ZOOLOGICAL SCIENCE 2: 731–737 (1985)

On the Larval Development of *Parthenope (Platylambrus) valida* De Haan (Brachyura, Parthenopinae)

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ABSTRACT—Larvae of the parthenopid crab, *Parthenope (Platylambrus) valida* De Haan, were successfully reared in the laboratory from hatching through megalopa stage on *Artemia* nauplii. Four zoea stages and one megalopa stage are described and illustrated in detail.

INTRODUCTION

Little has been known on the larval development of the parthenopid crabs. On the larval forms of the Japanese species, *Parthenope (Platylambrus) valida* De Haan, Aikawa [1] described the first zoea stage hatched out in the laboratory and Fukuda [2] reported some characteristics of larve from the first zoea through megalopa in a short note without figures. They adopted the names *Lambrus valida* De Haan and *Platylambrus valida* (De Haan), respectively. Heegaard [3] described the first zoea stage of two Mediterranean species, *P. massena* Roux and *P. angulifrons* Latreille (*Lambrus massena* Roux and *L. angulifrons* (Latreille)), presenting the chromatophore patterns in a color plate. Yang [4] was the first to study the complete larval development in *P. (P.) serrata* (H. Milne Edwards) from U. S. A.

Parthenope (Platylambrus) valida, frequently found in the Sea of Enshunada, Central Japan, is distributed in Japan, China, Samoa, Singapore, Torres Strait and Queensland [5]. The purpose of the present paper is to give a detailed description of all developmental stages of this parthenopid.

MATERIALS AND METHODS

An ovigerous female used in the present study was caught with a gill-net from the bottom of the Sea of Enshunada consisting of sand and broken shells, 15 m deep, on June 5, 1984. The female was kept alive in a running seawater aquarium (60 $\times$40$\times$30 cm) with a sandy bottom until larvae hatched out. During the period, the female was not fed but water was renewed every three days. After hatching on June 12, 1984, the stage I zoeae were separated from the female and transferred to glass vessels (15 cm in diameter, 10 cm in depth) with filtered seawater from Enshunada about 7 cm deep, approximately 300 larvae being placed in each vessel. Newly hatched *Artemia* nauplii were given as food and culture water was changed daily. Water temperature at 11 a.m. during the period of observation ranged from 23.0 to 26.0°C. The larvae were checked daily for moulting and dead individuals were removed for microscope observation, at least eight larvae and five exuviae at each developmental stage were preserved in 6% buffered seawater-formalin. The larval appendages for drawing were dissected in 80% lactic acid. Drawings were made by means of a camera lucida. Details of appendages were studied at a magnification $\times$400 or more. Three specimens of each stage were measured with a calibrated ocular micrometer. The C length of zoeae was measured in lateral profile from the anterior edge of the eye to the extremity of the posterior margin of the carapace, and R–D length from the tip of the rostral spine to the tip of the dorsal carapace spine. C length of megalopa was measured dorsally from the base of the rostrum to the posterior margin of the carapace, and the C width across the widest part of the carapace. The size given for each stage is the arithmetic average of three specimens ex-

Accepted June 22, 1985
Received April 20, 1985

amined.

OBSERVATIONS

Four zoea stages were distinguished. Neither prezoea nor additional zoea stages were found in the present species. The minimum intermolt duration was five days for stage I, four days each for stages II and III, and five days for IV. Thus, *Parthenope (Platylambrus) valida* took at least 19 days to reach the megalopa stage. In zoeae, C and R–D lengths were 0.40 mm and 0.91 mm, 0.45 mm and 1.03 mm, 0.65 mm and 1.80 mm, and 0.70 mm and 1.95 mm, from stages I to IV, respectively. In megalopa stage, C length and C width were 1.42 mm and 1.03 mm, respectively.

1. Zoea stages

Structures remaining unchanged throughout zoeal development except for gradual increase in size

