" in sponges (Krüger, 1911).

Weltner (1922) cited a bottom temperature of about 14° C. for specimens recovered from a depth of 25 meters off the coast of western Africa. Broch (1931) cited a bottom water temperature of 18.6° C. for specimens dredged from 44 to 60 meters in Indo-Malayan waters. The hydrothermal range for this species, as recorded during the present expedition, was from 15.5° C., at Station 11, to 23° C., at Station 32, with a mean of 19.7° C. More data are needed before any conclusions can be drawn as to limiting hydrotemperatures of this species.

In the littoral region this species probably does not occur higher than the mean low-tide mark. Depths of 450 meters (Nilsson-Cantell, 1921) and 3000 meters (Gruvel, 1907) have been recorded. The mean bathymetric occurrence, as based on the "Puritan" collections, was approximately 7.5 fathoms.

OCCURRENCE: *Recent:* Station 2, South Bay, Cedros Island, 5–10 fathoms. Station 11, south side of Hughes Point, Magdalena Island, intertidal. Station 19, off Point Cove, Magdalena Island, Magdalena Bay, 4–7 fathoms. Station 21, off Point Belcher, Magdalena Island, Magdalena Bay, 9 fathoms. Station 22, north of Puerto Magdalena, Magdalena Island, intertidal. Station 24, about 1 mile south of Puerto Cortes, Santa Margarita Island, 0.5–1 fathom. Station 32, off creek bed about 2 miles north of Puerto Balleto, María Madre Island, Tres Marías Group, 0.5–2 fathoms. Station 34, Puerto Balleto, María Madre Island, Tres Marías Group, intertidal. Station 41, off southeastern end of San Juanito Island, Tres Marías Group, 0.5–4 fathoms. Station 77, about 300 meters south of Signal Station Point, west side of Cape Vigia, Mazatlán, Sinoloa, 0.5–1.5 fathoms. Station 81, about 125 meters west of White Top Rock Light, Mazatlán Harbor, Sinoloa, 3 fathoms. Station 86, off mouth of wash, west side of Los Frailes Bay, Baja California, 1.25 fathoms. Station 87, Pulmo Reef, Baja California, 2–4 fathoms. Station 93, San Lorenzo Reef, San Lorenzo Channel, 2 fathoms. Station 102, west side of Ballena Island, 1.25–2 fathoms. Station 108, second headland north of southwestern end of Isla Partida, 0.5–3.25 fathoms. Station 111, southwestern side of San Francisco Island, 0.5–4 fathoms. Station 115, off Amortajada Bay, southwestern side of San José Island, 13.5–17.5 fathoms. Station 117,

off west side of San José Island, 35–41.5 fathoms. Station 133, off Salinas Bay, east side of Carmen Island, 20 fathoms. Station 144, off west side of Coronados Island, 13–16.5 fathoms. Station 155, ocean side of San Carlos Bay, Sonora, 1–2.5 fathoms. Station 156, San Pedro Bay, Sonora, intertidal. Station 157, southeast side of Red Bluff, south end of Tiburón Island, intertidal. Station 160, off Red Bluff, south side of Tiburón Island, 20–22 fathoms. Station 167, off southeast end of Angel de la Guarda Island, 15–17 fathoms. Station 168, off southeast end of Angel de la Guarda Island, 16–17 fathoms. Station 171, Mejia Island, off north end of Angel de la Guarda Island, intertidal. Station 172, Puerto Refugio, north end of Angel de la Guarda Island, 16–18 fathoms. Station 173, Puerto Refugio, north end of Angel de la Guarda Island, 17–19 fathoms. *Pleistocene:* F-1, South Bay, Cedros Island. F-2, approximately 2 miles south of Cedros Village, east side of Cedros Island. F-5, east side of Magdalena Island, just south of Puerto Magdalena. F-6, east side of Magdalena Island, ½ mile north of Puerto Magdalena. F-7, about 4 miles south of Puerto Cortes, Santa Margarita Island. F-8, about 1.5 miles north of Puerto Cortes, Santa Margarita Island. F-13, southeast corner of María Magdalena Island, Tres Marías Group.

DISTRIBUTION: In the eastern Pacific *B. trigonus* is not known to have ranged farther north than San Diego, California, during Recent times (Henry, 1942). The world distribution of this species is as follows: Pacific-Japan, Malay Archipelago, New South Wales, New Zealand, western Americas from Peru to California; Indian Ocean; Red Sea; Mediterranean; Atlantic-West Indies to southern Brazil, Maderia, Azores to South Africa (Hiro, 1937). Broch (1922) reported this species from the Hawaiian Islands, and Henry (1954) has reported it from the Gulf of Mexico.

No data are available at this time concerning the distribution of *B. trigonus* in the eastern Pacific during the late Tertiary. Fossil evidence, as gathered by the "Puritan," suggests a northern Pleistocene limit somewhere between latitudes 28° N. and 29° N. This species is also known from Miocene deposits in Hungary (Kolosváry, 1955, 1959) and Cuba (Withers, 1953).

Balanus nubilus Darwin, 1854

Balanus nubilus DARWIN, 1854, A monograph on the sub-class Cirripedia, p. 253, pl. 6, figs. 2a–2c.

Balanus nubilus, GRUVEL, 1905, Monographie des cirrhipèdes ou thécostracés, p. 226.

Balanus flos PILSBRY, 1907, Bull. U. S. Bur. Fish., vol. 26, p. 201, fig. 3, pl. 9, figs. 1–7.

Balanus nubilis [*sic*], PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 131, pl. 30, figs. 1–4, pl. 31, figs. 3, 3a, 4, 5.

Balanus flos, PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 135, figs. 37, 38, pl. 32, figs. 1–1f.

Balanus nubilis [*sic*], PILSBRY, 1921, Proc. U. S. Natl. Mus., vol. 69, p. 112.

Balanus nubilis [*sic*], CORNWALL, 1925, Contrib. Canadian Biol., new ser., vol. 2, p. 479, fig. 3, pl. 2, figs. C–F.

Balanus nubilis [*sic*], TAIT AND EMMONS, 1925, Proc. Roy. Soc. Edinburgh, vol. 45, p. 42.

Balanus nubilis [*sic*], CORNWALL, 1927, Univ. California Publ. Geol., vol. 16, p. 408, pl. 59, figs. 1, 2, 4.

Balanus nubilis [*sic*], NILSSON-CANTELL, 1931, Verhandl. Naturf. Gesell. Basel, vol. 42, p. 112.

Balanus nubilis [*sic*], SHELFORD *et al.*, 1935, Ecol. Monogr., vol. 5, p. 281.

Balanus nubili [*sic*], CORNWALL, 1936, Jour. Biol. Board Canada, vol. 1, p. 471, figs. 3a, 4b.

Balanus altissimus, CORNWALL, 1936, Jour. Biol. Board Canada, vol. 1, p. 472, figs. 3b, 4a.

Balanus nubilis [*sic*], HENRY, 1940, Univ. Washington Publ. Oceanogr., vol. 4, p. 29, pl. 3, figs. 5–8.

Balanus nubilis [*sic*], HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 112, pl. 3, figs. 5–12.

B[*alanus*] *flos*, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 112.

B[*alanus*] *altissimus*, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 113.

Balanus nubilis [*sic*], RIGG AND MILLER, 1949, Proc. California Acad. Sci., vol. 26, p. 343.

Balanus flos, CORNWALL, 1951, Wasmann Jour. Biol., vol. 9, p. 334, pl. 5, figs. D, E.

Balanus nubilus, CORNWALL, 1951, Wasmann Jour. Biol., vol. 9, p. 335, pl. 5, fig. F, pl. 6, fig. A.

Balanus nubilus, CORNWALL, 1953, Jour. Fish. Res. Board Canada, vol. 10, p. 80, fig. 4.

Balanus altissimus, CORNWALL, 1953, Jour. Fish. Res. Board Canada, vol. 10, p. 80, fig. 7.

