

## The Systematics of the Aeolidacea (Nudibranchia: Mollusca) of the Hawaiian Islands, with Descriptions of Two New Species<sup>1</sup>

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**ABSTRACT:** Nineteen species of aeolid nudibranchs are here recorded from the Hawaiian Islands. The natural history and distribution of each species is described. Morphological accounts of these taxa are provided and their systematic status is discussed. The status of an additional three species, previously recorded from the Hawaiian Islands but not encountered in this study, is reviewed. Based on the study of the Hawaiian aeolidacean nudibranch fauna, the systematics of the Facelinidae are reviewed. An examination of the zoogeographical affinities of the Hawaiian aeolid fauna suggests that many taxa have a typical Indo-West Pacific distribution. However, a significant portion of the fauna is substantially more widely distributed and appears to be circum-tropical.

THE FIRST SERIOUS ATTEMPTS to characterize the Hawaiian opisthobranch fauna are those of Kay (1961, 1962a, 1962b, 1964a, 1964b) and Kay and Young (1969). Kay described most of the anaspideans and several sacoglossans, and Kay and Young dealt with the dorid nudibranchs. Aeolid nudibranchs have only sporadically been described or recorded from Hawaii. Pease (1860) described two species, *Aeolis semidecora* and *A. parvula*. Bergh (1900) described *Samla annuligera* from Laysan Island. Edmondson (1946) recorded five species of aeolids, but identified only *Glaucus* by name. Zahl (1959) figured *Pteraeolidia semperi* and *Aeolidiella* sp. from Kaneohe Bay, Oahu. Harris (1968, 1970) recorded *Phestilla melanobranchia* and *P. sibogae* from the Hawaiian Islands. Rosin (1969) recorded *Herviella* sp., and Baba (1969) recorded *Learchis indica*.

The purpose of this study is to revise the earlier work on the Hawaiian aeolids and to report on previously unrecorded species. In this synthesis I include the collection records of E. Alison Kay which are primarily from

the islands of Oahu and Kauai and span a period of over 10 years. My own observations were made from September 1972 to October 1973. During this period, monthly collections were made at four principal sites on Oahu: Kaneohe Bay, Ala Moana Beach Park, Diamond Head Beach Park, and Kewalo Basin. Collections were also made at other localities in the islands, including Fleming's Beach, Maui, and on the Kona coast, Hawaii.

At least 22 species of aeolid nudibranchs can be attributed to the Hawaiian Islands. Three species have been recorded that were not encountered in this study: *Samla annuligera* Bergh (known only from the holotype collected at Laysan); *Embletonia gracile* Risbec 1928 [here tentatively identified from a figure by Edmondson (1946)]; and *Aeolis parvula* Pease 1860 (which is not identifiable from Pease's brief description). At least five additional species of aeolids have been collected by Kay but are not included in this study because few specimens are available.

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### CLASSIFICATION OF THE AEOLIDACEA

The aeolid nudibranchs have been extensively studied, yet their phylogeny is not clearly understood. Thompson (1961) and

Ghiselin (1965) have suggested that the Aeolidacea are polyphyletic, but the evidence is not conclusive as the more primitive members of the suborder, *Notaeloidia* and the Coryphellidae, have been poorly studied.

Odhner (1939) proposed the system of classification whereby the aeolids are divided into three tribes, the Pleuroprocta, Aceio-procta, and Cleioprocta, on the basis of anal position. This system is not entirely satisfactory, because there are numerous examples of genera that differ in anal position from other members of the family. *Flabellina* has the anus intermediate to the pleuroproct and aceio-proct position, whereas the remainder of the Coryphellidae are typically pleuroproctic. *Selva*, a cuthonid, has the anus in the cleio-proct position, but others of the Cuthonidae are aceio-proctic (Edmunds 1964). One specimen of *Cuthona perca* (Ernst Marcus, 1958) in this study was cleio-proctic, while seven other specimens were aceio-proctic. Basing aeolid classification solely on anal position produces a polyphyletic, and hence artificial, classification system.

The pleuroprocts are considered primitive, and most members (except *Babakina* Roller, 1973) have a triseriate radula. The families within the tribe are not easily distinguished, and various workers subdivide the tribe into one to five families.

Like the pleuroprocts, the more primitive aceio-procts, the Eubbranchidae, and possibly *Cuthona* (Ernst Marcus 1961), are distinguished by a triseriate radula. The more advanced aeolids have a uniseriate radula, as do most cuthonids, *Fiona*, and the Piseinotecidae. Most aceio-procts have a simply rounded head and anterior margin of the foot. The reproductive system is distinctive within the Cuthonidae, where there is a distal receptaculum seminis near the gonopore and frequently a penial gland. The aceio-procts seemingly have polyphyletic origins within the Aeolidacea (Edmunds 1970). This is particularly evident in the cuthonids and Piseinotecidae, which are similar in external form but have markedly different radulae and reproductive systems.

The cleio-procts represent the most diverse tribe of aeolids in both degree of morpholo-

gical variation and number of species. Two major groups exist, the facelinids with cuspidate radular teeth and the aeolidids with pectinate radular teeth. The Aeolidiidae appear to be monophyletic, since members are similar in morphology and habits. Most species are known to feed on sea anemones.

The facelinids include a wide range of morphological forms. They are the subject of a great deal of taxonomic confusion and are in need of revision. The controversy falls into two schools of thought. One (Ernst Marcus 1958, Miller 1974) contends that the major distinction is between the favorinids, with the cerata grouped in arches, and the facelinids, with the cerata arranged in rows. The other point of view is that of Edmunds (1970), who states that reproductive characters, particularly the development of the receptaculum seminis and bursa copulatrix, should take taxonomic precedence over ceratal arrangement, and that ceratal arrangement should be considered polyphyletic. I agree with Edmunds's contention that a serial receptaculum seminis is more primitive than a semiserial receptaculum.

Miller (1974) contends that *Babakina* Roller, 1973 is not closely allied to the Coryphellidae but with the glaucids and represents a subfamily in the Glaucidae. His argument is primarily based on the similarity of the uniseriate radula and oral glands. Miller suggests that the two bursae in *Babakina* are not significant in their taxonomic placement since some coryphellids and glaucids share this characteristic.

I contend that it is not so much the fact that two bursae are present that is significant, but that their structure and form are distinctive. The fact that *Antionetta* and *Dictata* both have two bursae and are unquestionably glaucids, is not supportive of *Babakina*'s placement in the Glaucidae as stated by Miller (1974). While they have advanced glaucid characteristics of cleio-proctic anus, well-developed liver system, and general body form of a glaucid, they also have a serial receptaculum. It is unlikely that *Babakina* would maintain its primitive coryphellid characters of pleuroproctic anus, primitive digestive system, prominent notal brim,

and club-shaped rhinophores, and be more advanced reproductively, with a semiserial receptaculum, when *Antionetta* and *Dictata* retain a serial receptaculum. It seems much more reasonable that *Babakina* is allied to the Coryphellidae. The animals are identical to members of the Coryphellidae except for their lack of lateral rows of teeth. Miller maintains that the oral glands of *Babakina* are glaucid. Oral glands have not been studied to any degree in aeolids and cannot be deemed systematically significant at present.

Miller (1974) did not make clear whether the rhinophores in *Babakina caprinsulensis* are joined in a common insertion. Roller (1972) questioned the taxonomic level at which joined rhinophores can be considered significant, and this question remains largely unsettled.

Miller suggested that the genera *Glaucus* and *Pteraeolidia* are closely allied to the facelinids. I feel that, while they are obviously allied on the basis of reproductive and radular form, they are significantly aberrant in their external form and ecology as to warrant familial status and that the Facelinidae, Glaucidae, and Pteraeolididae, should be maintained as familial taxa.

Edmunds (1970) argued that the Favorinidae and Facelinidae are polyphyletic and that separation of the two families on the basis of branching of the digestive system does not accurately reflect evolution within the groups. Miller's (1974) placement of the Favorininae, Crateninae, Facelininae, and Herviellinae as subfamilies within the Glaucidae does not solve the problem. They are still polyphyletic units established on the basis of convergence in ceratal arrangement. Establishment of phyletic units on the basis of reproductive system seems more accurate and decreases the number of polyphyletic taxa. I suggest that the subfamilies proposed by Miller be discarded and that the species be retained in the single large family, the Facelinidae.

Miller (1974) combined all the genera of his Facelininae, except *Antionetta*, in the genus *Phidiana*. While the generic distinctions within the family are not entirely clear, Miller's method of placing all but a single

genus of his Facelininae in *Phidiana*—but recognizing several genera within his Favorininae—is inconsistent, because characteristics of the penis are different in both groups. While the distinctions of genera are not precise, the maintenance of genera seems appropriate because it stresses differences among the groups rather than combining them because the differences are difficult to discern.

Miller also stated that differences in what he considers *Phidiana* are based entirely on the structure of the penis. The statement is erroneous. *Facelinella* does not have an ejaculatory vas deferens, while *Facelina* does. *Palisa* differs in having papillate rhinophores and a serial receptaculum, and its significance in discerning the Facelinidae is well known (Edmunds 1970). Other genera (i.e., *Hermisenda*, *Emarcusia*, etc.) differ significantly in radular and external form. *Phidiana* is unique in that members of the genus lack tentacular foot corners. On the above bases, I suggest that the genera placed in synonymy under *Phidiana* by Miller be retained as distinct genera until more accurate relationships can be assessed.

#### SYSTEMATIC ACCOUNT

##### Family Coryphellidae

*Flabellina annuligera* (Bergh, 1900)

*Samla annuligera* Bergh, 1900; *Flabellina annuligera* (Marcus & Marcus 1967)

This species was described from a single specimen from Laysan Atoll (Bergh 1900), and has not since been recognized. Bergh separated *Samla* from *Flabellina* on the basis of its rounded anterior margin of the foot compared to the tentacular foot corners of *Flabellina*. Marcus and Marcus (1967) referred to this species as *Flabellina annuligera* without stating any reasons. However, the generic separation of *Samla* and *Flabellina* solely on the basis of pedal termination should not be maintained.

Abbott (1974) misinterpreted Marcus and Marcus (1967) and erroneously reported this species from Puget Sound, Washington.

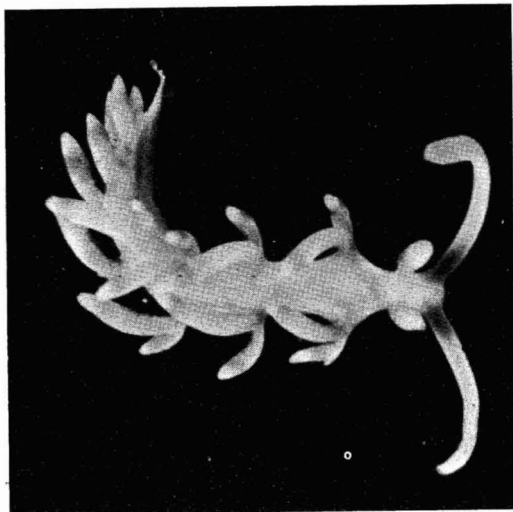


FIGURE 1. *Flabellina alisonae*. Length, 7 mm.

*Flabellina alisonae* spec. nov.

*Coryphella ornata* (Baba 1936); *Flabellina ornata* (Baba 1955, Abe 1964, Marcus and Marcus 1967, Schmekel 1970)

TYPE LOCALITY: Diamond Head Beach Park, Oahu, Hawaii

TYPE MATERIAL: The holotype is deposited in the Bernice P. Bishop Museum, Honolulu, Hawaii (BPBM 218720). A paratype radula has been deposited in the invertebrate zoology collection of the California Academy of Sciences, San Francisco, California (CASIZ paratype 00714 and type slide series 532).

DISTRIBUTION: Southern Japan (Abe 1964, Baba 1955), Okinawa (Baba 1936)

HABITS AND OCCURRENCE: *Flabellina alisonae* was collected in the vicinity of various hydroids, but no direct relationship can be suggested. One egg mass was found on an unidentified ectoproct. Eleven specimens have been found in tidepools at Poipu, Kauai; on patch reefs in Kaneohe Bay, Oahu; at Diamond Head, Oahu, in less than 1 m of water, and from a depth of 2 m, Honaunau, Hawaii. This species has also been found at Enewetak, Marshall Islands (Kay, personal communication).

DESCRIPTION: Animal slender (Figure 1), 7 to 15 mm in length. Body color purple or white. Rhinophores cream-yellow distally, red-brown at base, bulbous in form, and perfoliate. Cerata white with an orange subapical ring. Oral tentacles elongate, more than half the body length. Foot corners short, sharply recurved, tentacular. Cerata pedunculate in groups of two or three, with four to eight pairs of peduncles. Gonopore directly ventral to anteriormost group of cerata. Anus intermediate between pleuroproctic and acleioproctic position, dorsolateral, immediately anterior to second ceratal group. Radular formula 14–18 × 1.1.1 in three specimens. Rachidian teeth (Figure 2A) 55  $\mu$ m in length, sharply arched with seven or eight denticles on each side of central cusp. Laterals (Figure 2B) triangular, 28  $\mu$ m in length with four to six denticles. Jaws (Figure 2C) thin, 0.42 to 0.46 mm long, masticatory border denticulate with four rows of denticles. Thirty-five denticles in outermost row of cutting edge. Penis unarmed. Reproductive system (Figure 2D) with saccate ampulla, proximal receptaculum seminis, distal bursa copulatrix, and nodular prostate.

DISCUSSION: Baba (1936) identified an aeolid from Okinawa as *Coryphella ornata* Risbec, 1928, stating that his specimen had several rows of denticles on the jaws while Risbec's contained only one. Subsequently, Baba (1955) transferred the species to *Flabellina* because of the pedunculate cerata present in his material from Japan and Okinawa. Marcus and Marcus (1967), in a discussion of the generic distinctions between *Coryphella* and *Flabellina*, noted that the cerata in Baba's material are clearly pedunculate while in Risbec's description the cerata do not appear to be pedunculate.

In a review of the genus *Flabellina*, Schmekel (1970) noted the differences in ceratal arrangement between the Risbec animals and those of Baba and suggested that there was a high probability they represent two species. Schmekel also noted differences in dentition of the lateral teeth.

In comparing the shape of the radular



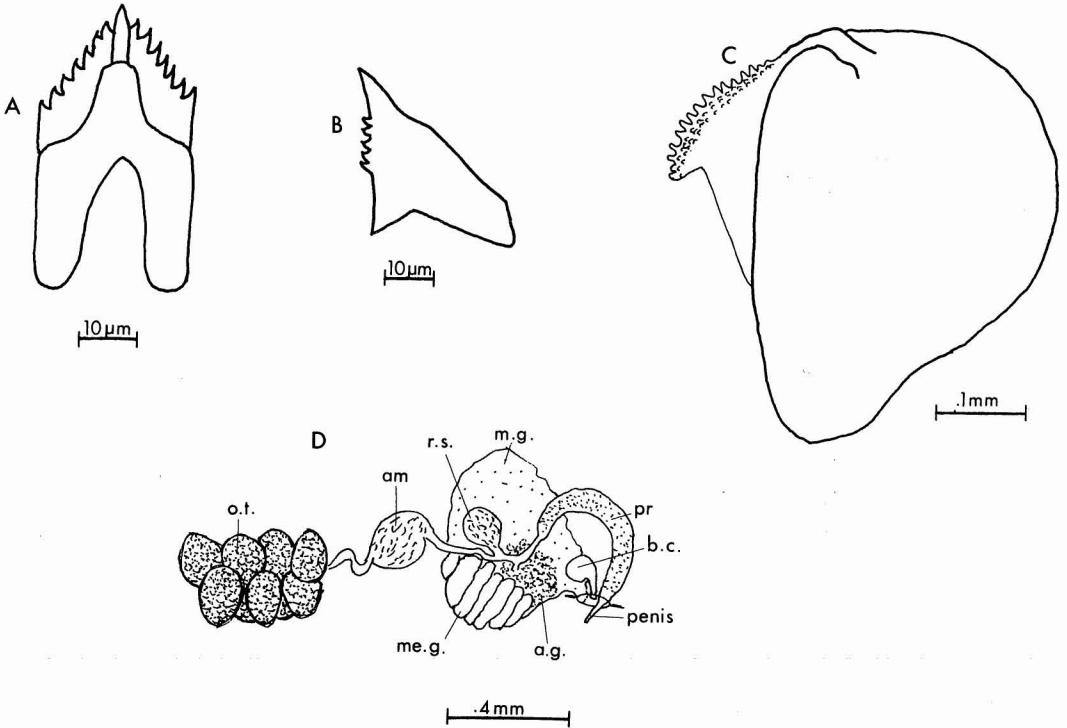


FIGURE 2. *Flabellina alisonae*: A, rachidian tooth; B, lateral tooth; C, jaw; D, reproductive system (a.g., albumen gland; am, ampulla; b.c., bursa copulatrix; m.g., mucous gland; me.g., membrane gland; o.f., ovotestis; pr, prostate; r.s., receptaculum seminis).

teeth of Baba's and Risbec's specimens, I note that the rachidian of the New Caledonian examples has a prominent central cusp while the specimens from Japan and Okinawa have a central cusp that is not significantly larger than the adjacent denticles. The laterals also differ significantly. In *Coryphella ornata* Risbec, the lateral is quadrate with denticles only on the upper half of the tooth; in Baba's material, the teeth are triangular with denticles only along the basal two-thirds of the inner margin. There are two clusters of cerata anterior to the anus in the New Caledonian animals while in the Japanese and Okinawan animals there is a single preanal ceratal peduncle. There seems to be little doubt that the animals described by Baba represent a species distinct from *C. ornata* Risbec. Because there is no evidence to suggest that *C. ornata* Risbec has pedunculate cerata, it is preferable to maintain the species within *Coryphella* until further material can

be examined. Within the description of *C. ornata*, Risbec indicated the existence of another individual described as *C. ornata* var. *violacea*. The radular teeth and coloration differ markedly from the typical form. In my opinion, these differences warrant specific separation, and the name *Coryphella violacea* comb. nov. is suggested.