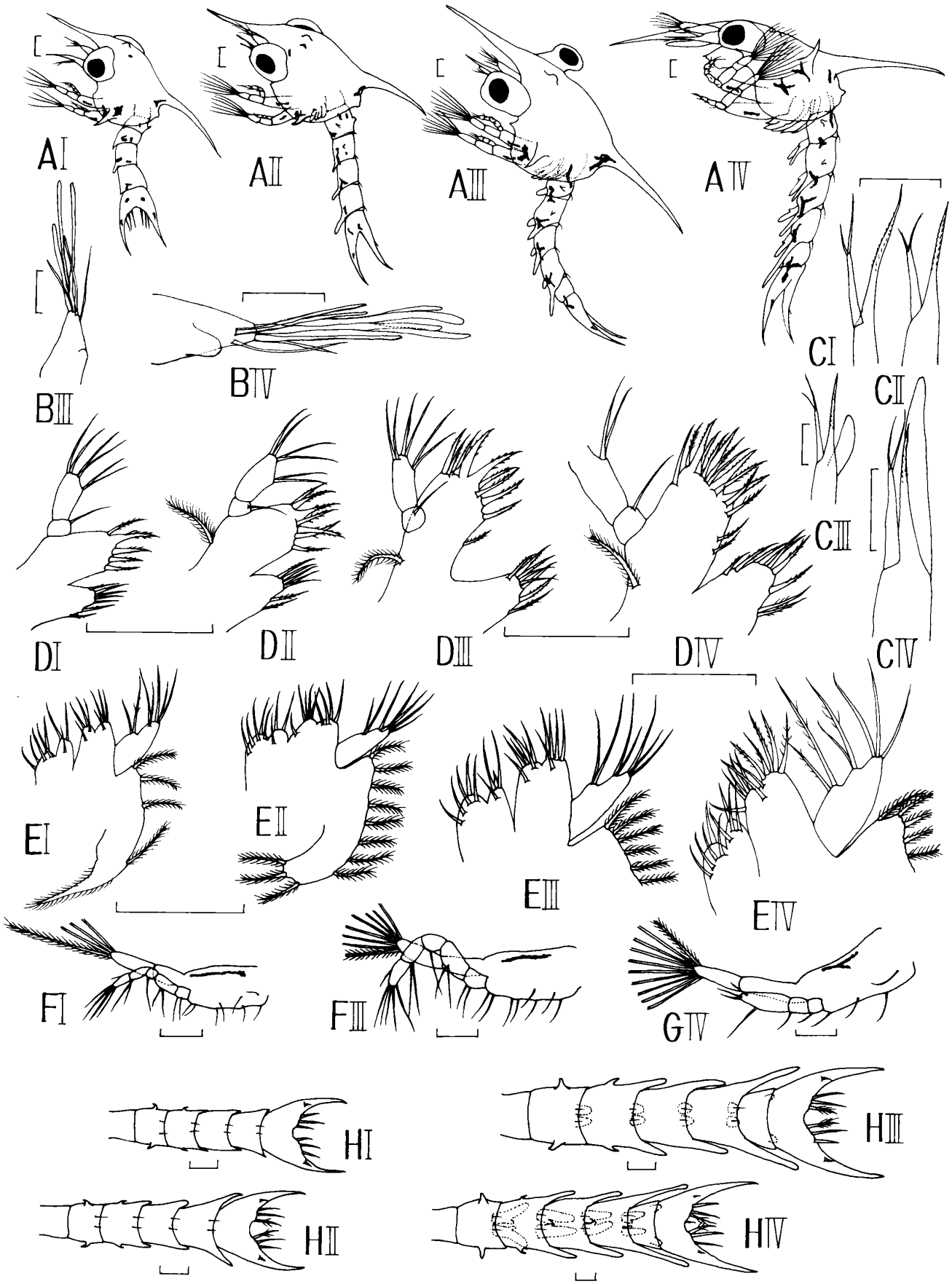
Cephalothorax (Fig. 1, AI–AIV) spherical in shape, with rostral, dorsal and lateral spines, tapering terminally from thickened base. Rostral spine approximately as long as dorsal spine, but more than four times as long as lateral spines. Small protuberances present on forehead between rostral and dorsal carapace spines, and postero-dorsal part of carapace. Chromatophores (Fig. 1, AI–AIV, FI, FIII, GIV) distributed on the lateral surface of carapace, at the base of dorsal carapace spine and basipods of both maxillipeds I and II. Abdominal segment II (Fig. 1, HI–HIV) has a mid-lateral spine projecting anteriorly on either side, and segment III with smaller one projecting posteriorly. The postero-dorsal margin of abdominal segments II to V with a pair of small hairs. Antenna II (Fig. 1, CI–CIV) consists of an elongated spinous process with two rows of minute spines on its distal half and a truncated exopod with two terminal setae unequal in size. Exopod about two-thirds the length of spinous process. According to Aikawa's criteria [6, 7], this antenna II falls into the type B_4. Maxilla I (Fig. 1, DI–DIV) consists of a basal and coxal endites and two-segmented endopod. Endopodial setation is 4·2–1 (i.e. four apical and two inner lateral setae on the distal segment, and one on the proximal). Maxilla II (Fig. 1, EI–EIV) as large as the maxilla I, much flattened, composed of basal and coxal endites, unsegmented endopod and large plate-like scaphognathite. Bilobed endopod has setation of 3:2·2 (i.e. three apical and two inner setae on the outer lobe and two on the inner). Maxilliped I (Fig. 1, FI, FIII) furnished with five-segmented endopod, bisegmented exopod and unsegmented basipod. Setation formula of basipod 2·2·2·2 (i.e. four series of setae, two, two, two, and two from the base to the top). Maxilliped II (Fig. 1, GIV) very similar in structure to the maxilliped I, except for three-segmented endopod. Setation of endopod is 2·2–1–1 (i.e. two terminal and two subterminal setae on terminal segment, and one each on middle and basal segments), and that of basipod is 1·1·1·1 proximo-distally. Telson (Fig. 1, HI–HIV) lunate in shape, bearing a dorsal spine on each fork, thus falling into the type A_{1+0} [8].

