

SPONGE-INHABITING BARNACLES (CIRRIPEDIA:
ARCHAEOBALANIDAE) OF THE CAROLINIAN
PROVINCE, SOUTHEASTERN UNITED STATES,
WITH THE DESCRIPTION OF A NEW SPECIES
OF *MEMBRANOBALANUS* PILSBRY

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Abstract.—*Acasta cyathus* Darwin, 1854, previously known from the tropical western Atlantic north to Sapelo Island, Georgia, is reported from a variety of demosponges on the middle and outer continental shelf between Cape Fear and Cape Lookout, North Carolina. *Membranobalanus declivis* (Darwin, 1854), known previously from the tropical western Atlantic south of Cape Canaveral, Florida, occurs in *Spheciospongia vesparium* (Lamarck) from the mid-shelf region off Cape Fear, North Carolina. *Membranobalanus costatus*, new species, is found in *Anthosigmella varians* (Duchassaing and Michelotti) off Cape Fear. The new species is most readily distinguished from *M. declivis* by its prominently ribbed shell and rostrum of normal length. The number and distribution of specimens encountered in this study suggest that sponge-inhabiting barnacles are a common, but overlooked element of the Carolinian Province.

Species of the archaeobalanid barnacle genera *Acasta* Leach and *Membranobalanus* Pilsbry are obligate symbionts of sponges, occurring in tropical, subtropical, and warm temperate regions of the world. Most of the species ascribed to these genera are found in Indo-West Pacific waters, and only two species, one of each genus, have been reported from the western Atlantic. *Acasta cyathus* Darwin, 1854, is known from southern Georgia, southern Florida, the eastern Gulf of Mexico, and the Caribbean (Wells 1966; Newman and Ross 1976; Zullo and Lang 1978; Spivey 1981), but is also found in the eastern Atlantic, Red Sea, and Indo-west Pacific (Newman and Ross 1976). *Membranobalanus declivis* (Darwin, 1854) has been reported from Bermuda, southern and western Florida, and the West Indies (Wells 1966; Newman and Ross 1976; Spivey 1981).

The U.S. Bureau of Land Management (BLM) Live Bottom Study, conducted by the Duke University Marine Laboratory on the North Carolina continental shelf, has yielded an array of sponges, some of which contain sponge barnacles. *Acasta cyathus* is the most ubiquitous species, occurring in several different sponges at depths between 17 and 116 m. *Membranobalanus declivis* was discovered in two specimens of the loggerhead sponge, *Spheciospongia vesparium* (Lamarck), between 22 and 30 m depth southwest of Cape Lookout. Specimens of another sponge, *Anthosigmella varians* (Duchassaing and Michelotti), collected off Cape Fear at depths between 28 and 32 m, contain a new and rather unusual species of *Membranobalanus* characterized by a prominently ribbed shell and a rostrum of normal length. The presence of *Acasta* and *Membranobalanus* on the North Carolina continental shelf extends the western Atlantic range of these