Balanus nubilus, CORNWALL, 1955, British Columbia Prov. Mus., Handbook, no. 7, p. 23.

Balanus nubilus, CORNWALL, 1955, Canadian Pacific fauna, sect. 10, pt. 10e, p. 36, figs. 28, 29.

Balanus nubilus, CORNWALL, 1956, Jour. Paleont., vol. 30, p. 647, text figs. 1a–1d.

B[*alanus*] *nubilis* [*sic*], BARNES AND GONOR, 1958, Nature, vol. 181, p. 194.

Balanus nubilus, CORNWALL, 1958, Canadian Jour. Zool., vol. 36, p. 81, figs. 39–41.

Balanus nubilus, BARNES, 1959, Canadian Jour. Zool., vol. 37, p. 234.

B[*alanus*] *nubilus*, BARNES AND BARNES, 1959, Canadian Jour. Zool., vol. 37, p. 237.

B[*alanus*] *nubilus*, CORNWALL, 1959, Canadian Jour. Zool., vol. 37, p. 404, pl. 3, fig. 23.

Balanus nubilus, BARNES, 1959, Canadian Jour. Zool., vol. 37, p. 607.
B[alanus] nubilus, BARNES AND BARNES, 1959, Oikos, vol. 10, p. 21.
Balanus nubilis [*sic*], EMERSON AND HERTLEIN, 1960, Amer. Mus. Novitates, no. 2004, p. 7.

A rather large barnacle, strong, and conic to cylindrical in shape. Occasionally the parietes are smooth, although they are usually moderately to strongly folded. The orifice is ovate and large, and the peritreme is toothed. The radii are narrow to broad, and their summits are oblique and jagged. The sutures between the compartments are complex. Basally the inner lamina is moderately to strongly ribbed. The parietal pores are narrow and subrectangular. There are no incomplete septa on the inner surface of the outer lamina. Transverse septa are usually absent. The basis is strong, imperfectly porose, and, when deepened, seldom exceeds the height of the walls.

REMARKS: The data for *B. nubilus* suggest that they tend to settle in areas that are characterized by moderate to strong tidal action or agitated water (Henry, 1940; Rigg and Miller, 1949; Cornwall, 1955b). This is often reflected by the eroded condition of the shell and opercular valves. Another factor in determining the site of attachment is the type of substratum. Pilsbry (1916) stated that this species prefers rough, rocky, or shelly bottoms, while Henry (1940) found that this species is less commonly found on mollusk shells than on a rock substratum. This fact, however, may be a function of the preponderance of a rock substratum in areas subject to diurnal tidal scouring. In certain cases, where a rocky substratum does not occur or is not available, *B. nubilus* may settle on the holdfasts of kelp, as Cornwall (1955a, 1955b) has found.

Although *B. nubilus* is eurybathyal, it is seldom found above mean low tide (Pilsbry, 1916; Henry, 1940; Rigg and Miller, 1949; Cornwall, 1955a, 1955b). *Balanus altissimus* (= *B. nubilus*), which does occur in the intertidal zone, may on further examination prove to be ecophenotypically distinct.

The Pliocene specimens recorded by Emerson and Hertlein (1960), and described above, are well preserved. The terrace sediments from which these fossils were collected are a "poorly consolidated, light gray, fine sand" (Emerson and Hertlein, 1960, p. 5). The general character of the sediment and the degree of preservation of the specimens suggest a shallow-water, depositional environment, with moderate to slight tidal action. In all probability these specimens were swept into, and finally deposited, in this environment. Pectens, which comprise the greatest percentage of the megafauna, further suggest a warm-temperate climate prior to the time of deposition.

OCCURRENCE: Pliocene: Punta Rosalía, Baja California, latitude 28° 40′ N., longitude 114° 16′ W., August 1, 1959.

DISTRIBUTION: During Recent times this species has been reported as occurring only in the northeastern Pacific region. It ranges from southern Alaska to San Quintín, Baja California (Henry, 1942).

Emerson and Addicott (1953) record Pleistocene specimens, apparently referable to this species, from San Diego County, California. Emerson (1956), Emerson and Addicott (1958), and Addicott and Emerson (1959) record specimens, which they questionably refer to this species, as occurring, respectively, in Pleistocene deposits at Punta China, Punta Baja, and Punta Cabras, Baja California. The "Puritan" specimens were recovered from a Pliocene terrace deposit at Punta Rosalía, Baja California (Emerson and Hertlein, 1960). All the fossil localities range through and beyond the southern limit for Recent occurrences of this species. Fossil evidence thus suggests that during Pliocene and Pleistocene times this species ranged farther south than it does at the present time.

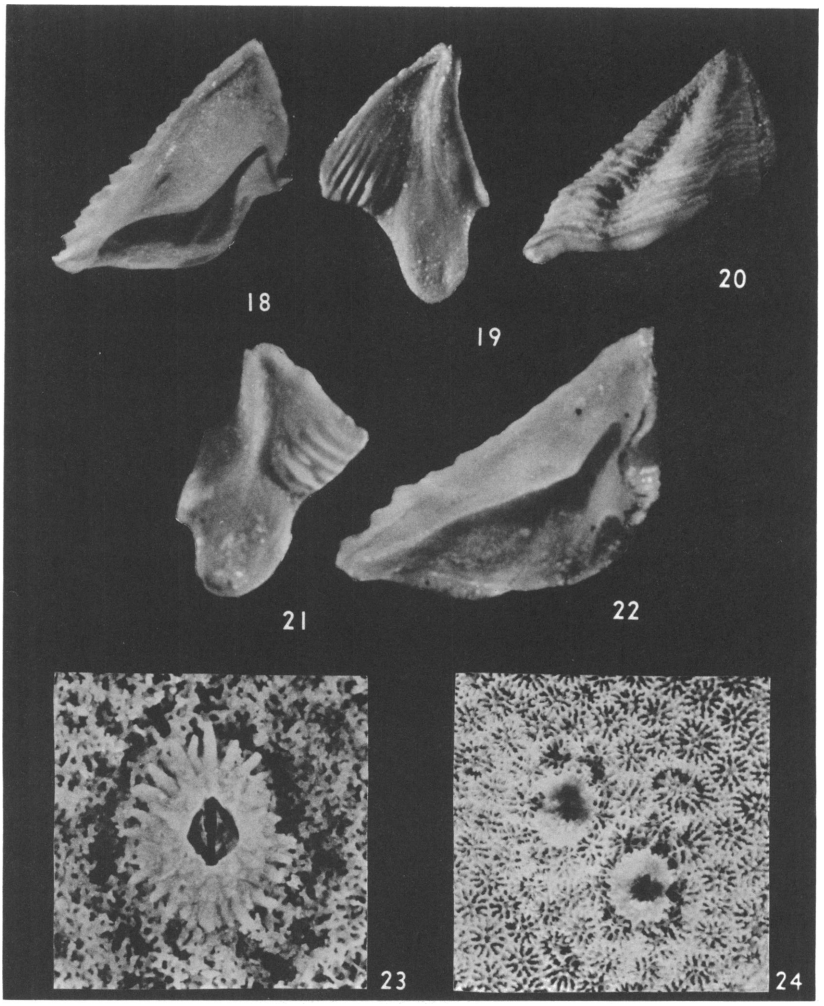
Balanus nubilus is not recognized in the eastern Pacific until the late Oligocene (Cornwall, 1958). Cornwall, basing his identification on the interlaminate figure of a fragment approximately 3 by 3 mm., sent to him by G. Kolosváry, cites *B. nubilus* from the Miocene of Hungary (1958; personal communication, 1961; see also Kolosváry, 1959). In a recent discussion of the Cenozoic history of the Bering land bridge, Hopkins (1959) notes that the Bering seaway, which serves as a dispersal route for North Atlantic and North Pacific marine invertebrates through the Arctic Ocean, came into existence after the middle Pliocene. However, Hopkins believes that (p. 1520) "Water barriers between the continents existed only briefly, if at all, from middle Eocene until middle Pliocene time." In the absence of contradictory data, the area in which there is the oldest, that is, earliest, occurrence of a species may be taken as the area of origin. Under this assumption it does not seem improbable that *B. nubilus*, dwelling in the northeastern Pacific, could migrate, with the opening of the Bering portal sometime during the late Oligocene or early Miocene, across the northern margin of North America and finally enter the North Atlantic. Once this species gained entrance to the North Atlantic, it was only a question of time until it reached the Miocene shores of Europe.

