

NOTES

STAGE I ZOEAE OF A CRANGONID SHRIMP, *CRANGON FRANCISCORUM ANGUSTIMANA*, HATCHED FROM OVIGEROUS FEMALES COLLECTED IN KACHEMAK BAY, ALASKA

Information on the larval stages of crangonid shrimp of the North Pacific Ocean is meager. Needler (1941) described the first zoeal stage of *Crangon septemspinosa* (as *Crago septemspinus* Say) hatched in the laboratory from ovigerous females and the remaining four zoeal stages from plankton collected near Prince Edward Island, Canada. Kurata (1964) described the larval stages of *C. affinis* de Haan and various larval stages of six unidentified *Crangon* spp. from Japanese waters. He obtained the first zoeal stage of *C. affinis* from known parentage, but the remaining stages were collected from plankton. Makarov (1967) briefly described larvae of *C. dalli* Rathbun and *C. septemspinosa* (Say) which were collected from plankton along the western Kamchatka shelf. He suggested that *C. dalli* was an analog of *C. allmani* Kinahan and *C. septemspinosa* was an analog of *C. crangon* (Linnaeus). *Crangon allmani* and *C. crangon* are eastern Atlantic species. He assumed that the *C. affinis* larvae described by Kurata (1964) were actually larvae of *C. septemspinosa*. Loveland (1968) described larvae of *C. alaskensis* Rathbun reared in the laboratory from females collected near Anacortes, Wash.

Morphology of Stage I larvae is closely related to Caridean development and can be used to estimate the number of larval stages, classify species, categorize larvae for identification purposes, and identify subsequent larval stages (Needler 1938; Pike and Williamson 1961, 1964; Kurata 1964; Ivanov 1971; and others). In this report I describe and illustrate the first zoeal stage of *C. franciscorum angustimana* Rathbun from ovigerous females and compare these zoeae with Stage I zoeae of crangonids described by other authors. Also, I show that the criterion of the absence of exopodites on the second pair of pereopods for distinguishing larvae of *Crangon* from other genera of the Crangonidae is invalid for Crangonidae of the North Pacific Ocean.

Methods

Ovigerous *C. franciscorum angustimana* were caught at 30 m (16 fathoms) in shrimp pots in early May 1976 in Kachemak Bay, Alaska. Four females were kept in seawater in a plastic bucket for about ½ h and then each female was put into a 4 l glass jar containing filtered, aerated seawater. The water was about 35‰ salinity, about 6°C, and was changed daily until zoeae were released, about 5 days later. Most zoeae were released at night. I did not determine whether the larvae were hatched as prezoae.

Terms used in the text, nomenclature of gills and appendages, and techniques of measurement and illustration are given by Haynes (1976). As an aid to the study of segmentation and setation, some larvae were cleared in 10% KOH and the exoskeleton stained with Turttox¹ CMC-S (acid fuchsin stain mountant). Only the left number is figured because the paired appendages of the larvae are symmetrical; except, the mandibles are drawn as a pair. There was no morphological variation, except variation in total length, among the zoeae used for the description.

Stage I Zoea

Mean total length of Stage I zoeae (Figure 1A) was 3.1 mm (range 2.8-3.3 mm; 10 specimens). Rostrum slender, spiniform, without teeth, about one-third length of carapace. Carapace with small rounded prominence near posterior margin. Two distinct denticles immediately posterior to pterygostomian spine; no supraorbital or antennal spines. Eyes sessile.

ANTENNULE (Figure 1B).—First antenna, or antennule, an unsegmented peduncle (inner flagellum) bearing a conical projection and a setulose spine. Conical projection bears a simple seta and three aesthetascs of about equal length.

