Bull. Inst. Zool., Academia Sinica **28**(2): 139-151 (1989)

STUDIES ON THE LARVAL DEVELOPMENT OF *PALAEMON (EXOPALAEMON) ORIENTIS* HOLTHUIS (CRUSTACEA: DECAPODA)

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(Accepted November 23, 1988)

I-Ming Chen and Reijiro Hirano (1989) Studies on the larval development of *Palaemon (Exopalaemon) orientis* Holthuis (Crustacea: Decapoda). *Bull. Inst. Zool., Academia Sinica* **28**(2): 139-151. Larval development of *Palaemon (Exopalaemon) orientis* Holthuis was described from the specimens reared with living *Artemia* nauplii at 24.5±0.5°C and 20.0±0.2 ppt S. in the laboratory.

After hatching, the larval took 8 to 17 days to develope to postlarva. The larval stages can be divided as follow: after hatching, it is the zoea stage. After the second molt it develops into the mysis stage. After the fifth molt it becomes the postlarva. A few individuals had a sixth molt to become postlarva. The morphology of the larva after the fifth molt is similar to previous one.

Key word: Larva, Metamorphosis, Shrimp.

Palaemon (Exopalaemon) orientis Holthuis distributes along the coastal area of Taiwan and Japan. They usally occur at mud bottom near estuary. When the females carrying eggs invade into the culture ponds of tiger shrimp (*Penaeus monodon* Fabricius) from inhalant or outhalant channel, the population of *P. orientis* increases quickly. They compete food with the tiger shrimp. Therefore the benefit of tiger shrimps culture increases.

There is little ecological survey about *P. orientis* (Yasuda, 1956; 1958). Knowledge of the larval development of genus *Palaemon* was mostly obtained from the planktonic larvae collected from nature water (Kubo, 1932; Kurata, 1968a, b). Thus, there is little agreement on either the form or the number of larval stages of these species. Larval metamorphosis of *Palaemon (Palaemon) serrifer* has been studied but the rearing condition and feeding were not controlled (Utunomiya *et al.*, 1959).

This paper describes larval development of *Palaemon (Exopalaemon) orientis* Holthuis based on the specimens reared in the laboratory. Considerations on the variation of the number and structures of larval intermolts were also addressed.

MATERIALS AND METHODS

Mature adults of *Palaemon (Exopalaemon) orientis* were caught in sea water lake of Shin Hama (Japan). Egg-bearing

females were held individually in glass tanks with Shih Hama lake water (20 pptS) in the laboratory. The water temperature was kept around 25°C.

Newly hatched larvae of the same eggs clutch were placed in clean beaker (200 ml) with two individuals in each beaker. Sea water was changed every day and sediments were removed by siphon. Living *Artemia* nauplii were used as larval food. *Artemia* were controlled at 10 to 15 individuals/ml and uneaten ones were removed dally before adding fresh food. The water temperature was kept at 24.5±0.5°C and salinity was 20.0± 0.2 ppt.

Each larva was inspected by stereoscopic binocular microscope. The presence of an exuvium or casted exoskeleton was regarded as an evidence of molting and the casted exoskeleton was kept as a record of larvae molting. The morphology of the whole body and individual appendages from alcoholic-preserved specimens was studied and drawn.

RESULTS

The size of the fertilized eggs carried by adult female was about 0.46×0.58 mm, but right before hatching, it increased to about 0.65×0.78 mm. After hatching, the larva took 8 to 17 days to develop to postlarva. The life span of each larval instar is given in Table 1.

Table 1
Duration of each larval stage of *Palaemon* (*Exopalaemon*) *orientis* reared in 25°C and 20 ppts

Instar	Stage	Duration (days)	Mode (days)	Number of observations
1	zoea			
		0—2	1	29
2				
		1—2	2	27
3	mysis			
		2—3	2	23
4				
		2—3	2	20
5				
		3—4	3	16
6	postlarva			
6*		2—3	3	4

* Some shrimps passed this instar

First instar (After hatching, Fig. 1)

Total length about 2.2 mm. Rostrum curved slightly downward and short than basal segment of antennule. Carapace length about 1/4 of total length. Eyes sessile, contained beneath carapace. Six somites of abdomen and the last one is not separated from the fan-shaped telson and length about 1/2 of abdomen length.

Pleura of fifth abdominal somite terminates as a posteriorly directed tooth (Fig. 1-A).

Antennule (Fig. 1-B) simple; the single basal segment bears terminally a long plumose seta and a short outer flagellum with 4 slender setae and 1 short plumose seta. Antenna (Fig. 1-C) biramous; scale with 6 horizontal ripples near tip, 7 long plumose setae on inner margin and 3 short plumose setae on outer margin. Flagellum of 1 segment, shorter than scale with a long terminal plumose seta.

Mandible (Fig. 1-D) without palp; incisor teeth larger than molar; 2 movable teeth in angle between molar and incisor processes. First maxilla (maxillulae) (Fig. 1-E) biramous; exopod 2-lobed and with many large spines; endopod simple, palp-like, with a terminal seta. Second maxilla (mixilla) (Fig. 1-F) plate like, biramous; coxa 3-lobed and armed with 3 or 4 plumose setae, endopod with 3 plumose setae, exopod (scaphognathite) as a flattened gill bailer with 3 plumsoe setae anteriorly and 1 posteriorly.

First maxilliped (Fig. 1-G) biramous; coxa reduced, basis with 3 setae, endopod with 4 apical setae and 1 sub-apical seta, exdopod longer than endopod and with 6 apical plumose setae. Second mixilliped (Fig. 1-H) biramous; coxa reduced, basis

