HOKKAIDO UNIVERSITY

Title	The Complete Larval Development of the Edible Crab, Cancer setosus Molina and Observations on the Prezoeal and First zoeal Stages of C. coronatus Molina (Decapoda: Brachyura, Cancridae) (With 19 Text-figures and 2 Tables)
Author(s)	QUINTANA, Rodolfo; SAELZER, Hugo
Citation	北海道大學理學部紀要, 24(4), 267-303
Issue Date	1986-10
Doc URL	http://hdl.handle.net/2115/27699
Type	bulletin (article)
File Information	24(4)_P267-303.pdf

Instructions for use

Hokkaido University Collection of Scholarly and Academic Papers : HUSCAP

The Complete Larval Development of the Edible Crab, *Cancer setosus* Molina and Observations on the Prezoeal and First zoeal Stages of *C. coronatus* Molina (Decapoda: Brachyura, Cancridae)

By

Rodolfo Quintana

Zoological Institute, Faculty of Science, Hokkaido University, Sapporo 060, Japan

and

Hugo Saelzer

Departamento de Oceanología, Universidad de Concepción, Casilla 2407, Concepción, Chile

(*With 19 Text-figures and 2 Tables*)

Introduction

Four cancrid species occur along the western coasts of South America. Their latitudinal distribution has been reviewed by Nations (1975), and more recently by Brattström and Johanssen (1983), indicating a more southerly distribution for three of these species along the Chilean coasts (Fig. 1). *Cancer setosus* Molina is a littoral species occurring from Guayaquil, Ecuador to Taitao, Chile in depths *ca* 45 m and *C. coronatus* Molina is distributed from Ancon, Peru to Picton Channel, Chile (Retamal, 1981; Brattström and Johanssen, *op. cit.*). Together with the third species, *C. edwardsi* Bell, *C. setosus* is also the object of local fisheries in coastal waters. The total landings for both species in 1985 were 3, 187 ton (439 for the VIII Region), indicating 15.3 per cent of total landings for edible crustacean in Chile.

Jour. Fac. Sci. Hokkaido Univ. Ser. VI, Zool. 24 (4): 267-303 (1986)

C. setosus is sold in local markets under the vernacular name of "jaiba peluda" (Hairy crab) and *C. edwardsi* as "marmola" (Dunce crab). In spite of their commercial interest, our knowledge of the larval development of these cancrids in still deficient. Fagetti (1960) described the first zoeal stage of *C. porteri* Rathbun, also inhabiting the Chilean coasts. Although the prezoeal stage has been described for three of these species, the complete larval development is known only for *C. edwardsi* (Quintana, 1983; 1984).

The present study deals with laboratory-reared larvae of *C. setosus* Molina

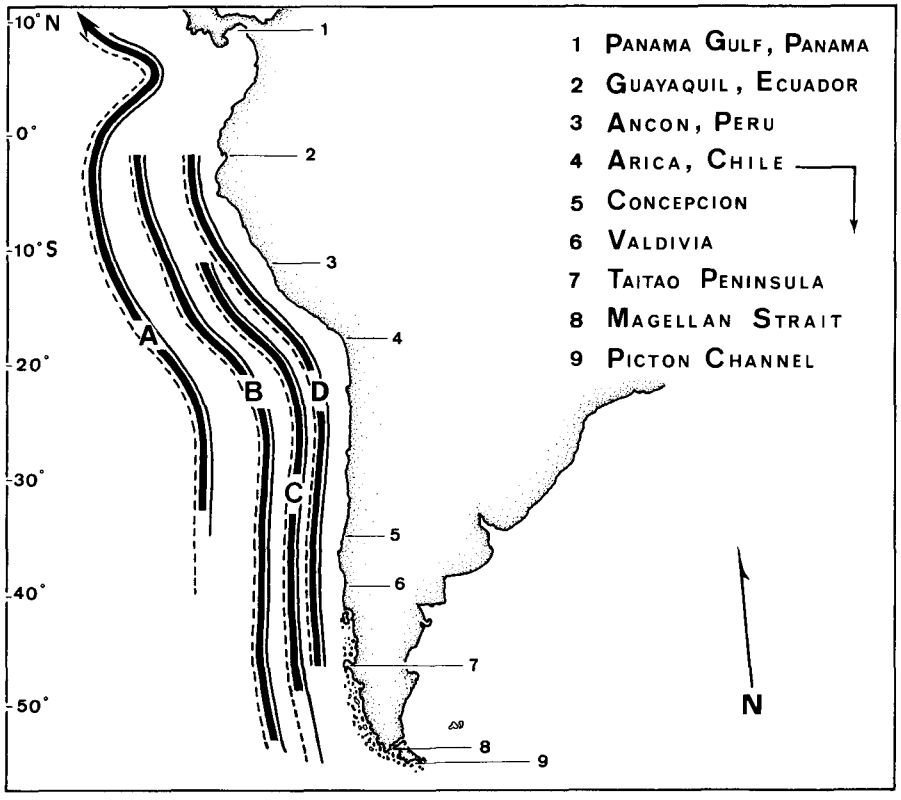

Fig. 1. Geographical distribution of *Cancer* species of Pacific coasts of South America. A, *C. porteri* Rathbun; B, *C. edwardsi* Bell; C, *C. coronatus* Molina; D, *C. setosus* Molina. Lines are indicative of latitudinal rather than longitudinal distribution. Numbers indicate nine localities of interest, listed on right side. After distributional ranges given by Nations, 1975 (wide, solid lines), Retamal, 1981 (fine, continue lines), and Brattström and Johanssen, 1983 (fine, dashed lines). The Chilean coast-line where these four *Cancer* species occur ranges between 18° and 55° S.

and *C. coronatus* Molina, the former comprising the first zoeal stage to the first crab stage, and being the first account of the development of this species. Scanning electronic microscope observations of the prezoea stage of *C. coronatus*, together with a detailed description of all appendages of the first zoeal stage also comprises the first larval account for this species. The present material is compared with other studies on congeneric species, and suggested grouping of all the known cancrid zoeae is also given.

Materials and Methods

Ovigerous females of *C. setosus* and *C. coronatus* were obtained by local fishermen and also by SCUBA diving on rocky bottoms off Coliumo Bay, Burca Point, Chile. The crabs were maintained in the laboratory until hatching. Rearing methods for larvae of these species were basically the same as described by Quintana (1983) for *C. edwardsi*. In November, 1980, during routine planktonic and epibenthic sampling on board the R/V "LUND", a number of cancrid megalopas were obtained alive off Coliumo Bay and transported to the laboratory in large tanks. After 2-3 days, two of these successfully moulted to first crabs which were identified as belonging to *C. setosus*. This material provides the descriptions of the megalopal stage because laboratory-reared larvae that reached fifth zoeal stage died while moulting to megalopa.

Recently, laboratory-reared material of *C. coronatus* and *C. setosus* were sent to one of us (R.Q.) for re-examination of all appendages of the first zoea, and also for SEM observations. Specimens of the prezoea and first zoea of the former species and of the first zoea of *C. setosus* were rinsed in distilled water and dehydrated through ethanol of increasing strengths. After critical point drying,

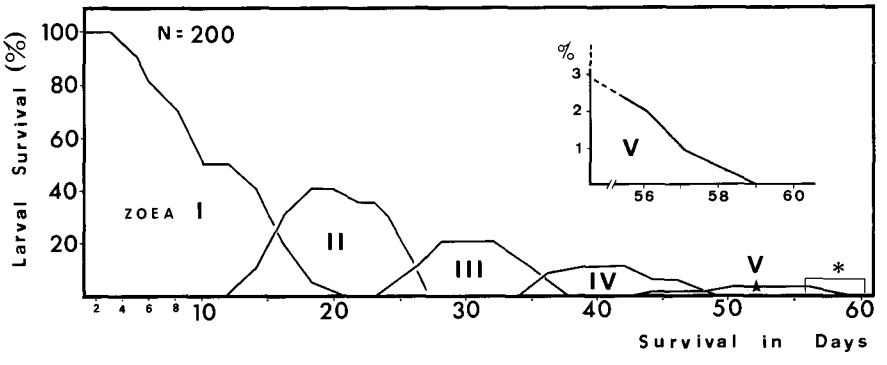

Fig. 2. Rearing results of larvae of *Cancer setosus*, at 13.5-14.6°C and 33.2 ppt salinity. Inset is an enlargement of survival curve for zoeae V during the period 56-60 days (indicated by an asterisk).

specimens were attached to metal stubs and sputter-coated with gold. Observations were made in a JEOL, JSM-T20 at gun potential of 20 kV.

Illustrations and measurements were made with the aid of a *camera lucida*. In the descriptions, setation is referred to from proximal to distal. The complete larval series is deposited in the Dichato Marine Biological Station, University of Concepción and duplicates of prezoeas and first zoeas are deposited in the Zoological Institute, Faculty of Science, Hokkaido University, Japan (ZIHU 385 and ZIHU 386).

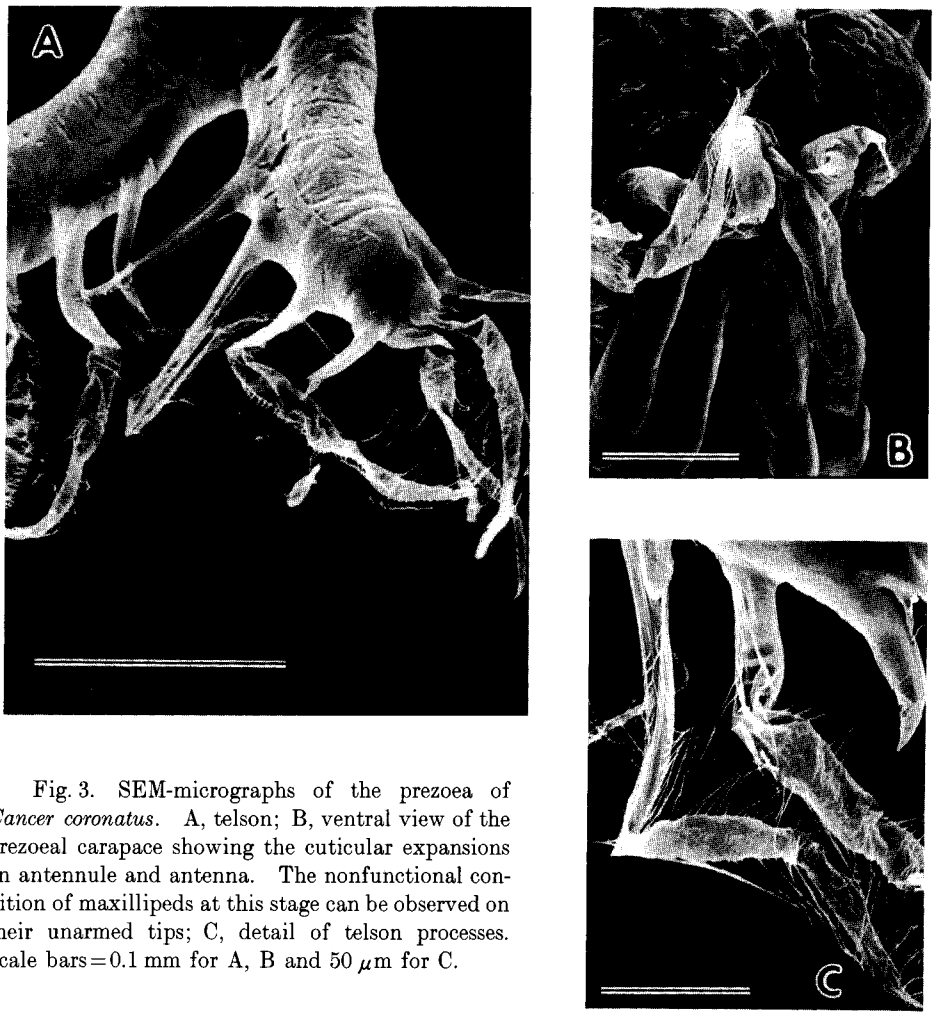

Fig. 3. SEM-micrographs of the prezoea of *Cancer coronatus*. A, telson; B, ventral view of the prezoeal carapace showing the cuticular expansions on antennule and antenna. The nonfunctional condition of maxillipeds at this stage can be observed on their unarmed tips; C, detail of telson processes. Scale bars = 0.1 mm for A, B and 50 μm for C.

Results

Rearing results

As in most *Cancer* species, *C. coronatus* and *C. setosus* normally hatch as a prezoea (a short-duration, non-planktonic stage), molting through five subsequent zoeal stages and one megalopal stage before reaching the first crab stage. Six zoeas of *C. setosus* successfully moulted to the fifth zoeal stage after 43 days (mean value), and the last two specimens died after 59 days of rearing without reaching the megalopal stage. Rearing results are summarized in Fig. 2.

