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CARIDEA—THE CARIDINA (ATYIDAE), THE
PALAEMONETES AND THE PALAEMON
(PALAEMONIDAE)



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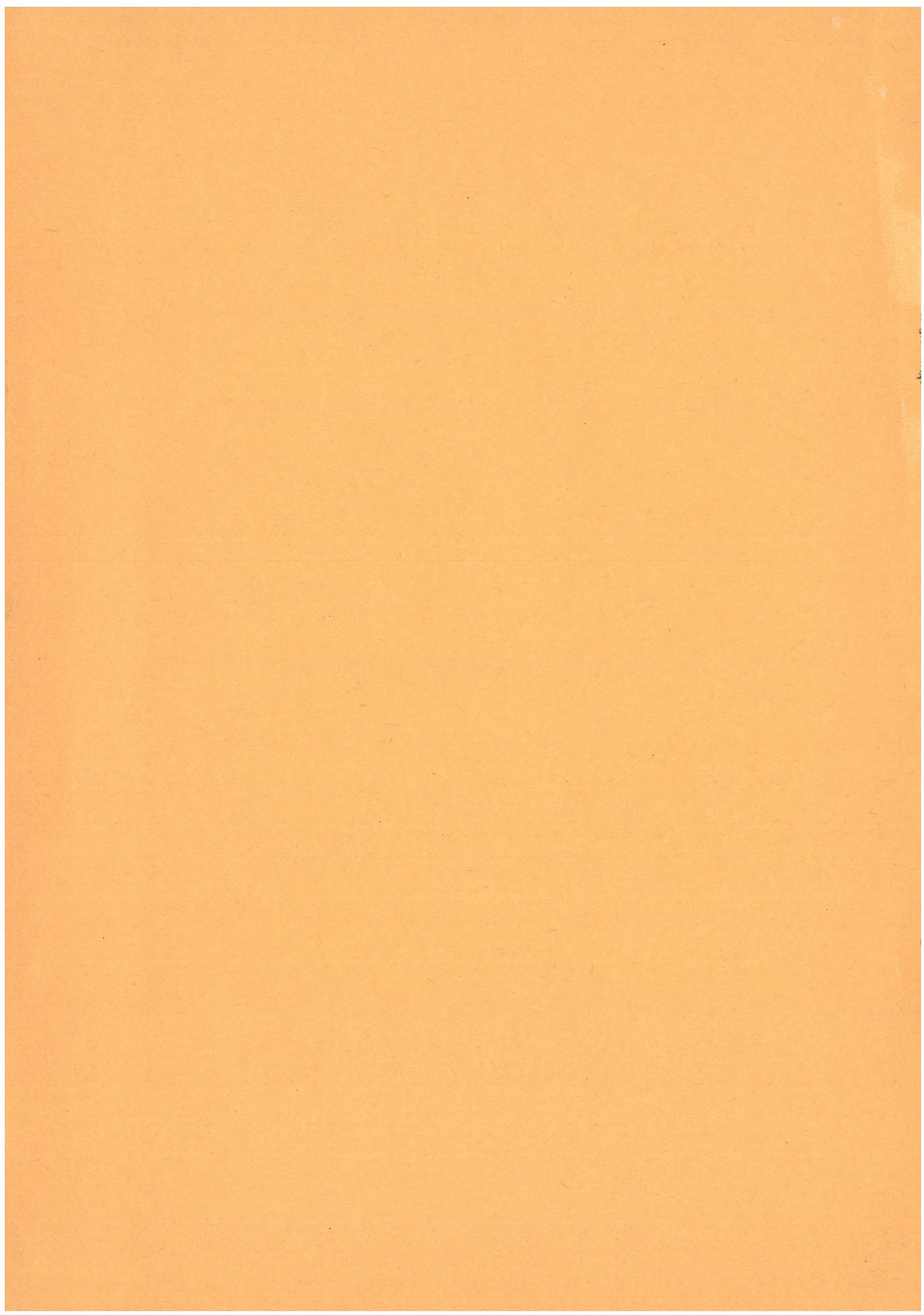
BY

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THE LARVAL DEVELOPMENT OF SOME PEIPING
CARIDEA—THE CARIDINA (ATYIDAE), THE
PALAEMONETES AND THE PALAEMON
(PALAEMONIDAE)*

BY

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(Plates I-XIII)**

During the last decade, some leading zoologists called much attention than ever before to the study of larval development of certain lower animals such as Annelida by Mr. D. P. Wilson, Mollusca by Dr. M. V. Lebour and mostly Crustacea by Dr. R. Gurney and the lady zoologist, Dr. M. V. Lebour.

The knowledge on larval development is extremely interesting, if we are desirous to trace the systematic relationships or eager to see evidences for the phylogeny of certain groups of animals. For such purposes, Decapod Crustacea is, of course, one of the good subjects for investigation.

From May to July, 1937, some dozens of egg-bearing females of the three species of shrimps were successively brought into my laboratory from the streams or creeks at Peiping. They were placed separately into some ordinary aquaria adjusted with slowly running water. The

* This work was commenced in the zoological laboratory of the National University of Peking, Peiping. It was continued in the Fan Memorial Institute of Biology, Peiping for few days in October, 1937 and now I am enabled to conclude it in the Department of Biology, the National Southwestern Associated University, Kunning, Yunnan, with the support of the China Foundation, after more than one year's interruption.

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** For explanation of plates see pages 211-223.

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eggs on the pleopods were found to increase in size day by day. Most of them hatched out and the larvae attached themselves to the water plants or by far most the wall of the aquaria. I transferred one or two larvae of each species to a glass bowl filled with sufficient amount of pond water, which was changed everyday. One bowl represents one series and thus twenty series for each species were prepared. I reared them with diatoms at very early stages and ciliated protozoa later on. The skins cast off in each bowl were preserved in alcohol with respective labels.

The larvae of *Caridina denticulata* are comparatively hardy, they cast their skins continuously until the fifth larval stage; the larvae of the *Palaemonetes sinensis* are relatively less durable in living in the captivity, there remained only four series growing up to the fourth larval stage; and of the last species of *Palaemon nipponensis* are found to be the most difficult one to live in a confined environment, they died soon after hatching and never sloughed their skins with the exception of only a few examples, which also stopped to grow after the first ecdysis.

The moults were passed through at intervals of 2 to 3 days without any great increase of size.

The cast skins from each ecdysis should be collected and preserved in the due time, if not, it would be devoured by the animal itself, and consequently the series for certain individual would be rendered incomplete. Such difficulty has been experienced by myself in the present work.

The illustrations made for this paper are therefore not based upon a single series in any one of the species. For making up the missing links, some stages are supplemented by different individuals from different series.

LARVAL DEVELOPMENT

I. *Caridina denticulata* de Haan

Very little is known about the larval characters of the family Atyidae to which the genus *Caridina* Milne-Edwards belongs (Shen, 1934, p. 540), the following notes on the larval development of this species are perhaps for the first time recorded in the larval history of Decapod Crustacea.

The first collection of the egg-bearing females was made on May 4th, 1937, carrying each about 80 eggs in average. The eggs when first taken were almost roundish in shape (0.82×0.58 mm.) gradually becoming elongated in the advanced stages. They measured 1.04×0.56 mm.

just before hatching. The larvae, enclosed in a thin transparent egg-membrane, brightly coloured, the chromatophores are tea-green, the eyes conspicuously black, the yolk granules pumping fore and backwards near the heart region, could be seen curled up.

The larvae first hatched out on May 10, are in an advanced condition. They generally assume the form of the adult, excepting the most remarkable character of the telson. I got the stage V on May 25.

The descriptions of their successive stages or metamorphosis are given below:

Stage I: Length about 3.2 mm.. (Pl. I, fig. 1; Pl. II, figs. 3-6; Pl. III, figs. 7-20; Pl. V, figs. 32-35).

Rostrum pointed anteriorly, curved slightly downwards and reaching little beyond the antennular basal segment, with 5-6 spinules along the dorso-median line and 1 spinule and 2 setae on the ventral surface (Pl. III, fig. 7).

Carapace smooth, more than $1/3$ of the body length. Supraocular spine small.

Abdomen smooth, somite 6 fused with the telson (Pl. I, fig. 1; Pl. II, fig. 3).

Telson club-shaped, very characteristic for the genus, distal border with a shallow median emargination, and 8+8 plumose setae, seta 1 with plumes on posterior side only, setae 2-8 on both sides, setae 1-7 increasing successively in length, seta 8 smallest (Pl. I, fig. 1; Pl. II, fig. 3; Pl. V, fig. 35).

Eyes large, peduncle short, stout and immovable.

Antennule, peduncle of 3 segments, segment 1 more than twice the length of segments 2 and 3 together, with a small stylocerite on the posterior half of the lateral side; segment 2 with 5 plumose setae; segment 3 with 3 similar setae. Outer flagellum 5-segmented, of which the segment 3 bears 2 club-shaped sensory hairs; inner flagellum 8-segmented (Pl. III, fig. 8).

Antenna flagellum quite long, about 35-segmented, reaching backwards as far as the abdominal somite 5. Scale large, with a pointed spine at the outer distal angle and a number of plumose setae along the apical and medial borders (Pl. I, fig. 1; Pl. II, fig. 3).

Mandible without palp, but incisor and molar processes well-developed, with 2 setae between them (Pl. III, fig. 9).

Maxilla 1 with 2 endites and 1 apical lobe. Endite 1 naked; endite 2 with a series of denticles along the medial border; apical lobe with a small apical seta (Pl. III, fig. 10).