The specimens described in this study are virtually identical to Baba's animals from Okinawa and Japan. The coloration in all cases is white, but with a purple tinge in some of the Hawaiian specimens. The cerata are uniformly spindle-shaped with a subapical orange band. In the Hawaiian material, as in Baba's specimens, the cerata are arranged in peduncles of one, two, or three cerata with one preanal peduncle per side. The extremely elongate oral tentacles are characteristic of all the material. The shape of the jaws from the Okinawan animal is close to that of the three Hawaiian specimens examined. The

TABLE 1  
COMPARATIVE DATA ON *Flabellina* AND TWO SPECIES OF *Coryphella*

SPECIES	LOCALE	COLOR	NUMBER OF RADULAR ROWS	NUMBER OF DENTICLES ON EACH SIDE OF RACHIDIAN CUSP	NUMBER OF DENTICLES ON LATERAL	MASTICATORY BORDER	RIGHT ANTERIOR DIGESTIVE SYSTEM CERATA	REPRODUCTIVE SYSTEM
<i>Flabellina affinis</i> (Gmelin, 1791)	Mediterranean	Lilac	34	6-7	6	—	Compound peduncles	Receptaculum only
<i>F. alisonae</i> sp. nov.	Hawaii, Japan, Okinawa	Purple-white cerata with orange ring	14-20	7-12	4-7	Short	Simple, 1 preanal row	Receptaculum and bursa
<i>F. annuligera</i> (Bergh, 1900)	Laysan Atoll	Blue, white cerata with orange ring	20	8-10	5-7	Elongate	Simple, 1 preanal row	Receptaculum only
<i>F. babai</i> Schmekel, 1970	Naples	Blue-white cerata with orange ring	18-24	5-10	5-8	Short	Simple, 2 preanal rows	Receptaculum only
<i>F. engeli</i> Marcus & Marcus, 1968	Curaçao	Pink with brown cerata with white	20	7-11	5-10	Unknown	Simple, 1 preanal row	Receptaculum only
<i>F. macassarana</i> Bergh, 1905	Macassar	Pink-yellow	17	5	4-5	Unknown	Simple, 2 preanal rows(?)	Unknown
<i>F. stohleri</i> Bertsch & Ferreira, 1974	Gulf of California	Orange with white	14	6-8	9	Unknown	Simple, 3 preanal rows	Unknown
<i>F. telja</i> Marcus & Marcus, 1967	Gulf of California	Blue cerata; orange with white tip	28	8-11	6-8	Elongate	Simple, 4 preanal rows	Receptaculum and bursa
<i>Coryphella ornata</i> Risbec, 1928	New Caledonia	White cerata with orange	20	7	8	Elongate	Compound, 2 preanal groups	Unknown
<i>C. violacea</i> comb. nov.	New Caledonia	Rose-violet 3 longitudinal red lines	—	5	5	Unknown	Unknown	Unknown

jaws are broad and ovoid with a short masticatory border containing several rows of denticles. The radulae bear a strong resemblance, with 16 or 17 rows of teeth in the Japanese and Okinawan animals and 14 to 18 rows in the Hawaiian material. Schmekel (1970), apparently based on a specimen from Japan, described a radula with 20 rows. In Baba's and Schmekel's animals, the rachidian tooth contains nine or ten denticles on each side of the central cusp compared to seven or eight in the Hawaiian aeolids, while the laterals in their specimens have six to nine denticles compared to four to seven in the present study. These differences are not considered significant, particularly in view of the similarity in the shape of the teeth in all citations. Therefore, I consider the specimens described by Baba (1936) as *Coryphella ornata* and *Flabellina ornata* (Abe 1964, Baba 1955, Schmekel, 1970) to be conspecific with *Flabellina alisonae* spec. nov.

The only description of the reproductive system of *Flabellina alisonae* is that of Schmekel (1970). She noted that the penis is unarmed, as in Baba's (1955) and the present material, and that a distal bursa copulatrix and proximal receptaculum seminis are both present.

Several characteristics of the described species of *Flabellina* and those of *Coryphella ornata* and *C. violacea* are summarized in Table 1. Of the six species of *Flabellina* for which the reproductive system has been described, only *F. alisonae* and *F. telja* Marcus & Marcus, 1967 are known to have both a proximal receptaculum and distal bursa. *Flabellina telja* is clearly separable from *F. alisonae* because it has more numerous rows of radular teeth (28 as compared to 14–20 in *F. alisonae*), and has four preanal ceratal rows compared to a single row in *F. alisonae*. The coloration is also strikingly different. *Flabellina alisonae* differs from *F. stohleri* Bertsch & Ferreira, 1974 in its coloration and the fact that *F. stohleri* has three preanal ceratal rows. *Flabellina macassarana* Bergh, 1905 differs from *F. alisonae* in its pink-yellow body color, more numerous cerata (six cerata each within the first two ceratal rows, which are preanal), and rachidian teeth with a prominent central cusp.

Of the species that have only a receptaculum seminis, *Flabellina affinis* (Gmelin, 1791) can be distinguished on the basis of its numerous radular rows (34 as compared to 14–20 in *F. alisonae*), compound ceratal peduncles with two preanal peduncles, and coloration. *Flabellina babai* Schmekel, 1970 possesses two preanal ceratal peduncles and proportionately shorter oral tentacles than does *F. alisonae*. *Flabellina annuligera* (Bergh, 1900) and *F. engeli* Marcus and Marcus, 1968 have a simply rounded anterior foot margin and only a single row of denticles on an elongate masticatory border.

The present species is named in honor of E. Alison Kay of the University of Hawaii, Honolulu, Hawaii.

#### Family Cuthonidae

*Cuthona perca* (Ernst Marcus, 1958)

*Catriona perca* Ernst Marcus, 1958 (Edmunds 1964); *Trinchesia perca* Marcus & Hughes 1974; *Cuthona reflexa* Miller, 1977

DISTRIBUTION: Brazil (Ernst Marcus 1958); Jamaica (Edmunds 1964); Florida (Eveline Marcus 1972); Barbados (Marcus and Hughes 1974); New Zealand (Miller 1977)

HABITS AND OCCURRENCE: Three specimens were found associated with the sea anemone, *Aiptaisia* sp., on the floating docks at Coconut Island, Kaneohe Bay, Oahu, in October 1972; four specimens in the thermal pollution tables at Coconut Island in July 1973; and single specimens in August and September 1973 from the same locality. Several specimens have been found from St. Petersburg, Florida (Joseph L. Simon, University of South Florida, personal communication, 1975).

DESCRIPTION: Animal (Figure 3A) 5 to 15 mm in length. Color translucent white with scatterings of opaque white and dark olive green; orange tinge sometimes present on the head and dorsal surface; olive green pigment in ceratal core. Cerata often unusually elongate. Animals typically cuthonid, with rounded head and smooth rhinophores. Cephalic tentacles shorter than rhinophores and terete.

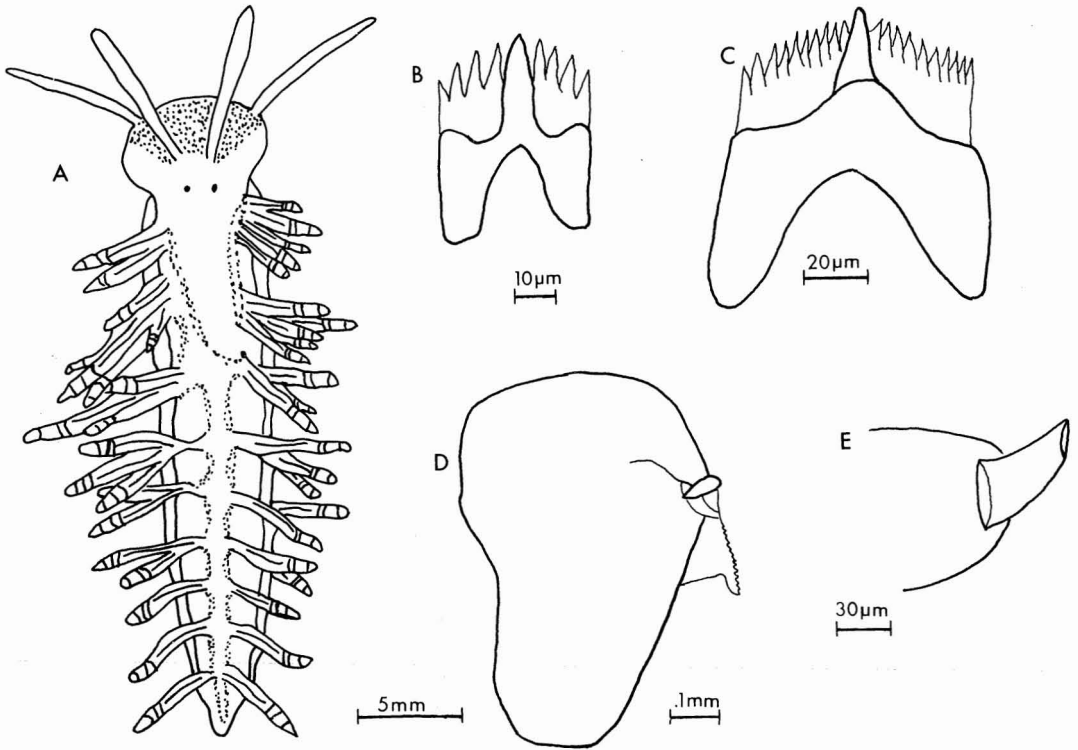


FIGURE 3. *Cuthona perca*: A, dorsal view of living animal; B, posterior radular tooth; C, anterior radular tooth; D, jaw; E, penial stylet.

Anterior margin of foot simply rounded. Anterior digestive system of two rows of cerata. Left digestive system containing five to ten pairs of rows. Gonopore between first two rows of cerata. Anus acleioproctic, cleioproctic in one specimen. Strongly tapering radula (Figure 3B, C) of 35 rows of teeth in a 12-mm specimen. Posterior teeth smallest,  $38\ \mu\text{m}$  wide, with four denticles on each side of central cusp. Anterior teeth 2.5 times broader, up to  $87\ \mu\text{m}$  wide, with 11 denticles on each side of central cusp. Jaws thin and elongate (Figure 3D), 0.78 mm long. Masticatory border with a row of 18 denticles in one specimen. Penis (Figure 3E) with accessory gland and terminal stylet,  $75\ \mu\text{m}$  long.

DISCUSSION: *Cuthona perca* (Ernst Marcus, 1958) is known from the western Atlantic from Cananea, Brazil (Ernst Marcus 1958); Jamaica (Edmunds 1964); Miami, Florida (Eveline Marcus 1972); the Barbados (Mar-

cus and Hughes 1974); and from New Zealand (Miller 1977). The specimens from Hawaii and St. Petersburg, Florida, agree with the described variation of the species.

The dark-green to black color in the cerata, with dark coloration on the head anterior to the rhinophores, is distinctive. All the Hawaiian animals had two subapical bands of opaque white on the cerata, but several specimens lacked orange pigment on the head and notum. The cerata of the larger Hawaiian animals were significantly more elongate than previously described material from the Atlantic. The radular configuration is similar to the range described (Edmunds 1964, Ernst Marcus 1958, Miller 1977): 35 teeth in the present material compared to 16 to 33. The unusual tapering of the radula with marked differences in the width of the teeth and number of denticles from anterior to posterior is characteristic of this species in all accounts. This tapering is especially

evident in members of the Aeolidiidae, which feed largely on sea anemones. *Cuthona perca* feeds exclusively on the sea anemone, *Aiptasia* sp. in Hawaii. It is suggested that this radular shape represents a convergent adaptation in *C. perca* and the Aeolidiidae associated with feeding on sea anemones.

The configuration of the digestive system in the Hawaiian specimens agrees with that described by Edmunds (1964), but at least two more rows were present in the posterior digestive system of the larger Hawaiian animals than in those described from Jamaica. The presence of a penial stylet and penial accessory gland in the Hawaiian material further substantiates the conspecific nature of the organisms. Penial armature cannot be used to separate *Trinchesia* from *Cuthona*, and the species must be regarded as belonging to *Cuthona* (Williams and Gosliner, in press).

The coloration of *Cuthona reflexa* Miller, 1977 is similar to that described for *C. perca* in that it also possesses dark hepatic tissue in the ducts of the digestive gland. The radular morphology, number of teeth, and denticulation of *Cuthona reflexa* lie within the range of variation described for *C. perca*. Both taxa have an armed penis with an accessory penial gland and a prostatic vas deferens. The only morphological character which differs is the number of ceratal rows in the right anterior digestive system; there are two rows in *C. perca* and three to four rows in *C. reflexa*. Owing to their extreme morphological similarity, *Cuthona reflexa* Miller, 1977 is here regarded as a junior synonym of *C. perca* (Marcus, 1958).

*Cuthona pinnifera* (Baba, 1949)

*Cratena pinnifera* Baba, 1949; *Trinchesia pinnifera* (Burn 1964)

DISTRIBUTION: Sagami Bay, Japan (Baba 1949)

HABITS AND OCCURRENCE: A single specimen was found under a dead coral head on a largely dead reef in Kaneohe Bay, Oahu, in August 1973. It was associated with the plumularid hydroid, *Halopteris diaphana* (Heller, 1868), on which it presumably feeds.

A single egg mass was also found on the same hydroid colony.

DESCRIPTION: Single individual (Figure 4A) 7 mm in length. Color translucent white with opaque white pigment throughout body surface. Rhinophores (Figure 4B) with seven to eight semicircular annulations. Length of rhinophores and oral tentacles equal. Foot simply rounded anteriorly. Cerata in seven rows, three rows in anterior right digestive system. Cerata (Figure 4C) with two bulbous swellings in distal portion. Opaque white pigment present at swellings. Gonopore between first two ceratal rows. Anus subdorsal, acleioproctic, anterior to fourth ceratal row. Radula uniseriate (Figure 4D), elongate, of 41 rows of teeth 45  $\mu$ m wide. Central cusp elongate with five or six denticles on each side. Jaws elongate (Figure 4E), 0.70 mm long. Masticatory border a single row of 28 denticles. Penis bulbous (Figure 4F) with apical stylet at apex and penial gland.

DISCUSSION: In 1949 Baba described *Cratena pinnifera* from Sagami Bay. Burn (1964) applied the name *Trinchesia pinnifera* in a discussion of the rhinophores in *Toorna*, stating that *T. pinnifera* is the only *Trinchesia* with annulate rhinophores. Again, penial armature cannot be used to separate *Trinchesia* from *Cuthona*, and the species must be regarded as belonging to *Cuthona* (Williams and Gosliner, in press).

The single specimen found in this study is similar to those described by Baba from Sagami Bay, Japan, and is considered conspecific with the Japanese animals. Baba's animals ranged in length from 7 to 10 mm, as compared to 7 mm in the Hawaiian animal. In Baba's animals, the cerata were arranged in eight to nine rows, as compared to seven in the specimen from Kaneohe Bay. Both the Japanese and the Hawaiian animals had three ceratal rows in the anterior right digestive system. In the Japanese specimens, the gonopore was located ventral to the second ceratal row; in the Hawaiian animal, it is between the first and second rows. The anus in animals from both localities is located anteriorly, adjacent to the dorsal end of the



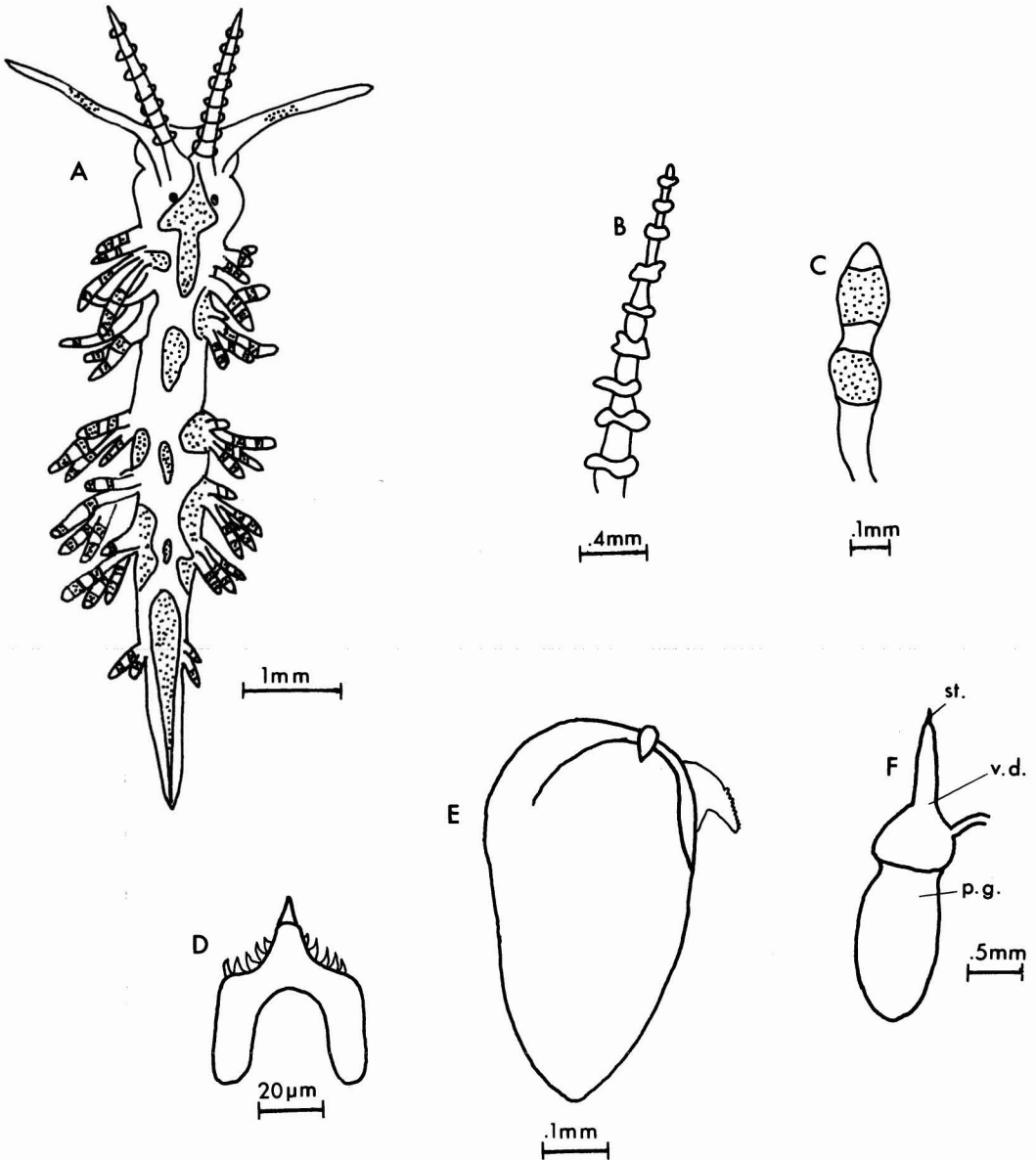


FIGURE 4. *Cuthona pinnifera*: A, dorsal view of living animal; B, rhinophore; C, cerata; D, radular tooth; E, jaw; F, penis (p.g., penial gland; st., stylet; v.d., vas deferens).

fourth ceratal group, in a typical acleioproct position. In animals from both localities, the foot corners are simply rounded.

