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The Larval Development of *Petrolisthes japonicus* (De Haan, 1849) (Decapoda, Porcellanidae) in Laboratory Culture

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The larval characters of *Petrolisthes japonicus* (De Haan, 1849), Porcellanidae, were described and illustrated. The larval development of *P. japonicus* includes the two zoeal and one megalopal stages. The first and second zoeal stages lasted about 4 and 10 days, respectively. It took about 14 days to attain megalopa from hatching. The larval characteristics of *P. japonicus* were compared with those of other known species of *Petrolisthes*. Consequently, the larvae of *P. japonicus* are more closely related to *P. elongatus* and *P. ornatus* than other *Petrolisthes* species, but the present species can be distinguished from these *Petrolisthes* species by morphological characteristics.

KEY WORDS: *Petrolisthes japonicus*, Porcellanidae, Larval development

Petrolisthes japonicus, a shallow-water porcellanid crab, is distributed in high tidal zones along the Korea Strait, Yellow Sea, Cheju Island, Malacca, Borneo, Hong Kong and Japan (Kim, 1973). The larval stages of the genus *Petrolisthes* have been described by authors from various area. The larval development of *P. armatus* (Gibbes) was described by Gore (1970, 1972a), that of *P. rufescens* (Heller) by Yaqoob (1974), of *P. novaezelandiae* Filhol and *P. elongatus* (H. Milne Edwards) by Greenwood (1965), of *P. tridentatus* Stimpson by Gore (1971), of *P. platymerus* Haig by Gore (1972b), of *P. tonsorius* Haig by Pellegrini and Gamba (1985), of *P. granulosus* (Guerin) by Saelzer *et al.* (1986), and of *P. ornatus* by Yaqoob (1977). However, the complete larval development of *P. japonicus* has not been described. The main purpose of the present study is to provide a detailed description and illustrations of the complete larval development of *P. japonicus* for the first time and to discuss the morphological characteristics in relation to the *Petrolisthes* zoeae.

Materials and Methods

Ovigerous females of *Petrolisthes japonicus* were collected beneath stones at the high tide from the City of Cheju, Cheju Island, on July 29, 1985. The females were shipped to the laboratory, where each of them was isolated in 30 cm diameter glass bowl filled with filtered seawater. Rearing temperatures varied from 25 to 28°C. Hatching occurred on August 8, 1985. Larvae of *Petrolisthes japonicus* hatch as prezoeae, remaining for approximately one hour. Some larvae were preserved for each stage for later use in 10% formalin solution. Drawings of intact larvae, as well as dissected appendages, were made using a compound microscope with camera lucida attached on it. Chromatophore pattern was checked from living specimens.

Results

First zoea

Carapace length 1.4 mm. rostral spine length 5.7 mm; posterior spine length 3.4 mm. N 10.

Carapace (Fig.1A).-Typically porcellanid, smooth and without spines. Rostral spine about 4X carapace length, armed dorso-ventrally with many pointed spinules and laterally with scattered spinules. Posterior carapace spines about 2.4X

