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Marine Flora and Fauna of the Northeastern United States. Arthropoda: Cirripedia

Victor A. Zullo

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U.S. DEPARTMENT OF COMMERCE
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U.S. DEPARTMENT OF COMMERCE
Juanita M. Kreps, Secretary

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National Marine Fisheries Service

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FOREWARD

This issue of the "Circulars" is part of a subseries entitled "Marine Flora and Fauna of the Northeastern United States." This subseries will consist of original, illustrated, modern manuals on the identification, classification, and general biology of the estuarine and coastal marine plants and animals of the northeastern United States. Manuals will be published at irregular intervals on as many taxa of the region as there are specialists available to collaborate in their preparation.

The manuals are an outgrowth of the widely used "Keys to Marine Invertebrates of the Woods Hole Region," edited by R. I. Smith, published in 1964, and produced under the auspices of the Systematics-Ecology Program, Marine Biological Laboratory, Woods Hole, Mass. Instead of revising the "Woods Hole Keys," the staff of the Systematics-Ecology Program decided to expand the geographic coverage and bathymetric range and produce the keys in an entirely new set of expanded publications.

The "Marine Flora and Fauna of the Northeastern United States" is being prepared in collaboration with systematic specialists in the United States and abroad. Each manual will be based primarily on recent and ongoing revisionary systematic research and a fresh examination of the plants and animals. Each major taxon, treated in a separate manual, will include an introduction, illustrated glossary, uniform originally illustrated keys, annotated checklist with information when available on distribution, habitat, life history, and related biology, references to the major literature of the group, and a systematic index.

These manuals are intended for use by biology students, biologists, biological oceanographers, informed laymen, and others wishing to identify coastal organisms for this region. In many instances the manuals will serve as a guide to additional information about the species or the group.

Geographic coverage of the "Marine Flora and Fauna of the Northeastern United States" is planned to include organisms from the headwaters of estuaries seaward to approximately the 200-m depth on the continental shelf from Maine to Virginia, but may vary somewhat with each major taxon and the interests of collaborators. Whenever possible representative specimens dealt with in the manuals will be deposited in the reference collections of major museums in the region.

After a sufficient number of manuals of related taxonomic groups have been published, the manuals will be revised, grouped, and issued as special volumes. These volumes will thus consist of compilations of individual manuals within phyla such as the Coelenterata, Arthropoda, and Mollusca, or of groups of phyla.

CONTENTS

Marine Flora and Fauna of the Northeastern United States. Arthropoda: Cirripedia[1]

VICTOR A. ZULLO[2]

ABSTRACT

This manual treats the estuarine and coastal marine barnacles of the northeastern Atlantic from the Gulf of St. Lawrence to Cape Hatteras, N.C. The introduction includes a review of the general biology, classification, and diagnostic features of the five orders of Cirripedia, and an annotated species list covers those cirripeds reported from the region. The bulk of the manual is devoted to aids in the identification of barnacles (Order Thoracica), and includes an illustrated systematic key to species augmented by a discussion and glossary of morphologic terms, and a guide to study methods.

INTRODUCTION

The objectives of this manual are to provide the nonspecialist with a summary knowledge of Cirripedia and the means to locate and identify those species of barnacles encountered along the coast from the Gulf of St. Lawrence to Cape Hatteras, N.C. The barnacles of the Atlantic coast of North America have not been studied as a faunal unit and, as a consequence, most of the records of morphologic variation, ecology, and geographic distribution have come from scattered observations contributed by a number of investigators. The closest approach to a systematic survey was that of Pilsbry (1907, 1916) who monographed the American thoracican cirripeds based on museum collections. However, these early collections often were not representative either of the geographic area or of the range of environments in which individual species occur.

Cirripeds are seldom adequately represented in faunal surveys, partly because they are adapted to a wide variety of habitats, of which many are likely to be overlooked by the casual observer. For example, the diminutive burrowing acrothoracican *Trypetesa lampas* is found only in the floor and sides of the interior of the body whorl of the shells of such gastropods as *Lunatia heros* and *Polinices duplicatus*, and only when these shells are inhabited by hermit crabs. Anyone who has seen a marine turtle has probably noticed large barnacles attached to its carapace, but the same turtle may be hosting two or three additional species of as many genera embedded in the gullet, flippers, and plastron.

Another factor involves the difficulty of distinguishing cirriped taxa in the field. Many barnacles bear superficial resemblance to one another and cannot be separated without extended experience in identification or laboratory examination. Some species exhibit widely varying growth forms dependent upon such factors as crowding and substratum. Growth forms were often regarded as separate species in earlier surveys, thus multiplying the problems involved in the evaluation of past distributional records.

This manual draws on data available in the literature and on personal field observation. Emphasis is placed on the "true" barnacles (Order Thoracica), which are the most commonly encountered cirripeds. Regional representatives of the Orders Acrothoracica and Rhizocephala are included in the Annotated Systematic List and in the general discussion.

Zoogeographic considerations. The cirriped fauna of the Atlantic coast is depauperate relative to those of other coastlines at similar latitudes, and is characterized by species having broad distributional ranges. In the area under consideration only nine balanomorph ("acorn") barnacles of self-determined distribution have been recognized, and only three of these (33%) are endemic to the western Atlantic region. Within the same latitudinal range on the Pacific coast of North America (lat. 35° to 50°N) there are at least 19 species, of which 9 (47%) are confined to the eastern Pacific.

The Atlantic coast has been divided into four faunal provinces. These include a tropical province (Floridian) in southernmost Florida, a subtropical province (Carolinian) north to Cape Hatteras, a warm temperate province (Transition or Virginian) between Cape Hatteras and Cape Cod, Mass., and a cold temperate province (Boreal) north of Cape Cod. Thus in the area here considered, two faunistic regions and a major provincial boundary are included.

The inshore fauna can be divided conveniently into two parts based on mode of distribution as related to habitat. The permanent fauna is found in the region throughout the year and is dependent almost entirely on larval dispersal for its distribution, as the adults settle primarily on fixed substrata in the intertidal and subtidal. The transient fauna, on the other hand, occurs only seasonally (usually during the summer), and includes those species which normally settle on pelagic or motile objects and organisms as adults, and therefore continue

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the opportunity for dispersal throughout their adult life. The distribution of species in the permanent fauna is determined by the barnacle, whereas that of transient species is, at least during adult life, determined by the wanderings of the object to which it is attached.

The significance of this difference in habitat as related to distribution can be seen readily in the following summary of the distribution of the total fauna:

Geographic range	*Permanent fauna*	*Transient fauna*
Confined to northwest Atlantic	4	0
Confined to North Atlantic	2	0
Confined to Atlantic and Indian Oceans	1	0
Confined to Northern Hemisphere	3	3
Essentially worldwide	0	15
Total fauna	10	18

The distinction between permanent and transient components of this fauna is not always clear cut. Some permanent species can be included among those barnacles notable as fouling organisms. *Balanus eburneus* is native to the tropical and warm temperate shores of the western Atlantic, but has been introduced primarily by shipping to widely scattered parts of the world. Conversely, some fouling barnacles native to other regions occasionally are encountered in the northeast Atlantic. *Balanus amphitrite amphitrite*, spawned from parents attached to the hulls of vessels brought north from Florida, has been found living in the Cape Cod region in the fall months before temperatures dropped below adult survival limits. The tropical and subtropical species *B. calidus* and *B. trigonus* have been found on turtle barnacles attached to migrating turtles in the Cape Cod region. Also, a few species included in the transient fauna are capable of living on fixed objects. *Lepas anatifera* and *Conchoderma virgatum* are often found on sea buoys off the northeast Atlantic coast throughout the year.

GENERAL BIOLOGY

The following discussions are intended purely as an introduction to the Cirripedia. Those interested in a more comprehensive treatment of these subjects are referred to the chapter on Cirripedia by Newman et al. (1969), on which much of the following is based.

General Characteristics

Cirripeds are unique among Crustacea in having taken on an exclusively sessile habit either as free-living filter feeders or as highly specialized parasites. They are marine and estuarine organisms that are found at all depths of the oceans in a wide variety of habitats, but it is in the intertidal and on the shelf that the cirripeds have achieved their greatest development. Cirripeds are of such abundance along many shorelines that paleontologists of future times might well regard the present as the "Age of Barnacles."

In basic body plan cirripeds resemble Branchiura, Copepoda, and Mystacocarida, and have been included with these groups in the Maxillopoda of Dahl (1956). The maxillopod plan is obscured in most adult cirripeds by major body modifications related to a sessile existence, but it can be reconstructed from larval stages and from the adults of a few phylogenetically primitive species. Fundamentally, the cirriped body consists of: 1) a head region of five segments bearing (from the anterior end) first and second antennae, mandibles, and first and second maxillae; 2) a thorax of six segments, each bearing a pair of biramous appendages; and 3) a five-segment abdomen without appendages, except for a caudal furca on the last. The female genital openings are near the bases of the first thoracic appendages, whereas the male apertures are located on the first abdominal segment, or the last thoracic segment in those that have lost the abdomen.

Reproduction

Cirripedia are either separate sexed or hermaphroditic. In those with separate sexes the male is greatly reduced, consists of little more than reproductive structures, and is attached in or about the external aperture of a normal size female or hermaphrodite. In all cirripeds, eggs develop external to the body, but within the mantle cavity (body chamber) enclosing the animals. Eggs are usually deposited in sheets (lamellae) on either side of the body near the base of the mantle cavity. Sperm from a neighboring hermaphrodite or attached male is introduced into the body chamber by means of an extensible, muscular intromittent organ or penis, which is located in the midline immediately posterior to the thoracic limbs.

Development

The eggs develop into free swimming, feeding, nauplius larvae, which are released into the water column. In a few species some or all of the naupliar stages are passed within the mantle cavity. The nauplius is characterized by frontolateral horns on the dorsal shield (except in Ascothoracica), a single eye, uniramous first antennae, and biramous, natatory second antennae and mandibles. The nauplius passes through six increasingly complex stages of development.

The sixth naupliar stage metamorphoses into a cyprid larva. The cyprid possesses a bivalved carapace derived from the naupliar dorsal shield, prehensile first antennae (the second antennae are lost), compound eyes in addition to the naupliar eye, and six pairs of biramous, natatory thoracic appendages. Although the cyprid differs markedly from the nauplius, its body plan is foreshadowed in the sixth naupliar stage, which bears compound cyprid eyes and six incipient thoracic segments. The cyprid is short lived and does not appear to feed. After a period of site selection, it attaches to the substratum by means of cement glands on the first antennae and metamorphoses into the adult stage. In most endoparasitic Rhizocephala the cyprid stage is succeeded by

an internal kentrogen stage which, in turn, metamorphoses into the adult. The calcareous plates characteristic of the adult shell in Thoracica may appear before or after the bivalved cyprid carapace is cast.

Adult Arthropodal Morphology

Modifications of the maxillopod body plan take several different forms in the various groups of cirripeds. The adult rhizocephalan cannot be distinguished as either a crustacean or an arthropod. It lacks appendages and a digestive tract, and consists primarily of ramified nutritive tissues and reproductive structures. Only through larval development can the cirriped relationships of the Rhizocephla be deduced.

The remaining groups are much more conservative in their modifications, and their structural homologies are more easily recognized. Here the head segments are fused to form an enlarged sac (prosoma) bearing the head appendages and, in most, the first pair of thoracic appendages. The first antennae form the basis of attachment, the second antennae are absent, and the mandibles and the first and second maxillae are grouped together about the mouth and enclosed by the labrum or upper lip. Mandibular palps are found attached to the mandibles in Acrothoracica or to the lateral edges of the labrum in Thoracica.

These mouth parts or trophi are located on the true ventral side of the cirriped adjacent to the thorax, and serve to gather food or to handle and reduce food passed to the mouth. In the parasitic Ascothoracica, the trophi are modified to form an oral cone for piercing and sucking. In the free living Acrothoracica and Thoracica, the trophi transfer and comminute food particles gathered by the thoracic appendages.

In the parasitic Ascothoracica, the thoracic appendages are not involved in feeding and retain the natatory appearance of their cyprid homologs. Those of Acrothoracica and Thoracica, however, are used in food gathering and transfer and are much modified in form. These appendages, termed cirri, are characteristically flattened laterally, curled anteriorly, bear fine setae, and increase in length posteriorly. The first one to three pairs of cirri are usually further modified as mouth appendages and can be recognized by their shorter length, lesser curvature, and stouter appearance. In Acrothoracica, only the first pair serve as mouth appendages. They are situated on the prosoma with the trophi and are well separated from the terminal grouping of feeding cirri. In Thoracica, the anterior one to three pairs of cirri may be modified as mouth appendages, and there is no noticeable separation between these and the feeding cirri, which are arranged in linear fashion rather than as a terminal grouping. Characteristically, the feeding cirri expand into a broad fan and sweep the water in a rhythmic motion for food particles that become entrapped in the setae. As the feeding cirri are retracted, the mouth cirri remove these particles and transfer them to the trophi.

Posterior of the thoracic appendages, many Acrothoracica and some Thoracica bear a pair of caudal appendages. These appendages may range in size from barely observable nubbins to long, slender, multiarticulate limbs. The function of caudal appendages is not known, but personal observations on the feeding behavior of the British barnacle *Verruca stroemia* (Müller) suggest that they aid in environmental sensing. Caudal appendages are homologous to the caudal furca of larval stages and of adult Ascothoracia.

The function of the intromittent organ or penis located in the midline immediately posterior to the thoracic appendages has been discussed. The penis is muscular, capable of great extension, and annulate, but not segmented. Usually it bears a few setae often arranged in longitudinal rows and a denser tuft at its tip, but in some species more complex armature is present. Mention must also be made of the filamentary appendages characteristic of one group (Lepadomorpha) of Thoracica. These filaments are soft, rather fragile extensions of the body located at or near the bases of the first cirri. They have been considered to be of respiratory function, but are more probably involved in the formation of egg lamellae.

CLASSIFICATION

The Subclass Cirripedia of the Class Crustacea is divided into the following five Orders based primarily on adult life habit and form.

Order Acrothoracica

Acrothoracicans are unshelled, nonparasitic cirripeds having separate sexes. The females live in self-excavated burrows in the shells of mollusks, in coral skeleton, and in limestone, and have a full complement of trophi and from four to six pairs of cirri. The first pair of cirri is always associated with the trophi as a mouth appendage, and is separated from the posterior group of from three to five pairs of feeding cirri. Minute males are found near or about the aperture of the female, are without feeding structures, and appear to consist of little more than reproductive material. Both naupliar and cyprid larval stages are present.