Appendages showing morphological changes during zoeal development

Antennae I and II

Antenna I (Fig. 1, BIII, BIV) conical in shape, unsegmented, with a group of aesthetes and simple setae at its tip. Aesthetes and setae vary in number with advance of stage: 2·2 (i.e. two aesthetes and two setae), 2·2, 3·3 and (9) (total number of aesthetes and setae), in stages I to IV, respectively. Endopod of antenna I first appears in stage III as a small bud at the basal region and grows up to about one-third the length of the antenna I in stage IV. Endopod of antenna II (Fig. 1, CI–CIV) still absent in stage II, but becomes visible in stage III in the basal region of spinous process as a small bud about half as long as spinous process. In stage IV, endopod about 1.3 times longer than spinous

FIG. 1. Zoea stages of *Parthenope (Platylambrus) valida* De Haan.
A, total view (lateral); B, antenna I; C, antenna II; D, maxilla I; E, maxilla II; F, maxilliped II; G, maxilliped II; H, abdomen (dorsal). Numerals associated with respective alphabets indicate the ordinal numbers of zoea stages. Scales: 0.1 mm.



process.

Maxilla I (Fig. 1, DI–DIV)

Basal endite possesses five setae in stage I, and seven, ten or 11, and 15 in the subsequent stages. Setae on coxal endite are seven in number in the first two stages, increase to eight in stage III and to nine in stage IV. One developed plumose seta appears at the outer edge of basal endite in stage II, and retained throughout the subsequent zoea stages.

Maxilla II (Fig. 1, EI–EIV)

Endites feebly bilobed, each lobe with several setae. Basal endite has setation of 4·4 (i.e. four setae on outer lobe and four on inner) in stage I, 4·5 in II, 5·6 in III, and 6·6 in IV. Setation of coxal endite is 3·1:4 (i.e. outer lobe with three setae and inner lobe one apical and four lateral setae) in stages I and II, and 4·1:4 in stages III and IV. Scaphognathite in stage I has four plumose setae along its anterior and lateral margins, and a long plumose posterior projection, setation being 4·1. In stage II plumose setae increase to 11, three of them situated along the rounded distal margin (setation: 8·3). In stages III and IV, setae on the whole margin increase to 25 or 26 and 29 to 31, respectively.

Maxillipeds I and II

Five-segmented endopod of maxilliped I (Fig. 1, FI, FIII) has a setation pattern of 4·1–2–1–2–2 (i.e. four apical and one outer lateral setae on segment V, two on I, II and IV, and one on III) in stages I and II, and 4·2–2–1–2–2 on both III and IV. Exopod composed of two segments, ending in four natatory setae in stage I, six in II, eight in III, and ten or 11 in IV. Exopod of maxilliped II (Fig. 1, GIV) also two-segmented, with four, six, eight or nine and ten terminal natatory setae in stages I to IV, respectively.

Abdomen (Fig. 1, HI–HIV)

Telson not separated from abdominal segment VI in stages I and II, articulation occurring in stage III. Postero-lateral spines of segments III to V rounded at its end in stage II onwards. Telson fringed with six spines on the distal border between caudal furcae in stages I to III, a tiny spine added to the corner of median notch of the distal margen in stage IV.