Maxilla 2 with 3 endites and 1 slender apical lobe. Endite 1 with a number of longer setae; endites 2 and 3 with minute setae along their medial borders; apical lobe with a single apical seta. Exopodite or scaphognathite large, with long plumose setae on the anterior border and 4 similar setae on the posterior end (Pl. III, fig. 11).

Maxilliped 1, endopodite with 2 endites and 1 elongated apical lobe. Endite 1 small and setose; endite 2 oblong in shape, with a series of fine denticles along the medial border; apical lobe with 4 small plumose setae. Exopodite curved inwards distally, with a series of plumose setae on the lateral border and 3 apical plumose setae (Pl. III, figs. 12, 13).

Maxilliped 2, endopodite of 5 segments, segment 5, the dactylus, oval in shape, directed backwards, with a series of denticles on the distal half of the medial border. Exopodite slender and longer than its fellow, with 1 bristle and 4 plumose setae at the extremity (Pl. III, fig. 14).

Maxilliped 3, endopodite longer than exopodite, 5-segmented, segment 5 with 2 strong terminal claws. Exopodite slender, with 1 bristle and 4 plumose setae at the distal end (Pl. III, fig. 15).

Pereiopods all uniramous. Leg 1 shorter but stouter than leg 2. Finger tips all denticulated. Legs 3 and 4 similar in shape, dactylus with 2 spinules on the ventral border and a strong claw at the tip. Leg 5 longer than either leg 3 or 4, dactylus with 6 spinules on the ventral border (Pl. III, figs. 16-20).

Pleopods of 5 pairs, appear on somites 1-5, all biramous. Of the pleopod 1, the endopodite is small, heart shaped, bearing a single seta, the exopodite is spatulate, bearing 3 outer, 2 distal and 4 inner swimming setae. Of the following pairs, the endopodite all increased in length, each with 2 outer, 2 distal and 2 inner swimming setae and a slender appendix interna, which bears 2 or 3 hooks. The exopodite bears 4 outer, 2 distal and 4 inner swimming setae (Pl. V, figs. 32-34).

Variation: There occurs some variations in stage I. Three of the specimens at this stage with the rostrum bifurcated at the tip (Pl. II, figs. 3-6) and in some others, the telson shows emargination on either lateral side, at the base of seta 1 (Pl. V, fig. 35).

Stage II: Length about 3.6 mm. in average. Structures change considerably at this stage. (Pl. 1, fig. 2; Pl. IV, figs. 21-31; Pl. V, figs. 36-38).

Rostrum reaching the distal end of segment 2 of the antennular peduncle, with 6-7 spinules along the dorso-median line and 2 setae on the ventral surface near the proximal end (Pl. IV, fig. 21).

Carapace $1/3$ of the body length. Supra-ocular spine present.

Abdomen now 7-segmented, somites decreasing in breadth posteriorly (Pl. I, fig. 2).

Telson longer than somite 6, its length to the greatest width is about 5:3, distal border rounded, with a median emargination and 8+8 setae, setae 1-3 without plumes and moved a little up the sides, setae 4-8 with plumes. Besides the setae, another denticle added on the middle region of either lateral border. Dorsal surface with 2 pairs of denticles at the proximal half (Pl. I, fig. 2; Pl. V, fig. 38).

Uropods appear at this stage, outer ramus larger than inner, all bearing plumose setae (Pl. I, fig. 2; Pl. V, fig. 38).

Eye-peduncles now movable.

Antennule similar in shape to those of the preceding stage. Stylocerite increased in size (Pl. IV, fig. 22).

Antenna flagellum 38-segmented.

Mandible similar to that of the preceding stage in appearance.

Maxilla 1 with 2 endites and 1 apical lobe. Endite 1 now setose along the inner border; endite 2 more elongated, with 2 setae at apex and a series of denticles on inner border (Pl. IV, fig. 23).

Maxilla 2 with 3 endites, 1 apical lobe and a large piece of exopodite. All endites with plumose setae. Exopodite with 27 plumose setae along the anterior border and only 2 at the posterior end (Pl. IV, fig. 24).

Maxilliped 1, endite curved inwards distally, with long setae along the inner and distal borders, apical lobe now smaller and with only a single apical seta. Exopodite similar in shape to that of the preceding stage (Pl. IV, fig. 25).

Maxilliped 2, dactylus of endopodite more oval in shape, with long setae on inner border, propodus with 4 long plumose setae. Exopodite similar to that of the stage I in shape (Pl. IV, fig. 26).

Maxilliped 3 similar in form to that of the preceding stage (Pl. IV, fig. 27).

Pereiopods, finger tips of leg 1 and 2 all bearing hair pincels. This is one of the characteristics of the genus *Caridina*. Legs 3, 4 and 5 similar in shape to those of the stage I, excepting the dactylus of leg 5 now is armed with 8 denticles on the ventral border (Pl. IV, figs. 28-31).

Pleopods increased much in size but not changed much in form. Exopodite of pleopod 1 with 4+2+4 plumose setae, endopodite with only 3 plumose setae. Exopodite of pleopod 2 with 4+2+5 plumose setae,

endopodite with 2+2+2 plumose setae and the appendix interna now with 3 hooks (Pl. V, figs. 36-37).

Stage III: Length about 4.6 mm.. (Pl. VI, figs. 39-50).

Rostrum pointed almost straight forwards, armed with 10 spinules along the dorso-median line and 2 bristles on ventral surface near the proximal end (Pl. VI, fig. 39).

Carapace armed with 2 denticles on the anterior border, one situated at the antero-lateral corner and the other above it with some distance apart (Pl. VI, fig. 39).

Telson becoming gradually narrow posteriorly, its length to the greatest width is about 8:3, distal border with a median emargination and 6+6 plumose setae, of which, the seta 1 is small, not plumose, seta 2 is plumose only on the posterior border, the next 3 successively increased in length, but the one near the emargination is the shortest. Two pairs of spines on either lateral border behind the middle region (Pl. VI, fig. 50).

Uropods, the outer ramus slightly broader than inner, all with plumose setae (Pl. VI, fig. 50).

Antennule, peduncle of 3 segments, segment 1 longer than segments 2 and 3 together, with 1 plumose seta; segment 2 with 3; segment 3 with 5. Segment 1 depressed on dorsal surface but elevated along the medial border. Stylocerite standing laterally at proximal half, not overlapping the dorsal surface of segment 1 (Shen, 1934, p. 548, Pl. II, fig. 14), so the statocyst is not so formed as that of the *Palaemonetes* (Pl. IX, fig. 83). Outer flagellum 5-segmented, segment 3 with 3 club-shaped sensory hairs; inner flagellum 8-segmented (Pl. VI, fig. 40).

Antenna as in the preceding stages.

Mandible, incisor consisting of 4 teeth, molar process large, surrounded by bristles; 2 curved setae and a small knob-like structure situated between these 2 processes (Pl. VI, fig. 41).

Maxilla 1, endite 1 fringed with bristles; endite 2 elongated and projected, with a series of bristles along medial border and 2 setae at the apex. Apical lobe slender, with 1 seta only (Pl. VI, fig. 42).

Maxilla 2 with 3 endites, all bearing dense bristles, no more plumose setae. Apical lobe was not seen at this stage. Exopodite with 22 plumose setae on the anterior border (Pl. VI, fig. 43).

Maxilliped 1, endopodite now becoming broad distally and still bearing bristles along medial border. Apical lobe slender, apical seta absent. Exopodite with the distal portion much slender and curved in-

wards, no more plumose setae on lateral border, but with only 3 bristles at the extremity. A large metepipodite (Borradaile, 1926, p. 204) is situated beneath the exopodite, with plumose setae on the lateral border (Pl. VI, fig. 44).

Maxilliped 2, the propodus of endopodite now bearing 5 plumose setae, dactylus with 12 long bristles (Pl. VI, fig. 45).

Maxilliped 3 (Pl. VI, fig. 46), pereiopods (Pl. VI, figs. 47-49) and pleopods similar to those in stage II in shape.

Stage IV: Length about 5 mm.. It is generally resembling the stage III in various features, with the exception of a few minor points (Pl. VII, figs. 51-57).

Rostrum with 11 spinules along the dorso-median line.

Telson becoming narrow at distal 3rd, its length to the greatest width is about 2:1, distal border with a slightly shallow median emargination and 6+6 plumose setae. Seta 3 becoming unusually short in all specimens (Pl. VII, fig. 57), and 2 denticles on either distal half of the lateral border.

Mandible has almost the same form as that in the preceding stage (Pl. VII, fig. 51).

Maxilla 1, endite 1 increased in size; endite 2 elongated, both borne with longer bristles, apical lobe narrowed distally (Pl. VII, fig. 52).

Maxilla 2, endites changed slightly in shape but more densely setose. Exopodite increased in size (Pl. VII, fig. 53).

Maxilliped 1, endopodite elongated with numerous plumose setae; apical lobe shortened, with 3 apical setae. Exopodite much slender, curved gently inwards, with 4 apical plumose setae. Metepipodite still present (Pl. VII, fig. 54).

Maxilliped 2 more or less similar in shape to that in the stage III, excepting the endopodite which is now more segmented (Pl. VII, fig. 55).

Maxilliped 3 has the same appearance as that in the preceding stage.

Pereiopods and pleopods increased in size (Pl. VII, fig. 56).

