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Reinstatement and further description of *Eualus subtilis* Carvacho & Olson, and comparison with *E. lineatus* Wicksten & Butler (Crustacea: Decapoda: Hippolytidae)

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Abstract.—*Eualus subtilis* Carvacho & Olson 1984 is presently considered a synonym of *E. lineatus* Wicksten & Butler 1983. Comparisons of the two forms revealed differences in the armature of the antennular peduncle, stylocerite, and pereopods, as well as differences in color and maximum size, indicating that *E. subtilis* is a valid species. Furthermore, *E. subtilis,* unlike *E. lineatus,* exhibits marked sexual dimorphism, and characteristics of the previously undescribed, diminutive males of this species are provided.

The genus *Eualus* Thallwitz, 1891 is comprised of relatively small caridean shrimps that occur primarily in the higher latitudes. Butler (1980) illustrated a small, striped shrimp as *E. herdmani* (Walker, 1898), and mentioned that it could be trawled in small numbers in Departure Bay, Canada. However, subsequent examination of the holotype and only known specimen of *E. herdmani* by Wicksten & Butler (1983) revealed that *E. herdmani* belonged in the genus *Heptacarpus* (Holmes, 1900) and the specimens illustrated by Butler (1980) were described as a new species, *E. lineatus* Wicksten & Butler, 1983. One of the characters distinguishing *E. lineatus* was the presence of three moderate dorsodistal spines on the first article of the antennular peduncle (hereafter referred to as "antennular spines").

A second description of a small eualid, *E. subtilis* Carvacho & Olson, 1984 was published based on a single specimen trawled off Baja California. As Carvacho & Olson did not mention *E. lineatus,* and still referred to "*E. herdmani*", they were evidently unaware of Wicksten & Butler's (1983) paper. *Eualus subtilis* strongly resembled *E. lineatus* in the size and armature of the rostrum, but had only a single, stout, dorsolateral antennular spine. Wicksten (1988) considered *E. subtilis* to fall within the range of variation of *E. lineatus* and thus a junior synonym, and used the record as a southern range extension for *E. lineatus.*

Subtidal sampling in the Puget Sound region revealed an extremely abundant small eualid that matched the description of *E. subtilis.* However, out of hundreds of specimens examined, all had a single antennular spine. Based on the length of the rostrum some of these specimens keyed out to *E. pusiolus* (Krøyer, 1841), yet they bore several strong, distal spines on the merus of the walking legs while *E. pusiolus* has only a single spine (Squires 1990). Furthermore, this species exhibited marked sexual dimorphism, whereas there is no distinct differences between sexes in *E. pusiolus* (Greve 1963). In view of these observations, a study was undertaken to determine if *E. subtilis* is distinct from *E. lineatus,* and provide information about the unusual, small males.

Materials and Methods

Due in part to the ambiguity of existing keys, museum specimens of these shrimps have been variously cataloged under the names *E. herdmani, E. pusiolus,* or *E. lineatus.* These specimens needed to be reexamined. Sixty-one specimens from the British Columbia Provincial Museum collection were examined, as was the holotype of *E. lineatus* (AHF 4129) deposited in the Natural History Museum of Los Angeles County and the paratype from the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM). The two paratypes reportedly deposited in the National Museum of Canada were not sent at the time *E. lineatus* was described and now cannot be located. Additional material was acquired from Friday Harbor Laboratories of the University of Washington (43 specimens), the California Academy of Sciences (8 specimens), and our own collections ranging from the Pribilof Islands to Puget Sound (45 specimens). Twenty-two North Atlantic specimens of *E. pusiolus* from the Royal Norwegian Society of Sciences were examined for comparison.

Live specimens having a single antennular spine were abundant in shell rubble and easily collected while diving by carefully placing dead bivalve shells in a fine-meshed bag. Hand-operated suction devices were used to sample in rock crevices.

Measurements were taken using an image analysis system (Optimus®) on a Wild MC3 dissecting microscope, with additional measurements taken using an ocular micrometer. Carapace length (cl) was measured from the posterior margin of the orbit to the middorsal posterior margin of the carapace; rostrum length, from the same position on the orbit to the tip. Sex, rostral formula, number of distal spines on the basal article of the antennular peduncle, and relative lengths of the stylocerite and rostrum were also noted, as was the number of meral spines on pereopods 3–5. Drawings were made with the aid of a camera lucida on a Wild® M5 microscope.

