

DESCRIPTION OF LARVAE OF THE GOLDEN KING CRAB, *LITHODES AEQUISPINA*, REARED IN THE LABORATORY

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ABSTRACT

Larvae of golden king crab, *Lithodes aequispina*, were reared in the laboratory from Stage I through Stage V (glaucothoe). Each of the five larval stages is described and illustrated. Zoeae of *L. aequispina* are distinguished from zoeae of *L. maja* and *L. antarctica* by the number of telsonic setae and the length of the posterolateral spines on somites 2-5. The glaucothoe of *L. aequispina* are distinguished from glaucothoe of *L. maja* and *L. antarctica* by the terminal configuration of the carapace spines. Zoeae of *L. aequispina* are distinguished from zoeae of *Paralithodes* spp. by number of telsonic setae and by setation of the antennal flagellum. Morphological differences between larvae of Lithodidae and Paguridae are greater than previously believed.

Information on the larval stages of the genus *Lithodes* is meager—only the larvae of *Lithodes maja* (Linnaeus) from the North Atlantic Ocean and larvae of *L. antarctica* (Jacquinot) from the South Pacific Ocean have been described (Sars 1890; MacDonald et al. 1957; Campodonico 1971). In this paper, I describe larvae of the golden king crab, *L. aequispina* (Benedict), from the North Pacific Ocean and compare them with larvae of *L. maja*, *L. antarctica*, and *Paralithodes* spp., and with larvae of the subfamily Pagurinae (family Paguridae).

METHODS

An ovigerous *L. aequispina* releasing larvae was collected from waters of southeastern Alaska (lat. 58°41.5'N, long. 135°05'W) during a National Marine Fisheries Service trawling survey. The specimen was caught 9 March 1979 at 292 m. Bottom water temperature was 2.3°C. The female was placed in about 2,500 l of filtered seawater at 2.3°C. Hatching resumed immediately, and the first samples were taken about 10 min later. No prezoae were seen. The samples were preserved in a 5% solution of Formalin² and seawater.

About 4 h after hatching, 10 larvae were transferred to each of 30 250 ml jars containing about 200 ml of filtered seawater at 6.8°C. The jars were checked daily for exuviae, and a few larvae

were preserved every other day. The individuals and cast skins of various stages provided a continuous sequence of stages. Seawater in the holding containers was changed every other day, and the larvae were fed plankton daily that was strained through a 0.333 mm mesh. The density of food was controlled only to the extent that a few food items remained in the container at the end of each feeding period.

Terminology, methods of measuring, techniques of illustration, and nomenclature of appendages follow Haynes (1973, 1976). Setation formulae are the number of setae per segment from the distal segment to the proximal segment. For clarity in the illustrations, setules on setae are usually omitted, but spinulose setae are shown. A minimum of five larvae of each stage was used to verify segmentation and setation.

Only those morphological characteristics useful for readily identifying each stage are given.

STAGE I ZOEAE

Mean total length of Stage I zoeae (Fig. 1A), 7.3 mm (range 6.8-7.7 mm, 20 specimens). No chromatophores; internal thoracic area orange—coloration same throughout all larval stages. Rostrum slightly sinuate, without teeth, about three-fourths length of carapace. Posterolateral spines on carapace. Eyes sessile.

Antennule (Fig. 1B).—First antenna, or antennule, with unsegmented, tubular basal portion (peduncle) and two distal, conical projections.

