A New Species of *Dulichia* (Amphipoda, Podoceridae) Commensal with a Sea Urchin[1]

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THIS REPORT is a description of a new species of amphipod, *Dulichia rhabdoplastis* n. sp. (Gammaridea; Podoceridae), with observations on its distribution, behavior, and unique commensal relationship with the red sea urchin *Strongylocentrotus franciscanus* (Agassiz). The work was done during a period of postdoctoral support at Friday Harbor Laboratories under NSF Grant GB-5531.

Taxonomy

Gurjanova's key (1951, p. 987) to the Podoceridae lists only the three genera found in Russian waters. Stebbing's key (1906, p. 695) does not include *Neoxenodice* Schellenberg. Therefore a key to the nine genera in the family is included here.

KEY TO THE GENERA OF PODOCERIDAE

1. Antenna I without accessory flagellum . . . 2
   Antenna I with accessory flagellum 4
2. Pleon with only five distinct segments preceding the telson . . . . . .g. *Laetmatophilus* Bruzelius
   Pleon with six distinct segments preceding the telson 3
3. Pleon segment 5 carrying uropods . . . . . .g. *Cyrtophium* Dana
   Pleon segment 5 not carrying uropods . . . . . .g. *Leipsuropus* Stebbing
4. Three pairs of uropods present 5
   Only two pairs of uropods present 8
5. Antenna I longer than antenna II 6
   Antenna I shorter than antenna II 7
6. Inner lobe of maxilla I fringed with 7 or 8 setae; inner margin of inner lobe in maxilla II with long row of setae . . . . . .g. *Xenodice* Boeck
   Inner lobe of maxilla I short and without setae; inner margin of inner lobe of maxilla II with a few bristles . . . . . .g. *Neoxenodice* Schellenberg
7. Gnathopods I and II subchelate . . . . . .g. *Podocerus* Leach
   Gnathopods I and II simple . . . . . .g. *Icilius* Dana
8. Last pair of uropods normal . . . . . .g. *Dulichia* Krøyer
   Last pair of uropods rudimentary . . . . . .g. *Paradulichia* Boeck

Dulichia Krøyer, 1845

Body long, slender, cylindrical; first pereonite the shortest; sixth and seventh segments fused. Pleon of only five segments—three pleosomal and two urosomal. Pleon segment IV (i.e., first urosome segment) very long and narrow. Head produced in front. Coxal plates small, not contiguous, often with spines or projections. Antenna long and slender, peduncle longer than flagellum; antenna I the longer; accessory flagellum very small. Mandibular palp of three articles, third article shorter and narrower than second. Maxilla I inner lobe small. Maxilla II inner lobe fringed on inner margin. Gnathopod I not subchelate; fifth article longer than sixth. Gnathopod II in male subchelate; sixth article powerful. In female, gnathopod II simple, not subchelate. First two pairs of pereopods short and weak. Last three pairs longer and stronger, increasing in length from III to V; second article linear, fourth elongate. Gills narrow, bubble-shaped, usually on gnathopod II and pereopods I–III. Mar-

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supial plates very broad, especially the two middle ones. Pleopods large, with strong peduncles. Uropods I and II with narrow linear, unequal rami. Uropod III absent. Telson oval, entire.

TYPE SPECIES: *Dulichia spinosissima* Krøyer, 1845.

REMARKS: The genus is generally restricted to arctic and boreal waters, with the southernmost record (for *D. monacantha*) apparently being Point Conception, California (Barnard, 1962, p. 63). Little is known about the ecology of any species in the genus, and information on zoogeographic distribution is minimal. Ten of the 17 described species are known from depths less than 100 meters; the remaining 7 are found in deeper water (> 100 meters). None has been noted to be commensal, though *D. spinosissima* is reported from clumps of hydroids (Gurjanova, 1951, p. 991).

A translation of Gurjanova's key (1951, pp. 989–990), somewhat modified and with the new species included, is presented here.