Results

Of the 159 shrimp measured, only 17 were found bearing multiple antennular spines, and these were compared with 93 specimens that had only a single antennular spine and multiple spines on the merus of the third pereopod. The remaining 49 specimens were identified as *E. pusiolus* based on published descriptions and comparison with the specimens from Norway.

The 17 specimens with multiple antennular spines reached substantially larger sizes than those bearing a single spine (Fig. 1a, b). Multiple antennular spines were also correlated with a reduced number of meral spines on the third pereopod. Those with multiple antennular spines typically had only one meral spine, although some specimens had a second, much reduced spine present on at least one side. Shrimp with a single antennular spine had significantly more meral spines ($\chi^2 = 81.21$; $p \ll 0.001$), the great majority bearing three strong meral spines and the remainder varying from two to five (Fig. 2).

Those with multiple antennular spines also had a curved, dorsal tooth near the base of the stylocerite not previously noted in the literature (Fig. 3); that tooth was lacking in those with a single antennular spine. A blunt suborbital carapace spine was also present in those with multiple antennular spines, and missing in those with a single antennular spine and more than one spine on the merus.

Males with a single antennular spine typically had a very thin, bifid rostrum (Fig. 4c); the largest male (2.1 mm cl) was smaller than any of the ovigerous females (2.6–3.8 mm). Unlike that of females, the propodus of pereopods 3–5 of males was distinctly broadened distally and armed with two rows of spines forming a dense comb on the flexor margin, with spines increasing in length distally (Fig. 4a); the male dactylus was also armed with an unusual series of compound spines on the flexor margin (Fig. 4b). The appendix masculina was subequal in length to the appendix interna, and tipped with two long spinules and five short ones. Males comprised only 10% of the samples.

