Abbreviated Larval Development of Fresh-water Atyid Shrimp, Caridina brevirostris Stimpson from Iriomote Island of the Ryukyus (Decapoda, Atyidae)

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Summary

The atyid shrimp, *Caridina brevirostris* Stimpson was reared in the laboratory from egg to young shrimp. This shrimp bears large eggs containing much yolk, and the egg hatches as a considerably advanced zoea of benthonic habit. The zoeal larva reaches the first juvenile stage passing through a megalopal stage by at least 3 days. In this report some characteristics of the larvae and juvenile are described and illustrated. The newly-hatched larva shows the adult form in all the appendages but the uropods. Until juvenile, the larvae do not take food, subsisting on the stored yolk.

Introduction

The taxonomical studies of the family Atyidae from Japanese and its adjacent inland water have hitherto been made by many workers (de Haan, 1849[1]; Stimpson, 1860[2]; Rathbun, 1902[3]; Balss, 1914[4]; Kemp, 1918[5]; Kaki & Tsuchiya, 1923[6]; Ueno, 1935[7]; Kubo, 1938[8]; 1941[9]; Kamita, 1970[10] etc.). However, only a few reports have been done with regard to the larval development.

Yokoya (1931)[11] reported on the larval development of *paratya compressa* with normal larval life. Mizue and Iwamoto (1961)[12] gave some detailed illustrations of the larval development of *Caridina* (=*Neocaridina*※) *denticulata*. In this species free-swimming larval life is completely abbreviated.

Caridina brevirostris is a rather small fresh-water shrimp with the body-length of approximately 13 to 17 mm in the ovigerous females and bears a few and large eggs. This shrimp is usually found in fresh-water such as mountain or hill rivulets, caves and springs. No detailed investigation of the larval development of this shrimp has been reported; so far as I am aware.

The present study has been carried out for the purpose of rearing the larvae of *C. brevirostris* from hatching to young shrimp in the laboratory, providing a detailed illustration and description of each stage.

Material and Method

The berried females of *Caridina brevirostris* were collected in the upper-stream of

Received November 20, 1972

*Contribution No. 7 from the Okinawa Prefecture Fisheries Experiment Station, Ishigaki-shi, Okinawa, Japan.

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※The genus *Neocaridina* was created by Kubo (1938)[8], but this genus has been included in the *Caridina* by Holthuis (1955)[14]. In the present paper, I employed the *Caridina* as a synonym of the *Neocaridina*.

the Urauchi River which flows from east to west of Iriomote Island (24° 20′ N 124° 50′ E) in the Ryukyu Islands. The shrimps were transported on June 30, 1970 to the Okinawa Prefecture Fisheries Experiment Station at Ishigaki Island, and were kept in an aquaria containing fresh-water provided with moderate aeration. Temperature was not controlled during the course of the study, varying from 28.0° C to 29.5° C.

When hatched, larvae were siphoned out and removed to a circular plastic jar (36 cm diameter x 30 cm height in size) with clean fresh water, in which they were reared to young shrimps. The juvenile shrimps were fed on an artificial diet which is commonly used in the eel culture in Japan.

The specimens of each growth stage were fixed in 5% formalin. Thereafter they were preserved in 50% ethylene glycol. The larvae were dissected under a stereomicroscope, and all the drawings were made with the aid of a profile projector and a binocular compound microscope. Measurements were made by a low power microscope with an ocular micrometer. Body-length was measured from the base of the eyes to the tip of telson excluding terminal setae. Size of eggs was shown by the average of ten eggs.

The names in each larval phase are used "zoea" and "megalopa", which were employed in the wide sense by Williamson (1969)[13]. The terms "juvenile" and "young" applied to the stages following the megalopa were used after Williamson (1969)[13] and Kurata (personal communication).

Results

Number and size of eggs

The eggs of *Caridina brevirostris* are oval in shape, and measure 1.2 × 0.8 mm on an average when freshly laid (Table 1). The egg of this shrimp is the largest in size as compared with any other known atyid shrimp in Japan.