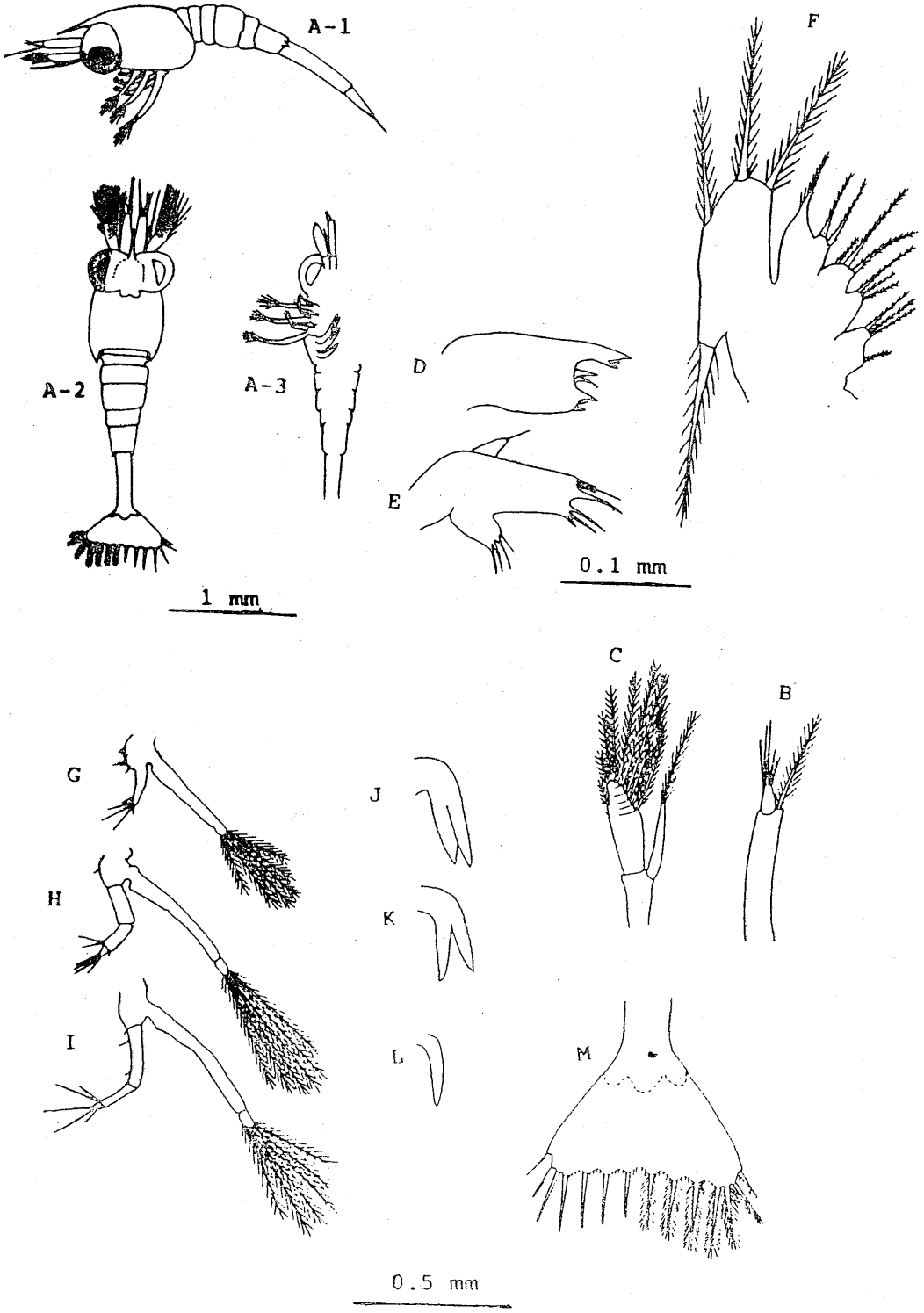

Fig. 1. First instar. A-1, lateral view; A-2, dorsal view; A-3. ventral view; B, antennule; C, antenna; D, mandible; E, maxillulae; F, maxilla; G, 1st maxilliped; H, 2nd maxilliped; I, 3rd maxilliped; J, 1st pereiopod; K, 2nd pereiopod; L, 5th pereiopod; M, telson.

with 1 seta, endopod 3-segmented and with seta on penultimate and ultimate segments; exopod longer 2-segmented than endopod, with 6 apical plumose setae. Third maxilliped (Fig. 1-I) biramous, larger than second maxilliped, but generally similar to it; endopod with 2 setae on proximal segment and several setae on penultimate and ultimate segments, exopod with 6 apical plumose setae.

First and second pereiopods (Fig. 1-J, K) biramous, rudimentary. Fifth pereiopod (Fig. 1-L) uniramous, rudimentary. Telson (Fig. 1-M) with 14 plumose setae, but the 2 pairs of setae on the outer side of the telson have plume on their inside part only.

Second instar (Fig. 2)

Total length from 2.6 to 3.0 mm (Fig. 2-A). Carapace length about 1/3.5 of total length. Different from first instar in the following: Carapace with supraorbital spines. Eyes with stalk.

