DESCRIPTIONS OF PREZOEAE AND STAGE I ZOEAE OF *CHIONOECETES BAIRDI* AND *C. OPILIO* (OXYRHYNCHA, OREGONIINAE)

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ABSTRACT

Prezoeae and stage I zoeae of *Chionoecetes bairdi* and *C. opilio* from larvae of known parentage are described. The prezoeae of the two species are essentially identical, and the stage I zoeae differ only in minor detail. The larvae are similar to others of the subfamily Oregoniinae but are separable from them by slight differences in morphology and size.

Snow crabs, genus *Chionoecetes*, are fished commercially in Bristol Bay, Alaska, by three nations—the United States, the Soviet Union, and Japan. Catches of snow crabs in Bristol Bay by all three nations have increased markedly in recent years and in 1970 totaled nearly 85 million pounds. Most of the catches consist of *C. bairdi* Rathbun, but some *C. opilio* (O. Fabricius) are caught also. In 1968 the National Marine Fisheries Service began an intensive investigation into the biology of the snow crabs in Bristol Bay, which includes studies on the early life history stages, especially larval distribution and abundance. Positive identification of larvae of *C. bairdi* and *C. opilio* is important in these studies.

The morphology of prezoeae and stage I zoeae of *C. bairdi* and *C. opilio* (subfamily Oregoniinae) from the Bering Sea are described in this report. The larval forms of the two species are so similar that only the larvae of *C. bairdi* are described in detail; for *C. opilio*, only those morphological features that differ from *C. bairdi* are described. Larvae of the two species from the Bering Sea are compared with larvae of the same subfamily from the North Pacific Ocean.

MATERIALS AND METHODS

During a National Marine Fisheries Service trawling survey for snow crabs in Bristol Bay in May 1970, I obtained two females of *C. bairdi* and two of *C. opilio* that were releasing larvae. The *C. bairdi* were caught May 9 in 55 fathoms at lat. 55°22'N, long. 164°35'W. Their carapace widths (greatest width excluding lateral spines) were 99 mm and 105 mm. One of the *C. opilio* (77-mm carapace width) was caught May 9 in 51 fathoms at lat. 55°40'N, long. 164°37'W, and the other (82-mm carapace width) was caught May 12 in 46 fathoms at lat. 56°01'N, long. 162°25'W. My identification of the two species is based on characters used by Garth (1958).

Larvae were obtained in the following manner. Each gravid female was kept in about 20 liters of filtered sea water with a temperature of about 2.5°C. Hatching began immediately, and the first samples, which consisted mostly of prezoeae, were taken after about 2 h. Other samples were collected about 24 h later, when most of the larvae had molted to stage I. Only prezoeae and stage I zoeae were obtained because it was not practical to keep the zoeae alive at sea long enough to allow molting to the next zoeal stage. The larvae were preserved in a 5% solution of Formalin[2] and sea water.

Drawings of whole animals and appendages (Figures 1 and 2) were made from preserved specimens cleared in lactic acid; the illustrations were prepared with the aid of a camera

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lucida. The left appendage is shown in the figures. When setae were plumose, the fact is noted in the text but is not always shown in the drawings; this omission made it possible to show other details. At least 10 specimens each of prezoeae and stage I zoeae of *C. bairdi* and *C. opilio* were dissected and studied in detail with respect to appendage setation and other characteristics.

An ocular micrometer was used to measure the following body dimensions of the larvae: Carapace length—straight-line distance from posterior margin of orbit to middorsal posterior margin of carapace; dorsal-rostral length—straight-line distance from tip of dorsal spine to tip of rostral spine; width between tips of lateral spines of carapace—horizontal straight-line distance between tips of spines; total body length—distance from tip of rostrum to posterior margin of telson, not including telson spines (except in prezoeae, in which it is distance from folded rostrum to posterior margin of telson). Total body length is difficult to measure accurately in preserved larvae because the abdomen is generally flexed beneath the carapace; the measurement therefore requires the summation of several straight-line measurements or chords of the arch formed by the dorsal margin of the body.