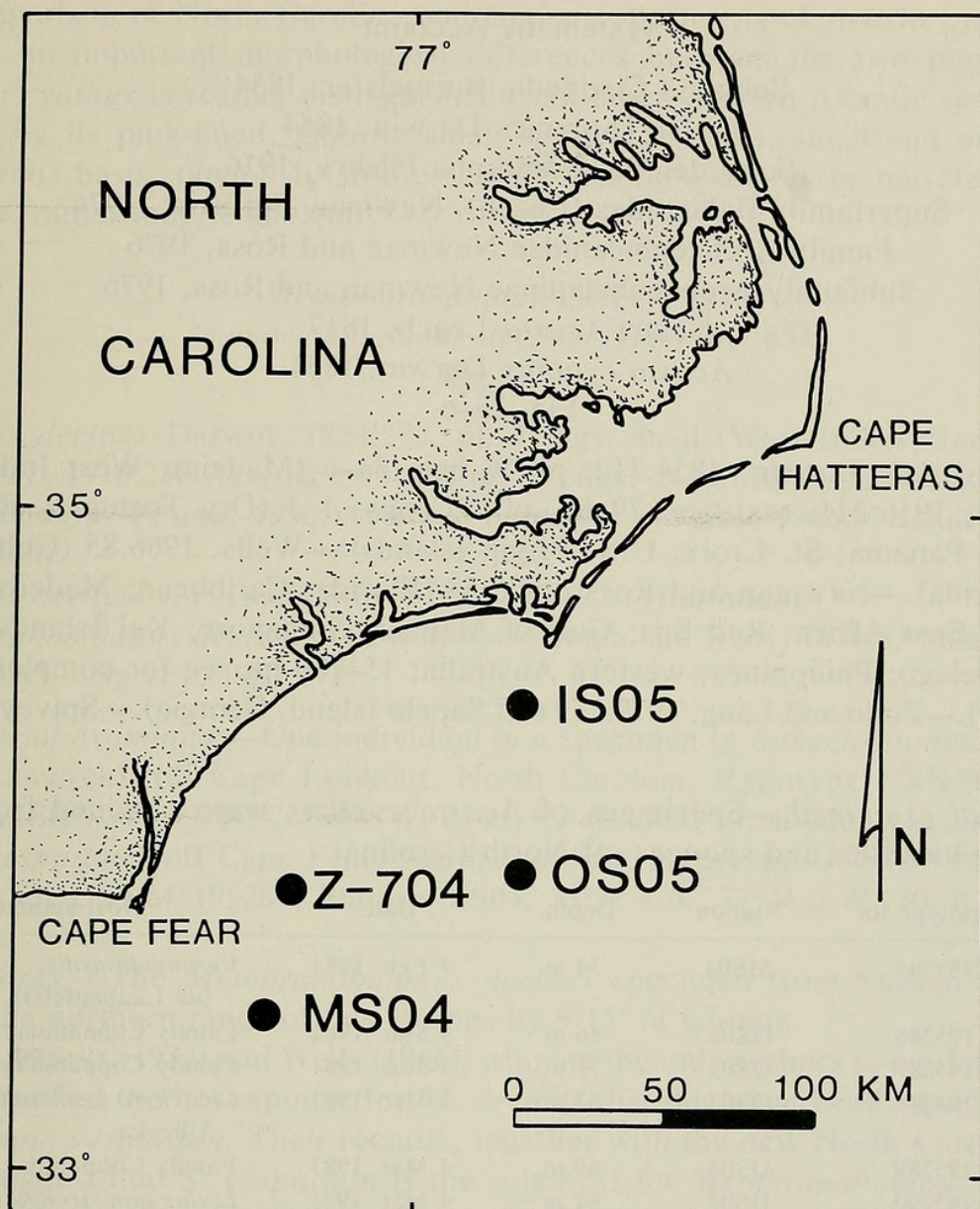


Fig. 1. General location of stations for sponge-inhabiting barnacles off the North Carolina coast.

genera nearly to the northern limit of the Carolinian Province. North Carolina localities are shown in Fig. 1.

Station Descriptions

IS05.—South-southwest of Cape Lookout, North Carolina, $34^{\circ}23.0'N$, $76^{\circ}34.0'W$, 19–27 m, BLM Live Bottom Study station, 1981.

MS04.—Southeast of Cape Fear, North Carolina, $33^{\circ}31.0'N$, $77^{\circ}25.0'W$, 27–55 m, BLM Live Bottom Study station, 1981.

OS05.—East of Cape Fear, North Carolina, $33^{\circ}49.0'N$, $76^{\circ}33.5'W$, 55–100 m, BLM Live Bottom Study station, 1981.

Z-704.—WR-4 buoy, east-northeast of Cape Fear, North Carolina, $33^{\circ}51.9'N$, $77^{\circ}29.4'W$, on superstructure of wreck, 17 m, Department of Earth Sciences collection, University of North Carolina at Wilmington, T. Prestia and P. Wheaton, collectors, 10 July 1982.

Systematic Account

Subclass Cirripedia Burmeister, 1834

Order Thoracica Darwin, 1854

Suborder Balanomorpha Pilsbry, 1916

Superfamily Balanoidea (Leach), Newman and Ross, 1976

Family Archaeobalanidae Newman and Ross, 1976

Subfamily Archaeobalaninae Newman and Ross, 1976

Genus *Acasta* Leach, 1817*Acasta cyathus* Darwin, 1854

Fig. 2a-e

Acasta cyathus Darwin, 1854:312, pl. 9, figs. 3a-c (Madeira; West Indies).—Pilsbry, 1916:244, text-figs. 79–80, pl. 57, figs. 1–3 (Dry Tortugas, Florida; Colon, Panama; St. Croix, U.S. Virgin Islands).—Wells, 1966:85 (Gulf coast of Florida).—Newman and Ross, 1976:53 (Florida; Caribbean; Madeira; Morocco; East Africa; Red Sea; Gulf of Manaar; Singapore; Kei Islands; Sulu Archipelago; Philippines; western Australia; 15–180 m; see for complete synonymy).—Zullo and Lang, 1978:159 (off Sapelo Island, Georgia).—Spivey, 1981:172.