SUBGENUS *HEXACREUSIA* ZULLO, 1961

Balanus durhami Zullo, 1961

Figures 18–24

Balanus (*Hexacreusia*) *durhami* ZULLO, The Veliger, vol. 4, pp. 73–74, fig. 1, pl. 17, figs. 1–8.



FIGS. 18–24. *Balanus durhami* Zullo. 18. Internal view of scutum, San Esteban Island, hypotype, A.M.N.H. No. 11863. × 23.3. 19. Internal view of tergum, San Esteban Island, hypotype, A.M.N.H. No. 11863. × 23.7. 20. External view of scutum, San Esteban Island, hypotype, A.M.N.H. No. 11863. × 23.3. 21. Internal view of tergum, San Juanito Island, Tres Marías Group, hypotype, A.M.N.H. No. 11865. × 45.2. 22. Internal view of scutum, San Juanito Island, Tres Marías Group, hypotype, A.M.N.H. No. 11865. × 45.2. 23. External view of shell on *Porites californica* Verrill, Los Frailes Bay, Baja California, hypotype, A.M.N.H. No. 11864. × 5. 24. Internal view of basis embedded in *P. californica*, San Esteban Island, hypotype, A.M.N.H. No. 11864. × 3.8. Photograph by the American Museum of Natural History.

DESCRIPTION: *Balanus durhami* is a coral epizoan and has been found only on *Porites californica* Verrill (see Zullo, 1961b). The shell (fig. 23) is low, conic, spreading, and is colored a pale violet. The surface is ornamented by numerous low ribs, and it is divided into six unequal sectors by the radii and sutures. Usually the ribs extend well beyond the shell circumference. The orifice, with slight variations, is diamond-shaped. The parietes and radii are without pores. The radii are white or light pink, glossy, smooth, and moderately narrow. The summits of the radii are either sub-horizontal or flush with the orifice. The alae have sub-horizontal summits. Most of the Recent specimens have been overgrown by the host coral, and, owing to secondary calcification, the sutures, and to some extent the radii, are obliterated in most cases. Some fossil specimens show no external sutures or radii but only internal sutures. This may also be due to secondary calcification. The carinolateral compartments are extremely narrow and tend to be aborted. Disarticulated compartments reveal prominent, coarse, interlocking denticles on the radii and shallow recipient grooves on the alae. Both the sheath and inner lamina are tinted a pale violet. The sheath occupies the upper two-thirds of the shell, and the continuous basal margin depends freely. The inner lamina is very strongly ribbed from the base of the compartments to the sheath. These internal ribs are continuous with those ornamenting the external shell surface. The connection between the external and internal ribs, on the basal margin of the compartments, is strongly denticulate.

As in *Pyrgoma*, the basis (fig. 24) may be either cup-shaped or cylindrical, deep or shallow. In juvenile specimens the basis straddles the coenosteum of the coral. However, in larger forms, the basis is almost always embedded in the corallum. The basis appears to have two major growth stages. The first is characterized by a small, smooth cup which, with later growth, flares into the second stage, which is cylindrical or cup-shaped and slightly to strongly furrowed. The basis is usually poreless, but in some cases pores are present.

The opercular valves are covered with a purple-black membrane, both internally and externally. The scutum (figs. 18, 20, 22) is approximately twice as wide as high. The occludent margin is strongly pectinate; the basal margin is bisinuate. The specimens from station 36 (see below) do not have so truncate a basitergal angle as specimens from other stations (compare figs. 18 and 22). A deep, broad sulcus divides the external surface of the valve. High, irregular, growth ridges ornament the surface. The ridges appear to be slightly beaded along the crest. Internally the upper two-thirds or less of the valve is a bright purplish pink. The articular

ridge is long, slightly reflexed, and is evenly rounded basally. The articular furrow is moderately wide and shallow. On some specimens this furrow is broad and deep. The adductor ridge extends from approximately the mid-point of the tergal margin, where it is united with the articular ridge, to the rostral angle, to which it is also united; thus a bridge or shelf is formed between the two sides of the valve (see fig. 18). On a few of the specimens this union of the adductor and articular ridges does not occur (compare figs. 18 and 22). The ovate adductor muscle pit is poorly delimited. The depressor muscle pit is small, shallow, and is situated on the basal margin, in the basitergal angle. A ridge arises on the basal margin, approximately midway between the two sides, and extends upward beneath the deeply undercut adductor ridge.

The tergum (figs. 19, 21) is almost flat and is approximately one-third longer than broad. The external longitudinal furrow is broad but very shallow. The furrow lips are not infolded. The length of the spur is greater than one-third of the length of the valve. It is evenly rounded and from one-half to one-third of the width of the valve. The carinal margin is convex, and the basal margin is concave. Internally the articular ridge is erect and long; the furrow is moderately broad and shallow. Crests for the depressor muscle are numerous, long, high, and are equidistantly spaced.

REMARKS: An examination of more than 200 specimens of shallow-water stony corals showed that *Balanus durhami* was associated with only one coral, i.e., *Porites californica.* Fossil specimens of Pliocene and Pleistocene age were also found only on this species of coral, thus showing a high degree of association.

Bathymetric data are given below for each occurrence. Water temperatures ranged from 16.6° C. at station 164, to 24° C. at station 45, with a mean of 21.6° C. for the eight stations at which specimens were collected.

OCCURRENCE: *Recent:* Station 36, southeastern side of San Juanito Island, Tres Marías Group, intertidal. Station 44, off southeast side of María Magdalena Island, Tres Marías Group, 4.5–6 fathoms. Station 45, off southeast side of María Magdalena Island, Tres Marías Group, 9 fathoms. Station 86, off mouth of wash, west side of Los Frailes Bay, Baja California, 1.25 fathoms. Station 87, Pulmo Reef, Baja California, 2–4 fathoms. Station 111, southwestern side of San Francisco Island, 0.5–4 fathoms. Station 123, Aqua Verde Bay, Baja California, 1–3.25 fathoms. Station 155, ocean side of San Carlos Bay, Sonora, 1.25 fathoms. Station 158, between Red Bluff Point and Monument Point, south end of Tiburón Island, 1–3 fathoms. Station 164, southeastern end of San Esteban Island, 0–3.25 fathoms. Station 174, Puerto Refugio, north end

of Angel de la Guarda Island, intertidal. Station 175, Gonzaga Bay, Baja California, 1–3.25 fathoms. *Pleistocene:* F-5, east side of Magdalena Island, just south of Puerto Magdalena. F-6, east side of Magdalena Island, ½ mile north of Puerto Magdalena. F-26, north of San Carlos Bay and south of San Telmo Point in small cove. *Pliocene:* F-30, Marquer Bay, Carmen Island, Gulf of California.

DISTRIBUTION: This species was previously known only from the Gulf of California (Zullo, 1961b). The "Puritan" personnel collected Recent specimens of this species as far south as the Tres Marías Group, thus extending the southern range considerably.

SUBGENUS *CONOPEA* SAY, 1822

Balanus galeatus (Linnaeus), 1771

Lepas galeata LINNAEUS, 1771, Mantissa plantarum altera, p. 544 (original citation not seen).

Balanus galeatus, PILSBRY, 1907, Bull. U. S. Bur. Fish., vol. 26, p. 204, pl. 7, figs. 5–6, pl. 9, figs. 8–11.