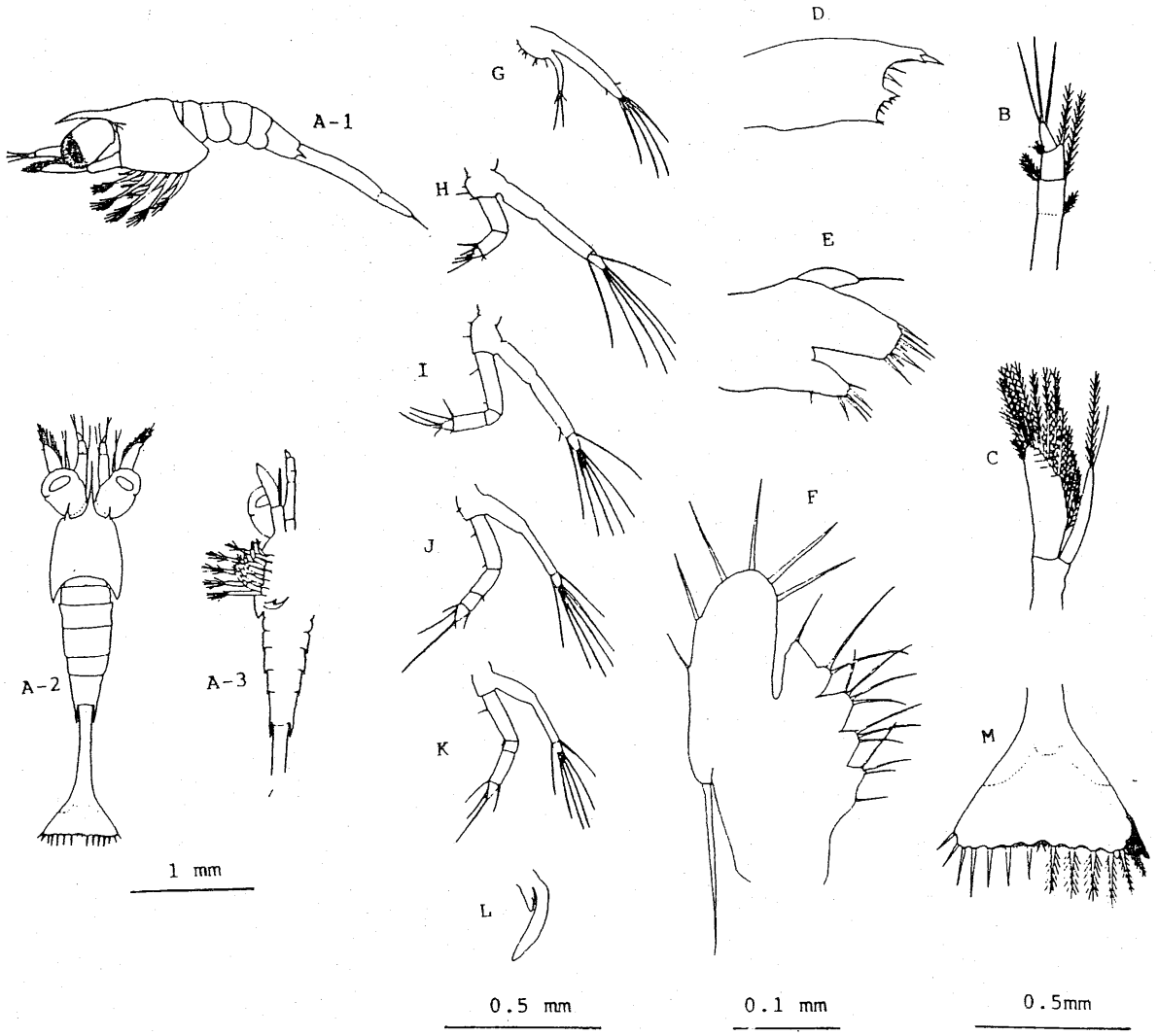

Fig. 2. Second instar. A-1, lateral view; A-2, dorsal view; A-3, ventral view; B, antennule; C, antenna; D, mandible; E, maxillulae; F, maxilla; G, 1st maxilliped; H, 2nd maxilliped; I, 3rd maxilliped; J, 1st pereiopod; K, 2nd pereiopod; L, 4th and 5th pereiopods; M, telson.

Antenule (Fig. 2-B) with peduncles segmented, segments marked by plumose setae. Outer flagellum with 3 slender setae. Antennal scale (Fig. 2-C) with 15 plumose setae. Antennal flagellum terminated into 1 plumose seta and 1 short seta.

Mandible (Fig. 2-D) and first maxilla (Fig. 2-E) not different from first instar. Second maxilla (Fig. 2-F) with 7 plumose setae on exopod.

First maxilliped (Fig. 2-G) with 4 apical plumose setae and 2 reduced setae on exopod. Second maxilliped (Fig. 2-H) not different from first instar. Third maxilliped (Fig. 2-I) with 4 segments on endopod.

First and second periopods (Fig. 2-J, K) biramous; endopod 4-segmented and exopod with 6 plumose setae. Fourth and fifth pereiopods (Fig. 2-L) rudimentary and bases joined together. Telson (Fig. 2-M) similar to first instar, but a pair of setae on the outer side of the telson has plume on thier inside part only; center of telson with a pair small spines.

Third instar (Fig. 3)

Total length from 3.0 to 3.4 mm (Fig. 3A). Rostrum with 1 dorsal rostral tooth located on carapace just behind orbit.

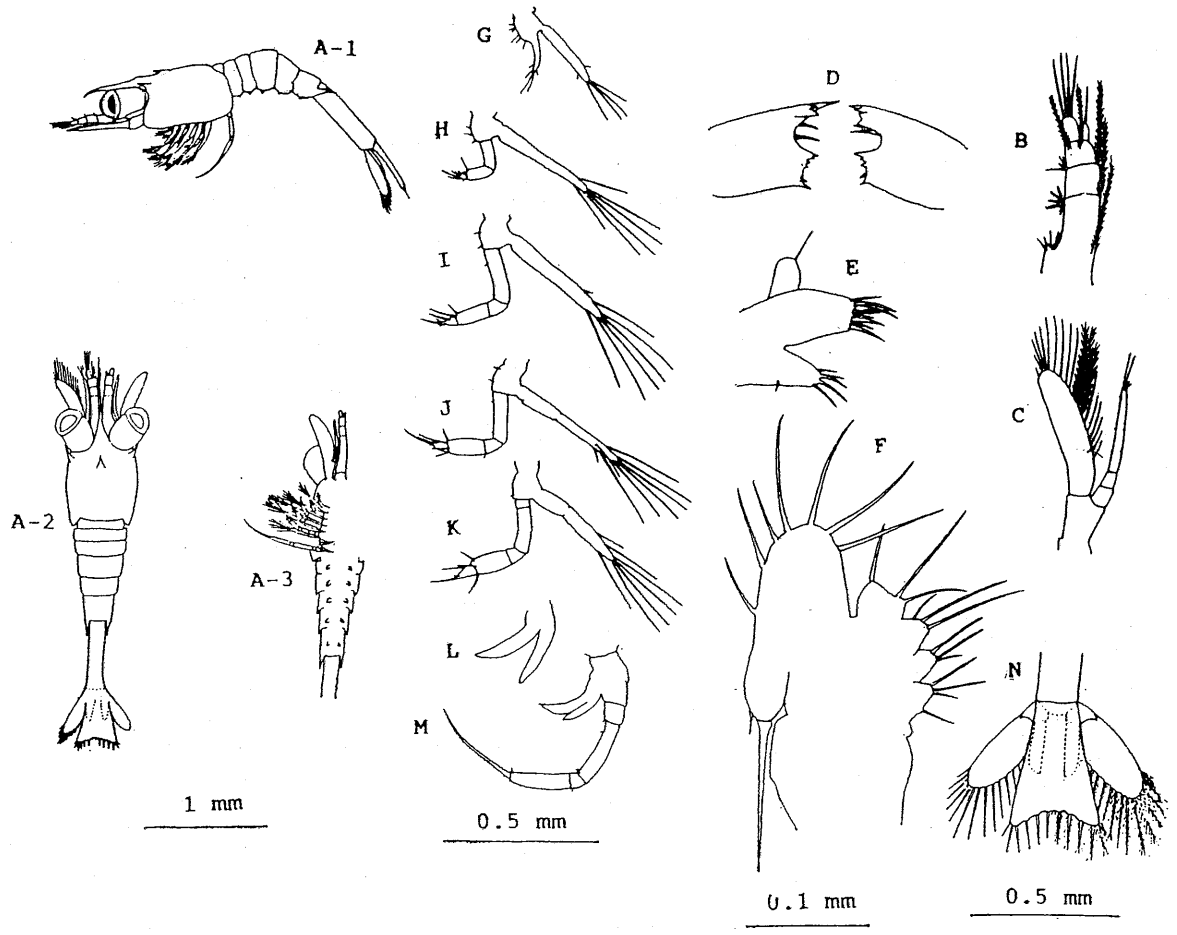

Fig. 3. Third instar. A-1, lateral view; A-2, dorsal view; A-3, ventral view; B, antennule; C, antenna; D, mandible; E, maxillulae; F, maxilla; G, 1st maxilliped; H, 2nd maxilliped; I, 3rd maxilliped; J, 1st pereiopod; K, 2nd pereiopod; L, 3rd pereiopod; M, 4th and 5th pereiopods; N, telson.

Sixth abdominal somite separated from telson.