Nomenclature of the larval appendages follows that of Gurney (1942). The setation formula of the endopodite is the number of setae per segment from the distal to the proximal segment.

DESCRIPTION OF LARVAL STAGES

Chionoecetes bairdi

Prezoeae (Figure 1a)

Cuticle of antennules, antennae, and telson delicately plumed. Antennule (Figure 1b) has two projections, one appreciably shorter than the other; shorter projection nonpulmose. Exopodite of antenna (Figure 1c) has four plumose projections; endopodite has a simple nonplumose projection, no projection arising from area of rudimentary flagellum. Endopodites and exopodites of first maxilliped (Figure 1d) and second maxilliped (Figure 1e) consist of simple sheaths. Telson (Figure 1f) has seven projections on each side; following Lebour (1928), these are numbered from the inside 1 to 7; fourth projection short and nonplumose and covers spine that in zoea forms tip of telson fork; seventh projection also nonplumose but may occasionally have a few hairs.

The average carapace length (50 specimens) is 0.39 mm (range 0.32 to 0.46 mm) and the average total body length is 2.48 mm (range 2.22 to 2.80 mm).

Stage I Zoeae

General shape (Figure 2a, b) characteristic of larvae of subfamily Oregoniinae. All spines well developed and armed with fine spinules on at least the distal half of their length. Dorsal and rostral spines long, tapering, and usually slightly "s" shaped; dorsal spine slightly longer than rostral. Lateral spines large; at right angles to carapace and curved downward slightly. Eyestalks short, not articulated, and each bears a minute protuberance about midway between eye and carapace. Carapace has slight medial crest with noticeable hump on front of head. Distinct protuberance on carapace posterior to dorsal spine. A minute hair on each side of carapace between lateral spine and base of dorsal spine. Total of six setae along posterior edge of carapace all arising from inner side of carapace; posterior three setae longer and stouter than anterior three setae. Lateral margin of carapace strongly indented just posterior to eye.

The averages for the following measurements (50 specimens) are: carapace length 0.54 mm (range 0.45 to 0.73 mm); dorsal-rostral length 4.17 mm (range 3.96 to 4.55 mm); width between tips of lateral spines 2.73 mm (range 2.52 to 2.97 mm); and total body length 5.15 mm (range 4.96 to 5.60 mm).

ANTENNULE (FIGURE 2c).—Antennule conical and uniramous, with five terminal processes—three long aesthetes and two shorter setae; two aesthetes about equal in length, but third only slightly longer than longest setae.