ANTENNA (Figure 1C).—Consists of inner flagellum (endopodite) and outer antennal scale (exopodite). Flagellum unsegmented, slightly

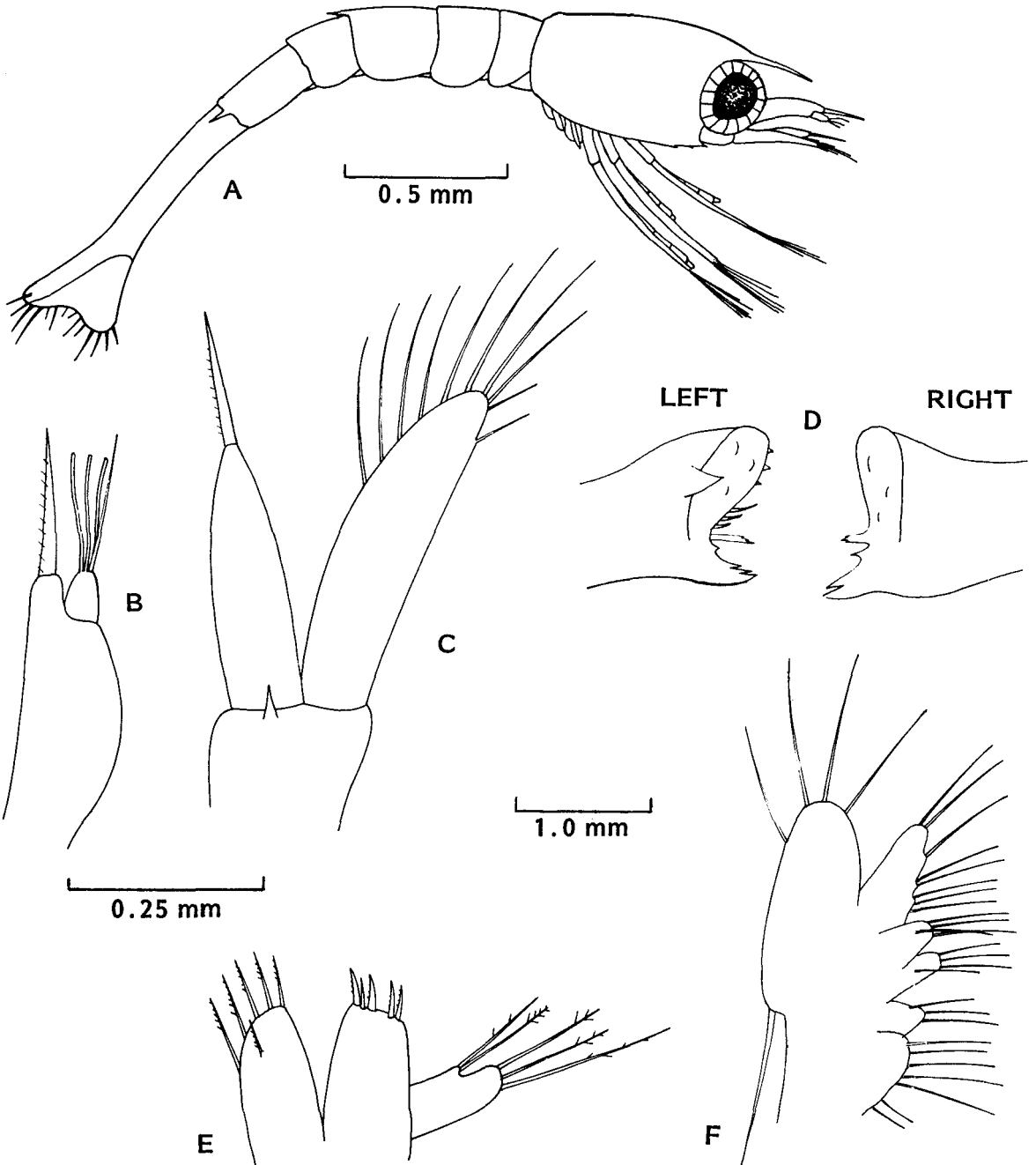
¹Reference to trade names does not imply endorsement by the National Marine Fisheries Service, NOAA.

shorter than scale, bears a setulose spine. Antennal scale not distally segmented, fringed with nine heavily plumose setae and subterminal plumose seta on outer margin. Protopodite bears spine at base of flagellum but not at base of scale.