The coloration of Baba's animals was a uniform white, but some specimens had a yellow ring around the middle of the cephalic tentacles and cerata with a subapical yellow

ring below the opaque white apex. The Hawaiian specimen lacks yellow pigment.

Baba described five to eight semicircular annulations on the rhinophores as compared to seven or eight in the Hawaiian animal. Baba did not mention the two bulbous swellings seen in the cerata of the Hawaiian

individual, nor did he figure or describe the general shape of the jaws. The Japanese animals had 20 to 22 denticles on the masticatory border of the jaws as compared to 28 in the animal from Kaneohe Bay.

The radula in the material from Japan consisted of a uniseriate radula of 45 rows of teeth with six to seven denticles on each side of the central cusp. This compares with a radula of 41 rows with five denticles on each side of the central cusp in the animal from Hawaii.

*Cuthona diminutiva* spec. nov.

**TYPE LOCALITY:** The seawater tables of the thermal pollution study at the Hawaii Institute of Marine Biology (Coconut Island), Oahu, Hawaii, serve as the type locality.

**TYPE MATERIAL:** The holotype is deposited in the Bernice P. Bishop Museum, Honolulu, Hawaii, where it bears the number BPBM 218719. Paratype material resides in the author's personal collection.

**HABITS AND OCCURRENCE:** *Cuthona diminutiva* was abundant in the thermal pollution study tables at Coconut Island from July to August 1973, where it apparently feeds on an unidentified corynid hydroid and is frequently found with its egg masses.

**DESCRIPTION:** Animals small (Figure 5A), 3 to 5 mm in length. Animals sexually mature, laying small, semicircular egg masses 3 to 5 mm long. Coloration generally white with encrustations of white and brown pigment. Eyes readily visible. Rhinophores smooth and terete. Oral tentacles approximately equal to rhinophores in length and diameter. Anterior foot corners simply rounded. Ceratal formula (after Edmunds 1970) 4, 2; 1, 1 and 2, 3; 1, 1 in two specimens. Cerata (Figure 5B) one to four per row with bulbous inflation about midway of their length. Gonopore ventral to most anterior ceratal row. Anus acleioproctic in posterior half of body. Radula (Figure 5C) consisting of 24 to 34 teeth 35  $\mu$ m wide with five or six denticles on each side of the slightly prominent central cusp. Jaws elongate (Figure 5D), 0.48 mm

long with large expanded masticatory border bearing 18 denticles along its length. Penis armed with a curved stylet (Figure 5E) 110  $\mu$ m long, with penial gland. Receptaculum seminis distal, opening near female gonopore.

**DISCUSSION:** *Cuthona diminutiva* reaches a maximum length of 5 mm. Animals maintained in the laboratory and fed on corynid hydroids never exceeded this size. The specific epithet *diminutiva* was chosen because of the small size of the animals.

*Cuthona diminutiva* resembles *Trinchesia boma* Edmunds, 1970 and *Trinchesia* sp. (Edmunds 1970) in several aspects of morphology, but there are significant differences that warrant specific separation. *Trinchesia* is considered a junior synonym of *Cuthona* (Williams and Gosliner, in press). *Cuthona boma*, *C. diminutiva*, and *Cuthona* sp. are all sexually mature when only 3 mm in length and have few cerata (three to five rows, with one to four cerata per row and two preanal rows). Each of the three species possesses a penial stylet; all three are similar in reproductive morphology. The radular teeth are similar in number of rows and shape. In *C. diminutiva* and *C. boma* the cerata are elongate, but in *C. diminutiva* there is a prominent bulbous swelling bear the middle of the ceras. In *C. boma* the cerata begin near the base of the rhinophores, whereas in *C. diminutiva* the cerata begin in the posterior two-thirds of the animal's length. *Cuthona boma* has seven to nine denticles on each side of the central cusp of the rachidian, while *C. diminutiva* possesses five or six. The penial stylet of *C. boma* is straight, while it is curved in *C. diminutiva*. *Cuthona boma* and *C. diminutiva* also differ in coloration: there is orange pigment on the dorsum and rhinophores of *C. boma* that is absent in *C. diminutiva*, and *C. diminutiva* has uniformly distributed brown flecks that are absent in *C. boma*.

*Cuthona* sp. (Edmunds 1970) differs from *C. diminutiva* in having fewer, shorter cerata, a straight penial stylet, and orange pigment on the dorsum.

The following species also have two preanal

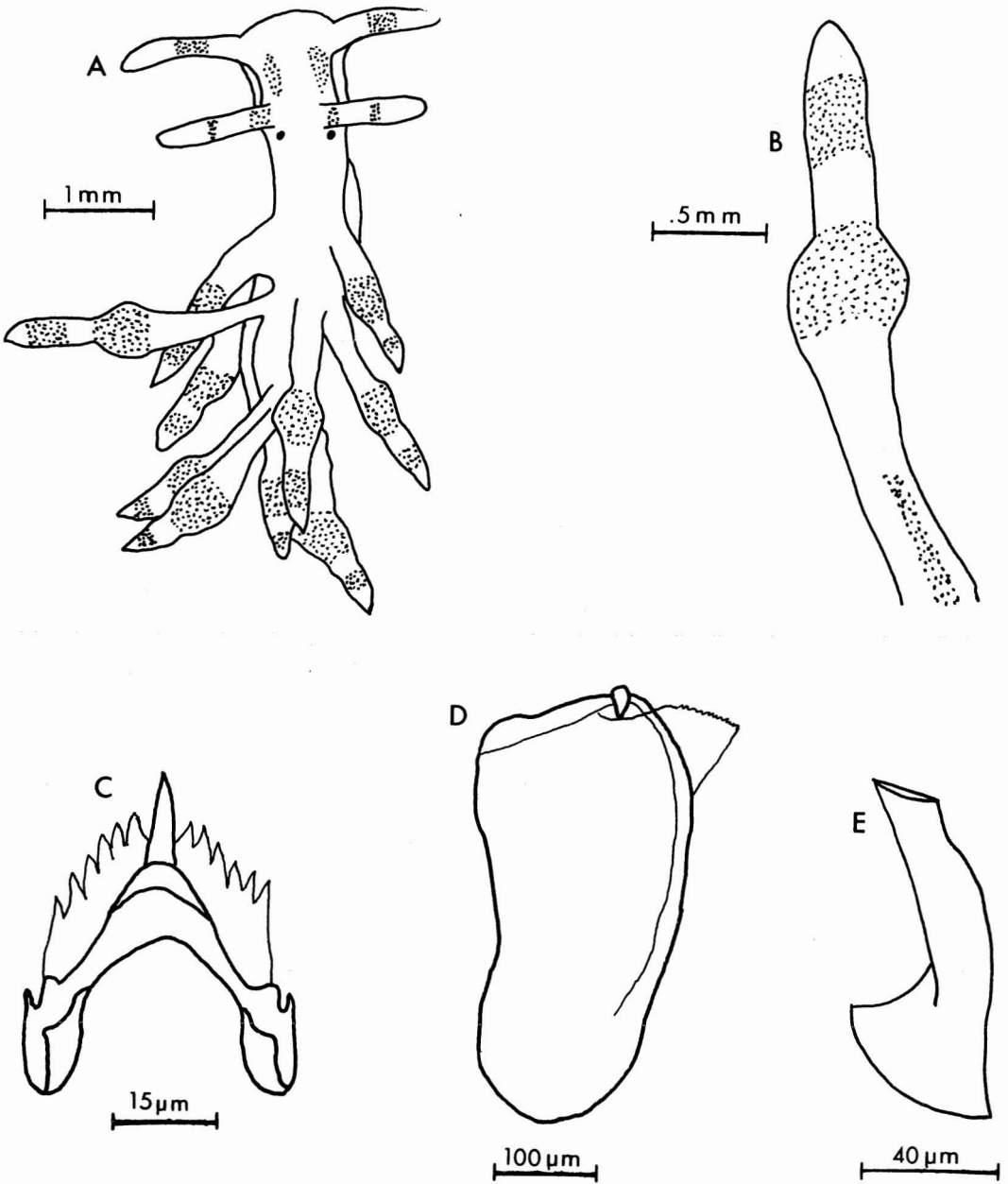


FIGURE 5. *Cuthona diminutiva*: A, dorsal view of living animal; B, ceras; C, radular tooth; D, jaw; E, penial stylet.

ceratal rows: *Cuthona bylgia* (Bergh, 1870); *C. colmani* (Burn, 1961); *C. cuculatta* (Bergh, 1905); *C. ornata* (Baba, 1937); *C. pupillae* (Baba, 1961); *C. rubrata* (Edmunds, 1970); and *C. taita* (Edmunds, 1970). All these have significantly more numerous cerata than *C.*

*diminutiva*. Ernst Marcus (1958) listed most species that can currently be considered as members of the genus *Cuthona*. Schmekel (1968) summarized the species described after Marcus' work. *Cuthona diminutiva* differs from all other species listed. Only *C. pusilla*

(Bergh, 1898) is similar to *C. diminutiva*, in that the anus is located in the posterior half of the body.

*Phestilla sibogae* Bergh, 1905

*Phestilla sibogae* Bergh, 1905, (Bonar and Hadfield 1974, Hadfield and Karlson 1969, Harris 1970, Kawaguti 1943);  
*Aeolidiella edmondsoni* Ostergaard, 1955

DISTRIBUTION: Roti Island, Timor Sea (Bergh 1905); Palau (Kawaguti 1943); Hawaii (Bonar and Hadfield 1974, Hadfield and Karlson 1969, Harris 1970, 1975, Ostergaard 1955).

HABITS AND OCCURRENCE: *Phestilla sibogae* is apparently quite uncommon in the field. Only one specimen was seen during the course of this study. Kay (personal communication) reports only two specimens in more than 10 years of field collection. The single specimen in this study was found under a dead chunk of the coral *Porites compressa* in Kaneohe Bay, Oahu. A single egg mass was found on the underside of a living *Porites lobata* colony in Hanauma Bay. Under laboratory conditions, where a head of *Porites* is in a water table and unfiltered seawater is allowed to pass over it, the species flourishes (Hadfield and Karlson 1969). In these colonies, *Phestilla* feeds voraciously upon the polyps, and egg masses are deposited abundantly on the undersurface of the coral. The coloration of the cerata in *Phestilla* is largely dependent upon the color of the *Porites* colony on which it has been feeding.

DESCRIPTION: Color variable, green, yellow-green, or purple, with opaque white on head and cerata. Head and anterior margin of foot rounded. Rhinophores smooth and conical. Cerata nodular with numerous swellings, arranged in pedunculate rows, six in anterior right digestive system, eight rows in posterior digestive system. Radula (Figure 6A) uniseriate, 21 to 31 teeth, 100  $\mu\text{m}$  wide, with five to nine denticles on each side of prominent central cusp. Jaws (Figure 6B) strong, 2.2 to 4.0 mm long, with smooth masticatory border. Gonopore ventral to third ceratal row. Anus anteriodorsal to

seventh ceratal row. Reproductive system (Figure 6D) typically cuthonid. Penis with short, 40  $\mu\text{m}$  long stylet (Figure 6C) and penial gland.

DISCUSSION: *Phestilla sibogae* was described from Roti Island in the Timor Sea (Bergh 1905). The animals were described from preserved material; the color in the living state was not described. The radula was variable, consisting of 24 to 44 teeth with six to seven denticles on each side of the central cusp.

Kawaguti (1943) recorded *Phestilla sibogae* from Palau and cited its association with the coral genus *Porites*. In 1955, Ostergaard described *Aeolidiella edmondsoni* from Hawaii on the basis of external characteristics. Hadfield and Karlson (1969) reported that the larvae in the laboratory are induced to metamorphose in the presence of mucus from living *Porites*. Bonar and Hadfield (1974) described the development of the species. Harris (1970) stated that Ostergaard's species is a junior synonym of *P. sibogae* but gave no specific basis for this contention. However, it is obvious from Ostergaard's plate of the animal that they are conspecific.

*Phestilla melanobrachia* Bergh, 1874

DISTRIBUTION: Philippines (Bergh 1874, Harris 1968), Sagami Bay, Japan; Okinawa, Singapore, Hawaii (all Harris 1968)

HABITS AND OCCURRENCE: The occurrence and feeding habits of *Phestilla melanobrachia* are described by Harris (1968). During the present study two specimens were collected from the ahermatypic coral, *Tubastrea aurea*, from a depth of 2 to 5 m in Kaneohe Bay, Oahu, in December 1972.

DESCRIPTION: Length 10 to 16 mm. Color orange, with areas of translucent white in oral region. Rhinophores smooth, conical. Oral tentacles short. Anterior margin of foot rounded. Cerata thin, elongate, in pedunculate rows: six in anterior right system, six in posterior system. Gonopore ventral to third ceratal row. Anus acleioproctic anteriodorsal to seventh ceratal row. Uniseriate radula

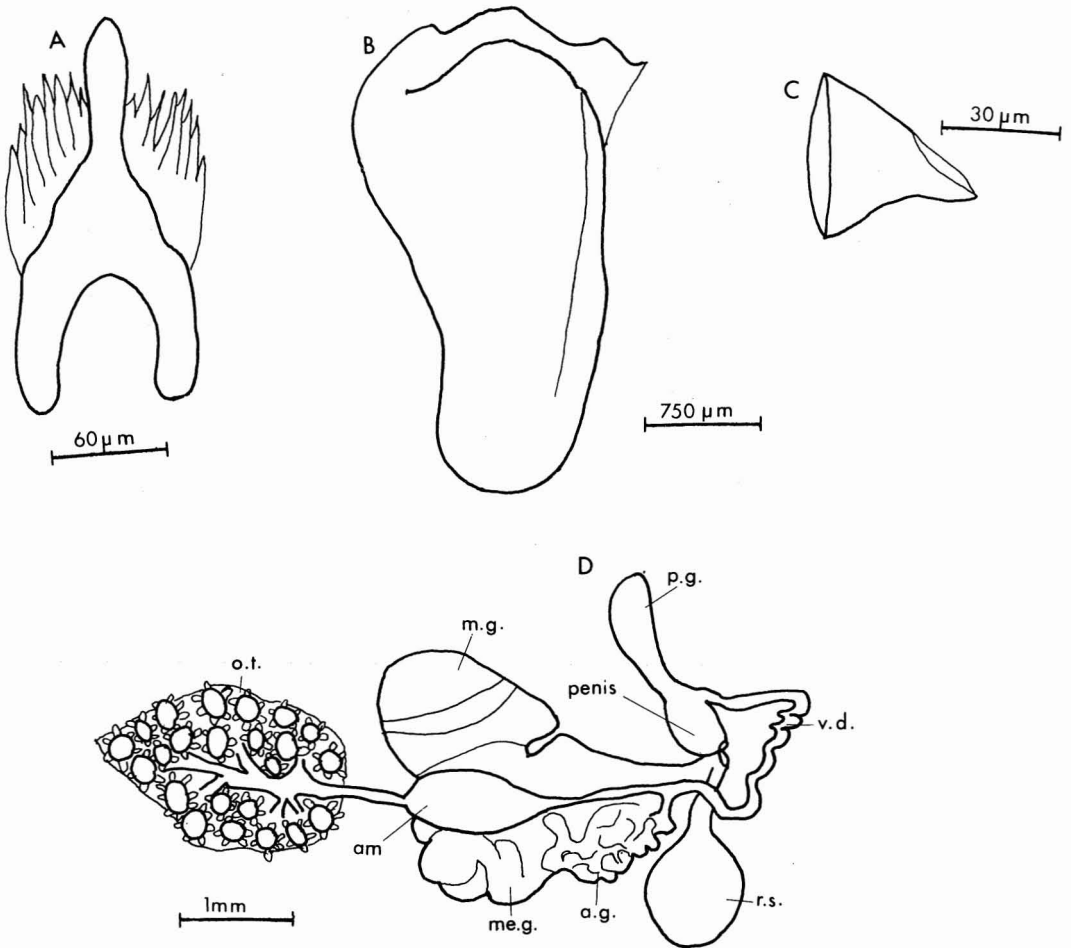


FIGURE 6. *Phestilla sibogae*: A, radular tooth; B, jaw; C, penial stilet; D, reproductive system (a.g., albumen gland; am, ampulla; m.g., mucous gland; me.g., membrane gland; o.t., ovotestis; p.g., penial gland; r.s., receptaculum seminis; v.d., vas deferens).

(Figure 7A) consisting of 71 teeth,  $160\ \mu\text{m}$  wide with eight to ten denticles on each side of prominent central cusp. Jaws (Figure 7B) elongate, 4.0 mm long. Penis (Figure 7C) with penial gland and armed with short cuticular stilet. Reproductive system similar to *P. sibogae*.

DISCUSSION: Harris (1968, 1970, 1975) observed many of the biological aspects of this species in several Indo-Pacific localities. He noted that variation in color of *Phestilla melanobranchia* is dependent upon its food source. Most recently he described the life history of the species. The fact that *P. melano-*

*branchia* and *P. sibogae* in the present study both have an armed penis alters the generic diagnosis, since Bergh (1874, 1905) described the penis as unarmed.

