ANTHURIDEAN ISOPODS (CRUSTACEA) OF CALIFORNIA AND THE TEMPERATE NORTHEAST PACIFIC

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I. Introduction

Literature on the anthuridean isopod fauna of California and the northeast Pacific has not recently been synthesized. Since the most recent comprehensive report (Schultz 1977) family and generic level reviews have altered the nomenclature of several species. Environmental survey and monitoring programs have generated many new geographic and bathymetric distributional records for eastern Pacific anthurideans, most as yet unpublished, and have collected several undescribed species. The current review was undertaken to update and standardize anthuridean taxonomy in California, and to disseminate information derived from a variety of unpublished sources.

II. Definition of the Group

Isopods of the suborder Anthuridea are most easily recognized by their slender elongate bodies (usually 7 or more times longer than wide), lateral uropods that curve up and over the pleotelson, and presence of (usually) one or two pleotelsonic statocysts (Fig. 1.1). Unlike most isopods, anthurideans are not much flattened dorso-ventrally and are circular or oval in cross-section. According to Brusca and Wilson (1991), the specific defining synapomorphies of the Anthuridea are: mandible without distinct lacinia mobilis or spine row, instead with a lamina dentata (which may be secondarily lost in some species); maxillae reduced, minute, fused to paragnath (or lost entirely); coxae of maxillipeds fused to head; maxillipedal endite without coupling spines; and uropodal exopod folded dorsally over pleotelson.

Brusca and Wilson (1991) placed this suborder within the "flabelliferan complex" (the Flabellifera *sensu lato*). The suborder contains four families, all now known to occur in the temperate northeast Pacific. Most species achieve a moderate size (8-15mm length), but a few are much smaller (4mm) or larger (45mm). Most anthurideans are marine, but some genera have marine, brackish, and freshwater members (e.g. *Cyathura*), some are exclusively freshwater (e.g. *Cruregens*), some are primarily stygofaunal (e.g. *Stygocyathura*), and some are primarily anchialine or interstitial (e.g. *Curassanthura*). About 200 species have been described, but this is almost certainly only a small percentage (probably less than half) of the world fauna.

III. Aspects of Anthuridean Biology

Reproduction - Mature male and female anthurideans are easily separated by secondary sexual characters, particularly the enlarged, multiarticulate, aesthetasc-fringed flagellum of the male first antenna (Fig. 2). In some cases males and females differ so greatly in gross morphology that they were initially described as separate species. The apparent separation of sexes can, however, be misleading, as protogynous sequential hermaphroditism occurs in many species. In others, as in some tanaids (Buckle-Ramirez 1965), there is also male polymorphy, with some animals always male and some males developing secondarily from post-brood females (Legrand & Juchalt 1963, Burbanck & Burbanck 1974, 1979).

Predators - Many fishes are known to feed on the west Atlantic estuarine species *Cyathura polita*, as do blue crabs (Burbanck and Burbanck 1979). Predation by crabs, and other invertebrates is likely for eastern Pacific species, but has not been documented. In an evaluation of trophic relationships between fishes and benthic invertebrates at Catalina Island, Hobson & Chess (Ms.) found 11 fishes feeding on anthuridean isopods. Forty-one anthurids were found in the guts of 28 fish. Most of the isopods were consumed by three species; black surfperch *Embiotoca jacksoni* (6 guts, 10 isopods), blackeye goby *Coryphopterus nicholsi* (5 guts, 8 isopods), and California sheephead *Pimelometopon pulchrum* (5 guts, 10 isopods). Species taking anthurideans at lower frequencies were rock wrasse *Halichoeres semicinctus*, señorita *Oxyjulis californicus*, kelp surfperch *Brachyistius frenatus*, island kelpfish *Alloclinus holderi*, garibaldi *Hypsypops rubicundus*, halfmoon *Medialuna californica*, kelp bass *Paralabrax clathratus*, and blue-banded goby *Lythrypnus dalli*.

Anthurideans are slow compared to many other peracarids, and they swim only clumsily. Outside their refuges their movements are awkward, and they are probably easy prey to predatory nemerteans, annelids, and other arthropods. Despite the lack of special protective or offensive structures, some anthurideans respond aggressively to attack. If seized from behind, *Paranthura elegans* will twist around and strike at it's attacker (pers. obsv.). Perhaps this aggressive response is sufficient to deter some would-be predators.