Order Apoda

This order was created by Darwin (1854) for a single specimen of an enigmatic crustacean parasitic on the cirriped *Heteralepas cornuta* (Darwin) from the West Indies. This curious animal, named *Proteolepas bivincta* Darwin, has not been reported since, but as indicated by Newman et al. (1969), its morphology is equally suggestive of either a copepod or an epicaridean, and its assignment to the Cirripedia must be regarded as tentative.

Order Ascothoracica

The ascothoracicans, although highly specialized ecto- and endoparasites of corals and echinoderms, retain many, presumably primitive features. Some have separate sexes, but the majority are hermaphrodites. The

adult body, consisting of a prosoma, thorax, and abdomen, is housed in an uncalcified bivalved carapace. The prosoma bears prehensile first antennae, a pair of filamentous appendages that might represent the second antennae, and the trophi, which are modified to form an oral cone used in sucking and piercing. The six pairs of biramous thoracic appendages are not involved in feeding and retain a natatory appearance. The abdomen has five segments. The most anterior bears the penis, and the last a caudal furca. Both naupliar and cyprid larval stages are present, but the nauplii differ from those of other cirripeds in lacking frontolateral horns on the dorsal shield.

Order Rhizocephala

The Rhizocephala are parasites of crustaceans, and particularly of decapods. Until recently rhizocephalans were thought to be wholly hermaphroditic, but a few species are now known to have separate sexes. The adult is highly modified in body form and bears no resemblance to other cirripeds. The affinities of this group are exhibited only by the larval stages which include nauplii with characteristic frontolateral horns (although lacking an alimentary canal) and a cyprid. In the majority of species another larval stage, the kentrogen, composed of a mass of mesodermal cells surrounded by an ectodermal chitinous sac is produced under the old cyprid carapace. The kentrogen initiates penetration of the host tissues and is the precursor to the adult stage which consists of internal nutritive structures and an external reproductive body.

Order Thoracica

This order encompasses the majority of cirripeds and includes the true barnacles. Thoracicans are predominantly free living or commensal forms which, as adults, live attached to a variety of substrata and are most notable for their development of external calcareous armature secreted by the carapace. Their life history and adult arthropodal morphology are similar to those described for Acrothoracica, but thoracicans differ in having a serial rather than grouped arrangement of the cirri, and in the association of the palps with the labrum rather than with the mandibles. In this regard acrothoracicans might be considered as modified thoracicans that seek protection by burrowing in calcareous substrata, rather than by secreting their own calcareous shell. Most thoracicans are hermaphroditic, but in some groups minute males are found in association with normal sized hermaphrodites or females. Although instances of self fertilization have been reported, cross fertilization, enhanced by the tendency of populations to be gregarious, is the rule.

Ordinal characteristics are summarized in Table 1.

MORPHOLOGY OF THORACICA

Lepadomorpha, or "Goose Barnacles"

The goose barnacle is divided into two parts: a fleshy, muscular stalk (peduncle), and a laterally flattened carapace (capitulum). The peduncle forms the attach-

Table 1.—Summary of the general characteristics of the recognized orders of Cirripedia.

	Acrothoracica	*Ascothoracica*	*Rhizocephala*	*Thoracica*
Larval stages	6 nauplii	6 nauplii without frontolateral horns	6 nauplii without alimentary canal	6 nauplii
	cyprid	cyprid	cyprid	cyprid
	—	—	kentrogen (in most)	—
Adult				
Body	prosoma	prosoma	internal nutritive structures;	prosoma
	thorax	thorax	external reproductive body	thorax
	—	abdomen	—	—
Trophi	mouth parts for transfer and breakup of food; palps on mandibles	mouth parts formed into oral cone for piercing and sucking	none	mouth parts for transfer and breakup of food; palps on labrum
Thoracic appendages	4-6 pairs of cirri used in food gathering	6 nonfeeding pairs; natatory in appearance	none	6 pairs of cirri used in food gathering
Carapace	uncalcified	uncalcified, bivalved	none(?)	armed with external calcified plates
Reproduction	separate sexes	mostly hermaphroditic	mostly hermaphroditic	many hermaphroditic, some separate sexed
Habit	free livingg burrowing in calcareous substrata	parasites of cnidarians and echinoderms	parasites of crustaceans	mostly free living and commensals; attached to various substrata

ment with the substratum, is flexible to varying degrees, and, in some groups, is armed with spines or small calcareous plates. In all inshore lepadomorphs dealt with here, the peduncle is devoid of plates. The capitulum houses the body of the animal and usually bears external calcareous plates, whose number and arrangement are significant at the generic and, in some instances, at the specific level.

The basic number of capitular plates in lepadomorphs appears to be five. A single elongate plate (carina) extends vertically along one edge as in the spine of a book. Two pairs of plates of dissimilar size and shape cover the flattened sides. The upper pair are the terga; the lower the scuta. The orifice is located on the edge opposite the carina and between the paired scuta and terga. An adductor muscle, connecting the scuta, regulates the opening and closing of the orifice. Among local lepadomorphs, *Lepas* and *Trilasmis* bear this basic complement of capitular plates. In *Conchoderma*, however, the plates are reduced or missing and do not cover the capitulum completely.

The trophi of lepadomorphs include a large, tentlike labrum, and paired palps, mandibles, first maxillae, and second maxillae. The labrum is swollen (bullate) with a straight to gently concave cutting edge (crest) that may be lined with denticles or hairs (setae). The palps bear long, fine setae and are attached to the exterior-lateral margins of the labrum. The mandibles and maxillae are enclosed by the labrum. The pair of second maxillae are central in position and are flanked right and left by the paired first maxillae. The mandibles are situated between the first maxillae and the lateral margins of the labrum. The entire trophic complex stands above and surrounds the mouth. The shape and arrangement of teeth, denticles, and spines on the cutting edge of the mandibles, and the arrangement of spines and the shape of the cutting edge of the first maxillae appear to be related to feeding habits. These features have proven to be of systematic value at the generic and specific level.

The first pair of biramous cirri are modified, at least slightly, as mouth appendages in all lepadomorphs. In most, both the first and second pairs serve as mouth appendages, with the first exhibiting a greater degree of modification than the second.

Balanomorpha, or "Acorn Barnacles"

Acorn barnacles differ basically from goose barnacles in lacking a peduncle. The balanomorph shell, which is homologous to the calcareous plated capitulum of the lepadomorph, is attached directly to the substratum. The shell is floored by membrane or by a calcareous disc (basis). The conical shell wall is formed primitively of eight plates, including a single rostrum and carina at either end and lateral pairs of rostrolaterals, laterals, and carinolaterals. The rostrum and carina are homologs of similarly named plates of lepadomorphs, and the laterals correspond to the rostral, median, and carinal latera of the basal whorl of plates in certain multiplated lepadomorphs. The paired terga and scuta (opercular plates) framing the aperture are removed from the plates of the shell wall and are arranged symmetrically within the dorsal orifice of the shell. The opercular plates are attached at their basal edges to an opercular membrane that extends across the dorsal orifice of the shell and is itself attached to the inner surface of the wall plates (sheath). Opening and closing of the aperture and movement of the opercular plates are effected by the adductor muscle connecting the scuta, and depressor muscles extending from the basal margins of the opercular plates to the base of the shell.

The trophic complex is similar in arrangement to that of lepadomorphs. The labrum is bullate in Chthamaloidea, weakly bullate in Coronuloidea, and nonbullate with a median cleft in Balanoidea. Denticulation of the labrum, and the arrangement of denticles and spines on the cutting edges of the mandibles and first maxillae are useful systematic characteristics at the generic and specific level.

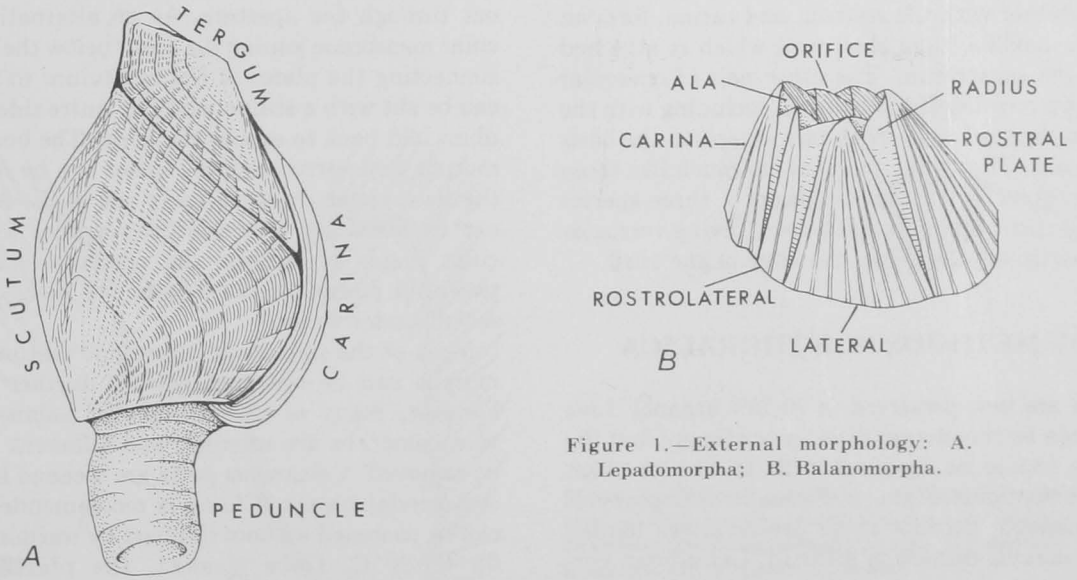


Figure 1.—External morphology: A. Lepadomorpha; B. Balanomorpha.

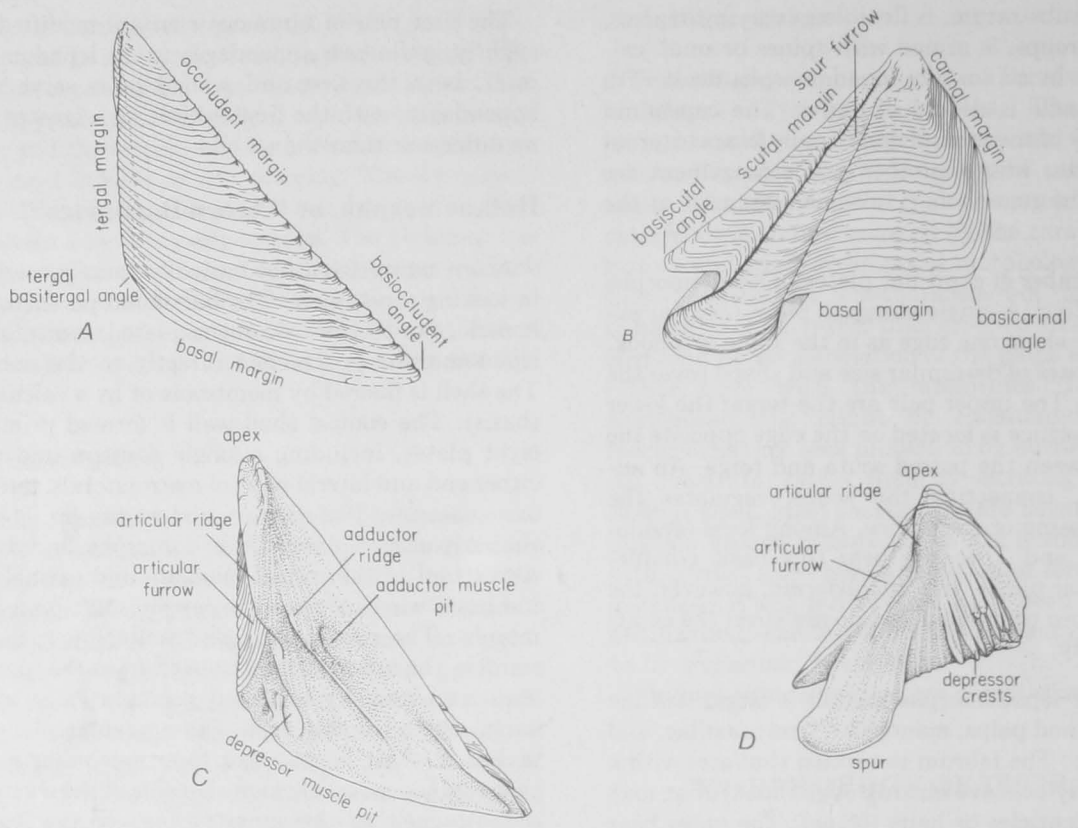


Figure 2.—Morphology of opercular plates of Balanomorpha: A. exterior of scutum; B. exterior of tergum; C. interior of scutum; D. interior of tergum.

In Chthamaloidea only the first and second cirri are modified as mouth appendages. In Coronuloidea the third cirrus is somewhat modified, and in Balanoidea the third cirrus is completely modified for use as a mouth appendage.

Verrucomorpha, or Asymmetric Barnacles

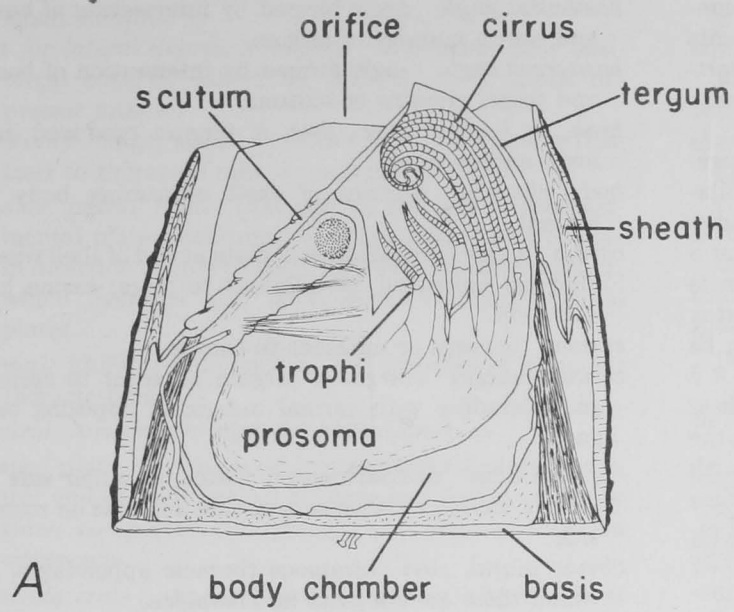
The shell of *Verruca*, the only extant verrucomorph genus, consists of four opercular plates, a rostrum, and a carina. Two of the opercular plates (paired tergum and scutum), together with the rostrum and carina, form an asymmetric, boxlike, rigid shell wall which is attached directly to the substratum. The other pair of opercular plates forms a movable lid to the box, occluding with the fixed pair in the shell wall. With rare exception the basis is membranous. The trophi and cirri are much like those of Lepadomorpha. With the exception of three species found in intertidal and subtidal waters, living verrucids are restricted to depths below the edge of the shelf.