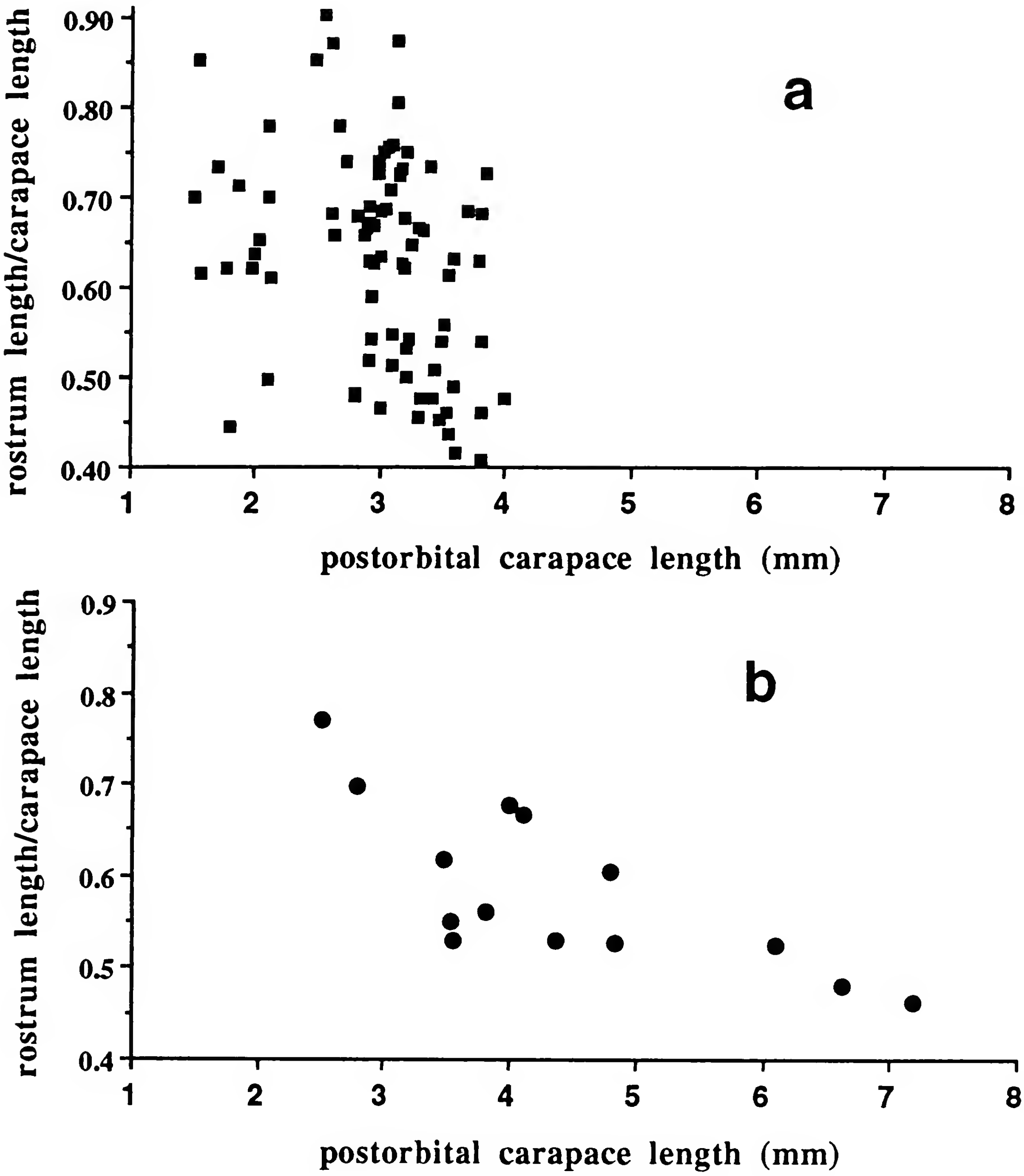

Fig. 1. Scatterplot of postorbital carapace length vs. proportional rostrum length for specimens having a single distodorsal spine on the basal article of the antennular peduncle (a), and specimens with multiple distodorsal spines on the basal article of the antennular peduncle (b).

Only two males with multiple antennular spines were available for examination, but other than the presence of an appendix masculina they did not appear to differ from females with multiple spines. The appendix masculina in these specimens was slightly more than half the length of the appendix interna and tipped with eight long spinules, as previously described (Wicksten & Butler 1983; Fig. 2d).

The form with only a single antennular spine consistently displayed the color pattern described for *E. lineatus* (Wicksten & Butler, 1983) as shown in Butler (1980: plate 1C), having thin red diagonal lines on the carapace and first two abdominal segments and red spotting on the remainder of the abdomen. In contrast, a live specimen of the form that has multiple antennal spines was boldly marked on both the car-

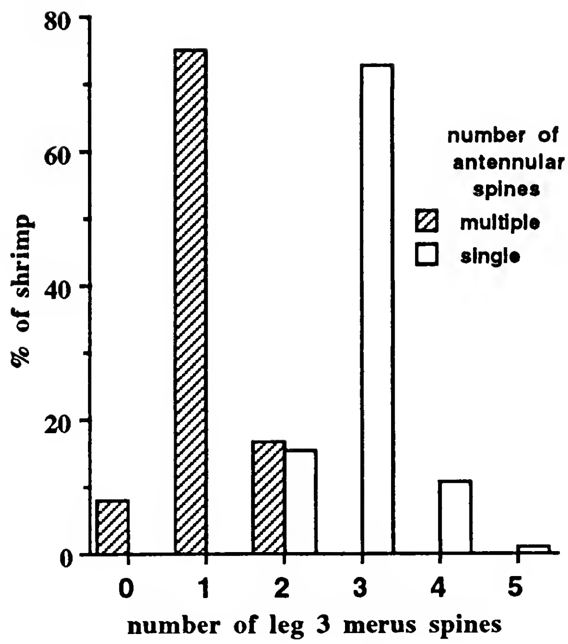

Fig. 2. Bar graph showing number of lateral spines on the merus of the third pereopod for specimens with single (n = 85) or multiple (n = 12) distodorsal spines on the first article of the antennular peduncle.

apace and abdomen with broad orange bands against a translucent background (Fig. 5).