Table 1

Size of females and their pre-eyed eggs in *Caridina brevirostris*

Sp. No.	Body-length (mm)	Size of eggs (mm)
1	14.4	1.19×0.82
2	15.5	1.28×0.77
3	15.5	1.18×0.73
4	15.5	1.29×0.88
5	15.7	1.22×0.69
6	16.0	1.28×0.84
7	16.2	1.27×0.82
8	16.5	1.24×0.70
9	16.5	1.26×0.88
10	16.7	1.19×0.75
Average	15.9	1.24×0.79

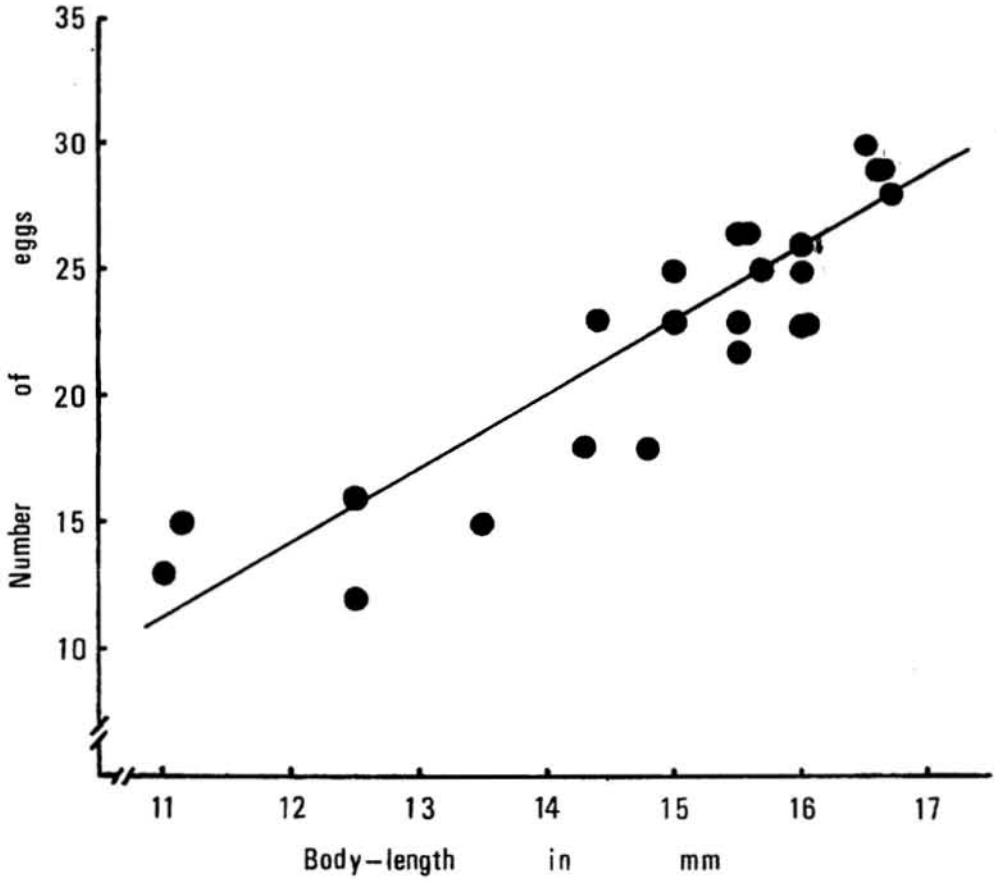

Fig. 1. The relationship between the number of eggs (Y) and body-length (X) in *Caridina brevirostris*.

The number of eggs varies 13 to 30. Figure 1 shows the relationship between number of eggs (Y) and body-length (X) in the females of *C. brevirostris* from Iriomote Island. There is a linear relation between the body-length and the number of eggs. During the embryonic development the eggs undergo color change from orange to bright-gray and this change is closely correlated with the increase in the size of the eggs.

Larval development

Caridina brevirostris reared in the laboratory may attain the juvenile stage after one zoeal and megalopal intermolt. Major characteristics of the larval and juvenile stages are as follows:

Zoea (Fig. 2)

Size : body-length 2.56 mm, carapace length 0.84 mm. Duration : 1 day.