KEY TO THE GENUS *Dulichia*

1. On third abdominal segment a large, posteriorly directed, spinous keel; on last thoracic and first two abdominal segments a pair of spinelike outgrowths, studded with hairs ..... *D. spinosissima* Krøyer, 1845
   Dorsal side of body smooth 2
2. One or two of first coxal plates of male with a sharp projection 3
   None of the coxal plates (in either sex) with a spinelike projection 8
3. First and second coxal plates in male each bearing a long, sharp, spinelike projection ..... *D. bispina* Gurjanova, 1930
   Only one of the coxal plates, either I or II, bearing a sharp projection 4
4. Elongated sharp projection on coxal plate I in male 5
   Sharp outgrowth on coxal plate II in male 6
5. Basal article of gnathopod II dilated and armed with two teeth; external ramus of uropod II twice as long as peduncle ..... *D. arctica* Murdoch, 1885
   Basal article of gnathopod II slender and without teeth; external ramus of uropod II scarcely longer than peduncle ..... *D. monacantha* Metzger, 1875
6. Anteriorly pointing spine on coxal plate II in male, short, equal to about half the length of the coxal plate ..... *D. porrecta* (Bate, 1957)
   Anteriorly pointing spine on coxal plate II in male, long, greater than 1½ the length of coxal plate 7
7. External ramus of uropod I considerably shorter than the internal ramus; on outside edge of peduncle and inside edge of internal ramus, a linear row of closely arranged minute spinules in addition to coarse spines .... *D. spinosa* Stephensen, 1944
   External ramus of uropod I scarcely longer than internal ramus; margin of basal articles and rami of uropod I with only coarse spines ..... *D. unispina* Gurjanova, 1951
8. Eyes dark in color (red, dark brown, or black) 11
   Eyes reduced, present as irregular spots of white pigment 9
   Eyes fused parietally into a single eye with light pigment .... *D. cyclops* Gurjanova, 1946
   Eyes entirely absent ..... *D. abyssi* Stephensen, 1944
9. Sixth article of gnathopod II of male with two short teeth located on distal edge; proximal region of palm without a tooth ..... *D. nordlandica* Boeck, 1871
   Sixth article of gnathopod II of male with two teeth, one on distal corner of palm; the other, considerably larger, in proximal region of palm 10

10. Proximal tooth of sixth article of gnathopod II in male located near base of palm ..... *D. macera* G. Sars, 1879
    Proximal tooth of sixth article at the level of middle of palm..*D. hirticornis* G. Sars, 1876
11. Eyes large, protruding, of reddish or dark brown pigment.....12
    Eyes very small, oval, black.....*D. normani* G. Sars, 1895
12. In gnathopod II, proximal tooth on palm of sixth article arising from about middle of article, and reaching to level of distal margin..*D. knipowitschi* Gurjanova, 1933
    Proximal tooth on palm arising near base of article, and never extending to the distal margin.....13
13. Distal tooth on palm of sixth article weak; large proximal tooth strongly expanded in the middle and sharply tapered distally.....*D. falcata* (Bate, 1957)
    Proximal tooth uniformly tapered from base to tip; palm edge between proximal and distal teeth concave.....14
14. Distal tooth weak; proximal tooth curved away from palm....*D. tuberculata* Boeck, 1871
    Distal tooth strong; proximal tooth recurved toward palm.....*D. rhabdoplastis* n. sp.

Dulichia rhabdoplastis, new species
Figs. 1–18

DESCRIPTION: *Holotype male.* Body smooth, elongate, caprellid-like; internal organs giving the body a general rust-brown color. Coxal plates smoothly rounded, without spines or projections. The rostral area of the cephalon visor-shaped; cephalon when viewed from above spade-shaped. Eyes prominently convex, bright red in life. Length 4 mm.