Stage V: Length about 5.5 mm.. (Pl. VII, figs. 58-59). The forms of various structures are closely resembling those in the preceding stage, with the exception of the telson.

Telson with the lateral borders parallel to each other at proximal 1/3 and converging distally at distal 2/3. Its length to the greatest width

is about 5:2. Distal border with a very shallow emargination and 6+6 plumose setae, seta 3 turned longer again but still shorter than seta 2, seta 6 very minute. Distal 3rd of the lateral border with a pair of spinules on either side (Pl. VII, fig. 59).

Maxilla 1, endites elongated and borne with more bristles (Pl. VII, fig. 58).

II. *Palaemonetes sinensis* (Sollaud)

The collections of the egg-bearing females were made in April and May. One of the females was carrying 156 eggs, the biggest number so far we have found. The first group of larvae hatched on May 24, 1937 and the others in the next few days. It took about 8 days to the stage IV.

The larval history of the genus *Palaemonetes* has been investigated by some authors such as Faxon (1879), Mayer (1881), Boas (1889) and Gurney (1924), mostly on the species *Palaemonetes vulgaris* and *Palaemonetes varians*. But the larval development of these species can not be taken as applying to that of the oriental form, *Palaemonetes sinensis*. No account of the development of the latter has been published. The following results, will bring some more light upon the development of Caridea and possibly will be sufficient for making a comparison between the above mentioned species (p. 202)*.

Stage I: Length 4.0 mm.. (Pl. VII, fig. 60; Pl. VIII, figs. 62-73).

Rostrum reaching distal end of the peduncular basal segment, bending slightly downwards anteriorly, with 1 or 2 spinules along the dorso-median line (Pl. VIII, fig. 62).

Carapace smooth, about 1/3 of the body length.

Abdomen smooth, somite 6 marked with a faint indication of segmentation with the telson (Pl. VII, fig. 60, Pl. VIII, fig. 62).

Telson fan-shaped, its length to the greatest width is about 5:4. Distal portion broader than proximal. Distal border gently convex, with a median emargination and 13+13 plumose setae, setae 1 and 2 with plumes on posterior borders only (Pl. VII, fig. 60; Pl. VIII, fig. 62).

Uropods enclosed in the skin of the telson, not yet appeared (Pl. VII, fig. 60).

Eyes large, stalk short, immovable.

* Dr. Gurney had compared the larval development between *Palaemonetes varians* and *Palaemonetes vulgaris* (1924, p. 326).

Antennule, peduncle large, with 2 faint indications of segmentation. Segment 3 distally with a small inner branch, which bears a large plumose seta, and a larger unsegmented outer branch, which bears an apical plumose seta and 4 bristles. Stylocerite lobed, situated at the outer basal indentation of the peduncle (Pl. VIII, fig. 63).

Antenna flagellum consisting of about 22 segments, scale reaching middle region of the flagellum, with about 25 apical and medial plumose setae and a spine at the outer distal angle (Pl. VIII, fig. 62).

Mandible, incisor with 2 teeth, molar process developed but not much projected (Pl. VIII, fig. 64).

Maxilla 1 with 2 endites and 1 apical lobe, all naked and almost equal in size (Pl. VIII, fig. 65).

Maxilla 2 with 3 small endites, naked, and 1 apical lobe bearing 2 spinules. Exopodite large, with a series of plumose setae along distal and lateral borders and 3 large plumose setae at posterior end (Pl. VIII, fig. 66).

Maxilliped 1, endites 1 and 2 squarish in shape, apical lobe elongate and slender. Exopodite very long, with 1 bristle and 4 plumose setae at the apex (Pl. VIII, fig. 67).

Maxilliped 2, endopodite large, about $\frac{2}{3}$ as long as exopodite, 5-segmented, segment 5 distally with a very long claw, which is finely serrated on the ventral border, and 2 smaller spines and 2 bristles. Exopodite with 2 terminal segments and 1 bristle and 4 plumose setae at the apex (Pl. VIII, fig. 68).

Maxilliped 3, endopodite as long as the exopodite. Endopodite of 5 segments, with a claw at distal end. Exopodite similar to that of maxilliped 2 (Pl. VIII, fig. 69).

Pereiopods, all uniramous. Legs 1 and 2 chelate, leg 2 longer than 1. Legs 3, 4 and 5 slender (Pl. VIII, figs. 70-71).

Pleopods of 5 pairs appeared on abdominal somites 1-5, all biramous and naked. Endopodite of pleopod 1 very small; of pleopod 2 about $\frac{1}{2}$ the length of exopodite bearing an appendix interna; of pleopods 3, 4 and 5 similar to that of pleopod 2, but gradually decreased in size posteriorly (Pl. VIII, figs. 72-73).

Stage II: Length about 4.3 mm.. (Pl. VII, fig. 61; Pl. VIII, fig. 74; Pl. IX, figs. 75-81).

Rostrum extending slightly behind the basal segment of the antennular peduncle, with 2-4 spinules along the dorso-median line (Pl. IX, fig. 75).

Carapace with 2 denticles on the antero-lateral border on either side (Pl. VIII, fig. 74).

Abdominal somite 6 now much more elongated than that in the stage I and distinctly separated from telson (Pl. VII, fig. 61).

Telson similar to that of the stage I in shape. Its length to the greatest width is about 3:2. Uropods not appeared at this stage but the new uropods and telson of the next stage can be seen enclosed in the skin (Pl. VII, fig. 61).

Antennule, increased much in size, segment 1 more than twice the length of segments 2 and 3 together. Segment 1 with 4 plumose setae; segment 2 with 3; segment 3 with 4 plumose setae. Inner flagellum becoming larger, tapering distally and with a small apical seta. Outer flagellum larger than inner, unsegmented, bearing 2 apical sensory hairs. Stylocerite lobed, projected laterally at base of the peduncle (Pl. IX, fig. 76).

Antenna similar in shape to that of the stage I.

Mandible, incisor with 3 teeth, molar process now projected (Pl. IX, fig. 77).

Maxilla 1, endites now better shaped, endite 2 larger than 1, with 2 tiny spinules on inner border, the latter naked. Apical lobe with a lobule pointed medially (Pl. IX, fig. 78).

Maxilla 2, endites naked, endite 1 small; endites 2 and 3 now larger and projected inwards. Apical lobe much elongated. Exopodite large, with uniform plumose setae along the entire border (Pl. IX, fig. 79).

Maxillipeds similar to those of stage I, with the exception of the claws, on the endopodites of maxillipeds 2 and 3, becoming shorter at this stage, endite 2 of maxilliped 1 projected much inwards (Pl. IX, fig. 80).

Pereiopods, dactylus of each leg now with a distinct fine claw.

Pleopods increased in size and now with plumose setae. Endopodite of pleopod 1 small and naked; of pleopod 2 longer and with 0+2+1 plumose setae (Pl. IX, fig. 81); of pleopod 3 with 1+2+1 plumose setae; of pleopod 4 and 5 each with 1+2+0 plumose setae. Appendix interna on pleopods 2-5. Exopodite of pleopod 1 with 2+2+2 plumose setae; of pleopods 2, 3, 4 and 5 each with 2+2+3 plumose setae (Pl. IX, fig. 81).

Stage III: Length about 4.8 mm.. (Pl. IX, figs. 82-88; Pl. X figs. 89-92).

Rostrum reaching distal end of antennular peduncle, with 3 spinules along dorso-median line, a tiny one at middle region of the ventral border (Pl. IX, fig. 82).

Abdominal somite 6 distinctly separated from telson (Pl. X, fig. 92).

Telson elongated and broadened distally. Its length to the greatest width is about 6:5. Distal border almost truncate, with a slight median emargination and 13+13 plumose setae (Pl. X, fig. 92).

Uropods appear at this stage, outer ramus very big, with plumose setae; inner ramus small and naked (Pl. X, fig. 92).

Antennule, peduncular segment 1 more than twice the length of segments 2 and 3 together, with 5 plumose setae laterally. Statocyst well formed, partly covered by stylocerite. Outer flagellum larger than inner one, 3-segmented, bearing 2 club-shaped sensory hairs at apex; inner flagellum 2-segmented, bearing 2 tiny bristles distally (Pl. IX, fig. 83).

Antenna flagellum longer, consisting of about 26 distinguishable segments.

Mandible much advanced in form, incisor tri-dentate; molar process projected inwards, surface surrounded by 6 teeth (Pl. IX, fig. 84).

Maxilla 1 changed much in shape. Endites 1 and 2 now larger, all bearing bristles on distal borders. Apical lobe bifurcated distally, inner portion with a hook like structure (Pl. IX, fig. 85).

Maxilla 2, endite 2 degenerated or disappeared; endites 2 and 3 and apical lobe much elongated and all projected inwards, the former each bears 4 long bristles. Exopodite with plumose setae along the entire free border (Pl. IX, fig. 86).

Maxilliped 1 changed considerably in form. Endites 1 and 2 all bearing long bristles. Apical lobe with a single large plumose seta. Exopodite slender, but unusually broadened at basal 3rd, where it bears 6 plumose setae on lateral border and 4 plumose setae at the apex. Metepodite large, situated at base of exopodite (Pl. X, fig. 89).

Maxilliped 2, endopodite of 5 segments, propodus with 4 and dactylus with 12 bristles. Exopodite also of 5 segments, with 4 plumose setae at the apex (Pl. X, fig. 90).

Maxilliped 3, endopodite consisting of 5 segments, segment 5 with a distal claw; exopodite smaller, segments indistinct, with 4 plumose setae at the extremity (Pl. X, fig. 91).