Larval descriptions

With regard to the prezoeal stage, a recent account has been given by

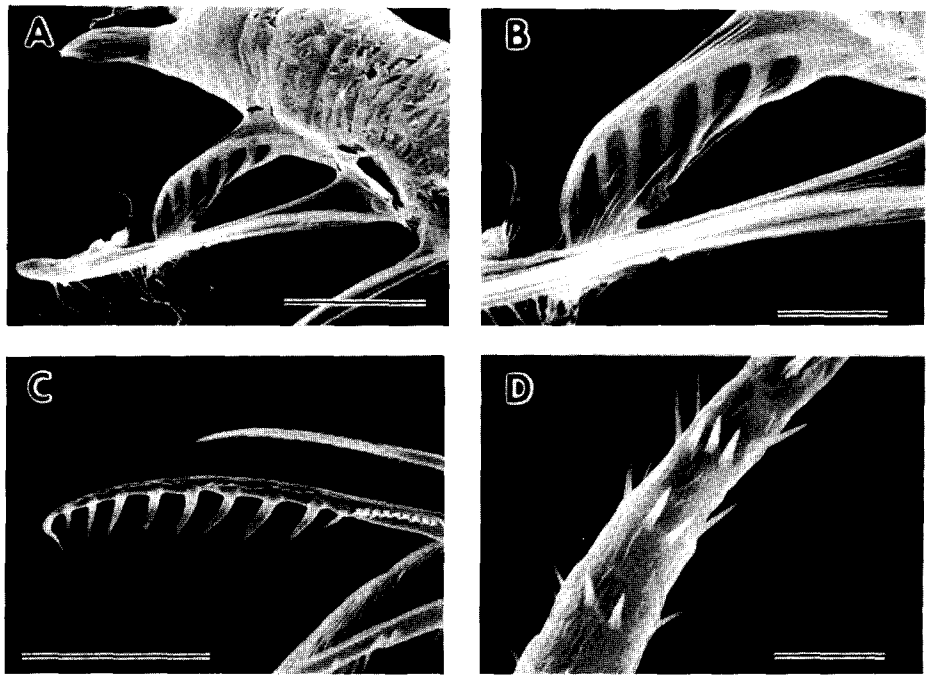

Fig. 4. SEM-micrographs of prezoea and first zoeal stages of *Cancer coronatus* (A-C) and *C. setosus* (D). A, telson processes of the prezoea; B, enlargement of cuticular sheaths of the prezoea, beneath which the zoeal pectinate seta can be observed (at SEM gun potential of 20 kV); C, the same seta, completely developed, after molting to the first zoeal stage; D, detail of medial portion of spinous process of antenna, first zoea. Scale = 20 μm for B, D and 50 μm for A, C.

Quintana (1984) for three *Cancer* species. However, new evidence of the prezoeal stage and the nature of the embryonic cuticle have been revealed by SEM observations (Figs. 3, 4). The cuticular expansions of the antennule, antenna and telson are long, very soft, delicate setose sheaths, making it difficult to resolve their structure by light microscopy, even by using methylene blue-stained specimens. The translucent structure of this fine membrane was resolved as high gun potential (Figs. 3C; 4A, B).

Cancer coronatus Molina, 1782

(Figs. 3-6, 9)

FIRST ZOEA

Length from tip of rostral spine to tip of dorsal spine, 1.83 mm.

Carapace (Figs. 5A, B): Rostral and dorsal spines well-developed, slightly curved and longer than the downturned laterals. Dorsomedian elevation prominent; cephalothorax smooth, 2 setae present near base of dorsal spine. SEM observations also revealed the presence of a more minute seta on inner base of each lateral spine, shown in Fig. 5B. Eyes not stalked.

Antennule (Fig. 5C): Unsegmented, uniramous, with 3 terminal aesthetascs and 1 fine seta.

Antenna (Fig. 5D): Protopod long, spinulate on distal half; exopod length, one-fourth of spinous process, and with 2 unequal terminal setae.

Mandible (Fig. 5E): Small (difficult to dissect), with incisor and molar processes developed; surface irregular.

Maxillule (Fig. 5F): Endopod 2-segmented, one long, plumodenticulate seta on proximal segment, distal segment with 2 subterminal and 4 terminal setae; basial endite with 4 serrate spines and 1 fine, plumodenticulate seta; coxal endite with 7 plumose setae.

Maxilla (Fig. 5G): Endopod bilobed, proximal with 3 setae, distal with 5 setae, arranged into two groups (2+3); basial and coxal endites also bilobed, with 5+4 and 3+3 setae respectively; scaphognathite with 4 finely plumose setae and a terminal plumose projection; endopod covered with fine setules on borders.

First maxilliped (Fig. 6C): Protopod with 9 or 10 setae along inner margin, arranged in groups of 2 or 3; endopod 5-segmented, with setal formula 3, 2, 1, 2, 4+1 setae; exopod 2-segmented, with 4 long, natatory, plumose terminal setae. Endopod slightly shorter than exopod.

Second maxilliped (Fig. 6D): Protopod with 4 inner marginal setae; endopod 3-segmented, setal formula 1, 1, 5; exopod 2-segmented, distal segment with 4 long, natatory, plumose terminal setae. Endopod similar to basial exopod segment in length.

Third maxilliped and ***pereiopods***: Not developed at this stage.

Abdomen (Figs. 5A, 6A): Five somites+telson; all except the first somite,

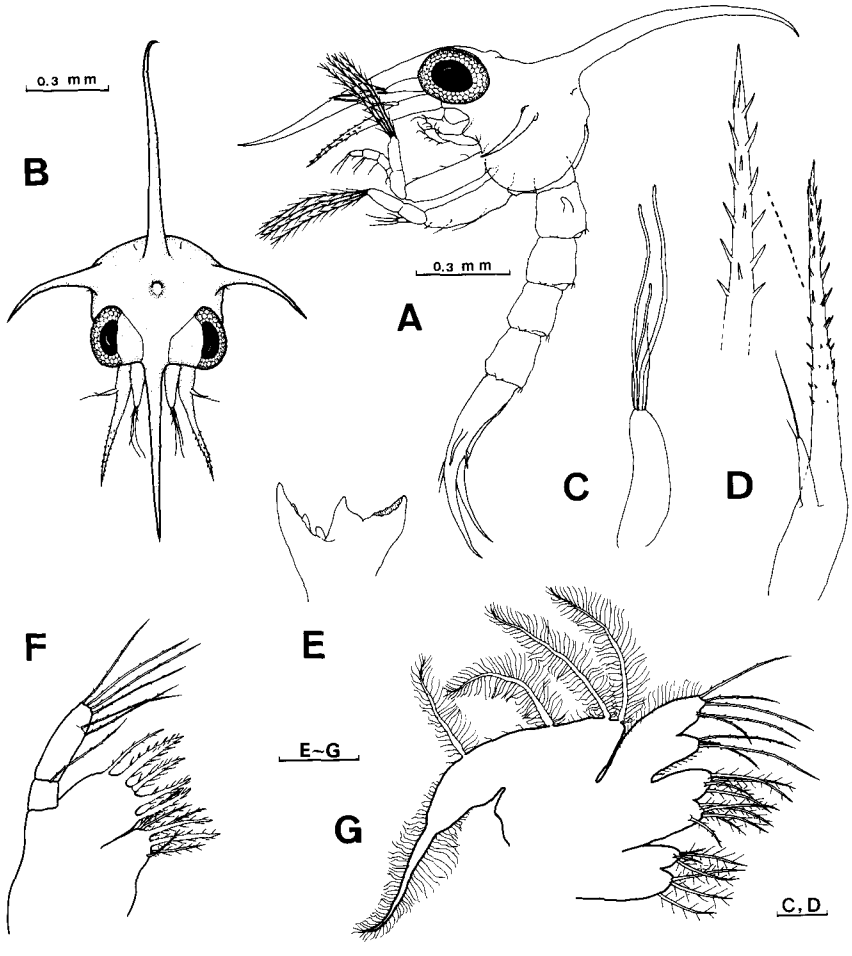

Fig. 5. *Cancer coronatus*, first zoea. A, lateral view; B, frontal view of carapace; C, antennule; D, antenna, with details of spinous process; E, mandible; F, maxillule; G, maxilla. Scale bars=50 μm, except for A and B.

with 2 minute dorsal setae; second somite with distinct lateral knobs, slightly directed upward; posterolateral margins of each abdominal somite project as incipient spines.

Telson (Figs. 6A, B; 9): Bifurcated, divergent posteriorly, recurved backwardly (as shown in Fig. 5A), furcae pointed terminally, each with a large, outwardly directed lateral spine and a shorter dorsal spine, medially placed on each furca; inner margin of furcae with 3 setae, the second of each series the longest and finely setulose, the outermost seta pectinate on inner distal margin, the

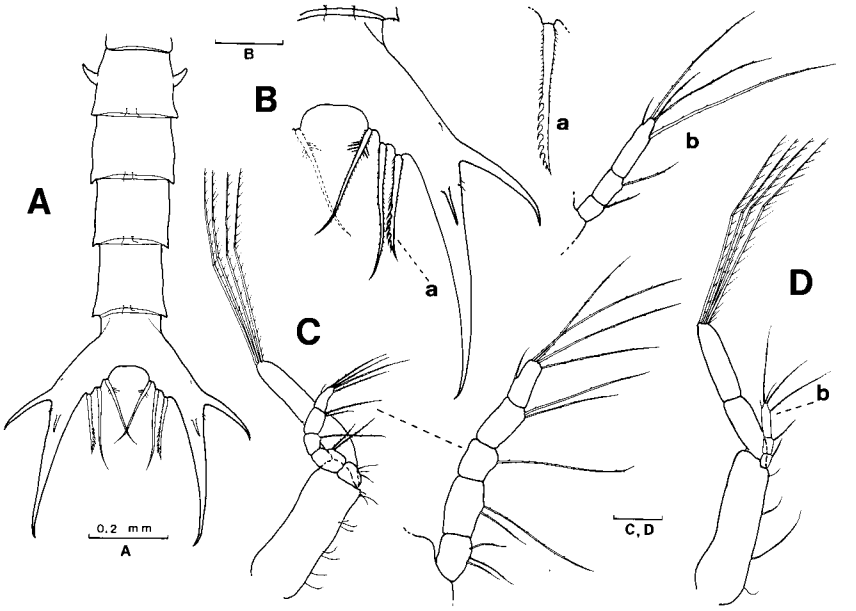

Fig. 6. *Cancer coronatus*, first zoea. A, abdomen and telson, dorsal view; B, enlargement of telson furca, with details of outer seta (a); C, first maxilliped, with details of endopod; D, second maxilliped, with details of endopod (b). Scale bars = 0.1 mm, except for A.

innermost seta finely spinulose along outer margin, and with a group of short, transverse setules on proximal portion (Fig. 9A). SEM observations revealed the presence of 3 minute setules on the medio-lateral margin of each furca, as shown in Fig. 9B, which are lost in the subsequent zoeal stages, as also occurs in *Cancer novaezelandiae* (Wear and Fielder, 1985: 17).

Cancer setosus Molina, 1782

(Figs. 4, 7–18)

First Zoea

Length from tip of rostral spine to tip of dorsal spine, 1.78 mm.

Carapace (Fig. 7A, B): Rostral spine long, dorsal spine backwardly directed, slightly longer than rostral spine; lateral spines shorter, curved downward. Dorso-median elevation prominent. Cephalothorax smooth, with 2 minute setae near base of dorsal spine, and 1 minute seta on inner base of each lateral spine. Eyes not stalked.

Antennule (Fig. 7C): Unsegmented, uniramous, with 3 terminal aesthetascs, two of them similar in length, and 2 short setae.

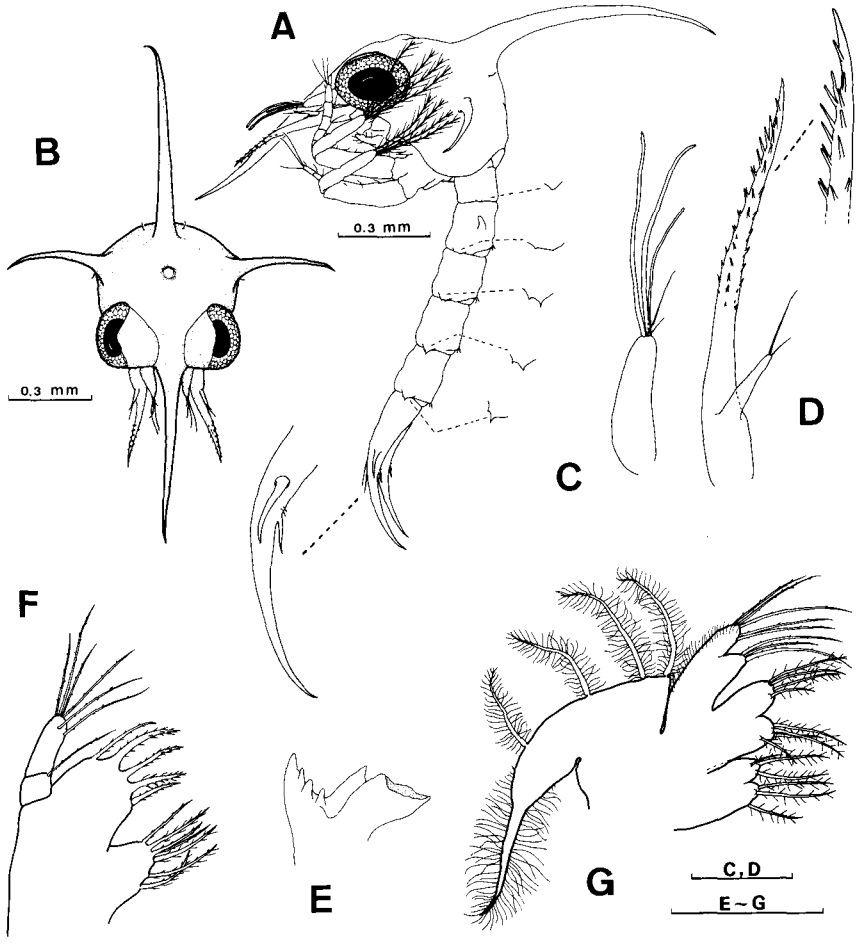

Fig. 7. *Cancer setosus*, first zoea. A, lateral view, with details of lateral edges of somites 1-5 and telson furca, lateral view; B, frontal view of carapace; C, antennule; D, antenna, with details of distal portion of spinous process; E, mandible; F, maxillule; G, maxilla. Scale bars=0.1 mm, except for A and B.

Antenna (Fig. 7D): Protopod long, narrowing distally, spinulate on distal half (Fig. 4D); exopod slightly less than one-fourth the length of spinous process, and with two unequal terminal setae.

Mandible (Fig. 7E): Small, with incisor and molar processes developed.