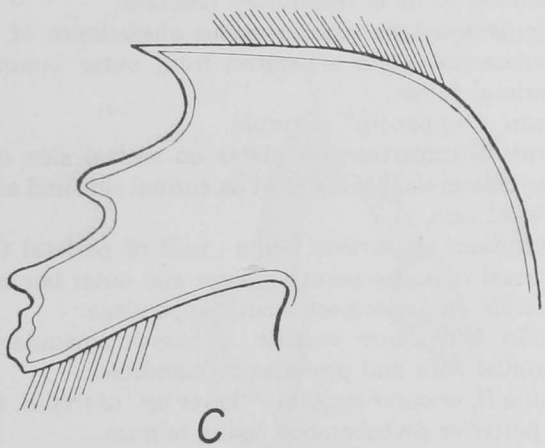
STUDY METHODS FOR THORACICA

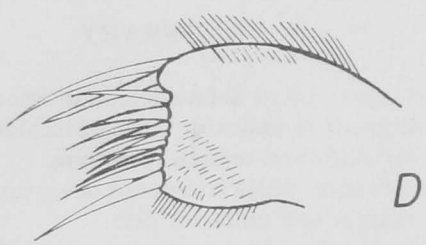
Barnacles are best preserved in 70-75% ethanol. Live specimens can be transferred directly to ethanol, but the preservative should be replaced in 24 to 48 h to offset dilution by body fluids. Fixing in Formalin or isopropyl is not recommended, because these preservatives harden the cuticle, making dissection difficult. Unbuffered Formalin softens or destroys calcareous parts. If Formalin is used, transfer the specimens to ethanol as soon as possible after thorough rinsing in water.

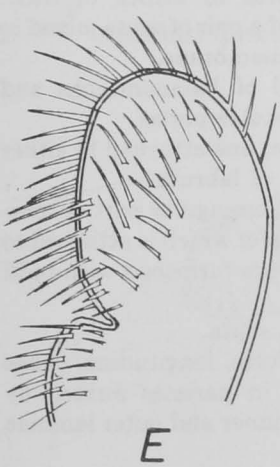
In most cases, barnacles can be identified from shell and opercular plate morphology, but it also may be necessary to examine features of the trophi and cirri, and the body of the barnacle should be removed before disarticulation and cleaning of the calcareous parts are attempted. The body of a lepadomorph is readily removed with forceps by freeing the adductor muscle from the scuta at the base of the aperture and drawing the body out through the aperture. As an alternative, the cuticular membrane joining the scuta below the aperture and connecting the plates of the capitulum to the peduncle can be slit with a scalpel and the entire side of the capitulum laid back to expose the body. The body of balanomorphs and verrucomorphs either can be removed from the base (after chipping away the basis, if present), or can be lifted out of the orifice together with the opercular plates by cutting the opercular membrane between the plates and the sheath. The body should be dissected under water.

Most of the important taxonomic features of lepadomorphs can be observed without further preparation, however, many of the features of balanomorphs and verrucomorphs are internal, and adherent tissues must be removed. Calcareous parts are cleaned by soaking in commercial bleach (Clorox is recommended). Cleaning can be hastened without ill effect by warming the bleach up to 90°C. Once cleaned, the plates are rinsed









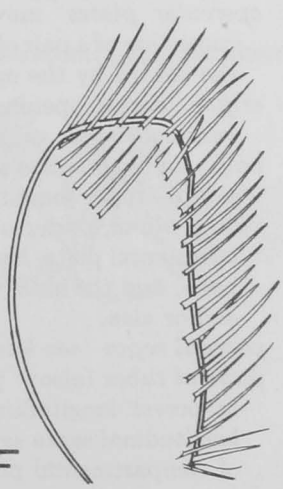


Figure 3.—Internal morphology of Balanomorpha: A. cutaway view of shell showing position and major features of body; B. biramous thoracic appendage (cirrus); C. mandible; D. maxilla I; E. maxilla II; F. palp; G. labrum.

thoroughly in water, dried, and placed in convenient containers. Curtin deep hole paleontological slide mounts are recommended for small opercular and compartmental plates. Replace the plastic cover slip with glass to reduce static electricity.

Gross characteristics of the body, such as arrangement of appendages and number and placement of filamentary appendages, are examined in water under a dissecting microscope. If dissection is required, prepare a standard microscope slide (or two if the specimen is large) either with glycerin jelly or a 3:1 mixture of Turtox media CMC-10 to CMC-S. The dissected parts can be transferred to these media directly from water. Use # 5 jewelers forceps to remove appendages from either side of the body and place in sequence (cirri I through VI) on the slide. It is convenient to arrange those of one side with the inner surface up, and the other with the outer surface up. The trophi are more difficult to dissect and will require some practice. The mouth parts can be steadied by grasping the base of the labrum with forceps at its juncture with the prosoma. Remove the mandibles and the first maxillae by pulling them out from underneath the labrum. The basally fused second maxillae are removed together and teased apart on the slide. The palps may be left on the labrum, but they often obscure the labral crest. It is best to remove at least one palp for separate mounting. The labrum is cleaned of attached musculature before mounting. A cover slip completes the preparation, although permanency is enhanced by ringing with clear nail polish.

GLOSSARY

adductor pit pit or depression on interior of scutum for attachment of adductor muscle; located between adductor ridge and occludent margin.

adductor ridge ridge on interior of scutum between tergal margin and adductor pit.

ala; plural, alae that part of the side of the compartmental plate, triangular in shape and delimited from the paries, which is overlapped by a part (radius) of the adjacent compartmental plate.

aperture opening into body chamber between paired scuta.

apex upper angle of either scutum or tergum.

articles individual segments of the thoracic limbs.

articular furrow furrow on tergal margin of scutum, or scutal margin of tergum forming part of the articulation between tergum and scutum.

articular ridge ridge on tergal margin of scutum, or scutal margin of tergum, adjacent to articular furrow, and together with articular furrow forming articulation between tergum and scutum.

basal margin lower margin of either scutum or tergum.

basicarinal angle angle formed by intersection of basal and carinal margins of tergum.

basioccludent angle angle formed by intersection of basal and occludent margins of scutum.

basis membranous tissue or calcareous plate attached to substratum; forms floor of shell.

basiscutal angle angle formed by intersection of basal and scutal margins of tergum.

basitergal angle angle formed by intersection of basal and tergal margins of scutum.

beak, or beaked apex apex of tergum produced into long, narrow point.

body chamber interior of shell containing body of animal.

carina single compartmental plate at end of shell where cirri are protruded, or adjacent to terga; carina has alae only.

carinal towards or adjacent to carina.

carinal margin margin of tergum adjacent to carina, and occluding with carinal margin of opposing tergum.

carinolaterals compartmental plates on either side of carina, having radii on carinal side and alae on rostral side.

cirrus; plural, cirri biramous thoracic appendages, of which there are six pairs in Thoracica.

compartmental plates, or compartments rigid, articulated plates forming wall of shell.

crests for depressor muscles crests or grooves on interior of tergum near basicarinal angle for attachment of depressor muscles; crests may extend apically.

filamentary appendages tapering filaments of tissue attached to base of one or more cirri, or to prosoma; believed to be of respiratory function.

inner lamina or lamella inner shell layer of compartmental plate separated from outer lamina by parietal tubes.

labrum "upper lip" of trophi.

laterals compartmental plates on rostral side of the carinolaterals, having radii on carinal side and alae on rostral side.

longitudinal or parietal septa wall of parietal tubes, normal to and separating inner and outer laminae.

mandible anteriormost mouth appendage.

maxilla I, or inner maxilla a mouth appendage set parallel with and posterior to mandible.

maxilla II, or outer maxilla "lower lip" of trophi, set on a posterior protuberance facing labrum.

occludent margin margin on rostral side of scutum, and occluding with same margin on opposing scutum.

opercular plates movable plates in orifice of shell, consisting of a pair of terga and a pair of scuta joined to the sheath by the opercular membrane.

orifice dorsal opening of shell of balanomorphs and verrucomorphs; contains opercular plates.

palp an oval, setose appendage; one attached to either side of upper margin of crest of labrum.

paries; plural, parietes central, triangular part of compartmental plate, basal margin of which is attached to basis, and the sides of which are furnished with radii and/or alae.

parietal septa see longitudinal septa.

parietal tubes (also: parietal pores, longitudinal tubes or pores) longitudinal tubes in parietes formed by longitudinal septa separating inner and outer laminae of compartmental plate.

peduncle fleshy stalk between shell and substratum in lepadomorphs.

pit for lateral depressor muscle depression near basitergal angle of scutum for attachment of lateral depressor muscle.

prosoma large, sac-like body of barnacle anterior (rostral) to thoracic limbs in position of "head."

radius; plural, radii that part of the side of compartmental plates, delimited from the paries by a change in direction of growth and a depressed exterior surface, which overlaps alae of adjacent compartd-mental plates.

ramus; plural, rami each of the branches of biramous thoracic limbs.

rostral towards or adjacent to the rostrum.

rostral plate a compound compartmental plate at rostral end of shell formed by apparent fusion of two or three compartmental plates, and bearing radii on either side.

rostrolaterals compartmental plates on either side of the rostrum, having radii both on carinal and rostral sides.

rostrum compartmental plate at end of shell opposite carina and adjacent to scuta; bears alae only.

scutal margin margin of tergum adjacent to scutum.

scutum; plural, scuta the pair of triangular opercular plates at the rostral end of the orifice.

septum; plural, septa ribs between inner and outer walls of some balanomorpha.

seta; plural, setae bristles or spines on trophi and cirri.

sheath thickened upper part of internal shell wall and alae which forms a cylindrical collar to which opercular membrane is attached.

shell a general term denoting the calcareous plates of barnacles, excepting opercular plates.

spur dependent projection on basal margin of tergum.

spur furrow or fasciole depression, furrow, or other expression on spur on exterior surface of tergum; spur furrow continues to apex in line with spur.

suture line or seam at juncture of two compartmental plates.

sutural edge edge of compartmental plate forming suture; often denticulate.

tergal margin margin of scutum adjacent to tergum.

tergum; plural, terga the pair of opercular plates at carinal end of orifice.

transverse septa septa normal to longitudinal septa and parallel to basis that divide parietal tubes into a series of cells.

trophi the mouth parts, including labrum, mandibles, maxillae, and palps.

KEY TO THORACICAN CIRRIPEDIA OF THE NORTHEASTERN COAST OF NORTH AMERICA

1 Attached to substratum by fleshy peduncle ..... Suborder Lepadomorpha 21

Figure 4.—*Lepas anatifera*: lepadomorph attached to floating board by fleshy peduncle. Scale in millimeters.

1 Attached directly to substratum; peduncle absent ..... Suborders Balanomorpha, Verrucomorpha 2

Figure 5.—*Semibalanus balanoides*: balanomorph attached directly to rock. Scale in millimeters.

2(*1*) Calcareous plate (basis) covering base of shell (NOTE: this plate may be left on substratum when barnacle is removed) 12

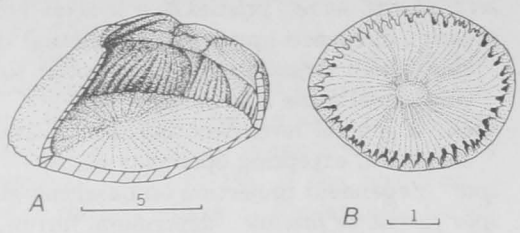


Figure 6.—A. *Balanus improvisus*, cutaway view of shell showing underlying calcareous basis; B. *Balanus crenatus*, dorsal view of calcareous basis. Scale in millimeters.

2(*1*) No basal plate; base of shell covered by membrane 3

3(*2*) Opercular plates filling dorsal orifice of shell; scutum and tergum articulated 4

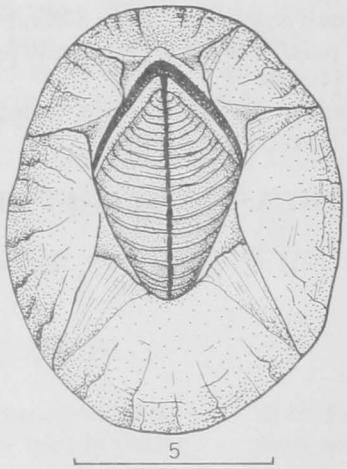


Figure 7.—*Chirona hameri*: dorsal view showing articulated opercular plates filling orifice. Scale in millimeters.

3(*2*) Opercular plates greatly reduced or absent, not filling dorsal orifice; orifice closed primarily by membrane which may be greatly produced to form false "peduncle" above shell; tergum and scutum not articulated; barnacles attached to marine mammals, turtles, some fish and crabs ..... Family Coronulidae 5

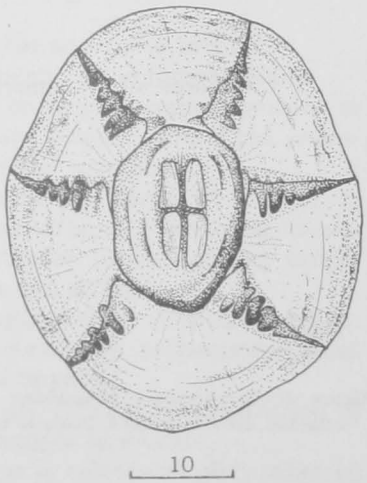


Figure 8.—*Chelonibia testudinaria*: dorsal view of shell showing reduced, unarticulated opercular plates that do not fill orifice. Scale in millimeters.