Pereiopods slender, leg 2 longer than 1, all chelate and scarcely hairy. Legs 3-5 each increased in length (Pl. IX, figs. 87-88).

Pleopods, exopodites gradually decreased in length, while endopodites increased in length towards the posterior. Endopodite of pleopod 1 very small, with 1 seta only; of pleopods 2-5 about 1/3 as large as the corresponding exopodite, each with 1+2+1 plumose setae and an appendix interna, the latter bears each 2 hooks. Exopodite of pleopod

The general appearance of the adult is resembling that of the *Palaemonetes* but the most remarkable feature in this form is that, when they alive, a blue roundish spot is present on the pleuron of each abdominal somite. Judging from the structures of the somite 5, the telson and the appendages in the first larva are of the usual *Palaemon* type (Menon, 1938).

Stage I: Length 4.8 mm.. (Pl. X, figs. 95-96; Pl. XII, figs. 104-111; Pl. XIII, figs. 112-120).

Carapace smooth, slightly more than $1/3$ of the body length.

Rostrum long, extending almost to the distal end of the antennular peduncle. It curved downwards at middle region and again at distal portion, with a spinule at proximal region (Pl. XII, fig. 104).

Abdomen tapering posteriorly from somites 4-6. Somite 5 has a posterior spine on either side (Pl. XII, fig. 105). Somite 6 with lateral borders almost parallel to each other, faintly segmented with the telson (Pl. XII, fig. 104).

Telson fan-shaped, broadened distally, about twice as broad as long, distal border truncate, with 7+7 plumose setae, setae 1 and 2 with plumes on posterior borders only (Pl. XII, figs. 104, 111).

Eyes large, stalk short, immovable.

Antennule, peduncle indistinctly 3-segmented, bearing a large plumose seta at outer distal angle and an inner branch bearing 2 plumose setae and a bristle at the tip. I did not see any trace of the statocyst yet at this stage (Pl. XII, fig. 106).

Antenna, scale broad, with plumose setae along the inner and apical borders; flagellum slightly longer than the scale, basal portion 2-segmented, distal portion not segmented yet (Pl. XII, fig. 107).

Mandible, incisor well formed, molar process with no much significance in its development (Pl. XII, fig. 108).

Maxilla 1, endite 1 naked; endite 2 with 2 terminal spinules. Apical lobe with a spinule at the apex (Pl. XII, fig. 109).

Maxilla 2, endites 1-3 each with 2 or 3 bristles. Apical lobe with 2 denticles and 1 bristle. Exopodite very large, with about 13 plumose setae along the anterior border and a large plumose seta at the posterior end (Pl. XII, fig. 110).

Maxillipeds: Endopodite of maxilliped 1 small, indistinctly (about 3) segmented, with few bristles at apex; of maxillipeds 2 and 3, all 4-segmented, each with a long claw distally. Exopodites of maxilliped 1, 2 and 3 indistinctly segmented, each bearing about 4-6 apical plumose setae (Pl. XIII, figs. 112-114).

Pereiopods: All biramous, with the exception of the legs 4 and 5, and all naked. Legs 1 and 2 chelate, leg 2 longer than 1, their exopodites indistinctly segmented, reaching about the base of the movable finger. Legs 3-5 unsegmented. Exopodite of leg 3 about $\frac{1}{2}$ the length of the endopodite (Pl. X, figs. 95, 96).

Pleopods of 5 pairs, appeared on somites 1-5, not setose at all. Appendix interna not seen on the endopodites 2-5. Endopodites gradually increasing in size and exopodites decreasing in length towards the posterior (Pl. XIII, figs. 115-119).

Stage II: About 5.4 mm. in length. (Pl. III, fig. 120).

Unfortunately the larvae all died during the first moulting, so the general form and the appendages at this stage could not be properly displayed for making descriptions and illustrations, with the exception of the telson and the abdominal somite 6. The distal border of the telson is deeply emarginated at the middle region and bearing 7+7 plumose setae.

SUMMARY

1. Very little is known about the larval development of the freshwater Caridea, of which these three species are perhaps for the first time recorded in the larval history of the Decapod Crustacea.

2. *Caridina denticulata*: a. The rostrum bears variable number of spinules in each stage.

b. The telson at the stage I is club-shaped, bearing 8+8 plumose setae; at stage II, it changes in shape, with the lateral borders parallel to each other; from the stages III-V, the telson in each case, becomes tapering towards the posterior, the distal border has only 6+6 plumose setae, besides, there develops two pairs of spines on the lateral borders.

c. The stylocerite always stands at the lateral side of the antennular basal segment even up to the stage V and consequently the statocyst is rudimentary in form, not developed as of the usual palae-monid type.

d. Pereiopods are all uniramous from the stage I onwards, no exopodite develops on any one of the legs. Finger tips each bears a cluster of bristles.

e. Metepipodite appears on maxilliped 1 at stage III.

f. Pleopods of 5 pairs, appear on the abdominal somites 1-5 at stage I.

g. Uropods appear at the stage II, both rami with plumose setae.

3. *Palaemonetes sinensis*: a. The rostrum bears 1 spine at the stage I, 2 at the stage II, 3 at the stage III, and 4 at the stage IV.

b. The telson at the stage I and II are all fan-shaped, distinctly broader than long, the distal border is convex and bearing 13+13 plumose setae. It changes shape suddenly at the stage III and becomes much elongated at the stage IV, when it possesses only 10+10 plumose setae on the distal border and 3+3 denticles on the lateral borders.

c. The statocyst develops very well at the stage III, it is partly covered by the stylocerite.

d. Maxilla 1 and 2 improve in their structures successively from the stage I to IV.

e. Maxilliped 1 changes considerably in form at the stage III.

f. Pereiopods are all uniramous through the larval stages.

g. Pleopods of 5 pairs, appear on the abdominal somites 1 to 5 at the stage I.

h. Uropods appear at the stage III, the inner ramus is hairless until the next stage.

4. *Palaemonetes nipponensis*: a. The rostrum bears 1 spinule at the stage I.

b. The telson at the stage I is fan-shaped, about twice as broad as long, the distal border is truncate, bearing 7+7 plumose setae.

c. The pereiopods are biramous, with the exception of the legs 4 and 5.

d. The pleopods of 5 pairs appear on the abdominal somites 1 to 5, without hairs at the stage I.

e. The abdominal somite 5 bears a posterior spine on either side.

5. Key to the Larvae of Peiping Caridea.

I. Telson at stage I club-shaped.

Distal border of telson with 8+8 plumose setae.

Caridina denticulata.

II. Telson at stage I fan-shaped.

a. Distal border of telson convex, with 13+13 plumose setae.

Pereiopods all uniramous.

Palaemonetes sinensis.

- b. Distal border of telson truncate, with 7+7 plumose setae.
Pereiopods all biramous with the exception of legs 4 and 5.

Palaemon nipponensis.

DISCUSSION

1. The larval development of these three freshwater Caridea are much abbreviated than those of the marine forms. The eggs are becoming very large when they approach the time of hatching and the early appearance of the adult characters will also prove to have a shortened larval life. As in the case of *Caridina*, the cephalic appendages are all in advanced form, pereiopods have no exopodites developed, and the five pairs of pleopods appear at once on the abdominal somites 1 to 5, all with plumose setae, at the larval stage I. Such abbreviated development is probably partly due to the different conditions of life (Borradaile, 1923, pp. 200-211), the condition in freshwater is more inconstant and changeable than in the sea. They have to pass through their larval life as early as possible, in order to avoid any unnecessary death caused by the nature.

2. The telson of the *Caridina denticulata* (Atyidae) at the stage I gives the appearance of a club-like form. It strikingly differs from those of fan-shaped forms as found in the following cases:

a. Palaemonidae

- Palaemon*, Menon, 1938, p. 289, fig. 9.
Palaemonetes, Gurney, 1924, p. 303, figs. 1, a-b.
Typton, Lebour, 1925, p. 852, figs. 1a, 2a.
Anchistioides, Gurney, 1936, p. 620, pl. 1, fig. 1.
Periclimenes, Gurney, 1936, p. 620, pl. 2, fig. 13.
Mesocaris, Gurney, 1936, p. 621, pl. 3, fig. 24.

b. Pandalidae

- Chlorotocella*, Gurney, 1937a, p. 331, pl. 6, fig. 82.

c. Hippolytidae

- Hippolyte*, Lebour, 1931, pp. 7-8, pl. 1, figs. 6, 7.
Caridion, Lebour, 1930, p. 190, pl. 3, fig. 1; pl. 7, fig. 1.
Latreutes, Gurney, 1935, p. 792, pl. 6, fig. 38.

d. Crangonidae

- Crangon*, Lebour, 1931, pl. 1, figs. 1, 2.
Philocheras, Lebour, 1931, pl. 1, figs. 3-5.

e. Processidae

Processa, Gurney, 1936, p. 625, pl. 6, figs. 53-54; 1937, p. 92, pl. 2, fig. 33.

Lebour, 1936, p. 615, pl. 5, fig. 1.

Nikoides, Gurney, 1937, p. 94, pl. 3, fig. 38.

f. Alpheidae

Athanas, Lebour, 1932, p. 464, pl. 1, fig. 1.

Alpheus, Lebour, 1932, p. 466, pl. 2, fig. 14.

g. Stenopidae

Stenopus, Gurney, 1936a, p. 380, fig. 1, b, c.