#### *Embletonia gracile* Risbec, 1928

*Embletonia gracile* was described from two specimens collected in Canala Bay, New Caledonia. The animals were white, the cerata arranged in seven rows, and digitate at their apices. Baba (1959) recorded *E. gracile* from Sagami Bay, noting that the terminal branchial papillae (cerata) distinguish *E. gracile* from the type of the genus,



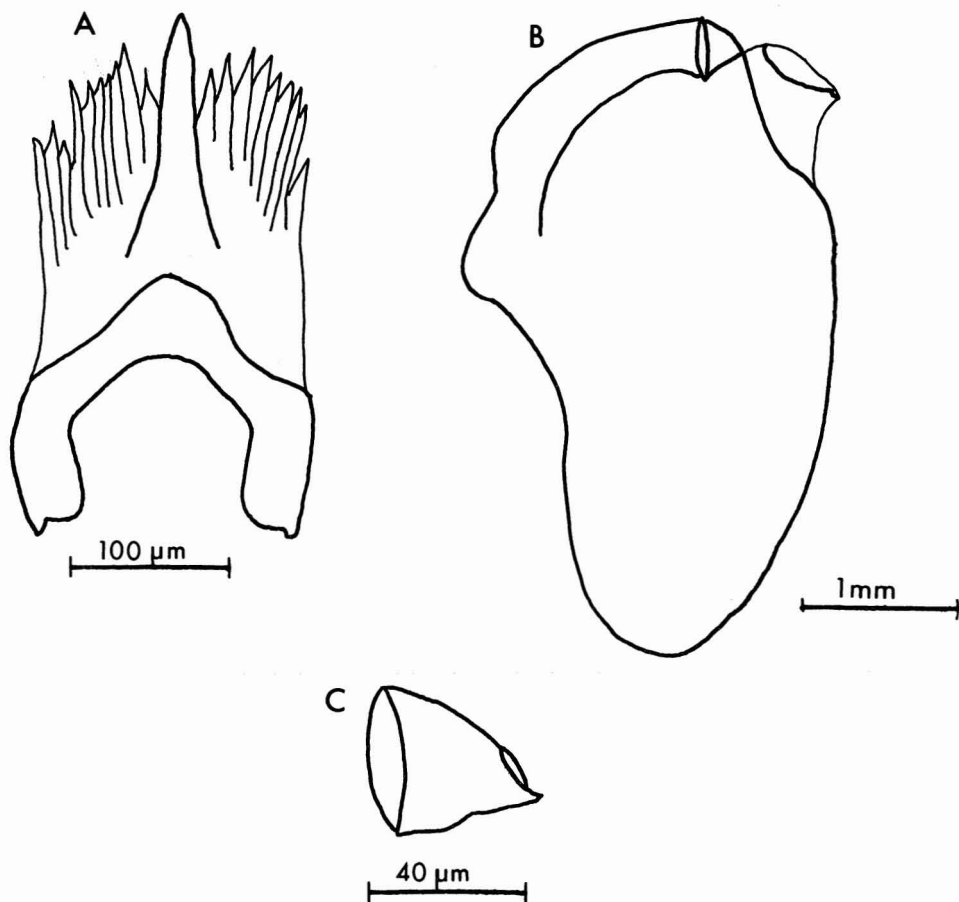


FIGURE 7. *Phestilla melanobrachia*: A, radular tooth; B, jaw; C, penial stylet.

*E. pulchra* (Alder & Hancock, 1844) from England, *E. faurei* Labbe, 1923 from France, and *E. evelinae* Marcus, 1957 from Brazil.

A subspecies, *E. gracile paucipapillata*, is distinguished from the typical form in having four or five rows of cerata per side, with vivid orange-yellow digestive diverticula, as opposed to seven or eight ceratal rows with pale-yellow diverticula. This subspecies was described by Baba and Hamatani (1963).

The Hawaiian record is based on a short description and a figure by Edmondson (1946, fig. 98b). The presence of apical ceratal papillae and the distinctive body shape in *Embletonia* strongly suggest that the animals figured by Edmondson are conspecific with *E. gracile*. Dr. Hans Bertsch (personal communication) has recently found a 15 mm

specimen of this species off Waikiki Beach at a depth of 25 m.

Family Facelinidae

*Facelinella semidecora* (Pease, 1860)

*Aeolis semidecora* Pease, 1860 (Pruvot-Fol 1947); *Coryphella semidecora* (Bergh 1890); *Facelinella anulifera* Baba, 1949 (1965)

DISTRIBUTION: Hawaii (Pease 1860) and Sagami Bay, Japan (Baba 1949, 1965)

HABITS AND OCCURRENCE: This aeolid is commonly found on the undersurface of rocks in the intertidal to depths not exceeding 5 m. It is common throughout the year. The species is widely distributed within the Ha-

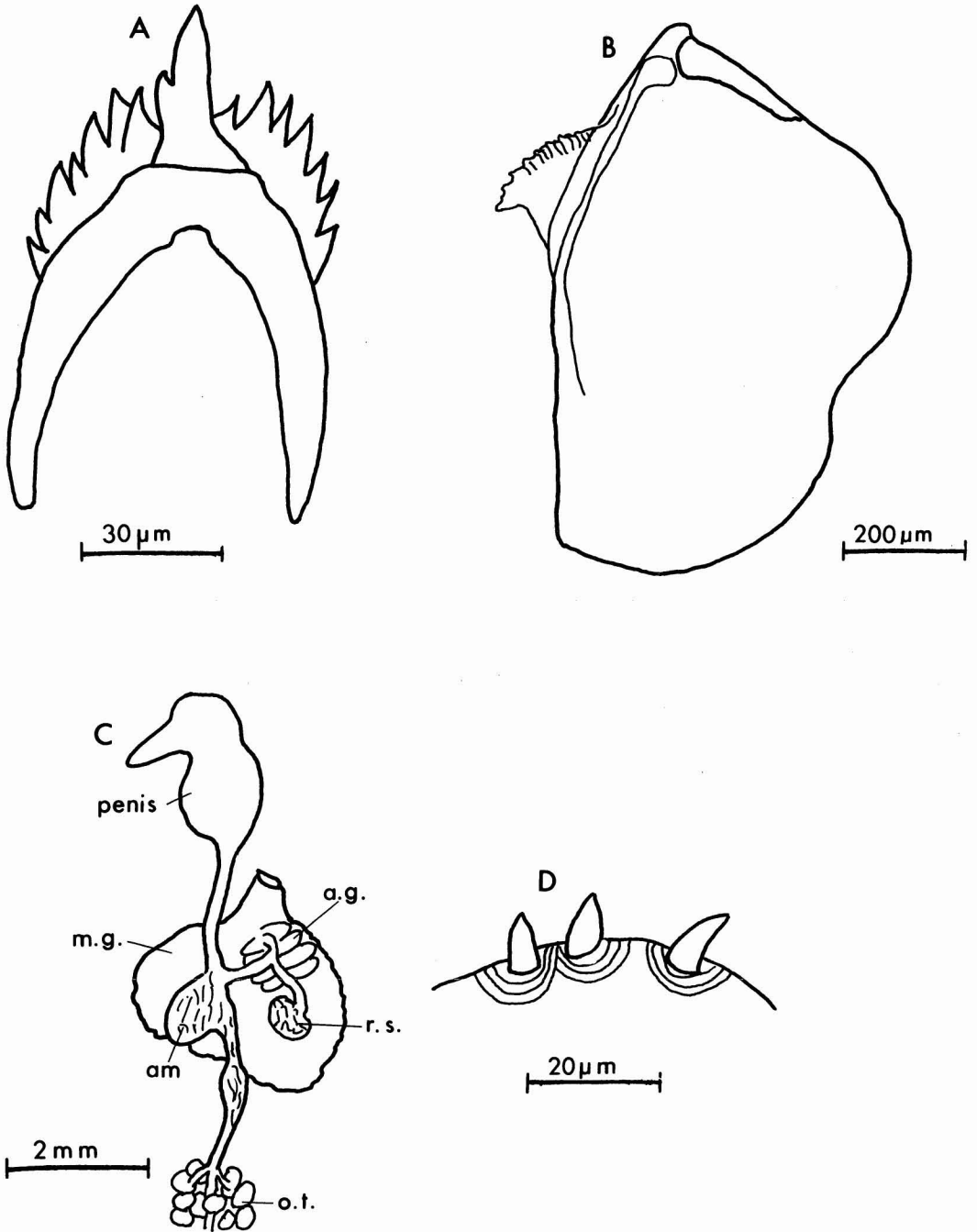


FIGURE 8. *Facelinella semidecora*: A, radular tooth; B, jaw; C, reproductive system (a.g., albumen gland; am, ampulla; m.g., mucous gland; o.t., ovotestis; r.s., receptaculum seminis); D, penial spines.

waiian Islands, found at Poipu, Kauai; Ala Moana Beach Park, Kewalo Basin, Diamond Head Beach Park, and Kaneohe Bay, all on Oahu; Fleming's Beach, Maui; and Honau-nau, Hawaii. Egg masses have been observed throughout the year.

**DESCRIPTION:** Animals 6 to 12 mm in length. Body thin, elongate. Color translucent white, with opaque white maculations; oral tentacles banded with opaque white and red, with single band of each near center and a long band of white at apex; apical portion of rhinophores with large band of opaque white; varying amounts of red-orange often present around head and medially; cerata brown internally with opaque white pigment concentrated at apices. Rhinophores conical with two to five slight annulations. Oral tentacles sharply tapered, one-third length of rhinophores. Anterior foot corners tentacular. Cerata short, five rows in anterior digestive system and seven rows in posterior system. Ceratal rows of posterior digestive system in two distinct groups. Gonopore ventral to posterior portion of right anterior digestive system. Anus anterior to second ceratal row of posterior digestive system. Radula (Figure 8A) consisting of 17 to 20 teeth, 60 to 70  $\mu$ m wide, with five to eight denticles on each side of central cusp. Jaws (Figure 8B) 0.92 mm long, with masticatory border of 15 denticles. Penis (Figure 8C) paddle-shaped, lacking an ejaculatory vas deferens. Lateral edge of penis with single row of hook-shaped spines (Figure 8D). Ampulla saccate, entering elongate oviduct. Receptaculum seminis semi serial, with duct entering oviduct near junction with albumen gland. Female gland mass large.

**DISCUSSION:** *Aeolis semidecora* was described from the Hawaiian Islands (Pease 1860). Pease's description closely matches the specimens found in the present study, and there is little doubt that the present material is conspecific.

*Facelinella anulifera* was described from Sagami Bay, Japan (Baba 1949). Similarity in color pattern, radular structure, and reproductive morphology lead me to consider it a junior synonym of *F. semidecora* (Pease

1860). The color pattern and external morphology are within the range of variation of the material from Hawaii. The rhinophores were annulated with four or five rings, and the cerata were arranged in eight to twelve rows with five to six rows in the right anterior digestive system.

The radula of Baba's specimens and the present material is also similar. The Hawaiian specimens have 17 to 20 teeth with five to eight denticles on each side of the central cusp; there are 16 rows with three to five denticles on each side of the central cusp in the Japanese animals. The general shape of the teeth is the same, despite the variation in the number of denticles. Baba (1965) mentioned a row of spines on the peculiarly shaped, nonejaculatory penis, and stated that the nonejaculatory vas deferens separates *Facelinella* from *Facelina*.

The similarity in reproductive morphology of the present material to that of *F. quadrilineata* (Baba, 1930) and *F. anulifera* further suggests the affinity between the material from Japan and Hawaii (Baba 1965).

*Caloria militaris* (Alder & Hancock, 1864)  
*Eolis militaris* Alder & Hancock, 1864 (Eliot 1906); *Hervia militaris* Farran 1905 (Narayanan 1969, O'Donoghue 1932, Satyamurthi 1952); *Learchis indica* Bergh, 1896 (Baba 1969); *Hervia dangeri* Risbec, 1953; *Learchis howensis* Burn, 1966; *Caloria militaris* (Burn & Narayanan 1970); *Phidiana militaris* (Miller 1974)

**DISTRIBUTION:** India (Alder and Hancock 1864, Burn and Narayanan 1970, Eliot 1906, Narayanan 1969, O'Donoghue 1932, Satyamurthi 1952); Ceylon (Farran 1905); Australia (Burn 1966, Burn and Narayanan 1970); middle Japan (Baba 1969); Amboina (Bergh 1896); New Caledonia (Risbec 1953); Funafuti (Burn and Narayanan 1970); Hawaii (Baba 1969, Burn and Narayanan 1970); and New Zealand (Miller 1974)

**HABITS AND OCCURRENCE:** *Caloria militaris* feeds on colonies of the hydroid *Halocordyle* (= *Pennaria*) *tiarella* (McCrary, 1857). This

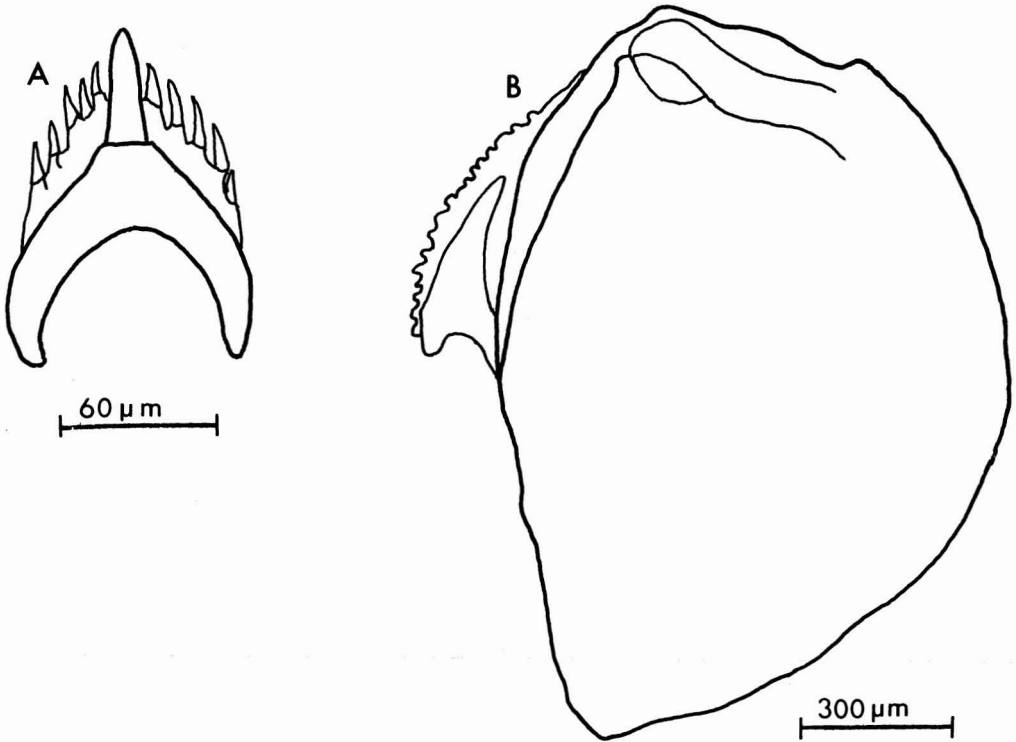


FIGURE 9. *Caloria militaris*: A, radular tooth; B, jaw.

species is commonly encountered in Kaneohe Bay, Oahu, on patch reefs, and also on the floating docks of Coconut Island, throughout the year. *Halocordyle* colonies on the leeward coast of Oahu apparently support smaller populations of *Caloria*. Single specimens have been seen at Ala Moana Beach Park and from 12 m off Pokai Bay (Kay, personal communication).

**DESCRIPTION:** Length 7 to 35 mm (from 50 animals). Body long and slender. Vividly and variably colored: body color translucent yellow-white, head bright red-orange with opaque white lines, oral tentacles opaque white for distal three-fourths, rhinophores translucent white with medial band of opaque white and apical band of red, cerata red from base to middle, followed by band of slate blue, terminated by white apex. Rhinophores conical, smooth. Oral tentacles long, sharply acute. Foot corners tentacular, elongate. Cerata arranged in seven to nine rows with two rows in anterior digestive system

followed by five to seven rows in posterior system. Gonopore ventral to first and second ceratal rows. Anus posterior to first row of posterior digestive system. Radula (Figure 9A) uniseriate, 20 rows of teeth, 100  $\mu$ m wide, with five to twelve denticles on each side of the more elongate central cusp. Jaws rounded (Figure 9B), thickened anteriorly, 1.4 mm long. Masticatory border a single row of 20 denticles. Reproductive system as described by Baba (1969).

**DISCUSSION:** Burn and Narayanan (1970) presented an extensive synonymy under *Caloria militaris*, contending that this taxon cannot be included in *Facelina* (= *Hervia*) because of the presence of an unarmed penis and smooth rhinophores, and that it should be placed in *Learchis*. They stated that their specimens are identical with the junior synonym, *Learchis indica* Bergh, 1896, but gave no basis for this statement. The type of *Learchis*, *L. indica*, was distinguished from *Caloria maculata*, the type of *Caloria*, only on the

basis of jaw shape. Burn and Narayanan considered these two genera synonymous, with *Caloria* having priority. Miller (1974) contended that *Caloria* is a synonym of *Phidiana*. My reasoning for separating *Phidiana* and *Caloria* was explained earlier (see discussion of Facelinidae.)

In their synonymy Burn and Narayanan (1970) studied specimens from Lord Howe Island; Funafuti; Kaneohe Bay, Oahu; and the Gulf of Kutch, India. They indicated no variation. Miller (1974) compared material from New Zealand with that from other localities. The general body shape is the same in each description. Burn (1966) described *Learchis howensis* as having six to eight annulae on the rhinophores but did not mention the fact when he characterized *Caloria militaris* as having smooth rhinophores. Annulate rhinophores must, therefore, be within the variation of the species but appear to be uncommon. Miller (1974) mentioned papillations on the head in a few specimens from New Zealand.

The coloration of *Caloria militaris* is predictable. Most workers cite red-orange pigment arranged in a V shape on the head or other orange coloration over a translucent cream to yellow body. The cerata are brick red to brown with blue and white pigment. There may be as many as nine pairs of rows of cerata.