Antennule (Fig. 3-B) with 3 peduncle segmentes, inside and dorsal surfaces with plumose setae, outside with small setae and base with a bulge, Anterior with a protuberance is the rudiment of the inner flagellum. Antenal flagellum (Fig. 3-C) divided into 3 segments and terminates with 2 large setae and 2 small setae.

Mandible (Fig. 3-D) and first maxilla (Fig. 3-E) not different from second instar in type of sharp, but larger than those of latter. Second maxilla (Fig. 3-F) with 9 plumose setae on exopod.

First, second and third maxillipeds (Fig. 3-G, H, I) not different from second instar in type of shape.

First pereiopod (Fig. 3-J) not different from second instar in type of shape. Endopod of second pereiopod (Fig. 3-K) 5-segmented. Third pereiopod (Fig. 3-L) biramous and rudimentary. Fourth and fifth pereiopods (Fig. 3-M) with bases joined together. Fourth pereiopod larger

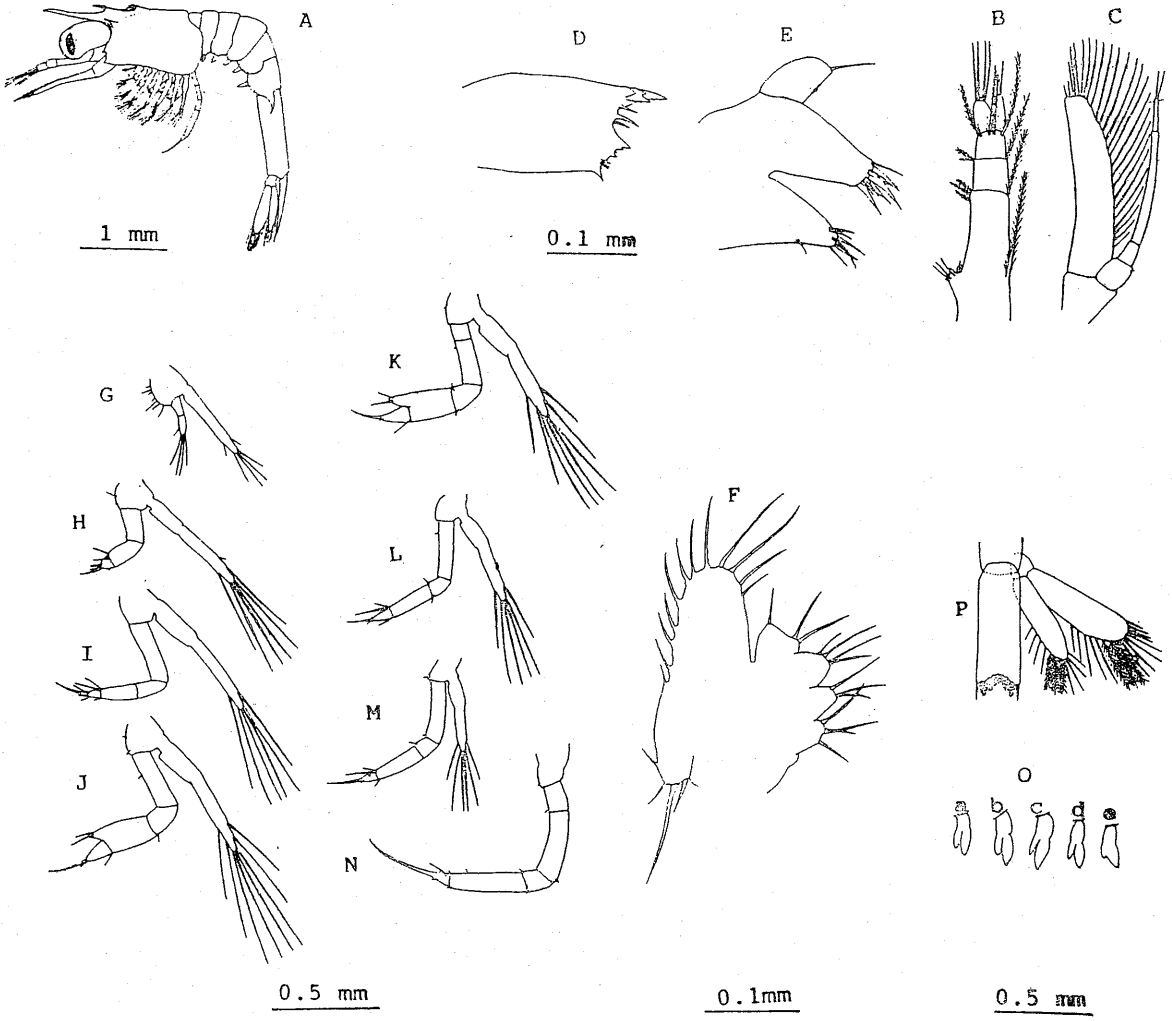

Fig. 4. Fourth instar. A, lateral view; B, antennule; C, antenna; D, mandible; E, maxillulae; F, maxilla; G, 1st maxilliped; H, 2nd maxilliped; I, 3rd maxilliped; J, 1st pereiopod; K, 2nd pereiopod; L, 3rd pereiopod; M, 4th pereiopod; N, 5th pereiopod; O(a-e), pleopods (1st-5th); P, telson.

than that of second instar, but rudimentary. Fifth pereiopod 5-segmented, with ultimate segment claw-shaped. Telson (Fig. 3-N) with 12 plumose setae and pair of small spines. Uropod biramous, basis segmented, inner ramus rudimentary and outar ramus with 10 plumose setae.

Fourth instar (Fig. 4)

Total length from 3.4 to 4.0 mm (Fig. 4-A). Different from third instar as follows: Carapace with branchiostegal spines and pterygostomial angle. Rostrum with 2 dorsal rostral teeth.

Antennule (Fig. 4-B) with length of inner flagellum similar to outer flagellum. Antennal flagellum (Fig. 4-C) divided into 4 segments.

Mandible (Fig. 4-D) and first maxilla (Fig. 4-E) not different from third instar in type of shape, but larger than third instar. Second maxilla (Fig. 4-F) with 16 plumose setae on exopod.

First, second and third maxillipeds (Fig. 4-G, H, I) not different from third instar in type of shape.