4(3) End plates of shell wall (carina and rostrum) overlapped by adjacent lateral plates; adult shell usually dark colored; found only in upper intertidal ..... *Chthamalus fragilis*

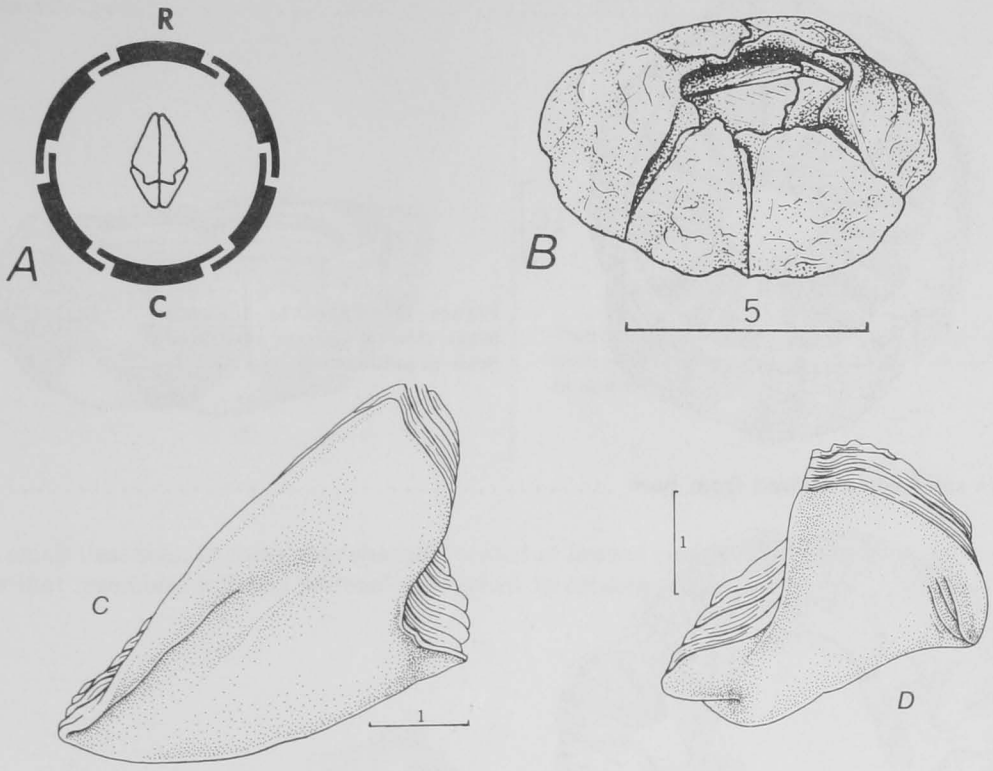


Figure 9.—*Chthamalus fragilis*: A. diagram of compartmental plate arrangement (R = rostrum; C = carina); B. lateral view of shell with opercular plates; C. interior of scutum; D. interior of tergum. Scale in millimeters.

4(3) One end plate (carina) overlapped by adjacent laterals, the other (rostral plate) overlapping adjacent laterals; adults often in dense columnar masses; usually white; in middle and lower intertidal ..... *Semibalanus balanoides*

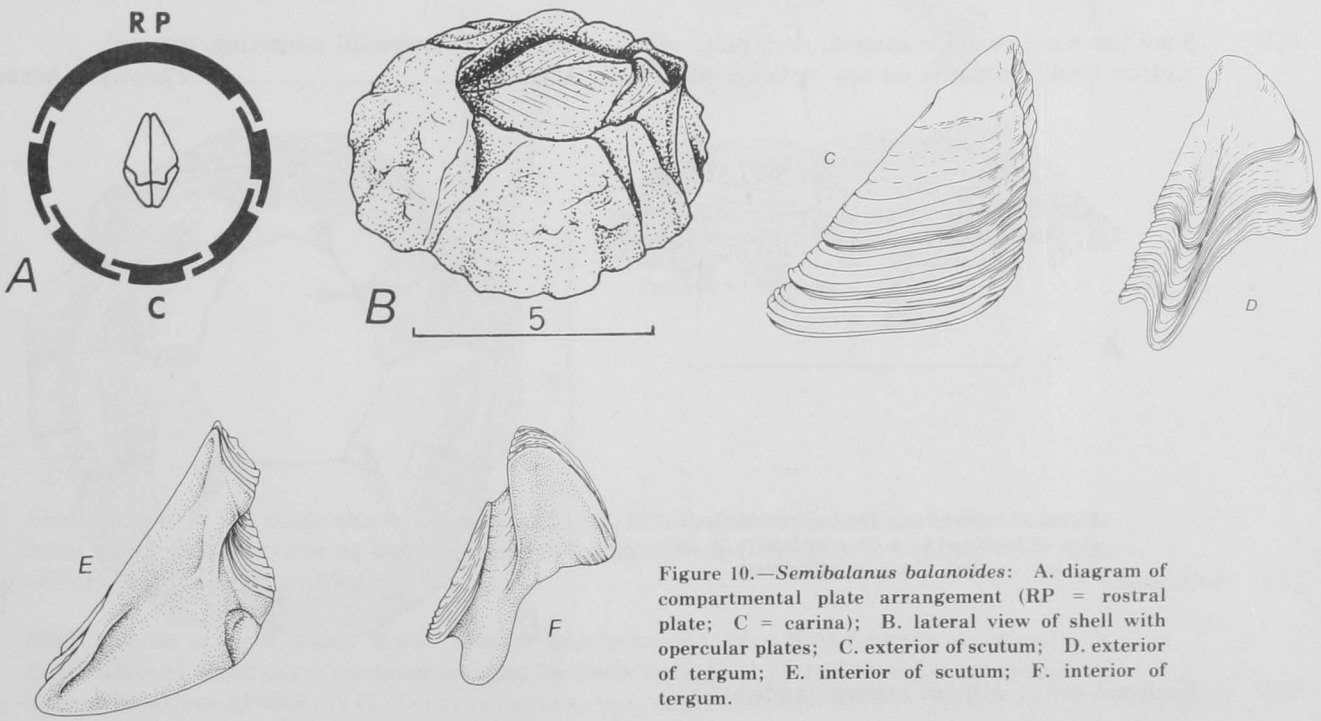


Figure 10.—*Semibalanus balanoides*: A. diagram of compartmental plate arrangement (RP = rostral plate; C = carina); B. lateral view of shell with opercular plates; C. exterior of scutum; D. exterior of tergum; E. interior of scutum; F. interior of tergum.

5(3) Plates of wall when viewed from base septate between an inner and outer wall 8

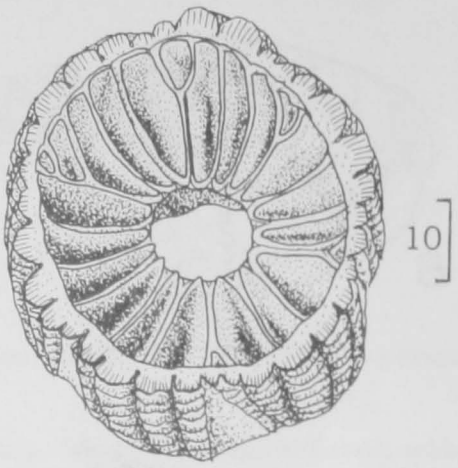


Figure 11.—*Coronula diadema*: basal view of septate shell wall. Scale in millimeters.

5(3) Shell plates solid when viewed from base 6

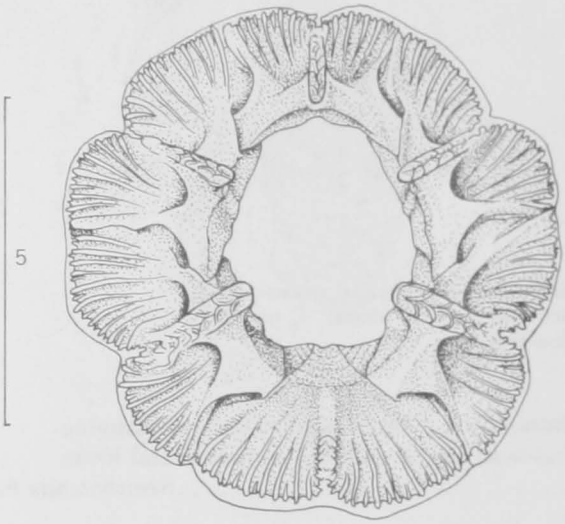
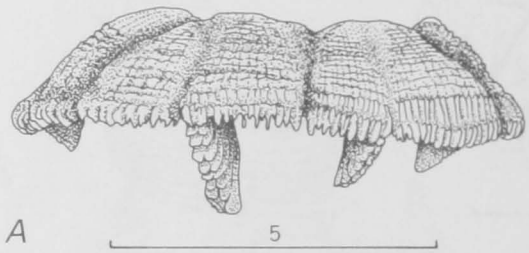


Figure 12.—*Platylepas hexastylos*: basal view of solid shell wall showing midribs. Scale in millimeters.

6(5) Shell low conic or dome shaped; each plate with a conspicuous downward projecting, internal midrib; found primarily on sea turtles in the North Atlantic ..... *Platylepas hexastylos*



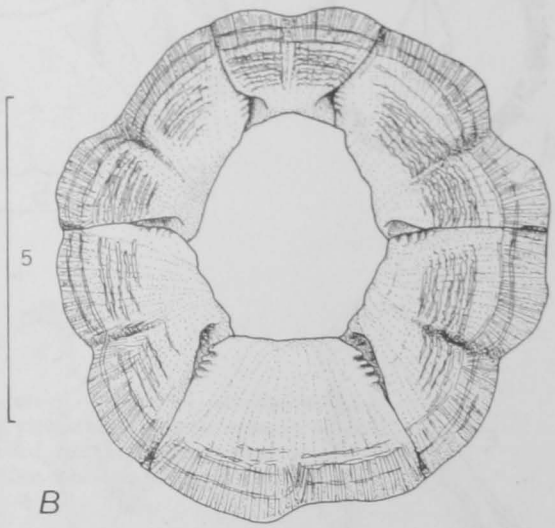


Figure 13.—*Platylepas hexastylos*: A. lateral view of shell and projecting midribs; B. dorsal view of shell. Scale in millimeters.

6(5) Shell not conic, without internal midribs 7

7(6) Shell small (2-8 mm), bowl shaped (orifice much larger than basal opening); surface of shell ornamented by numerous, small, overlapping "scales"; embedded in soft skin or in throat of sea turtles ..... *Stomatolepas elegans*

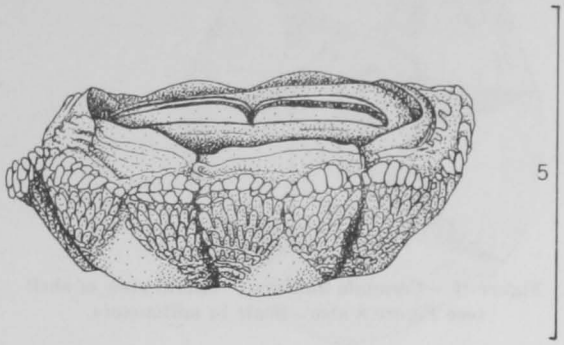


Figure 14.—*Stomatolepas elegans*: lateral view of shell with opercular plates showing "scales." Scale in millimeters.

7(6) Shell small (less than 10 mm), star shaped; located at base of greatly expanded opercular membrane that resembles a fleshy peduncle; attached to cetaceans ..... *Xenobalanus globicipitis*

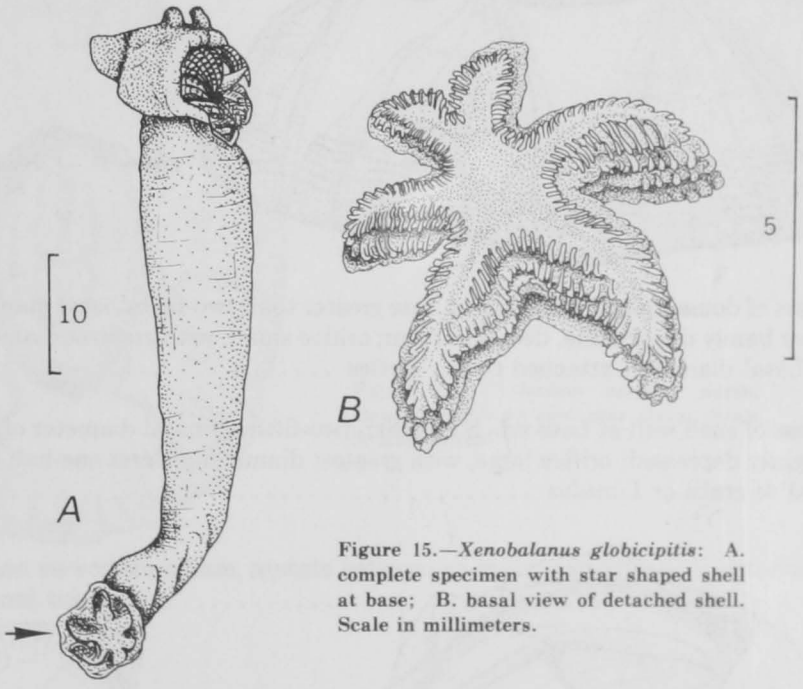


Figure 15.—*Xenobalanus globicipitis*: A. complete specimen with star shaped shell at base; B. basal view of detached shell. Scale in millimeters.

8(5) Shell conic or of low dome shape; septa of wall thin, closely spaced, unbranched, denticulate at basal edge; chamber housing body of barnacle cylindric (basal opening as wide or wider than orifice); on turtles or crabs ..... *Chelonibia* 10

8(5) Shell globose or conic; septa of wall thicker, widely spaced, branching towards outer wall, not denticulate at basal edge; chamber housing barnacle body bowl shaped (basal opening smaller than orifice); on whales ..... *Coronula* 9

9(8) Shell globose, with distinctly rounded external ribs; barely embedded in whale skin . . . *Coronula diadema*

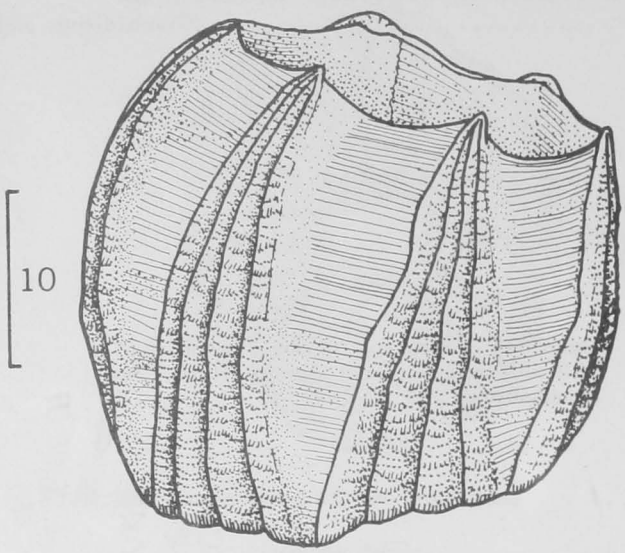


Figure 16.—*Coronula diadema*: lateral view of shell (see Figure 8 also). Scale in millimeters.