The holotype of *E. lineatus* has multiple antennular spines, a suborbital carapace spine, dorsal tooth on the stylocerite, and two spines on the merus of the third pereopod, whereas the USNM paratype of *E. lineatus* has only a single antennular spine, no suborbital spine or stylocerite tooth, and three strong spines on the merus of the third pereopod.

Discussion

The combination of size, color and morphological differences clearly indicate that *E. subtilis* should be considered a valid species, distinctly separate from *E. lineatus*. *Eualus subtilis* lacks the multiple dorsodistal spines on the basal article of the antennular peduncle, the suborbital carapace spine, and the dorsal tooth on the stylocerite that are all present in *E. lineatus*. Furthermore, the largest *E. subtilis* barely exceed half the length of *E. lineatus*, and *E. subtilis* exhibits marked sexual dimorphism while *E. lineatus* does not. The number of spines on the merus of the third walking leg is usually reliable for differentiating the two species, but there is some slight overlap, with *E. subtilis* varying from 2 to 5 (usually 3) spines whereas *E. lineatus* varies from 0 to 2 (usually 1). The type series for *E. lineatus* consists of a mix of both of these species, but since the specimen designated as the holotype has multiple antennular spines and a spine on the stylocerite, this is the form that should retain the name *E. lineatus*.

Much of the confusion regarding these species is due to variability in the length of the rostrum of *E. subtilis* (Fig. 4c–f). Most keys continue to follow the pattern established by Rathbun (1904) of separating *E. pusiolus* and "*E. herdmani*" (= *E. lineatus*) solely on the basis of whether the rostrum overreaches the second article of the antennular peduncle. We found many cases where, depending on the length of the rostrum, specimens of *E. subtilis* from the same haul had been cataloged as *E. pusiolus* and *E. herdmani* or *E. lineatus*.

The presence of multiple antennular spines makes *E. lineatus* very easy to differentiate from *E. subtilis* and *E. pusiolus*. The latter two species can be reliably separated by the number of meral spines on the pereopods: *E. subtilis* has 2 to 5 strong, distal spines on the merus of the third pereopod (and normally multiple spines on the fourth), whereas *E. pusiolus* has only a single spine on each of these pereopods. *Eualus pusiolus* has a small, rounded suborbital carapace spine, while *E. subtilis* has none. In this respect *E. subtilis* resembles the South American species *E. dozei* (A. Milne Edwards, 1891), but this species also has only single meral spines (Holthuis 1952).

We found that some of the characters given by Carvacho & Olson (1984) to differentiate *E. subtilis* were not useful. The ventral spines on the abdomen (considered by these authors to be unique to this species) were present on all males and most non-ovigerous females of *E. pusiolus* and