Balanus galeatus, PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 236, fig. 75.

B[*alanus*] *galeatus*, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 126.

Balanus galaetus [*sic*], CORNWALL, 1951, Wasmann Jour. Biol., vol. 9, p. 235, pl. 3, fig. F, pl. 4, fig. A.

Usually the shell is elongated along the carinorostral axis, with the carina decidedly higher and longer than the other compartments. In most cases the shell is overgrown by the octocoral upon which this barnacle lives, but cleaning reveals that the parietes are smooth and colored pink or dark red. The radii are broad, slightly sunken, and are not permeated with pores. The basis is also usually elongated along the carinorostral axis.

The scutum is concave between the basal margin and the apex. Externally, this valve is sculptured with rather prominent striae, and its basal margin is bisinuate. The prominent, long, articular ridge terminates in a point; there is no adductor ridge. The pit for the depressor muscle is deep and short.

The apex of the tergum is truncate, and widely spaced low growth ridges ornament its exterior surface. The longitudinal furrow is shallow and open. The short parallelogrammic spur is about one-half of the width of the basal margin. Internally the articular ridge is extremely prominent; the articular furrow is deep and narrow. The depressor muscle crests are poorly developed.

REMARKS: The distribution and ecological occurrence of *B. galeatus* are governed by its association with the Octocorallia. Octocorals occupy

several different biotopes but seldom occupy those characterized by reduced salinity, dessication, or undue sedimentation (Bayer, 1956). Observations made by the author at Sea Horse Key, Florida, have shown that *B. galeatus* and its substratum *Leptogorgia setacea* (Pallas), are capable of tolerating a salinity of approximately 28 parts per thousand (unpublished data).

As a rule most octocorals live below the low-tide mark, and therefore it may be expected that this is the minimum depth at which *B. galeatus* might occur. Specimens of *B. galeatus* collected by the steamer "Albatross" were recovered from a depth of 272 fathoms (Pilsbry, 1907b, 1916). During the "Puritan" expedition specimens of this species were collected at depths ranging from 1 fathom to 50 fathoms.

OCCURRENCE: Station 87, Pulmo Reef, Baja California, 2–4 fathoms. Station 158, between Red Bluff Point and Monument Point, south end of Tiburón Island, 1–3 fathoms. Station 163, off south end of Tiburón Island, 50 fathoms. Station 165, west side of San Lorenzo Island, 1–3.25 fathoms. Station 170, southeast side of Angel de la Guarda Island, "reef" south of Pond Island, 1–3.25 fathoms. Station 175, Gonzaga Bay, Baja California, 1–3.25 fathoms.

DISTRIBUTION: According to Pilsbry (1916), this species was probably first described from the West Indies. In the western Atlantic it is known to range from South Carolina through the West Indies (Henry, 1942) to northern South America (Pilsbry, 1927; Nilsson-Cantell, 1939). Henry (1954) has reported its occurrence in the Gulf of Mexico. In the eastern Pacific *B. galeatus* was previously known only from southern California (Pilsbry, 1907b; Cornwall, 1951).

SUBFAMILY TETRACLITINAE NILSSON-CANTELL, 1921

GENUS *TETRACLITA* SCHUMACHER, 1817

Tetraclita squamosa stalactifera (Lamarck), 1818

Balanus stalactiferus LAMARCK, 1818, Histoire naturelle des animaux sans vertèbres, vol. 5, p. 394.

Tetraclita porosa var. *nigrescens* DARWIN, 1854, A monograph on the sub-class Cirripedia, p. 329, pl. 10, fig. 1c.

Tetraclita squamosa stalactifera, PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 254, pl. 59, figs. 5, 5a, 5b.

Tetraclita squamosa stalactifera, CORNWALL, *in* Steinbeck and Ricketts, 1941, Sea of Cortez, p. 430.

Tetraclita squamosa stalactifera, HENRY, 1941, Proc. New England Zool. Club, vol. 18, p. 105, pl. 16, figs. 10-14, 16.

T[*etraclita*] *squamosa stalactifera*, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 125.

Tetraclita squamosa stalactifera, HENRY, 1943, Proc. U. S. Natl. Mus., vol. 93, p. 367.

Tetraclita squamosa stalactifera, HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 147.

The shell is low conic or depressed, slightly eroded, and varies from cream-white to plumbeous black. Usually the sheath also is plumbeous black. The orifice is ovate and moderately small. The sutures are deep, narrow clefts owing to the obsolescence of the radii.

Internally the scutum is tinted violet-black, with paler, almost white, borders and adductor ridge. The adductor ridge is long, low, deeply undercut, and is separated from the articular ridge. There are usually four to six strong, oblique teeth along the occludent margin.

The tergum is narrow and is about one-half as wide as high. The distal end of the spur is obliquely truncated. Internally the carinal portion of the valve is the same color as the scutum; the scutad portion and spur are white. The numerous crests for the tergal depressor muscle are very prominent and moderately long. The articular ridge is high and strong, and the articular furrow is narrow and deep.

REMARKS: This subspecies occurs in the mid-littoral zone, in areas subjected to all degrees of wave action. The literature suggests that there is little variation in the vertical zonation of this subspecies from one region to another (Steinbeck and Ricketts, 1941; Stephenson and Stephenson, 1950, 1952; Newell *et al.*, 1959; Voss and Voss, 1960). However, Stephenson and Stephenson (1950) note that the areal distribution of *T. squamosa stalactifera* in Florida is rather erratic. They found that in some places this cirriped is totally absent, whereas in others it is quite abundant and occurs in "dense sheets or masses." Stephenson and Stephenson also observed that on the Atlantic side of the Florida Keys, *T. squamosa stalactifera* varies from being absent to fairly common. No evidence is presented to account for these differences in density.

OCCURRENCE: Station 33, below salt works, south side of María Madre Island, Tres Marías Group, intertidal. Station 36, southeastern side of San Juanito Island, Tres Marías Group, intertidal, on *Pseudochama corrugata* (Broderip).

DISTRIBUTION: In the western Atlantic this subspecies ranges from Charleston, South Carolina (Stephenson and Stephenson, 1952), to southern Brazil (Pilsbry, 1916). Newell and others (1959) and Voss and Voss (1960) record the occurrence of this subspecies at Bimini, Bahamas, the West Indies. Its occurrence has also been noted in Bermuda (Verrill, 1901; Henry, 1958). In the eastern Pacific *T. squamosa stalactifera* ranges from the Gulf of California to Acapulco, Mexico (Henry, 1941).

Nilsson-Cantell (1939) reported the occurrence of fossil *T. porosa stalactifera* (= *T. squamosa stalactifera*) in a biogenic limestone [Plio-Pleistocene?] on the northern slope of Seroe Cabaje, Porto Marie, Curaçao, and from an elevated terrace [Pleistocene?] north of Carirubana, Paraguana.

Tetraclita squamosa stalactifera forma *confinis* Pilsbry, 1916

Tetraclita squamosa stalactifera forma *confinis* PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 255, fig. 81, pl. 60, fig. 2.

Tetraclita squamosa stalactifera forma *confinis*, HENRY, 1941, Proc. New England Zool. Club, vol. 18, p. 105, pl. 16, figs. 11, 12.

Tetraclita squamosa stalactifera forma *confinis*, HENRY, 1943, Proc. U. S. Natl. Mus., vol. 93, p. 369.

Tetraclita squamosa stalactifera forma *confinis*, HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 143.

This form is easily distinguished from the nominate subspecies by its blue-gray or light gray shell. In addition, the terga are much narrower, and the spur projects only a very short distance below the basiscutal angle.

REMARKS: Hertlein and Emerson (1956) recorded the occurrence of Pleistocene specimens, probably referable to this form, from the vicinity of Puerto Peñasco, Sonora.

OCCURRENCE: Station 153, San Carlos Bay, Sonora, intertidal, on *Ostrea palmula* Carpenter.