Maxillule (Fig. 7F): Endopod 2-segmented, with 1 seta on proximal and 6 on distal segments, arranged in 2+4; this is constant through successive zoeal stages; basial endite with 4 serrate spines and 1 plumodenticulate seta; coxal endite with

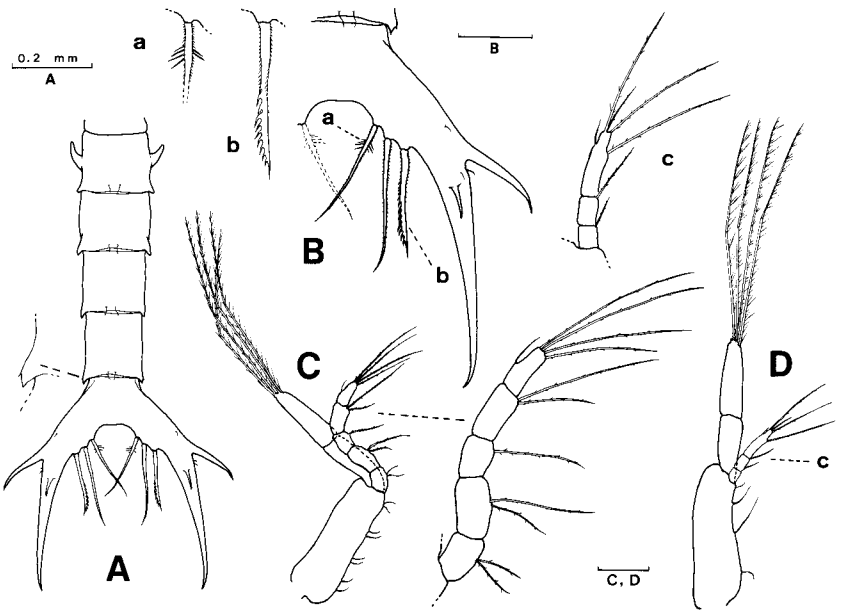

Fig. 8. *Cancer setosus*, first zoea. A, abdomen and telson, dorsal view; B, telson furca, with details (a, b) of setae; C, first maxilliped, with details of endopod; D, second maxilliped, with a detail of endopod (c). Scale bars = 0.1 mm, except for A.

7 plumose setae.

Maxilla (Fig. 7G): Endopod bilobed, proximal lobe with 3 long setae, distal lobe with 2+3 setae; basial endite bilobed, with 4+4 setae; coxal endite bilobed, with 3 setae on each lobe; scaphognathite with 4 finely plumose setae and a terminal plumose projection. Fine setules cover the outer margin of endopod.

First maxilliped (Fig. 8G): Protopod with 7 or 8 setae along inner margin, arranged in groups of 2; endopod 5-segmented, setal formula 2 (occasionally 3), 2, 1, 2, 4+1; exopod 2-segmented, with 4 long, natatory, plumose setae distally. Endopod shorter than exopod.

Second maxilliped (Fig. 6D): Protopod with 4 marginal setae; endopod 3-segmented, setal formula 1, 1, 5; exopod 2-segmented, with 4 long, terminal, plumose setae. Endopod similar in length to basial segment of exopod.

Third maxilliped and ***pereiopods***: Not developed at this stage.

Abdomen (Figs. 7A, 8A): Five somites+telson; somites 2-5 each with 2 minute setae dorsally; second somite with two distinct, lateral knobs; postero-lateral margins of each abdominal somite projected outward, as incipient spines.

Telson (Fig. 8A, B): Bifurcated, recurved backwards (Fig. 7A), each furca pointed distally, slightly convergent at tips, and with 1 developed medio-lateral,

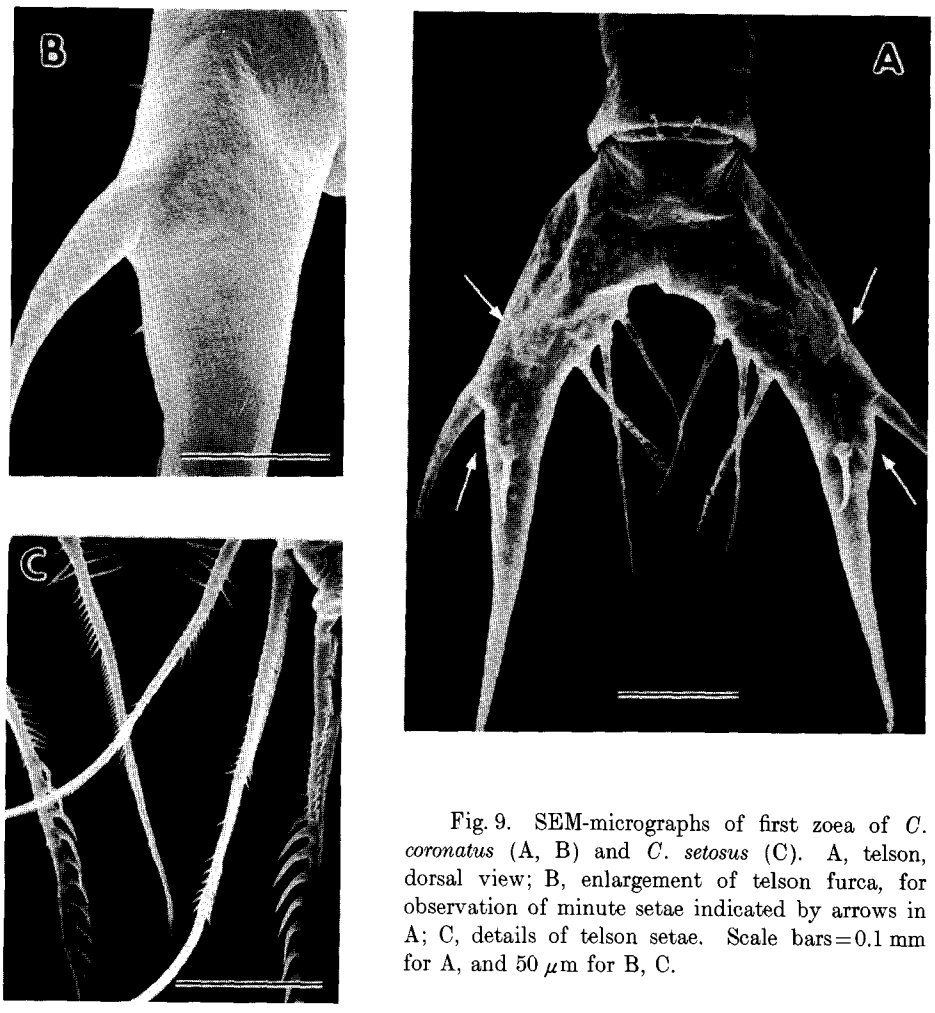

Fig. 9. SEM-micrographs of first zoea of *C. coronatus* (A, B) and *C. setosus* (C). A, telson, dorsal view; B, enlargement of telson furca, for observation of minute setae indicated by arrows in A; C, details of telson setae. Scale bars = 0.1 mm for A, and 50 μm for B, C.

smooth spine, and one smaller, dorso-medial spine; inner margin of furcae with 3 setae, with morphology as shown in Figs. 8B and 9C.

Second Zoea

Length from tip of rostral spine to tip of dorsal spine, 2.32 mm. Eyes stalked (Fig. 10A); this character remains constant through successive zoeal stages.

Antennule (Fig. 11A): With 4 aesthetascs and 1 fine seta.

Antenna (Fig. 11B): Unchanged from previous stage.

Mandible (Fig. 11C): Similar to that of previous stage, with dentition appar-

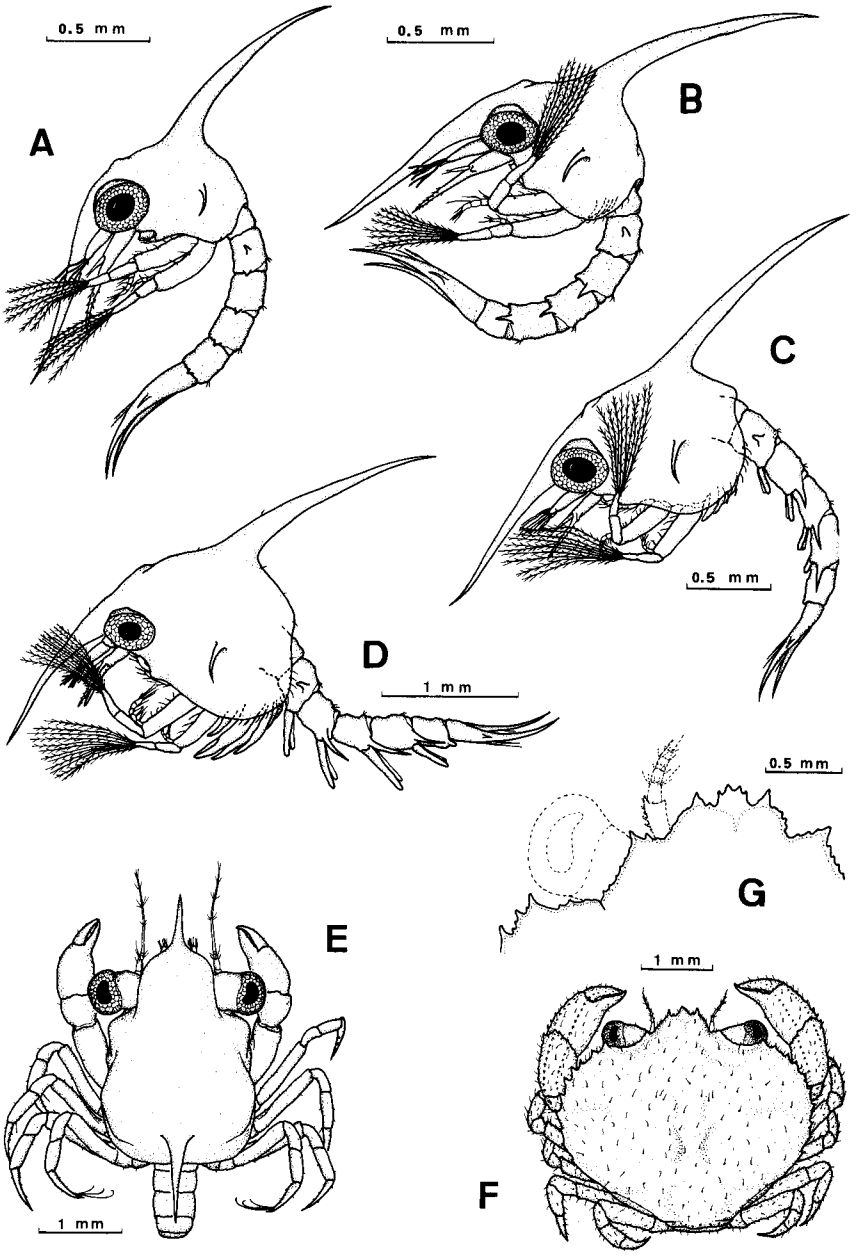

Fig. 10. *Cancer setosus*. A-D, second to fifth zoeal stage, lateral view; E, megalopa, dorsal view; F, first crab, dorsal view; G, frontal margin of first crab. Scales, as indicated.

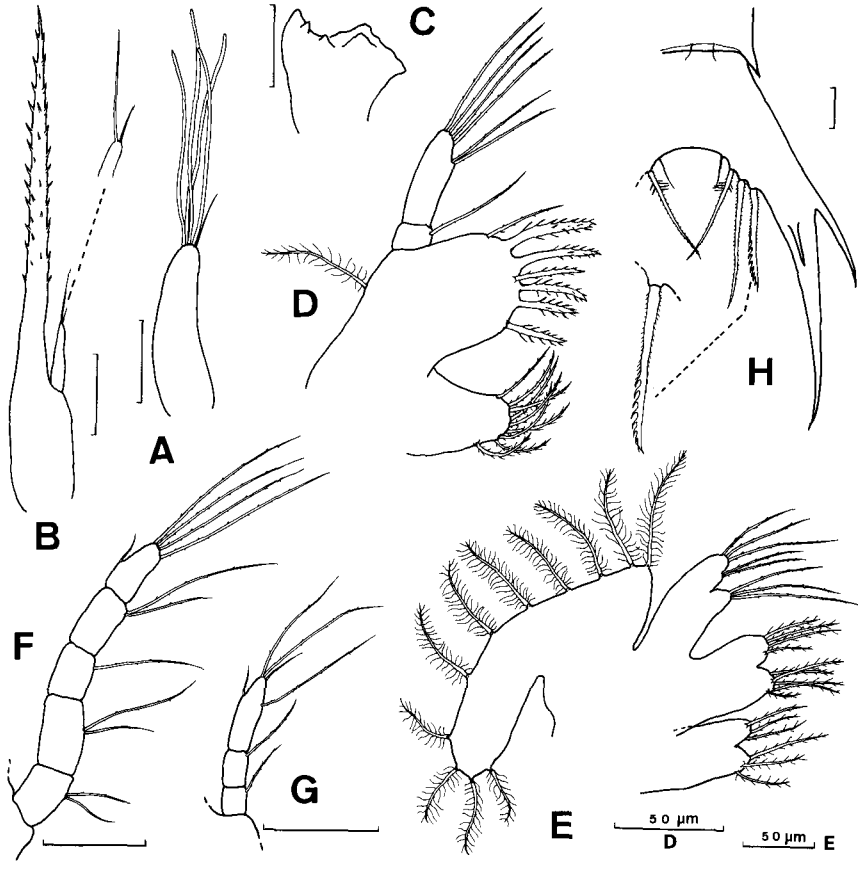

Fig. 11. *Cancer setosus*, second zoea. A, antennule; B, antenna, with details of apical setae of exopod; C, mandible; D, maxillule; E, maxilla; F, first maxilliped, endopod; G, second maxilliped, endopod; H, telson furca, dorsal view, with details of a seta. Scale bars = 0.1 mm, except for D and E.

ently reduced.

Maxillule (Fig. 11D): Basial endite with 7 setae-spines; coxal endite with 9 plumose setae; a soft, plumose seta on the lateral margin of the basial endite.