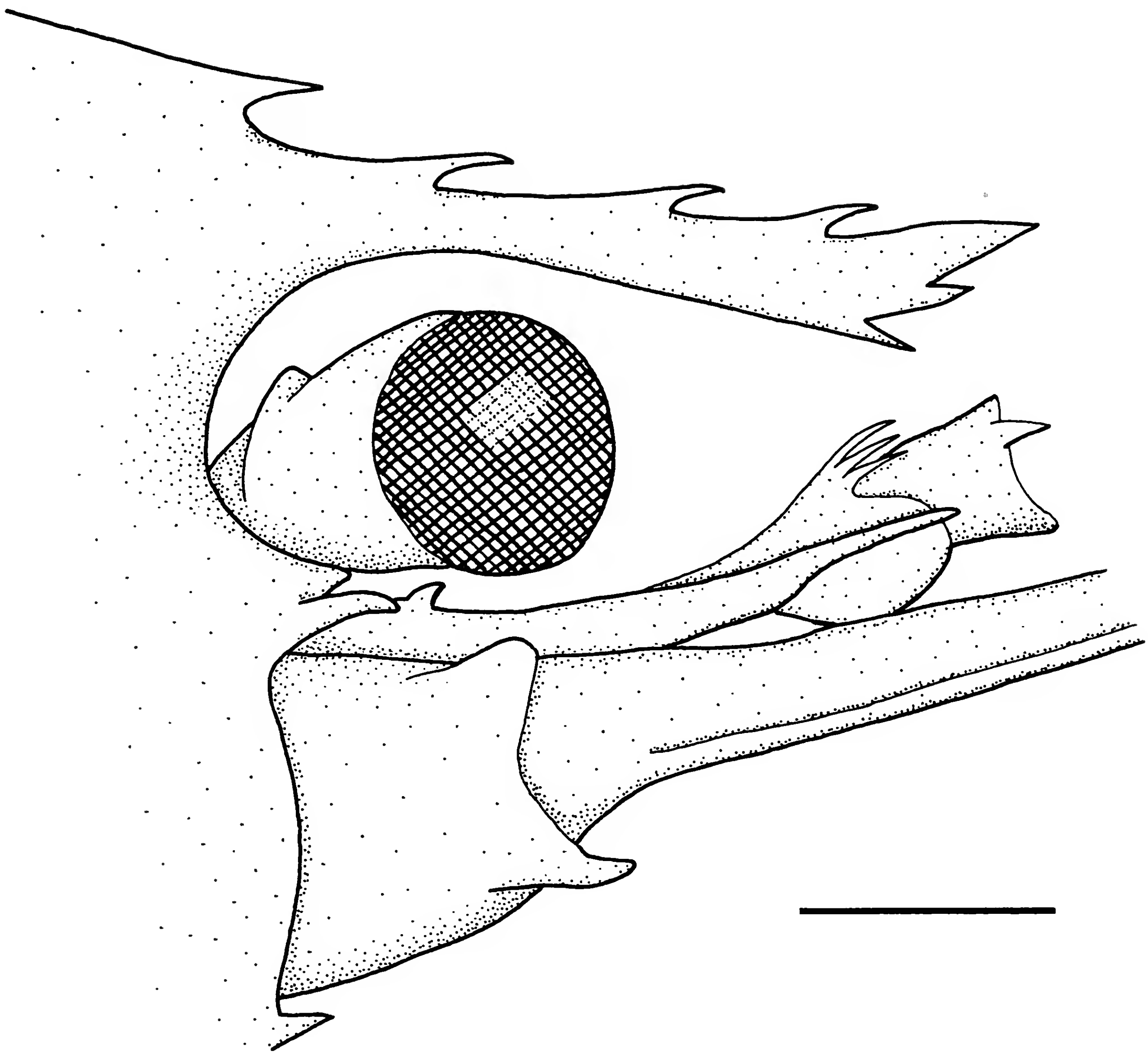

Fig. 3. *Eualus lineatus* Wicksten & Butler, 1983. Lateral view of anterior region of carapace, showing curved tooth on the base of the stylocerite and multiple spines on the basal article of the antennular peduncle. Scale bar is 1 mm.

E. lineatus. Furthermore, the basicerite of *E. pusiolus* has only one (not two) lateral spines, so this character is not useful for separating this species from *E. subtilis.*

Eualus subtilis is quite possibly the most abundant shrimp in Puget Sound, occurring subtidally on virtually any bottom type from mud to solid rock. It sometimes occurs in the low intertidal and has been collected in trawls to at least 74 m, and to date has been found from Barkley Sound, British Columbia (this study) to Bahía de Todos Santos, Punta Banda, Baja California (Carvacho & Olson 1984). Males of *E. subtilis* are fairly uncommon in collections, probably due to their very diminutive size. Although males were always much smaller than ovigerous females, the presence of small females suggests that the species is not strictly protandric. The unusual modifications to the pereopods bear some resemblance to those described by Bauer (1986) for another small hippolytid, *Thor manningi* Chace, 1972, a species that exhibits a novel reproductive strategy involving nearly equal proportions of protandric individuals and primary males.

Less is known about the habits and habitat of the much rarer *E. lineatus.* Specimens have been collected at depths of 12–