DISTRIBUTION: Pilsbry (1916) first described this form from St. Georges Island, in the Gulf of California. It has since been described from Guaymas, Sonora (Henry, 1941, 1960), and San Francisquito Bay, Baja California (Henry, 1943).

Tetraclita squamosa rubescens Darwin, 1854

Tetraclita porosa var. *rubescens* DARWIN, 1854, A monograph on the sub-class Cirripedia, p. 329, pl. 10, fig. 1b.

Tetraclita squamosa rubescens, PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 257, pl. 61, figs. 1–1e.

Tetraclita squamosa forma *rubescens*, BROCH, 1922, Vidensk. Meddel. Dansk Naturhist. For. Kjøbenhavn, vol. 73, p. 352.

Tetraclita squamosa rubescens, HEWATT, 1935, Ecology, vol. 16, p. 250.

Tetraclita squamosa rubescens, RASMUSSEN, *in* Shelford *et al.*, 1935, Ecol. Monogr., vol. 5, p. 307.

Tetraclita squamosa rubescens, HEWATT, 1937, Amer. Midland Nat., vol. 18, p. 185.

Tetraclita squamosa rubescens, WILLET, 1937, Trans. San Diego Soc. Nat. Hist., vol. 8, p. 383.

Tetraclita squamosa rubescens, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 122, fig. 5, pl. 4, figs. 1–7.

Tetraclita squamosa rubescens, HEWATT, 1946, Ecol. Monogr., vol. 16, p. 199.

Tetraclita squamosa rubescens, CORNWALL, 1951, Wasmann Jour. Biol., vol. 9, p. 312, pl. 2, figs. A, B.

Tetraclita squamosa rubescens, EMERSON, 1956, Bull. Amer. Mus. Nat. Hist., vol. 111, p. 339.

Tetraclita squamosa rubescens, BARNES, 1959, Canadian Jour. Zool., vol. 37, p. 234.

Tetraclita squamosa rubescens, BARNES AND BARNES, 1959, Veröffentl. Inst. Meeresfor. Bremerhaven, vol. 6, p. 515.

Tetraclita squamosa rubescens, HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 147.

The walls form a high, steep-sided cone. The roughened parietes are brownish red or brownish red and white. The orifice is small, trigonal, and often subapical. The peritreme is strongly toothed.

The occludent margin of the scutum has from one to three rather long, oblique teeth. The basal margin of the valve is but slightly truncated at the basitergal angle. Internally the valve is tinted Corinthian red above the adductor ridge and white below it. The adductor ridge is long, deeply undercut, and is separated from the low, reflexed, articular ridge.

The upper portion of the tergum is Corinthian red gradually fading to white towards the spur. The width of the valve is approximately one-third of its length. The carinad portion of the basal margin is almost in line with the adjacent portion of the spur. Crests for the depressor muscle are long, narrow, and high.

REMARKS: This subspecies is the northern counterpart of the south-ranging *T. squamosa stalactifera*. It is found in the mid-littoral zone, as is the southern form, and under similar ecological conditions (Rasmussen, *in* Shelford *et al.*, 1935; Hewatt, 1935, 1937, 1946; Cornwall, 1951; Barnes and Barnes, 1959).

OCCURRENCE: Isla Barosa, Scammons Lagoon, Baja California, latitude 27° 58′ N., longitude 114° 23′ W., intertidal, on sandstone substratum, July 28, 1959.

DISTRIBUTION: This subspecies ranges from the Farallon Islands, California, to Cape San Lucas, Baja California (Pilsbry, 1916; Henry, 1942).

Tetraclita squamosa rubescens has been reported from a Pleistocene assemblage in the Baldwin Hills, Los Angeles County, California (Willet, 1937), and from a Pleistocene terrace deposit at Punta China, Baja California (Emerson, 1956).

Tetraclita squamosa rubescens forma *elegans* Darwin, 1854

Tetraclita porosa var. *elegans* DARWIN, 1854, A monograph on the sub-class Cirripedia, p. 330, pl. 10, fig. 1d.

Tetraclita squamosa rubescens forma *elegans*, PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 258, pl. 61, fig. 2.

Tetraclita squamosa rubescens forma *elegans*, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 123.

Tetraclita squamosa elegans, CORNWALL, 1951, Wasmann Jour. Biol., vol. 9, p. 316, pl. 2, figs. C, D.

Tetraclita squamosa rubescens forma *elegans*, HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 147.

The form *elegans* is distinguished from the subspecies by the low-spreading form of the shell. This infrasubspecific form is either white or a mixture of pale pink and white. These features, plus the fact that the parietes are strongly ribbed and seldom worn, should serve to distinguish this form from *T. squamosa rubescens*.

OCCURRENCE: Station 11, south side of Hughes Point, Magdalena Island, intertidal, on *Thais biserialis* (Blainville).

DISTRIBUTION: This form has been recorded from Catalina Island, California, the south end of Cedros Island, Baja California (Pilsbry, 1916), and from north of Rosario, Baja California (Henry, 1942). Its occurrence on Magdalena Island greatly extends the southern limit of this form.

FAMILY CHTHAMALIDAE DARWIN, 1854

GENUS *CHTHAMALUS* RANZANI, 1817

Chthamalus fissus Darwin, 1854

Chthamalus fissus DARWIN, 1854, A monograph on the sub-class Cirripedia, p. 462, pl. 18, figs. 6a, 6b.

Chthamalus fissus, GRUVEL, 1905, Monographie des cirrhipèdes ou thécostracés, p. 202.

Chthamalus fissus, PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 317, pl. 74, figs. 1, 1a, 1b.

Chtamalus [*sic*] *fissus*, BROCH, 1922, Vidensk. Meddel. Dansk Naturhist. For. Kjøbenhavn, vol. 73, p. 308.

Chthamalus fissus, JOHNSON AND SNOOK, 1927, Seashore animals of the Pacific coast, p. 269, figs. 222, 228.

Chthamalus fissus, RASMUSSEN, *in* Shelford *et al.*, 1935, Ecol. Monogr., vol. 5, p. 307.

Chthamalus fissus, COE AND ALLEN, 1937, Bull. Scripps Inst. Oceanogr., tech. ser., vol. 4, p. 127.

Chth[*amalus*] *fissus*, KOLOSVÁRY, 1941, Zool. Anz., vol. 133, p. 71, figs. 7f, 7i.

Chthamalus fissus, CORNWALL, *in* Steinbeck and Ricketts, 1941, Sea of Cortez, p. 432.

Chthamalus fissus, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 121.

Chthamalus fissus, HENRY, 1943, Proc. U. S. Natl. Mus., vol. 93, p. 368.

C[hthamalus] fissus, BARNES AND BARNES, 1958, Ecology, vol. 39, p. 550.
C[hthamalus] fissus, BARNES AND BARNES, 1959, Veröffentl. Inst. Meeresfor. Bremerhaven, vol. 6, p. 516.
Chthamalus fissus, HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 144.

The shell is white, depressed, and conic or tubulo-conic in shape. The olive-brown or olive cuticle is not persistent. Occasionally the ovate orifice is subapical. The parietes are usually strongly folded, and the radii are extremely narrow, but are seldom obsolete.

The scutum is white elongate, and is externally sculptured with moderately low growth striae. The articular ridge is reflexed and does not project beyond the tergal margin. The adductor ridge is strong, short, and erect. The elongate-oval adductor muscle pit is rather deep.

The tergum is nearly as wide as long, and it has nearly the shape of an equilateral triangle. The basal and carinal margins of the valve are convex. The spur is broad, extremely short, and basally broadly rounded.