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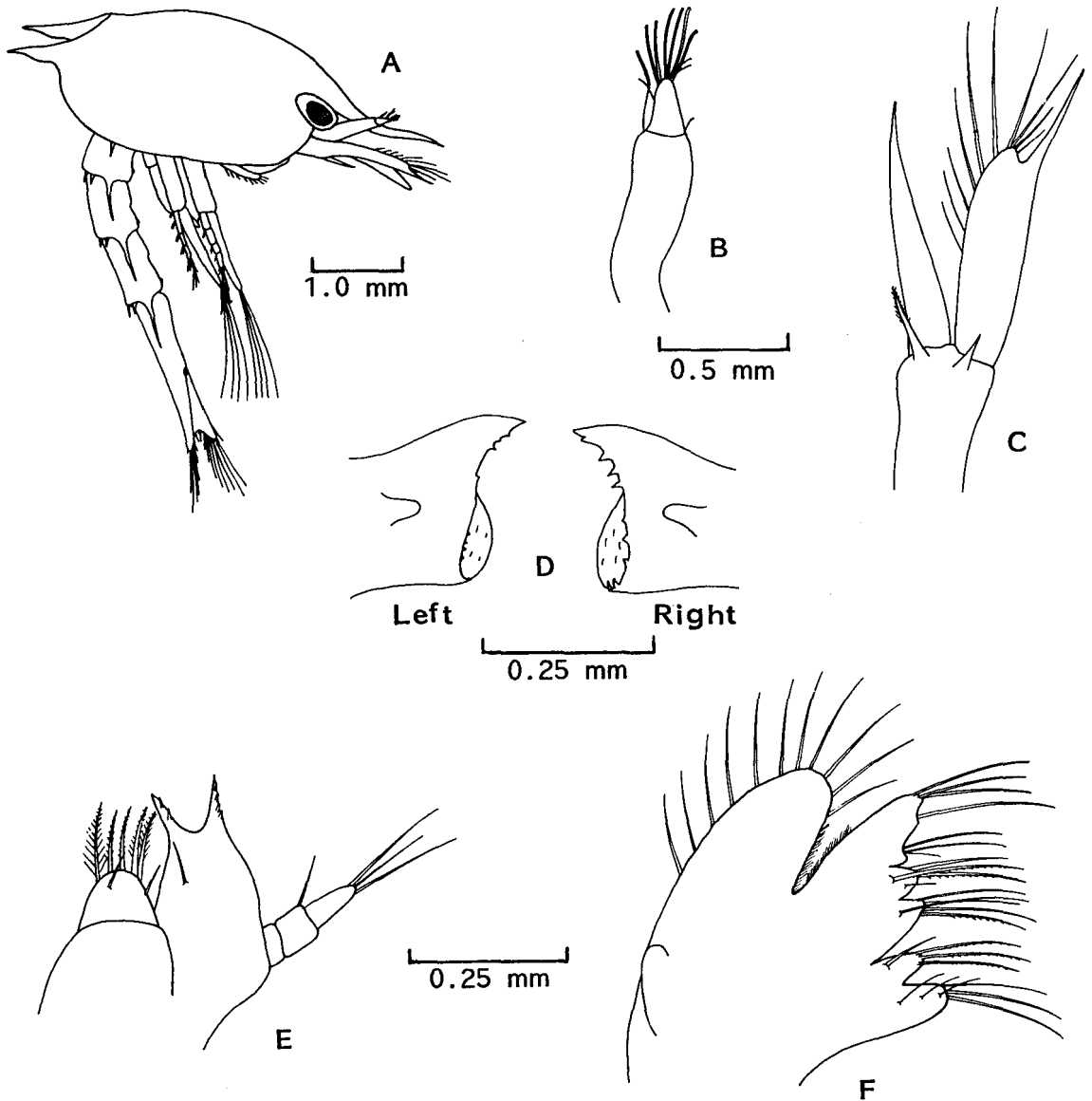


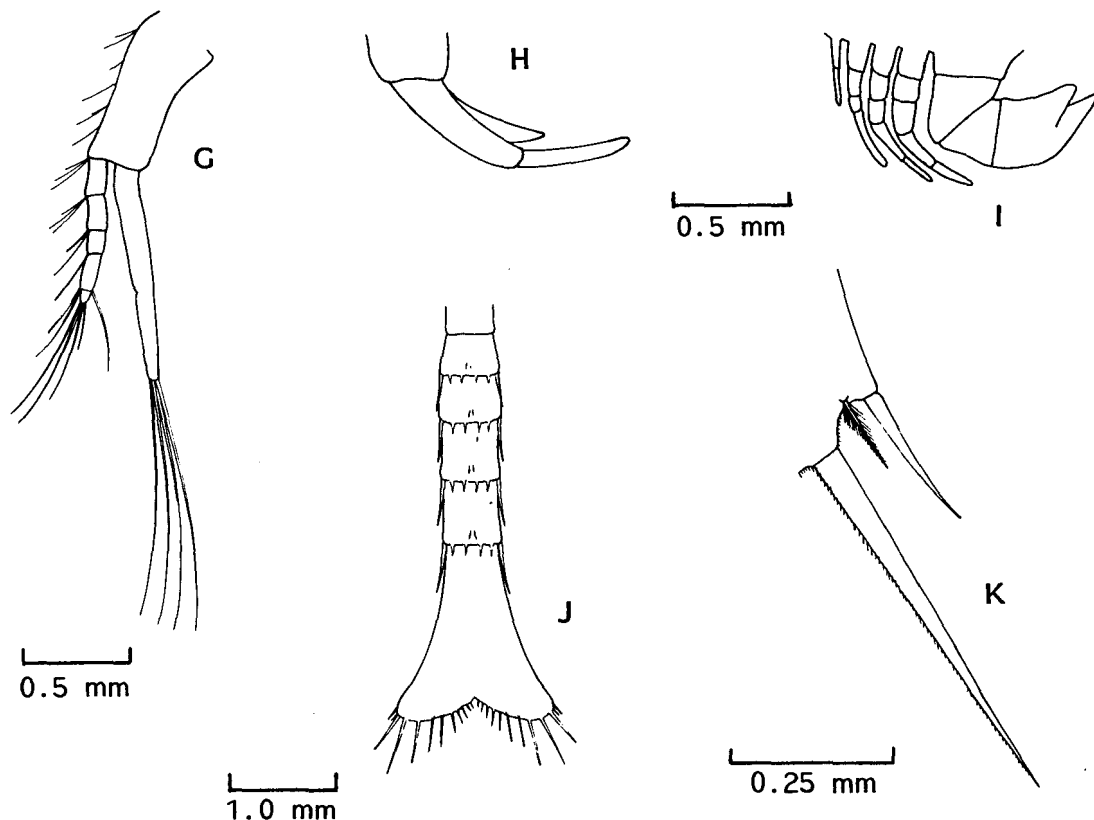
FIGURE 1.—Stage I zoea of *Lithodes aequispina*: A, whole animal, right side; B, antennule, dorsal; C, antenna, ventral; D, mandibles (left and right); E, maxillule, ventral; F, maxilla, dorsal; G, first maxilliped, lateral; H, third maxilliped, lateral; I, pereopods 1-5,