Rostrum short, acute, straight, directed somewhat downwards, and triangular in upper aspect, reaching tip of 3rd antennular peduncle; toothless on both upper and lower borders. Carapace with antennal and pterygostomian spines, alone. Eyes stalked. Telson fan-shaped, slightly longer than 6th abdominal somite, with 8 pairs of plumose

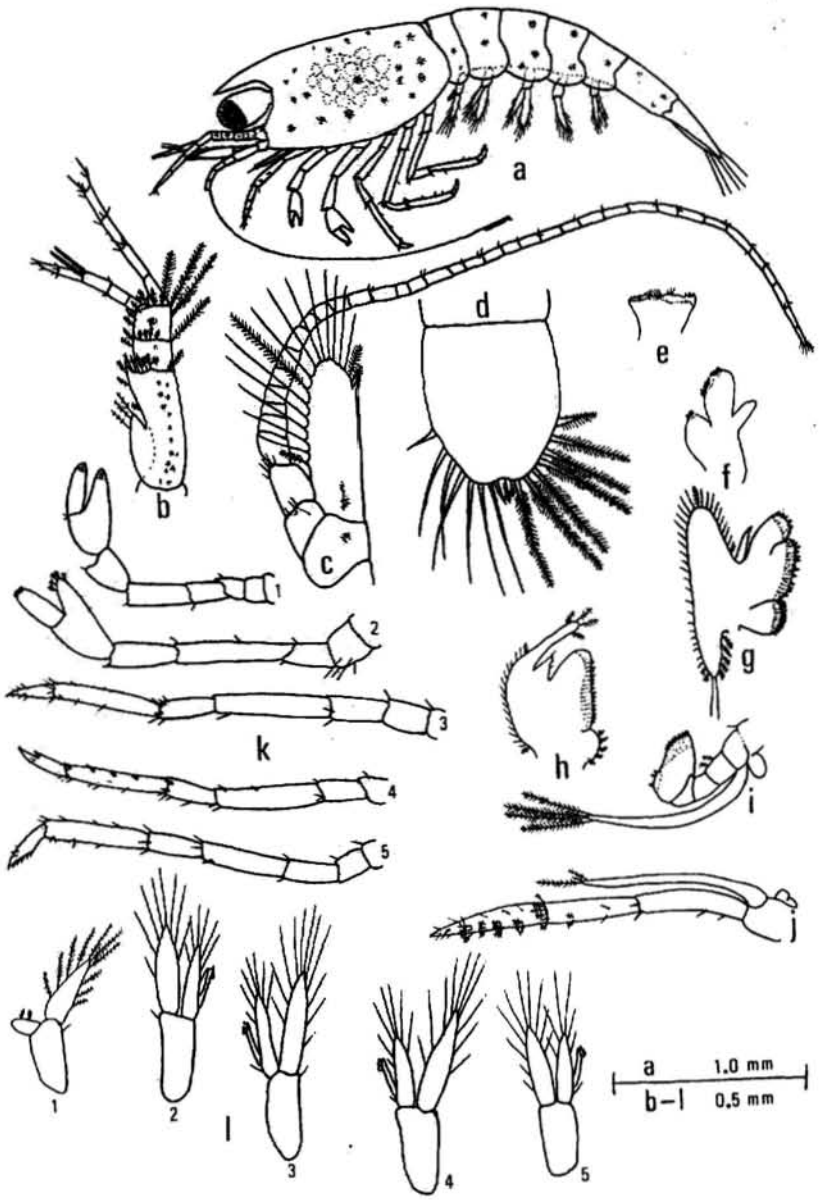

Fig. 2. *Caridina brevirostris* Stimpson. Zoal stage: a, lateral view; b, antennule; c, antenna; d, telson; e, mandible; f, maxillule; g, maxilla; h, first maxilliped; i, second maxilliped; j, third maxilliped; k-1~5, 1st, 2nd, 3rd, 4th and 5th pereiopods; I-1~5, 1st, 2nd, 3rd, 4th and 5th pleopods.

setae.