First and second pareiopods (Fig. 4-J, K) with swollens and protuberances at

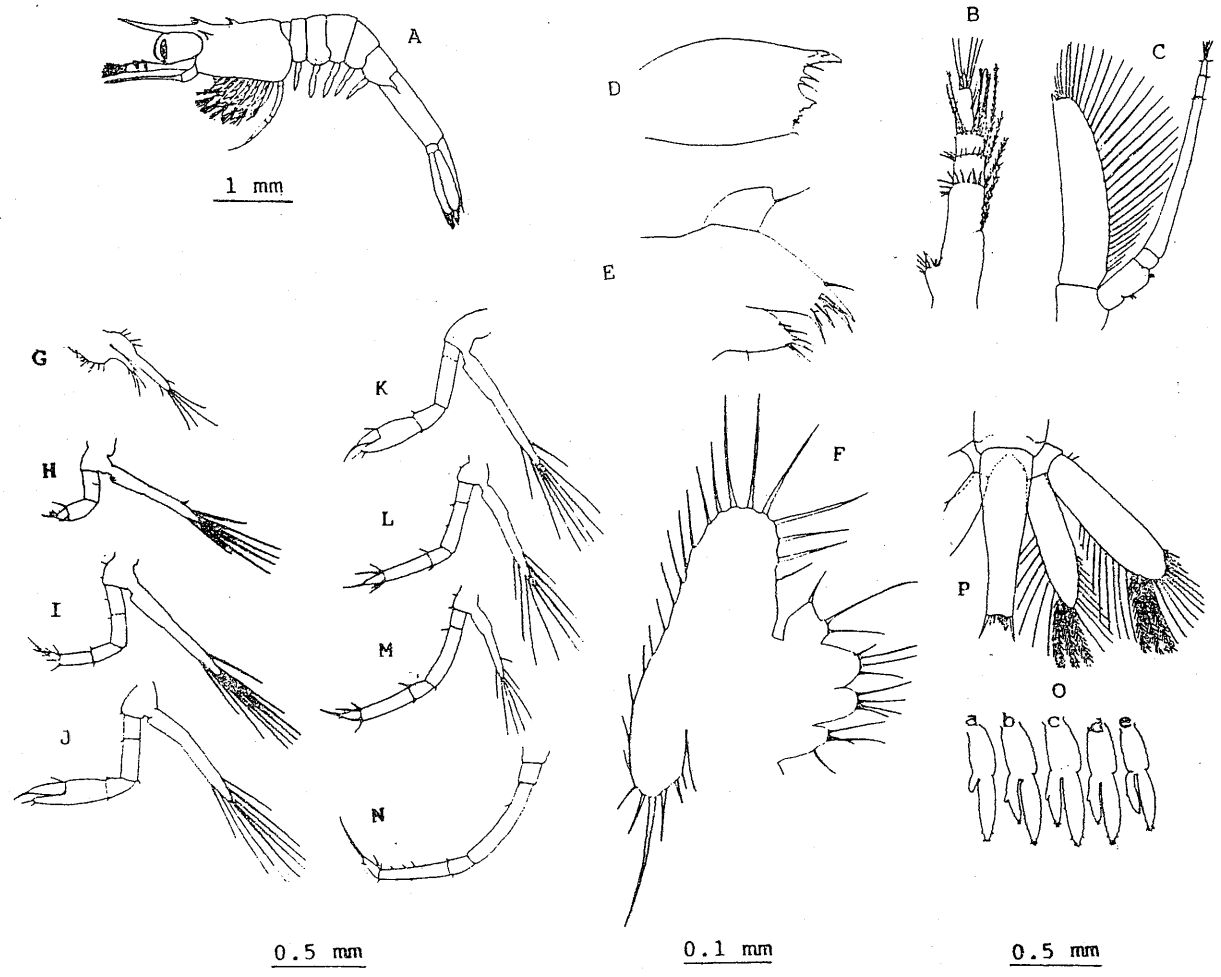

Fig. 5. Fifth instar. A, lateral view; B, antennule; C, antenna; D, mandible; E, maxillulae; F, maxilla; G, 1st maxilliped; H, 2nd maxilliped; I, 3rd maxilliped; J, 1st pereiopod; K, 2nd pereiopod; L, 3rd pereiopod; M, 4th pereiopod; N, 5th pereiopod; O(a-e), pleopods (1st-5th); P, telson.

distal corner of endopod inner forming, with dactylus, beginning of chela. Third and fourth pereiopods (Fig. 4-L, M) biramous; endopod 4-segmented and exopod with 6 plumose setae. Fifth pereiopod (Fig. 4-N) not different from third instar. Pleopods (Fig. 4-O) biramous rudimentary, third pleopod larger than other. Telson (Fig. 4-P) becoming narrower posteriorly, posterior margin with 6 plumose setae, a pair of small spines at center and a pair of large spines on edge. Uropod biramous; endopod shorter than exopod and bearing 11 plumose setae and 16 plumose setae respectively.

Fifth instar (Fig. 5)

Total length from 3.9 to 4.8 mm. Whole body not significantly differ from fourth instar (Fig. 5-A).

Antennular outer flagellum (Fig. 5-B) not different from fourth instar. Antennal scale (Fig. 5-C) with 31 plumose setae and 1 small spine on frontal outside edge; flagellum 5-segmented and longer than scale.

Mandible (Fig. 5-D) and first maxilla (Fig. 5-E) not different from fourth instar. Second maxilla (Fig. 5-F) with 21 plumose setae on exopod.

First maxilliped (Fig. 5-G) with bulage at base and 4 plumose setae on exopod.