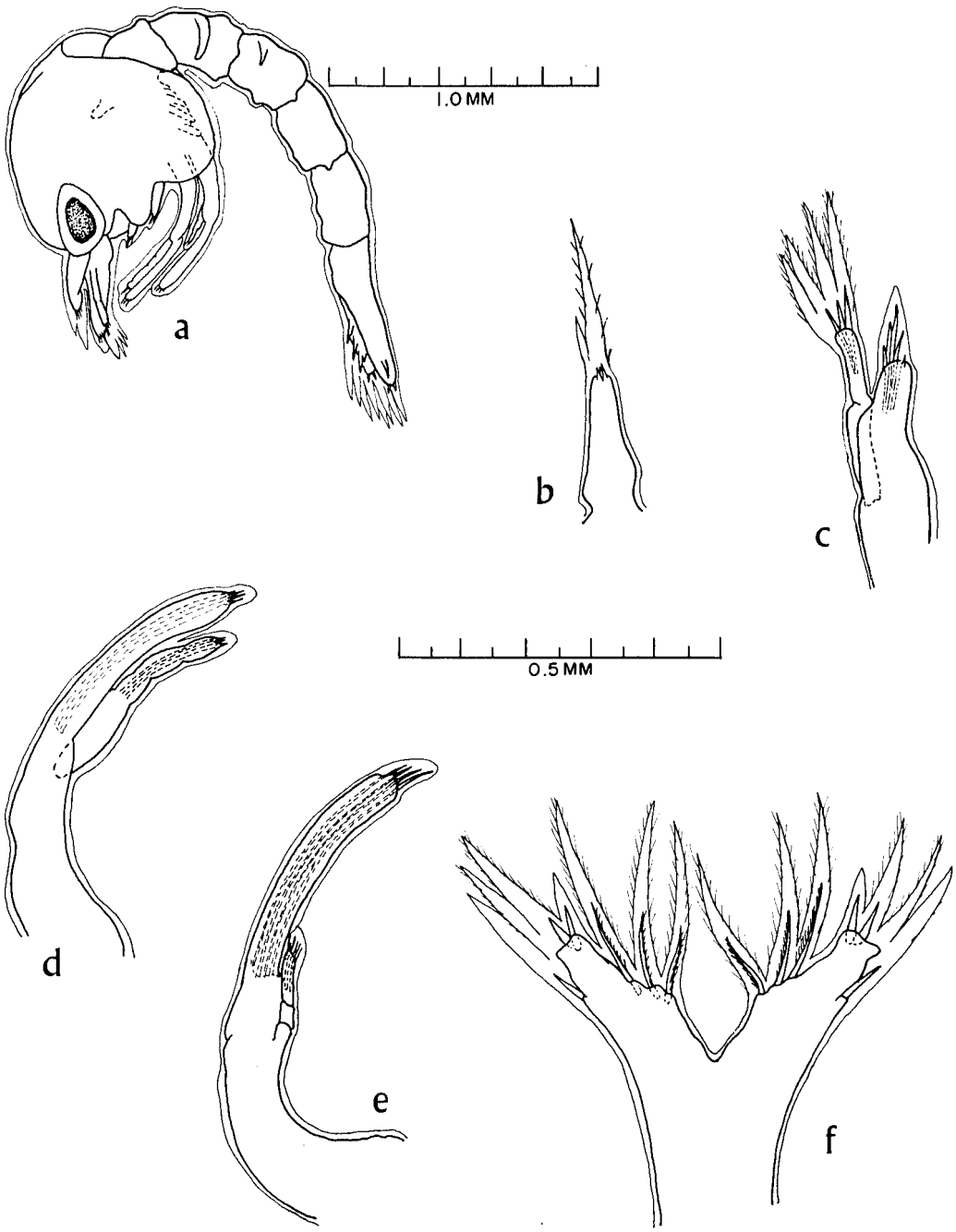

FIGURE 1.—(a) Prezoea of *Chionoecetes bairdi*, (b) antennule, (c) antenna, (d) first maxilliped, (e) second maxilliped, (f) telson.