MANDIBLES (Figure 1D).—Without palps; well developed. Incisor process of left mandible

bears three teeth in contrast to biserrate incisor process of right mandible. Left mandible bears a movable premolar denticle (lacinia mobilis) adjacent to incisor process and large subterminal tooth on truncated molar process.

MAXILLULE (Figure 1E).—First maxilla, or maxillule, bears coxal and basal endites and an



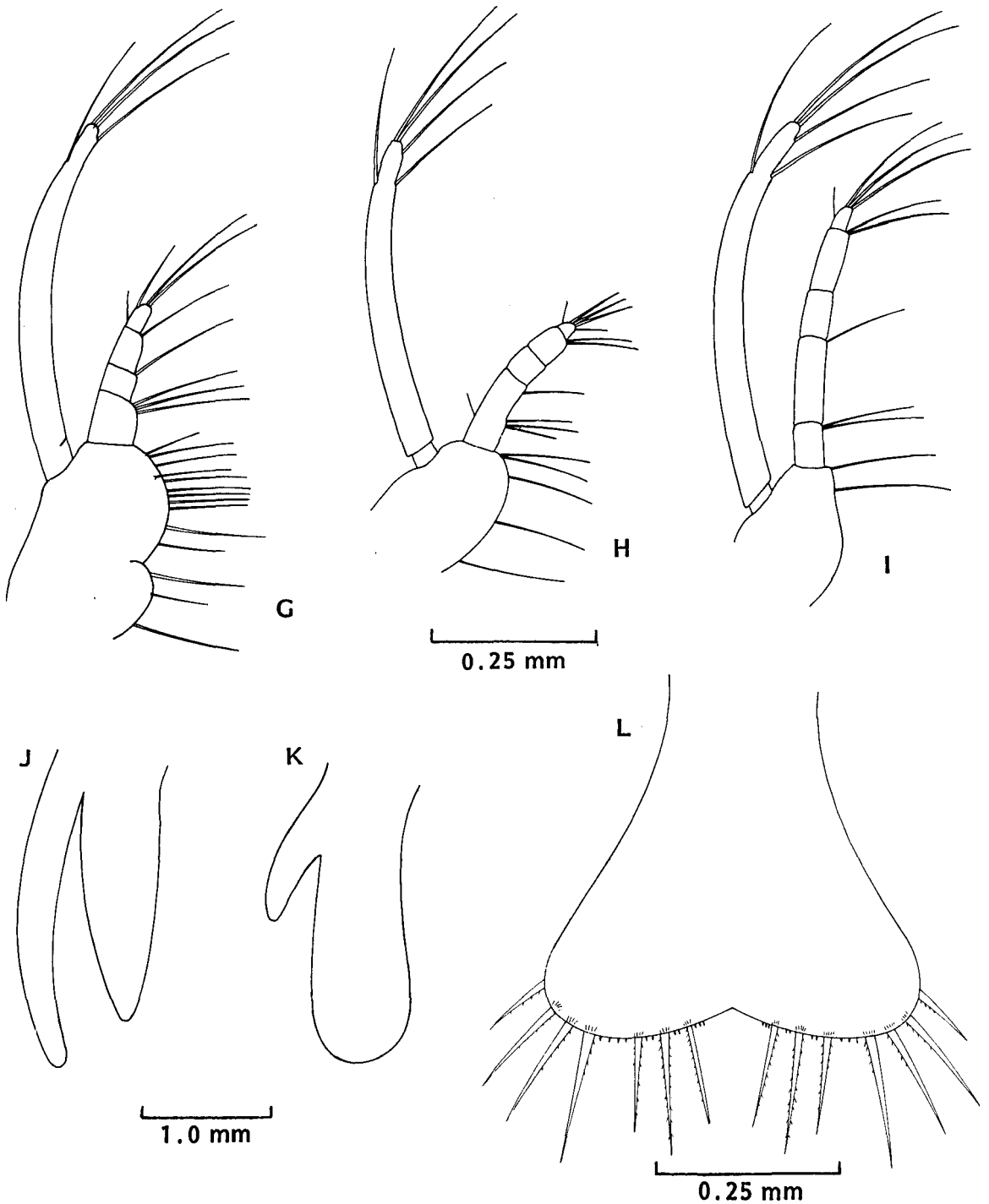


FIGURE 1. — Stage I zoeae of *Crangon franciscorum angustimana*: A, whole animal, right side; B, antennule, ventral; C, antenna, ventral; D, mandibles, left and right, posterior; E, maxillule, ventral; F, maxilla, dorsal; G, first maxilliped, dorsal; H, second maxilliped, dorsal; I, third maxilliped, dorsal; J, first pereopod, right side; K, second pereopod, right side; L, telson, dorsal. Setules on setae are omitted for clarity; spinulose setae are shown.

endopodite. Proximal lobe (coxopodite) bears six spinulose setae. Median lobe (basipodite) bears five spinulose spines terminally. Unsegmented endopodite originates from lateral margin of basipodite and bears three terminal and two subterminal spinulose setae. No outer seta on maxillule.

MAXILLA (Figure 1F).—Exopodite (scaphognathite) bears four long plumose setae and a proximal seta; proximal end not projected posteriorly. Endopodite unsegmented; bears eight setae. Both basipodite and coxopodite bilobed. Basipodite bears eight setae, four on each lobe. Coxopodite bears 10 setae, three on distal lobe and seven on proximal lobe. Most setae on basipodite and coxopodite spinulose.

FIRST MAXILLIPED (Figure 1G).—Unsegmented protopodite bilobed; bears 14 setae. Endopodite four-segmented; setation formula 4, 1, 1, 3. Exopodite bears four natatory setae. No epipodite.

SECOND MAXILLIPED (Figure 1H).—Unsegmented protopodite not lobed; bears five setae. Endopodite four-segmented; setation formula 5, 2, 0, 5. Exopodite bears five natatory setae.