This type of telson is closely allied to that of the *Leptochela* (Pasi-
pheidae, Gurney, 1935, p. 786, pl. 1, fig. 2), of which the telson at the stage
I is somewhat club-shaped, but they still differ from each other in certain
respects. Therefore, the telson of the *Caridina* type is very characteristic
for the genus itself.

3. The exopodites are commonly present in the first larval stage
of many Palaemonids, such as *Palaemon rudis* Heller with the legs 1-2
(Menon, 1938, p. 291), *Anchistioides antiquensis* (Schmitt) with the legs
1-3 (Gurney, 1936, p. 620); *Periclimenes americanus* (Kingsley) with
the legs 1-2 (Gurney, 1936, p. 621); *Mesocaris* sp. with the leg 1 (Gurney,
1936, p. 622); *Palaemonetes varians* (Leach) with the legs 1-4 (Gurney,
1924, p. 303) all biramous; and the *Palaemon nipponensis* described in
this paper has the legs 1-3 also biramous. But in *Palaemonetes sinensis*
(Sollaud), the complete suppression of the exopodites on the pereopods
through the larval stages is a surprising fact. This also happens in
Caridina denticulata of the family Atyidae. The complete regression of
the exopodites on legs in freshwater Caridea is unknown, but its occurrence
is quite possible, if as far as the abbreviation of their larval development
is concerned. While the temporary regression of the exopodites on legs
has been pointed out by Dr. Gurney (1935, p. 791) in the genus *Leptochela*,
of the family Pasi-
pheidae, in which the exopodite does not appear until
the stage III. This is possibly to show that the marine species usually
have a fairly long larval life.

4. The pleopod 1 usually develops at later larval stages in the
marine Caridea, but the case represented here is rather different. The
five pairs of pleopods without retardation in their development, all appear
on the abdominal somites 1 to 5 at the stage I, with plumose setae in
Caridina but without any in *Palaemonetes* and *Palaemon*. The uropods
appear at the stage II in *Caridina* and at the stage III in *Palaemonetes*.
Thus the *Caridina* get the complete set of motile organs earlier than the
Palaemonetes and the latter seems to have a relatively longer larval
life.

LITERATURE REFERRED TO

Boas, J. E. v.

1889. Zool. Jahrb. Syst. iv, p. 793.

Borradaile, L. A.

1923. The Animal and its Environment. Henry Prowde, 1, Bedford Street, Strand, London.
1926. Notes upon Crustacean limbs. Ann. & Mag. Nat. Hist. (9) XVII, pp. 193-214, pls. VII-X.

Faxon, W.

1879. Transformations of the larvae of *Palaemonetes vulgaris* Say. Bul. Mus. Comp. Zool. V, p. 303.

Gurney, R.

1924. The larval development of some British Prawns (*Palaemonidae*)—I. *Palaemonetes varians*. Proc. Zool. Soc. London, pp. 297-328, 11 text figs.
1935. Notes on some Decapod Crustacea of Bermuda—I. The larvae of *Leptochela* and *Latreutes*. Proc. Zool. Soc. London, pp. 785-794, 6 pls.
1936. Notes on some Decapod Crustacea of Bermuda—III-V. The larvae of the *Palaemonidae* and *Processa*. Proc. Zool. Soc. London, pp. 619-630, 7 pls.
1936a. Larvae of Decapod Crustacea, pt. 1-3, Discovery Reports, Vol. XII, pp. 377-440, 42 figs.
1937. Notes on some Decapod Crustacea from the Red Sea. I. The Genus *Processa*. Proc. Zool. Soc. London, ser. B., pp. 87-102, 6 pls.
1937a. Notes on some Decapod and Stomatopod Crustacea from the Red Sea. III-V. Proc. Zool. Soc. London, ser. B., Vol. 107, pt. 3, pp. 319-336 pls. I-VIII.

Lebour, M. V.

1925. The Eggs and newly hatched larva of *Typton spongicola* O. G. Costa. J. Mar. Biol. Ass., U. K., Vol. 13, No. 4, pp. 848-853, 3 text figs.
1930. The larval stages of Caridion, with a description of a new species, *C. steveni*. Proc. Zool. Soc. London pp. 181-194, 8 pls.
1931. The Larvae of the Plymouth Caridea 1. The larvae of the Crangonidae, II. The larvae of the Hippolytidae. Proc. Zool. Soc. London, 10 pp., 3 pls.
1932. The larvae of the Plymouth Caridea IV. The Alpheidae. Proc. Zool. Soc. London, pp. 463-470, 4 pls.
1936. Notes on the Plymouth *Processa* (Crustacea). Proc. Zool. Soc. London, pp. 609-718, 6 pls.

Mayer, P.

1881. Carcinologische Mitteilungen.—IX. Die Metamorphosen von *Palaemonetes varians* Leach. Mittl. Zool. Station Neapel, Bd. II, Leipzig, pp. 196-221, Pl. X, fig. 1.

Plate II.

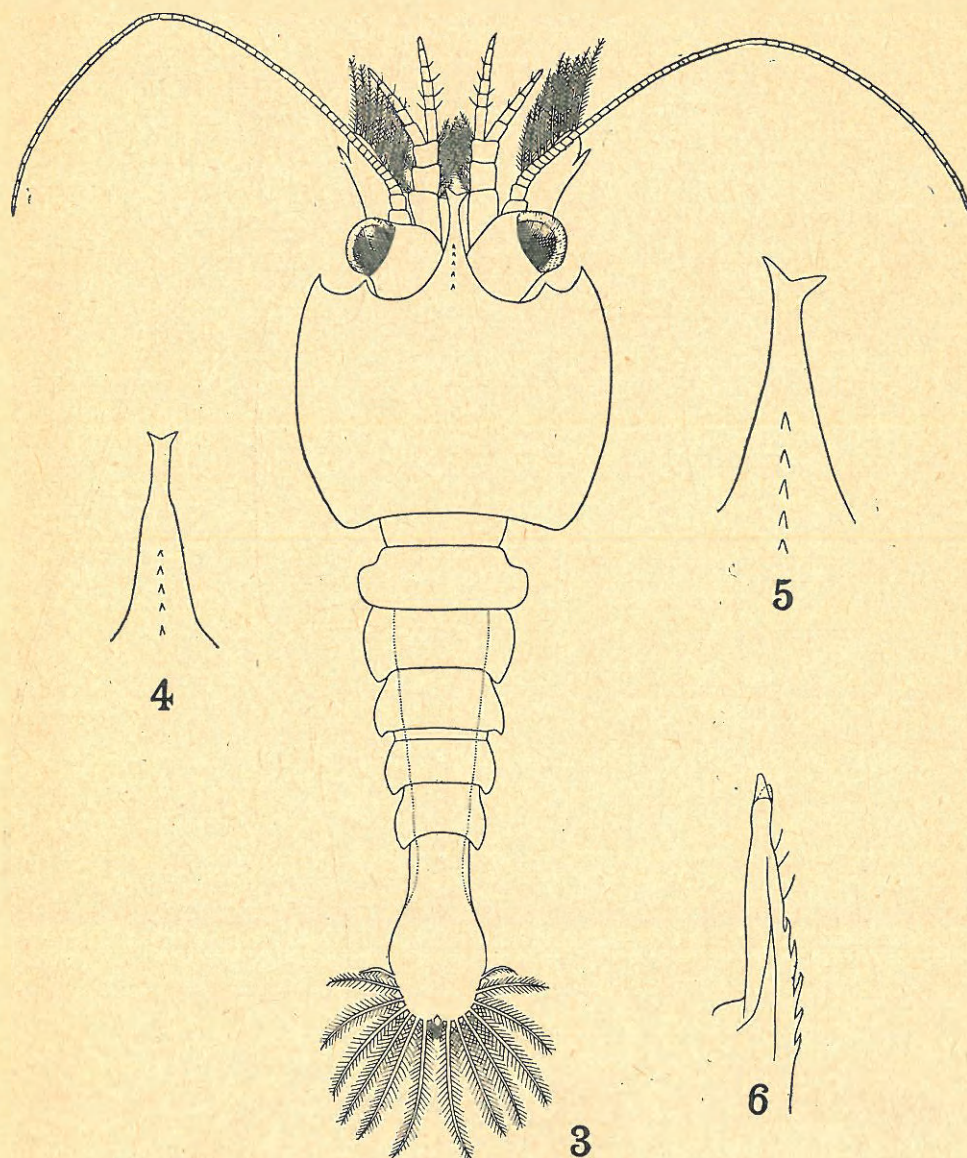
Caridina denticulata

Fig. 3. Stage I. Dorsal (variation).

4. „ Rostrum.

5. „ Rostrum.

6. „ Rostrum, side view.

Plate V.