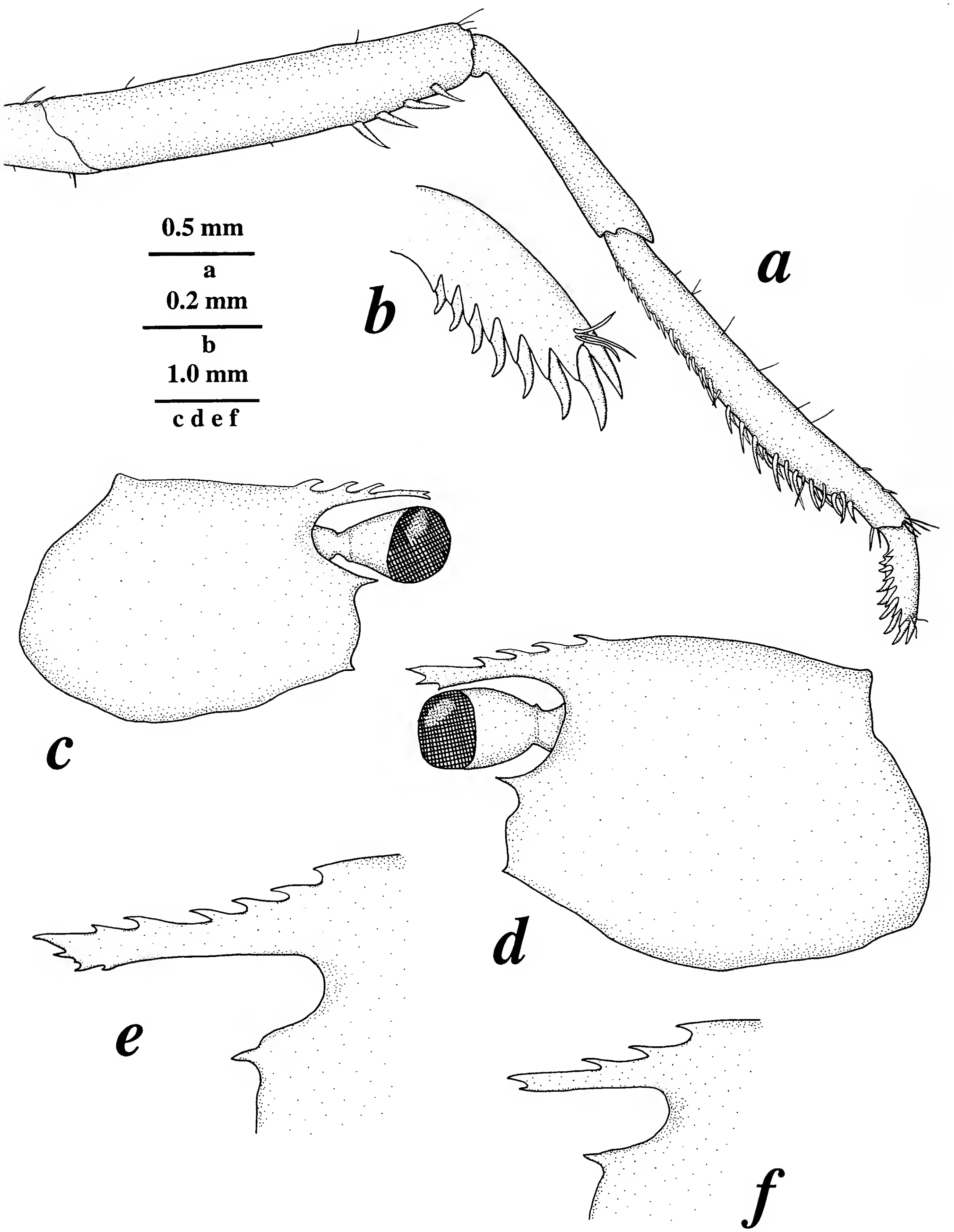

Fig. 4. *Eualus subtilis* Carvacho & Olson, 1984. a, Third pereopod of male, lateral view; b, dactyl of third pereopod of male, lateral view; c, lateral view of male carapace; d, lateral view of female carapace; e, rostrum variation, female, lateral view; f, rostrum variation, female, lateral view.