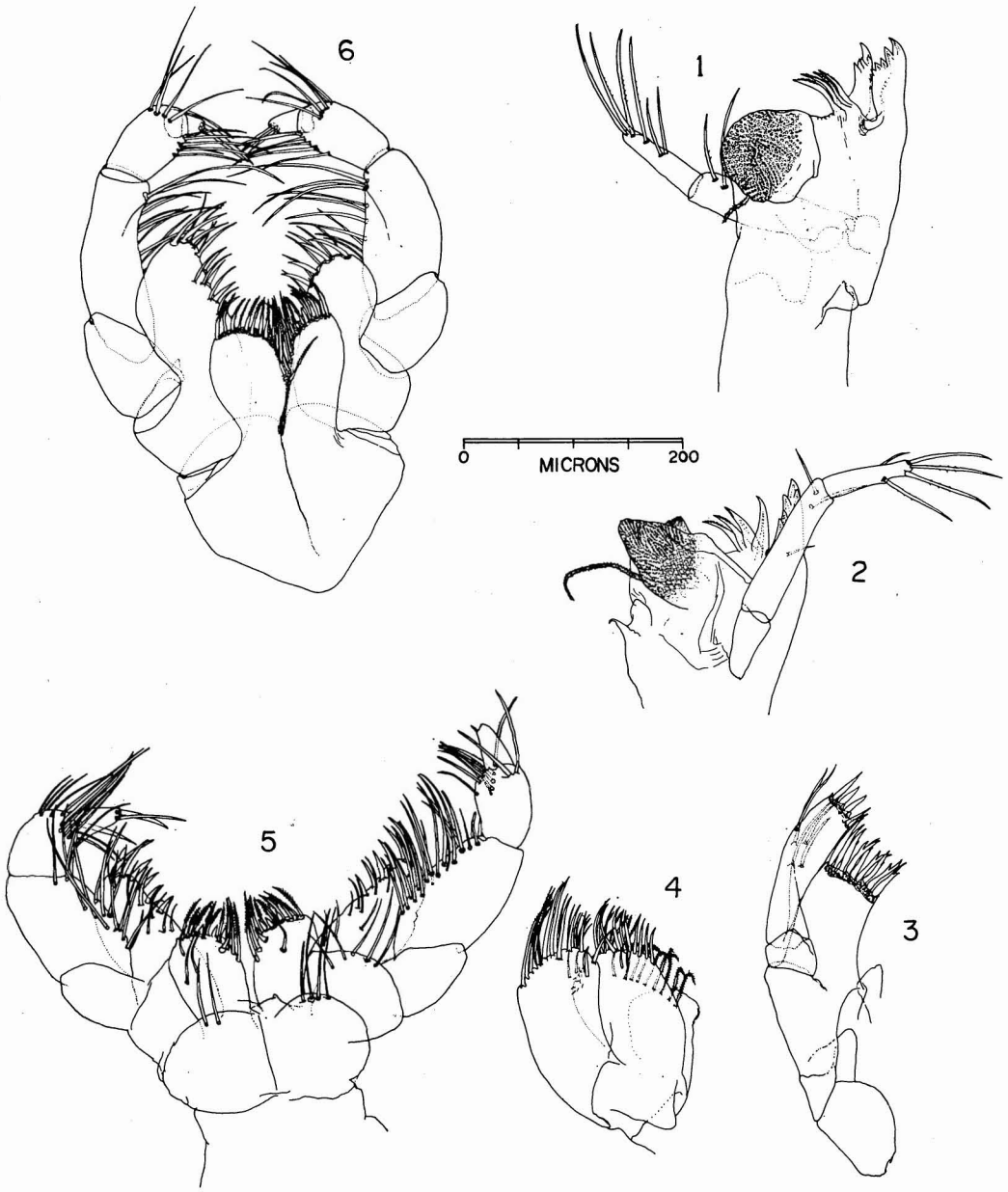
Antenna I longer than body. Accessory flagellum arising from the joint between third and fourth antennal articles. Antenna I generally unpigmented except for rust-brown distal portion of third article, and chartreuse proximal portion of fourth article (including accessory flagellum); pigmentation variable or entirely absent. Antenna II approximately half the length of antenna I.