Caridina denticulata

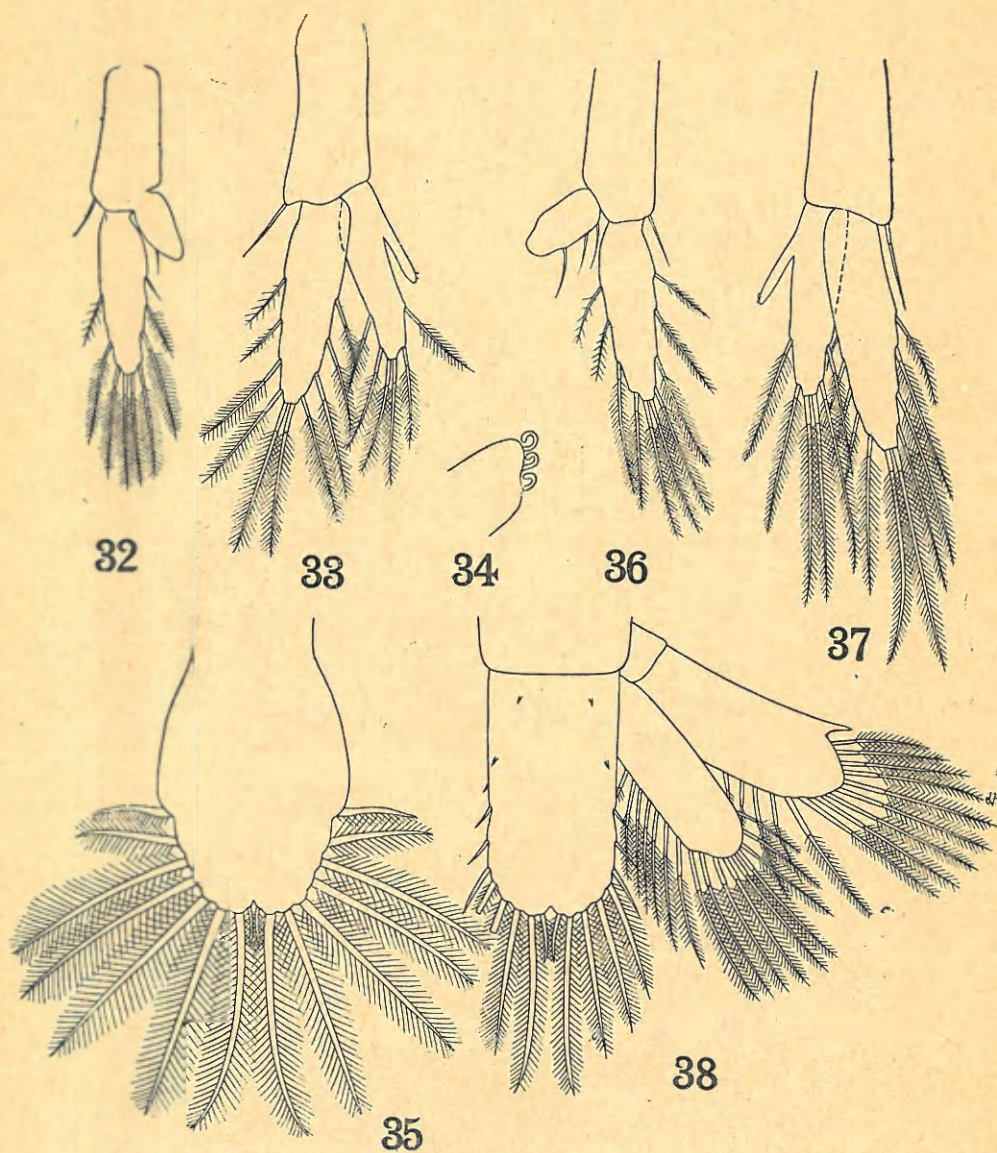


Fig. 32. Stage I. Pleopod 1.
 33. " Pleopod 2.
 34. " Appendix interna from pleopod 2.
 35. " Telson.
 36. Stage II. Pleopod 1.
 37. " Pleopod 2.
 38. " Telson & Uropods.

Plate VI.

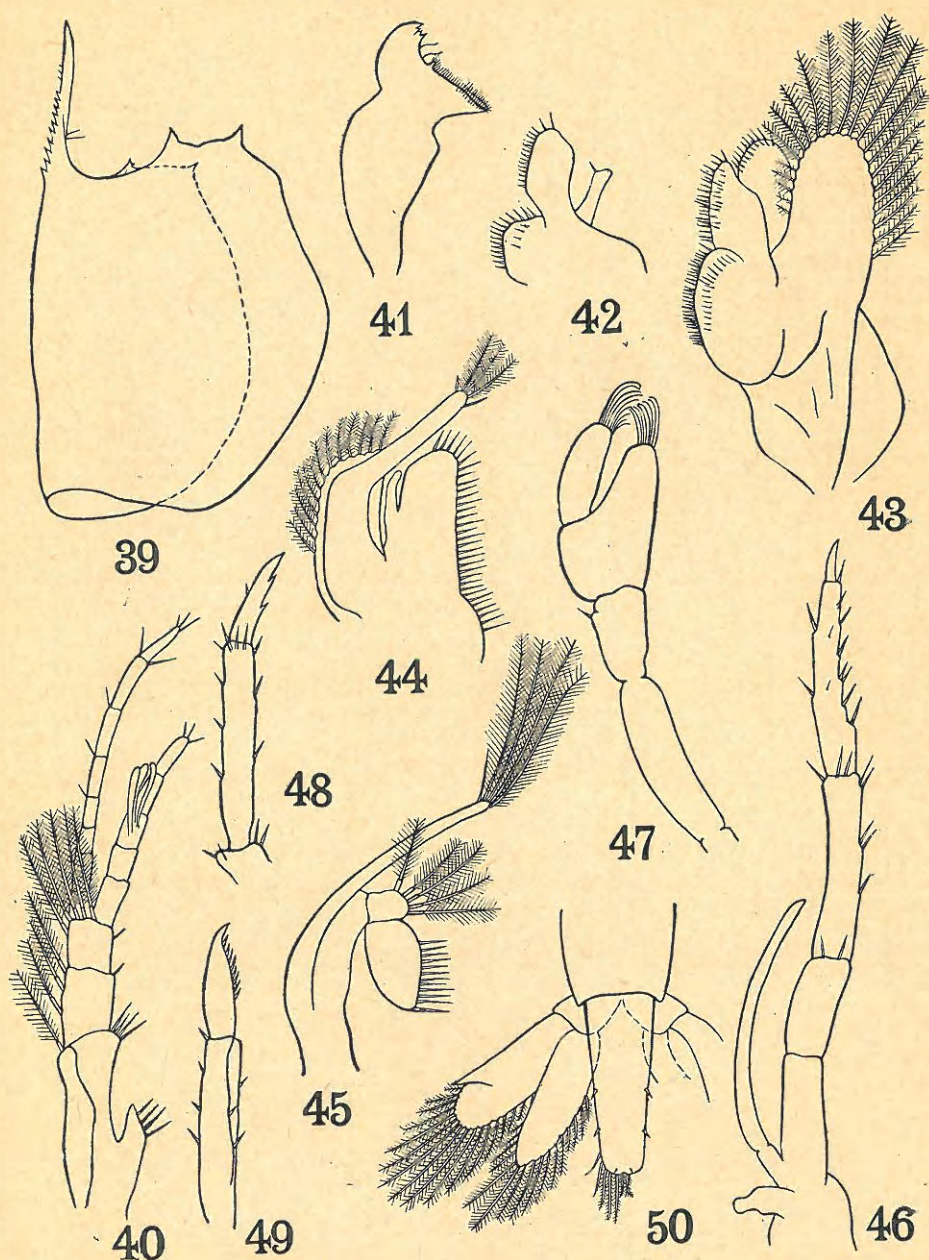
Caridina denticulata

Fig. 39.	Stage III.	Carapace, side view.	45.	"	Maxilliped 2.
40.	"	Antennule.	46.	"	Maxilliped 3.
41.	"	Mandible,	47.	"	Leg 1.
42.	"	Maxilla 1.	48.	"	Leg 3.
43.	"	Maxilla 2.	49.	"	Leg 5.
44.	"	Maxilliped 1.	50.	"	Telson & Uropods.

Plate VII.