The jaws are always described as strong with a denticulate masticatory border containing 9 to 25 denticles on the margin. The radula has 14 to 25 teeth with five to eight denticles on each side of the prominent central cusp. Both the radula and jaws are consistent in shape.

The penis is unarmed in all citations.

*Godiva quadricolor* (Barnard, 1927)

*Hervia quadricolor* Barnard, 1927; *Aeolidiella* sp. (Zahl 1959); *Godiva quadricolor* (MacNae 1954)

DISTRIBUTION: South Africa (Barnard 1927, MacNae 1954) and Hawaii (Zahl 1959)

HABITS AND OCCURRENCE: This species was found throughout the year in the seawater

tables of the thermal pollution study at Coconut Island, Kaneohe Bay, Oahu.

DESCRIPTION: Length 7 to 35 mm. Body color translucent white with varying amounts of opaque white and orange-brown, as in anterior half of oral tentacles; cerata transparent white with opaque white flecks and apices, often with orange and blue pigment; ceratal core chocolate brown. Rhinophores smooth, translucent with opaque white and orange. Body typically facelinid, with elongate oral tentacles more than twice the length of rhinophores. Foot corners tentacular, sharply recurved. Cerata elongate, thin, arranged in four to eight horseshoe-shaped arches. Cerata become erect when disturbed and are readily detachable. Gonopore ventral to anterior portion of first horseshoe. Anus within second horseshoe and nephroproct anterior to first arch of posterior digestive system. Radula (Figure 10A, B) consisting of 24, 26, 27 teeth in three specimens, 65 to 130  $\mu\text{m}$  wide with three or four large denticles on each side of central cusp. Jaws (Figure 10C) 1.8 to 2.5 mm in length with 20 denticles along masticatory border. Penis (Figure 10D) armed with curved spine 230  $\mu\text{m}$  long. Ampulla narrow, elongate, convoluted. Vas deferens thick, prostatic throughout. Receptaculum seminis semiseriale.

DISCUSSION: Barnard (1927) described *Hervia quadricolor* from False Bay (near Cape of Good Hope), South Africa. The radula and jaws were described but not illustrated. The anatomy of the reproductive system was not discussed. Barnard was quite specific as to the pattern of coloration on the cerata, describing it as orange, ultramarine, dark brown, and sulfur yellow.

MacNae (1954) described *Godiva* and designated *Hervia quadricolor* as the type species. He noted that the coloration was highly variable and that one or more of the bands of color may be reduced or wanting. MacNae illustrated the radula, jaws, elaboration of the digestive diverticula, and the reproductive system, thus providing a detailed account of the morphology of the species.

The material from Hawaii closely approaches that from South Africa in color and



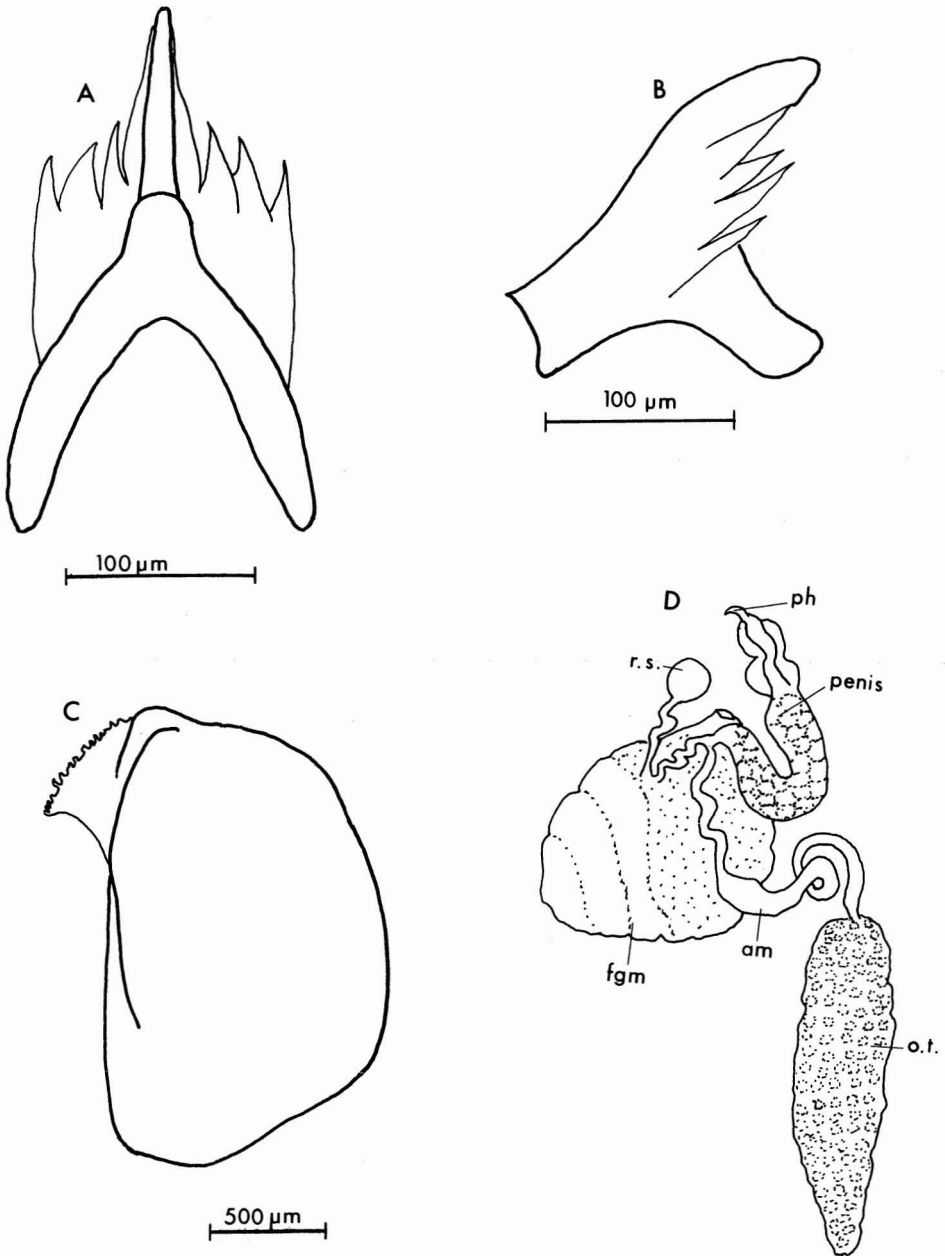


FIGURE 10. *Godiva quadricolor*: A, radular tooth, dorsal view; B, radular tooth, lateral view; C, jaw; D, reproductive system (am, ampulla; fgm, female gland mass; o.t., ovotestis; ph, penial hook; r.s., receptaculum seminis).

morphology. The specimen photographed by Zahl (1959) especially resembles the African specimens in coloration. Other Hawaiian specimens vary in color.

The radula of the Hawaiian specimens

contained 24 to 27 teeth as compared to 26 to 30 teeth in the African animals. The teeth in all accounts have three or four large denticles on each side of the central cusp. The masticatory border of the jaw had slightly

fewer denticles in the Hawaiian animals than previously described for the species, but this variation is considered within the range of intraspecific variation.

The reproductive system, as described by MacNae (1954), is virtually identical with that of the present material. Specimens from both localities have an elongate ampulla; short, thick, prostatic vas deferens; and terminal penial spine. The only difference noted was in the receptaculum seminis, where it was directed anteriorly lying on the top of the prostate in the Hawaiian animal and was directed posteriorly and rested on the mucous gland in the African specimens.

MacNae (1954) included *Rizzolia australis* Bergh, 1884 in *Godiva*, and subsequently, Edmunds (1964) described *G. rubrolineata* from Jamaica. Both species lack a terminal penial spine and have a simple, nonglandular penis. They more closely approach *Setoelolus* Baba 1965 and are here regarded as members of this genus.

*Favorinus japonicus* Baba, 1949

*Favorinus japonicus* Baba, 1949 (Abe 1964, Baba and Hamatani 1964, Carlson and Hoff 1973)

DISTRIBUTION: Middle and southern Japan (Abe 1964, Baba 1949, Baba and Hamatani 1964), Guam (Carlson and Hoff 1973)

HABITS AND OCCURRENCE: *Favorinus japonicus* has been found at Ala Moana Beach Park, along the seawall at Kewalo Basin, in the seawater tables of the Pacific Biomedical Research Center at Kewalo Basin, all on Oahu; and at Poipu, Kauai. The animals occur throughout the year as do their egg masses.

These aeolids feed on the egg masses of various opisthobranchs, such as *Aplysia juliana*, *A. dactylo-mela*, *Dolabrifera dolabrifera*, *Melibe pilosa*, and *Pleurobranchus semperi*.

DESCRIPTION: Length 8 to 17 mm. Color translucent white to green; oral tentacles translucent white from middle to apex; foot and rhinophores translucent white; remainder of body, except cerata, translucent white

with dense encrustations of opaque white; cerata light brown, pink, white, or green with opaque white apices. Rhinophores conical with two prominent bulbous swellings, one near the middle, the other just below the apex. Oral tentacles elongate and sharply pointed. Anterior foot corners elongate and tentacular. Cerata in five pairs of horseshoe-shaped arches. Single arch in anterior digestive system and four arches in posterior system. Cerata papillate and slightly recurved toward central body axis. Gonopore ventral to cerata of first horseshoe. Anus within second horseshoe. Radula (Figure 11A) uniseriate, consisting of 22 teeth, 140  $\mu$ m long. Teeth with single cusp, lacking lateral denticles. Jaw (Figure 11B) elongate, 1.1 mm long, with three to five rows of denticles on masticatory border.

DISCUSSION: *Favorinus japonicus* was described by Baba (1949) based on three specimens from Sagami Bay, Japan. Baba and Hamatani (1964) redescribed the species in greater detail and tentatively placed it in synonymy with *Eolis nodulosa* Keelart, 1859 and *Favorinus gouaroi* (Risbec, 1928). Both of these species seem distinct from the present species. *Eolis nodulosa* is figured (Eliot 1906) with smooth cerata and bulbous portions on the rhinophores. Because several species of *Favorinus* have bulbous swellings on the rhinophores [*F. branchialis* (Rathke, 1806), *F. auritululus* Marcus, 1955, and *F. ghanensis* Edmunds, 1968], the presence of rhinophoral swellings cannot be regarded as sufficient evidence to imply that *F. japonicus* and *E. nodulosa* are conspecific. While *F. gouaroi* (Risbec, 1928) resembles *F. japonicus* in external features, there are six denticles on each side of the central cusp of the radula teeth. Also, *F. gouaroi* lacks swellings on the rhinophores (Risbec 1928, pl. 12, fig. 13). *Favorinus branchialis*, *F. auritululus*, and *F. ghanensis* all have denticles adjacent to the median cusp of the radular teeth.

The Japanese specimens of *F. japonicus*, those from Guam (Carlson and Hoff 1973), and those from Hawaii are similar in form and coloration. Baba (1949) described *F. japonicus* as yellow with opaque white encru-

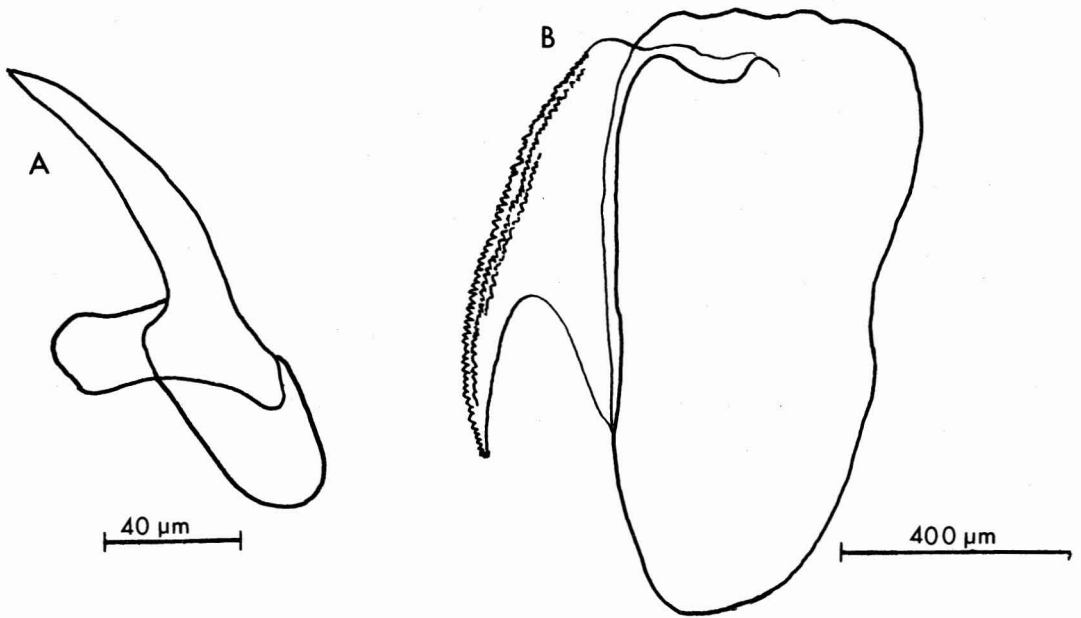


FIGURE 11. *Favorinus japonicus*: A, radular tooth; B, jaw.

stations and red cerata. The specimens from Guam were described as transparent with white masking, but Carlson and Hoff (1973) stated that the color varies with feeding habits. Baba (1949) described the cerata as arranged in rows, whereas the Hawaiian animals had ceratal horseshoes. However, the cerata often appear as double rows rather than arches. The position of the gonopore and anus are identical in animals from Japan and Hawaii.

Internally, Baba's animals and the present material are even more similar. The uniseriate radula from the Japanese specimens consisted of 17 to 20 teeth without any lateral denticles, as compared to 22 teeth in a Hawaiian specimen. The jaws in the Japanese specimens contained five or six rows of denticles as compared to three to five in the Hawaiian material.

Neither Baba (1949) nor Carlson and Hoff (1973) mentioned the feeding habits in their animals, but Haefelfinger (1969) stated that *F. branchialis* [as *F. alba*, synonymized by Lemche (1964)] feeds on the egg masses of opisthobranchs and that its color is dependent on the eggs upon which it feeds. Thompson and Brown (1976) noted that *F. blianus*

feeds on opisthobranch eggs as well as hydroids.

*Herviella mietta* Marcus & Burch, 1965  
*Herviella mietta* Marcus & Burch, 1965;  
*Herviella* sp. nov. Baba, Rosin 1969

DISTRIBUTION: Enewetak Atoll, Marshall Islands (Marcus and Burch 1965); Hawaii (Rosin 1969)

HABITS AND OCCURRENCE: Two specimens were found in this study, one from the north side of Coconut Island and a second from Portlock, Koko Head, Oahu. Kay (personal communication) reports specimens from Black Point and Kewalo Basin, Oahu. Rosin (1969) reported specimens from Kewalo Basin, Oahu, where they reportedly feed upon *Anthopleura nigrescens*. Kay (personal communication) has also found this species at Fanning Atoll, Line Islands.

DESCRIPTION: Length 7 to 40 mm. Body colors translucent white and dark green to black; dark pigment most pronounced on head; area around eyes and rhinophores lacking dark pigment and appearing as two translucent white patches; foot translucent

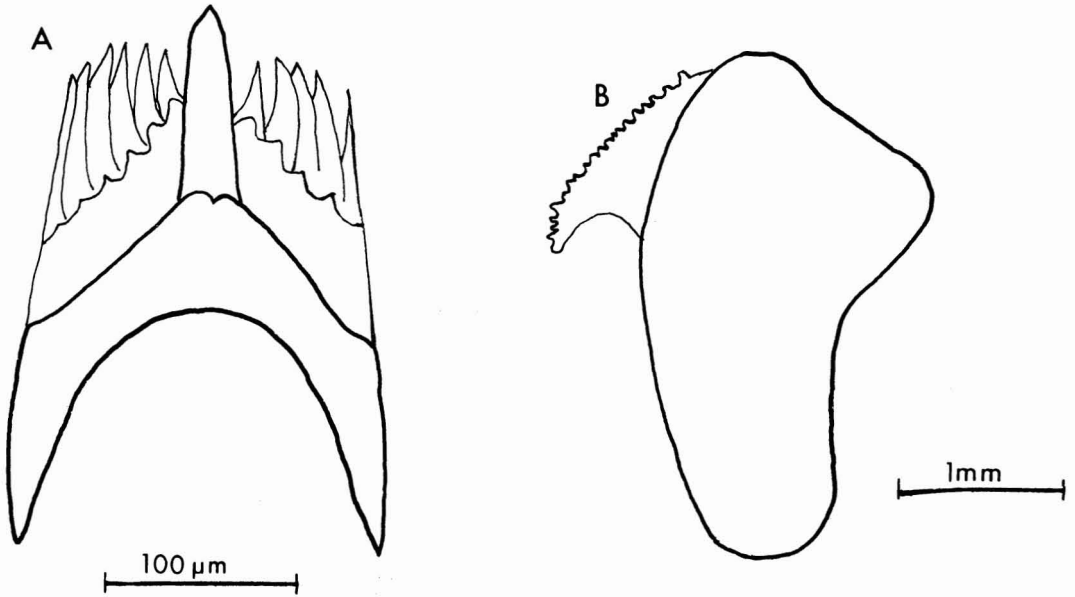


FIGURE 12. *Herviella mietta*: A, radular tooth; B, jaw.

white. Rhinophores approximating oral tentacles in length, smooth and conical. Both short relative to rest of body. Anterior portion of foot simply rounded. Cerata long and thin, arranged in five or six rows, with a single row in right anterior digestive system. Gonopore ventral to first row of cerata. Anus posterior to second ceratal row. Uniseriate radula (Figure 12A) consisting of 23 to 37 teeth, 150 to 200  $\mu\text{m}$  wide with six to eight denticles on each side of much thickened central cusp. Jaws (Figure 12B) elongate, 2.0 to 4.0 mm long, with ten irregularly spaced denticulations.

**DISCUSSION:** *Herviella mietta* was described from Enewetak, Marshall Islands (Marcus and Burch 1965). The prey-predator relationship between *Herviella* sp. and the sea anemone *Anthopleura nigrescens* was described by Rosin (1969). The similar external description between the specimens found by Rosin and those found by Marcus and Burch, and the identical habitat between Rosin's and the present material, suggest that they are all conspecific.