The relatively indurated pleotelsonic region of many anthurideans apparently serves as an operculum to block access to certain tube or burrow-dwelling species. Observations on living *Eisothistos* (Wägele 1981) indicated that they adopt a head down position in serpulid worm tubes while feeding on the original occupant. This leaves the ornamented pleotelson and uropods in the position of the worm's operculum (Fig. 3.2). Foraminiferans and sponges observed attached to the tail-fan of *Eisothistos* sp B suggest they may move little once established in a tube, thus minimizing exposure to predators.

IV. Anthuridea of the West Coast of North America (North of Mexico)

Apart from *Edanthura linearis* Boone, 1923, the first anthurideans known from the northeastern temperate Pacific were those described by Menzies (1951). The temperate fauna of the northeast Pacific currently contains at least 15 recognizable species. Three are undescribed species and 12 are nominate species, of which one is a *nomen nudum* (*Paranthura linearis*), one may be a misidentification or incorrect locality record (*Paranthura algicola*), and one is clearly a questionable record (*Cyathura carinata*). Holotypes (**) or paratypes (*) of most of these species are in the collection of the Los Angeles County Museum of Natural History (LACMNH)(Wetzer et al. 1991), as noted below. North of California, anthuridean isopods are both less common and less diverse. No members of this suborder were reported by Richardson (1905) for the northeast Pacific, by Hatch (1947) from Washington, or by George & Strömberg (1968) from Puget Sound. In a detailed environmental analysis of benthic communities in Puget Sound, Lie (1968) reported *Haliophasma geminatum*, and three other species have since been reported from the northeast Pacific: *Cyathura carinata, Calathura branchiata*, and *Eisothistos sp B*.

Family Antheluridae

Ananthura luna (Schultz, 1966)** Formerly placed in *Bathura;* see comments below.

Family Paranthuridae

Califanthura squamosissima (Menzies, 1951)* Formerly placed in *Colanthura;* see comments below.

Colanthura bruscai Poore, 1984*

Paranthura algicola Nunomura, 1978 Questionable species; see comments below.

Paranthura elegans Menzies, 1951*

Paranthura linearis nomen nudum. Formerly placed in *Edanthura* ; see comments below.

Müller's (1981) record from the Gulf of Alaska, establish this species as circum-north Pacific in distribution. It has not been reported south of Alaska, and it's reported depth range is 20-1500m

Califanthura squamosissima (Fig. 7). Schultz (1977) sunk *Colanthura* Richardson, on the basis of a supposed synonymy of *Colanthura tenuis* Richardson (the type species) and *Paranthura infundibulata* Richardson, and he erected *Califanthura* as a replacement genus for *Colanthura squamosissima*. Poore (1980), however, resurrected *Colanthura*, declaring both it and *C. tenuis* to be valid taxa. Poore's conclusion was based, in part, on a reexamination of the types of *C. tenuis* and *P. infundibulata* by Kensley, who also did not substantiate their synonymy (in Poore 1980). Although Poore's (1980) move sunk Schultz' *Califanthura* into *Colanthura*, he later (Poore 1984) reestablished it as a valid genus, which now contains six species worldwide. *C. squamosissima* is a small species, reaching only about 5.2mm in length. It occurs in shallow water (18-90m) from Dillon Beach, California (Schultz 1977) to Magdalena Bay, west Baja California (Nunomura 1978), and has also been collected intertidally at Morro Bay and La Jolla.

Colanthura bruscai (Fig. 8) is similar to *C. squamosissima* in general appearance and size. However, it is predominantly Panamic in distribution, with it's northernmost occurrence at San Clemente, California (Poore 1984), and from there ranging south to at least Costa Rica. It occurs intertidally at most locations, although some northern records are subtidal to a maximum depth of 27m. The maximum reported length is 5.4mm (Poore 1984).

Cyathura carinata is a northern European species. Bernard's (1978:576) record from the Strait of Georgia (British Columbia, Canada), if accurate, may reflect a relict north Pacific population from a former circumboreal distribution. However, because there are no other reports of this well-known Atlantic species from the Pacific Ocean, this unpublished Pacific record needs confirmation. The record in Austin (1985) presumably is derived from Bernard's report. This species was originally placed in *Anthura*; and transferred to *Cyathura* by Norman and Stebbing (1886). It is not included in our key.