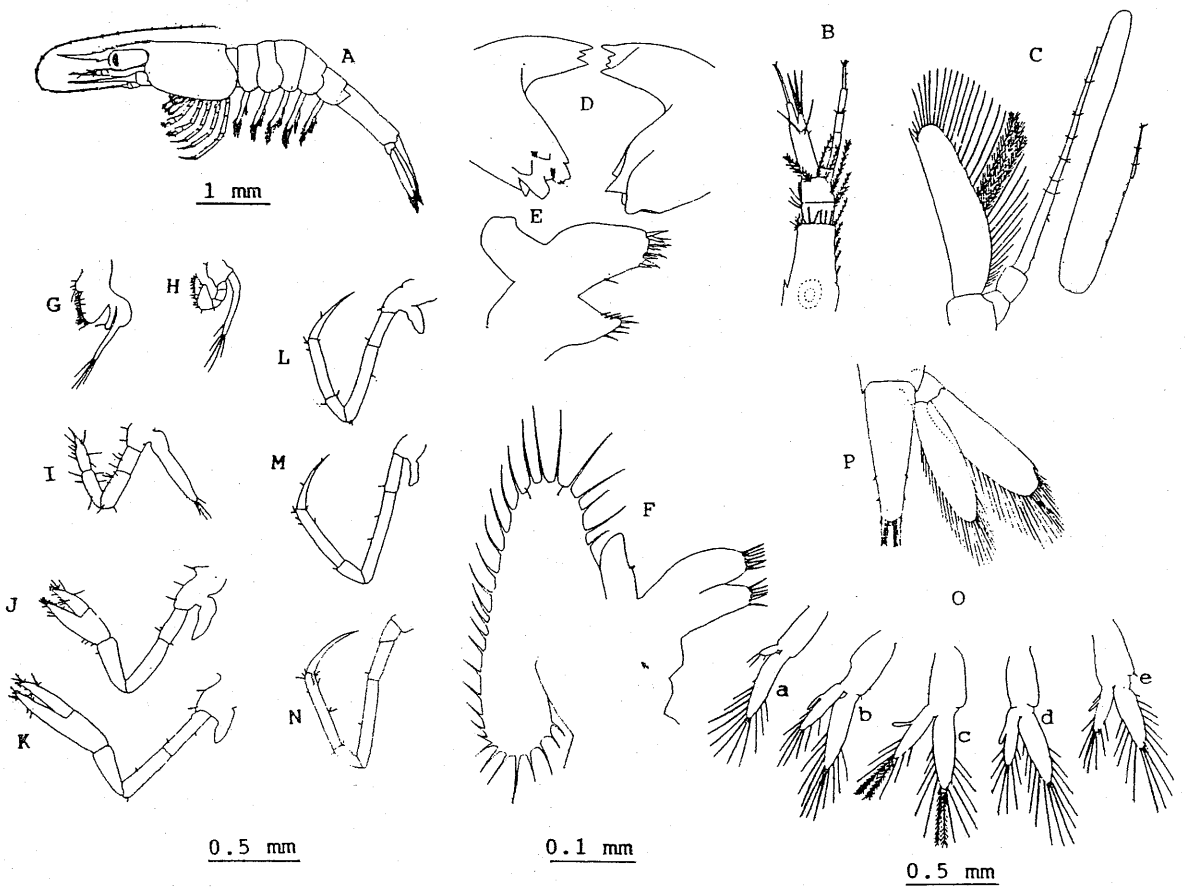

Fig. 6. Sixth instar. A, lateral view; B, antennule; C, antenna; D, mandible; E, maxillulae; F, maxilla; G, 1st maxilliped; H, 2nd maxilliped; I, 3rd maxilliped; J, 1st pereiopod; K, 2nd pereiopod; L, 3rd pereiopod; M, 4th pereiopod; N, 5th pereiopod; O(a-e), pleopods (1st-5th); P, telson.

Second maxilliped (Fig. 5-H) not different from that of fourth instar. Third maxilliped (Fig. 5-I) having 8 plumose seate on exopod.

Chelae at first and second pereiopods (Fig. 5-J, K) which length of movable finger shorter than immovable finger. Third pereiopod (Fig. 5-L) with 5-segmented endopod and exopod having 8 plumose setae. Fouth pereiopod (Fig. 5-M) with 5-segmented endopod. Fifth pereiopod (Fig. 5-N) not different from that of fourth instar. Pleopods (Fig. 5-O) having 4 to 6 small spines on exopods, endopods with 0 to 4 small spines, exopods were larger than endopods. Posterior of telson (Fig. 5-P) narrower than anterior. Uropod with 21 plumose setae on endopod and 23 on exopod.

Sixth instar (Postlarva, Fig. 6)

Total length from 4.9 to 5.8 mm (Fig. 6-A). Rostrum with 6 dorsal teeth and 1 ventral tooth. Supraorbital spines degenerated. Posterior margins of abdominal pleurae rounded.

Antennule (Fig. 6-B) with tip of outer flagellum divided into 2 sections; inner

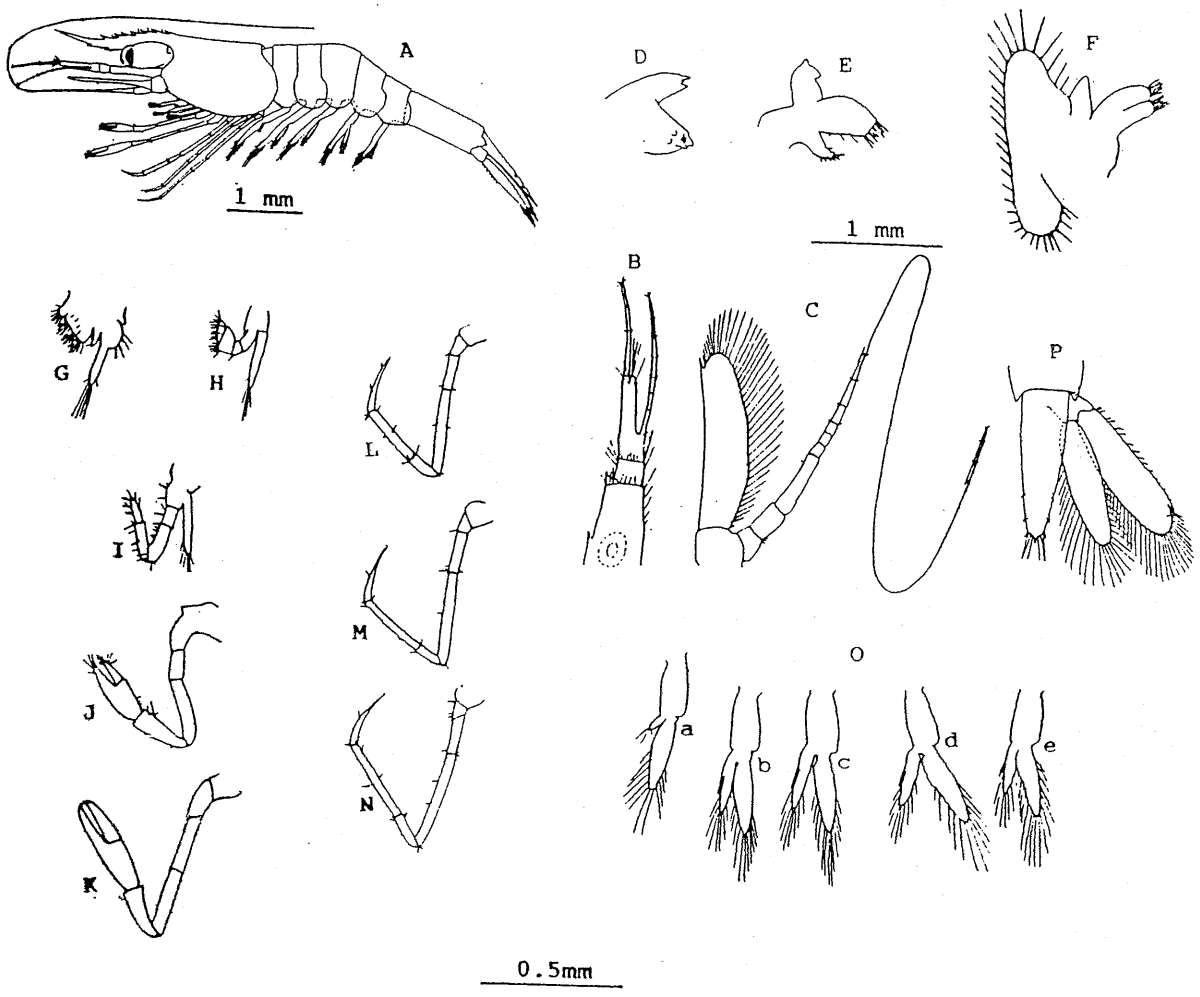

Fig. 7. Seventh instar. A, lateral view; B, antennule; C, antenna; D, mandible; E, maxillulae; F, maxilla; G, 1st maxilliped; H, 2nd maxilliped; I, 3rd maxilliped; J, 1st pereiopod; K, 2nd pereiopod; L, 3rd pereiopod; M, 4th pereiopod; N, 5th pereiopod; O(a-e), pleopods (1st-5th); P, telson.

flagellum 5-segmented and longer than outer flagellum; bulge developed into spine at peduncle and center of basal segment containing statocyst. Antenna (Fig. 6-C) with flagellum divided into many segments and longer than scale 2.5 times.