Maxilla (Fig. 11E): All endites bilobed, endopod with 3+5 setae; basial endite with 5+4 setae; coxal endite unchanged; scaphognathite with 11 marginal, plumose setae.

First and ***second maxillipeds*** (Fig. 11 F, G): Setation of endopods unchanged. Exopod (not drawn) now with 6 terminal, natatory plumose setae.

Third maxilliped not developed at this stage.

Abdomen (Fig. 10A); Somites with short, acute posterolateral margins; somites 2-5 each with 2 short setae dorsally.

Telson (Fig. 11H): Inner margin of furcae with an additional fine seta.

Third Zoea

Length from tip of rostral spine to tip of dorsal spine, 2.52 mm. Posterolateral margin of carapace with 6 minute setae. Rudiments of pereiopods visible

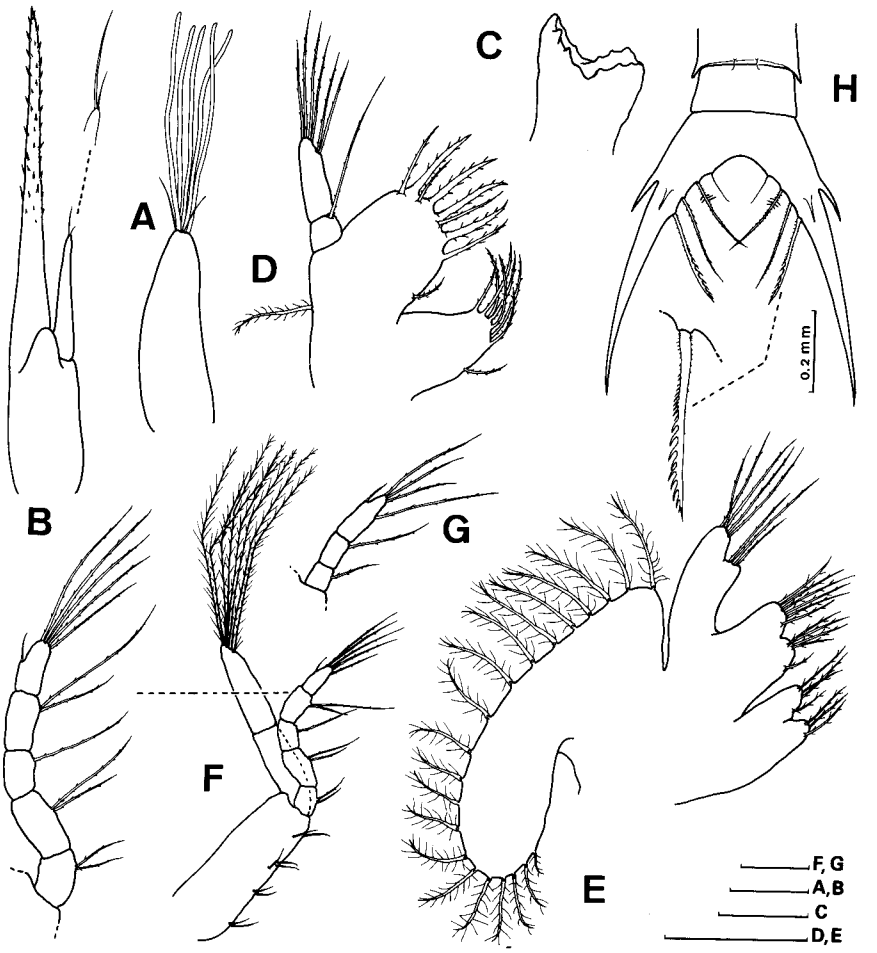

Fig. 12. *Cancer setosus*, third zoea. A, antennule; B, antenna, with details of apical setae of exopod; C, mandible; D, maxillule; E, maxilla; F, first maxilliped, with details of endopod; G, second maxilliped, endopod; H, abdomen (somites 5-6) and telson, dorsal view, with details of a seta. Scale bars = 0.1 mm, except for H.

laterally beneath carapace (Fig. 10B)

Antennule (Fig. 12A): With 5 similar terminal aesthetascs, and 2 setae.

Antenna (Fig. 12B): Exopod longer than in previous stage; an incipient endopod bud arises near the base of exopod.

Mandible (Fig. 12C): Without remarkable changes from previous stage.

Maxillule (Fig. 12D): Basial endite with 8 (occasionally 9) setae-spines; coxal endite with 8 setae. Endopod and outer margin of protopod unchanged.

Maxilla (Fig. 12E): Endopod setation as in previous stage; basial endite with 5+6 setae; coxal endite with 3+4 setae; scaphognathite now with 20 marginal, plumose steae.

First maxilliped (Fig. 12F): Endopod setation basically unchanged, except the terminal segment now with 6 setae; exopod (not drawn) with 8 terminal plumose setae.

Second maxilliped (Fig. 12G): Endopod setation unchanged; exopod (not drawn) with 8 terminal plumose setae.

Third maxilliped (not drawn), as bud.

Abdomen (Fig. 10B): Sixth somite now separated, shorter than others, unarmed; posterolateral margins of somites 3-5 acute, longer than in previous stage, reaching one-third the length of subsequent segments. The latero-external spine of each furca markedly shorter than in previous stages. Pleopods present as small buds, ventrally on segments 2-5. Telsonal setation as in previous stage (Fig. 12H).

Fourth Zoea

Carapace length (C.L.), 1.08 mm; length from tip of rostral spine to tip of dorsal spine, 3.38 mm. Posterolateral margins of carapace fringed with 9 fine setae. Rudiments of pereiopods visible laterally, projected downward (Fig. 10C).

Antennule (Fig. 13A): With 7 aesthetascs and 3 setae.

Antenna (Fig. 13B): Exopod slightly more than one-third the length of spinous process, bearing 3 apical setae, one of which is very long; endopod bud now one-half the length of exopod.

Mandible (Fig. 13C): Incisor and molar processes robust, with inner and marginal dentition.

Maxillule (Fig. 13D): Basial endite with 13 setae-spines; coxal endite unchanged in setation.

Maxilla (Fig. 13E): Endopod with 4+5 setae; basial endite with 6+6 setae; coxal endite with 4+4 setae; scaphognathite fringed with 26 plumose setae.

First and ***second maxilliped*** (Fig. 13F, G): Setation of respective endopod unchanged; exopod (not drawn) now with 10 terminal, plumose setae.

Third maxilliped (not drawn). Rudimentary.

Abdomen (Figs. 10C, 13H): Lateral spines of somites 3-5 long, reaching one-half the length of respective segment, last somite unarmed. Pleopod buds 2-5 noticeably longer than in previous stage; sixth somite now with pleopod buds.

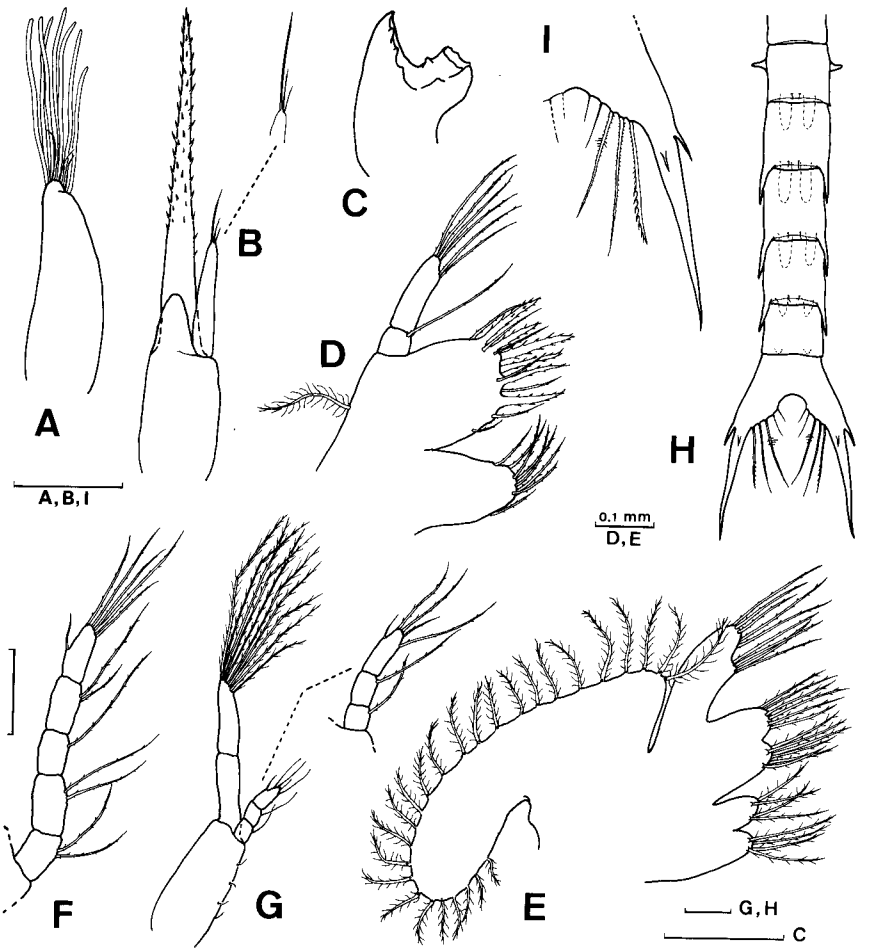

Fig. 13. *Cancer setosus*, fourth zoea. A, antennule; B, antenna, with an apical detail of exopod; C, mandible; D, maxillule; E, maxilla; F, first maxilliped, endopod; G, second maxilliped, with details of endopod; H, abdomen and telson, dorsal view; I, telson furca. Scale bars = 0.2 mm, except for D and E.

Telson (Fig. 13H, I): With an additional simple seta on inner margin of each furca, a total of 10 telson setae.

Fifth Zoea

C.L., 1.36 mm; length from tip of rostral spine to tip of dorsal spines, 3.7 mm. Posterolateral margins of carapace (Fig. 10D) with 14 fine setae; minute setules on

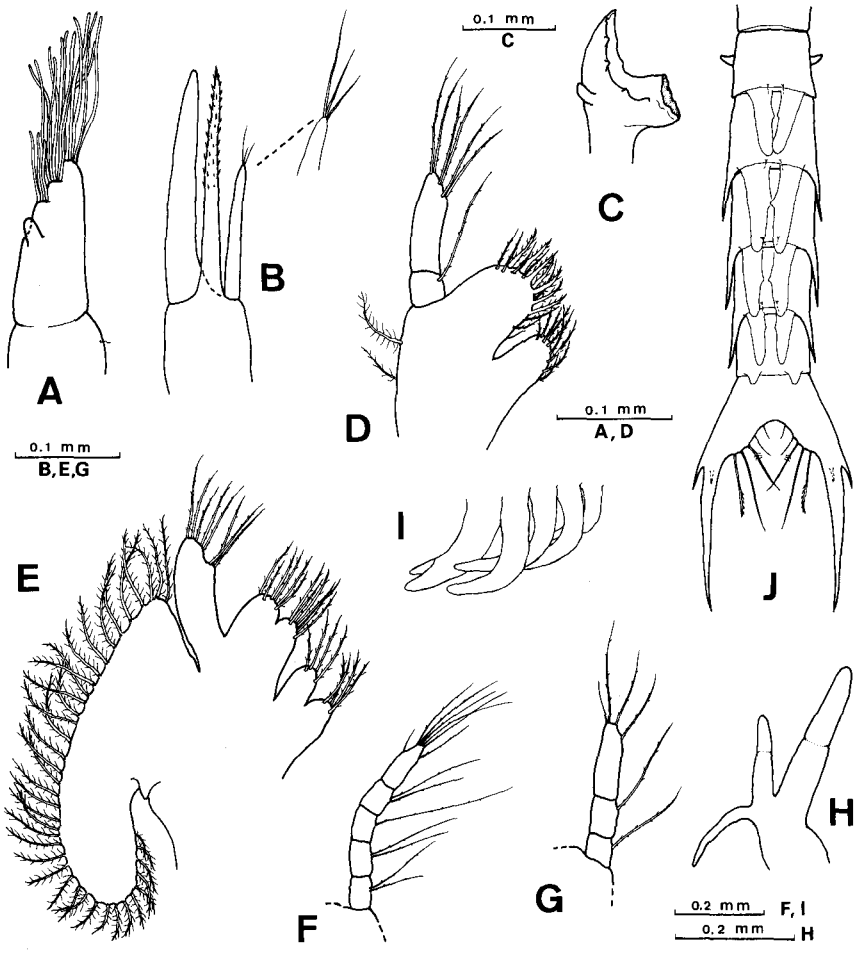

Fig. 14. *Cancer setosus*, fifth zoea. A, antennule; B, antenna, with an apical detail of exopod; C, mandible; D, maxillule; E, maxilla; F, first maxilliped, endopod; G, second maxilliped, endopod; H, third maxilliped; I, pereiopods 1-5; J, abdomen and telson, ventral view. Scales, as indicated.

dorsal surface of carapace.

Antennule (Fig. 14A): Aesthetascs arranged into three tufts, the proximal tuft with 3, the medial with 8 and the distal with 4 aesthetascs; endopod represented as a bud.

Antenna (Fig. 14B): Exopod slender, more than one-half the length of spinous process; endopod greatly developed, reaching the length of spinous process.

Mandible (Fig. 14C): With a rudimentary palp laterally.

Maxillule (Fig. 14D): Basial endite with 15 setae-spines; coxal endite with 9 setae; outer margin of protopod with 2 plumose setae.

Maxilla (Fig. 14E): Endopod with 8 or 9 setae; setation of basial and coxal endites unchanged; scaphognathite with 39 marginal setae.

First and ***second maxillipeds*** (Fig. 14F, G): Setation of endopods unchanged; exopods (not drawn) with 12 terminal plumose setae; marginal setation of protopods (not drawn), 9 and 4 setae on the respective maxillipeds.