The radulae of the type specimens were uniseriate, consisting of 18 teeth with eight or nine denticles on each side of the central

cusp (Marcus and Burch 1965). In specimens from Hawaii, there are 22 to 37 rows with six to eight denticles on each side of the central cusp. The denticles in the Hawaiian animals are all approximately equal in length, while in the animals from Enewetak, the outer denticles are more elongate than the inner and central denticles.

The jaws in specimens from both localities are similar in shape, but are somewhat broader in specimens from Enewetak. The specimens from Enewetak had 18 denticles on the masticatory border as compared to 10 in a Hawaiian animal.

The type specimen had a penial stylet (Marcus and Burch 1965).

*Noumeaella* sp. cf. *rehderi* Ernst Marcus, 1965

**HABITS AND OCCURRENCE:** A single specimen of *Noumeaella* sp. was found in 2 m of water at Keauhou Bay, Hawaii, on 3 September 1973.

**DESCRIPTION:** Body slender and elongate, 11 mm. Color translucent white with dense patches of encrusting opaque white pigment arranged randomly. Rhinophores short and

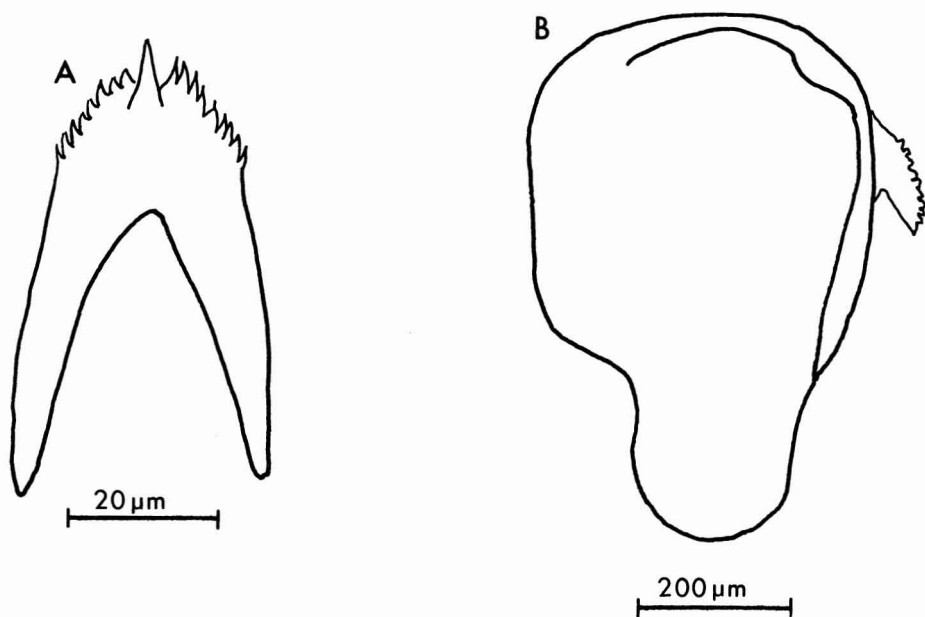


FIGURE 13. *Noumeaella* sp. cf. *rehderi*: A, radular tooth; B, jaw.

thick, anteriorly smooth, and densely papillate posteriorly. Oral tentacles approximating rhinophores in length and tapering to acute apex. Foot corners tentacular. Five pairs of ceratal groupings arranged in horseshoe-shaped arches, inserted commonly at base. Single arch in anterior digestive system. Cerata long, fusiform, and recurved. Gonopore within first ceratal arch, anus within second. Uniseriate radula (Figure 13A) 40  $\mu\text{m}$  wide, consisting of 19 rows with nine or ten denticles on each side of the prominent median cusp. Jaws (Figure 13B) generally round, 0.70 mm long. Masticatory border with 28 denticles.

**DISCUSSION:** The description of *Noumeaella rehderi* was based on a single specimen collected in Palau (Ernst Marcus 1965). The specimen was 3.5 mm long and was described as colorless (apparently meaning translucent white rather than transparent and clear).

The animal from Hawaii is similar in many respects to *N. rehderi*. Both are translucent white, although the Hawaiian animal has opaque white pigment as well. The jaws are similar in shape in both specimens; however, the jaws in Marcus' animal contained 40

denticles on the masticatory border as compared to 28 in the Hawaiian animal.

The radulae demonstrate more substantial similarity. The animal from Palau had 18 rows of teeth with six or seven lateral denticles on each side of the central cusp as compared to 19 teeth with nine or ten denticles on each side. The overall shape of the teeth is similar in the two animals.

While it appears that the specimen described by Ernst Marcus (1965) bears substantial similarity to the specimen from Hawaii, the lack of material in both instances makes more positive identification difficult.

#### Family Pteraeolididae

##### *Pteraeolidia ianthina* (Angas, 1864)

*Flabellina ianthina* Angas, 1864; *F. semperi* Bergh, 1870; *F. scalopendrella* Risbec, 1928; *Pteraeolidia semperi* Bergh, 1875 (Edmunds 1970, Eliot 1903, 1904a, Ernst Marcus 1965, Ernst and Eveline Marcus 1960, Risbec 1953, 1956); *P. ianthina* (Burn, 1965, Ernst and Eveline Marcus 1970)



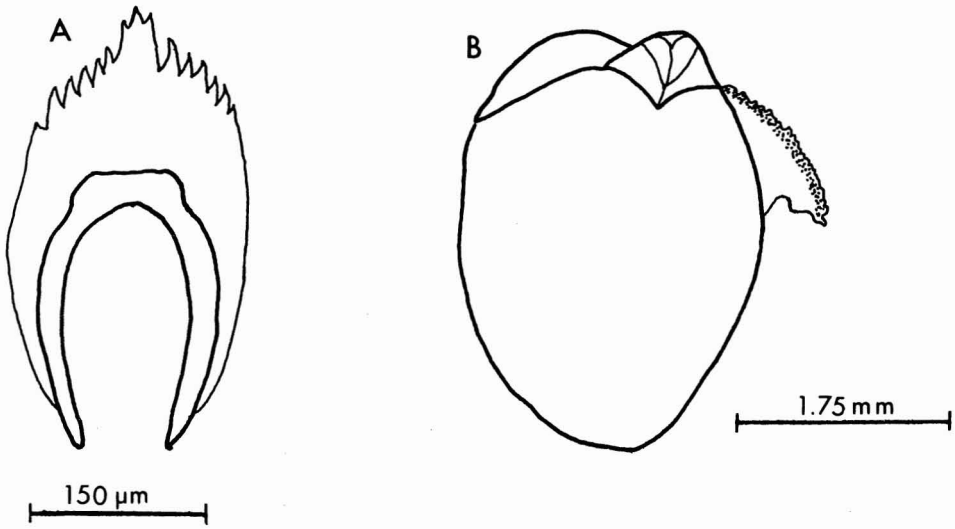


FIGURE 14. *Pteraeolidia ianthina*: A, radular tooth; B, jaw.

**DISTRIBUTION:** Red Sea (Ernst and Eveline Marcus 1960); Zanzibar (Eliot 1903, 1904a); Viet Nam (Risbec 1956); Australia (Angas 1864, Burn 1965); New Caledonia (Risbec 1928, 1953); middle Japan (Baba 1949); Philippines (Bergh 1870); Micronesia (Ernst Marcus 1965); and Hawaii (Zahl 1959)

**HABITS AND OCCURRENCE:** A single specimen was collected from each of three localities: 10 to 20 m from Kaneohe Bay, Oahu, in February 1973; 20 m off Waikiki, Oahu, in March 1973; and from 10 m, off Molokini, off the shore of Maui in November 1972. Specimens from the Kona coast of Hawaii found in August 1971 (Kay, personal communication) were associated with the octocoral *Sarcothelia edmondsoni*.

**DESCRIPTION:** Animals large, reaching 80 mm. Color exceedingly variable: body color generally green; green cephalic tentacles banded with opaque white and black pigments; dorsal surface with gold reticulations or opaque white patches; cerata green or purple, sometimes with opaque white pigment, with a yellow or gold apex. Rhinophores perfoliate throughout. Oral tentacles smooth with acute apex. Anterior foot corners tentacular. Body long and slender with 5 to 18 pairs of ceratal groups, winglike in

form, as the generic name implies. Gonopore below posterior portion of single ceratal group. Anus within first arch of posterior digestive system. Uniseriate radula (Figure 14A) consisting of 36 rows, 190 µm wide with five to seven denticles on each side of the central cusp. Central cusp may have one to three small denticles. Jaws (Figure 14B) 3.0 to 4.2 mm long, with many dense rows of small papillate denticles on masticatory border.

**DISCUSSION:** This species was described as *Flabellina ianthina* from Australia (Angas 1864). Bergh (1870) described *Flabellina semperi* from the Philippines and in 1875 named it as the type species of *Pteraeolidia*. Many other workers have recorded this species from various localities. Burn (1965) and Ernst and Eveline Marcus (1970) placed Angas' *F. ianthina* in *Pteraeolidia* and asserted that *P. semperi* is a junior synonym of *P. ianthina*, but they provided no basis for their decisions.

Baba (1949) recorded *P. semperi* from Japan, and described yellowish animals with blue cerata. The radula consisted of 20 rows of teeth with 10 to 20 denticulations on each side of the central cusp, as compared to 35 rows with five to seven denticles in a Hawaiian specimen. Risbec (1953) stated that the num-

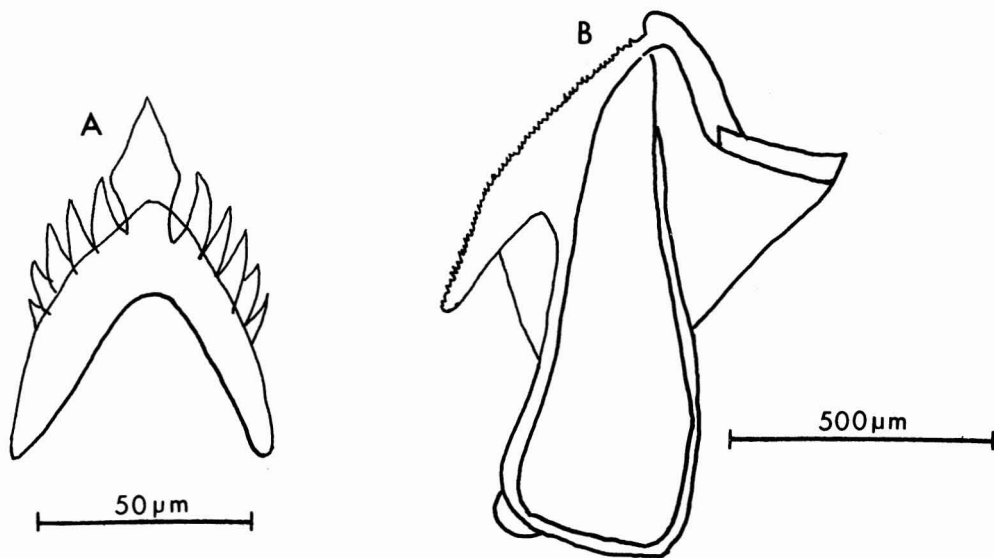


FIGURE 15. *Glaucus atlanticus*: A, radular tooth; B, jaw.

ber of rows of teeth and denticles per tooth in material from New Caledonia is exceedingly variable. The jaws in Baba's and Risbec's accounts of *P. semperi* resemble those of the Hawaiian specimens in shape and denticulation of the masticatory border.

#### Family Glaucidae

##### *Glaucus atlanticus* Forster, 1777

*Hirudinia marina* Breyn, 1705; *Glaucus atlanticus* Forster, 1777 (Miller 1974, Thompson and McFarlane 1967); *Doris radiata* Gmelin, 1790; *Scyllaea margaritacea* Bosc, 1802; *G. hexapterygius* Cuvier, 1808; *G. octopterygius* Cuvier, 1808; *Laniogeras blanvilli* Goldfuss, 1820; *L. elfortii* Blainville, 1825; *G. forsteri* Lamarck, 1836; *G. linectus* Bergh, 1868; *G. gracilis* Bergh, 1868; *G. longicirrus* Bergh, 1868 (Edmondson 1946); *G. marinus* (Baba 1949)

DISTRIBUTION: Circumtropical

HABITS AND OCCURRENCE: Pelagic, feeds on siphonophores and chondrophores. Two specimens were collected off Moku Manu, Oahu, in plankton hauls in December 1972.

DESCRIPTION: Length, 7 to 30 mm. Body

colors dark blue-purple and silver. Rhinophores and oral tentacles reduced. Anterior margin of foot simply rounded. Cerata in two to three groups on both sides of the body, most anterior group largest. In a 30 mm specimen, 16 cerata in first group, 11 in second, and 6 in third. In a 7 mm specimen, uniseriate radula (Figure 15A) consisting of 16 teeth 62  $\mu$ m wide with five denticles on each side of central cusp. Jaws (Figure 15B) 1.0 mm long, sharply angular, with straight, elongate masticatory edge bearing 130 denticles. Penis armed with dark-brown penial spine.

DISCUSSION: *Glaucus atlanticus* and its many synonyms are known from throughout tropical seas. The genus *Glaucus* Forster, 1777 is separated from *Glaucilla* Bergh, 1868 by the presence of a penial spine (Thompson and McFarlane 1967). Thompson and McFarlane (1967) emphasize the high degree of variability found in specimens of *G. atlanticus*. The coloration is especially variable, but is basically silvery-white and blue.

Thompson and McFarlane (1967) state that the radula contained 18 to 20 teeth, with two to ten denticles on each side of the median cusp. The specimen from Hawaii, in which the radula was observed, contained

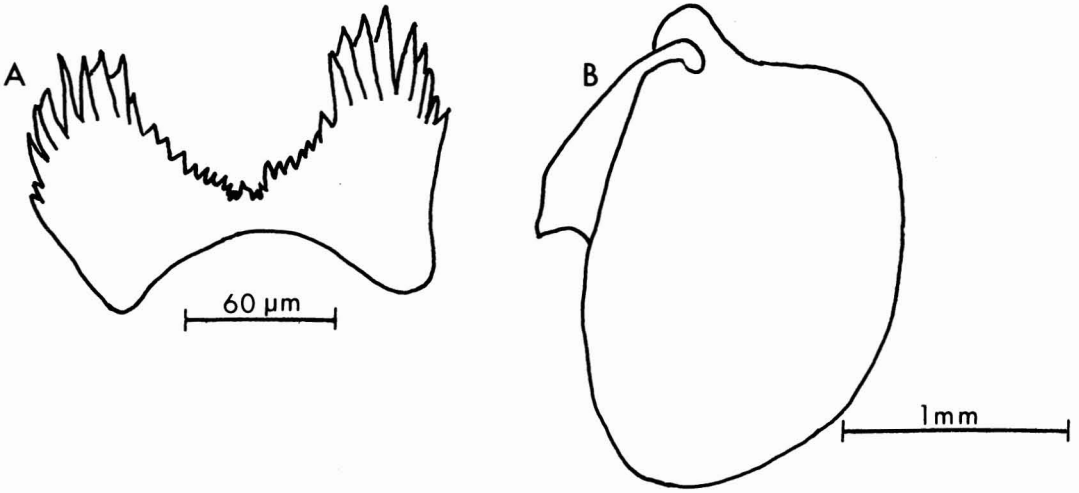


FIGURE 16. *Aeolidiella takanosimiensis*: A, radular tooth; B, jaw.

16 teeth with five denticles on each side of the median cusp. Neither Thompson and McFarlane nor Baba (1949) reported the number of denticulations on the masticatory border.

Family Aeolidiidae

*Aeolidiella takanosimiensis* Baba, 1930

*Aeolidiella takanosimiensis* Baba, 1930, 1949 (Sphon 1971)

DISTRIBUTION: Middle Japan (Baba 1930, 1949); southern California (Sphon 1971)

HABITS AND OCCURRENCE: Four specimens were collected from Kewalo Basin seawall, Oahu, in April 1973; three specimens from the thermal pollution study tables, Coconut Island, Kaneohe Bay, Oahu, in August 1973; a single specimen from Portlock, Koko Head, Oahu, in June 1973; and three specimens from Poipu, Kauai, in January 1965 (Kay, personal communication). Eggs were found throughout the year. Kay (personal communication) has found this species at Fanning Atoll, Line Islands.

DESCRIPTION: Length 9 to 21 mm. Animals translucent white with varying amounts of orange in head region, often with opaque white spots posterior to rhinophores, encircled by red-orange; cerata brick red to dark

brown; generally with a subapical white band on cerata; oral tentacles and rhinophores translucent white or orange; specimens from thermal pollution study tables lack orange. Rhinophores smooth and conical. Oral tentacles elongate. Anterior foot corners short and tentacular. Foot long and tapered posteriorly. Cerata with four to eight rows in right anterior digestive system in single group, with 11 to 16 in posterior system in groups of one to four rows. Gonopore ventral to anteriormost ceratal group. Anus in first ceratal group of posterior digestive system. Uniseriate radula (Figure 16A) consisting of 15 to 17 teeth, 150 to 200 µm wide, with 16 to 19 denticles on each side of central cusp. Jaws (Figure 16B) rounded, 1.1 to 2.3 mm long, with smooth masticatory border.

DISCUSSION: *Aeolidiella takanosimiensis* was described from middle Japan (Baba 1930). The Japanese animals are identical in coloration with the specimens found at Kewalo Basin and at Portlock, Oahu (Baba 1949, pl. 49, fig. 167). Baba does not mention a wide range in color, as was noted in the Hawaiian animals.

The radulae of the Japanese animals consisted of 16 teeth with 24 to 34 denticles on each side of the median cusp as compared to 15 to 17 teeth with 16 to 19 denticles in a

Hawaiian animal. The teeth are much more rounded in the Japanese animals. The jaws of the specimens from both localities are virtually identical but slightly more rounded in the Hawaiian animals.