Mandible (Fig. 6-D) with molar teeth larger than incisor, left with 4 teeth while right with 3 teetm as incisor and teeth of molar forming triangular surface. First maxilla (Fig. 6-E) with terminal seta on endopod degenerated and palp-like. Second maxilla (Fig. 6-F) with basal portion bilobe, inner surface of each lobe bearing numerous coarse setae; endopod unsegmented with neither lobes nor setae; exopod had 31 plumose setae around edge.

First maxilliped (Fig. 6-G) with basal portion developed into large lobe and with coarse setae; endopod reduced, bearing 1 apical seta; exopod with 4 long setae at tip. Second maxilliped (Fig 6-H) with 5-segmented endopod, ultimate and penultimate segments wider than long, armed with coarse spines; exopod with 4 plumose setae on tip and 1 on edge. Third mixilliped (Fig. 6-I) with 4-segmented endopod, coarsely setose throughout; exopod reduced.

First pereiopod (Fig. 6-J) with chela

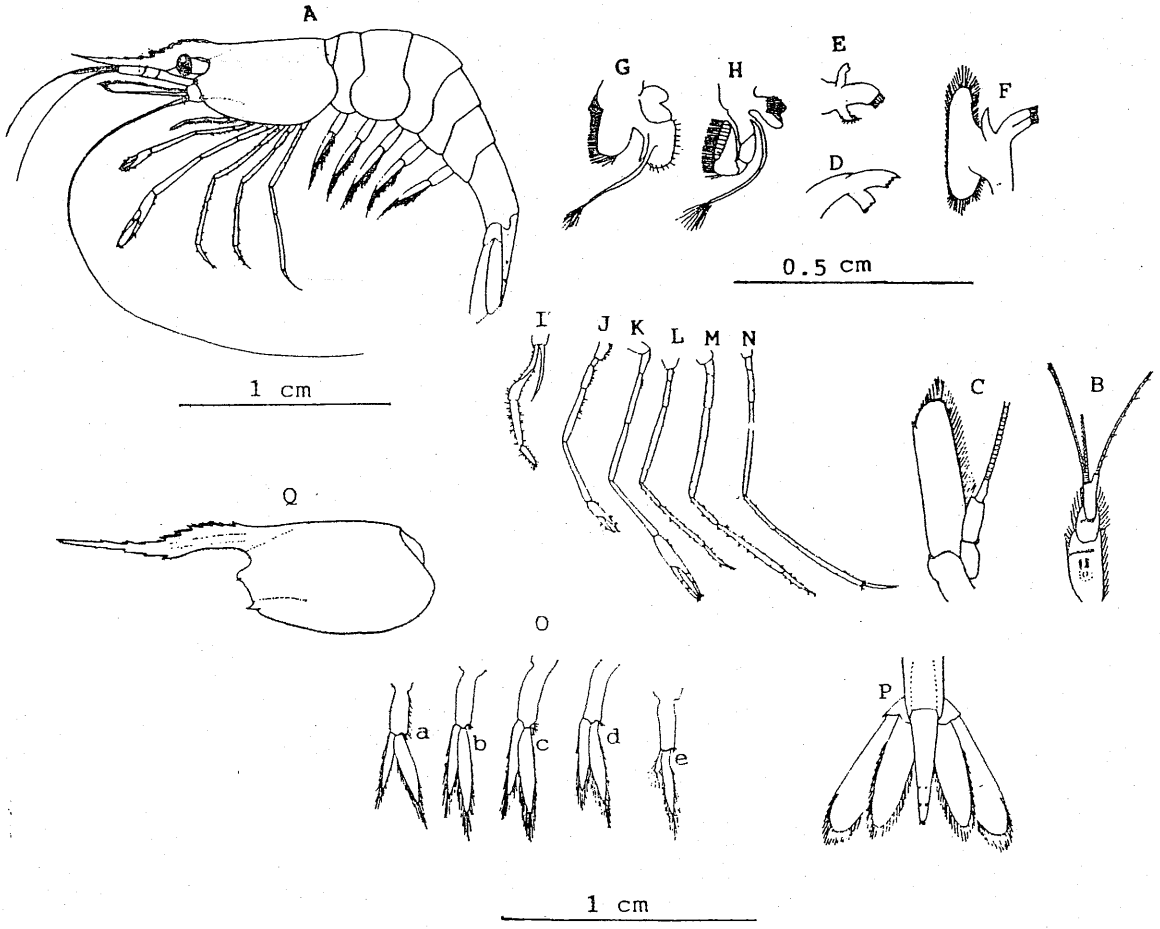

Fig. 8. Adult *Palaemon* (*Exopalaemon*) *orientis* Holthuis. A, lateral view; B, antennule; C, antenna; D, mandible; E, maxillulae; F, maxilla; G, 1st maxilliped; H, 2nd maxilliped; I, 3rd maxilliped; J, 1st pereiopod; K, 2nd pereiopod; L, 3rd pereiopod; M, 4th pereiopod; N, 5th pereiopod; O(a-e), pleopods (1st-5th); P, telson; Q, carapace.

stouter and shorter than that of second pereioped (Fig. 6-K); exopod degenerated. Second pereiopod chelate, cutting edges of chela without serrations or teeth; exopod degenerated. Third and fourth pereiopods (Fig. 6-L, M) not chelate, exopods degenerated. Fifth pereiopod (Fig. 6-N) 6-segmented.

Exopods of pleopods (Fig. 6-O) larger than endopods and with 11 to 15 plumose setae; endopod with 8 plumose setae except that of first pleoped. Telson (Fig. 6-P) with protuberance at mid-posterior and with a pair of small spines at center, a pair of plumose setae and a pair of large spines on edges, 3 pairs of dorso-lateral spines on posterior portion of telson. Uropodal exopod with spine on disto-lateral corner, numerous plumose setae around tip and on inner edge; endopod with plmose setae on inner edge and around tip.