THIRD MAXILLIPED (Figure 1I).—Unsegmented protopodite not lobed; bears two setae. Endopodite nearly as long as exopodite; five-segmented; setation formula 4, 2, 0, 1, 2. Exopodite bears five natatory setae.

PEREPODS (Figure 1J, K).—Only pairs one to four present; pairs one and two (Figure 1J, K) biramous, pairs three and four uniramous. All pereopods poorly developed, unsegmented, and compacted tightly under cephalothorax.

PLEOPODS.—Absent.

ABDOMEN AND TELSON (Figure 1A, L).—Abdomen consists of five somites (somite six is fused with telson in Stage I). Third somite bears a dorsal spine on posterior margin; fifth somite bears pair of spines on posterolateral margin that extend posteriorly about one-fourth length of fifth abdominal somite. Telson emarginated distally; bears 7 + 7 pairs of densely plumose setae. Minute spinules at base of each seta, except possibly last pair, and along posterior margin of telson to fourth setal pair and on setae themselves. No anal spine.

Comparisons of Zoal Stage I With Descriptions by Other Authors

Of the published descriptions of Stage I zoeae of *Crangon* spp. from the North Pacific Ocean, Stage

I zoeae of *C. franciscorum angustimana* are most similar to Stage I zoeae of *C. alaskensis*, *C. affinis*, *C. septemspinosa*, and Kurata's (1964) "Species A" and "Species D." These examples are characterized by a median dorsal spine on the posterior margin of the third abdominal somite and by posterolateral spines on the fifth abdominal somite.

Stage I zoeae of *C. alaskensis* can be distinguished from Stage I *C. franciscorum angustimana* by the rostrum and pereopods. In Stage I *C. alaskensis* the rostrum does not extend beyond the eyes and the pereopods are absent (Loveland 1968), but in Stage I *C. franciscorum angustimana* the rostrum extends beyond the eyes and the larvae bear undeveloped pereopods 1-4.