Material examined.—Specimens of *Acasta cyathus* were obtained from the following localities and sponges off North Carolina:

USNM hypotype lot	Station	Depth	Date	Host sponge
USNM 195285	MS04	34 m	7 Feb 1981	<i>Verongula ardis</i> (de Laubenfels)?
USNM 195286	OS05	66 m	3 Mar 1981	Family Coppatiidae sp. A
USNM 195287	OS05	77 m	3 Mar 1981	Family Coppatiidae sp. A
USNM 195288	OS05	62 m	3 Mar 1981	<i>Cinachyra keukenthali</i> Uliczka
USNM 195289	OS05	69 m	4 Mar 1981	Family Coppatiidae sp. A
USNM 195290	OS05	64 m	4 Mar 1981	<i>Erylus ministrongulus</i> Hechtel
USNM 195291	OS05	116 m	14 May 1981	Family Coppatiidae sp. A
USNM 195292	OS05	104 m	14 May 1981	Family Coppatiidae sp. A
USNM 195293	OS05	99 m	14 May 1981	Family Coppatiidae sp. A
USNM 195294	MS04	32 m	18 May 1981	Family Mycalidae sp. A
USNM 195295	MS04	30 m	10 May 1981	<i>Ircinia campana</i> (Lamarck)
	Z-704	17 m	10 Jul 1982	undetermined

Remarks.—The 40 *Acasta cyathus* specimens from station Z-704 (from a single 25 cm diameter, bowl-shaped sponge) represent a northern range extension of 2°22' in latitude and indicate that the species is common in North Carolina waters. The absence of prior records from this region is most likely the result of lack of collection, rather than a recent immigration from southern regions.

The North Carolina *Acasta* were found in at least six different species of Demospongea, occurring most frequently in an unidentified coppatiid sponge. Other host records for *A. cyathus* from the western Atlantic include sponges of the genus *Aplysina* (= *Verongia*), *Ircinia campana* (Lamarck), *Ircinia felix* (Duchassaing and Michelotti) (= *I. fasciculata*), *Spinoseella* (= *Callyspongia*) *vaginalis* (Lamarck), and *Spongia tubulifera* Lamarck, (= *S. officinalis*) (Darwin 1854; Wells 1966).

Comparison of North Carolina and Georgia specimens of *Acasta cyathus* revealed no important morphological differences between the two populations. *Acasta cyathus* is readily distinguished from other western Atlantic sponge barnacles by its pink-hued, globose shell, spinose parietes, small and nearly flat calcareous basis, obviously striate scutum lacking a depressor muscle pit, and narrow, rather long tergal spur.

Membranobalanus Pilsbry, 1916
Membranobalanus declivis (Darwin, 1854)
 Fig. 2f–o

Balanus declivis Darwin, 1854:275, pl. 7, figs. 4a–d (West Indies; Jamaica).—Pilsbry, 1916:230, text-figs. 73–74, pl. 55, figs. 1–1d (off Cape Sable, Florida; Bermuda).—Pearse, 1932:119 (Dry Tortugas).—Wells, 1966:83 (Gulf coast of Florida).

Balanus declivis var. *cuspidatus* Verrill, 1901:22 (Bermuda).

Membranobalanus declivis (Darwin).—Newman and Ross, 1976:53 (see for synonymy).—Spivey, 1981:172.

Material examined.—One individual in a specimen of *Spheciospongia vesparium* (Lamarck), off Cape Lookout, North Carolina, Hypotype USNM 195282, Station IS05, 34°23.6'N, 76°34.9'W, 22 m, 9 Feb 1981; 5 individuals in a specimen of *S. vesparium*, off Cape Fear, North Carolina, Hypotype USNM 195283, Hypotype lot USNM 195284, Station MS04, 33°31.4'N, 77°24.0'W, 30 m, 19 May 1981.