Third maxilliped (Fig. 14H): More developed than in previous stages, endo- and exopod indistinctly 2-segmented; epipod slender, unsegmented.

Pereiopods (Fig. 14I): Rudimentary, first pair chelate; all pereiopods unsegmented.

Abdomen (Fig. 14J): Pleopods 2-5 longer than in previous stage, but unarmed, each with an incipient endopod; uropods rudimentary.

Telson (Fig. 14J): Setation unchanged; furcae less divergent than in previous stage.

Megalopa

C.L., 3.30 mm, measured from tip of rostral spine to median posterior margin of carapace. Carapace almost rectangular in outline (Fig. 10E); frontal region broad at its base, projecting in an acute rostral spine, directed almost horizontally; the zoeal dorsal spine becomes posterior in position in the megalopal stage and backwardly projected from cardiac region, almost in same plane as rostrum; no lateral carapace spines; posterior spine slightly longer than rostral spine. Eyes stalked, large. Maxillipeds, pereiopods and pleopods all well-developed.

Antennule (Fig. 15A): Considerably modified from previous stage, with a clearly 3-segmented peduncle, basial segment swollen, with several setae on surface, second segment with 3 shorter distal setae, distal segment broader, with 1 minute seta; outer flagellum 4-segmented, with 12, 12 and 8 aesthetascs on segments 2-4, the distal tuft clearly medial in position; 2 additional setae in outer margin of third segment, and 2 long, apical setae on distal segment; inner flagellum slender, usegmented, with 4 terminal and 1 shorter subterminal setae.

Antenna (Fig. 15B): Peduncle 3-segmented, with 4 long setae on third segment; flagellum 8-segmented, basal segment, the shortest; total setal formula of antenna, 3, 2, 4, 0, 0, 4, 0, 4, 0, 3, 5 (proximal to distal).

Mandible (Fig. 15C): Mandibular plate broadly expanded, without teeth; palp 2-segmented, curved inward, the distal segment fringed with 11 setae on outer margin.

Maxillule (Fig. 15D): Endopod 2-segmented, with 1 long, simple seta on proximal segment and 2 short terminal setae on distal segment; basial endite with 22 setae-spines; coxal endite with 15 setae.

Maxilla (Fig. 15E): Endopod unilobed, basally broad, with 3 or 4 short setae on outer basal margin and 1 terminal seta on tip; basial and coxal endites bilobed,

longer than in zoeal stages, armed with 10+12 and 4+5 setae respectively; scaphognathite broadly expanded, fringed with 68-70 marginal setae.

First maxilliped (Fig. 16A): Protopod (basis+coxa) bilobed, basial endite with 20-24 setae; coxal endite with 10-12 setae; endopod unsegmented, curved inward, acute at tip, and with 3 setae on outer margin and 1 apical seta; exopod 2-segmented, proximal segment longer than endopod, with 3 plumose setae on

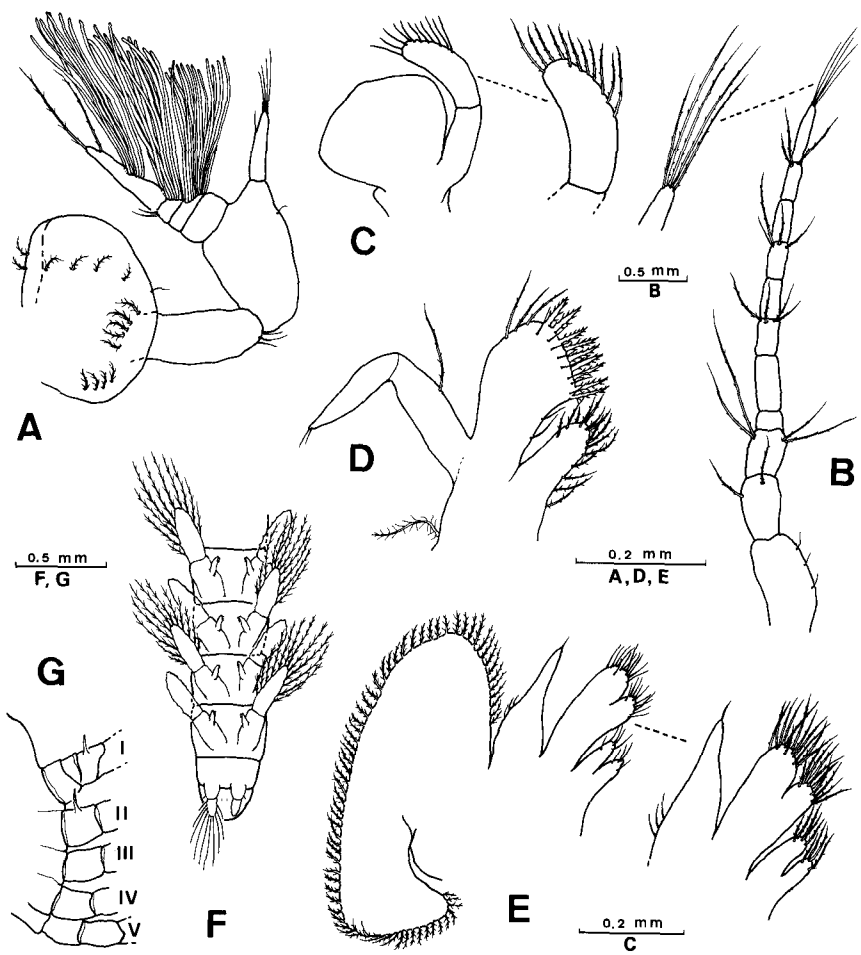

Fig. 15. *Cancer setosus*, megalopa. A, antennule; B, antenna, with a detail of terminal setae; C, mandible, with details of palp; D, maxillule; E, maxilla, with details of inner endites; F, abdomen and telson, ventral view, setation of one pleopod of each pair has been omitted; G, basis of pereiopods 1-5, ventral view. Scales, as indicated.

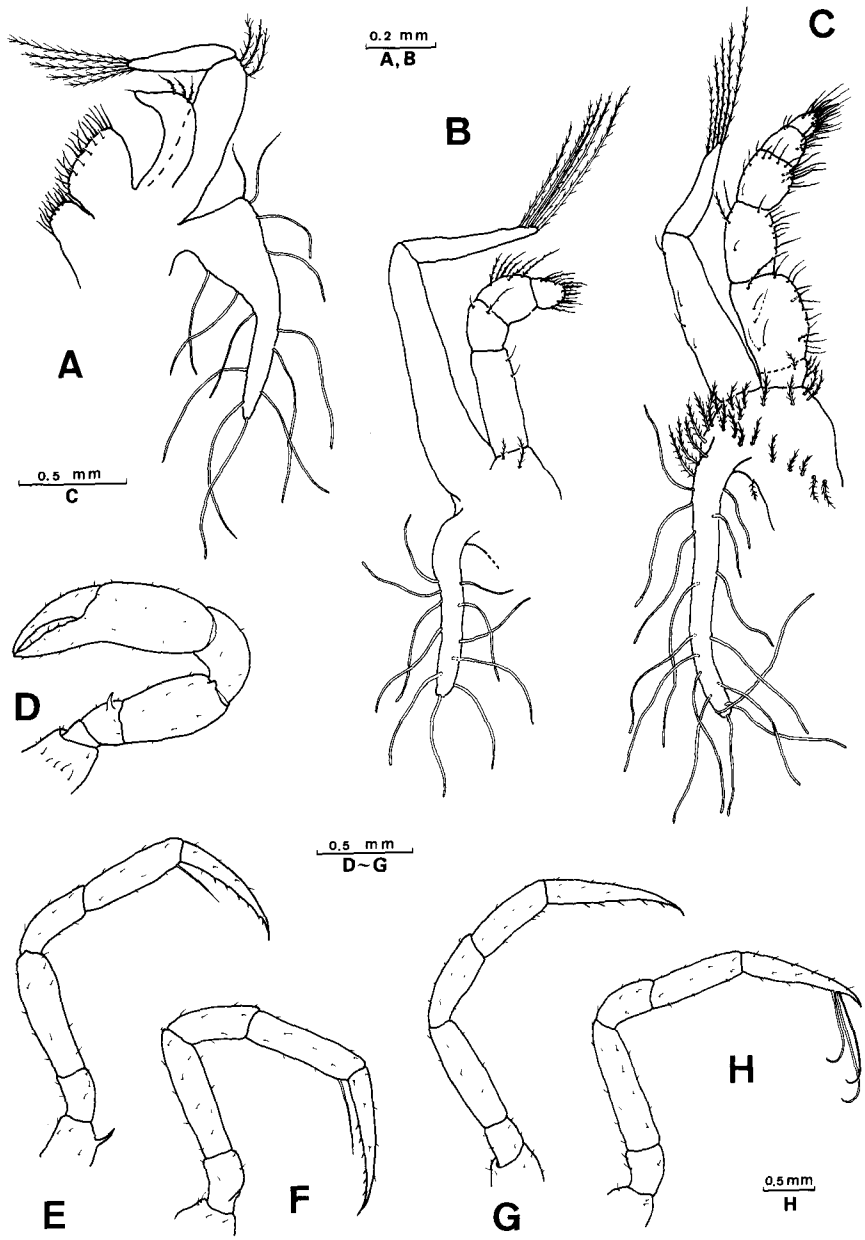

Fig. 16. *Cancer setosus*, megalopa. A-C, first to third maxillipeds; D, cheliped; E-H, second to fifth pereiopods. Scales, as indicated.

outer distal margin, distal segment with 5 long, terminal setae; epipod well developed, basal portion broad, triangular-shaped, and fringed with 11–13 long, non-plumose setae.

Second maxilliped (Fig. 16B): Protopod with 2 setae on upper margin: endopod apparently 4-segmented, with setation 2, 2, 7, 9 setae respectively (setae+spines on the distal segment); exopod 2-segmented, slender, proximal segment shorter than endopod, unarmed, distal segment with 5 long setae; epipod digitiform, relatively short, with 10–12 long, non-plumose setae; rudiment of podobranch, not drawn.

Third maxilliped (Fig. 16C): Protopod broad, with numerous setae on surface; basis-ischium partly differentiated, basis with 4 or 5 setae on inner margin; endopod 5-segmented, ischium the broader segment, all segments armed with numerous setae on surface and margins; exopod 2-segmented, proximal segment with short setae on outer margin, distal segment with 5 long setae; epipod digitiform, long, armed with 15 or 16 long, non-plumose setae, and with plumodenticulate setae on or near its basis.

Pereiopods (Figs. 16D-H): All sparsely covered with short setae; cheliped stout, with a prominent spine on ventral surface of ischium; inner border of immovable finger armed with blunt teeth and setae; second pereiopod with an acute spine on coxa (Fig. 15G, 16E); inner distal propodal margin of pereiopods 2–3 with a prominent rigid seta, inner margin of dactyls 2–4 armed with several stout short setae; dactyl of fifth pereiopod with 3 long subterminal setae.

Abdomen (Fig. 15F): Somites 2–5 each with well-developed pleopods, exopods with 11 or 12 long plumose, marginal setae, endopods armed distally with 3 short hooked setae. Uropods 2-segmented, with no endopod, basal segment with 1 seta on outer distal margin, distal segment with 10 plumose, marginal setae.

Telson (Fig. 15F): Broader than long, with 2 minute setae ventromedially; posterior margin rounded, without marginal setae.

First Crab

C.L., 3.25 mm, measured from frontal margin to median posterior margin of carapace, maximum carapace width, 3.50 mm.

Carapace subcircular in outline, broader than long (Fig. 10F), and slightly inflated dorsally. Carapace, chelipeds and walking legs finely granulose and profusely setose (character "setosus" of this species). Borders of carapace irregularly denticulate, with 10 distinct short teeth on each antero-lateral margin. Frontal and orbital margins irregularly denticulate; front projected beyond the orbits, and with 3 major "teeth", indistinctly demarcated due to additional spines between them (Fig. 10G).

Antennule (Fig. 17A): Peduncle 3-segmented, basal segment swollen, with setae on surface (not drawn), second segment with 4 inner distal setae, distal segment with 4 short and 1 longer setae on inner and outer margins respectively; outer flagellum now 7-segmented, basal, fifth and penultimate segments unarmed,

segments 2-4 each with dense tufts of long aesthetascs, apical segment with 2 terminal setae; inner flagellum slender, 3-segmented, with setae on second and distal segments.

Antenna (Fig. 17B): Peduncle 3-segmented, basal segment broad, setose, finely granulose along outer margin and with a prominent stout outer distal process, second and third segment with several setae around distal margin; flagellum 9-segmented, basal segment shorter, unarmed, but all remaining segments setose around distal margins.