Antennular peduncle 3 segmented, not reaching distal margin of antennal scale; first segment the largest, its proximal part with a stylocerite bearing 3 plumose setae; second and third segments subequal in length, much shorter than first. Inner antennular flagellum 4 segmented, outer 5 segmented with 2 aesthetes on junction between 3rd and 4th joints. Antenna biramous. Antennal scale unsegmented distally; blade with 18 plumose setae along inner and terminal margins; disto-lateral tip pointed to a spine; flagellum about 35 jointed, slightly shorter than body-length.

Mandible without palp, molar and incisor processes undefined. First maxilla uniramous; inner lacinia with 3 small spines, and upper with several small spines. Second maxilla biramous; endopod palp-like, unsegmented; exopod ear-like, large, with 36-37 plumose and naked setae around almost entire margin, 2 posterior naked of them longer than anterior and lateral setae; endite 3 lobed, lower lobe with several naked setae, median lobe with about 12 small spines and twice as wide as lower and upper lobes, upper lobe with 5 small spines.

First maxilliped biramous; endopod enlarged, unsegmented, with 1 apical and 2 sub-apical naked setae; exopod 3 times as long as endopod, with 2 apical and 2 sub-apical plumose setae (not always developed); caridean lobe well developed with 17-18 plumose setae; protopod bilobed; lower lobe with 5 plumose setae; upper lobe larger than lower, with numerous lacerated spines. Second maxilliped biramous; endopod 4 segmented, shorter than exopod; exopod with 2 apical and 2 sub-apical plumose setae; epipod simple, bud. Third maxilliped biramous; endopod 3 segmented, lst and 3rd segments of subequal length and slightly longer than 2nd segment; exopod shorter than endopod, with 1 apical plumose and 2 short naked setae, and 1 sub-apical plumose seta distally.

First and second pereiopods chelate, 5 segmented, former shorter than latter. Third, fourth and fifth pereiopods well developed with sensory hairs. All pereiopods lacking exopods. Pleopod biramous; endopod of lst pleopod expanded with 2 short plumose setae; endopods of 2 to 5 bearing appendices internae with distal hooklets; endo- and exopod of plepods with several plumose setae around margin.

There are prominent pink chromatophores scattering on carapace, dorso-lateral parts of all abdominal somites, antennular peduncle and base of antennal scale.

MAGALOPA (Fig. 3)

Size: body-length 2.76 mm, carapace length 0.91 mm. Duration: 2-3 days.

Rostrum, eyes, carapace and abdominal somites almost similar to those in the preceding stage. Telson sligthly longer than 6th abdominal somite; dorso-lateral margin with a pair of strong spines in distal three-eighths of telson, and 2 pairs of bristles at postero-lateral margin; posterior margin with 5 pairs of plumose setae, of which the medial one shortest. Uropod biramous, unsegmented; exopod with 16 to 18 plumose setae along inner and terminal margins and 3 short plumose setae along outer margin; disto-lateral tip pointed to a spine bearing 3 small stout spines along inner margin; endopod sligthly shorter than exopod, with 15 to 16 plumose setae.