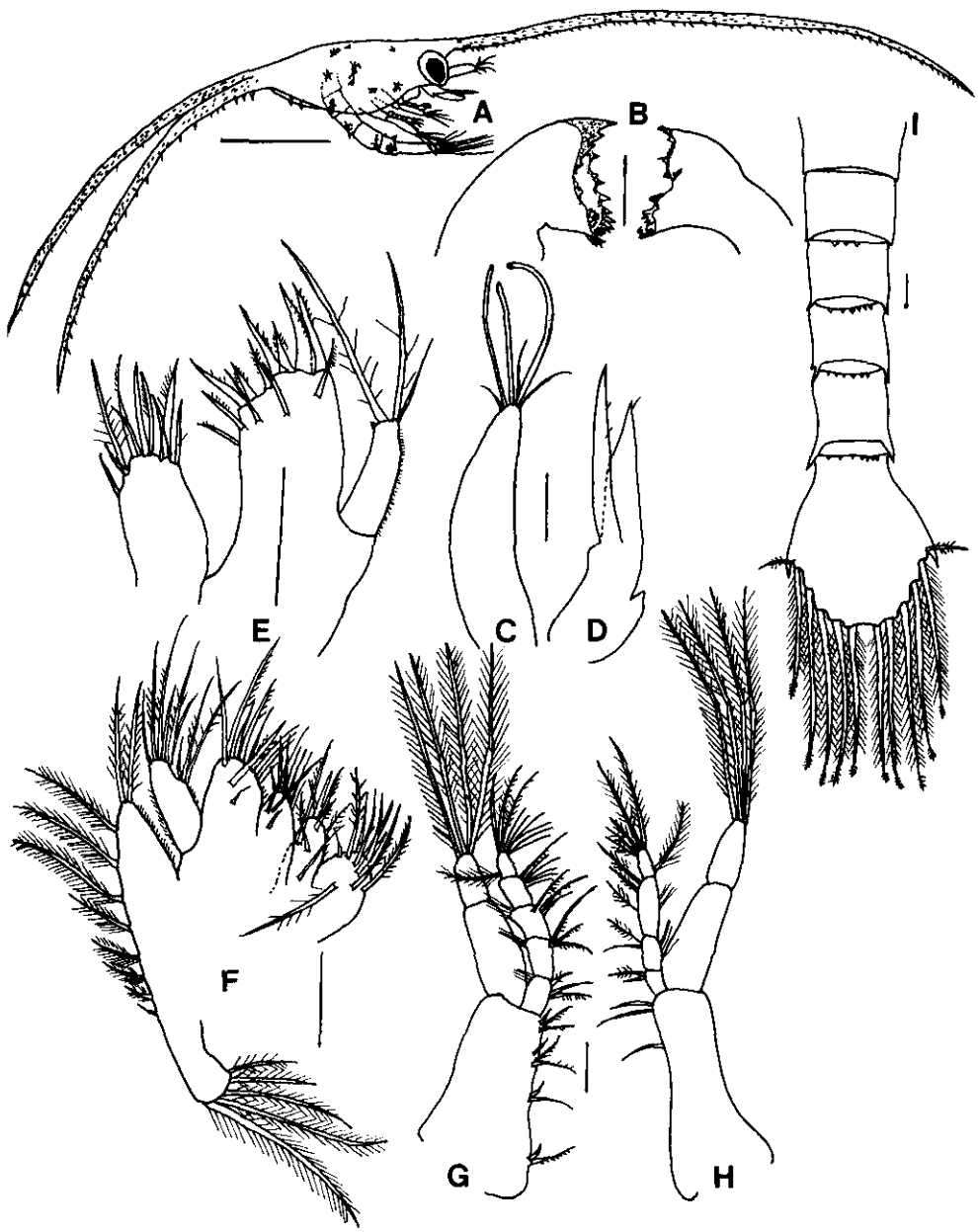

Fig. 1. *Petrolisthes japonicus* (De Haan, 1849), first zoeal appendages. A, lateral view; B, mandibles; C, antennule; D, antenna; E, maxillule; F, maxilla; G, first maxilliped; H, second maxilliped; I, abdomen and telson. Scale line A = 1 mm, B – I = 0.1 mm.

carapace length, armed dorso-ventrally with small spinules and laterally with irregularly placed spinules. Posterior lateral edges of carapace with two pairs of small spinules.

Antennule (Fig.1C).-Unsegmented, with 3 aesthetascs and 3 setae.

Antenna (Fig.1D).-Biramous. Exopodite longer than endopodite and with 2 subterminal setae on its inner border. Endopodite with 1 terminal seta.

Mandibles (Fig.1B).-Asymmetrical, without palps and with numerous acute teeth.

Maxillule (Fig.1E).-With unsegmented endopodite bearing 3 terminal setae, 1 small subterminal spinule, and fine hairs on outer margin. Basal endite with 7 spines and 5 setae. Coxal endite with 10 setae.