Peduncle with simple seta terminally. Larger projection with two aesthetascs subterminally, four aesthetascs and two simple setae terminally. Smaller projection with aesthetasc and simple seta terminally.

Antenna (Fig. 1C).—Second antenna (antenna) with inner flagellum (endopodite) and outer antennal scale (exopodite). Naked flagellum unsegmented, slightly shorter than scale (scale length includes spine). Antennal scale unjointed

distally, fringed with 10 heavily plumose setae along terminal and inner margins; prominent spine distally on outer margin. Ventral surface of protopodite with spinulose spine at base of flagellum, naked spine at base of scale. Shape and spination of protopodite same as in later zoeal stages except fewer spinules on spinulose spine.

Mandibles (Fig. 1D).—With unsegmented palps in all larval stages. Incisor process of left man-



lateral; J, abdomen and telson, dorsal; K, minute seta of telson, ventral.

dible a tooth; right mandible with diserrate incisor process. Anterior margins of each mandible with three or four small teeth between incisor and molar processes. Neither mandible with subterminal tooth on molar process in any larval stage.

Maxillule (Fig. 1E).—First maxilla (maxillule) with coxal endites, basial endites, and endopodite. Coxopodite (proximal lobe) two-segmented, distal segment with plumose seta and six spines: four spines spinulose, two simple. Basipodite (median lobe) with two spinulose spines terminally, simple seta subterminally. Endopodite originates from lateral margin of basipodite. Endopodite three-segmented with three setae terminally and one seta distally on second segment.

Maxilla (Fig. 1F).—Second maxilla (maxilla) with platelike exopodite (scaphognathite). Exopodite with 11 long, evenly spaced plumose setae along outer margin. Future location of proximal expansion indicated by small lobe. Endopodites

unsegmented in all larval stages; in Stage I, setation formula of endopodite 3, 1, 3. Basipodite and coxopodite bilobed. Basipodite with four setae on distal lobe, five setae on proximal lobe; coxopodite with four setae on distal lobe, six setae on proximal lobe.

First maxilliped (Fig. 1G).—Most heavily setose of natatory appendages. Unsegmented protopodite with 10 setae. Endopodite distinctly five-segmented; setation formula 4, 3, 1, 2, 3. Exopodite a partially segmented long, slender ramus with four terminal natatory setae.

Second maxilliped.—Essentially same as first maxilliped except endopodite four-segmented.

Third maxilliped (Fig. 1H).—Endopodite and exopodite undeveloped, naked; exopodite two-segmented.

Pereopods (Fig. 1I).—Poorly developed, without exopodites in all larval stages; segmentation may be indistinct.

Pleopods (Fig. 1A).—Absent on first somite in all larval stages; in Stage I, present on somites 2-5 as distinct buds. Pleopod 6 absent until Stage III.

Abdomen and telson (Fig. 1A, J).—Abdomen with five somites and telson (somite 6 fused with telson until Stage IV). Somites 2-5 with pair of posterolateral spines, four short spines along posterior margin, pair of hairs near dorsoposterior margin. Telson slightly emarginate posteriorly, with 11 + 11 (rarely 10 + 11) densely plumose setae. Ninth pair of setae on telson longest, almost one-third telson width. All setae jointed with the telson except ninth pair; ninth pair fused with telson. Minute plumose seta between setal pairs 10 and 11 (Fig. 1K). Except outer pair of setae, setae with setules. Setules along terminal margin between bases of setae. Without uropods in all larval stages. Anal spine absent in all larval stages.

STAGE II ZOEAE

Mean total length of Stage II zoeae, 7.5 mm (range 7.0-8.0 mm, 10 specimens). Rostrum and carapace same shape as in Stage I. Eyes stalked.

Antennule (Fig. 2A).—Large plumose seta and three small simple setae at distal joint of unsegmented peduncle.