Remarks.—The *Membranobalanus declivis* specimen from Station IS05 extends the northern range of this species by 9°15' of latitude.

Both Pearse (1932) and Wells (1966), who are the only authors to our knowledge that identified the host sponge for *M. declivis*, list the loggerhead sponge, *Spheciospongia vesparium*. Their records, together with the new North Carolina records, suggest that *S. vesparium* is the sole host for *Membranobalanus declivis*. The North Carolina *M. declivis* agree with the descriptions and illustrations presented by Darwin (1854) and Pilsbry (1916). *Membranobalanus declivis* is distinguished from *Acasta cyathus* by its membranous basis and non-spinose parietes, and from other Western Hemisphere species of *Membranobalanus* by its non-costate shell bearing narrow to broad radii and an elongate rostrum.

Membranobalanus costatus, new species
 Figs. 2p–x, 3a–x

Holotype.—Complete shell, opercular plates, and body, USNM.

Dimensions of holotype.—Height, 8.8 mm; carinorostral diameter 10 mm; lateral diameter, 7.8 mm.

Type locality.—Station MS04, 33°31.0'N, 77°25.0'W, off Cape Fear, North Carolina, 28 m depth, 12 Aug 1981.

Material examined.—8 individuals from a specimen of *Anthosigmella varians* at the type-locality, Holotype USNM 195270, paratypes USNM 195271 through 195277; 4 individuals from a specimen of *A. varians*, Station MS04, 33°32.8'N, 77°24.3'W, 32 m, 18 May 1981, paratypes USNM 195278 through 195281.