Pereiopods and pleopods

Five pairs of pereiopods (Fig. 1, AI–AIV) appear for the first time in stage II as biramous buds, undergoing further development during the following two stages. Pleopods (Fig. 1, AI–AIV, HI–HIV) first appear on the ventral surface of abdominal segments II to VI as small buds in stage III, developing into rod-like limbs in stage IV . In the final stage, each pleopod with a simple endopod; abdominal segment I without pleopods. Uropod smaller than pleopods without endopod.

2. Megalopa stage

Carapace (Fig. 2, A) globular in dorsal view, with elongated rostrum and a large dorsal spine, without lateral spines. Rostrum projecting forward about half the length of dorsal spine. Eyes are distinctly stalked. Antenna I (Fig. 2, B) with peduncle composed of three large segments, the basal one the largest. Distal peduncular segment with two flagella. The inner flagellum made up of a single segment. The outer flagellum four-segmented, with numerous aesthetes except for the basal segment. Antenna II (Fig. 2, C) elongated and seven-segmented (probably eight-segmented, as suggested by a suture surrounding the sixth segment). Setal formula 4–3–4–0–1–1–3, from distal to proximal. Mandible (Fig. 2, D) reduced to smooth cutting edge; three-segmented palp extending from the base with seven setae on its distal segment. Molar processes have disappeared. Endopod of maxilla I (Fig. 2, E) non-segmented, having seven setae, four apical, two subterminal and one located more basally. The number of setae on basal and coxal endites are about 22 and 13, respectively. Unsegmented endopod of maxilla II (Fig. 2, F) with one terminal and three inner setae. Setal formula of bilobed basal and coxal endites are 8·8 and 6·12, respectively. Scaphognathite very large, fringed with about 46 plumose setae. Maxillipeds I and II differ much from those of zoeae. Epipod of maxilliped I arising from coxopod (Fig. 2, G) well-developed, bearing ten long non-plumose setae along distal