Mandible (Fig. 17C): Mandibular plate rigid, slightly concave, broadly oval, cutting borders powerful, obtuse, projected medially into a stout tooth; palp

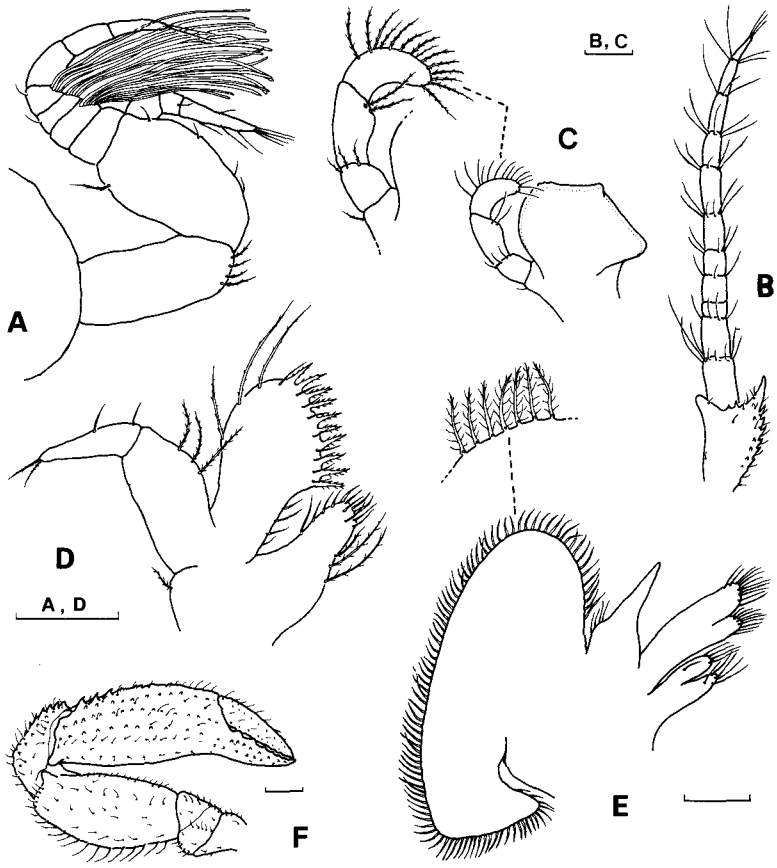

Fig. 17. *Cancer setosus*, first crab. A, antennule; B, antenna; C, mandible, with details of palp; D, maxillule; E, maxilla, with details of setation of scaphognathite; F, cheliped. Scale bars = 0.2 mm.

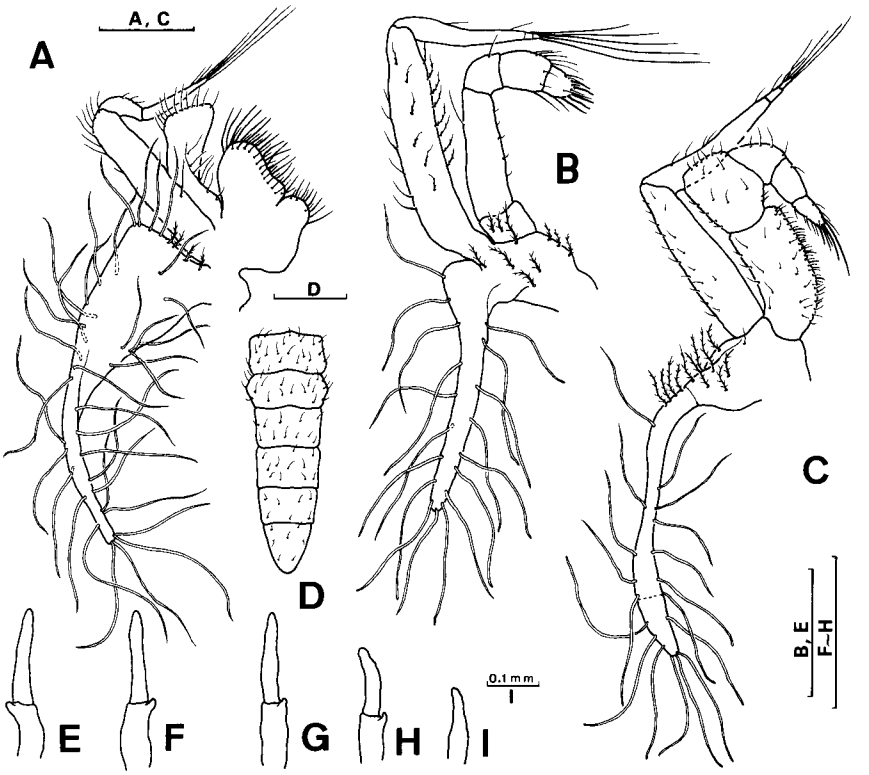

Fig. 18. *Cancer setosus*, first crab. A-C, first to third maxillipeds; D, abdomen, dorsal view; E-I, first to fifth pleopods. Scale bars = 0.5 mm, except for I.

distinctly 3-segmented (normally covered by mandibular plate) and with setal formula 3, 2, 14, and 1 additional basal seta.

Maxillule (Fig. 17D): Not significantly different to that of previous stage, but more setose; endopod 2-segmented, basial segment broad, with 3 medial, long, marginal setae, distal segment with 4 shorter setae, two of which are terminal; basial and coxal endites profusely armed with setae and spines.

Maxilla (Fig. 17E): Without noticeable morphological changes from previous stage, but larger and armed with additional setae, especially along margins of scaphognathite.

Maxillipeds (Fig. 18A-C): Profusely setose in all segments and endites. The principal changes compared with the megalopal maxillipeds are: first maxilliped, endopod broader, exopod now 3-segmented, and epipod greatly developed, longer than the maxilliped itself; second maxilliped, endopod distinctly 5-segmented, exopod with basal segment setose on surface and margins, and epipod longer;

third maxilliped, all segments more rigid, broader, especially ischium and merus, epipod slender, indistinctly segmented near distal third.

Chelipeds (Fig. 17F): Surface setose and spinulose; merus with a blunt process distally, carpus with ridges of small blunt spines and setae on dorsal surface, propod with 5 longitudinal ridges of granules and setae, diagnostic characters which clearly distinguish this species from other cancrids of the Chilean fauna (Retamal, 1981, Figs. 152-155); fingers stout, with inner borders irregular.

Abdomen (Fig. 18D): Profusely setose on surface; each segment broader than long, second segment expanded laterally, last segment (telson segment) longer than broad, with oval posterior margin.

Pleopods (Fig. 18E-I): Rudimentary, 2-segmented, except the last pair (Fig. 18I) which is uniramous, unsegmented; endopod greatly reduced; distal segment long, unarmed.

Discussion

Larval descriptions of cancrid species

The genus *Cancer* is represented by *ca* 19 living species (Nations, 1975), of which several are commercially important.

At present, the larval development of sixteen *Cancer* species have been published (including the present species), corresponding this to about the 80.0 per cent of *Cancer* species with known larvae; additional accounts, with special reference to the prezoeal stage for a number of *Cancer* species, have also been given (*see* Roesijadi, 1976; Quintana, 1984). Excepting prezoeal descriptions, the following pretends to be a brief summary of such contributions (species listed in alphabetical order for each zoogeographical area):

North-Eastern Pacific (Pacific coasts of North America): *Cancer antennarius* Stimpson: Mir, 1961: 103, Pl. 1, figs. 1-4, Pl. 2, figs. 5, 6, Pl. 2, figs. 8, 11 (1st zoea); Roesijadi, 1976: 275; figs. 4-10 (1st-5th zoeas, megal.). *Cancer anthonyi* Rathbun: Mir, 1961: 103, Pl. 1, figs. 1-4, Pl. 2, figs. 5, 6, Pl. 2, figs. 9, 12 (1st zoea); Trask, 1974: 63, figs. 2-7 (1st-5th zoeas, megal.); Anderson, 1978: 55, figs. 1-7 (1st-5th zoeas, megal.). *Cancer gracilis* Dana: Ally, 1975: 231, figs. 2-8 (1st-5th zoeas, megal.). *Cancer magister* Dana: Mir, 1961: 103, Pl. 1, figs. 1-4, Pl. 2, figs. 5, 6, Pl. 2, figs. 7-10 (1st zoea); Poole, 1966: 83, figs. 1-7 (1st-5th zoeas, megal.). *Cancer productus* Randall: Trask, 1970: 133, figs. 1-7 (1st-5th zoeas, megal.).

North-Western Pacific (Pacific coast, northern Japan): *Cancer amphioetus* Rathbun: Iwata, 1973: 21, fig. 1, Pl. 1, C-E (1st zoea); Iwata and Konishi, 1981: 369, figs. 1-8 (1st-5th zoeas, megal.). *Cancer gibbosulus* (De Haan): Aikawa, 1937: 126, fig. 28 (1st zoea).

North-Western Atlantic (Atlantic coasts of North America): *Cancer borealis* Stimpson: Sastry, 1977_b: 290, figs. 1-6 (1st-5th zoeas, megal.). *Cancer irroratus* Say: Connolly, 1923: 337 (as *C. amoenus* (Herbst)), fig. 2, Pls. 1-4, figs. 1-40 (1st-4th zoeas, megal.); Sastry, 1977_a: 155, figs. 1-6 (1st-5th zoeas, megal.).

North-Eastern Atlantic (European coasts): *Cancer bellianus* Johnson: Rice and Williamson, 1977: 28 (not seen) (as *C. ? bellianus, fide* Ingle, 1981: 217), 5th zoea ?. *Cancer pagurus* Linnaeus: Lebour, 1928: 522, figs. 2 (11-15), Pl. 1, fig. 10, Pl. 5, fig. 5, Pl. 10, figs. 3-5 (1st-5th zoeas, megal., 1st-4th crab); Rice, 1975: 237, fig. 1 (1st zoea); Ingle, 1981: 211, figs. 1-13 (1st-5th zoeas, megal., 1st-3rd crab). See list of other early accounts in Ingle, 1980: 107; 1981: 211-212.

Coasts of New Zealand: *Cancer novaezelandiae* Jacquinot: Wear, 1965: 16, fig. 6C (megal.); Wear and Fielder, 1985: 12, figs. 1-37 (1st-5th zoeas, megal.)

South-Eastern Pacific (Pacific coasts of South America): *Cancer coronatus* Molina: Present study, figs. 4-6 (1st zoea). *Cancer edwardsi* Bell: Quintana, 1983: 1, figs. 4-9 (1st-5th zoeas, megal.). *Cancer porteri* Rathbun: Fagetti, 1960: 143, figs. 1-10 (1st zoea). *Cancer setosus* Molina: Present study, figs. 4, 7-18 (1st-5th zoeas, megal., 1st crab).

These accounts collectively represent a considerable advance in the larval knowledge of this group.

For species normally inhabiting Chilean coasts and other areas in South

Table 1. Comparison of first zoeal features of *Cancer* species (in alphabetical order) from South America (Pacific coasts). Setation of endopod of second maxilliped (1, 1, 5) and of inner margin of telson (3+3) has been omitted because it is invariable in these species. Setation, from proximal to distal. aest. = aesthetascs; set. = setae.

Features	*C. coronatus* (this study)	*C. edwardsi* (Quintana, 1983)	*C. porteri* (Fagetti, 1960)	*C. setosus* (this study)
Length*	1.83 mm	1.85 mm	1.87 mm	1.78 mm
Antennule	3 aest+1 set	2 aest+2 set	2 aest+2 set	3 aest+2 set
Antenna				
exopod	2	3	3	2
Maxillule				
endopod	1+6	1+6	1+5	1+6
basis	5	5	5	5
coxa	7	7	5	7
Maxilla				
endopod	3+5	3+5	3+4	3+5
basis	5+4	5+4	4+4	4+4
coxa	(3−4)+3	3+2	3+3	3+3
scaphogn.	4+1	4+1	4+1	4+1
I Maxpd.				
endopod	3, 2, 1, 2, 5	2, 2, 1, 2, 5	3, 2, 1, 2, 5	2, 2, 1, 2, 5

* measured from tip of rostral spine to tip of dorsal spine.

America (see Fig. 1), there are no previous descriptions of the larval stages for *C. setosus* neither for *C. coronatus*. Fagetti (1960) reported the first zoeal stage of *C. porteri* from Valparaíso, Chile, and Concha (unpublished) collected larvae of *Cancer* species, zoeas and megalopas from Concepción Bay, but these were not identified to species.

Larval development

The presence of five zoeal stages and a megalopa described here for *C. setosus* is consistent with previous accounts of the complete larval development of other *Cancer* species (*e.g.*, Ally, 1975; Sastry, 1977a, 1977b; Anderson, 1978; Ingle, 1981; Wear and Fielder, 1985). The first zoeal stage of *C. setosus* and of *C. coronatus* is compared in Table 1 with descriptions given on *C. porteri* (Fagetti, 1960) and *C. edwardsi* (Quintana, 1983).

Most cancrid species hatch as prezoea, of very short duration, before moulting to the first zoeal stage (*see* reviews given by Ally, 1975; Roesijadi, 1976). It is probably for this reason that prezoeas have never been reported from the plankton, so the remark mentioning planktonic occurrence (Quintana, 1984: 149) citing Aikawa (1937: 111) must be considered an error. SEM-micrographs taken of prezoeal specimens of *C. coronatus* are regarded here as the first for brachyuran prezoeas. Similar SEM evidence of this post-embryonic stage have recently been presented for prezoeas of pagurid species from Northern Japan (Quintana and Konishi, 1986).

The mean duration of the first through the fifth zoeal stages in *C. setosus* was 20.2, 15.2, 14.5, 15.0 and 16.0 days respectively. Although no megalopas were obtained from reared material in this study, it therefore seems that *C. setosus* requires about two months from hatching to megalopa, at 13.5-14.6°C temperature and 33.2 ppt salinity (*see* Fig. 2). Under similar conditions, *C. edwardsi* reached the megalopa stage after 60 days (Quintana, 1983).

Prolonged developmental times of 97 days for *C. productus* (Trask, 1970) and 80 days for *C. magister* (Poole, 1966) have been reported. No indications of larval duration are given by Iwata and Konishi (1981) for *C. amphioetus* from Hokkaido, northern Japan, but Konishi (*pers. com.*) suggests that about 35 days should be required to reach megalopa stage in this species. Thus, the larval duration in *C. setosus* or *C. edwardsi* is intermediate between these two extremes.

Suggested groupings of cancrid larvae

In the early zoeal stages, the Chilean cancrid species are not easily distinguishable using the setation of the appendages (Table 1) or other single character; this difficulty was also noted by Iwata (1973) in comparing larvae of *C. amphioetus* and *C. gibbosulus* from Japanese waters, and by Trask (1974) and Anderson (1978) in comparing early larvae of *C. anthonyi* with those of *C. magister* and *C. productus* from North America. Similarly, this difficulty was noted by Iwata and Konishi (1981) in a comparison including eight *Cancer* larvae.