Antenna (Fig. 2B).—Two-segmented flagellum extends slightly beyond plumose setae of scale. Antennal scale with 9 (rarely 10) heavily plumose setae along terminal and inner margins.

Mandibles.—Essentially same as in Stage I except with a few more teeth along anterior margin and palp slightly larger.

Maxillule.—Same as in Stage I except tip of basipodite somewhat more rounded.

Maxilla.—Scaphognathite (Fig. 2C) with 20 (sometimes 21) plumose setae along inner and outer margins; proximal expansion distinct, naked. Endopodite, basipodite, or coxopodite same as in Stage I except coxopodite occasionally with five setae on proximal lobe.

Maxillipeds.—Similar to Stage I maxillipeds, but exopodites of maxillipeds two-segmented; pairs 1, 2, and 3 with 9, 9, and 8 natatory setae, respectively.

Pereopods (Fig. 2D, pereopod 1).—Chelae of pereopod 1 similar to pereopod 1 of adult but without spines, setae, or teeth. Pereopods 2-5 same as in Stage I except longer and pereopod 5 four-segmented.

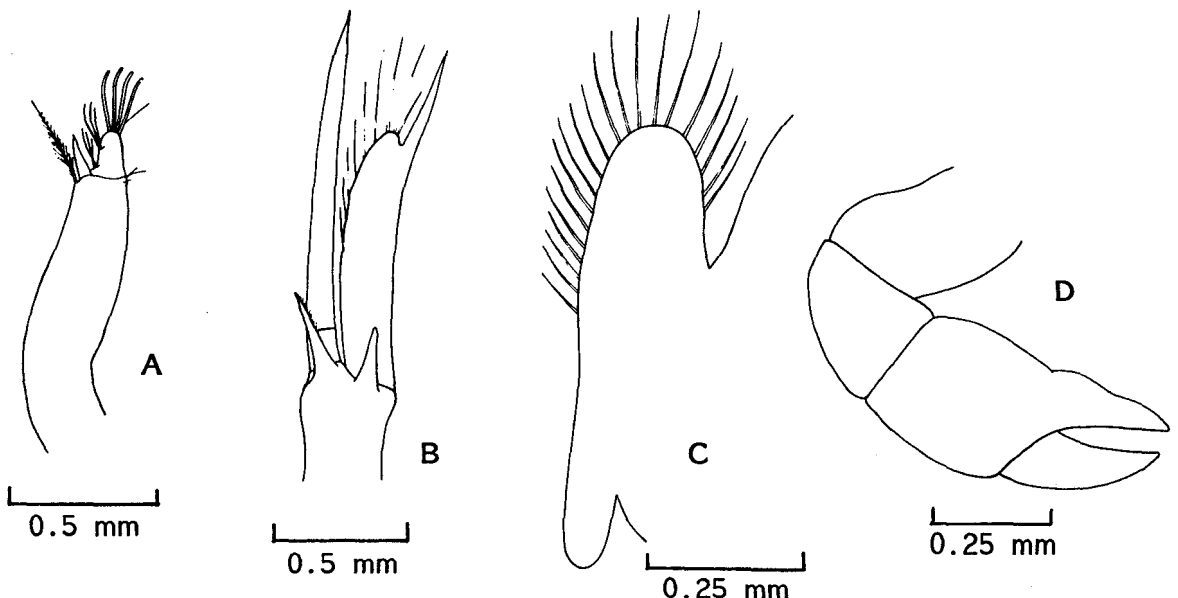


FIGURE 2.—Stage II zoea of *Lithodes aequispina*: A, antennule, dorsal; B, antenna, ventral; C, maxilla (scaphognathite), dorsal; D, pereopod 1, lateral.

Pleopods.—Pleopods 2-5 bilobed, unsegmented, without setae, about one-third height of somites.

Abdomen and telson.—Abdomen same shape and spination as in Stage I. In Stages II-IV, telson with 12 + 12 (rarely 11 + 12) densely plumose setae; tenth setal pair longest (about one-fourth telson width), fused with telson. Telson fused with somite 6.

STAGE III ZOEAE

Mean total length of Stage III zoeae, 7.6 mm (range 7.4-8.4 mm, 10 specimens). Rostrum (Fig. 3A) more styliform than in Stages I and II, about