Caridina denticulata

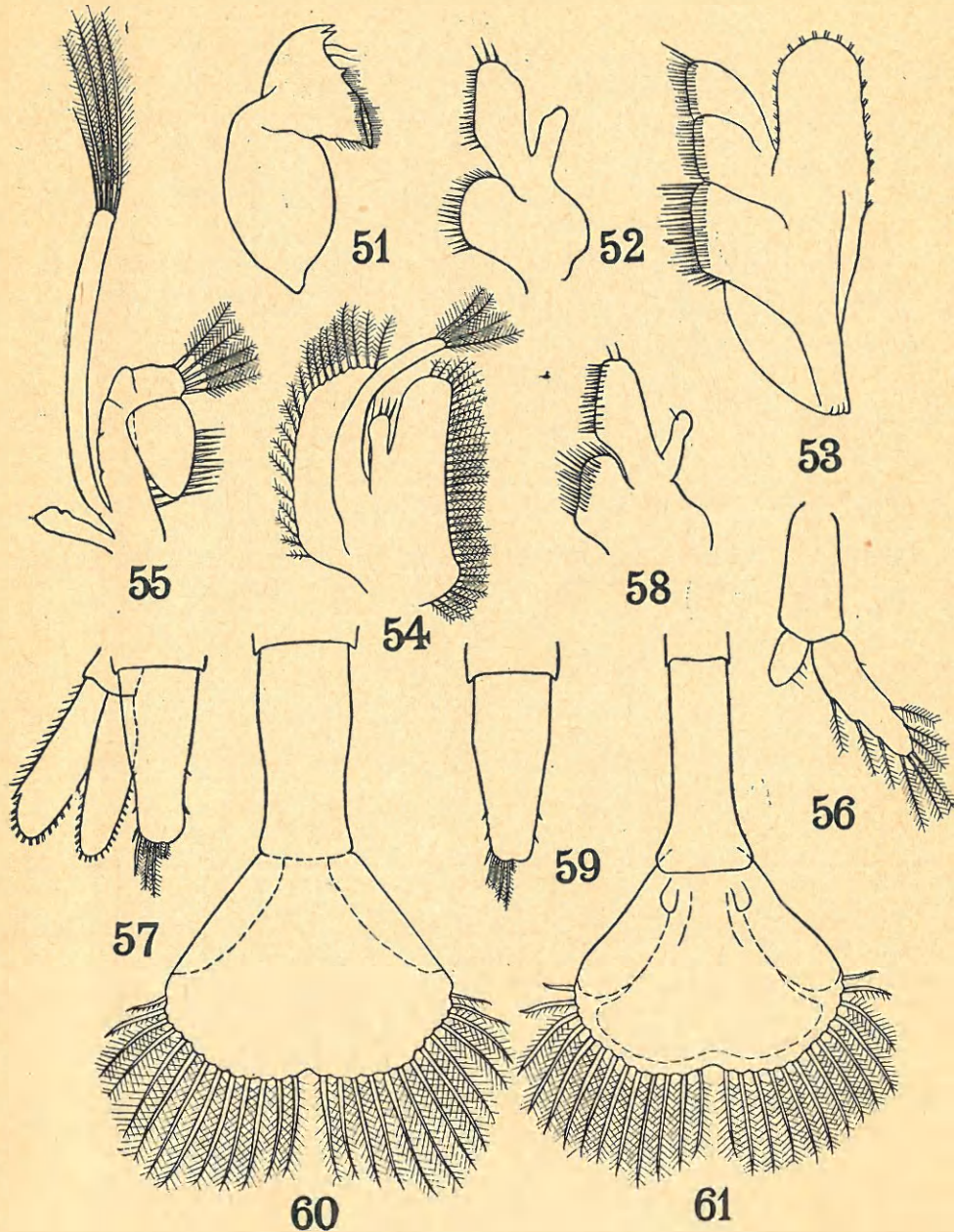


Fig. 51. Stage IV. Mandible.

52. " Maxilla 1.

53. " Maxilla 2.

54. " Maxilliped 1.

55. " Maxilliped 2.

56. " Pleopod 1.

57. " Telson & Uropods.

58. Stage V. Maxilla 1.

59. " Telson.

Figs. 60-61. *Palaemonetes sinensis*.

60. Stage I. Telson.

61. Stage II. Telson.

Plate X.

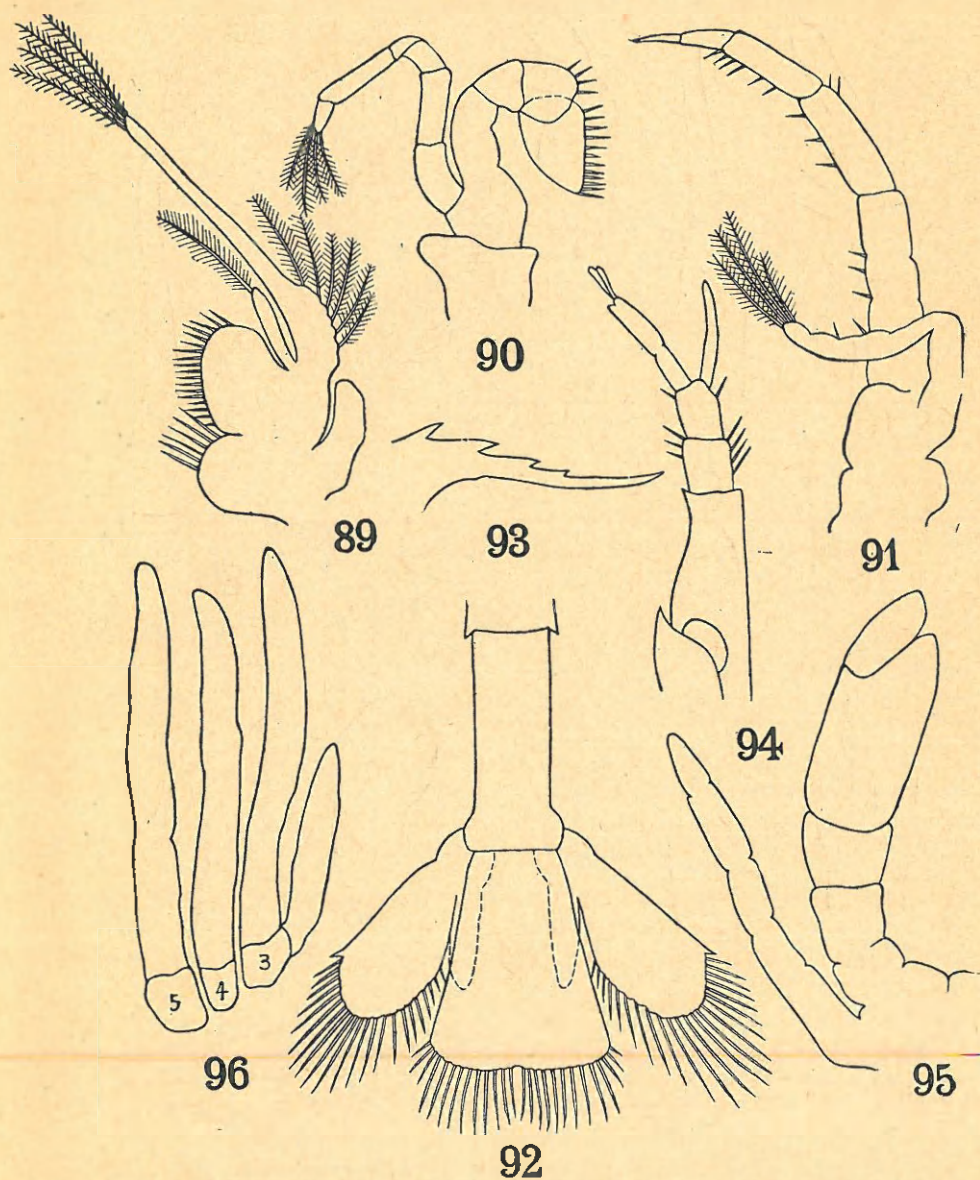
Palaemonetes sinensis

Fig. 89. Stage III. Maxilliped 1.
 90. " Maxilliped 2.
 91. " Maxilliped 3.
 92. " Telson & Uropods.

93. Stage IV. Rostrum, side view.
 94. " Antennule & Statocyst.
 Figs. 95-96. *Palaemon nipponensis*.
 95. Stage I. Leg 1.
 96. " Legs 3-5.

Plate XI.

Palaemonetes sinensis

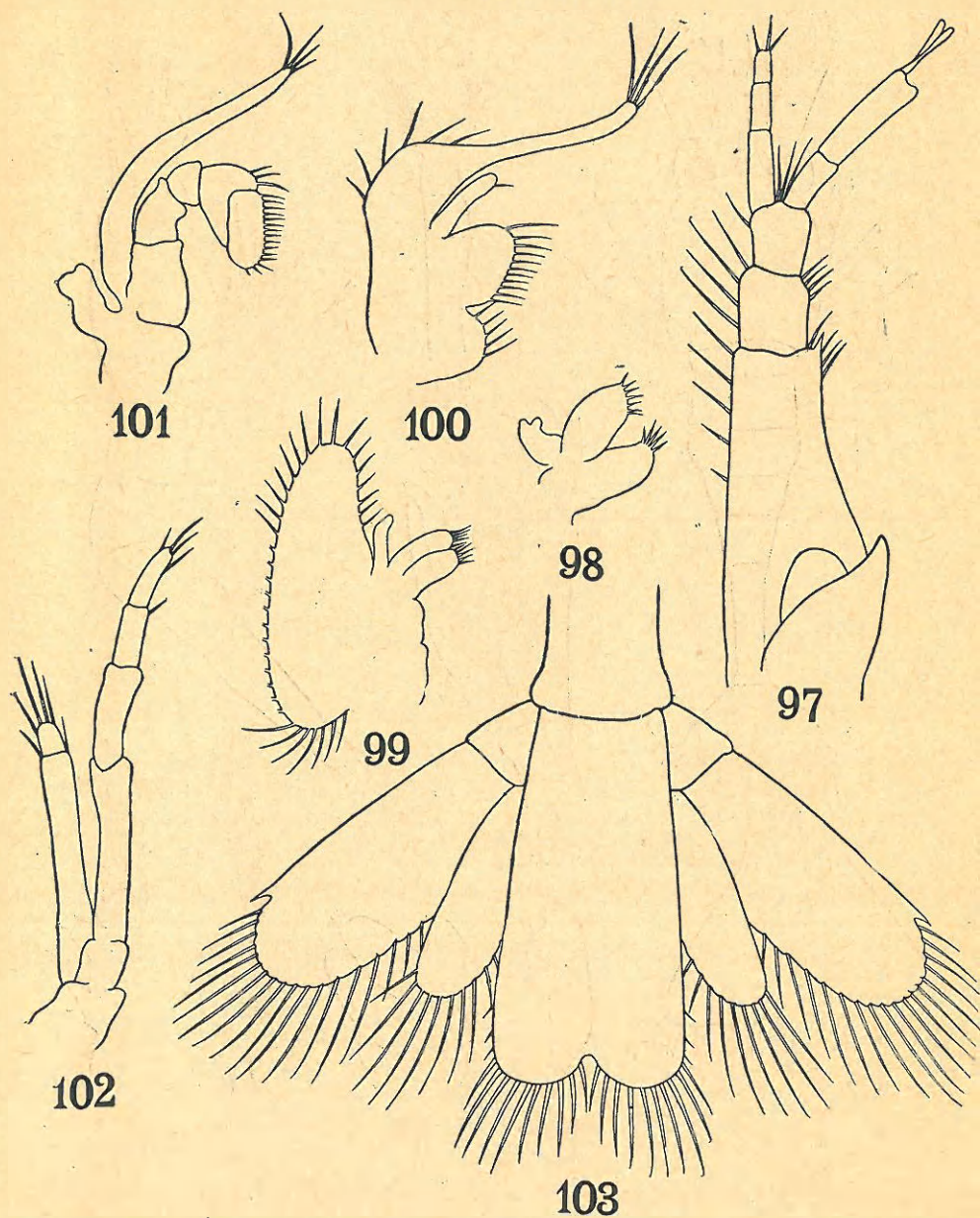


Fig. 97. Stage IV. Antennule & Statocyst
 (from another individual).
 98. " Maxilla 1.
 99. " Maxilla 2.
 100. " Maxilliped 1.
 101. " Maxilliped 2.
 102. " Maxilliped 3.
 103. " Telson & Uropods.