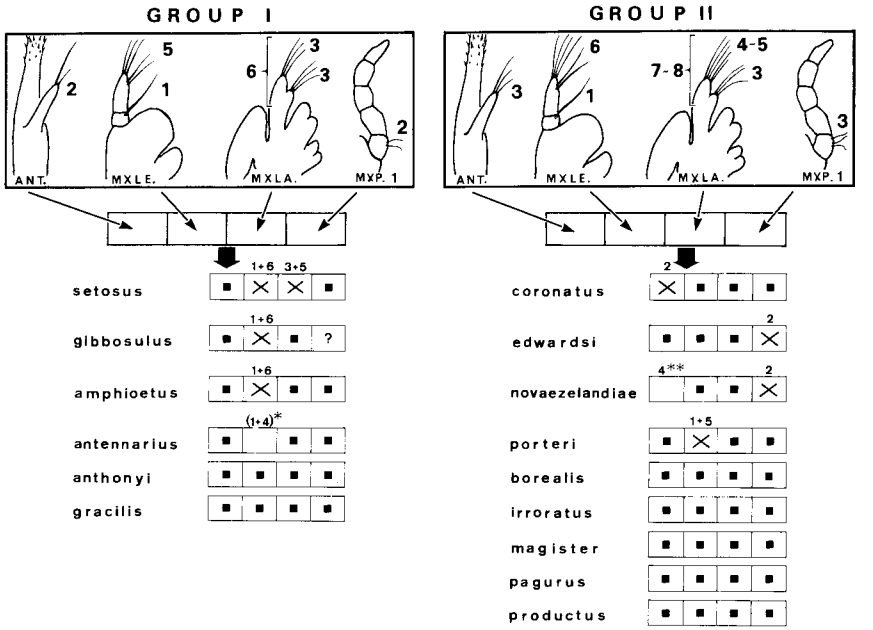

Fig. 19. Diagrammatical representation of the currently accepted grouping scheme for zoeae (Zoea I) of *Cancer* species (fifteen species, arranged by degree of combination of characters (■) and alphabetically). When a character is not combined (X) in the group in which the species was included, its variation has been indicated. *The setation of this character is 1+4 only in the first zoea, but is 1+5 in the second and subsequent zoeal stages. **Figured as having 4 setae, but in zoea V stage, this possesses 3 apical setae (*see* Wear and Fielder, 1985: 16, Fig. 14). *Cancer bellianus* Johnson has not been included in this revision (for explanation, see page 291).

Nevertheless, an easier observable difference can be traced by using megalopal characters (Table. 2).

Attempts at cancrid groupings based on zoeal characters have been proposed by Rice (1980) and Ingle (1981), but apparently no easily recognisable characters for separation of species seem to exist due to great similarity in setation in a number of appendages compared. A possible scheme for grouping cancrid zoeae is that summarized in Fig. 19, which takes into account the setation of (a) exopod of antenna, and of the endopods of the maxillule (b), maxilla (c), and the first maxilliped (d). In both groups, there are species with all characters combined, and others which do not share all the features of the group. Group I contains larvae of 5 species, and group II, larvae of the remaining 9 species. Since *C. setosus* has two features of one group and two of the other, it could equally be included in either. The variability of these and other characters in several

Table 2. Comparison of megalopal characters in twelve *Cancer* species. Setation (aesthetascs, setae or spines) are all referred from proximal to distal. Sources: (**1**) Roesijadi, 1976; (**2**) Trask, 1974; (**3**) Anderson, 1978; (**4**) Ally, 1975; (**5**) Poole, 1966; (**6**) Trask, 1970; (**7**) Sastry, 1977b; (**8**) Connolly, 1923; (**9**) Sastry, 1977a; (**10**) Iwata and Konishi, 1981; (**12**) Wear and Fielder, 1985; (**13**) Quintana, 1983; (**14**) present study.

SPECIES / CHARACTER	PACIFIC COASTS OF NORTH AMERICA					
	Cancer anthonyi					
	antennarius (**1**)	(**2**)	(**3**)	*gracilis* (**4**)	*magister* (**5**)	*productus* (**6**)
Carap. length(mm)⊙	ca. 3.10*	ca. 2.51*	3.20	2.21	ca. 6.0*	ca. 3.47*
Antennule						
inner flag. (setae)	5	5	7	6	9	5
out. flag.(aesthet.)	0, 10, 6, 4	22-27	0, 15, 10, 5	0, 12-14, 9, 5	0, 17, 15, 9	0, 13, 9, 6
Antenna						
peduncle	4, 2, 4	(2, 2, 4)*	5, 2, 3	5, 2, 4	(11, 11, 8)*	5, 4, 4
flagellum	0, 0, 4, 0, 5, 0, 4, 4	(0, 0, 4, 0, 4, 4, 4)*	0, 0, 4, 0, 5, 0, 5, 5	0, 0, 4, 0, 5, 0, 4, 5	(0, 2, 7, 0, 6, 2, 5, 5)*	0, 0, 3, 2, 3, 1, 3, 5
Mandible (palp)						
distal segment	9	7	13	8	18	12
Maxillule						
endopod	1+4(unsegmt.)	1+5(unsegmt.)	0*+3(unsegmt.)	1/2	(2+3)*(unsegmt.)	(2+3)*(unsegmt.)
basis	17	20	26-28	26	38-43	30-32
coxa	4+7	8	16	15	29-31	15-17
Maxilla						
endopod	0+1	0+2	(2-3)+0	3-4+0-1	(8-10)+0	0+1
basis	8+9 (17)	16	10+8-9 (18-19)	9+9 (18)	17+19-23 (36-40)	11+11 (22)
coxa	5+3 (8)	8	4+6 (10)	2+7 (9)	8+8 (16)	6+6 (12)
scaphognath.	53-55	45-50	47-53	53-59	110-124	62-64

Table 2. Continued.

1st. Maxilliped						
endopod (apically)	3+2	(0+4)*	3+3	3+1	(8-9)+10	5+4
basis	23	?	20 } ‡‡	20-23	numerous	(38-40)‡‡
coxa	10	?	15 }	14	numerous	
exopod	3/4	3/6	(3/5)*	(2-4)/5	4*/7	3*/6
epipod	10	8	11	8-11	34	16
2nd. Maxilliped						
endopod	1, 0, 7, 8	(0, 0, 5, 10)*	2, 1, 7, 10	1, 1, 1, 6-7, 9	7, 6, 20, 14	5, 0, 7, 7
exopod	0/4	(0/5)*	0*/5	1/5	4*/6	1*/5
epipod	4	7	3▲	4	19	6
3rd. Maxilliped						
exopod	0/5	(0/6)*	3*/6	2-4/5	(17/10)*	5*/6
epipod	16	10	16▲	12-15	31	13
Uropods	1/9	?/7	0/9-10	1/7-9	(3/20)* (in figs.) (22)□ (in text)	1*/12
	antennarius	*Cancer anthonyi*		*gracilis*	*magister*	*productus*

Indications: —, range of variation; 0, no setae; ?, no data; endites are indicated by "/" for emphasis when they are 2-segmented, and by "," for more than 2 segments; * from figures; ⊙ tip of frontal margin to median posterior carapace margin; ‡‡ referred as "lobes on the endopod"(!) (see Trask, 1970: 144; Anderson, 1978: 64); ▲ referred as "exopod"(!) (see Anderson, 1978: 65); □ referred as "pleopods of the telson"(!) (see Poole, 1966: 93); ○ occasionally 13-15; ∞ occasionally 10-12.

Table 2. Continued.

CHARACTER \ SPECIES	ATLANTIC COASTS OF NORTH AMERICA			JAPAN	ATL., EUROPE	NEW ZEALAND	PACIFIC COASTS OF SOUTH AMERICA	
	Cancer irroratus							
	borealis (7)	(8)	(9)	*amphioetus* (10)	*pagurus* (11)	*novaezelandiae* (12)	*edwardsi* (13)	*setosus* (14)
Carap. length (mm)	ca. 1.75*	1.80	ca. 2.50*	ca. 2.0*	2.4	4.75	3.20	3.30
Antennule								
inner flag.(setae)	4	5	6	5-6	4(in fig.) 5(in text)	(2)*	4	5
out. flag.(aesthet.)	0, 7, 7, 5	0, 9, . . ?	0, 12, 9, 5	0, 8-11, 7-8, 5	0, 8, 4, 0	?	0, 8, 6, 4	0, 12, 12, 8
Antenna								
peduncle	(0, 1, 3)*	(0, 1, 1, 1,	(0, 2, 2,	4, 2, 3	1, 1, 2	(0, 5, 4, 4,	2, 2, 3	3, 2, 4
flagellum	(0, 0, 5, 0, 3, 0, 4, 5)*	?, 4, 3, 4)*	4, 0, 3, 0, 6, 4, 4)*	0, 0, 4, 0, 5, 0, 4, 4	0, 3, 4, 0, 3, 4	4, 4, 4, 4, 4, 4, 4, 3)*	0, 0, 2, 0, 5, 0, 4, 4	0, 0, 4, 0, 4, 0, 3, 5
Mandible (palp)								
distal segment	9	6-7	(9)*	8-9	7	(9)*	13	11
Maxillule								
endopod	(1/5)*	1/2	1/6	3+3 (unsegmt.)	2+2 (unsegmt.)	(1+3)* (unsegmt.)	2/2	1/2
basis	14	(15)*	23	23-26	21	(18)*	22	22
coxa	11	(9)*	10	13-16	13-14	(16)*	(4+7)*	15
Maxilla								
endopod	4+0	(2-3)+0	0+1	(3-4)+2	0+0	(0)*	3+0	(3-4)+1
basis	8+10 (18)	(10+9)*(19)	9+9 (18)	6+6 (12)○	9+8 (17)	(10+10)*(20)	(9+12)*(21)	10+12 (22)
coxa	6+5 (11)	(4+4)*(8)	5+5 (10)	6+5(11)∞	5+3-4 (8-9)	(7+6)*(13)	(6+4)*(10)	4+5 (9)
scaphognath.	44-55	58	ca. 46	56	48-49	(55)*	74	68-70

Table 2. Continued.

1st Maxilliped								
endopod (apically)	3+2	(3+0)*	3+3	3+4	4+4	(4+2)*	4+1	3+1
basis	(20)*	(17)*	(29)*	23	19-22	(16)*	(24)*	20-24
coxa	(12)*	(11)*	(19)*	7	11-12	(6)*	(8)*	10-12
exopod	2/5(in fig.) 2/4(in text)	(3/5)*	3/4	3/6	2/4	(2/5)*	4/5	3/5
epipod	?	8	?	10-13	4-5	(12)*	(15)*	11-13
2nd Maxilliped								
endopod	1, 1, 7, 8	(0, 1, 2, 6, 9)*	0, 2, 6, 8	1, 0, 4, 12	0*, 1, 5, 10	(0, 4, 5, 14)*	(2, 3, 7, 10)*	2, 2, 7, 9
exopod	0*/5	(0/5)*	0*/5	1/5	0/4	(0/5)*	1/5	0/5
epipod	?	2	2	2-3	0 (gill?)	(4)*	10-12	10-12
3rd Maxilliped								
exopod	0*/5	(3/5)*	3*/5	0/6	0*/4	(0/5)*	5-8/5	4-5/5
epipod	(15)*	(10)*	9	24	13-14	(11)*	(19)*	15-16
Uropods	0/10	0/9	?/9	1/8	0*/18	0*/11	1/9-10	1/10
	borealis	*Cancer irroratus*		*amphioetus*	*pagurus*	*novaezelandiae*	*edwardsi*	*setosus*

Indications: —, range of variation; 0, no setae; ?, no data; endites are indicated by "/" for emphasis when they are 2-segmented, and by "," for more than 2 segments; * from figures; ⊙ tip of frontal margin to median posterior carapace margin; †† referred as "lobes on the endopod"(!) (see Trask, 1970: 144; Anderson, 1978: 64); ▲referred as "exopod"(!)(see Anderson, 1978: 65); □ referred as "pleopods of the telson"(!) (see Poole, 1966: 93); ○ occasionally 13-15; ∞ occasionally 10-12.

cancrid species, as well as variability in the course of their respective larval developments is discussed in detail by Iwata and Konishi (1981).

The characters of the megalopa

In the megalopa stage there are considerable discrepancies between the published descriptions of the same species. For example, the descriptions of the megalopa of *C. anthonyi* by Trask (1974) and Anderson (1978) share hardly any characters. Table 2 shows that the two accounts give distinct setations for all of the appendages except the exopod of second maxilliped. The major differences are in respect of the mandibular palp, coxal endite of maxillule and epipod of the second maxilliped, which show differences of about twice the number of setae on the respective appendage when the two accounts are compared (erroneous identification ?). If both apparently contradictory descriptions are based on a well-identified species, and if these are correct observations, such a great differences in setation should probably be explained considering the different localities from where the material was obtained. Other similar differences are apparent in descriptions for *C. irroratus* given by Connolly (1923) (as *C. amoenus*) when compared with that by Sastry (1977), but this can be explained because the descriptions by the former author are based entirely on material obtained from plankton collections made at different stations along the East coast of Canada. Other minor discrepancies found in the larval terminology are indicated in the foot-note of Table 2.

In all *Cancer* megalopas, the outer flagellum of the antennule is 4-segmented, and the aesthetascs are arranged in tufts from the second to fourth segment distally, but exceptionally the antennule of *C. anthonyi* is illustrated by Trask (1974: 71) with aesthetascs also on the basal segment. Most species have a 11-segmented antenna (3-segmented peduncle + an 8-segmented flagellum), but an exception to this pattern is exhibited by the antenna of *C. irroratus*, described as having 8 segments in total (*see* Connolly, 1923: 347). A peduncle indistinctly 3-4 segmented and a flagellum 6-segmented have been reported for *C. irroratus* (Sastry, 1977) and *C. Pagurus* (Ingle, 1981).