Postlarva after first molt (Fig. 7)

Total length about 6.2 mm (Fig. 7-A). Rostrum with 6 dorsal teeth and 2 ventral teeth.

Antennule (Fig. 7B) with inner flagellum 7-segmented and outer flagellum 3-segmented. Antenna (Fig. 7-C) not different from sixth instar but flagellum longer than that of sixth instar.

Mandible (Fig. 7-D), first and second maxillae (Fig. 7-E, F), first, second and third maxillipeds (Fig. 7-G, H, I) not different from sixth instar.

First and second pereiopod (Fig. 7-J, K) with exopod reduced. Endopod of second pereiopod 5-segmented. Third and fourth pereiopod (Fig. 7-L, M) with exopod reduced and endopod 6-segmented. Fifth pereiopod (Fig. 7-N), pleopods (Fig. 7-O) and telson (Fig. 7-P) not different from sixth instar.

After the sixth molting, the appearance of the larva similar to that of the adult (Fig. 8), execpt the number of rostral teeth is different.

DISCUSSION

There is little agreement on either the form or the number of larval stages on larval development of decapods. Waterman (1960) divided larve of caridea tribe to protozoea, soea and postlarva phase. Shino (1969) suggested if naupliar stage of decapods is developed within egg. After hatching, it is further divided into the protozoea and/or zoea, mysis and decapodid (macrura) phase. Generally, the protozoea stage comes after meta-naupliar. In this stage, the larva uses antenna for swimming. Its maxillipeds, pereiopods and pleopods are rudimentary. Zoea has 2 or 3 pairs of maxilliped which are used for swimming. Its eyes have stalk. In mysis stages, the larva use biramous of pereiopods for swimming. The final development stage is decapodid (macrura) of which abdominal spines and exopods of pereiopods are reduced. At this stage, pleopods are used for swimming. Williamson (1968) divided larval development of decapods and euphausiaceans into nauplaius, zoea, megalopa and juvenile stage. The naupliar stage has 3 pairs of setose appedages on cephalothorax to swim, other appendages are absent or rudimentary. Zoea use all or parts of appeadages on thorax to swim. Its pleopods are absent or rudimentary. Larva of megalopa stage use all or part of its abdominal pleopods for swimming. In juvenile stages, the form of larva is similar to that of the adult, but this stage is unmatured. Kurata (1968a, b) suggested that after zoea stage, the larva could be called megalopa, but the name of megalopa or decapodid used in shrimp still had some problems.

Hudinaga (1942) divided larva of *Penaeus japonicus* into four stages by the development of swimming organs. In naupliar and zoea stages, the larva uses antennule and antenna to swim first, then maxillipeds are used. In mysis stages,

periopods are used first, then maxillipeds. In postlarval stages pleopods are used first and uropods second.

Utunomiya and Maekawa (1959) divided the larvae of *Palaemon serrifer* into zoea, mysis and postlarva. Right after hatching, it is defined as zoea. After twice molting the zoea becomes mysis, then after sixth molting, the mysis becomes postlarva. Comparing to the larvae of *P. orientis* it was found that after the second molting (third instar) *P. orientis* is similar to the mysis of *P. serrifer*, while after the fifth molting (sixth instar) the larva of *P. orientis* becomes to postlarva and is similar to the postlarva of *P. serrifer*.

As a summary of previous studies, larval stages of *P. orientis* can be divided as follow: after hatching, it is the zoea stage. After second molt (third instar) it becomes mysis. In this stage, all pereiopods are developed and all or parts of pereiopods are used for swimming. Pleopods are absent or rudimentary in this stage. After fifth molt (sixth instar) the mysis becomes the postlarva. In this stage, pleopods with plumose setae are used for swimming and the basal segment of antennule containing a statocyst. The larva swims like adult.

After hatching, the molt stages of *P. orientis* progressed along molting times (Table 1). Usually after fifth molt (sixth instar) the larva went into postlarva stage, but a few individuals had to experience another molting to become postlarva, the morphology of the larva after the fifth molt was similar to that of previous stage, only the body length was 5.0 mm, and which is larger than that of the former.

REFERENCES

Hudinaga, M. (1942) Reproduction development and rearing of *Penaeus japonicus* Bate. *Jap. J. Zool.* **10**: 319-321.

Kubo, I. (1932) Studies on Japanese Palaemonoid shrimps, III. Leander. *Jour. Imp. Fish. Inst.* **35**: 25-36.

Kurata, H. (1968a) Larvae of Decapoda Macrura of Arasaki, Sagami bay—I. *Eualus gracilirostris* (Stimpson) (Hippolitidae). *Bull. Tokai Reg. Fish. Res. Lab.* **55**: 245-251.

Kurata, H. (1968b) Larvae of Decapoda Natantia of Arasaki, Sagami bay—IV. Palaemoninae. *Bull, Tokai Reg. Fish. Res. Lab.* **56**: 143-159.

Shino, S. M. (1969) Arthopoda. In *Invertebrate of fishery*. Biohookan Press, Tokyo. 254-255.

Utunomiya, T. and K. Maekawa (1959) Metamorphosis of the postlarvae of a shrimp, *Palaemon* (*Palaemon*) *serrifer* (Stimpson). *Jour. Yamaguchi Pref. Naikai Fish. Exp. Sta.* **10**: 107-120.

Waterman, T. H. and F. A. Chace, Jr (1960) General crustancean biology. In *The physiology of Crustacea*, I. Academic press, London. 1-34.

Williamsom, D. I. (1968) Names of larva in the decapoda and euphausiacea. *Crustacean* **15**: 210-213.

Yasuda, J. (1956) Biological studies on shrimps in inland sea or bay—II. Ecological studies on several species. *Bull. Naikai Reg. Fish. Res. Lab.* **9**: 1-18.

Yasuda, J. (1958) Biological studies on shrimps in inland sea or bay. *Bull. Naikai Reg. Fish. Res. Lab.* **11**: 171-198.

東方長臂蝦 *Palaemon* (*Exopalaemon*) *orientis* Holthuis 幼體之變態研究

陳 一 鳴　　平野禮次郎

本報告探討在實驗室飼育的東方長臂蝦 *Palaemon* (*Exopalaemon*) *orientis* Holthuis 幼體變態之情形，飼育水溫爲 24.5±0.5°C，鹽度爲 20.0±0.2 ppt。餌料爲活的豐年蝦無節幼體。

卵孵化後須經 8 至 17 天後變爲幼體後期，各幼體的變態階段分法如下：孵化後爲溞狀幼體，經過兩次脫皮後變爲糠蝦幼體，至第五次脫皮後爲幼體後期 。 通常幼體經過五次脫皮後可變成幼體後期，但也有少數個體須經過六次脫皮後才變爲幼體後期，且這些個體在五次脫皮前、後的形態並無差異。