Diagnosis.—Shell thin, white, with radii lacking or incipient; orifice deeply

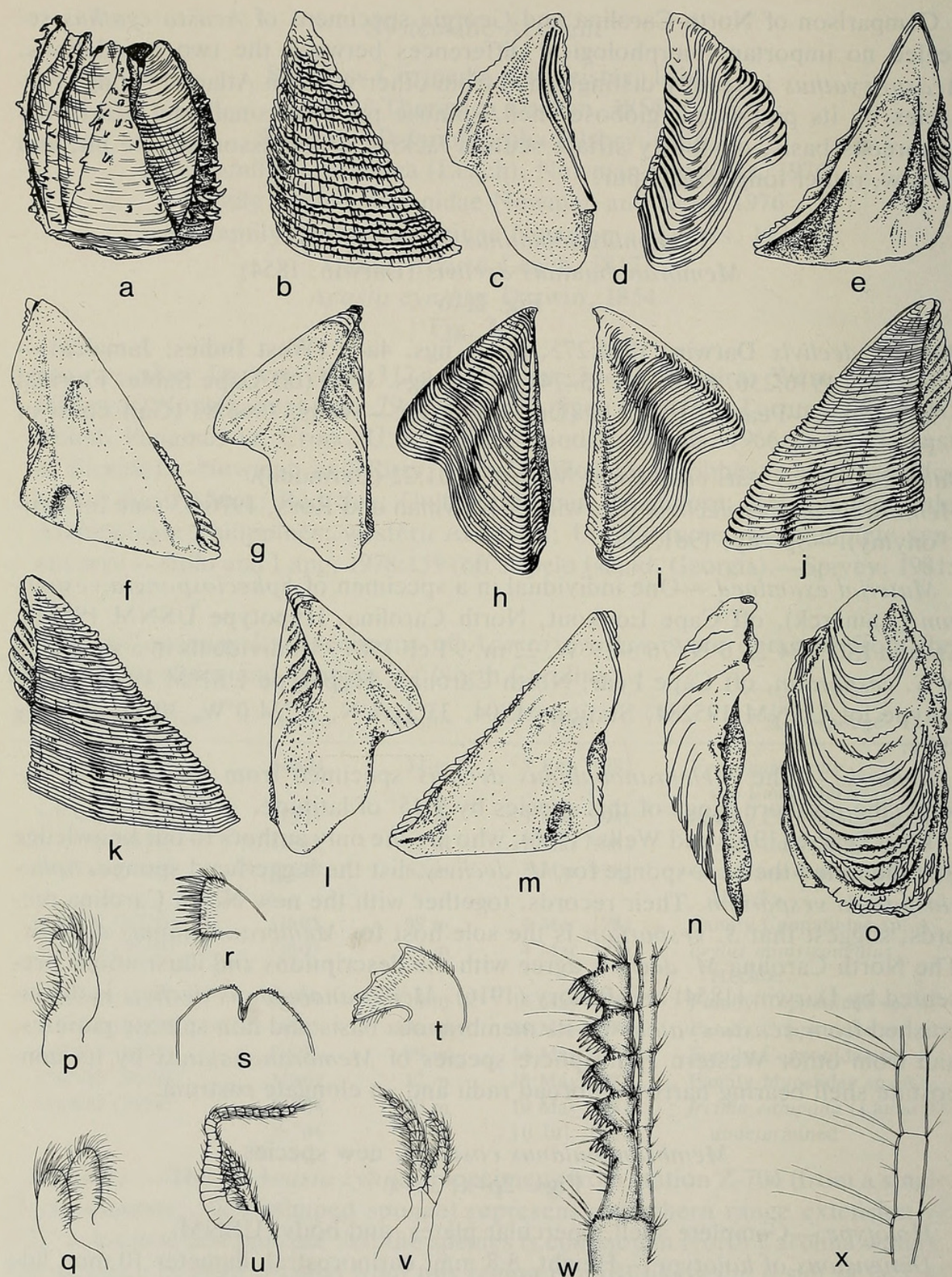


Fig. 2. *Acasta cyathus* Darwin, station Z-704: a, Shell, hypotype USNM 195285; b-e, Outer and inner views of opercular plates, hypotype USNM 195285. *Membranobalanus declivis* (Darwin), station MS04: f-m, Outer and inner views of opercular plates, hypotype USNM 195282; n-o, Side and exterior view of rostrum, hypotype USNM 195282. Mouth parts and cirri of *M. costatus* n. sp., paratype USNM 195278, station MS04: p, Palp; q, Second maxillae; r, First maxilla; s, Labrum; t, Mandible; u, Cirrus I; v, Cirrus II; w, Cirrus VI; x, Medial articles of Cirrus VI. Scale: Fig. a, $\times 3$; figs. b-m, $\times 6$; figs. n-o, $\times 4$; figs. p-q, $\times 20$; figs. u-v, $\times 10$; figs. w-x, $\times 20$.

toothed; rostrum same length as other compartmental plates; exterior of parietes with narrow, prominent, irregularly-spaced costae; opercular plates without intercalated chitinous lamellae; scutal adductor ridge incipient or lacking; tergal spur short, broad, usually occupying two-thirds of basal margin; outer ramus of Cirrus IV with up to 6 recurved teeth per article; medial articles of Cirrus VI with 3 pairs of spines per article, proximal pair minute.

Description.—Shell (Fig. 3a–j) high-conic, white, with deeply-toothed orifice; compartmental plates solid, thin, easily disarticulated; parietes ornamented externally with fine, closely-spaced, irregular growth lines crossed by fine, longitudinal striae on upper (younger) third and by prominent, narrow, irregularly-spaced costae on lower two-thirds; costae extend slightly below basal margin of parietes giving base of shell wall a denticulate appearance; rostrum larger than other compartmental plates, but not of greater length, narrow in upper third and increasing in width towards broadly V-shaped basal margin; carina narrow with nearly parallel parietal borders; apices of rostra and carinae with deeply incised notches, probably caused by cirral rasping; radii absent or at best represented by extremely narrow and irregular ledges; alae narrow and steeply oblique in upper third of compartmental plate, broadening markedly in central third, and narrowing abruptly in lower third; alar sutural edges smooth; sheath of rostrum one-half length of plate; sheath of other compartmental plates one-half to two-thirds length of plate; lower margin of sheath continuous with shell wall; interior of parietes often ribbed below sheath; internal ribs obverse of sulcations between external costae; basis membranous.