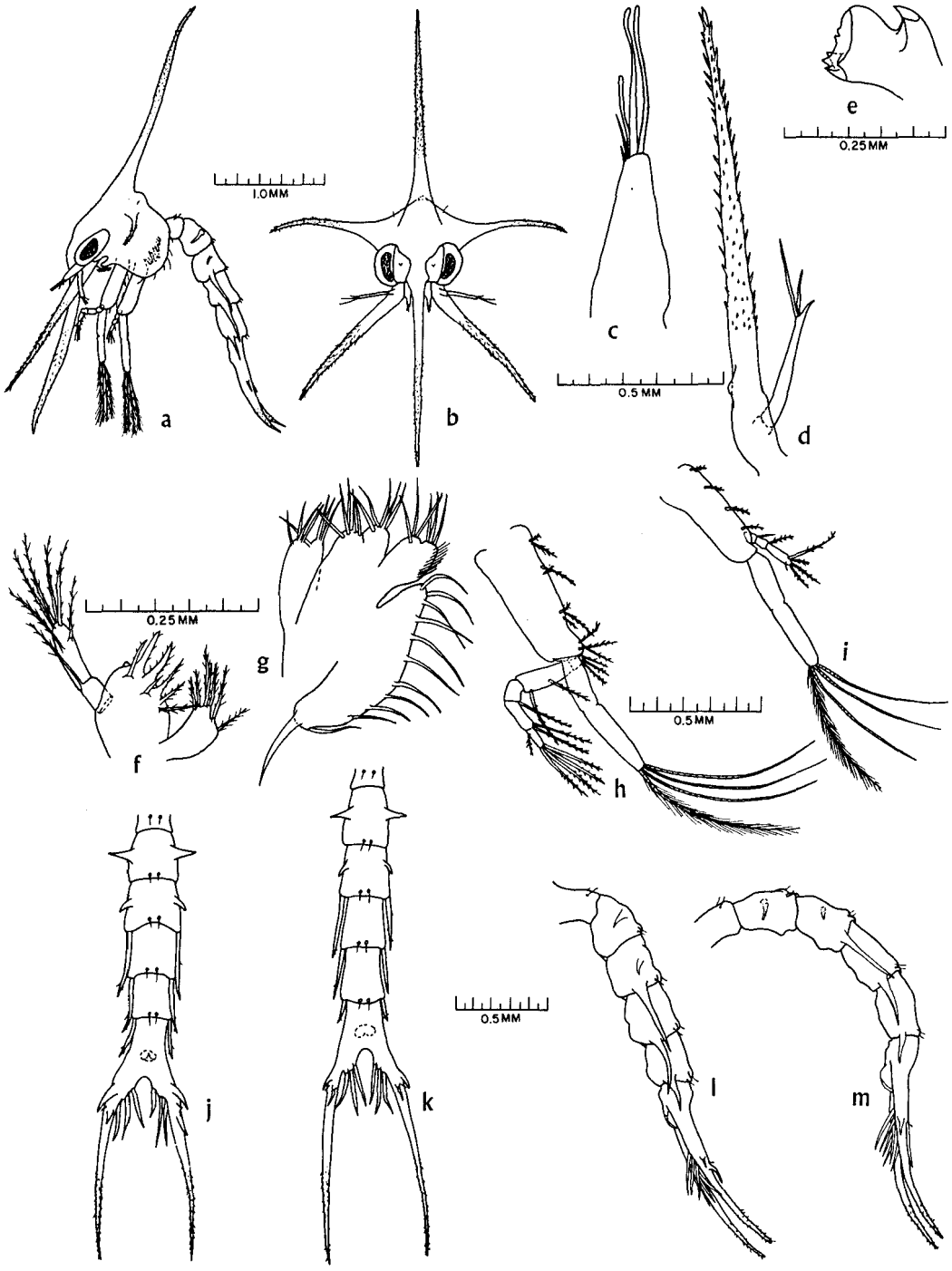

FIGURE 2.—Stage I zoea of *Chionoecetes bairdi* and two views of abdomen of *C. opilio* for comparison: (a) lateral view, (b) anterior view, (c) antennule, (d) antenna, (e) mandible, (f) maxillule, (g) maxilla, (h) first maxilliped, (i) second maxilliped, (j) abdomen (dorsal)—*C. bairdi*, (k) abdomen (dorsal)—*C. opilio*, (l) abdomen (lateral)—*C. bairdi*, (m) abdomen (lateral)—*C. opilio*.

ANTENNA (FIGURE 2d).—Protopodite (spinous process) of antenna elongate; slightly shorter than rostral spine and armed with numerous sharp spinules that increase in size distally. Exopodite slender; less than one-half length of protopodite; two setae near sharp tip, each with two rows of many fine setules. Endopodite (flagellum) rudimentary (represented by small protuberance near proximal end of protopodite).

MANDIBLES (FIGURE 2e).—Mandibles without palps. Incisor composed of two large pointed processes. A subterminal denticle that arises from ventral side of mandible occurs on molar process of right mandible but not on left mandible.