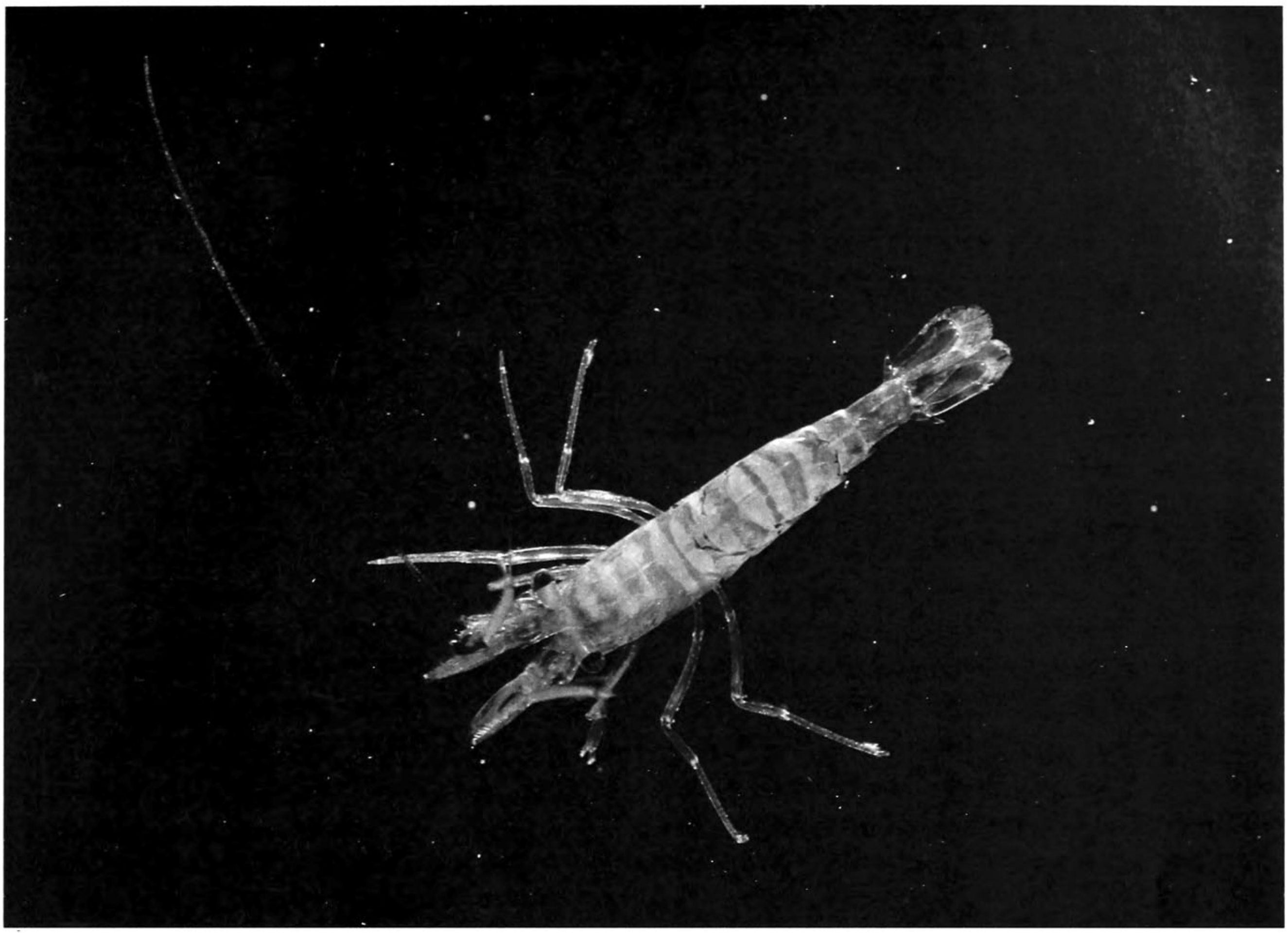

Fig. 5. *Eualus lineatus* Wicksten & Butler, 1984. Dorsal view of live specimen (male, 3.5 mm postorbital carapace length) showing pattern of broad orange bands.

120 m from Juneau, Alaska to at least Santa Cruz Island, California. This species may associate with sponges since the holotype was collected from "mud and sponge bottom," and the trawl collection records for the specimens examined often indicated that the shrimp were removed from sponge cavities, or noted the presence of sponges in the haul. The live specimen collected by one of us (GCJ) was found in a suction sampler that had been used in both crevices and small sponges on a vertical rock face, but it is not known at which point in the dive it was captured.

Given the confusion that has surrounded these species, any records should be considered suspect until the specimens have been reexamined. It is likely that at least some of the depth and range records will be revised, and perhaps new information on the habitat of *E. lineatus* will come to light.

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