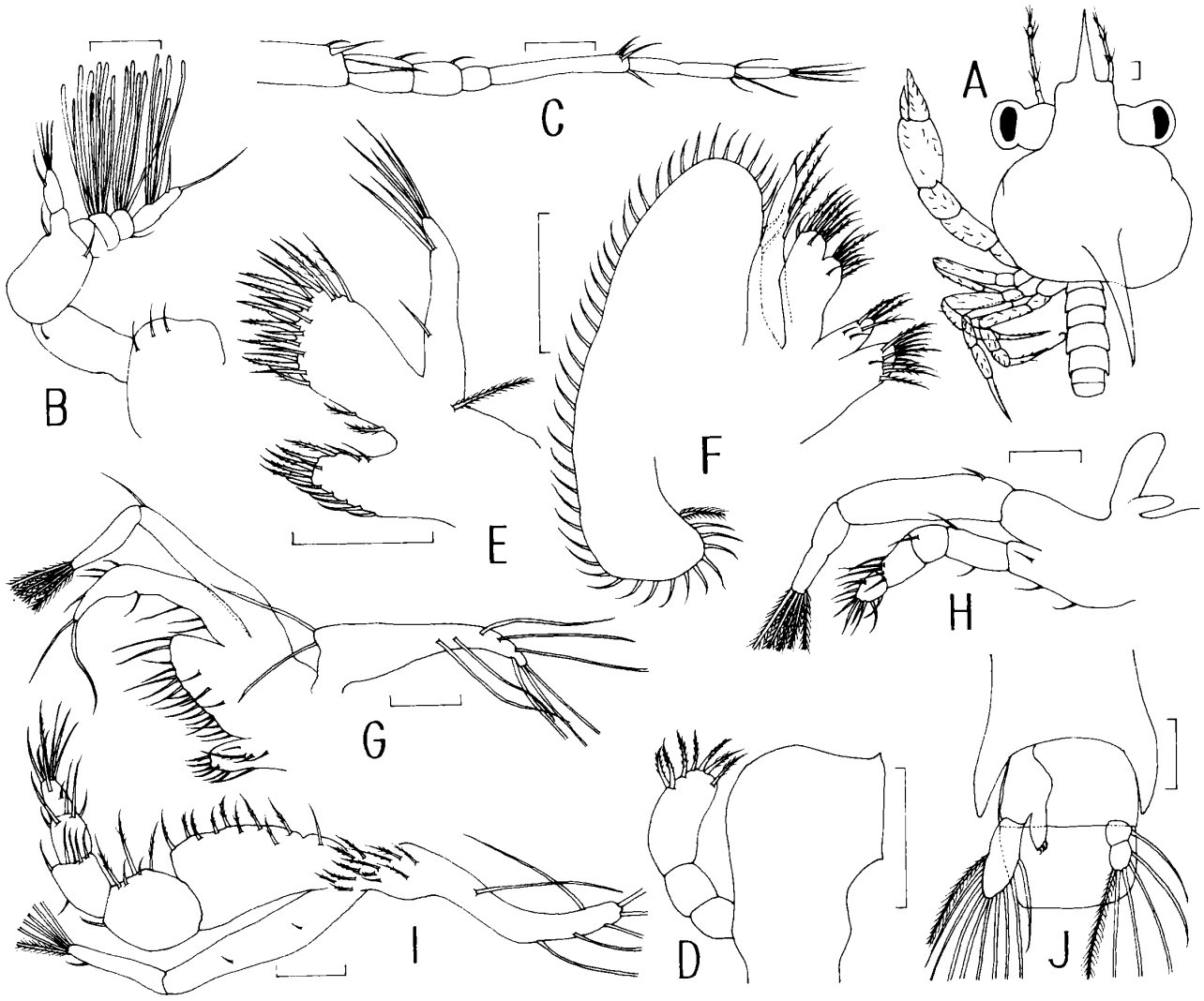


FIG. 2. Megalopa stage of *Parthenope (Platylambrus) valida* De Haan.
A, total view (dorsal); B, antenna I; C, antenna II; D, mandible; E, maxilla I; F, maxilla II; G, maxilliped I; H, maxilliped II; I, maxilliped III; J, telson (ventral). Scales: 0.1 mm.

and proximal margin. Bilobed protopod, masticatory in function, provided with numerous setae. Two-segmented exopod with four plumose setae on distal segment and one on outer side of proximal segment. Endopod unsegmented, bearing two apical, four outer and four inner setae. Maxilliped II (Fig. 2, H) has many setae on the distal two of four segments of endopod. Two-segmented exopod has five terminal plumose setae on distal segment and non-plumose spine near the outer base of proximal segment. Epipod bud without setae. Maxilliped III (Fig. 2, I) very well-developed. Five-segmented endopod bears numerous stout setae on all segments. Epipod of coxopod well-developed, bearing seven long non-plumose setae distally, and 13 setae proximally. Bisegmented exopod possesses six plumose setae on distal segment. Abdomen (Fig. 2, J) composed of six segments and telson, bearing four pairs of well-developed pleopods on the second through fifth segments and a pair of uropods on the sixth segment. Abdominal segment V with paired postero-lateral spines extending posteriorly beyond the middle of the next segment. Pleopods biramous; endopods furnished with three hooked setae on their distal end; protopods without setae; exopods larger than endopod and fringed with numerous plumose setae. Uropods (Fig. 2, J) uniramous, two-segmented, with one plumose seta on protopod, and five plumose setae on expod. Telson

TABLE 1. Comparison of the four species of Parthenopinae with

Species and reference		Number of zoea stage	Carapace spine R.D.L.	Type of antenna II	Type of telson
Parthenope massena	Heegaard, 1963	?	+ + +	B_4*	A_{2+0}*
P. angulifrons	Heegaard, 1963	?	+ + +	B_3*	A_{2+0}*
P. (Platylambrus) serrata	Yang, 1971	6	+ + +	B_4*	A_{1+0}*
P. (P.) valida	Terada (this paper)	4	+ + +	B_4	A_{1+0}

R, rostral spine; D, dorsal spine; L, lateral spines; +, present;

consists of a flat plate, without spines. Cheliders and walking legs (Fig. 2, A) well-developed and functional, with numerous setules on their surface. The fourth walking leg carries ventrally one long feeler near the tip of dactylus.

DISCUSSION

Regarding the larval development of *Parthenope (Platylambrus) valida*, Aikawa [1] reported on the features of the first stage zoea and Fukuda [2] briefly described the entire larval stages. The zoeae of the present species are provided with small protuberances on the forehead and in the postero-dorsal part of the carapace, a full sets of the carapace spines, the antenna II of the type B_4, and the mid-lateral projections in the abdominal segments II and III. These findings are in agreement with those reported by Aikawa and Fukuda. Furthermore, the present results accord well with Aikawa's descriptions with respect to the setations of the endopods of the maxillae I and II, and to the type of the telson, but differ in the endopodial setation of the maxilliped II. In the present specimens, the endopod of the maxilliped II has the setation 2·2–1–1 (or 4–1–1), instead of 3–1–1 as Aikawa reported. The present results agree with Fukuda's findings in the number of zoea stages and in the setation of the endopod of the maxilliped II. The telson is of the type A_{1+0} (or A_1) as Aikawa [1] noted and not A_2 as Fukuda [2] reported.