Cyathura munda (Fig. 9) is a moderate size (to 9 mm), narrow (length more than 9 times width) species, usually associated with brown algal holdfasts on hard substrates. The type material from northern California was all taken from the holdfasts of *Egregia* and *Laminaria*. All the subtidal records of Menzies & Barnard (1959) are from stations where the samples were noted to contain either kelp or rocks (Allan Hancock Foundation, 1965). LACMNH material of this species usually indicates collection from kelp or from surfgrass (*Phyllospadix*). This species has been taken from the intertidal zone (Menzies 1951) to 58m (Menzies and Barnard 1959), from Tomales Point to the Mexican border, and in the Gulf of California. More recent collections in the Santa Maria Basin extend the depth range down to 132m on rocks. Brusca and Iverson (1985) described a very similar species from intertidal habitats on the Pacific coast of Costa Rica (*C. guaroensis*).

***Eisothistos* sp. A.** A single juvenile specimen (1.4mm) of this species was taken off Tajiguas, Santa Barbara Co., California at 77m depth, in the washings of rocks retrieved during a submersible dive in 1984. It was initially called by the unpublished name *Heteranthura* sp. A. However, Wägele (1981) synonymized *Heteranthura* Kensley and *Eisothistos* Haswell, hence the generic reassignment. This specimen, while clearly not belonging to any other eastern Pacific anthuridean species, is not sufficiently adult to compare with other species of *Eisothistos*, of which there are over a dozen worldwide. Additional specimens were later taken by Hans Kuck (LACMNH) in 1989, in association with colonies of the coral *Coenocyathus bowersi* collected at 5-8m depth off the eastern shore of Catalina Island. These specimens were larger (2-2.5mm), but still not fully adult. In gross morphology this species is similar to *Eisothistos antarcticus* as described by Wägele (1984b), with serrate uropodal and pleotelsonic margins, and a single row of spines down the middle of the pleotelson. The range of this undescribed California species, as currently known, is 5-77m, Tajiguas to Catalina Island. The genus *Eisothistos* was recently transferred from Hyssuridae to Anthuridae by Poore & Lew Ton (1988c).

earlier literature. The records of Menzies and Barnard (1959) suggest that this is a shallow-water species, probably associated with either macroalgal holdfasts, or with algal mats or turf. Brusca (1980) reported a similar appearing congener (*Mesanthura* sp.) from intertidal algal mats in the Gulf of California that may, in time, prove to be a variant of *M. occidentalis*. *Mesanthura nubifera* Wägele, 1984, also from intertidal habitats in the Gulf of California, does not match the pigmentation of Brusca's (1980) species.

Paranthura algicola (Fig. 14) was described by Nunomura (1978) on the basis of two female specimens (5.5mm and 10mm in length) sent to him by Waldo Schmitt in the 1970's. The locality was given as simply a "rocky beach in California, washed from algae, 24 November 1916." Judging by Nunomura's illustrations, his animals may have been *Paranthura elegans* showing the effects of long-time preservation. Nunomura stated that *P. algicola* differed from *P. elegans* in having: "eyes with scattered ocelli" [sic], pleonites medially fused, and by the "shape of the posterior border of the sixth pleonal somite." In fact, the eyes of *P. elegans* are large with many ommatidia and could easily appear as figured and described by Nunomura after many years of preservation; the pleonites are free in *P. elegans* but the articulations are very faint and can easily be mistaken as being fused; and, we see no significant differences between these two species in the posterior margin of the sixth pleonite (aside from what could be attributed to poor renditions by both Nunomura and Menzies). Nunomura's description and figures are difficult to interpret, but the type material was reported as being at the USNM and should be reexamined to establish the correct disposition of this species. We did not include this species in the key that follows. Nunomura (1978) also described another species of *Paranthura*, which he gave the unfortunate name of *P. californiae*, from Magdalena Bay (Baja California, Mexico) that closely resembles *P. elegans*.

Paranthura elegans (Fig. 15) ranges from Dillon Beach at least to San Quintin Bay (west coast of Baja California, Mexico), from the intertidal zone to a depth of 55m (Schultz 1977), and also throughout the Gulf of California (Brusca 1980). It frequents algal mats and clumps, mud bottoms, encrusted pier pilings, and rocky low intertidal habitats. Adults reach about 9.5mm in length in California waters, but are larger in the warmer waters of the Gulf of California (8-15mm). Differences is adult size along a latitudinal gradient are not uncommon, and have been reported for idoteid isopods in the eastern Pacific (Brusca and Wallerstein 1979, Wallerstein and Brusca 1982), and for *Cyathura polita* on the east coast of America (Burbanck and Burbanck 1979).