Mandibular palp three-segmented; terminal article with six spines; middle article with five spines. Incisor of left mandible with five teeth, lacinia mobilis with four, and four serrate setae in setal row. Right mandible with five-toothed incisor, a narrow, sharply pointed lacinia mobilis, and a setal row of three serrate setae. Molar with a long hirsute seta originating near the base. Outer lobe of maxilla I with nine terminal spines, three bifurcate at the tip. Palp of maxilla I with five smooth terminal spines and five (varying from three to six in paratype males) subterminal setae. Maxilla II normal. Outer lobe of maxilliped with six (eight in paratype male No. 2) medial spines and 9 to 12 submarginal setae; inner lobe with three or four short, blunt spines arranged medio-terminally among 9 to 12 bottle-brush setae; palp of maxilliped abundantly setose, tipped with two larger setae.

Gnathopod I with dactyl finely serrate near the tip, and with three very small setae on the grasping margin. Grasping margins of merus, carpus, and propodus abundantly supplied with long serrate setae. Gnathopod II robust; propodus with two large teeth on grasping edge, the largest one arising near proximal joint and extending to level of base of the smaller, distal tooth; dactyl when folded reaching slightly beyond tip of the basal tooth. Both teeth extending at approximately a 45° angle from the palmar edge of the propodus. Inside region of palm abundantly setose.

Pereopods increasing in size from anterior to posterior. Pereopods I and II with a few scattered setae on distal articles; dactyls non-serrate and weakly curved. Pereopod III with only the ischium devoid of setae; pereopods III to V possessing prominent spines arranged in two rows on the ventral side of the carpus and propodus, each spine possessing a short seta arising about two-thirds the distance to the tip—giving a bifurcate appearance to the spine. Dactyls of pereopods III to V strongly hooked and finely serrate. Pereopods flexed backward; well adapted for grasping.