MAXILLULE (FIGURE 2f).—Endopodite two segmented, with six setae on terminal segment (arranged in pairs, one pair being terminal) and one seta on distal end of basal segment. Basal endite bears seven setae at distal end (two setae are especially stout). A bluntly pointed projection one-eighth the height of nearest seta occurs between basal endite setae and endopodite. Coxal endite bears seven setae at distal end. All setae on maxillule plumose.

MAXILLA (FIGURE 2g).—Maxilla bears large platelike exopodite (scaphognathite) with 11 (rarely 12) long, evenly spaced plumose setae along outer margin and one longer and thicker seta at proximal end. Endopodite only slightly bifurcate; bears many fine hairs along outer margin and three setae on each lobe. There are two endites, both slightly bifurcate; basal endite (distal) has five setae on each lobe, and coxal endite (proximal) has four setae on each lobe. All setae sparsely plumose except those on exopodite, which are heavily plumose.

FIRST MAXILLIPED (FIGURE 2h).—Exopodite appears to have two segments but segmentation not complete; four heavily plumose segmented (natatory) setae on distal end. Endopodite five segmented—setation formula is 5, 2, 1, 2, 3. Basis has 10 setae along posterior edge—setation formula is 3, 3, 2, 2. All setae except natatory setae sparsely plumose.

SECOND MAXILLIPED (FIGURE 2i). — Exopodite not completely segmented; four long, heavily plumose segmented (natatory) setae on distal end. Endopodite three segmented—setation formula is 5, 1, 1. Basis has four setae along posterior edge. All setae except natatory setae sparsely plumose.

THIRD MAXILLIPED (FIGURE 2a). — Developing third maxilliped small, rudimentary, and nonsegmented; tip bilobed.

PEREIOPODS (FIGURE 2a).—Five developing pereiopods beneath carapace; they are small, rudimentary, and not segmented or bilobed.

ABDOMEN AND TELSON (FIGURE 2j, l).—Abdomen consists of five segments and telson (somite six is fused with telson in stage I). Each segment has pair of hairs near dorsal posterior margin; second and third segments both have pair of slightly curved lateral knobs —pair on third segment about half the length of pair on second; pairs of long well-developed spines, which become progressively shorter posteriorly, on posterior lateral margin of third, fourth, and fifth segments; those on third and fourth segments extend beyond posterior margins of adjacent segments; those on fifth segment extend posteriorly to level of anus; lateral spines may or may not have few minute hairs. Telson bifurcate; furcations long, slender, and finely spinulate and have upcurved tips; each furcation bears three articulated telson setae on inner side, a prominent spine laterally on outer margin, a smaller dorsal spine posterior to telson setae, and a minute spinule[3] about midway between the lateral and dorsal spines; lateral and dorsal spines on furcations minutely spinulate. Each telson seta bears two rows of spinules, and each row has two types of spinules. First type short but wide at base, resembling row of

[3] The spinule was first described by Kurata (1963) for *C. o. elongatus* and is best seen in stained specimens under high (400X) magnification.

"teeth"; second type small and hairlike; first type extends about three-fourths the length of the seta and decreases in size proximally; second type covers distal one-fourth of seta; spinules in both rows fit this description, although those on one row are considerably smaller than those on the other. Pleopods and uropods developing, but not evident at this stage.

Chionoecetes opilio

Prezoeae of *C. opilio* are identical in all respects to those of *C. bairdi*. Stage I zoeae are identical except for a few subtle differences in abdominal morphology. The most obvious difference is in the length of the posterior lateral spines on the third and fourth abdominal segments. In *C. bairdi* (Figure 2j, l), the spines overlap the adjacent segments by about one-third the length of the spines. In *C. opilio* (Figure 2k, m), the spines on third segment barely extend past the posterior margin of the fourth segment, and those on the fourth segment do not quite reach the posterior margin of the fifth segment. Another, but small, difference is the thickness and shape of the abdomen. In *C. bairdi* the abdomen appears slightly deeper than in *C. opilio*, especially in the areas of the developing pleopods. Finally, the telson furcations of *C. opilio* are about one-sixth longer than those of *C. bairdi*. This last difference may be difficult to distinguish clearly because the degree of curvature of the furcations may vary considerably among specimens of both species.