Major differences and similarities in structure of zoeae among *P. (P.) valida* and the three parthenopids studied previously are shown in Table 1. The four species of *Parthenope* are similar to one another in the features of the carapace spines and the mid-lateral projections of the abdomen. However, the number of zoea stages, the types of the antenna II and telson, and the endopodial setations of the maxillae I and II are not always the same. In zoeae of both *P. (P.) valida* and *P. (P.) serrata* [4] , the endopod rudiment of the antenna I appears as a rod-like process in its basal region in the penultimate stage; a plumose seta on the outer side of the basal endite of the maxilla I remains unaltered from stages II to the last stage; setation of the endopod of the maxilliped I is 4·1–2–1–2–2 in the first two stages, but it changes into 4·2–2–1–2–2 in the following stages; and the telson is separated from the abdominal segment VI by an articulation in stage III. The telson of *P. (P.) serrata* zoeae always bears three pairs of spines between the caudal furcae in all stages. By contrast, a tiny spine is added in *P. (P.) valida* zoeae in the last stage.

Megalopae dealt with in the present paper bear the rostrum and dorsal spine on the carapace, and a feeler on the dactylus of the fourth walking leg, as mentioned by Fukuda [2]. However, Fukuda [2] made no mention on many other characters of megalopae. The megalopae of *P. (P.) serrata* and *P. (P.) valida* are very similar in the feature of most of the appendages, although there are some minor differences between the two species. In *P. (P.) valida* megalopae, the exopod of the uropod has five plumose setae, whereas *P. (P.) serrata* megalopae, four setae. The basal segment of the antenna II has a large spine in *P. (P.) valida*, but the same appendage of *P. (P.) serrata* has no spine. The setae on the distal segment of the mandibular palp are seven in number in *P. (P.) valida*, although these are six in *P. (P.) serrata.*

respect to major features unaltered throughout zoea stages

Setation of endopod			Setation of basipod		Mid-lateral projection of abdomen	Setation of inner lobe of coxal endite dite of maxilla II
Maxilla I	Maxilla II	Maxilliped II	Maxilliped I	Maxilliped II		
4–2–0*	2: 1·2*	3*	?	?	Segs. II and III	?
4–2–0*	2: 2·2*	1·2–1*	2·2·2·2*	?	Segs. II and III	?
4·2–1*	3: 2·2* 2: 2·2(IV)*	4–1–1*	2·2·2·2* 3·3·2·2(IV)*	1·1·1·1*	Segs. II and III	1: 4*
4·2–1*	3: 2·2	2·2–1–1	2·2·2·2	1·1·1·1	Segs. II and III	1: 4

* cited according to figure of reference.

ACKNOWLEDGMENTS

The author wishes to express his sincere thanks to Professor Emeritus K. Takewaki, University of Tokyo, for his valuable advice and reading the manuscript. Thanks are also due to the staff of the Thermal Excellent Utilization Research Center, Shizuoka Pref., for their valuable assistance in obtaining filtered seawater.

REFERENCES

1 Aikawa, H. (1937) Further notes on brachyuran larvae. Rec. Oceanogr. Works Jpn., **9**: 87–162.

2 Fukuda, Y. (1978) Preliminary notes recently obtained larvae of brachyuran Crustacea of the Sea around the Aitsu Marine Biological Station. Calanus, **6**: 10–16. (In Japanese with English abstract)

3 Heegaard, P. (1963) Decapod larvae from the Gulf of Napoli hatched in captivity. Vidensk. Medd. fra Dansk naturh. Foren., **125**: 449–493.

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

5 Sakai, T. (1976) Crabs of Japan and the Adjacent Seas, Kodansha Ltd., Tokyo.

6 Aikawa, H. (1929) On larval forms of some Brachyura. Rec. Oceanogr. Works Jpn., **2**: 17–55, *pls.* 2–5.

7 Aikawa, H. (1933) On larval forms of some Brachyura. II; A note on indeterminable zoeas. Rec. Oceanogr. Works Jpn., **5**: 124–254.

8 Terada, M. (1980) Zoea larvae of four crabs in the subfamily Xanthinae. Zool. Mag., **89**: 138–148. (In Japanese with English abstract)