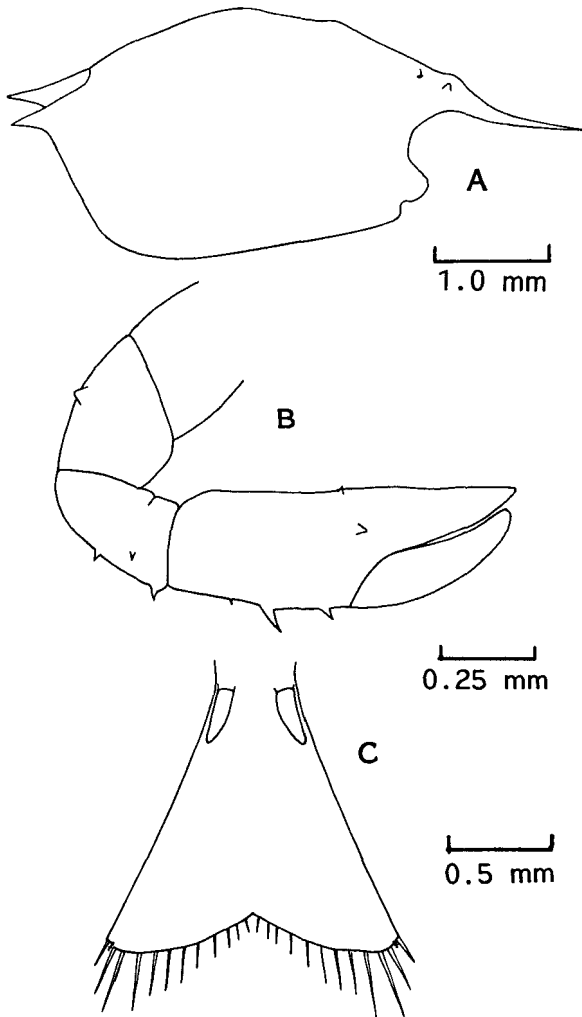


FIGURE 3.—Stage III zoea of *Lithodes aequispina*: A, carapace, lateral; B, pereopod 1, lateral; C, telson, ventral.

one-half carapace length, with short spine and minute hair at base. Lateral margin of carapace indented just posterior to eye.

Antennule.—Inner projection and peduncle two-segmented; outer projection three-segmented.

Antenna.—Inner flagellum of antenna five-segmented; terminal segment with four or five simple setae and small, distinct spine at tip.

Mandibles.—Essentially same as in Stage II.

Maxillule.—Basipodite with two or three additional short, blunt spines compared with Stages I and II.

Maxilla.—Scaphognathite with 23 plumose setae along inner and outer margins; naked proximal expansion slightly longer than in Stage II.

Maxillipeds.—Essentially identical to Stage II maxillipeds except naked endopodite of third maxilliped five-segmented; exopodite with nine natatory setae.

Pereopods (Fig. 3B, pereopod 1).—Essentially identical to Stage II except chelae of pereopod 1 slightly narrower than in Stage II; protopodite usually with five spines.

Pleopods.—Lengths of pleopods 2-5 about equal to heights of somites; pleopod 6 small, nonfunctional.

Telson (Fig. 3C).—With 11 + 11 plumose setae (rarely 11 + 12).

STAGE IV ZOEAE

Mean total length of Stage IV zoeae, 6.8 mm (range 6.3-7.4 mm, six specimens). Rostrum (Fig. 4A) about four-tenths carapace length. Carapace markedly more spiny than in Stage III.

Antennule.—Outer projection four-segmented, with about 14 aesthetascs; distal and penultimate segments each with long seta and two short setae.

Antenna (Fig. 4B).—Antennal flagellum eight-segmented, about 1.3 times length of scale.