9(8) Shell low conic, with flat ribs; at least half of the shell embedded in whale skin . . . . . *Coronula reginae*

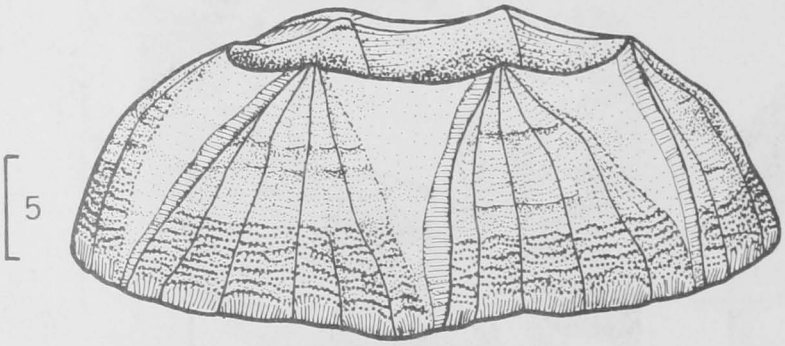


Figure 17.—*Coronula reginae*: lateral view of shell. Scale in millimeters.

10(8) Thickness of dome shaped shell wall at base greater than two-fifths basal diameter of shell; radii narrow or barely discernable, deeply sunken; orifice small, with greatest diameter less than one-half of basal diameter; attached to sea turtles 11

10(8) Thickness of shell wall at base much less than two-fifths of basal diameter of shell; radii broad, only slightly depressed; orifice large, with greatest diameter at least one-half of basal diameter; attached to crabs or *Limulus* . . . . . *Chelonibia patula*

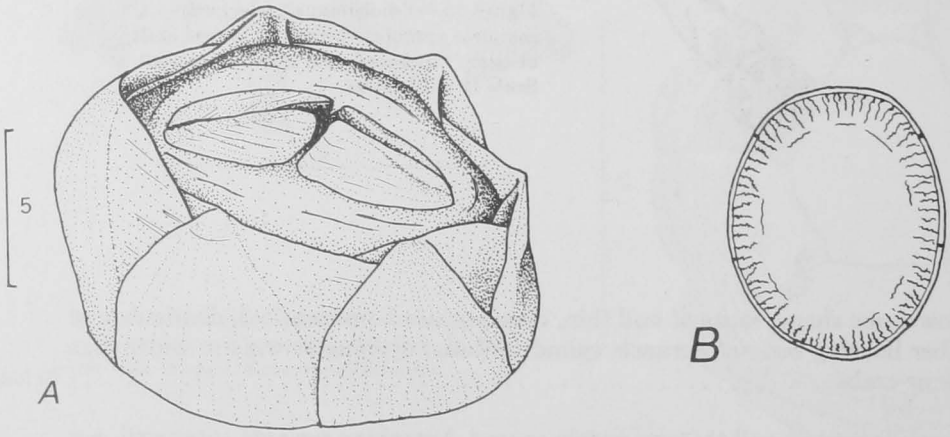


Figure 18.—*Chelonibia patula*: A. shell with opercular plates; B. diagram of base of shell wall. Scale in millimeters.

11(*10*) Radii usually transversely notched; spaces between septa of wall not filled with shell material (NOTE: spaces will be filled with tissue which can be removed with bleach); on surface of sea turtle carapace ..... *Chelonibia testudinaria*

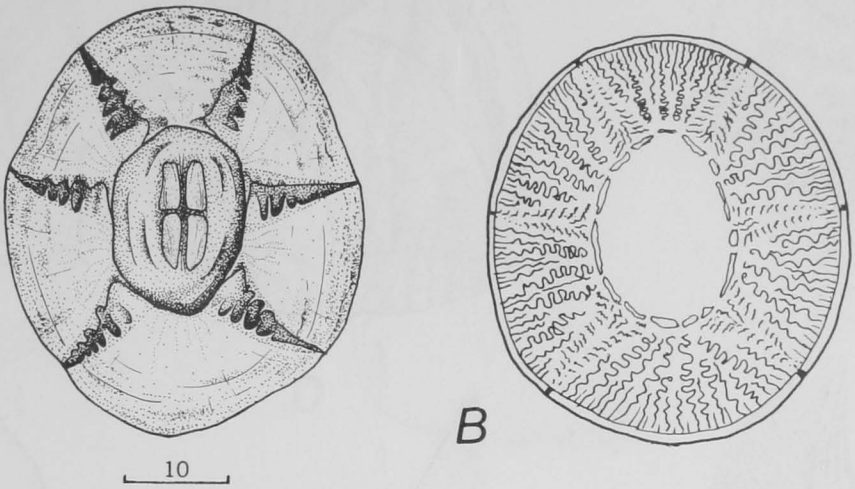


Figure 19.—*Chelonibia testudinaria*: A. dorsal view of shell with opercular plates showing notched radii; B. diagram of base of shell wall. Scale in millimeters.

11(*10*) Radii absent or very narrow, not notched; cavities between septa filled nearly to base with shell material; usually partially embedded in turtle carapace ..... *Chelonibia caretta*

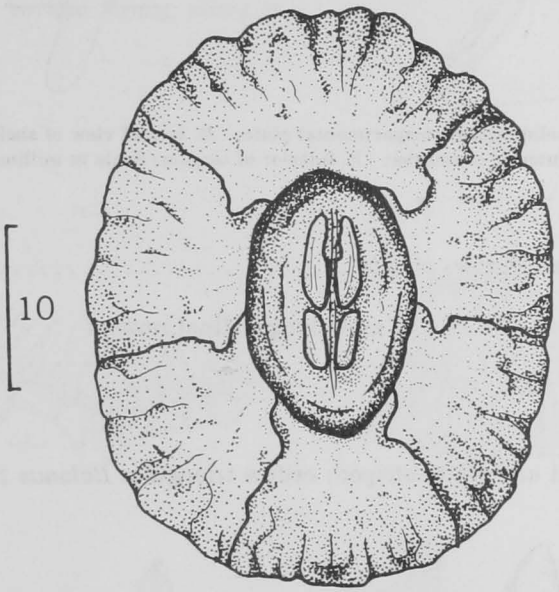


Figure 20.—*Chelonibia caretta*: dorsal view of shell with opercular plates. Scale in millimeters.

12(2) Plates of shell wall, when viewed from base, septate between an inner and outer wall, forming a single row of longitudinal tubes ..... Balanidae 13

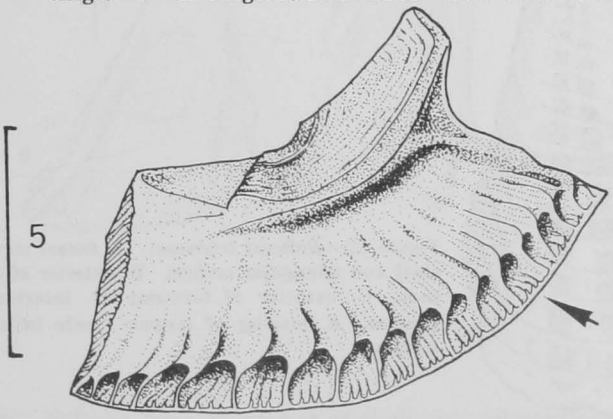


Figure 21.—*Balanus eburneus*: basal view of lateral compartmental plate showing septate shell wall and parietal tubes. Scale in millimeters.

12(2) Plates of shell wall solid when viewed from base ..... *Chirona hameri*

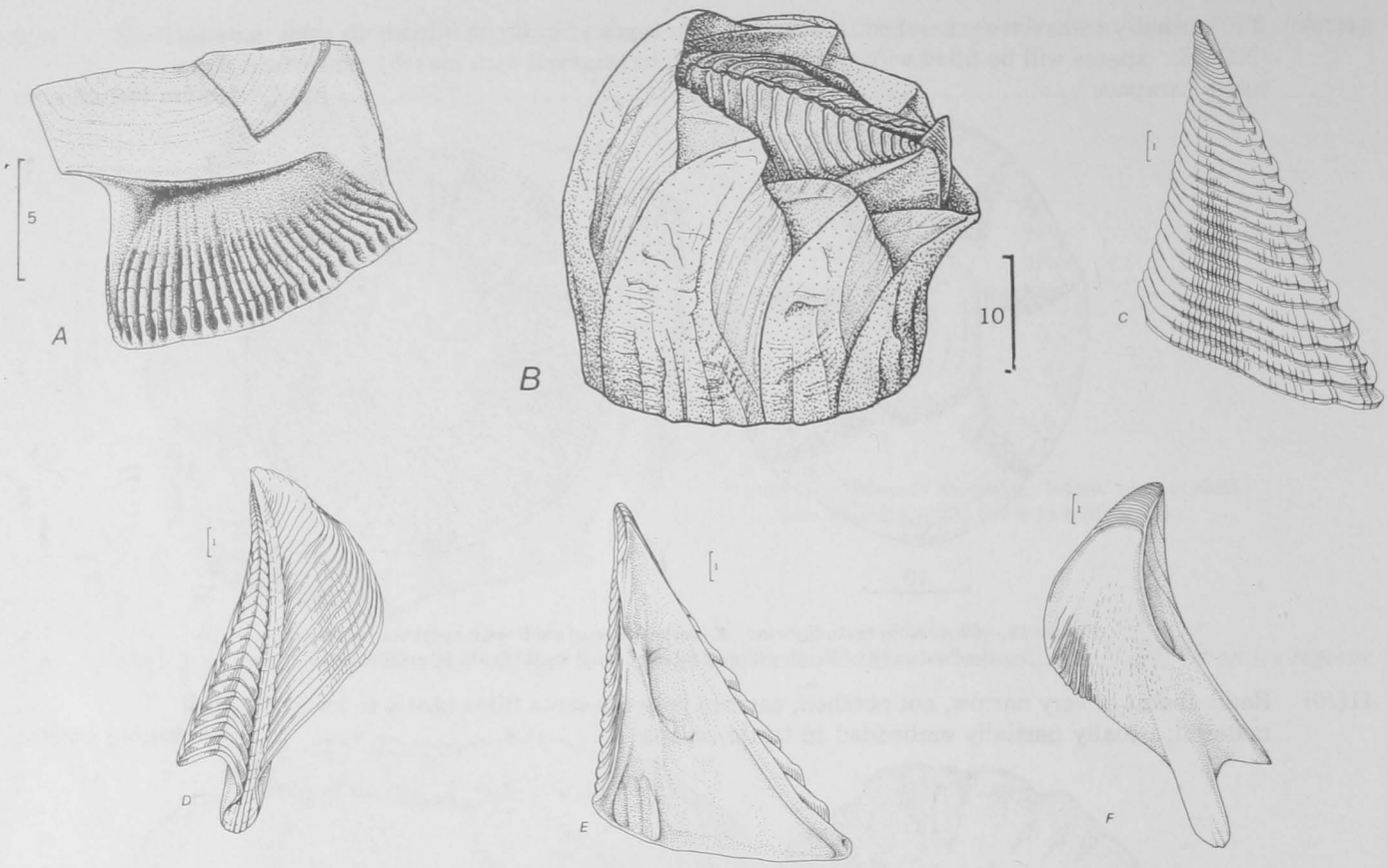


Figure 22.—*Chirona hameri*: A. basal view of internally ribbed, but solid lateral compartmental plate; B. lateral view of shell with opercular plates; C. exterior of scutum; D. exterior of tergum; E. interior of scutum; F. interior of tergum. Scale in millimeters.

13(*12*) Exterior of scutum lacking distinct longitudinal striae or rows of pits 17

13(*12*) Exterior of scutum distinctly striate longitudinally, or with one or more longitudinal rows of pits 14

14(*13*) Scutum with one or more rows of pits; shell wall red and white striped; orifice triangular *Balanus trigonus*

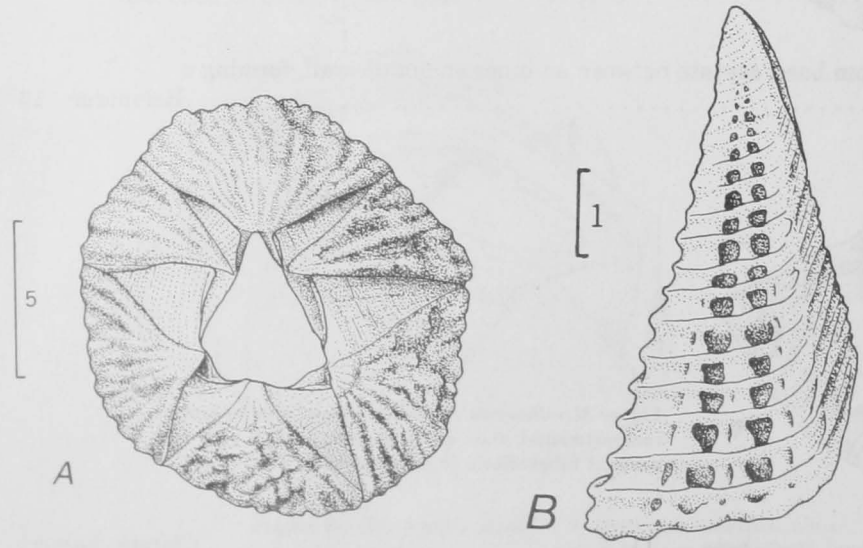
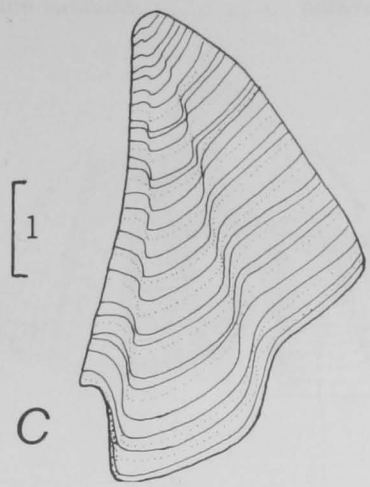
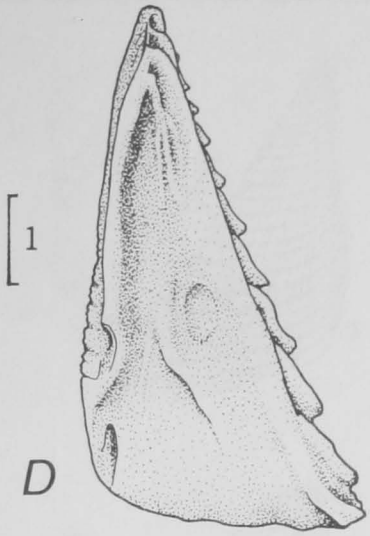
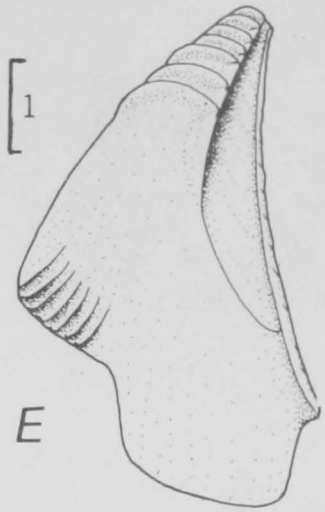


Figure 23.—*Balanus trigonus*: A. dorsal view of shell and triangular orifice; B. exterior of scutum; C. exterior of tergum; D. interior of scutum; E. interior of tergum. Scale in millimeters.