REMARKS: *Chthamalus* is usually found above either the *Tetraclita* or *Balanus* zone, although at times there may be some zonal overlapping (Stephenson and Stephenson, 1950). *Chthamalus fissus* occurs high in the intertidal zone, generally above the mean high-water level (Rasmussen, *in* Shelford *et al.*, 1935; Coe and Allen, 1937; Steinbeck and Ricketts, 1941; Barnes and Barnes, 1959). This species, and other Chthamali, have often become restricted to the upper littoral zone because of their inability to compete with the faster-growing *Tetraclita* and *Balanus* (Barnes and Barnes, 1959). Physiological studies carried out by Barnes and Barnes (1959) have shown that barnacles occurring high in the littoral zone have a low intrinsic metabolic rate which is, in part, an adaptation to the habitat.

OCCURRENCE: Station 22, north of Puerto Magdalena, Magdalena Island, intertidal, on *Acanthina lugubris* forma *tyrianthina* Berry. Station 23, about 1 mile south of Puerto Cortes, Santa Margarita Island, intertidal, on *Crepidula onyx* Sowerby. Station 76, north side of Olas Altas Bay, Mazatlán, Sinoloa, intertidal, on *Acmaea mitella* Menke and *Fissurella virescens* Sowerby. Station 84, Los Frailes Bay, Baja California, intertidal, on *Purpura patula pansa* Gould.

DISTRIBUTION: Henry (1960) records the distribution for this species as Santa Barbara, California, to Guaymas, Mexico. It has been reported from San Diego (Pilsbry, 1916), San Pedro (Broch, 1922) and La Jolla, California (Broch, 1922; Coe and Allen, 1937); Ensenada, Todos Santos Bay, San Quintín, and Socorro, Baja California (Henry, 1942); and from Guaymas, Sinoloa, Mexico (Henry, 1960).

Gruvel (1905) questionably recorded this species from the coast of "Pérou" (= Peru).

Chthamalus anisopoma anisopoma Pilsbry, 1916

Chthamalus anisopoma PILSBRY, 1916, Bull. U. S. Natl. Mus., no. 93, p. 317, fig. 93, pl. 74, figs. 2–2f.

Chth[amalus] anisopoma anisopoma, KOLOSVÁRY, 1941, Zool. Anz., vol. 133, p. 76, text fig. 6a (top fig.).

Chthamalus anisopoma, CORNWALL, *in* Steinbeck and Ricketts, 1941, Sea of Cortez, p. 431, pl. 34, fig. 5, pl. 37, fig. 2.

Chthamalus anisopoma, HENRY, 1942, Univ. Washington Publ. Oceanogr., vol. 4, p. 127.

Chthamalus anisopoma, HENRY, 1943, Proc. U. S. Natl. Mus., vol. 93, p. 372, pl. 31, figs. 1–3.

Chthamalus anisopoma, HENRY, 1960, Univ. Washington Publ. Oceanogr., vol. 4, p. 144.

The compartments form a depressed cone which is covered with an olive-brown to olive-green cuticle. The parietes are strongly folded. Although poorly developed, radii are present.

The opercular valves are conspicuously disparate in size and shape. The left scutum is an equilateral triangle, whereas the right is long and narrow. Neither scutum possesses an adductor ridge. The adductor muscle pit of the left valve is small, almost round, and moderately deep, while that of the right is elongate-oval and shallow. The lateral depressor muscle pit of the right scutum is situated on the basal margin, and it is broad, but shallow. On the left valve the depressor muscle pit is crossed by a row of from two to four low crests.

The thick and heavy left tergum is irregularly oblong. The smaller right tergum is triangular. The spur on both terga is extremely small and evenly rounded distally. Crests for the depressor muscle on the left valve are sinuous, prominent, and are more numerous than those on the right valve.

OCCURRENCE: Station 91, between Lupona Point and Bonanza Point, southeast side of Espíritu Santo Island, intertidal, on *Ostrea angelica* Rochebrune.

DISTRIBUTION: Pilsbry (1916) first described this species from San Luis Gonzales Bay, on the Gulf side of Baja California. Steinbeck and Ricketts (1941) noted its occurrence at Cape San Lucas; Point Lobos, Espíritu Santo Island; San Gabriel Bay, Espíritu Santo Island; Marcial Point, Angeles Bay, and Puerto Refugio, Angel de la Guarda Island. Henry cites this species from San Francisquito Bay, Port San Carlos (1943), and Guaymas, Mexico (1960).

LITERATURE CITED

ADDICOTT, WARREN O., AND WILLIAM K. EMERSON
1959. Late Pleistocene invertebrates from Punta Cabras, Baja California, Mexico. Amer. Mus. Novitates, no. 1925, pp. 1–33, figs. 1–8, tables 1–3.

ALEEM, ANWAR ABDEL
1957. Succession of marine fouling organisms on test panels immersed in deep water at La Jolla, California. Hydrobiologica, vol. 11, no. 1, pp. 40–58, figs. 1–5, tables 1–3.

ALESSANDRI, GIULIO DE
1906. Studi monografici sui Cirripedi fossili d'Italia. Paleont. Italica, vol. 12, pp. 207–324, figs. 1–9, pls. 13–18.

BARNES, HAROLD, AND MARGARET BARNES
1959. Studies on the metabolism of cirripedes. The relation between body weight, oxygen uptake, and species habitat. Veröffentl. Inst. Meeresfor. Bremerhaven, vol. 6, pt. 2, pp. 515–523, figs. 1–2, table 1.

BAYER, FREDERICK
1956. Octocorallia. *In* Moore, R. C. (ed.), Treatise on invertebrate paleontology. Lawrence, University of Kansas Press, pt. F, Coelenterata, pp. F167–F231, figs. 134–162.

BEAL, CARL H.
1948. Reconnaissance of the geology and oil possibilities of Baja California, Mexico. Mem. Geol. Soc. Amer., no. 31, pp. i–x, 1–138, pls. 1–11.

BROCH, HJALMAR
1922. Papers from Dr. Th. Mortensen's Pacific Expedition 1914–1916. X. Studies on Pacific cirripeds. Vidensk. Meddel. Dansk Naturhist. For. Kjøbenhavn, vol. 73, pp. 215–358, figs. 1–17.
1931. Papers from Dr. Th. Mortensen's Pacific Expedition 1914–1916. LVI. Indomalayan Cirripedia. *Ibid.*, vol. 93, pp. 1–146, figs. 1–41.

BRUFF, STEPHEN C.
1946. The paleontology of the Pleistocene molluscan fauna of the Newport Bay area, California. Univ. California Publ. Geol., vol. 27, no. 6, pp. 213–240, figs. 1–12.

CHACE, E. P.
1956. Additional notes on the Pliocene and Pleistocene fauna of the Turtle Bay area, Baja California, Mexico. Trans. San Diego Soc. Nat. Hist., vol. 12, pp. 177–180.

COE, WESLEY ROSWELL
1932. Season of attachment and rate of growth of sedentary marine organisms at the pier of the Scripps Institution of Oceanography, La Jolla, California. Bull. Scripps Inst. Oceanogr., tech. ser., vol. 3, no. 3, pp. 37–86, figs. 1–3, pls. 1–6.

COE, WESLEY ROSWELL, AND W. E. ALLEN
1937. Growth of sedentary marine organisms on experimental blocks and plates for nine successive years at the pier of the Scripps Institution of Oceanography. Bull. Scripps Inst. Oceanogr., tech. ser., vol. 4, no. 4, pp. 101–136, figs. 1–6, pls. 1–2.

CORNWALL, IRA E.
1951. The barnacles of California (Cirripedia). Wasmann Jour. Biol., vol. 9,

no. 3, pp. 311–346, pls. 1–7.

1955a. The barnacles of British Columbia. British Columbia Prov. Mus., Handbook, no. 7, pp. 1–69.

1955b. Arthropoda. 10e. Cirripedia. Canadian Pacific fauna, Fish. Res. Board Canada, sect. 10, pp. 1–49, figs. 1–40.

1959. More shell figures and notes on barnacles. Canadian Jour. Zool., vol. 37, pp. 401–406, figs. 1–25.

1960. Barnacle shell figures and repairs. *Ibid.*, vol. 38, pp. 827–832, pls. 1–2.

DARWIN, CHARLES ROBERT

1851. A monograph on the sub-class Cirripedia. The Lepadidae: or, pedunculated cirripedes. London, Ray Society, pp. i–xi, 1–400, pls. 1–10.