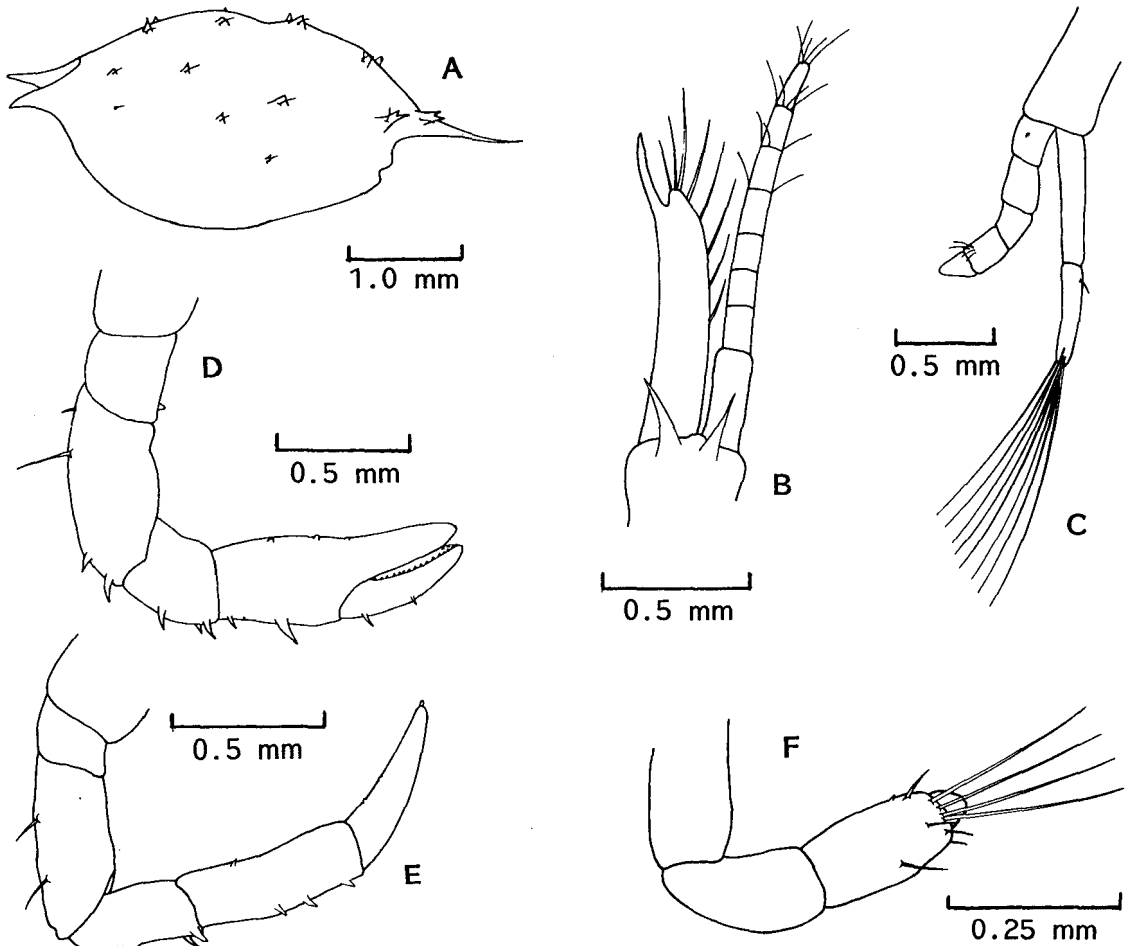


FIGURE 4.—Stage IV zoea of *Lithodes aequispina*: A, carapace, lateral; B, antenna, ventral; C, third maxilliped, lateral; D, pereopod 1, lateral; E, pereopod 2, lateral; F, pereopod 5 (terminal segments), lateral.

Terminal spine of antennal scale somewhat curved.

Maxillule and mandibles.—Essentially identical to Stage III.

Maxilla.—Scaphognathite with about 45 plumose setae along inner and outer margins.

Maxillipeds (Fig. 4C, third maxilliped).—No change in maxillipeds from Stage II except endopodite of third maxilliped with four simple setae on penultimate segment. Exopodite with eight or nine natatory setae.

Pereopods (Fig. 4D, pereopod 1; E, pereopod 2; F, pereopod 5).—Dactylopodite of chela of pereopod 1 with teeth. Pereopods 2-5 adult in shape. Propodite of pereopod 5 setose.

Pleopods.—Pleopods 2-5 about 1.4 times height of somites. Pleopods without setae; pleopod 6 unsegmented, about one-third length of telson, with two (sometimes three) short setae terminally.

Abdomen and telson.—Dorsoposterior spines on somites 2-5 reduced in size, often absent on somite 2. Telson jointed with somite 6; with 11 + 11 plumose setae (rarely 12 + 12).

STAGE V (GLAUCOTHOE)

Mean total length of Stage V larvae, 5.9 mm (range 5.2-6.3 mm, eight specimens). Glaucothoe characteristically spinous (Fig. 5A, J, K). Eye stalk with one anterior spine, three dorsal spines.

Antennule (Fig. 5B).—Adult in form.