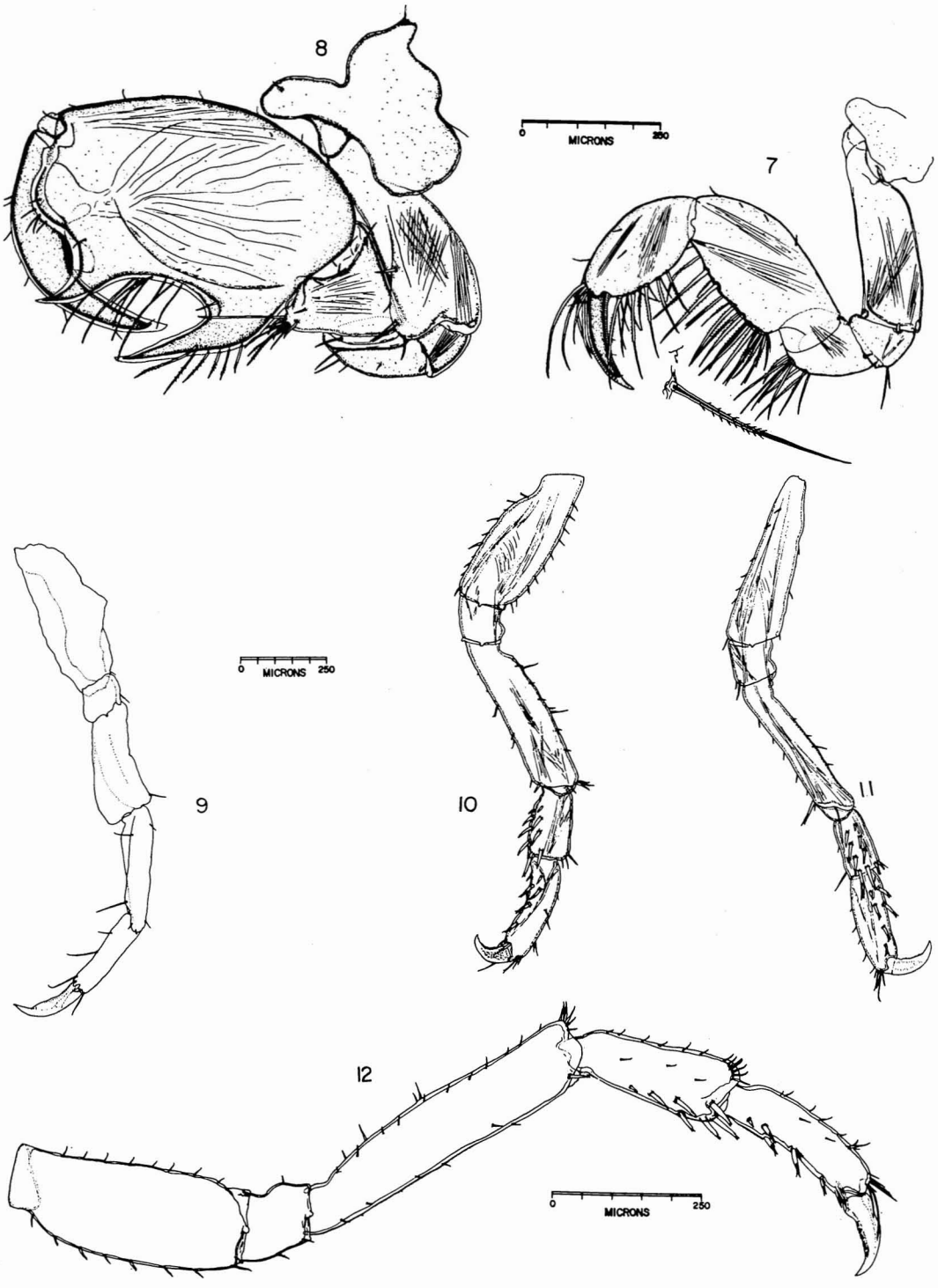
The distal medial angle of each basal seg-