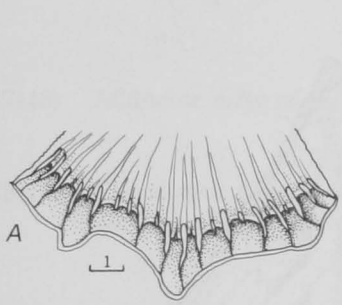


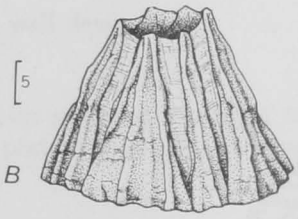


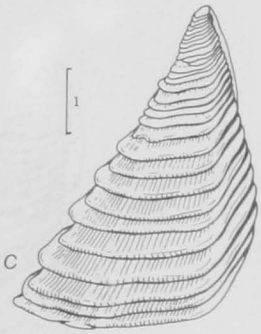


14(*13*) Scutum with distinct longitudinal striae; shell white; orifice diamond shaped 15

15(*14*) Ribs at base of interior of shell wall more numerous than septa; basal plate solid; shell with several strong, sharp ribs ..... *Balanus balanus*







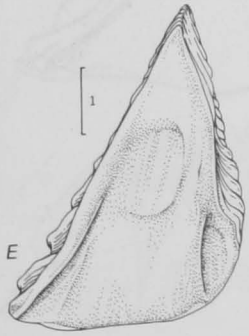


Figure 24.—*Balanus balanus*: A. basal view of compartmental plate showing internal ribs and septa; B. lateral view of ribbed shell; C. exterior of scutum; D. exterior of tergum; E. interior of scutum; F. interior of tergum. Scale in millimeters.

15(*14*) Ribs at base of interior of shell wall all continuous with septa; basis porous (see Fig. 18) 16

16(*15*) Shell wall smooth; carinal side of basal margin of tergum deeply excavated . . . . . *Balanus eburneus*

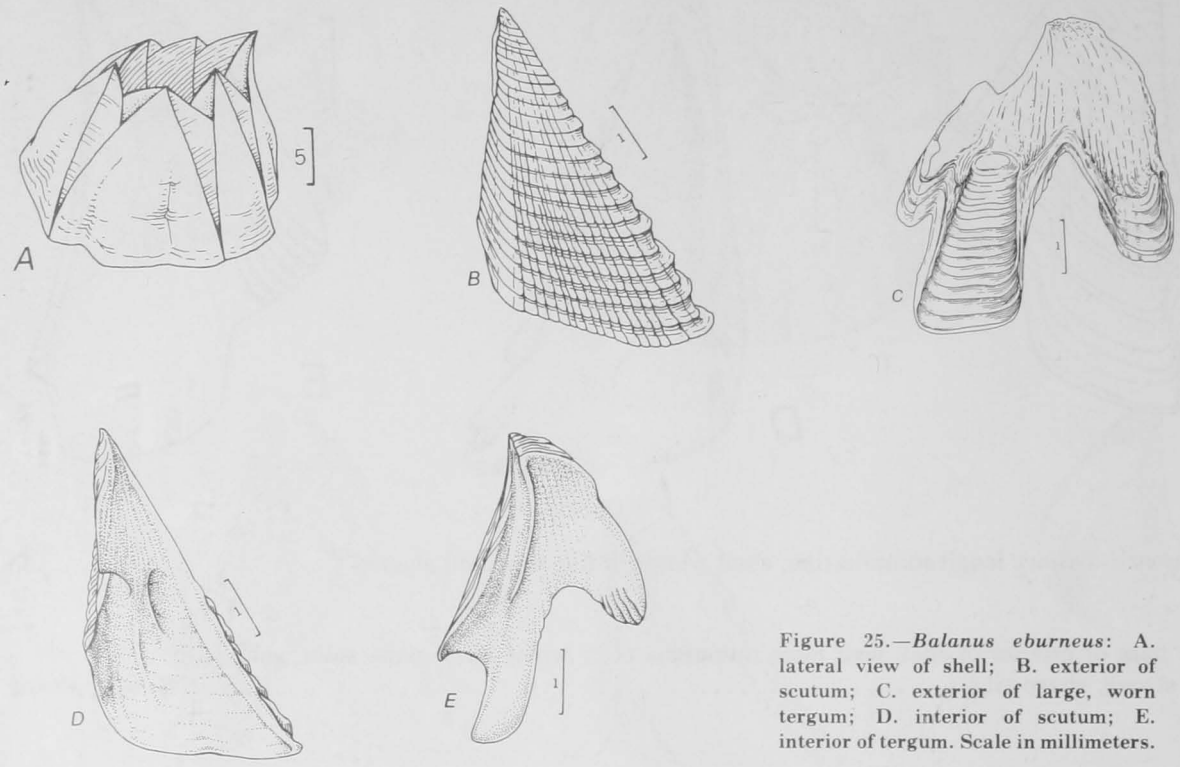


Figure 25.—*Balanus eburneus*: A. lateral view of shell; B. exterior of scutum; C. exterior of large, worn tergum; D. interior of scutum; E. interior of tergum. Scale in millimeters.

16(*15*) Shell wall plicate or with low, broadly rounded ribs; carinal side of basal margin entire . . *Balanus calidus*

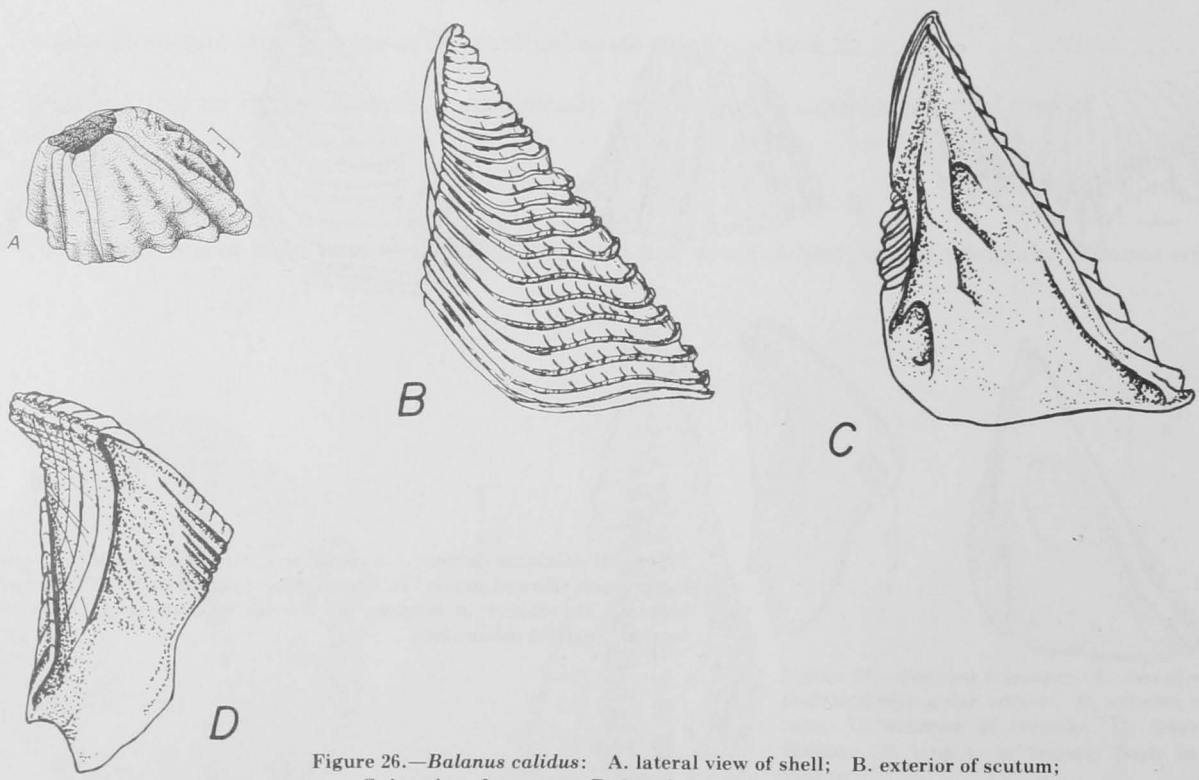


Figure 26.—*Balanus calidus*: A. lateral view of shell; B. exterior of scutum; C. interior of scutum; D. interior of tergum. Scale in millimeters.

17(*13*) Adductor ridge of scutum absent; radii usually narrow ..... *Balanus crenatus*

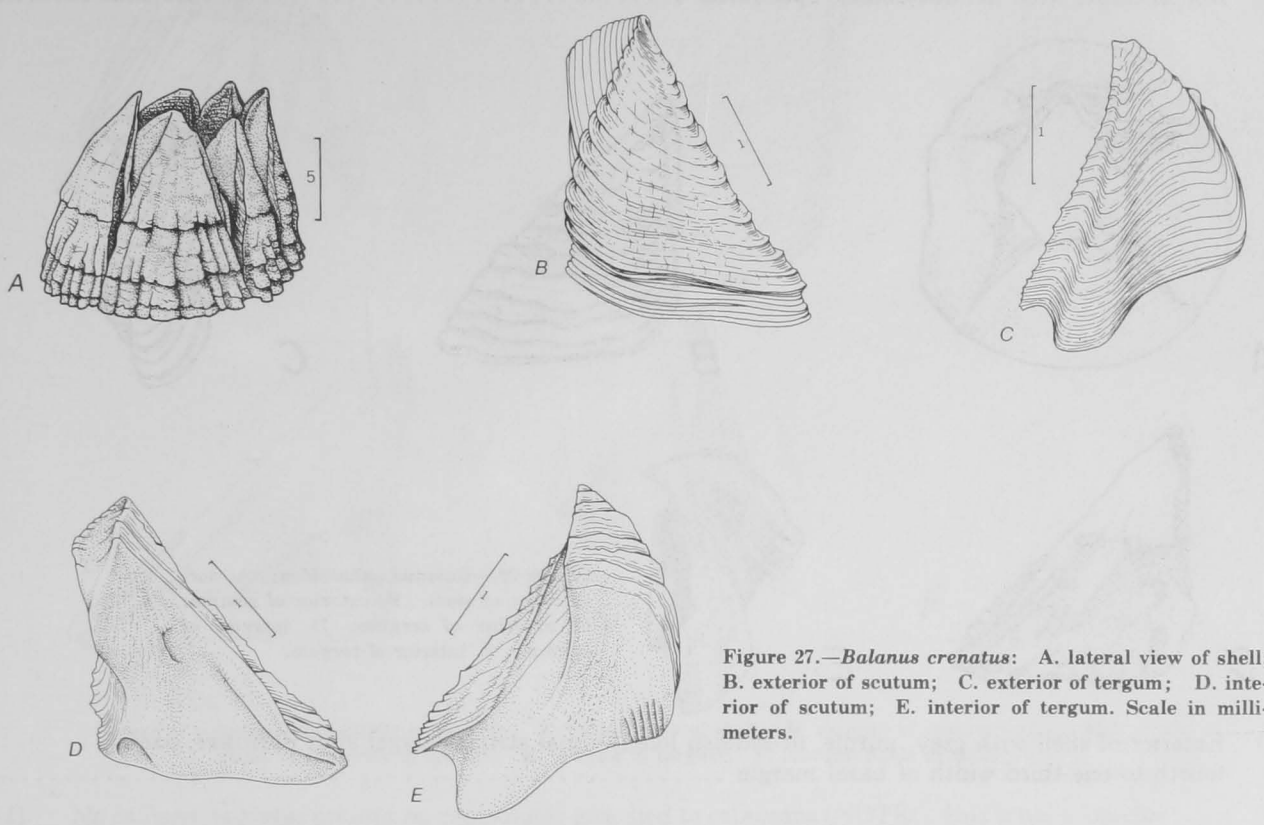


Figure 27.—*Balanus crenatus*: A. lateral view of shell; B. exterior of scutum; C. exterior of tergum; D. interior of scutum; E. interior of tergum. Scale in millimeters.