Stage I zoeae of *C. affinis* and "Species A" are distinguished from Stage I zoeae of *C. franciscorum angustimana* by the presence in Stage I zoeae of *C. affinis* and "Species A" of a shallow transverse groove in the carapace and two subterminal setae along the outer margin of the antennal scale. Also in Stage I *C. affinis* and "Species A," the endopodite of the third maxilliped is four segmented. In Stage I zoeae of *C. franciscorum angustimana*, the carapace does not have a shallow transverse groove; there is only one subterminal seta along the outer margin of the antennal scale; and the endopodite of the third maxilliped is five segmented.

Stage I zoeae of Kurata's "Species D" are distinguished from Stage I zoeae of *C. franciscorum angustimana* by the presence in Stage I zoeae of "Species D" of a five-segmented endopodite on the second maxilliped and pleopods that occur as distinct buds. In Stage I zoeae of *C. franciscorum angustimana*, the endopodite of the second maxilliped is four segmented and there are no pleopod buds.

Stage I zoeae of *C. septemspinosa* are like Stage I zoeae of *C. franciscorum angustimana* with some exceptions: the antennal scale of *C. septemspinosa* bears five plumose setae and the endopodite of the first maxilliped is unsegmented (Needler 1941); whereas, the antennal scale of *C. franciscorum angustimana* bears 10 plumose setae and the endopodite of the first maxilliped is four segmented.

Tesmer and Broad (1964) described nine zoal stages of *C. septemspinosa* reared in the laboratory from ovigerous females obtained off Beaufort, N.C. They found distinct morphological differences between their zoeae and zoeae of the same species as described by Needler, especially in the later stages. Based on Tesmer and Broad's descrip-

tion, Stage I zoeae of *C. septemspinosa* can be distinguished from Stage I zoeae of *C. franciscorum angustimana* by the exopodites of the maxillipeds. The exopodites of the maxillipeds are jointed in Stage I zoeae of *C. septemspinosa* and are not jointed in Stage I zoeae of *C. franciscorum angustimana*. Also, the fifth pair of telson spines are distinctly shorter than the fourth or sixth pair in *C. septemspinosa*; whereas, in my Stage I zoeae of *C. franciscorum angustimana*, the fifth pair of telson spines are about equal in length to the fourth and sixth pairs.

The occurrence in later zoeal stages of functional exopodites on the first pair of pereopods but not on pereopodal pairs 2-5 has been used as a criterion for distinguishing larvae of the genus *Crangon* from larvae of other genera of the family Crangonidae (Williamson 1960).

I found buds of exopodites on both the first and second pair of pereopods in Stage I zoeae of *C. franciscorum angustimana*. Assuming zoeae of *C. franciscorum angustimana* undergo typical development for crangonid larvae, these buds will become functional exopodites at Stage III or IV (Needler 1941; Kurata 1964; Makarov 1967). The criterion of the absence of exopodites on the second pair of pereopods for distinguishing larvae of *Crangon* from other genera of the Crangonidae, therefore, is invalid for the North Pacific Ocean. Unfortunately, larvae are described for only a few species of crangonids from the North Pacific Ocean, including the genus *Crangon*, and confirmation of the generic characteristics of the larvae is needed.

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LENGTH-WEIGHT RELATIONSHIPS OF WESTERN ATLANTIC BLUEFIN TUNA, *THUNNUS THYNNUS*¹

The Atlantic bluefin tuna, *Thunnus thynnus*, is seasonally distributed over most of the North Atlantic Ocean from Newfoundland to Brazil and from Norway to the Canary Islands (Gibbs and Collette 1967). There has been a great reduction in the Atlantic-wide catch (including Mediterranean) from 38,500 metric tons (t) in 1964 to 12,500 t in 1973 (Miyake et al. 1974). Because of this, a number of studies have been made and are being continued in order to understand the reason for this decline (Parks 1977; Shingu and Hisada 1977).

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