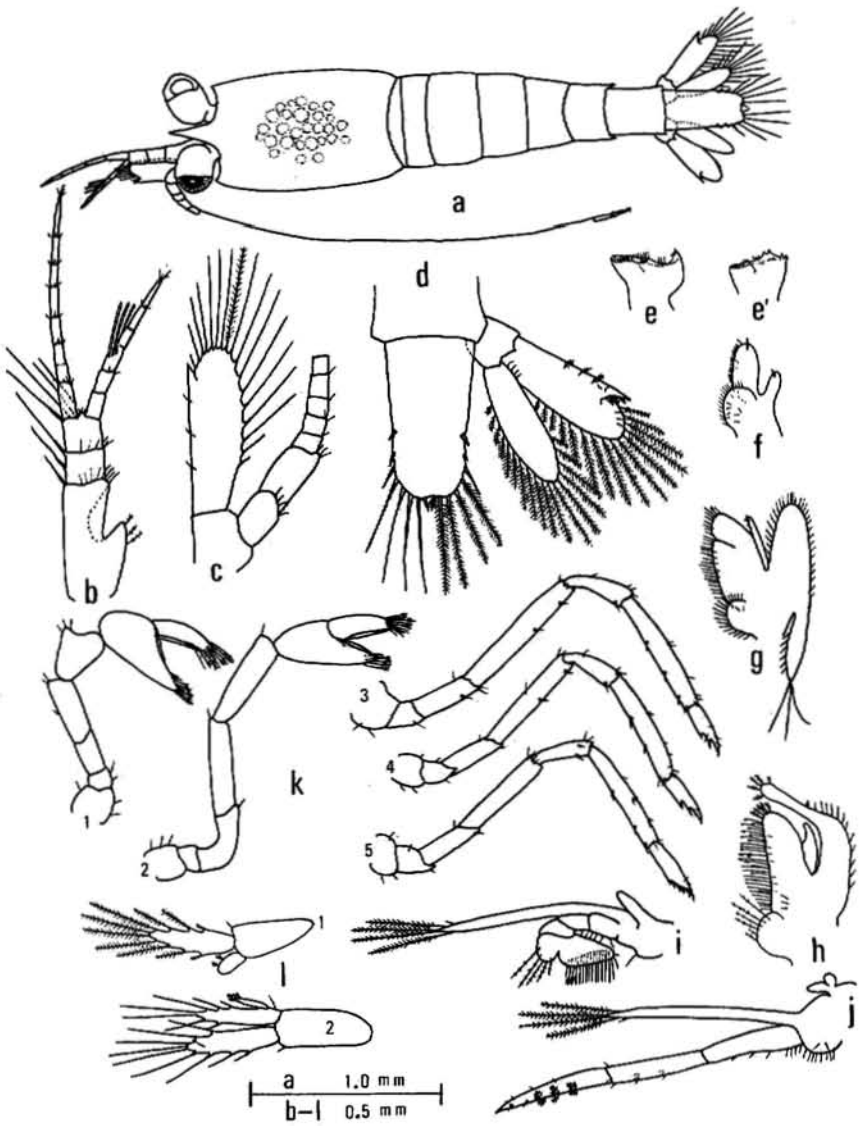

Fig. 3. *Caridina brevirostris* Stimpson. Megalopal stage:
a, dorsal view; b, antennule; c, antenna; d, telson and uropod; e and e', mandibles; f, maxillule; g, maxilla; h, first maxilliped; i, second maxilliped; j, third maxilliped; k-1~5, 1st, 2nd, 3rd, 4th and 5th pereiopods; I-1~2, 1st and 2nd pleopods.

Endopod of antennular flagellum 8 jointed, longer than exopod; exopod 6 jointed with 3 esthetes on medial portion of the 3rd segment. Antenna almost similar to the preceding stage in shape.

Mandible without palp, almost unchanged in form from that of the first zoea stage. First maxilla well developed; endopod with a stout spinule at tip; inner lacinia with numerous short plumose setae marginally; upper lacinia with several spinules. Endite of second maxilla trilobed; each lobe with many setae; endopod simple with a naked seta at tip; exopod or scaphognathite ear-like, with many plumose setae around margin and 3 long naked setae postero-distally.

Endite of lst maxilliped bilobed; lower lobe with 6 plumose setae; upper lobe with numerous naked and plumose setae; endopod simple, enlarged; exopod with 5 plumose setae at tip; caridean lobe with 13 plumose setae. Second maxillpied well developed; endopod of 4 segments, of which the ultimate bilobed, largest, with several naked and plumose setae. Third maxilliped almost similar to that of the preceding stage in form.

Fingers of chelae of lst and 2nd pereiopods well developed, spoon-like, ending in tufts of bristles. Third, fourth and fifth pereiopods fully developed.

All pleopods similar to those of the preceding stage except increment of setae.

First juvenile (Fig. 4)

Size: body-length 2.96 mm, carapace length 0.94 mm. Duration: 5-6 days.

Rostrum without tooth, lower border with 3 plumose setae.

Telson elongate and narrower posteriorly, with 2 pairs of strong dorso-lateral spines; posterior margin with a pair of spinules and of median short plumose setae and 4 pairs of plumose setae between spines and setae. Uropods well developed; a stout spine placed at disto-lateral tip of exopod with 4 to 5 spinules along its inner margin.