Iwata and Konishi (1981) pointed out that specific identification of cancrid megalopas is possible using a combination of characters, including the setation of antenna and of endopods of the maxillipeds. Nevertheless, we have not considered the setation of the latter appendage since the profuse setation (especially on the distal segments of endopod of the 3rd maxilliped) is frequently difficult to check, and rarely is illustrated in detail. From Table 2, the setation of the antennal flagellum and of the epipod of the first to third maxillipeds are regarded here as useful characters for identifying several *Cancer* megalopas, especially the epipod of the second maxilliped. Its setation varies from 2 (*C. irroratus*) to 10-12 long, non-plumose setae (*C. edwardsi* and *C. setosus*), with a maximum variation of 19 in *C. magister*, as indicated by Poole, (1966: 92). Ingle (1981: 214) described an epipod "short and broad" for *C. pagurus*, but probably he

observed the rudiment of podobranch (gill) and missed the true epipod which is exhibited by all species; the epipod is relatively less developed in *C. irroratus* (Sastry, 1977: 165) and *C. anthonyi* (Anderson, 1978: 65) but greatly developed in *C. magister* (Poole, 1966: 96), *C. anthonyi* (Trask, 1974: 71) and *C. edwardsi* (Quintana, 1983: 15).

Zoogeography of cancrid larvae

The species of *Cancer* normally found along Western coasts of South America show a very wide latitudinal distribution (Fig. 1) which evidently results from hydrographic differences, affecting probably the duration of larval devlopment in these and other brachyuran larvae. The significance of adults bionomics, larval ecology and other factors has been discussed by Sastry (1983). Similarly, there should be expected some minor differences in larval size as well as in setation of some appendages. The Chilean coastal line where four *Cancer* species occur is extended between 18° and *ca.* 55° S. Lat., and in such vast coastal area there are noticeable differences in topography, climate, hydrography and currents (*see* Brattström and Johanssen, 1983). Ingle (1981) observed some zoogeographical differences between zoeal stages of Pacific and Atlantic species of *Cancer*, but no reports concerning this aspect is known for larvae from South Eastern Pacific. Although the results presented here are valid for the laboratory reared larvae, one might expect a shorter larval duration if the same study is done in warmer waters. Comparing species latitudinally separated, there are apparent differences in larval development; as an example, larvae of *C. anthonyi* spent 6.1, 5.0, 4.8, 4.8 and 5.7 days from the first to fifth zoeae at 22°C and 35±0.5 ppt salinity (Anderson, 1978), requiring 26.4 days for reaching the megalopal stage, and 35.8 days for the appearance of the first crab. This time is considerably shorter than the corresponding time for *C. setosus* to reach the megalopal stage. However, at laboratory conditions similar to those used in the present study, larvae of *C. antennarius* required 10.0, 6.0, 6.0, 6.0, and 8.0 days from the first to fifth zoeae, and a total larval development time of 36 days to megalopa (Roesijadi, 1976). Probably this is indicative of genotypic responses rather than due to laboratory conditions used.

The previously mentioned prolonged developmental times for *C. productus* (97 days) and *C. magister* (80 days) seem to be indicative of distributional patterns. In fact, both species show the northernmost distribution of all the species along the Pacific coast of North America (*cf.* Nations, 1975).

Considerations

The descriptions given here may aid identification of the larval stages and to differentiate them from those of other brachyuran crabs normally present in the meroplankton of the area.

The cancrid zoeae resemble very closely those of portunids in general morphology and setation, so that distinguishing the larvae of the two families is not easy (Rice, 1980; Ingle, 1981). Nevertheless, the morphology of the outer-

most seta in the telson (see Figs. 4, 6, 9) seems consistently to distinguish larvae of both families. In the megalopal stage, the separation of the families is quite easy, mainly because portunid megalopas have (a) a very distinctive dactyl 5, which is markedly flattened, lanceolate, generally with more than 3 long, hooked setae, (b) the possession (in most of portunids) of a stout sternal spine at base of pereiopod 4, and (c) the absence of median posterior carapace spine. However, the external morphology of cancrid megalopal stage resembles that of the parthenopids (Yang, 1971; *cf*. Kurata and Matsuda, 1980; *cf*. Terada, 1985) rather than of the portunids.

With the exception of the early accounts of Lebour (1928) and recently Ingle (1981) on *C. pagurus*, descriptions and illustrations of the early post-larval stages (crab stages) are scarce in the literature. It is the authors' opinion that attention to these stages is also required to complement larval descriptions since distinguishing characters may not appear until after four or more crab instars, as has recently been indicated by Martin *et al.* (1984) for xanthid crabs, and more recently by Quintana (1986) for leucosiid early crabs. A knowledge of early post-larval stages of cancrid crabs and other groups is regarded here as necessary for resolving some interesting ecological problem; it is well known that many neritic and bentho-demersal fishes obtain their food from megalopas and young crabs, as proved by Reilly (1983) for *C. magister* in California.

Summary

The complete larval development of the edible crab, *Cancer setosus* Molina, 1782 under laboratory conditions, and observations on the prezoea and first zoea stages of *Cancer coronatus* Molina, 1782 are described in this paper. The larval development of the former species consists of a short-duration prezoea, five zoeal and one megalopal stage. The time required from hatching to reach the megalopal stage is about 60 days in *C. setosus*, at 13.5-14.6 °C temperature and 33, 2 ppt salinity. Scanning electronic microscopy observations of the prezoea stage of *C. coronatus* comprises the first account for this stage in brachyuran crabs. The present material from Chilean coasts (South-Eastern Pacific) is compared with previously published reports on larvae of congeneric species from other areas, and suggested groupings of all the known cancrid zoeae (15 species) is also presented. A comparison of the setation of megalopal appendages is also given, suggesting here that the setation of the antennal flagellum and of the epipod of the first to third maxillipeds are regarded as useful characters for identifying several *Cancer* megalopas.

Acknowledgements

The main part of this study was carried out at the University of Concepción, Chile (Dichato Marine Biological Station), partially supported by a grant (DI-203701), but the reexamination

of first zoeal stages and SEM observations of both species were carried out at the Faculty of Science, Hokkaido University, Japan. Therefore, one of us (R.Q.) is grateful to Prof. Fumio Iwata, Hokkaido University for all facilities provided for the completion of this work, and posterior reading of the manuscript, as well as to Dr. K. Konishi for helpful discussions, and to Y. Takakuwa for his technical assistance in SEM observations. We are particularly grateful to Dr. A.L. Rice (Institute of Oceanographic Sciences, Surrey, United Kingdom) and to Dr. R.W. Ingle (British Museum, Natural History, London, U.K.) who critically read the manuscript providing many helpful suggestions for its improvement.

References

Aikawa, H. 1937. Further notes on brachyuran larvae. Rec. Oceanogr. Wks. Japan **9**: 87-162.

Ally, J.R. 1975. A description of the laboratory-reared larvae of *Cancer gracilis* Dana, 1852 (Decapoda, Brachyura). Crustaceana **28**: 231-246.

Anderson, W.R. 1978. A description of laboratory-reared larvae of the Yellow Crab, *Cancer anthonyi* Rathbun (Decapoda, Brachyura), and comparisons with larvae of *Cancer magister* Dana and *Cancer productus* Randall. Crustaceana **34**: 55-68.

Brattström, H. and A. Johanssen 1983. Ecological and regional zoogeography of the marine benthic fauna of Chile. Report N° 49 of the Lund University Chile Expedition 1948-1949. Sarsia **68**: 289-339.

Concha, C. 1978. Contribución al estudio de las larvas de Crustacea Decapoda de Bahía Concepción, Chile. Unpublished Thesis, University of Concepción, Chile: 1-149.

Connolly, C.J. 1923. The larval stages and megalops of *Cancer amoenus* (Herbst). Contr. Canad. Biol. Fish., n. ser. **1**: 337-352.

Fagetti, E. 1960. Primer estadio larval de cuatro crustáceos Braquiuros de la Bahía de Valparaíso. Rev. Biol. Mar. **10**: 143-154.

Ingle, R.W. 1980. British Crabs. Br. Mus. (Nat. Hist.), Oxford University Press Inc., New York. pp. 1-213.

———— 1981. The larval and post-larval development of the Edible crab, *Cancer pagurus* Linnaeus (Decapoda: Brachyura). Bull. Br. Mus. Nat. Hist. (zool.) **40**: 211-236.

Iwata, F. 1973. On the first zoea of the crab, *Cancer amphioetus* Rathbun from Hokkaido, Japan. Proc. Jap. Soc. syst. Zool. **9**: 21-28.

Iwata, F. and K. Konishi 1981. Larval development in laboratory of *Cancer amphioetus* Rathbun, in comparison with those of seven other species of *Cancer* (Decapoda, Brachyura). Publ. Seto mar. biol. Lab. **26**: 369-391.

Kurata, H. and T. Matsuda 1980. Larval stages of a parthenopid crab, *Parthenope validus*, reared in the laboratory and variation of egg size among crabs. Bull. Nansei reg. Fish. Lab. Japan **12**: 31-42.

Lebour, M.V. 1928. The larval stages of the Plymouth Brachyura. Proc. Zool. Soc. Lond. **1928**: 473-560.

Martin, J.W., Felder, D.L. and F.M. Truesdale 1984. A comparative study of morphology and ontogeny in juvenile stages of four Western Atlantic xanthoid crabs (Crustacea: Decapoda: Brachyura). Phil. Trans. Roy. Soc. Lond., ser. B, **303**: 537-604.

Mir, R.D. 1961. The external morphology of the first zoeal stage of the crabs, *Cancer magister* Dana, *Cancer antennarius* Stimpson, and *Cancer anthonyi* Rathbun.

Calif. Fish and Game **47**: 103-111.

Nations, J.D. 1975. The Genus *Cancer* (Crustacea: Brachyura); Systematics, biogeography and fossil record. Los Angeles Co. Nat. Hist. Mus. Sci. Bull. **23**: 1-104.

Poole, R.I. 1966. A description of laboratory-reared zoeae of *Cancer magister* Dana, and megalopae taken under natural conditions (Decapoda, Brachyura). Crustaceana **11**: 83-97.

Quintana, R. 1983. Larval development of the Edible crab, *Cancer edwardsi* Bell, 1835 under laboratory conditions (Decapoda, Brachyura). Rep. Usa mar. biol. Inst. **5**: 1-19.

———— 1984. On the prezoeal stage of three species of the genus *Cancer* L. from Chilean coasts (Cancridae, Brachyura). Res. Crust. **13/14**: 143-151.

———— 1986. On the early post-larval stages of some leucosiid crabs from Tosa Bay, Japan (Decapoda: Brachyura, Leucosiidae). J. Fac. Sci. Hokkaido Univ. Ser. **6** Zool. **25**: 227-266.

———— and K. Konishi 1986. On the prezoeal stage: observations on three *Pagurus* species (Decapoda, Anomura). J. Nat. Hist. **20**: 837-844.

Reilly, P.N. 1983. Predation on Dungeness Crabs, *Cancer magister*, in Central California. *In*: Wild, P.W. and R.N. Tasto, eds., Life history, environment, and mariculture studies of the Dungeness Crab, *Cancer magister*, with emphasis on the Central California fishery resource. Calif. Dept. Fish and Game, Fish Bull. **172**: 155-164.

Retamal, M.A. 1981. Catálogo ilustrado de los Crustáceos Decápodos de Chile. Gayana, Zool. **44**: 1-110.

Rice, A.L. 1975. The first zoeal stages of *Cancer pagurus* L., *Pinnotheres pisum* (Pennant) and *Macrophthalmus depressus* Rüppell (Crustacea, Decapoda, Brachyura). Bull. Br. Mus. Nat. His. (zoology) **28**: 237-247.

———— 1980. Crab zoeal morphology and its bearing on the classification of the Brachyura. Trans. Zool. Soc. Lond. **35**: 271-424.

———— and D.I., Williamson 1977. Plankton stages of Crustacea Malacostraca from Atlantic Seamounts. "Meteor" Forsch. Rei. D, **26**: 28-64 (not seen).

Roesijadi, G. 1976. Descriptions of the prezoeae of *Cancer magister* Dana and *Cancer productus* Randall and the larval stages of *Cancer antennarius* Stimpson (Decapoda, Brachyura). Crustaceana **31**: 275-295.

Sastry, A.N. 1977_a. The larval development of the Rock Crab, *Cancer irroratus* Say, 1817, under laboratory conditions (Decapoda Brachyura). Crustaceana **32**: 155-168.

———— 1977_b. The larval development of the Jonah Crab, *Cancer borealis* Stimpson, 1859, under laboratory conditions (Decapoda Brachyura). Crustaceana **32**: 290-303.

———— 1983. Pelagic larval ecology and development. *In*: D.E. Bliss, ed., The Biology of Crustacea **7**: 214-282. Academic Press.

Terada, M. 1985. On the larval development of *Parthenope* (*Platylambrus*) *valida* De Haan (Brachyura, Parthenopinae). Zool. Sci. **2**: 731-737.

Trask, T. 1970. A description of laboratory-reared larvae of *Cancer productus* Randall (Decapoda, Brachyura) and a comparison to larvae of *Cancer magister* Dana. Crustaceana **18**: 133-146.

———— 1974. Laboratory-reared larvae of *Cancer anthonyi* (Decapoda, Brachyura) with a brief description of the internal anatomy of the megalopa. Mar. Biol. Berlin **27**: 63-74.

Wear, R.G. 1965. Zooplankton of Wellington Harbour, New Zealand. Zool. Publ. Victoria Univ. Wellington **38**: 1-31.

——— and D.R. Fielder 1985. The marine fauna of New Zealand: Larvae of the Brachyura (Crustacea, Decapoda). New Zealand Oceanogr. Inst., Mem. **92**: 1-90.

Yang, W.T. 1971. The larval and postlarval development of *Parthenope serrata* reared in the laboratory and systematic position of the Parthenopidae (Crustacea, Brachyura). Biol. Bull. **140**: 166-189.