Plate XII.

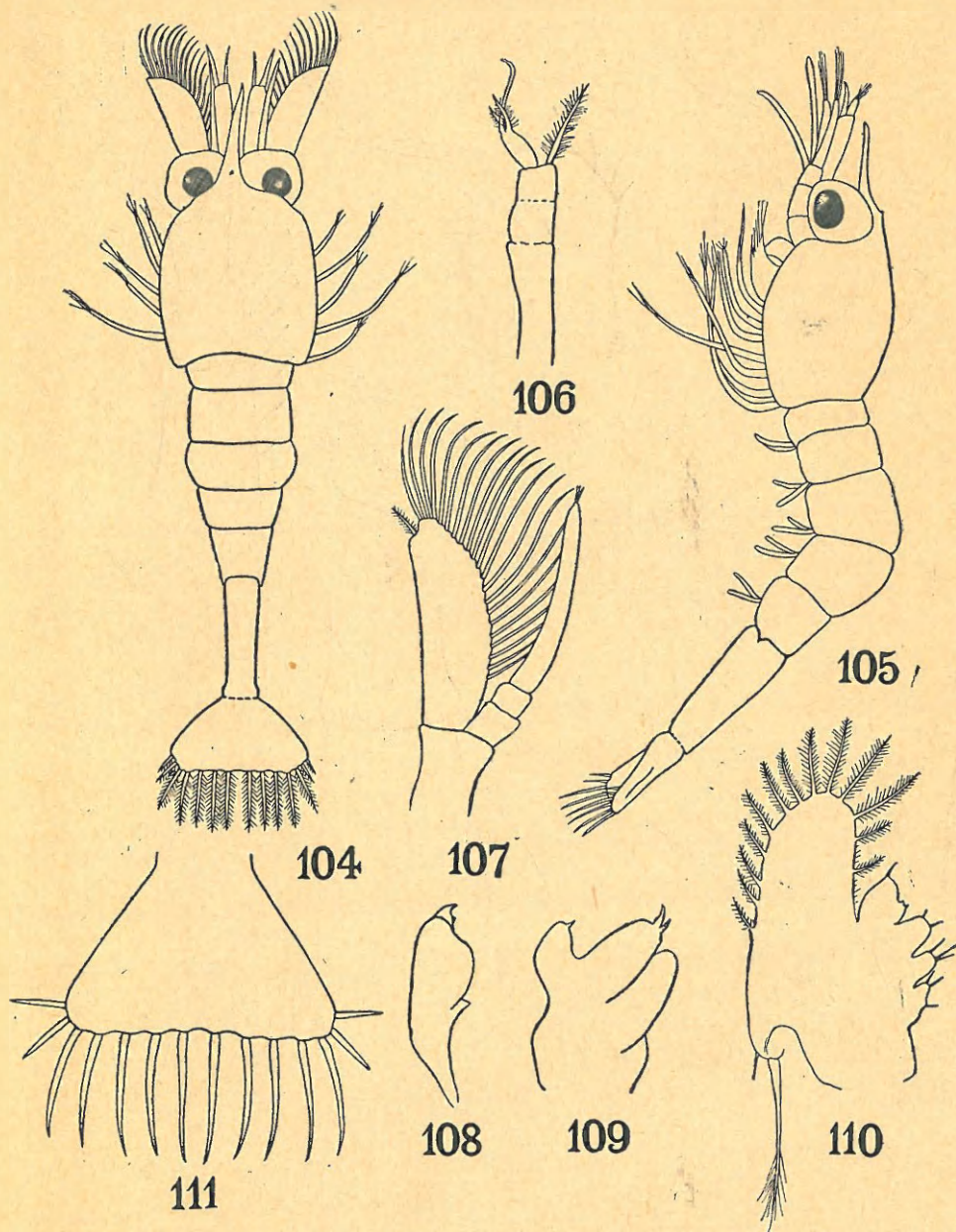
Palaemon nipponensis

Fig. 104. Stage I.	Dorsal.	108. "	Mandible.
105. "	Lateral.	109. "	Maxilla 1.
106. "	Antennule.	110. "	Maxilla 2.
107. "	Antenna.	111. "	Telson.

Plate XIII
Palaemon nipponensis

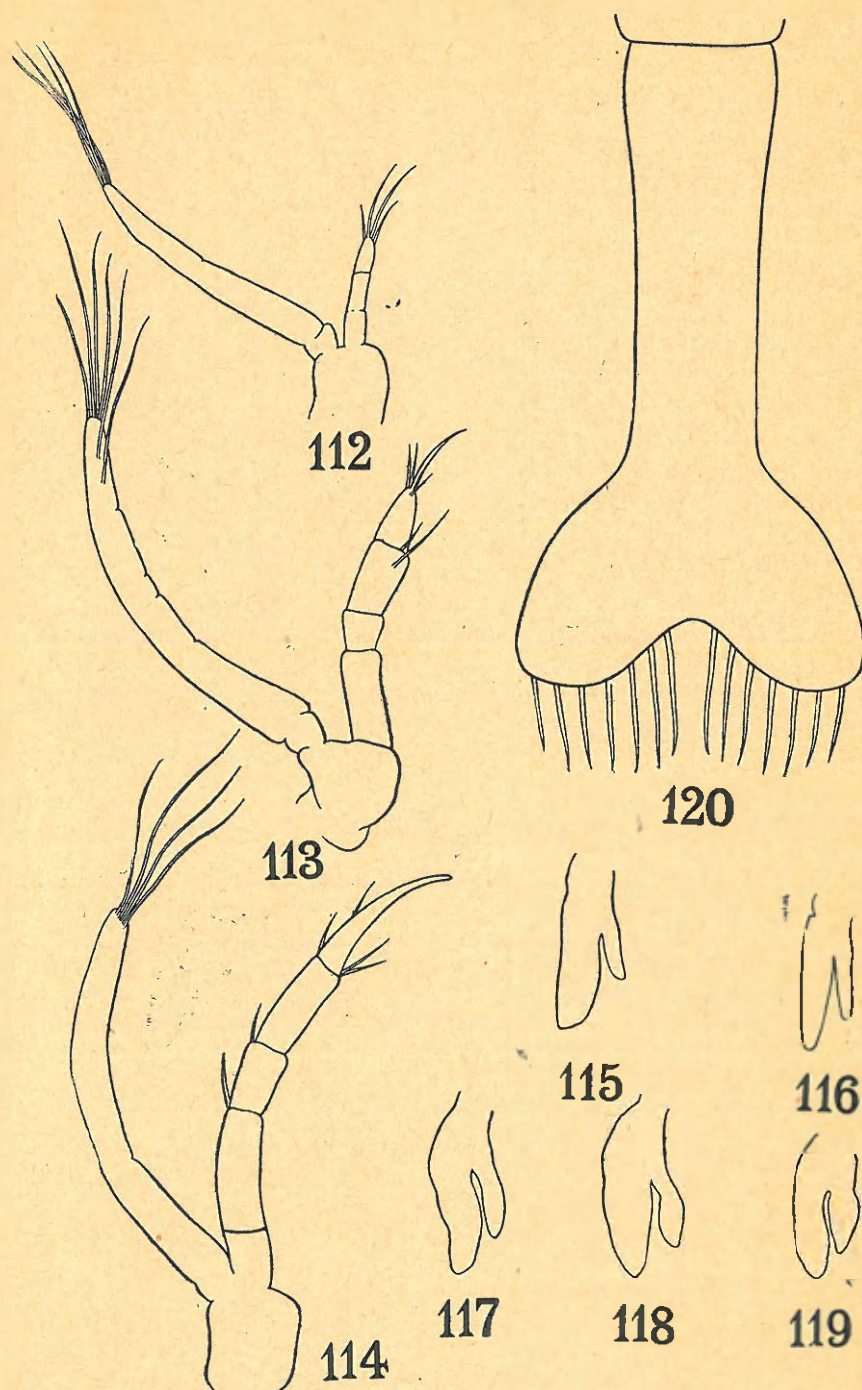


Fig. 112.	Stage I. Maxilliped 1.	117.	"	Pleopod 3.
113.	" Maxilliped 2.	118.	"	Pleopod 4.
114.	" Maxilliped 3.	119.	"	Pleopod 5.
115.	" Pleopod 1.	120.	"	Telson.
116.	" Pleopod 2.			