Dactylus of 5th pereiopod with 7 strong spinules in distal half.

Appendages almost similar to those in the preceding stage except in size and number of segments, setae and spines.

Discussion

Sollaud (1923)[15] divided the larval development of the farmily Palaemonidae into the following three types: The first is the common type which passes through normal zoeal stages, the second has some abbreviated zoeal stages, and the third lacks completely free-swimming larval life. The larval development of *Caridina brevirostris* may conform to the third type. The species fitting Sollaud's hitherto known third type are the following four palaemonid and atyid shrimps: *Palaemonetes mesogenitor* (Sollaud, 1923)[15], *Macrobrachium shokitai* (in press)[17], *Caridina denticulata* (Mizue & Iwamoto, 1960)[12] and *Caridina* sp. (Shokita, unpublished data). Such larval development occurs usually in the fresh-water shrimps (Gurney,1942)[16].

The first larval stage of *C. brevirostris* is characterized by the following features: (1) stalked eyes, (2) 3 segments of antennular peduncle, (3) long antennal flagellum, (4) absence of segmentation in antennal scale, (5) absence of exopods on pereiopods, (6) biramous setose pleopods, and (7) presence of 16 telson setae. In the first stage larvae the appendages are almost of adult form, but some larval characters still remain

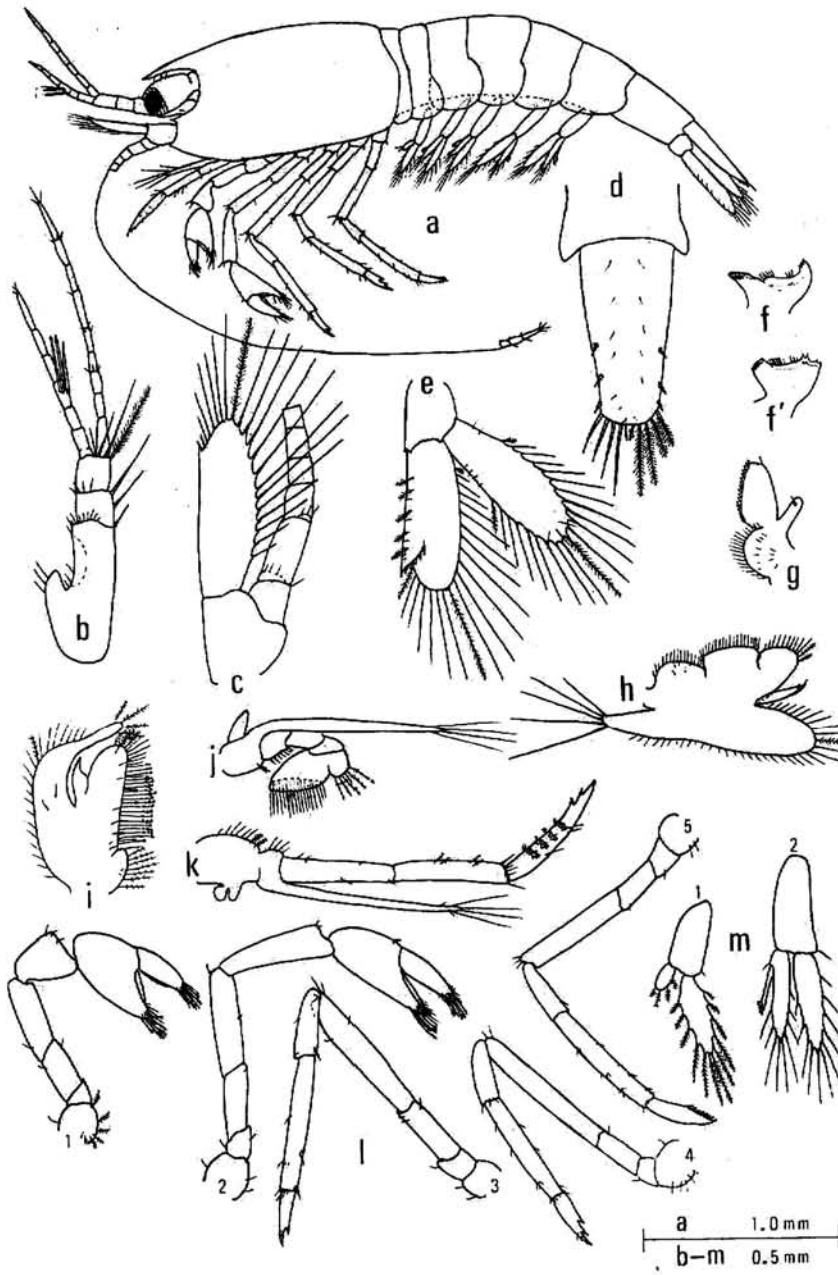

Fig. 4. *Caridina brevirostris* Stimpson. First juvenile stage:
a, lateral view; b, antennule; c, antenna; d, telson; e, uropod; f and f', mandibles; g, maxillule; h, maxilla; i, first maxilliped; j, second maxilliped; k, third maxilliped; l-1~5, 1st, 2nd, 3rd, 4th and 5th pereiopods. m-1~2, 1st and 2nd pleopods.

as shown in that the uropods are absent, while the mouth parts (mandible, lst, 2nd maxilla and lst, 2nd maxillipeds) and the lst and the 2nd pereiopods are not functional. The telson of the first stage larva could be considered homologous with such normal second zoea as seen in the other atyid and palaemonid shrimps. In the second stage larvae, their pleopods are well developed and functional. The second larvae have also the well-developed mouth organs and the lst and the 2nd pereiopods, but these appendages are not yet functional because they do not feed and subsist on the stored yolk until the next juvenile. So, the second stage may functionally be regarded as "megalopal larva" (Kurata, 1968[18]; Williamson, 1969[13]). The third stage juvenile has the full-developed appendages and begins to take food.