Sphon (1971) recorded *Aeolidiella takanosiensis* from Los Angeles and San Diego, California. While Sphon gave no detailed comparison of his animals, personal communication with Sphon and my own observations of animals from San Diego confirm their identification. Some specimens from California have a stouter body and lighter orange coloration than Japanese and Hawaiian animals.

*Spurilla neapolitana* (Delle Chiaje, 1823)

*Eolis neapolitana* Delle Chiaje, 1823; *Eolidina neapolitana* Delle Chiaje, 1844; *Eolis alderiana* Deshayes, 1865; *Flabellina neapolitana* A. Costa, 1866; *F. inornata* A. Costa, 1866; *Spurilla neapolitana* (Bergh 1864, 1876, Edmunds 1964, Haefelfinger 1969, Eveline and Ernst Marcus 1959, 1960, 1962, 1967, Pruvot-Fol 1953, 1954, Trinchese 1878, Vayssière 1888); *S. sargassicola* Bergh, 1861, 1877; *S. brasilana* MacFarland, 1909; *S. neapolitana* var. *brazilana* Marcus, 1955, 1957; *S. mogribiana* Pruvot-Fol, 1953; *S. dakarensis* Pruvot-Fol, 1953

**DISTRIBUTION:** Mediterranean (Bergh 1864, 1876, 1877, A. Costa 1866, Delle Chiaje 1823, 1844, Deshayes 1865, Haefelfinger 1969, Trinchese 1878, Vayssière 1888); Atlantic coast of France (Pruvot-Fol 1954); Morocco, Senegal, Cape Verde Islands (all Pruvot-Fol 1953); Sargasso Sea (Bergh 1861); Florida (Eveline and Ernst Marcus 1960, 1962, 1967); Texas (Eveline and Ernst Marcus 1959); Jamaica (Edmunds 1964); Sao Paulo, Brazil (Ernst Marcus 1955, 1957)

**HABITS AND OCCURRENCE:** A single specimen of *Spurilla neapolitana* was found on the undersurface of a rock at the seawall, Kewalo Basin, Oahu, in November 1972.

**DESCRIPTION:** Length 22 mm. Head, rhinophores, oral tentacles, and pericardial region with orange reticulate pigment; cerata

translucent white with dark gray-brown liver diverticula; remainder of animal translucent white. Rhinophores perfoliate with many lamellae. Tips of oral tentacles expanded as minute bulbs. Anterior foot corners short, tentacular appendages. Gonopore within first ceratal arch. Anus within first arch of posterior digestive system. Radula (Figure 17A) uniseriate, with 29 broadly arched, pectinate teeth, 500 to 700  $\mu\text{m}$  wide. Denticles: 37 to 53 on each side of central indentation of teeth. Jaws (Figure 17B) strong, ovoid in shape, 4.5 mm long, with elongate, smooth masticatory border.

**DISCUSSION:** *Spurilla neapolitana* is a well-known aeolid, which is extremely variable. The large number of synonyms attests to its variability.

*Spurilla neapolitana* ranges in color from pink to orange, with brown and gray liver diverticula. There may or may not be opaque white pigment. The single specimen found in Hawaii is within the described range of color seen in this species. Haefelfinger (1969) attributed the range of color in most nudibranchs to variable feeding habits and cited *S. neapolitana* as an example.

The cerata in all *Spurilla neapolitana* are reportedly recurved at the apex, as in the Hawaiian specimen. The cerata are arranged with a single arch in the anterior digestive system followed by a variable number of arches and rows in the posterior system. The single specimen from this study had a single arch followed by three arches and two rows. As in all material of the species, the gonopore is located in the first arch of cerata, and the anus is in the first arch of the posterior system.

In Italy (Trinchese 1878), *S. neapolitana* reaches a length of 70 mm, while in Brazil (Ernst Marcus 1955), it varies from 2 to 35 mm.

The radular teeth vary in number and denticulation. Previous workers report 11 to 28 teeth with 15 to 63 denticles on each side of the median cusp. The Hawaiian specimen has 29 teeth with 37 to 55 denticles on each side of the median notch.

The jaws in *Spurilla neapolitana* are vari-

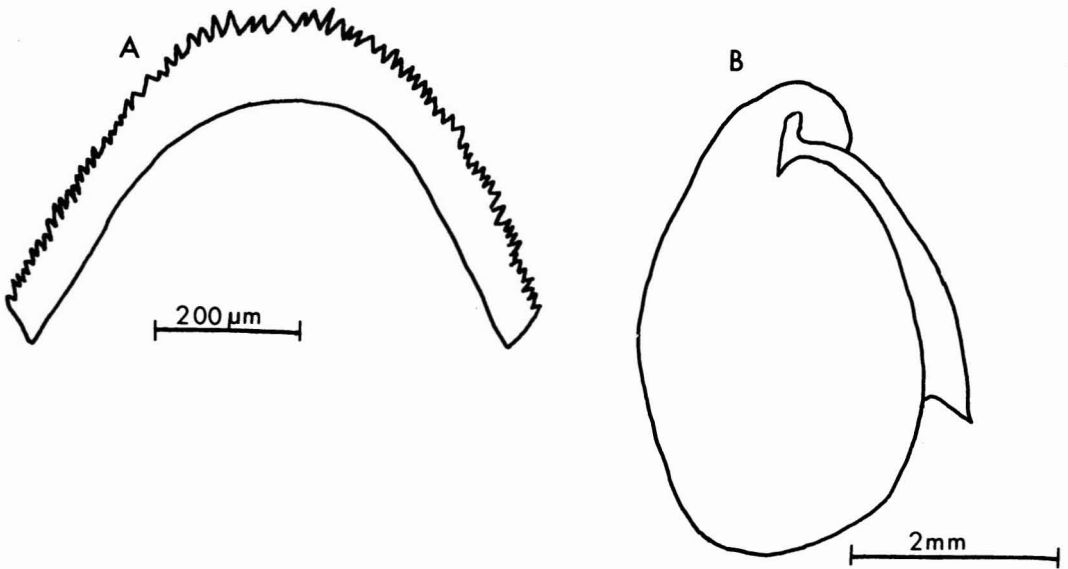


FIGURE 17. *Spurilla neapolitana*: A, radular tooth; B, jaw.

able. Bergh (1877, 1882) described a denticulate masticatory border, while all other workers have described a smooth masticatory edge. The specimen from Hawaii has a smooth masticatory border.

The occurrence of *Spurilla neapolitana* in Hawaii represents the first record of the species in the Indo-Pacific and implies that the species is circumtropical in distribution.

*Spurilla japonica* (Eliot, 1913)

*Aeolidiella japonica* Eliot, 1913 (Baba 1949); *Spurilla japonica* (Edmunds 1969)

DISTRIBUTION: Middle Japan (Baba 1949, Eliot 1913)

HABITS AND OCCURRENCE: Collections of this species were made from Poipu, Kauai, June 1972; Kewalo Basin, Oahu, April 1962 and January 1965; Kahuku, Oahu, December 1962; Kaimalino, Oahu, August 1963 and January 1966 (Kay, personal communication).

DESCRIPTION: Length 7 to 30 mm. Color translucent white with opaque white on rhinophores and as maculations on cerata, with solid white apex; cerata olive green.

Rhinophores short with enlarged bulbous portion around middle. Head broad, with red or orange pigment. Oral tentacles prominently constricted at middle. Anterior foot corners rounded. Cerata in 9 to 11 groups, all curved toward central body axis. Gonopore within first group of cerata. Anus in first group of cerata in posterior digestive system. Radula (Figure 18A) uniseriate, consisting of 23 teeth, 210 to 230  $\mu$ m wide with 22 to 28 denticles on each side of central cusp. Jaws (Figure 18B) thick, 1.3 to 2.3 mm long, with smooth masticatory border.

DISCUSSION: Burn (1969) differentiates *Spurilla* Bergh, 1864 from *Aeolidiella* Bergh, 1867 on the following bases: a more anterior anus in *Aeolidiella*, smooth rhinophores in *Aeolidiella* compared to perfoliate or annulate rhinophores in *Spurilla*, and difference in jaw shape. Based on these differences, Edmunds (1969) transferred *Aeolidiella alba* Risbec, 1928 and *A. japonica* Eliot, 1913 to the genus *Spurilla*.

*Spurilla japonica* was described from Japan (Eliot 1913). Baba (1949) described living material from Sagami Bay, Japan. The external body form in Baba's animals is similar to the material from Hawaii, but the coloration differs substantially. The Hawaiian

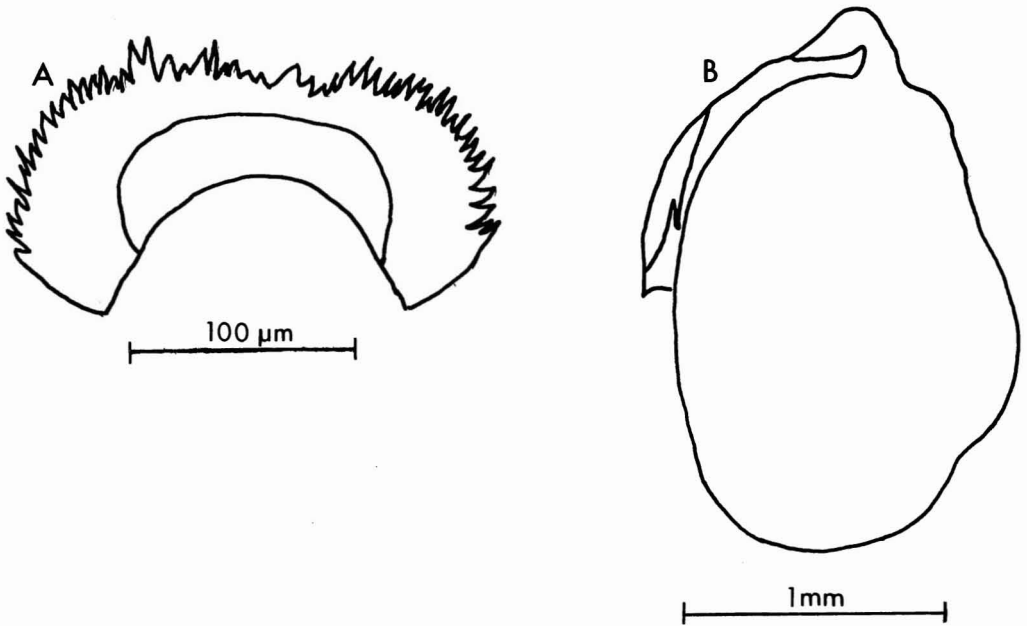


FIGURE 18. *Spurilla japonica*: A, radular tooth; B, jaw.

specimens lack the dark, reticulate pigment on the head evident in Baba's specimens.

Eliot described the radula of *Spurilla japonica* as having 18 teeth with as many as 65 denticles on each side of the central cusp. Baba described 16 to 30 teeth with 30 to 60 denticles on each side of the central cusp. The material from Hawaii has 23 teeth with 22 to 28 denticles on each side of the central cusp.

The jaws of specimens described by Eliot and Baba and those from Hawaii all have smooth masticatory borders.

Edmunds (1969) described the affinities between *Spurilla alba* and *S. japonica*, but stated that they differ in color, size, and number of digestive gland ramifications. The bulbous swellings of *S. japonica* also appear to be more pronounced than in Edmunds' figure of *S. alba* (1969, fig. 9A).

*Baeolidia nodosa* (Haefelfinger & Stamm, 1959)

*Limenandra nodosa* Haefelfinger & Stamm, 1959 (Bertsch 1972, Eveline and Ernst Marcus 1970)

**DISTRIBUTION:** Mediterranean (Haefelfinger and Stamm 1959); Bonaire (Eveline and Ernst Marcus 1970); Baja California (Bertsch 1972)

**HABITS AND OCCURRENCE:** A single specimen was found on the surface of sand flats in Kaneohe Bay, Oahu, in 1 m of water on 15 September 1973.

**DESCRIPTION:** Single specimen (Figure 19A, B) 26 mm in length. Body color brown, reticulated with translucent white; oral tentacles, rhinophores, and foot brown with white maculations; dorsal surface of body with series of 14 ocellae of blue-green, encircled by yellow and with three to nine large spots of opaque white; cerata yellow-brown reticulated with opaque white, and with a subapical band of white and translucent white apex. Rhinophores densely papillate on posterior side; apex sharply acute. Oral tentacles elongate. Anterior foot corners tentacular, with deep groove across width. Anterior digestive system of two rows and a reduced row, consisting of only two cerata; posterior digestive system of 16 rows of

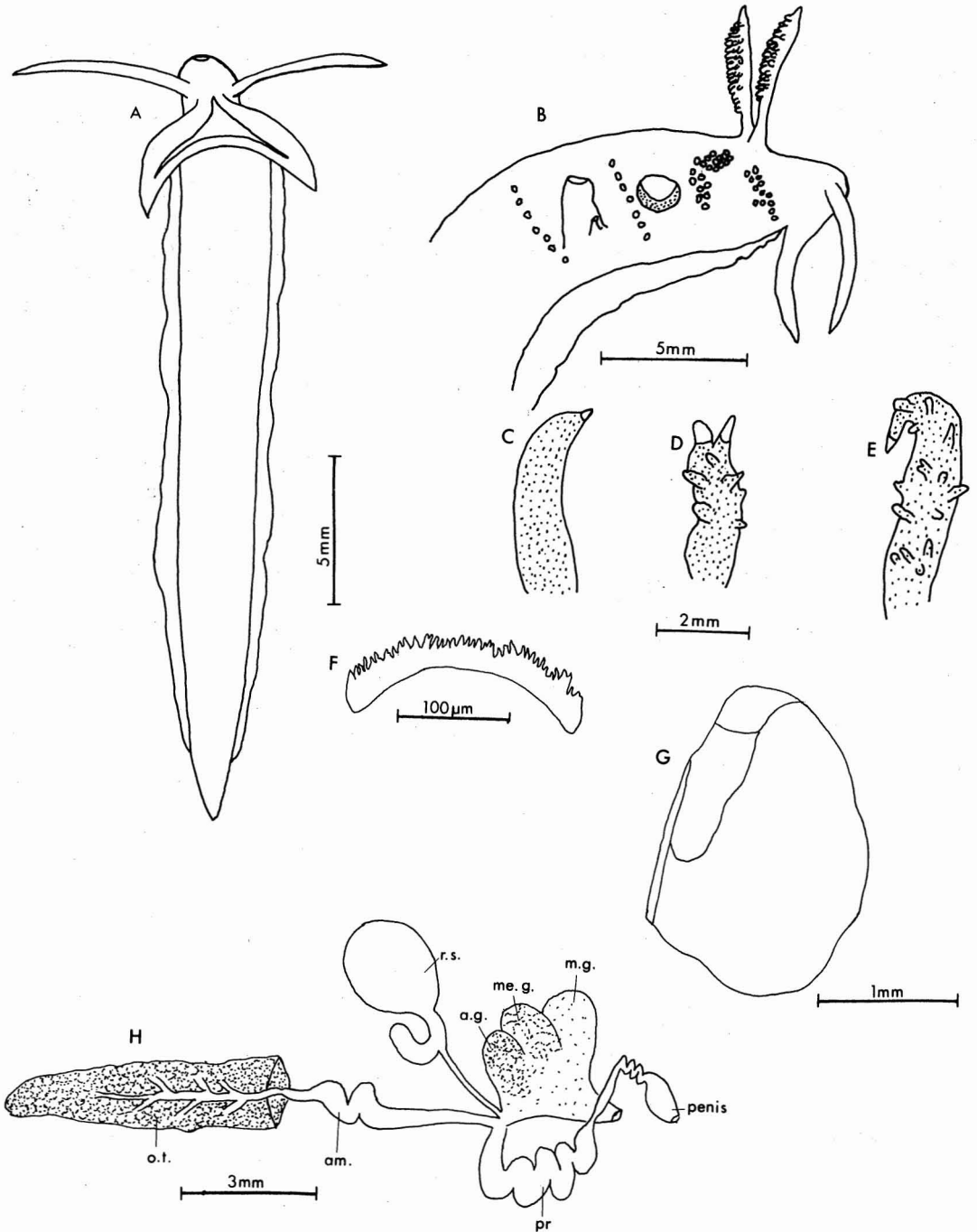


FIGURE 19. *Baeolidia nodosa*: A, ventral view of a living animal; B, lateral view of anterior portion of preserved animal; C-E, cerata showing variability in shape and ornamentation; F, radular tooth; G, jaw; H, reproductive system (a.g., albumen gland; am., ampulla; m.g., mucous gland; me.g., membrane gland; o.t., ovotestis; pr, prostate; r.s., receptaculum seminis).



cerata on each side. Cerata (Figure 19C–E) irregular in shape, dorsoventrally flattened, some papillate; apex of one to three cnidosacs within single ceras; tip sharply recurved or moderately arched. Gonopore between anterior and posterior digestive systems. Anus between first and second rows of posterior digestive system. Radula (Figure 19F) uniseriate, consisting of 21 pectinate teeth, 100 to 250  $\mu\text{m}$  wide with 30 to 70 denticles. Jaws (Figure 19G) weak, 2.3 mm long, with smooth masticatory border. Reproductive system (Figure 19H) with elongate ovotestis, convoluted ampulla. Receptaculum seminis large, bilobed, with elongate duct. Vas deferens elongate, convoluted, prostatic throughout most of its length. Penis paddle-shaped, unarmed.

**DISCUSSION:** The generic distinctions for *Berghia* Trinchese, 1877, *Baeolidia* Bergh, 1888, and *Limenandra* Haefelfinger & Stamm, 1959 are confusing. All are members of the Aeolidiidae and have papillate rhinophores. Bergh (1890, 1892) contended that deeply incised radular teeth in *Berghia* and evenly curved teeth in *Baeolidia* served as an essential generic distinction. Ernst Marcus (1958) argued that this radular distinction is invalid on a generic level. Drawings by Baba (1955, fig. 56) illustrate *Baeolidia major amakusana* with both indented and evenly curved radular teeth.