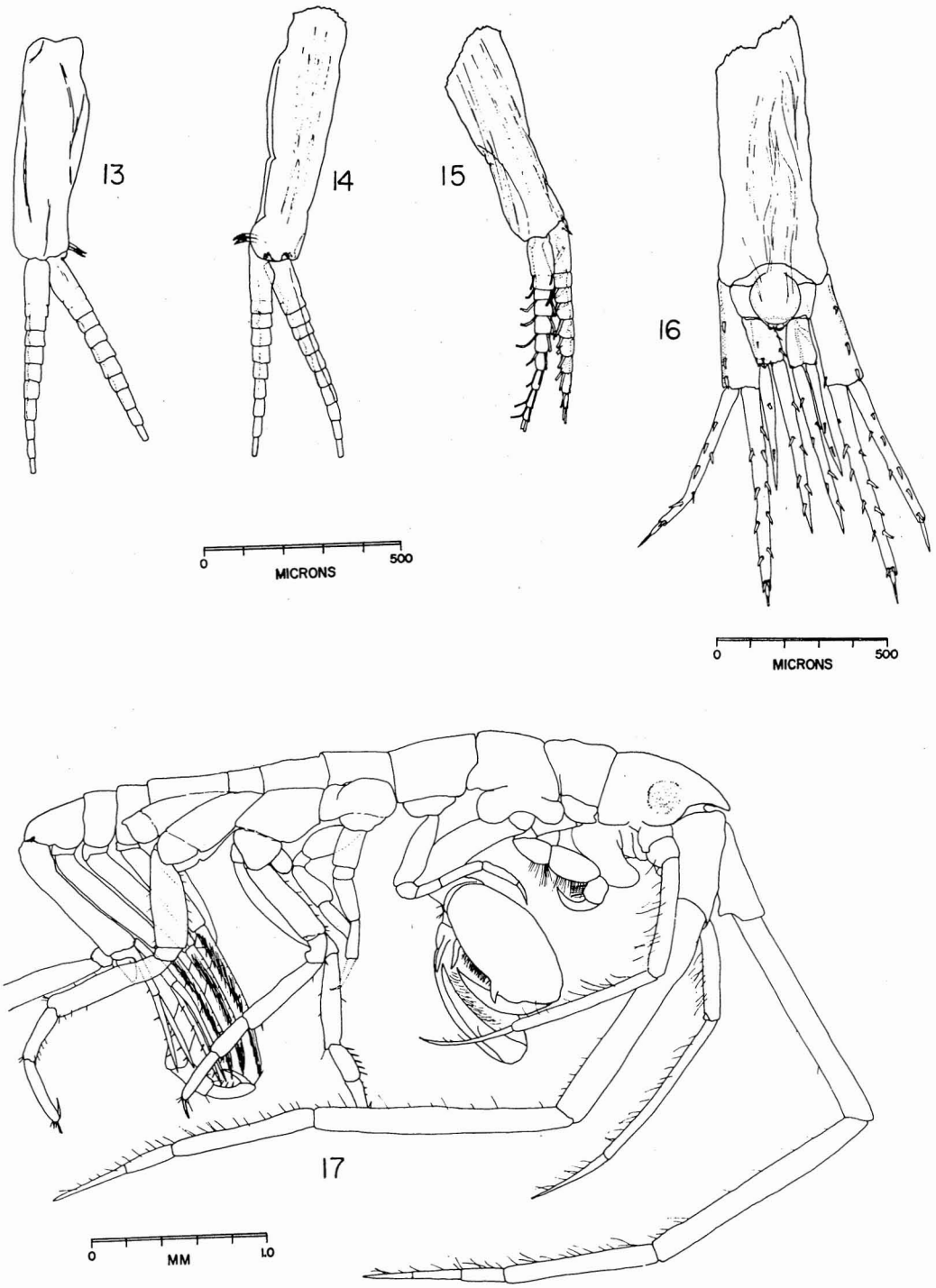
FIGS. 1–6. *Dulichia rhabdoplastis*. *1*, Left mandible, frontal view, allotype female. *2*, Right mandible, rear view, allotype female. *3*, First maxilla, allotype female. *4*, Second maxilla, allotype female. *5*, Maxillipeds, paratype male (No. 1). *6*, Maxillipeds, allotype female.

ment of pleopods with two shallowly concave serrate spines. Each pleopodal ramus of 10 or 11 articles, the proximal ones with indistinct joints. Long hairlike setae arising from distal lateral margin of each article.

Urosome greatly elongate and reflexed under body. Telson small, broadly ovate. Only two pairs of uropods. Pedicel of first pair twice as long as basal segment of second pair. Medial ramus of second uropod reaching to two-thirds



FIGS. 7–12. *Dulichia rhabdoplastis*. *7,* Gnathopod I, holotype male, left side. *8,* Gnathopod II, holotype male, left side. *9,* Pereopod 2, holotype male. *10,* Pereopod 3, holotype male. *11,* Pereopod 4, holotype male. *12,* Pereopod 5, holotype male.



Figs. 13–17. *Dulichia rhabdoplastis*. *13,* Pleopod1, right side, holotype male (setae omitted). *14,* Pleopod 2, right side, holotype male (setae omitted). *15,* Pleopod 3, right side, holotype male (setae omitted). *16,* Telson and uropods, holotype. *17,* Whole animal.

FIG. 18. Photograph of *Strongylocentrotus franciscanus* showing several amphipods clinging to detritus strands attached to the tip of the urchin spines.

the length of first uropod; medial rami of both pairs slightly longer than outside rami; both rami of first uropod tipped with a prominent articulated spine. All segments of uropods with blunt, posteriorly pointing spines.