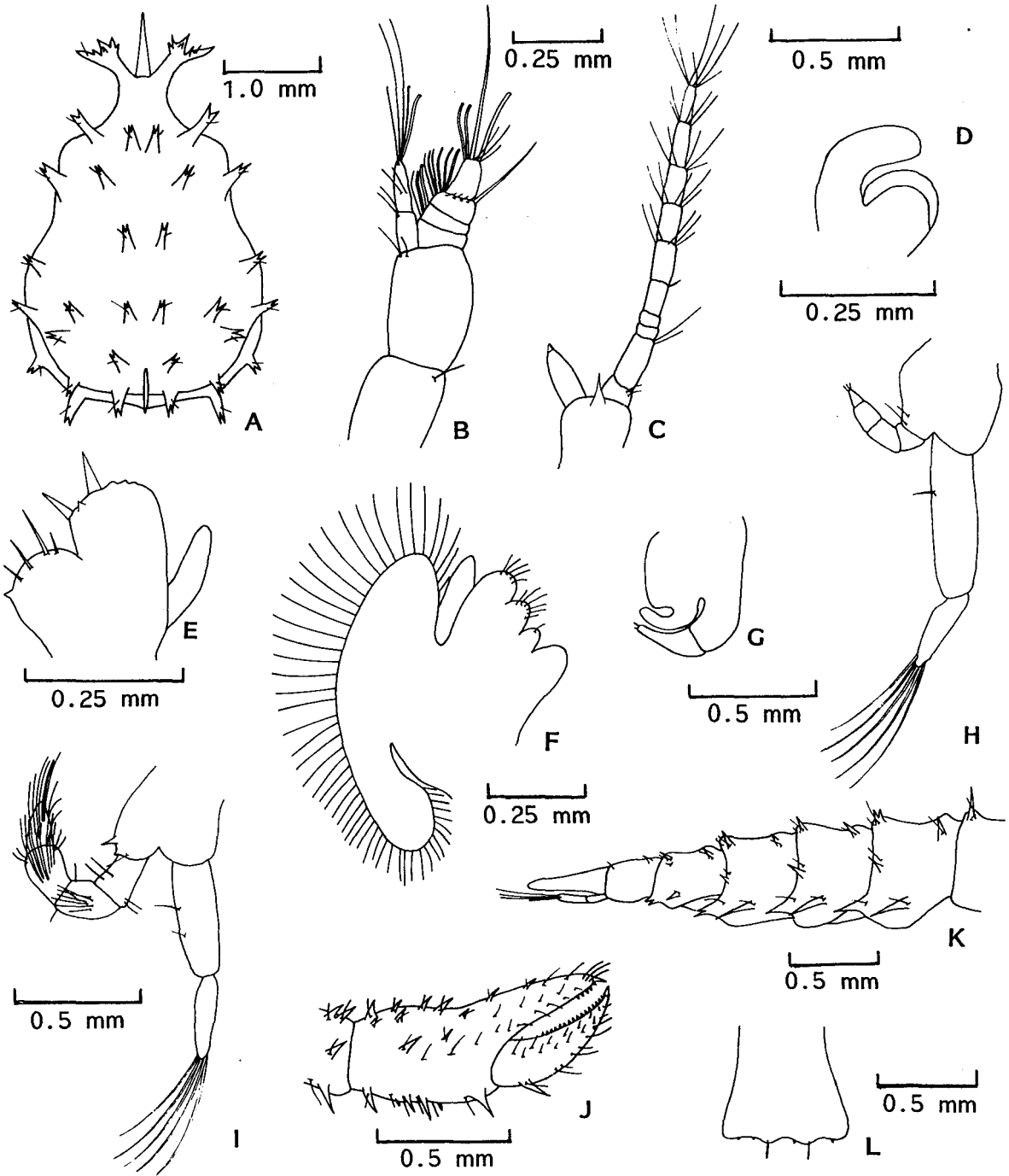


FIGURE 5.—Stage V (glaucothoe) of *Lithodes aequispina*: A, carapace, dorsal; B, antennule, dorsal; C, antenna, ventral; D, mandible (left), anterior; E, maxillule, ventral; F, maxilla, dorsal; G, first maxilliped, lateral; H, second maxilliped, lateral; I, third maxilliped, lateral; J, first maxilliped (chela), lateral; K, abdomen and telson, lateral; L, telson, dorsal.

Antenna (Fig. 5C).—Eleven-segmented flagellum more setose than in Stage IV. Scale a small

projection with short spine terminally. Proto-podite with spine ventrally.

Mandible (Fig. 5D).—Mandible grooved, without spines or teeth. Palp curved, naked.

Maxillule (Fig. 5E).—Coxopodite and basipodite more rounded than in zoeal stages. Coxopodite and naked endopodite unsegmented.

Maxilla (Fig. 5F).—Proximal expansion of scaphognathite somewhat bulbous. Endopodite without setae. Basipodite bilobed with five or six short setae on each lobe. Coxopodite bilobed with short seta on distal lobe.

First maxilliped (Fig. 5G).—Smaller, less developed than in zoeal stages. Endopodite and exopodite curved posteriorly; unsegmented endopodite without setae. Two-segmented exopodite with two minute spines at tip.

Second maxilliped (Fig. 5H).—Endopodite curved posteriorly, smaller and less developed than in Stage IV. Exopodite with five natatory setae.

Third maxilliped (Fig. 5I).—Posteriorly curved endopodite with numerous setae. Exopodite with five natatory setae.

Pereopods.—Chelae (Fig. 5J) of pereopod 1 typically adult, more spinous and setose than in Stage IV. Right chela slightly larger than left chela. Pereopods 2-4 typically adult in shape and spination. Pereopod 5 same as in Stage IV.

Pleopods.—Pleopods 2-5 setose, about 2.5 times height of somites. Endopodites with a few cincinnuli. Pleopod 6 with four setae terminally that extend considerably beyond telson.

Abdomen and telson (Fig. 5K, L).—Pair of dorso-posterior spines on somites 1-5. Somites 2-5 with pair of dorsoanterior spines and three pairs of posterolateral spines. Somite 6 with pair of dorsoanterior spines. All somites with hairs; one hair usually near each spine. Terminal margin of telson indented, with a few minute spines or setae.