Scutum (Fig. 3k–n, u–x) thick, markedly convex, white, with adherent exterior yellow-brown epidermis bearing fine hairs; basal margin shorter than tergal margin; tergal margin reflexed about 45°; exterior ornamented by narrow, closely-spaced, semi-erect growth ridges crossed by very fine radial striae, especially evident in medial part of plate, every other external growth ridge forming raised “tooth” on occludent margin; articular ridge prominent, triangular, between three-fifths and three-fourths length of tergal margin, and reflexed over narrow, shallow articular furrow; reflexed articular ridge extends well beyond tergal margin of scutum; adductor ridge represented by low, rounded, raised border of small, deep, oval adductor muscle pit just above and tergal of center of plate; depressor muscle pit large, deep, triangular, extending up under inner lamina of scutum and located at basal margin in angle formed by reflexed tergal margin; narrow, triangular “radius,” broadest at apical end, extending length of occludent margin.

Tergum (Fig. 3o–t) thin, about same width as scutum, white; basal margin slightly shorter or equal to length of scutal margin; exterior ornamented by fine, closely-spaced growth ridges, and covered in lower half by yellow-brown epidermis bearing fine hairs; spur furrow broad, very slightly depressed, bounded on either side by impressed lines; narrow strip along carinal border of tergum depressed below exterior surface of plate and with upturned growth lines; tergal spur short, broad (base of spur occupying about two-thirds of basal margin), basally truncate at angle to basal margin, and placed close to basiscutal angle; length of spur about one-half basal width of spur; depressor muscle crests absent, or represented by few inconspicuous, irregular ridges; articular ridge straight, erect, short, restricted to apical half of plate; articular furrow very broad, shallow.