Paranthura linearis has remained enigmatic since its description (as *Edanthura linearis*). Boone (1923) reported this animal from Laguna Beach, California. She described it's mouth parts only as "well developed, unique"; perhaps accurate but certainly imprecise. Menzies (1951) considered *Edanthura* Boone a synonym of *Paranthura* Bate and Westwood, and also recommended *E. linearis* be reduced to *nomen nudum* status. Poore (1984) and Negoescu & Wägele (1984) apparently agreed with these assignments. The type has not been found at the USNM (where Boone indicated it had been deposited), and its whereabouts remains unknown. This species is not included in the key that follows.

V. Key to the Species of Anthuridea Known from the Northeast Pacific (North of Mexico)

1. Mouth parts adapted for piercing and sucking, together forming an anteriorly directed cone-like structure under the head; maxillipedal palps long, thin, and tapering; mandibular incisor smooth, styliform, not toothed; mandible without molar process or lamina dentata; 0 or 1 statocyst in pleotelson; first pleopods enlarged and operculate to others 2
   - Mouth parts adapted for biting and chewing, not forming a conelike structure; maxillipedal palps broad; mandibular incisor often toothed; mandible usually with molar process and lamina dentata; 0, 1, or 2 pleotelsonic statocysts; first pleopods may or may not be operculate to others 4

Eisothistos **sp. B** was encountered in environmental monitoring samples from Alaska related to the Exxon Valdez oil spill. Although the exact locations of the sampling sites were unavailable because of litigation, the animals were collected between the intertidal zone and 10m depth somewhere in Prince William Sound. Numerous specimens were taken from the tubes of serpulid polychaetes, a common habitat for members of this genus. This species resembles both *Eisothistos* sp. A and *Eisothistos minutus* (Sivertsen and Holthuis, 1980) of the tropical east Atlantic. Post-brood adult females, which undergo elongation of pereonites 2-6 (Fig. 10) as described for other species (Wägele 1981), may reach 5mm in length. This species has not been recorded from California waters.

Haliophasma geminatum (Fig. 11). Schultz (1977) erected a new genus (*Silophasma*) for this species, which the revision of Poore (1975) had placed beyond the bounds of a redefined *Haliophasma* Haswell. Subsequently, the definition of *Haliophasma* was expanded such that *Silophasma* was no longer needed, and it fell into synonymy with *Haliophasma* (see Negoescu and Wägele 1984 and Poore and Lew Ton 1988a). Poore (1975) changed the spelling of the trivial name from "geminata" to "geminatum" to match the gender of the generic name. Schultz (1977) gave 7mm as maximum size for *Haliophasma geminatum*, but we have seen specimens from California as large as 12mm in length. This species ranges from Monterey, California (Iverson 1974) to San Quintin Bay, Baja California, Mexico (Menzies 1962) over a broad depth range (9-512m). Lie (1968) also recorded it from Puget Sound.

Hyssuridae gen. A sp. A (Fig. 12). Collections made in the western Santa Barbara Channel and in the Santa Maria basin in central California encountered scattered specimens of this small species (5-6mm length). This may be the same as the "Anthurid n. sp. & n. gen." reported but not well described by Menzies (1962) from off San Quintin Bay, Baja California. In his discussion, Menzies indicated a close affinity to *Kupellonura* for his specimens, but felt they might constitute a new genus. The present material matches the characters Menzies noted: indurated pleotelson with a ventral keel, separation of all pleonal segments, antennal flagellum article counts, and details of the uropods. Menzies did not illustrate his material, and nothing in his brief discussion is unique enough to definitely establish identity between his material and our own. Redefinition of the genera of the Hyssuridae by Poore and Lew Ton (1988c) places the current material close to both *Kupellonura* Barnard and *Hyssura* Norman and Stebbing. One might be inclined to assign it to *Kupellonura* because of the presence of lobes on the lateral margins of the uropodal exopods, a unique synapomorphy for this genus (Poore and Lew Ton 1988c). It also possess a triangular carpus on pereopods IV-VII, whereas the carpus of *Hyssura* species is rectangular in shape. However, the mouth parts are more characteristic of *Hyssura* in that the mandibular molar process is acute (not blunt, as is characteristic of *Kupellonura*), and the maxillipedal endite is short, reaching only the second palp article (rather than the third article, as is typical of *Kupellonura*). One of the specimens of this species we examined had a 4-articulate flagellum on the left antenna and an 8-articulate flagellum on the right. Other than our own observations and Menzies' possible record, this species has not been reported from the northeast Pacific. Our material came from a sample taken off the southeast end of San Miguel Island, and from seven MMS sampling stations between Oso Flaco and the north side of Anacapa Island, from 47 to 166m.