1854. A monograph on the sub-class Cirripedia. The Balanidae, the Verrucidae, etc. London, Ray Society, pp. i–viii, 1–684, pls. 1–30.

DAVADIE-SUAUDEAU, CLAUDE

1952. Contribution a l'étude des balanidés Tertiaires de l'Algérie. Bull. Ser. Carte Géol. l'Algérie, ser. 1, paleont., no. 14, pp. 1–109, pls. 1–25.

DURHAM, J. WYATT

1950. 1940 E. W. Scripps cruise to the Gulf of California. Part 2. Megascopic paleontology and marine stratigraphy. Mem. Geol. Soc. Amer., no. 43, pp. 1–216, pls. 1–48.

EKMAN, SVEN

1953. Zoogeography of the sea. London, Sidgwick and Jackson, pp. i–xiv, 1–417, figs. 1–121.

EMERSON, WILLIAM K.

1956. Pleistocene invertebrates from Punta China, Baja California, Mexico. With remarks on the composition of the Pacific coast Quaternary faunas. Bull. Amer. Mus. Nat. Hist., vol. 111, art. 4, pp. 313–342, fig. 1, pls. 22–23, tables 1–2.

1958. Results of the Puritan-American Museum of Natural History expedition to western Mexico. 1. General account. Amer. Mus. Novitates, no. 1894, pp. 1–25, figs. 1–9.

EMERSON, WILLIAM K., AND WARREN O. ADDICOTT

1953. A Pleistocene invertebrate fauna from the southwest corner of San Diego County, California. Trans. San Diego Soc. Nat. Hist., vol. 11, no. 17, pp. 429–444.

1958. Pleistocene invertebrates from Punta Baja, Baja California, Mexico. Amer. Mus. Novitates, no. 1909, pp. 1–11, figs. 1–2.

EMERSON, WILLIAM K., AND LEO GEORGE HERTLEIN

1960. Pliocene and Pleistocene invertebrates from Punta Rosalía, Baja California, Mexico. Amer. Mus. Novitates, no. 2004, pp. 1–8, figs. 1–3.

GAVINO, CANO

1888. Crostacei raccolti dalla R. corvetta Carracciolo nel viaggo intorno al globo duranti gli anni 1881-82-83-84. Boll. Soc. Nat. Napoli, vol. 2, pp. 161–206.

GRUVEL, ABEL

1905. Monographie des cirrhipèdes ou thécostracés. Paris, Masson et Cie, pp. i–xvi, 1–472, figs. 1–427.

1907. Note preliminaire sur les cirrhipèdes operculés recueillis par l'Expédi-

tion Antarctique allemande du "Gauss." Bull. Soc. Zool. France, vol. 32, pp. 104–106.

HENRY, DORA PRIAULX

1940. The Cirripedia of Puget Sound with a key to the species. Univ. Washington Publ. Oceanogr., vol. 4, no. 1, pp. 1–48, pls. 1–4.

1941. Notes on some sessile barnacles from Lower California and the west coast of Mexico. Proc. New England Zool. Club, vol. 18, pp. 99–107, pl. 16.

1942. Studies on the sessile Cirripedia of the Pacific coast of North America. Univ. Washington Publ. Oceanogr., vol. 4, no. 3, pp. 95–134, pls. 1–4.

1943. Notes on some barnacles from the Gulf of California. Proc. U. S. Natl. Mus., vol. 93, no. 3166, pp. 367–373, pl. 31.

1954. Cirripedia: The barnacles of the Gulf of Mexico. *In* Galtsoff, P. S. (ed.), Gulf of Mexico, its origin, waters, and marine life. Fish. Bull. U. S. Fish and Wildlife Serv., vol. 55, no. 89, pp. 443–446.

1958. Intertidal barnacles of Bermuda. Jour. Marine Res., vol. 17, pp. 215–234, fig. 1, pls. 1–9.

1960. Thoracic Cirripedia of the Gulf of California. Univ. Washington Publ. Oceanogr., vol. 4, no. 4, pp. 135–158, pls. 1–5.

HERTLEIN, LEO GEORGE

1931. Additional Pliocene and Pleistocene fossils from Lower California. Jour. Paleont., vol. 5, pp. 365–367.

HERTLEIN, LEO GEORGE, AND EDWIN C. ALLISON

1959. Pliocene marine deposits in northwestern Baja California, Mexico, with a description of a new species of *Acanthina* (Gastropoda). Bull. Southern California Acad. Sci., vol. 58, pt. 1, pp. 17–26, pls. 7–8.

HERTLEIN, LEO GEORGE, AND WILLIAM K. EMERSON

1956. Marine Pleistocene invertebrates from near Puerto Peñasco, Sonora, Mexico. Trans. San Diego Soc. Nat. Hist., vol. 12, no. 8, pp. 154–176, pl. 12, maps 1–2.

1959. Results of the Puritan-American Museum of Natural History expedition to western Mexico. 5. Pliocene and Pleistocene megafossils from the Tres Marías Islands. Amer. Mus. Novitates, no. 1940, pp. 1–15, figs. 1–5, tables 1–2.

HERTLEIN, LEO GEORGE, AND ERIC KNIGHT JORDAN

1927. Paleontology of the Miocene of Lower California. Proc. California Acad. Sci., ser. 4, vol. 16, no. 19, pp. 605–647, pls. 17–21.

HEWATT, WILLIS G.

1935. Ecological succession in the *Mytilus californianus* habitats as observed in Monterey Bay, California. Ecology, vol. 16, no. 2, pp. 244–251, figs. 1–2.

1937. Ecological studies on selected marine intertidal communities of Monterey Bay, California. Amer. Midland Nat., vol. 18, no. 2, pp. 161–206, figs. 1–15, pls. 1–2.

1946. Marine ecological studies on Santa Cruz Island, California. Ecol. Monogr., vol. 16, no. 3, pp. 185–208, fig. 1, tables 1–2.

HIRO, FUJIO

1935. The fauna of Akkeshi Bay. II. Cirripedia. Jour. Fac. Sci., Hokkaido Imp. Univ., ser. 6, vol. 4, no. 4, pp. 213–230, figs. 1–5, pl. 10.

1937. Studies on cirripedian fauna of Japan. 2. Cirripeds found in the vicinity of the Seto Marine Biological Laboratory. Mem. Coll. Sci., Kyoto Imp.

Univ., ser. B, vol. 12, no. 3, art. 17, pp. 385–478, figs. 1–43.

HOPKINS, DAVID M.

1959. Cenozoic history of the Bering land bridge. Science, vol. 129, no. 3362, pp. 1519–1528, figs. 1–5.

JORDAN, ERIC KNIGHT

1936. The Pleistocene fauna of Magdalena Bay, Lower California. Contrib. Dept. Geol. Stanford Univ., vol. 1, pp. 101–173, pls. 17–19. (With an introduction by Leo George Hertlein.)

JORDAN, ERIC KNIGHT, AND LEO GEORGE HERTLEIN

1926a. Expedition to the Revillagigedo Islands, Mexico, in 1925, IV. A Pliocene fauna from Maria Madre Island, Mexico. Proc. California Acad. Sci., ser. 4, vol. 15, no. 4, pp. 209–217, pl. 23.

1926b. Expedition to the Revillagigedo Islands, Mexico, in 1925, VII. Contributions to the geology and paleontology of the Tertiary of Cedros Island and adjacent parts of Lower California. *Ibid.*, ser. 4, vol. 15, no. 14, pp. 409–464, pls. 27–34.

KANAKOFF, GEORGE P., AND WILLIAM K. EMERSON

1959. Late Pleistocene invertebrates of the Newport Bay area, California. Los Angeles Co. Mus., Contrib. Sci., no. 31, pp. 1–47, figs. 1–5.