COMPARISON OF LARVAL STAGES WITH DESCRIPTIONS BY OTHER AUTHORS

All the larval stages of *L. maja* have been described. MacDonald et al. (1957) described the

two zoeal stages and the glaucothoe; Sars (1890) described the prezoa, first zoeal stage (both obtained from known parentage), and last zoeal stage (obtained from plankton). (The term "intermediate stage" in Sars' figure legend refers to the first zoea [MacDonald et al. 1957].) Sars' figures of the prezoal telson and of Stage I are shown by Gurney (1942). The only other published description of *Lithodes* larvae known to me is that of *L. antarctica* larvae described from specimens reared in the laboratory (Campodonico 1971).

Larvae of *L. aequispina*, *L. antarctica*, and *L. maja* can be distinguished (see Table 1). In general, larvae of *L. maja* have fewer stages and are more developed for a given stage than larvae of *L. aequispina* and *L. antarctica*. In Stage I *L. maja*, the eyes are stalked, and the telson and somite 6 are jointed. In contrast, the eyes of *L. aequispina* and *L. antarctica* are not stalked until Stage II, and the telson and somite 6 are not jointed until Stage IV in *L. aequispina* and Stage

TABLE 1.—Morphological characteristics for distinguishing between larvae of *Lithodes aequispina*, *L. antarctica*, and *L. maja*. ? = no information available.

Characteristic	<i>L. aequispina</i>	<i>L. antarctica</i>	<i>L. maja</i>
No. of stages	5	4	3
Stage I:			
eyes	sessile	sessile	stalked
peduncle of antennule	unsegmented	partially segmented	3-segmented
antennal flagellum	unsegmented	partially segmented	5-segmented
telson and somite 6	not jointed	not jointed	jointed
pairs of telsonic setae ¹	11	9	8 or 9
longest pair of telsonic setae jointed with telson	no	yes	no
Stage II:			
peduncle of antennule	unsegmented	partially segmented	3-segmented
telson and somite 6	not jointed	not jointed	jointed
endopodite of third maxilliped	unsegmented	unsegmented	5-segmented
pleopods	uniramous buds	biramous	biramous
pairs of telsonic setae ¹	11	9	8 or 9
longest pair of telsonic setae jointed with telson	no	yes	no
Stage III:			
pairs of telsonic setae ¹	11	9	—
longest pair of telsonic setae jointed with telson	no	yes	—
Glaucothoe			
tips of spines on carapace	bifid	bifid	most single
spine on rostral complex	6 small spines terminally	3 small spines terminally	toothed spine bifid, no small spines terminally
natatory setae on exopodites of second and third maxillipeds	5, 5	7, 7	?

¹In addition to a minute setal pair.

III in *L. antarctica*. The peduncle of the antennule and endopodite of the third maxilliped of Stage II *L. maja* are segmented, but are unsegmented in Stage II *L. aequispina* and *L. antarctica*.

Among genera of the family Lithodidae, larvae of *L. aequispina* are most similar morphologically to larvae of the genus *Paralithodes*. Zoeae of *L. aequispina* can be readily distinguished from *Paralithodes* zoeae (Sato 1958) by the number of telsonic setae and by the setation of the antennal flagellum. In *L. aequispina* zoeae, the telson has 11 pairs of setae in all stages, and the antennal flagellum is setose beginning in Stage III; whereas, in *Paralithodes* zoeae, the telson has nine or fewer pairs of setae, and the antennal flagellum is naked. In the glaucothoe, the carapace spines of *L. aequispina* are markedly larger and more spinous than in the glaucothoe of *Paralithodes*.

Formerly, zoeae of the family Lithodidae were considered similar morphologically to those of the subfamily Pagurinae (family Paguridae), because zoeae of Lithodidae differ only in the reduction or disappearance of the uropods (Gurney 1942; MacDonald et al. 1957). Zoal development of *L. aequispina* and *L. antarctica* varies somewhat from the pattern of development of the other known larvae of the family Lithodidae, as summarized by Gurney and MacDonald et al. Zoeae of the Pagurinae have the following characteristics: the antennal flagellum has fewer than three setae in all stages; the telson has six pairs of setae in Stage I and seven pairs in Stages II-IV; and the exopodites of the maxillipeds have 7, 7, 6 setae in Stage II, 7 or 8 setae in Stage III, and 8 setae in Stage IV. Zoeae of *L. aequispina* have an

antennal flagellum that is setose beginning in Stage III; the telson has 11 pairs of setae in all stages; and the exopodites of the maxillipeds have 9, 9, and 8 setae in Stage II and 9, 9, and 9 setae in Stages III and IV. Zoeae of *L. antarctica* differ from zoeae of the Pagurinae by having in all zoal stages nine pairs of telsonic setae and eight setae on each exopodite of the maxillipeds. The glaucothoe of the Paguridae and Lithodidae are similar to the adults and, thus, readily distinguished from each other.

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