Marcus (1958) attempted to settle this confusion by comparing the type species of the two genera. The type of *Baeolidia*, *B. moebii* Bergh, 1888, has linear rows of cerata in the right anterior digestive system, while *Berghia coerulescens* (Laurillard, 1830) has cerata arranged in horseshoe-shaped arches. Marcus contended that the difference is sufficient to distinguish the genera. Marcus (1958) confirmed that *Berghia coerulescens* has the anus in the first ceratal arch of the posterior digestive system while *Baeolidia moebii* has the anus located posterior to this position, and utilized this feature to distinguish the genera. Tardy (1962) considered this a questionable generic character because the position of the anus in *Baeolidia moebii* is not known.

Haefelfinger and Stamm (1959) erected a

new genus and species, *Limenandra*, with *L. nodosa* as the type, and included *Baeolidia fusiformis* Baba, 1949 in *Limenandra*. They differentiated *Limenandra*, noting that all cerata are arranged in rows rather than in horseshoe-shaped arches, with fewer rows than in *Baeolidia*, and the cerata are round rather than flattened as in *Baeolidia*. The shape of the cerata in *Limenandra nodosa* can be dorsoventrally flattened (Bertsch 1972). Eveline and Ernst Marcus (1970) suggested that the shape of the cerata (flattened in *Baeolidia*, fusiform in *Berghia*) was the only acceptable difference and placed *Baeolidia fusiformis* in *Berghia* while maintaining *Limenandra nodosa*. Basing the generic separation on the ceratal shape creates more problems than it solves, because this placement unites species that have arches in the digestive system with species that have linear rows. Also, species such as *Limenandra nodosa* have both round and flattened cerata.

It seems that a more reasonable approach would be to place those species with the digestive system arranged in arches in *Berghia*, as in the type, *Berghia coerulescens*, and those with cerata in linear rows in *Baeolidia*, as in the type, *Baeolidia moebii*. *Limenandra* would then be considered as a junior synonym of *Baeolidia* since a slightly more anterior anal position in *B. fusiformis* and *B. nodosa* does not warrant generic separation.

When one compares the reproductive systems of the species for which the genera have been described, some differences emerge. In both *Baeolidia bentveva* Marcus, 1958 and *Baeolidia nodosa* (present paper), the receptaculum seminis is bilobed. In *Berghia coerulescens* (Tardy 1962), *B. verrucicornis* (Tardy 1962), *B. crutzberghi* (Eveline and Ernst Marcus 1970), and *B. major* (present paper), the receptaculum is simple. This is a potentially valuable characteristic for generic separation.

*Baeolidia nodosa* has been found sporadically at a variety of localities, which suggests a wide distribution. Haefelfinger and Stamm (1959) described the species from 25 specimens from a single locale in Villefranche, France. Eveline and Ernst Marcus (1970) reported a single specimen from Bonaire in the southern Caribbean. Bertsch

(1972) described a single specimen from the Gulf of California. The presence of this species in Hawaii further substantiates the circumtropical distribution of the species.

The morphology of *Baeolidia nodosa*, with the exception of the reproductive system, was included in the original description. Eveline and Ernst Marcus (1970) stated only that the external morphology was virtually identical to Haefelfinger and Stamm's material. Bertsch (1972) stated that his animal was somewhat intermediate between *B. nodosa* and *B. fusiformis*. He noted that the radular rows and coloration are similar between the two species, and the cerata from his animal resemble those of Haefelfinger and Stamm's material despite their statement that *B. nodosa* has round cerata. Bertsch stated that the yellow-pink colored circles from his specimen were intermediate between the white, yellow, white, red circles of *B. nodosa* from France and the yellow spots of *B. fusiformis* from Japan. The yellow, blue-green circles of the specimen from Hawaii demonstrate that the essential difference between *B. nodosa* and *B. fusiformis* is not in the color similarities but the distinct arrangement of coloration in circular units on the dorsal surface of *B. nodosa*. Bertsch also said that the rhinophores of his specimen more closely resemble those of *B. fusiformis*, but described papillae beginning halfway up the length of the rhinophores with very few on the anterior surface. This accurately describes the figure of the rhinophores of *B. nodosa* (Haefelfinger and Stamm 1959, fig. 1B) and can also apply to all members of *Berghia* and *Baeolidia*. The presence of papillate cerata, distinct circles of coloration, and an elongate masticatory margin ensure that the specimen from Mexico is indeed *B. nodosa*. The specimen from Hawaii fits the original description of *B. nodosa* in color pattern, external morphology, radula, and jaws, and eliminates any doubts that it is conspecific and that *B. fusiformis* represents a distinct taxon.

*Berghia major* (Eliot, 1903)

*Baeolidia major* Eliot, 1903 (Allan 1947, Baba 1933, Morton and Miller 1968);  
*Baeolidia major amakusana* Baba, 1937,

1955; *Berghia amakusana* (Marcus, 1958, Farmer 1966); *Berghia major* (Edmunds, 1970)

DISTRIBUTION: Tanzania (Edmunds 1970, Eliot 1903); Japan (Baba 1933, 1937, 1955); Australia (Allan 1947); New Zealand (Morton and Miller 1968); and Mexico (Farmer 1966).

HABITS AND OCCURRENCE: More than fifty specimens have been found on the under-surface of rocks at the Kewalo Basin seawall, from the floating docks and thermal pollution study tables at Coconut Island, and from patch reefs in Kaneohe Bay, Oahu, in all months of the year. Egg masses also occur throughout the year, usually in close proximity to one or more specimens. *Berghia major* feeds on the sea anemones *Bolocerooides* sp. and *Aiptasia* sp. It is always in close proximity to one of these species of anemones, more commonly *Aiptasia*. However, there does not appear to be any feeding preference between the two species.

DESCRIPTION: Length 10 to 100 mm. General body color variable: translucent white, golden brown, dark gray-green; many variations in pattern of pigmentation; head region may have spot of dark pigment or may lack dark pigment; cerata, especially in specimens exceeding 30 mm in length, may be ornamented with opaque white spots and sub-apical blue rings. Rhinophores most frequently densely papillate, but occasionally may virtually lack papillae. Papillations strikingly more dense on posterior side, although variable. Oral tentacles elongate and used extensively in feeding where they establish contact with prey anemone. When contact is made with the anemone, an initial period of 1 to 3 sec of contact followed by quick withdrawal is observed. The behavior pattern is a rapid sequence in which the tentacles firmly grasp the anemone while engulfing it. Foot corners elongate and tentacular. Anterior border of foot with sharp notch. Cerata numerous, always dorsoventrally flattened, although degree of flattening is variable; smaller animals of 10 to 20 mm with only slightly flattened cerata, while cerata almost paddle-shaped in animals 20

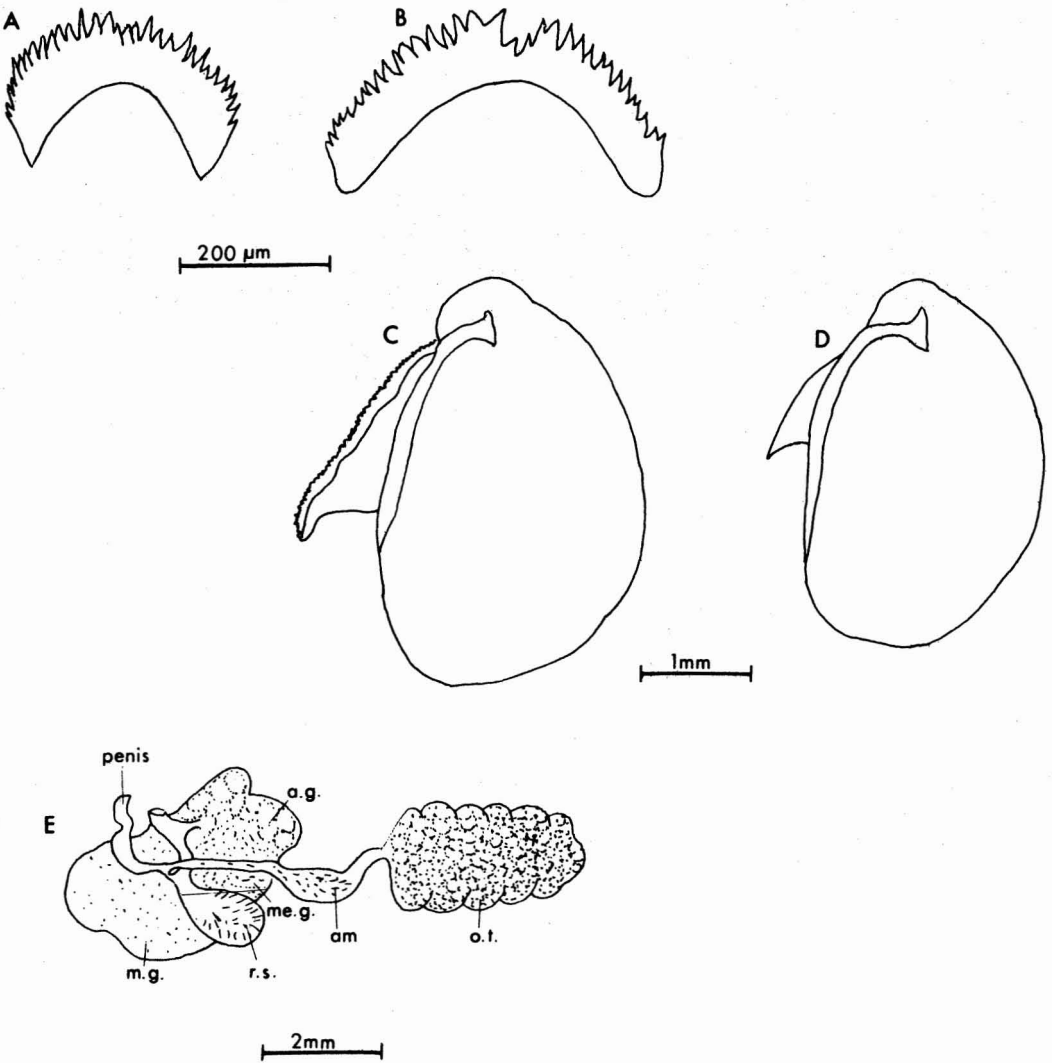


FIGURE 20. *Berghia major*: A, B, radular teeth; C, D, jaws; E, reproductive system (a.g., albumen gland; am, ampulla; m.g., mucous gland; me.g., membrane gland; o.t., ovotestis; r.s., receptaculum seminis).

to 100 mm; cerata of anterior right digestive system in a single horseshoe-shaped arch; first one to four ceratal groups of posterior system in this arrangement as well; cerata posterior to second to fifth arches in linear rows. Gonopore ventral to anterior portion of anterior ceratal group. Anus within first horseshoe of posterior right digestive system. Radular teeth (Figure 20A, B) 100 to 650 µm wide, uniform in shape within single specimen. Teeth indented at central region in some specimens. Most individuals with teeth

more or less entire at apex. Teeth progressively smaller in posterior region of radula, shape of entire radula tapered toward posterior. Teeth in 16 to 28 rows, with 25 to 65 denticles on anterior margin. Denticles somewhat recurved inwardly in more lateral portion, becoming progressively straighter toward center. Jaws (Figure 20C, D) 1.6 to 40 mm long, also variable, although general shape rather constant. Most individuals with highly denticulate masticatory border of 50 to 110 denticles, but some specimens with

TABLE 2  
MORPHOLOGICAL VARIABILITY IN *Berghia major* (ELIOT, 1903)

SOURCE	LENGTH (mm)	COLOR	CERATA	RADULA	MASTICATORY EDGE
Edmunds 1970 Tanzania	25	Pale gray with brown and blue	Flattened 4 arches 7 rows	21 teeth 36–84 denticles	Smooth
Baba 1955 Japan	60	Yellow-brown	Flattened, leaflike 7 arches 8 rows	32 teeth 140 denticles	Smooth
Farmer 1966 Mexico	20	Yellow-brown	—	22 teeth	—
Allan 1947 Australia	20–25	Light gray-brown with bluish cerata	Leaflike	32 teeth	—
Eliot 1903 Zanzibar	40	Grayish white	Flattened 17 groups	32 teeth 150 denticles	Smooth
Morton and Miller 1968 New Zealand	32	Brown, orange, with pale blue and crimson	—	—	—
Present paper Hawaii and Mexico	10–100	Translucent white, dark gray-green, or golden brown with opaque white and blue	Flattened dorsoventrally 2–5 arches 3–6 rows	16–28 teeth 25–65 denticles	Smooth or denticulate

smooth striated border. Reproductive system (Figure 20E) of two extremely large organs and several smaller ones. Otestis generally yellow and comprising entire posterior half of animal. Female gland mass consists of albumen, membrane, and mucous glands, and comprises bulk of anterior region of animal; it consists of several lobes and is transparent in the living animal. Penis elongate and unarmed. Receptaculum seminis small and inconspicuous. Ampulla wide and convoluted.

DISCUSSION: *Berghia major* was described from Zanzibar as *Baeolidia* (Eliot 1903). Baba (1933) attributed animals from Japan to *Baeolidia major* but later (Baba 1937) distinguished *B. major amakusana* as a subspecies, without giving a basis for distinction between his specimens and those described by Eliot.

Ernst Marcus (1958) transferred *Baeolidia major amakusana* to *Berghia*, while simultaneously raising it to specific status as *Berghia amakusana* on the basis of ceratal arrangement and anal position. Marcus

noted that Eliot made no distinction of ceratal distribution, but contended that *Baeolidia major* should probably remain in *Baeolidia* because the anus in Eliot's animals was situated behind the second ceratal group and maintained the separation of the two species (Ernst and Eveline Marcus 1970). Edmunds (1970) found specimens from Tanzania attributable to *Baeolidia major* Eliot, 1903. He stated that these animals were conspecific with Eliot's, but did not give reasons. Based on a single horseshoe of cerata in the right anterior digestive system, he placed *Baeolidia major* in *Berghia*. Edmunds also synonymized *Berghia amakusana* as a junior synonym of *B. major* without giving a basis for the synonymy. From this study it is readily evident that *Baeolidia major* and *Berghia amakusana* are conspecific. Several characteristics of *Berghia major* are summarized in Table 2.

In Hawaii, *Berghia major* feeds on the sea anemones *Aiptasia* sp. and *Bolocerooides* sp. Specimens from New Zealand feed on the anemone *Cricoplurus nutrix* (Morton and Miller 1968). Body color is variable. The

specimens from Hawaii exhibit most of the color range seen in the species known from other collections throughout the Indo-Pacific. A specimen collected by Farmer in the Gulf of California shows little difference from one specimen collected from Kaneohe Bay (Keen 1971, pl. 22, fig. 5), and, indeed, the variation within the Kaneohe Bay population is more substantial than between these two individuals.

The Hawaiian specimens range from 10 to 100 mm in length, which exceeds previous records for the species. The cerata of all *B. major* recorded are dorsoventrally flattened to varying degrees.

The radula in the Hawaiian specimens consists of 16 to 28 rows of teeth, with 25 to 65 denticles. Specimens have been recorded that have 32 rows of teeth (Allan 1947, Baba 1955, Eliot 1903) with 140 denticles (Baba 1955) and 150 denticles (Eliot 1903).

Probably the most unusual variation within the Hawaiian specimens occurs in the jaws. All other citations of *Berghia major* report a smooth masticatory border. Several specimens from Hawaii have a smooth masticatory border, but most specimens from Oahu have from 50 to 110 denticles on the cutting edge.

The reproductive system of *Berghia major* is previously unrecorded. It is very similar to that of *B. coeruleascens* (Laurillard, 1830) (Tardy 1962) and *B. crutzberghi* Marcus & Marcus, 1970.

#### ZOOGEOGRAPHICAL DISCUSSION

The zoogeographical affinities of the opisthobranchs of the Indo-Pacific region are poorly understood because vast areas have not been explored. Other areas have had only cursory examination. In the Indian Ocean, only Tanzania (Edmunds 1969, 1970, Eliot 1902, 1903, 1904a, 1904b) has been examined to any degree. In the Pacific, restricted areas of Australia have been well collected (Burn 1963, 1964, 1966). New Caledonia (Risbec 1928, 1953) has been fairly well studied. The recent work of Carlson and Hoff (1973) from Guam has

added significant information. The opisthobranch fauna of Japan has been exceedingly well studied (Baba 1930, 1949, 1955, Eliot 1913).

The opisthobranch fauna of the Hawaiian Islands has only recently been well studied. The zoogeographical affinities of the Hawaiian marine mollusks have been studied by Kay (1967), who estimated that approximately 20 percent of the Hawaiian marine mollusks are endemic to the archipelago. There is not enough information about the four aeolids known only from the Hawaiian Islands (*Flabellina annuligera*, *Cuthona diminutiva*, *Noumeaella* sp., *Aeolis parvula*) to imply that any species are, in fact, endemic. Eight species, *Flabellina alisonae*, *Cuthona pinnifera*, *Embletonia gracile*, *Facelinella semidecora*, *Favorinus japonicus*, *Herviella mietta*, *Aeolidiella takanosimiensis*, and *Spurilla japonica*, are reported from localities within the Pacific basin. Five species, *Phestilla sibogae*, *P. melanobranchia*, *Caloria militaris*, *Pteraeolidia ianthina*, and *Berghia major*, are known to occur in both Indian and Pacific oceans. Five species, *Cuthona perca*, *Godiva quadricolor*, *Glaucus atlanticus*, *Spurilla neapolitana*, and *Baeolidia nodosa*, are known to occur in the Atlantic and Pacific and are considered circumtropical. This latter group represents a significant percentage of aeolids that apparently are widespread in their distributions.

It is interesting that 15 of the 22 species described in this paper have been previously reported from Japan. Baba (1949) stated that the Japanese fauna is "rich in Indo-Pacific elements."

Members of the family Aeolidiidae appear to be particularly widespread. *Baeolidia nodosa* and *Spurilla neapolitana* are circumtropical, while *Berghia major* is known from the Indo-Pacific from Tanzania to Mexico (Edmunds 1970). *Aeolidiella takanosimiensis* is known from Japan to California, and *Spurilla japonica* is known from Japan and Hawaii. *Aeolidia papillosa* is boreal-temperate in its distribution (Ernst Marcus 1961) as it has been found from Europe, both coasts of North America, northern Japan, and southern Chile. Members of the family feed

on sea anemones and seem to have a high degree of plasticity in the number of available prey species.

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