KOLOSVÁRY, G. VON

1939. Die Cirripedien (Subordo: Balanomorpha) des Ungarischen Nationalmuseums. Ann. Mus. Nat. Hungarici, vol. 32, pp. 91–97, figs. 1–3.

1940. Über Tertiare Balaniden Ungarns. Palaeont. Zeitschr., vol. 22, pp. 105–109, pl. 1.

1942. Studien an Cirripedien. Zool. Anz., vol. 137, nos. 7–8, pp. 138–150, figs. 1–23.

1955. Über stratigraphischer Rolle der fossilen Balaniden. Acta Biol. Szeged, new ser., vol. 1, pts. 1–4, pp. 183–188.

1959. A statistical study of the Miocene balanids from Hungary. Jour. Paleont., vol. 33, no. 1, pp. 196–198.

1960. New fossil balanid localities in Hungary. *Ibid.*, vol. 34, no. 3, pp. 590–591.

KRÜGER, PAUL

1911. Beitrage zur Cirripedienfauna Ostasiens. Abhandl. Bayerischen Akad. Wiss., Math.-Phys. Kl., vol. 2, suppl., pp. 1–72, figs. 1–131, pls. 1–4.

MACDONALD, RODERICK

1929. A report on some cirripeds collected by the S. S. "Albatross" in the eastern Pacific during 1891 and 1904. Bull. Mus. Comp. Zool., Harvard College, vol. 69, no. 15, pp. 527–538, pls. 1–3.

NEWMAN, WILLIAM A.

1960. *Octolasmis californiana* spec. nov., a pedunculate barnacle from the gills of the California spiny lobster. The Veliger, vol. 3, no. 1, pp. 9–11, pl. 2.

NEWELL, NORMAN D., JOHN IMBRIE, EDWARD G. PURDY, AND DAVID L. THURBER

1959. Organism communities and bottom facies, Great Bahama Bank. Bull. Amer. Mus. Nat. Hist., vol. 117, art. 4, pp. 177–288, figs. 1–17, pls. 58–69.

NILSSON-CANTELL, CARL AUGUST

1921. Cirripeden-Studien. Zur Kenntnis der Biologie, Anatomie und Systematik dieser Gruppe. Zool. Bidr. Uppsala, vol. 7, pp. 75–395, figs. 1–89,

pls. 1–3.

1931. Revision der sammlung recenter Cirripedien des Naturhistorischen Museums in Basel. Verhandl. Naturf. Gesell. Basel, vol. 42, pp. 103–137, figs. 1–8, pl. 2.

1939. Recent and fossil balanids from the north coast of South America. Capita Zool., vol. 8, pt. 4, pp. 1–7.

ORCUTT, C. R.

1921. Pleistocene beds of San Quintin Bay, Lower California. West Amer. Sci., vol. 19, no. 3, pp. 23–24.

PALMER, ROBERT H., AND LEO GEORGE HERTLEIN

1936. Marine Pleistocene mollusks from Oaxaca, Mexico. Bull. Southern California Acad. Sci., vol. 35, pt. 2, pp. 65–81, pl. 19.

PILSBRY, HENRY A.

1907a. Notes on some Pacific cirripedes. Proc. Acad. Nat. Sci. Philadelphia, vol. 59, pp. 360–362, pl. 29.

1907b. Cirripedia from the Pacific coast of North America. Bull. U. S. Bur. Fish., vol. 26, pp. 191–204, figs. 1–4, pls. 6–11.

1907c. The barnacles (Cirripedia) contained in the collections of the U. S. National Museum. Bull. U. S. Natl. Mus., no. 60, pp. i–x, 1–122, figs. 1–36, pls. 1–11.

1916. The sessile barnacles (Cirripedia) contained in the collections of the U. S. National Museum; including a monograph of the American species. *Ibid.*, no. 93, pp. i–xi, 1–366, figs. 1–99, pls. 1–76.

1918. Cirripedia from the Panama Canal Zone. *Ibid.*, no. 103, pp. 185–188, pl. 67.

1927. Cirripedia of Curaçao. Bijdr. Dierk., vol. 25, pp. 36–37, figs. 1–3.

REEVE, LOVELL AUGUSTUS

1843. Monograph of the genus Pollicipes. *In* Conchologia iconica. London, [no pagination], pl. 1, figs. 1–5.

RIGG, GEORGE B., AND ROBERT C. MILLER

1949. Intertidal plant and animal zonation in the vicinity of Neah Bay, Washington. Proc. California Acad. Sci., ser. 4, vol. 26, no. 10, pp. 323–351, figs. 1–8.

SHELFORD, V. E., A. D. WEESE, LUCILE A. RICE, D. I. RASMUSSEN, ARCHIE MACLEAN, NETTIE M. WISMER, AND JOHN H. SWANSON

1935. Some marine biotic communities of the Pacific coast of North America. Ecol. Monogr., vol. 5, pp. 249–354, figs. 1–15.

SQUIRES, DONALD F.

1959. Results of the Puritan-American Museum of Natural History expedition to western Mexico. 7. Corals and coral reefs in the Gulf of California. Bull. Amer. Mus. Nat. Hist., vol. 118, art. 7, pp. 367–432, figs. 1–20, pls. 28–34, tables 1–7.

STEINBECK, JOHN, AND EDWARD F. RICKETTS

1941. Sea of Cortez. New York, Viking Press, pp. 1–598, pls. 1–40.

STEPHENSON, T. A., AND ANNE STEPHENSON

1950. Life between tidemarks in North America. I. The Florida Keys. Jour. Ecol., vol. 38, no. 2, pp. 354–402, figs. 1–10, pls. 9–15.

1952. Life between tidemarks in North America. II. Northern Florida and the Carolinas. *Ibid.*, vol. 40, no. 1, pp. 1–49, figs. 1–9, pls. 1–6.

UTINOMI, HUZIO (FORMERLY FUJIO HIRO)
1960. On the world-wide dispersal of a Hawaiian barnacle, *Balanus amphitrite hawaiiensis* Broch. Pacific Sci., vol. 14, no. 1, pp. 43–50, figs. 1–3, tables 1–2.

VERRILL, ADDISON E.
1901. Additions to the fauna of the Bermudas from the Yale Expedition of 1901; with notes on other species. Trans. Connecticut Acad. Arts Sci., vol. 11, pt. 1, pp. 15–62.

VOSS, GILBERT L., AND NANCY VOSS
1960. An ecological survey of the marine invertebrates of Bimini, Bahamas, with a consideration of their zoogeographical relationships. Bull. Marine Sci. Gulf and Caribbean, vol. 10, no. 1, pp. 96–116.

WELTNER, W.
1922. Cirripedia der Deutschen Tiefsee-Expedition. *In* Chun, Carl, Wissenschaftliche Ergebnisse der Deutschen Tiefsee-Expedition auf dem Dampfer "Valdivia" 1898–1899. Jena, vol. 32, no. 2, pp. 59–112, pls. 2–4.

WILLETT, GEORGE
1937. An upper Pleistocene fauna from the Baldwin Hills, Los Angeles County, California. Trans. San Diego Soc. Nat. Hist., vol. 8, no. 30, pp. 379–406, pls. 25–26.

WITHERS, THOMAS HENRY
1953. Catalogue of fossil Cirripedia in the Department of Geology. Vol. 3. Tertiary. London, British Museum (Natural History), pp. i–xv, 1–396, figs. 1–105, pls. 1–64.

ZULLO, VICTOR A.
1961a. A new whale barnacle from late Pleistocene deposits at San Quintín Bay, Baja California. The Veliger, vol. 4, no. 1, pp. 13–14, pl. 3, figs. 1–5.
1961b. A new subgenus and species of coral-inhabiting barnacle from the Gulf of California. *Ibid.*, vol. 4, no. 2, pp. 71–75, figs. 1–2, pl. 17.