Female allotype. Body generally similar to male except for enlarged oostegites. Allotype contained 14 embryos in brood pouch. Body length 4 mm.

Mouthparts as in male with but minor differences. The right mandibular palp with five terminal spines; middle article of left mandibular palp with but two spines. Incisor of left mandible with seven teeth, the medial one very weak.

Gnathopod I as in male. Gnathopod II only slightly larger than gnathopod I; propodus more swollen than in first gnathopod, with a noticeable hump in the midventral region. Carpus of gnathopod II roughly triangular, with the apex formed by a pronounced swelling on the ventral margin. Basis equal in length to propodus and possessing a thin dorsal ridge.

Pereopods I and II small, with weak, nonarticulated dactyls; coxa and ischium expanded and glandular. Pereopods II to V similar to male.

Pleopods and uropods similar to male, with a tendency for an increased number of spines on uropods. Telson slightly longer and narrower than in male.

DISTRIBUTION: *Type locality.* Off Turn Rock Light in San Juan Channel, Puget Sound, Washington; 10 meters; 28 May 1968; 1 male holotype; USNM 125663. Allotype female from Lonesome Cove in Spieden Channel, San Juan Island, Washington; 8 meters; 2 June 1968; USNM 125664. Paratype male (No. 1): Lonesome Cove, San Juan Island; 10 meters; 2 June 1968; USNM 125665. Paratype male (No. 2): Obstruction Pass, between Orcas and Obstruction islands, Puget Sound, Washington; 20 meters; 29 October 1968; USNM 125666. Paratype male (No. 3): off Cantilever Pier, Friday Harbor Laboratories, San Juan Island, Washington; 10 meters; 6 June 1968; USNM 125667. Metatypes, males, females, and juveniles: Eagle Point, San Juan Island, Washington; 18 meters; 22 April 1968; USNM 125668.

Dulichia rhabdoplastis has also been observed in Saanich Inlet, Vancouver Island, British Columbia and off the open coast of the Olympic Peninsula at Cape Flattery; it seemed to be absent, however, at Tofino on the west coast of Vancouver Island. It is unlikely that the animal is restricted to Puget Sound, but the delineation of its range depends upon future observations by divers.

ECOLOGY: *Dulichia rhabdoplastis* exhibits a remarkable relationship with the urchin *Strongylocentrotus franciscanus*. Within the depth range of approximately 3 to 25 meters these large urchins carry up to 30 strands of light-brown material trailing off from the tips of the spines. The initial impression is that these strands are injured or decaying spines, or perhaps a streamer of debris or algae which has become caught on the spine; for this reason their origin has been ignored by many divers. Close inspection reveals the strands to be smooth and compacted detritus rods, fastened to the urchin spines and occupied by one or more amphipods. Underwater field observations have revealed that *Dulichia rhabdoplastis*

fastens a bit of detritus to the end of a spine and proceeds to lengthen and form the strand upon which it will subsequently dwell and reproduce.

The detritus strands or rods are constructed primarily from the animal's feces and rejected food particles. The amphipod will flex to grasp one of its fecal pellets—in a manner reminiscent of a lagomorph—and, after manipulating it with maxillae and maxillipeds and adding an oral secretion, will cement it to the tip of the strand. Strands may attain a length of 4 cm, but the average is about 2 cm. The diameter at the base is the same as the urchin spine to which it is attached, tapering gradually to the distal tip.

During the summer months when young are most abundant, the surface of the rods generally contains a rich growth of a large pennate diatom. The diatoms pivot about on the end which is attached to the detritus strand, and a large patch appears to move in synchronal waves. Some strands possess a very rich growth, and the behavior of the amphipods at this time suggests that they aid the culture of the diatoms by removing all other settling organisms and silt. This is accomplished by the mechanical disturbance of their feeding and movement up and down the strand. The gut of both the adults and young are often completely packed with the diatom. It may be that some pass through the alimentary canal undamaged, and thereby seed newly constructed strands.