17(*13*) Adductor ridge of scutum well developed 18

18(*17*) Tergal spur narrow, less than one-fourth width of basal margin; radii narrow, not extending to parietes of adjacent shell plate; usually found in waters of low salinity ..... *Balanus improvisus*

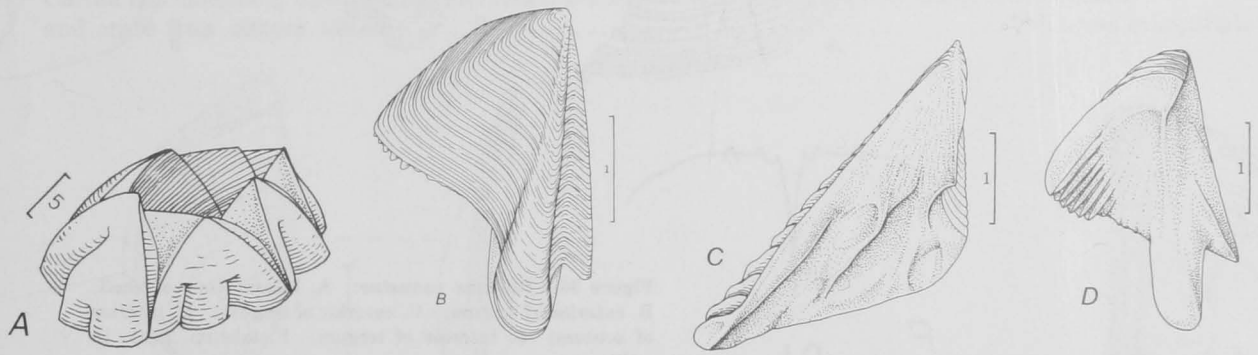


Figure 28.—*Balanus improvisus*: A. lateral view of shell with narrow radii; B. exterior of tergum; C. interior of scutum; D. interior of tergum. Scale in millimeters.

18(*17*) Tergal spur broader, at least one-fourth width of basal margin; radii narrow to broad 19

19(*18*) Shell usually white, without definite color pattern or color stripes; tergal spur about one-third width of basal margin and placed about two-fifths its own width from basiscutal angle; radii narrow in conic, wide in subcylindric specimens ..... *Balanus subalbidus*

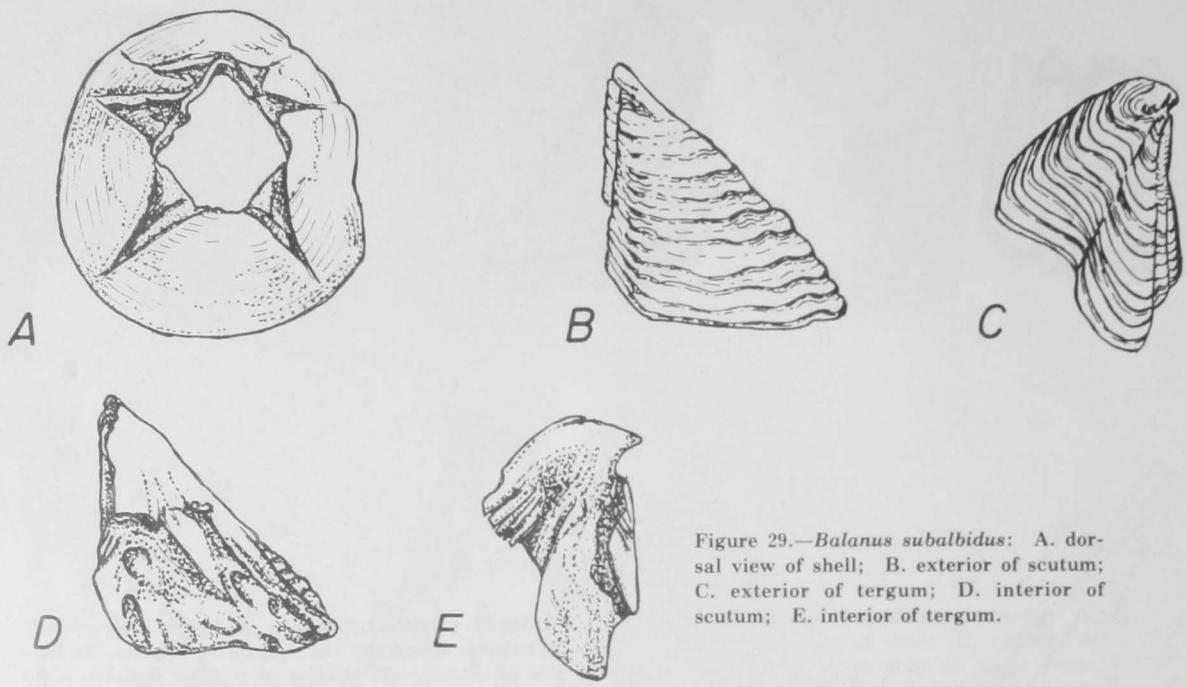


Figure 29.—*Balanus subalbidus*: A. dorsal view of shell; B. exterior of scutum; C. exterior of tergum; D. interior of scutum; E. interior of tergum.

19(*18*) Exterior of shell with gray, purple, or reddish longitudinal stripes; tergal spur narrower, one-fourth to one-third width of basal margin 20

20(*19*) Exterior of shell with narrow, regularly spaced, gray to purple longitudinal stripes; tergal spur less than one-half its own width from basiscutal angle; labrum with no more than three teeth on either side of central cleft; lowermost intertidal and subtidal ..... *Balanus venustus*

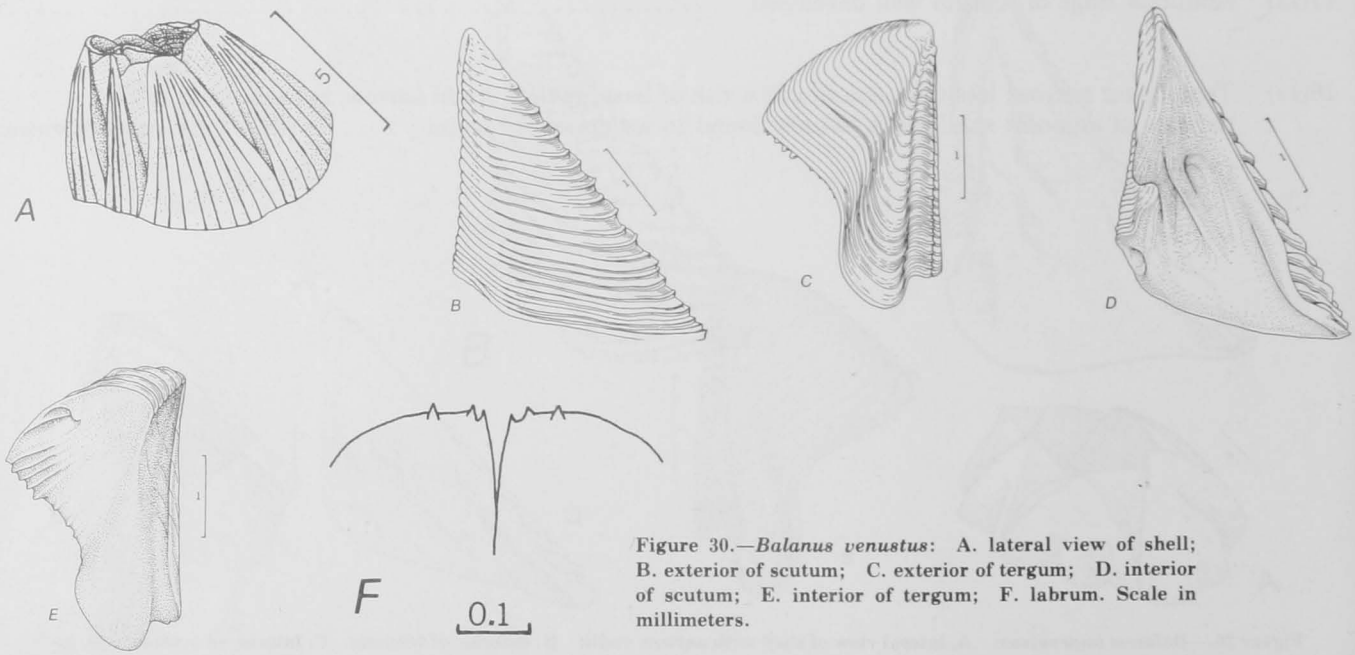


Figure 30.—*Balanus venustus*: A. lateral view of shell; B. exterior of scutum; C. exterior of tergum; D. interior of scutum; E. interior of tergum; F. labrum. Scale in millimeters.

20(*19*) Exterior of shell with broad, irregularly spaced, red-purple stripes, except on central areas of larger plates which are free of striping, leaving a broad, white band; tergal spur more than one-half its own width from basiscutal angle; labrum multidenticulate within and on either side of central cleft; usually midintertidal ..... *Balanus amphitrite amphitrite*

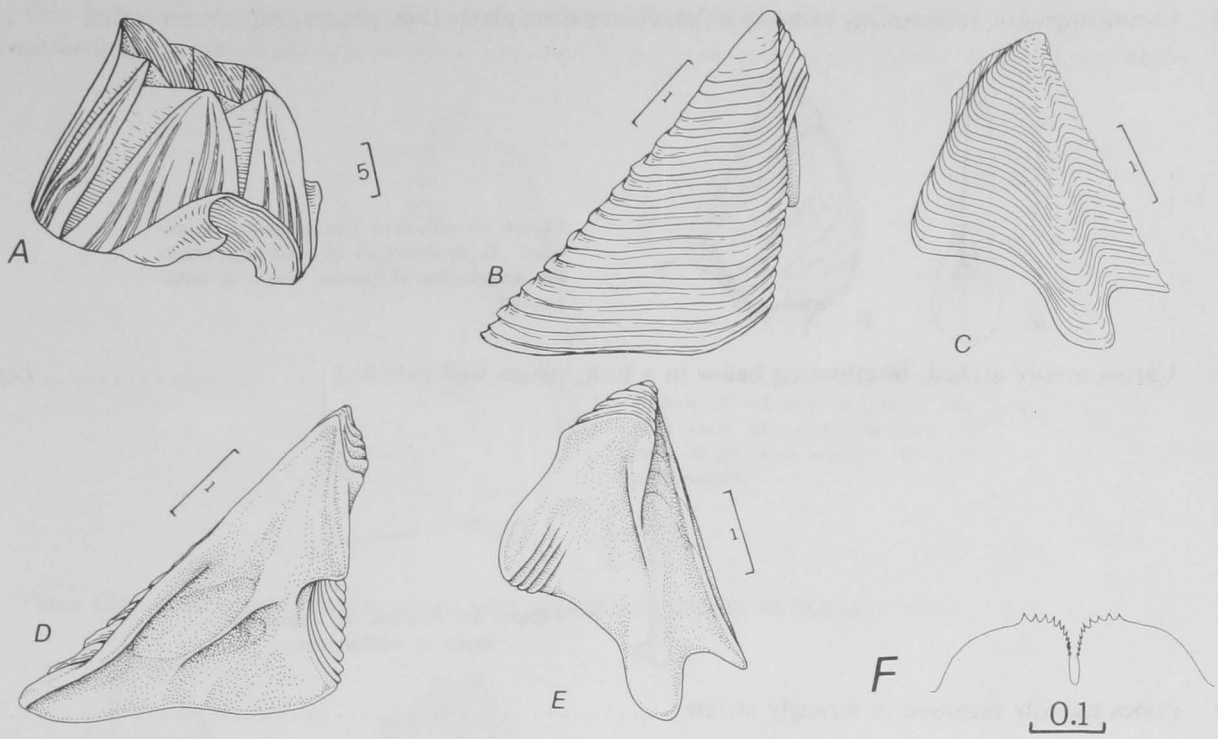


Figure 31.—*Balanus amphitrite amphitrite*: A. lateral view of shell; B. exterior of scutum; C. exterior of tergum; D. interior of scutum; E. interior of tergum; F. labrum. Scale in millimeters.

21(*1*) No calcareous plates present on capitulum; attached to cetaceans (NOTE: this is not a lepadomorph barnacle. The apparent "peduncle" is a prolongation of the opercular membrane extending out of a minute, star-shaped shell at its base. The shell is embedded in the skin of the cetacean and may be lost on removal of the barnacle. See Figure 12) ..... *Xenobalanus globicipitis*

21(*1*) Calcareous plates present on capitulum 22

22(*21*) Five calcareous plates on capitulum; plates in contact or separated by narrow interspaces 23

22(*21*) Two to five small, widely separated plates on capitulum 28

23(22) Carina not extending upward between tergal plates; shell in profile slightly skewed; on lobsters and crabs from deeper water. ..... *Trilasmis inaequilaterale*

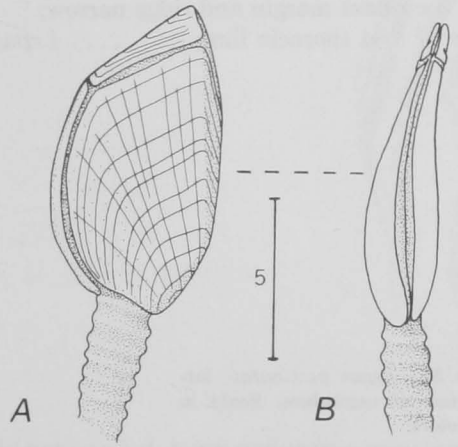


Figure 32.—*Trilasmis inaequilaterale*: A. lateral view showing placement of carina; B. apertural view showing curvature of capitulum. Scale in millimeters.

23(22) Carina extending upwards between tergal plates; shell not noticeably skewed in profile 24

24(23) Carina angulate, terminating below in a flat, oblong disc; plates thin, papery, slightly separated ..... *Dosima fascicularis*

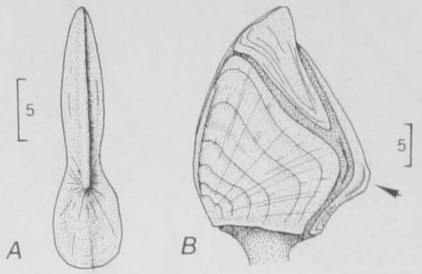


Figure 33.—*Dosima fascicularis*: A. carina; B. lateral view of capitulum showing angulation of carina. Scale in millimeters.

24(23) Carina evenly arched, terminating below in a fork; plates well calcified ..... *Lepas* 25

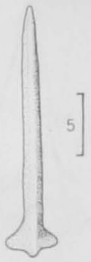


Figure 34.—Carina of *Lepas* sp. Scale in millimeters.

25(24) Plates radially furrowed or strongly striate 26

25(24) Plates smooth or minutely striate; may have one or more rows of brownish square spots diagonally across scutum and, rarely, across tergum 27

26(25) Occludent margin of scutum strongly arched; shelf between occludent margin and ridge from apex to basal margin broad; 5-6 filamentary appendages on either side of body at base of first thoracic limb ..... *Lepas anserifera*

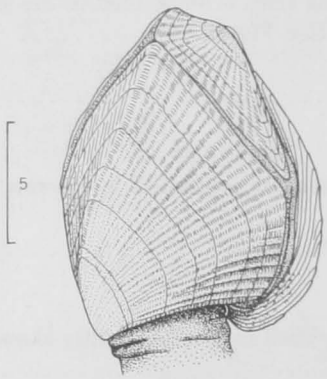


Figure 35.—*Lepas anserifera*: lateral view of capitulum. Scale in millimeters.