Mesanthura occidentalis (Fig. 13). The original description of this species distinguishes it solely on the basis of the dorsal pigmentation pattern. Illustrations of the pleotelson apex, the maxilliped, the antennae, and the last three articles of the first pereopod were provided, but not discussed. This was amplified by description of a paratype, with a more complete illustration of it's antennae, mouth parts, and appendages by Wägele (1984a). Although taken subtidally by grab, the 7mm holotype female came from a sample containing kelp fragments and red algae. Menzies and Barnard (1959) recorded this species from two localities (Point Conception and Point Fermin, California), both containing either kelp or rock, and both from shallow water (12-20m). An additional lot was reported by Schultz (1964) from off Palos Verdes, also in shallow water (20m). Schultz (1977) later gave this species' range as "Point Conception to San Quintin Bay, Baja California" and "from shallow water to 55m deep," perhaps a transcription error of

2. Pereonite 7 at least 50% as long as 6; seventh pereopods present ..... *Paranthura elegans*
- Pereonite 7 less than 20% as long as 6; seventh pereopods absent 3

3. Pereonite 1 twice as long as 2; pleonites free, not fused ..... *Colanthura bruscai*
- Pereonites 1 and 2 subequal; pleonites fused dorsally ..... *Califanthura squamosissima*

4. With no statocysts in pleotelson; first pleopods not enlarged and operculate to others; body extremely elongate, about 15 times longer than wide (Hyssuridae) ..... Hyssuridae gen. A, sp. A
- With 0, 1 or 2 statocysts in pleotelson; first pleopods always enlarged and operculate to pleopods 2-5; body length 6-10 times width 5

5. With 1 pleotelsonic statocyst; maxillipedal endite and palp very wide; pleonites 1-5 entirely free never fused dorsally (Antheluridae); the only known California anthelurid is blind and its uropodal tips bear radiating setal clusters ..... *Ananthura luna*
- With 0, 1 or 2 pleotelsonic statocysts; maxillipedal endite and palp normal, not especially broad; pleonites 1-5 free or dorsally fused (Anthuridae) 6

6. Pleotelson with a dorsal median spine row 7
- Pleotelson smooth or ridged, but without dorsal spines 8

7. Uropodal endopod with distolateral margin more or less evenly serrate ..... *Eisothistos* sp. A
- Uropodal endopod with distolateral margin divided into two cusps by three prominent denticles, evenly serrate between these points ..... *Eisothistos* sp. B

8. Pleonites 1-5 completely free and separate in both dorsal and lateral view ..... *Calathura branchiata*
- Pleonites 1-5 completely fused or fused mediodorsally, although segments may be visible in lateral view 9

9. Carpus of pereopods 4-7 rectangular; pleotelson with three raised dorsal longitudinal ridges ..... *Haliophasma geminatum*
- Carpus of pereopods 4-7 triangular; pleotelson without dorsal ridges 10

10. Pleonites 1-5 fused only along dorsal midline, segments free laterally; uropodal endopods narrow (<60% of pleotelson width), exopods much shorter than either pleotelson or endopods ..... *Amakusanthura californiensis*
- Pleonites 1-5 completely fused dorsally, segmentation indicated in lateral view only by faint lines and setal bundles; uropodal endopods subequal in width to pleotelson, exopods nearly as long as pleotelson and endopods 11

11. Maxillipedal palp 3-articulate; pereonites pigmented dorsally, with complete or nearly complete dark ovals on pereonites 2-6 ..... *Mesanthura occidentalis*
- Maxillipedal palp 2-articulate; pereonites pigmented dorsally with dark splotches, but without pigment rings ..... *Cyathura munda*