It seems unlikely that the diatoms obtain much, if any, of their nutriment from inorganic nutrients released by the detritus strands. The amphipod does "farm" the diatom, however, in the sense of weeding and cropping. There are no records of similar behavior in any marine crustacean, and this behavior may be without parallel in the marine environment.

During the winter months the strands are entirely devoid of diatoms, and of course the amphipod must obtain nutriment elsewhere. Their diet at this time becomes detritus or plankton which they filter from the water. In a strong current, the animals orient themselves on the strand so as to spread the large antennae, and appear to make capturing movements with the mouthparts and gnathopods; the antennae are also periodically drawn through the mouthparts.

It appears that the urchin derives no benefit whatsoever from its relationship with the amphipod. It is not clear whether the amphipod's strand destroys the tissue at the tip of the spine, or if the strand is attached to a spine previously injured. In any case, the base of the strand prevents healing, and spine tissue is usually seen bunched up around the base of the detritus cap, as if the spine tissue were trying to throw off or grow over the strand. The amphipod, on the other hand, probably benefits from the fact that *Strongylocentrotus franciscanus* is generally avoided by free-swimming animals. The relatively equal spacing between spines probably also limits interspecific competition. It is doubtful if any type of nutritive relationship occurs between the urchin and the amphipod.

Field observations indicate why the amphipod has never been collected by a surface vessel. The detritus strands break off easily, and the amphipods will vacate the strands and swim freely when disturbed. *Dulichia rhabdoplastis* is a surprisingly effective swimmer considering its normally sedentary habit. When the animal is swimming, the very long first antennae are brought together and pointed directly forward, the second antennae are folded laterally backward, and the urosome flexed upward so as to expose the pleopods. Each pleopodal ramus is supplied with 22 to 26 very long, lateral setae which are fanned outward on the power stroke. The amphipod will swim for several meters after vacating its strand and then will slowly sink in the water column. Free-swimming individuals have been observed to blunder into an urchin and immediately clasp a spine and climb to its tip. If a longer spine should brush against them in this position, they will transfer to it; consequently, the longest spines are nearly always the ones possessing strands.

Predators of *Dulichia rhabdoplastis* are unknown. It is probable that they are rapid-swimming pelagic forms—possibly fish. Some selection pressure has undoubtedly contributed to the animals' protective coloration, for they are very nearly the same shade of dark maroon

as the urchin. Their ability to vacate the strand and swim possibly also serves well as a predator escape mechanism; they would be able to vacate an urchin being captured by the large sunstar *Pycnopodia helianthoides.*

Females with young were observed from May to late September. Ten to 14 embryos develop in the brood pouch, and the young are carried therein until capable of clinging to the strands. While it is not uncommon to see strands occupied by two or three half-grown juveniles or nonbreeding adults, generally a gravid female is the sole occupant of a single strand. Such females aggressively defend their own strands from other adults, but ignore young amphipods. During the breeding season most of the strands have several young individuals of various sizes scurrying to keep from underfoot of the adults. When the young leave the parent's strand to construct their own is not known.

The spination and morphology of the pereopods and urosome ably suit *Dulichia rhabdoplastis* for its mode of living. Its congeners all appear to be generally similarly modified, and therefore they may also be thigmotactic species dwelling caprellid-like on small-diameter rods (*D. spinosissima* lives on hydroids, for instance). It would be interesting to learn if any other species in the genus also construct detritus strands or live with echinoids.

A number of aspects of the biology of these animals could not be answered satisfactorily, primarily because the amphipod is very difficult to maintain in the laboratory. They refuse to remain attached to their strands, and swim about until they are moribund or are caught in the surface film. Further information is therefore dependent upon observations by divers.

REMARKS: The species is named in reference to its rod-building ability.

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