26(25) Occludent margin of scutum evenly curved; shelf between occludent margin and ridge narrow; 0-2 filamentary appendages on either side of body at base of first thoracic limb ..... *Lepas pectinata*

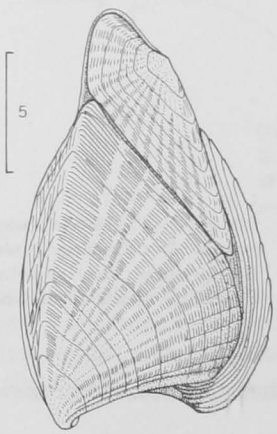


Figure 36.—*Lepas pectinata*: lateral view of capitulum. Scale in millimeters.

27(25) One or two filamentary appendages on either side of body at base of first thoracic limb; often with diagonal row of spots on scuta ..... *Lepas anatifera*

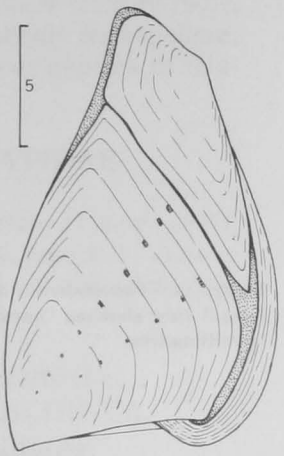


Figure 37.—*Lepas anatifera* lateral view of capitulum showing rows of spots on scutum. Scale in millimeters.

27(25) Three filamentary appendages; upper part of peduncle orange in live specimens ..... *Lepas hilli*

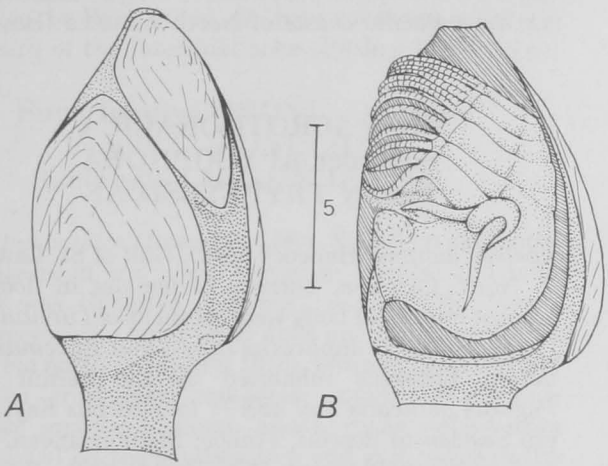


Figure 38.—*Lepas hilli*: A. lateral view of capitulum; B. cutaway of capitulum showing body with three filamentary appendages at base of first thoracic limb. Scale in millimeters.

28(22) Body traversed by dark longitudinal bands; calcareous plates small, but well developed .... *Conchoderma virgatum*

Figure 39.—*Conchoderma virgatum*: lateral view. Scale in millimeters.

28(22) Body not banded; terga and carina greatly reduced, sometimes absent in adults; a pair of large, tubular "ears" rising above capitulum behind terga ..... *Conchoderma auritum*

Figure 40.—*Conchoderma auritum*: lateral view showing "ears." Scale in millimeters.

ANNOTATED SYSTEMATIC LIST

This check list is arranged in a systematic hierarchy from class to family level. Genera are listed alphabetically within families and species within genera. Notes on distribution, habitat, and general occurrence are included with each listing. References in parentheses at the end of each listing are to publications of local importance. The classification of the Suborder Balanomorpha follows the recent revision of Newman and Ross (1976). Cross references to traditionally employed generic and specific names are provided in the Systematic Index.

Class CRUSTACEA
Subclass CIRRIPEDIA
Order RHIZOCEPHALA
Suborder KENTROGONIDA
Family PELTOGASTRIDAE

Peltogaster naushonensis Reinhard 1946. Vineyard Sound, Cape Cod, Mass.; on *Pagurus annulipes* Stimpson. 3-15 m (Reinhard 1946).

Peltogaster paguri Rathke 1843. (?)Labrador; Newfoundland to Cape Cod, Mass.; western North Atlantic; North Pacific; on *Pagurus pubescens* Krφyer. Intertidal to 157 m (Reinhard 1946).

Family SACCULINIDAE

Loxothylacus panopaei (Gissler 1884). York River, Chesapeake Bay, Va., on *Eurypanopeus depressus* (Smith); Caribbean Sea; Gulf of Mexico; (?)southern California; British Columbia. Intertidal to 250 m (Van Engel et al. 1966).

Family CLISTOSACCIDAE

Clistosaccus paguri (Lilljeborg 1861). Off Newfoundland and Nova Scotia (Grand Banks) on *Pagurus pubescens* Krφyer, in 64-66 m; North Atlantic; Bering Sea; Pacific coast of Alaska (Boschma 1928, Reinhard 1946).

Family SYLONIDAE

Sylon hyppolytes Sars 1870. Off Halifax, Nova Scotia, on *Spirontocaris spinus* (Sowerby); North Atlantic and northeast Pacific coasts of North America (Boschma 1928).

Order ACROTHORACICA
Suborder APYGOPHORA
Family TRYPETESIDAE

Trypetesa lampas (Hancock 1849). Gulf of St. Lawrence to North Carolina, burrows of females in floor and sides of interior of body whorl of shells of *Lunatia heros* (Say), *Polinices duplicatus* (Say), and *Buccinum undatum* Linnaeus inhabited by the hermit crabs *Pagurus pollicaris* Say and *P. longicarpus* Say; western Sweden to Roscoff, France; Mediterranean. Inner and outer shelf region (Tomlinson 1969; Weisbord 1975).

Order THORACICA
Suborder LEPADOMORPHA
Family LEPADIDAE

Conchoderma auritum (Linnaeus 1767). Cosmopolitan; attached to whale barnacles and occasionally to ships. Open surface waters (Pilsbry 1907).

Conchoderma virgatum (Spengler 1790). Cosmopolitan; on ships, offshore buoys, and fish; common in clusters attached to the copepod *Penella* that is parasitic on the sunfish *Mola mola* (Linnaeus) (Pilsbry 1907).

Dosima fascicularis (Ellis and Solander 1786). Cosmopolitan; on floating seaweed and driftwood in open water; found throughout the summer months in inshore waters (Pilsbry 1907).

Lepas anatifera Linnaeus 1758. Cosmopolitan; attached to floating seaweed and driftwood in open water; common inshore and on beaches during July and August (Pilsbry 1907).

Lepas anserifera Linnaeus 1767. Cosmopolitan; attached to floating sargassum weed and driftwood and

occasionally on whales in open water; most abundant in Gulf Stream waters (Pilsbry 1907).

Lepas hilli (Leach 1818). North Atlantic and North Pacific on floating debris; rare inshore (Pilsbry 1907).

Lepas pectinata Spengler 1793. Probably cosmopolitan; on floating seaweed and driftwood; appears in mid-July inshore (Pilsbry 1907).

Family POECILASMATIDAE

Trilasmis (*Poecilasma*) *inaequilaterale* (Pilsbry 1907). Attached to crustacean carapaces, especially those of geryonid crabs and *Homarus*. Occurs mainly at slope depths (Pilsbry 1907).

Suborder BALANOMORPHA
Superfamily CHTHAMALOIDEA
Family CHTHAMALIDAE
Subfamily CHTHAMALINAE

Chthamalus fragilis Darwin 1854. Cape Cod, Mass., south to the West Indies. On hard substrata in the upper third of the intertidal zone (Pilsbry 1916).

Superfamily CORONULOIDEA
Family CORONULIDAE
Subfamily CHELONIBIINAE

Chelonibia caretta (Spengler 1790). Found on carapaces of loggerhead and green turtles in tropical and temperate seas. Reported as far north as Cape Cod, Mass., on loggerheads (Zullo 1963; Zullo and Bleakney 1966).

Chelonibia patula (Ranzani 1818). Worldwide in warmer seas on crustacean carapaces; commonly on *Callinectes sapidus* Rathbun and *Limulus polyphemus* (Linnaeus) on the southeastern and gulf coasts of the United States; occasionally on aged female *Callinectes* in Chesapeake Bay (Van Engel 1972).

Chelonibia testudinaria (Linnaeus 1758). Worldwide in warmer seas on carapaces of marine turtles. Reported as far north as Newport, R.I., on a loggerhead (Pilsbry 1916).

Subfamily PLATYLEPADINAE

Platylepas hexastylos (Fabricius 1798). Worldwide in tropical and warm temperate seas on turtles, manatees, dugongs, and the gar *Lepisosteus*. Reported from loggerhead turtles from Delaware Bay, N.J. (Pilsbry 1916) and Cape Cod, Mass. (Zullo and Bleakney 1966).

Subfamily CORONULINAE

Coronula diadema (Linnaeus 1767), and

Coronula reginae Darwin 1854. The two species of *Coronula* found in the North Atlantic occur primarily on the humpback whale, but are known also from sperm and finback whales. They attach primarily to the underlip, throat, fins, and flukes. *Coronula reginae* is often associated with *C. diadema*, but is rarer and more deeply embedded in the skin (Pilsbry 1916).

Stomatolepas elegans (Costa 1838). Worldwide in warmer seas, embedded in the soft skin and throat of marine turtles. Reported as far north as Nova Scotia on leatherbacks (Zullo and Bleakney 1966).

Xenobalanus globicipitis Steenstrup 1851. Known from the North and South Atlantic, Mediterranean, and South Pacific on Ca'ing and finback whales and porpoises. Reported from the flippers of the Ca'ing whale, *Globiocephala intermedia*, landed at North Dennis and Woods Hole, Mass. (Pilsbry 1916).

Superfamily BALANOIDEA
Family ARCHAEOBALANIDAE
Subfamily ARCHAEOBALANINAE

Chirona hameri (Ascanius 1767). North Atlantic Ocean, from depths between 29 and 305 m. Most abundant at depths between 55 and 100 m on the shells of large mollusks, such as *Placopecten magellanicus* (Gmelin). This is the largest North Atlantic barnacle, achieving a height of 67 mm and a basal diameter of 68 mm. It has been reported as far south as Chesapeake Bay (Pilsbry 1916).

Subfamily SEMIBALANINAE

Semibalanus balanoides (Linnaeus 1767). Boreo-arctic regions of the Atlantic and Pacific Oceans. Found south to Cape Hatteras, N.C., in the middle and lower intertidal zone. This is the most commonly encountered intertidal barnacle along the northeastern Atlantic coast (Pilsbry 1916).

Family BALANIDAE

Balanus amphitrite amphitrite Darwin 1854. Cosmopolitan in tropical to warm temperate seas. Reproductive populations along the Atlantic coast of North America occur primarily in the middle and lower intertidal zone and appear to be restricted to regions south of Cape Hatteras, N.C. Rare individuals, spawned from shipborne fouling populations, can be found during summer months north to Cape Cod, Mass. This subspecies has been confused with *B. venustus* Darwin (Henry 1973; Henry and McLaughlin 1975; Zullo 1966).

Balanus balanus (Linnaeus 1758). Arctic, North Pacific, and North Atlantic Oceans; south to Long Island Sound on the Atlantic coast of North America. North of Cape Cod, Mass., this species ranges upwards into the lower third of the intertidal zone, but to the south it is restricted to submerged inner shelf depths (Pilsbry 1916).

Balanus calidus Pilsbry 1916. Reproductive populations are not found north of Cape Hatteras, N.C., but occasional live individuals have been observed on speci-

mens of *Chelonibia* and *Platylepas* attached to marine turtles taken off Cape Cod, Mass. (Pilsbry 1916; Zullo and Bleakney 1966).

Balanus crenatus Bruguiere 1789. This species has a distribution similar to that of *B. balanus*, with which it is often associated (Pilsbry 1916).

Balanus eburneus Gould 1841. Natural distribution includes the Atlantic coast of the United States south of Salem, Mass., the Caribbean Sea, the Gulf of Mexico, and the northeastern coast of South America. In addition this species has been introduced to various parts of the Pacific Ocean, and the Mediterranean and Black Seas. *Balanus eburneus* is a euryhaline species, but north of Cape Hatteras, N.C., it predominates in the middle intertidal to immediate subtidal zones of estuaries. The species is rarely encountered in areas of normal marine salinities in this region, probably because of competition with the more successful *Semibalanus balanoides* (Henry and McLaughlin 1975; Zullo et al. 1972).

Belanus improvisus Darwin 1854. Apparently worldwide in tropical and temperate seas. Some of its present distribution can be attributed to introduction by man. This species occurs predominantly in estuaries in association with *B. eburneus*. It tolerates lower salinities than *B. eburneus*, but is generally less abundant (Henry and McLaughlin 1975; Carlton and Zullo 1969).

Balanus subalbidus Henry 1973. Ranges from Massachusetts south into the Gulf of Mexico. Often associated with *B. improvisus* with which it may be confused (Henry 1973; Henry and McLaughlin 1975).

Balanus trigonus Darwin 1854. Worldwide in tropical and warm temperate seas. Reproductive populations are restricted to regions south of Cape Hatteras, N.C., but rare individuals have been found on specimens of *Chelonibia* and *Platylepas* attached to marine turtles taken as far north as Cape Cod, Mass. (Pilsbry 1916; Zullo and Bleakney 1966).

Balanus venustus Darwin 1854. Worldwide, except eastern Pacific, in tropical and warm temperate seas; on the Atlantic coasts of the Americas from Cape Cod, Mass., south to Brazil. Ranges vertically from the lowermost intertidal through the inner shelf. This is the most common subtidal barnacle of the Virginian province, and has often been confused with *B. amphitrite amphitrite*. The color variants (described as subspecies) *B. v. modestus*, *B. v. niveus*, and *B. v. obscurus* do not warrant separation (Henry and McLaughlin 1975; Pilsry 1916; Zullo 1966).

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SYSTEMATIC INDEX

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Publication of the "Marine Flora and Fauna of the Northeastern United States" is most timely in view of the growing universal emphasis on environmental work and the urgent need for more precise and complete identification of coastal organisms than has been available. It is mandatory, wherever possible, that organisms be identified accurately to species. Accurate scientific names unlock the great quantities of biological information stored in libraries, obviate duplication of research already done, and often make possible prediction of attributes of organisms that have been inadequately studied.

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