Mizue & Iwamoto (1960)[12] gave the illustration of the larval development of *Caridina denticulata*, but did not give the detailed descriptions. Judging from their figures, the larvae of *C. brevirostris* somewhat resemble those of *C. denticulata*, but is easily distinguished from it by the fact that *C. brevirostris* lacks teeth on the upper border of rostrum, instead of *C. denticulata* being armed with them.

Yokoya (1931)[11] reported on the larval development of an atyid shrimp, *Paratya compressa*, which bears numerous small eggs and passes through a long free-swimming larval life. There are very marked differences between *C. brevirostris* and *P. compressa* in the number of the larval stages and the morphology, in the latter there are ten larval stages, and the eggs hatch out as the planktonic zoea with the exopod.

As stated in the introduction, *Caridina brevirostris* is usually found in mountain and hill streamlets, springs and caves. In the Urauchi River, this shrimp lives exclusively in pools in very small streamlets of the upper-stream and river-head areas where *Macrobrachium shokitai* (in press)[17], which bears very large eggs containing much yolk, and the egg hatch out as a considerably advanced zoea of benthonic habit; is also found. Such environments provide a small amount of food for the larva to lead a long planktonic life. The palaemonid and atyid shrimps living in such environments generally show a tendency to lay a few but large eggs, and the eggs hatch as the advanced, non-natatory zoea. In case of potamonid crabs the larval stages are completely suppressed and the eggs hatch as juvenile crab.

On the other hand, the atyid shrimps, *Paratya compressa*, *Atya moluccensis*, *Caridina typus*, *C. leucosticta*, *C. grandirostris* and *C. serratirostris* are also found in the Urauchi River. These species are found in down stream to middle stream, at a comparatively short distance from the sea, and lay numerous small eggs. As their eggs hatch as a natatory zoea with the exopod, the larval life appears to lead in brackish and marine waters. In fact, the larvae of these species require some salinity to metamorphose (Shokita, unpublished data), while those of *C. brevirostris* grow only in fresh-water.

Acknowledgments

I wish to express my thanks to Professors S. Nishijima and K. Yamazato of Ryukyu University for their critical reading of the manuscript. I am also indebted to Dr. T. Fujino of Kyushu University for his advice and helpful criticism to this study. Thanks

are much extended to Dr. S. J. Townsley of Hawaii University for kindly translating Stimpson's Latin reference.

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