COMPARISON OF NORTH PACIFIC ZOEAE OF THE SUBFAMILY OREGONIINAE

The subfamily Oregoniinae comprises three genera, *Oregonia*, *Hyas*, and *Chionoecetes* (Garth, 1958). Zoeae of only a few species of the Oregoniinae that occur in the North Pacific are known. Hart (1960) reared and described the zoeae of *O. gracilis* and *H. lyratus* and showed that they were separable from each other by slight differences in size, color, and spinulation. Aikawa (1937) and Kon (1967) described prezoeae and Kurata (1963) described the first zoeal stage of *C. o. elongatus*, all from specimens of known parentage. Kurata also described zoeal stages of *H. coarctatus alutaceus*, but the specimens were obtained from the plankton. In the following discussion, I compare the morphology of the first zoeal stages of *C. bairdi* and *C. opilio* with the first zoeal stages of each of the species mentioned above, emphasizing the differences among them.

Kon's (1967) prezoeae of *C. o. elongatus* were nearly identical to my prezoeae of *C. bairdi* and *C. opilio* except that he described the short embryonic spine of the antennule as plumose, whereas I did not. Aikawa's (1937) prezoeae differed in several respects from mine and from Kon's: his specimens did not have an embryonic cuticle; the appendages and carapace spines were partially or fully extended; and a lateral knob was present only on the second abdominal somite. Apparently, Aikawa described a prezoea that had just cast its embryonic cuticle and was in the process of metamorphosing to stage I.

The stage I zoeae of *C. o. elongatus* described by Kurata (1963) differed slightly from my stage I zoeae of *C. bairdi* and *C. opilio*: the lateral knobs on the third abdominal segment of Kurata's stage I zoeae almost reached the posterior margin of the segment, but in my larvae they were considerably shorter. Also, in Kurata's specimens the posterior lateral spines on the abdomen were covered with spinules, whereas I found only one or two minute spinules on the lateral spines. Finally, the maxilla of Kurata's larvae had 15 setae along the outer margin of the exopodite in addition to the single stout seta at the proximal end; the larvae I studied had only 11 setae (rarely 12) along the outer margin in addition to the stout setae. This last difference may include phenotypic variation. J. Watson of the Fisheries Research Board of Canada (pers. comm.) has informed me that *C. opilio* in Atlantic waters have 12 (rarely 13) setae in addition to the stout seta. Unfortunately, Kurata did not mention whether any variation of the number of setae on the exopodite of the maxilla occurred in his specimens.

A comparison of Hart's (1960) specimens of *O. gracilis* and *H. lyratus* with my specimens of *C. bairdi* and *C. opilio* shows that morpho-

logical differences among the zoeae were slight. The most obvious difference was size—my stage I zoeae were nearly twice as large as Hart's stage I zoeae. Another difference is the morphology of the antennule: According to Hart (1960) zoeae of *O. gracilis* and *H. lyratus* had two aesthetes and one seta (although in specimens of *O. gracilis* sent me by Hart, the antennule had two setae instead of one), whereas in *C. bairdi* and *C. opilio* the antennule had three aesthetes and two setae. A third difference was the length of the posterior lateral spines: In stage I *C. bairdi* and *H. lyratus*, the spines extended beyond the posterior margin of the adjacent segment about one-third the length of the spine, but in *C. opilio* and *O. gracilis* they barely reached the posterior margin of the adjacent segment. In addition to the above differences, Hart did not describe the protuberances on the eyestalks or the minute spinule located between the dorsal and lateral spines on the telson furcations; on the specimens sent me by Hart, I found no minute protuberances on the eyestalks but did find the minute spinule.

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