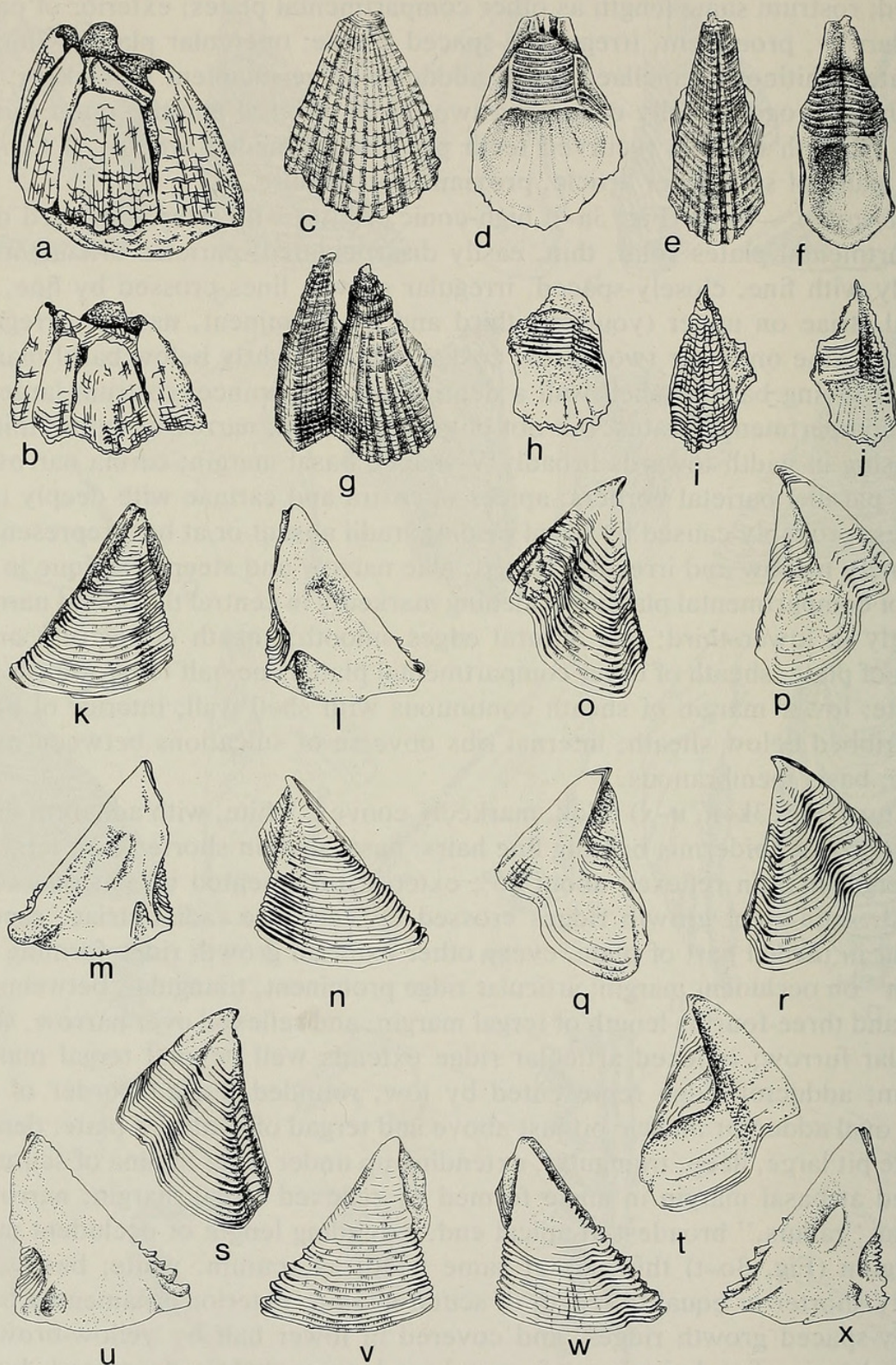


Fig. 3. *Membranobalanus costatus* n. sp., station MS04: a, Shell, holotype USNM 195270; b, Shell, paratype USNM 195271; c-d, Outer and inner view of rostrum, paratype USNM 195273; e-f, Outer and inner views of lateral, same specimen; g-h, Outer and inner views of carinolateral, same specimen; i-j, Outer and inner views of carina, same specimen; k-n, Outer and inner views of scuta, paratype USNM 194274; o-r, Outer and inner views of terga, same specimen; s-t, Outer and inner views of tergum, paratype USNM 195275; u-x, Outer and inner views of scuta, same specimen. Scale: Figs. a-b, $\times 4$; figs. c-j, $\times 7$; figs. k-x, $\times 8$.

Labrum (Fig. 2s) triangular, with deep notch at apex of crest; two to six teeth present on one or both sides of notch.

Palp (Fig. 2p) kidney-shaped, superior margin concave, densely setose, setae short, pectinate; inner margin densely setose, setae longer, pectinate; inferior margin nearly devoid of setae.

Mandible (Fig. 2t) with fine teeth on cutting edge; upper tooth largest; second tooth not bifid, slightly smaller than first tooth, and located at center of cutting edge; third tooth slightly smaller than second, located at center of lower half of cutting edge; fourth and fifth teeth considerably smaller, fourth larger than fifth, fifth barely visible in some specimens; inferior angle without obvious denticles or spines (may be result of wear); inferior and superior margins setose.

Maxilla I (Fig. 2r) with straight edge; uppermost 2 large spines of equal size; notch lacking or incipient below uppermost 2 spines, its position indicated by 1 or 2 minute spinules; middle section bears 4 or 5 shorter, more slender, and non-alternating spines; lower third of edge bears 4 or 5 spines of same size as uppermost pair; inferior angle with tuft of small spinules; inferior and superior margins setose, with those of inferior margin longer, more numerous.

Maxilla II (Fig. 2q) bilobed; outer lobe ovate, superior and posterior margins densely setose, setae of posterior margin primarily non-pectinate, those of superior margin pectinate; inner lobe small, circular, densely clothed with coarsely pectinate setae.

Cirrus I (Fig. 2u) with grossly unequal rami; anterior ramus about 3 times length of posterior ramus, anterior ramus reversed, antenniform; posterior ramus more setose than anterior, with slightly protuberant articles; Cirrus II (Fig. 2v) short, with outer ramus one-third again as long as inner ramus; articles of both rami slightly protuberant, covered with pectinate setae somewhat longer than those of Cirrus I, outer distal margins of articles bear comb-like patches of minute spinules at bases of setae; Cirrus III longer and more slender than Cirrus II; outer ramus longer than inner; articles of rami not protuberant; setation and distribution of spinule comb rows similar to those of Cirrus II; Cirri IV–VI longer and more slender than Cirri I–III, gradually increasing in length posteriorly; Cirrus IV (Fig. 2v) with inner ramus slightly longer than outer; pedicel about one-half length of outer ramus; outer ramus less slender than inner, bearing large, recurved teeth, up to 6 in number, on medial articles; distal margins of outer surface of pedicel and articles each bearing row of upright denticles; inner ramus with few upright denticles at distal-anterior corner, and comb-like rows of minute spinules along outer distal borders of articles; Cirrus V longer and more slender than Cirrus IV, with denticles and comb-like rows of spinules on both rami arranged as on inner ramus of Cirrus IV; Cirrus VI (Fig. 2x) longer than Cirrus V, with 3 pairs of spines on medial articles, distal pair long, median pair short, proximal hair minute; distal margins of outer surface of articles with few comb-like patches of spinules.

Etymology.—The specific name *costatus* is Latin for ribbed or costate, and refers to the externally costate shell of the new species.

Discussion.—*Membranobalanus costatus* is readily distinguished from previously described species of *Membranobalanus* by its costate parietes. The new species is related to Western Hemisphere *Membranobalanus*, all of which bear large, recurved teeth on the outer ramus of Cirrus IV. Of these species, *M.*

costatus is most similar in appearance to *M. nebrias* (Zullo and Beach, 1973) from the Galapagos Archipelago. In both species the shells lack radii, the rostra are short, and the opercular plates, trophi, and cirri are similar in overall conformation. *Membranobalanus costatus* differs consistently from *M. nebrias* in several features: (1) the rostrum is of "normal" length; (2) the opercular plates lack intercalated chitinous lamellae; (3) the scutum lacks a rostral depressor muscle pit in the basioccludent angle; (4) the scutal articular ridge is longer; (5) a "radius" is developed along the occludent margin of the scutum; (6) the tergal spur is broader; (7) the tergal articular ridge is longer; (8) the outer lobe of Maxilla II is much shorter; (9) the outer ramus of Cirrus IV bears up to six, rather than four, recurved teeth per article; and (10) the medial articles of Cirrus VI have up to three, rather than five, pairs of spines.

Membranobalanus costatus also resembles *M. declivis*, especially in features of the trophi and cirri and in the possession of a "radius" along the occludent margin of the scutum. *Membranobalanus costatus* is distinguished by its much shorter rostrum, absence of radii, shorter and thicker scutum that is markedly bowed from side to side, rather than nearly flat, its shorter and more equally triangular tergum, shorter and broader tergal spur, and vertical rather than oblique articular ridge.

Membranobalanus costatus differs from *M. orcutti* in having a short rostrum, a broader scutum with a much shorter adductor ridge and a "radius" along the occludent margin, a narrower tergum with a longer tergal spur, a simpler armature on the outer ramus of Cirrus IV, and three, rather than four, pairs of spines on the medial articles of Cirrus VI. The new species is most readily distinguished from the Indo-West Pacific species *M. brachialis* (Rosell), *M. cuneiformis* (Hiro), and *M. longirostrum* (Hoek) by the presence of large, recurved teeth on Cirrus IV.

If *M. costatus* is specific to *Anthosigmella varians*, as *M. declivis* appears to be with its host sponge, then this new barnacle species might be expected to occur in Florida, the Gulf of Mexico, the West Indies, and the Caribbean side of Central America (cf. Wiedenmayer 1977:245). We hope that queries such as this will stimulate further research on this interesting group of symbiotic barnacles.

Key to Western Hemisphere Species of *Acasta* and *Membranobalanus*

1. Basis membranous; shell high-conic, without calcerous spines on exterior of parietes 2
 - Basis calcareous, slightly cup-shaped; shell globular, with calcareous spines on exterior of parietes *Acasta cyathus*
2. Rostrum considerably longer than other compartmental plates, usually at least twice length of carina 3
 - Rostrum slightly longer or not noticeably longer than other compartmental plates 4
3. Radii present, narrow to broad; basal margin of scutum about same length as tergal margin; scutal adductor ridge, if present, confined to adductor muscle pit border; occludent margin of scutum bordered by sunken ledge ("radius") *Membranobalanus declivis*
 - Radii lacking; basal margin of scutum considerable shorter than tergal

- margin; scutal adductor ridge prominent, extending to basal margin; occludent margin of scutum lacks accessory ledge . . . *Membranobalanus orcutti*
4. Exterior of parietes smooth, except for growth bands; chitinous lamellae intercalated with calcareous lamellae of opercular plate apices; occludent margin of scutum lacks accessory ledge *Membranobalanus nebrias*
- Exterior of parietes prominently costate; apices of opercular plates lack chitinous lamellae; occludent margin of scutum bordered by sunken ledge ('radius') *Membranobalanus costatus*

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