Maxilla(Fig.1F).-With unsegmented endopodite bearing 6 terminal and 3 subterminal setae. Basal and coxal endites with 10 and 11, 10 and 8 setae on proximal and distal lobes, respectively. Scaphognathite with 10 plumose setae around margin plus five apical plumose setae. Fine hairs occurring along margins of endopodite, basal endite, coxal endite and scaphognathite, as illustrated.

Maxilliped 1 (Fig.1G).-Basipodite ventral setae progressing distally, 2, 2, 3, 3. Setae on 5 segmented endopodite ventrally 3, 3, 3, 6, 9, with 1 long plumose seta dorsally on distal segment. Long and fine hairs dorsally on segment 1-3. Exopodite 2-segmented, with 4 natatory setae.

Maxilliped 2 (Fig.1H).-Basipodite vental setae 1, 2 (rarely 1, 3). Setae on 4-segmented endopodite progressing distally, 2, 2, 1 + 2, 5 with 1 long plumose seta dorsally on distal segment. Fine hairs dorsally on segments 2 and 3. Exopodite 2-segmented, with 4 natatory setae.

Abdomen (Fig.1A).-5-segmented, somites 3, 4 and 5 each with distinct lateral spine, larger toward telson. Somites 2-5 serrated dorsally on posterior margin.

Telson (Fig.1I).-7 pairs of processes (setae formula 7 + 7). First pair consisting of short strong spines; the second pair of fine plumose setae, and five remaining pairs of plumose setae with distinct hooklike spines distally. Small anal spines present.

Colour.-Transparent. Eyes pale metallic green, dark brown or black eye spots. Red chromatophores as follows: on carapace at the level of pereiopods, at base of mandibles, on maxillulary region, in each abdominal segment along intestine and on gastric region.

Second zoea

Carapace length 2.3 mm. Rostral spine length 10.1 mm; posterior spine length 5.3 mm. N 10.

Carapace (Fig. 2A, B).-Smooth, lower margin of carapace appears distinctly crenulate. Rostral spine and posterior spine about 4.4X and 2.3X carapace length respectively, armed ventrally with a series of spines and laterally with numerous spinules.

Antennule (Fig. 2D).-Biramous; endopodite bud more than one-half exopodite length; 2 small setae on protopodite close to base of endopodite, and 2 small setae near it base. Exopodite with aesthetascs progressing distally as follows: 5, 7, 4, 4, plus 2 terminal setae and 2 small setae.

Antenna (Fig. 2E).-Endopodite now longer than exopodite, endopodite with apical single seta and exopodite with 3 subterminal setae.

Mandibles (Fig. 2C).-More developed than in previous stage; molar and incisor processes as shown, each with distinct palp.

Maxillule (Fig. 2F).-With unsegmented endopodite bearing 2 long terminal setae. Basal endite with 8 spines and 5 setae. Coxal endite with 10 setae.

Maxilla (Fig. 2G).-With unsegmented endopodite bearing 5 terminal and 2 subterminal setae. Basal and coxal endites with 9 and 11, 11 and 7 setae on proximal and distal lobes, respectively. Scaphognathite fringed with 21 plumose setae.

Maxilliped 1 (Fig. 2H).-Basipodite with 10 ventral setae, setation 2, 2, 3, 3. Endopodite 5-segmented, setae now 3, 3, 3, 4, 7, along ventral margin and long seta on dorsal margin of each segment except terminal segment. Exopodite 2-segmented, now bears 12 natatory setae.

Maxilliped 2 (Fig. 2I).-Basipodite with 4 ventral setae, setation 1, 3. Endopodite 4-segmented, setae as follows: 1, 1 + 2, 2 + 3, 5, with 1 and 2 setae on 2nd and 3rd segments respectively. Exopodite 2-segmented with 12 natatory setae.

Abdomen (Fig. 2A, B, J).-With 4 pairs of pleopod buds on abdominal somites 2-5.

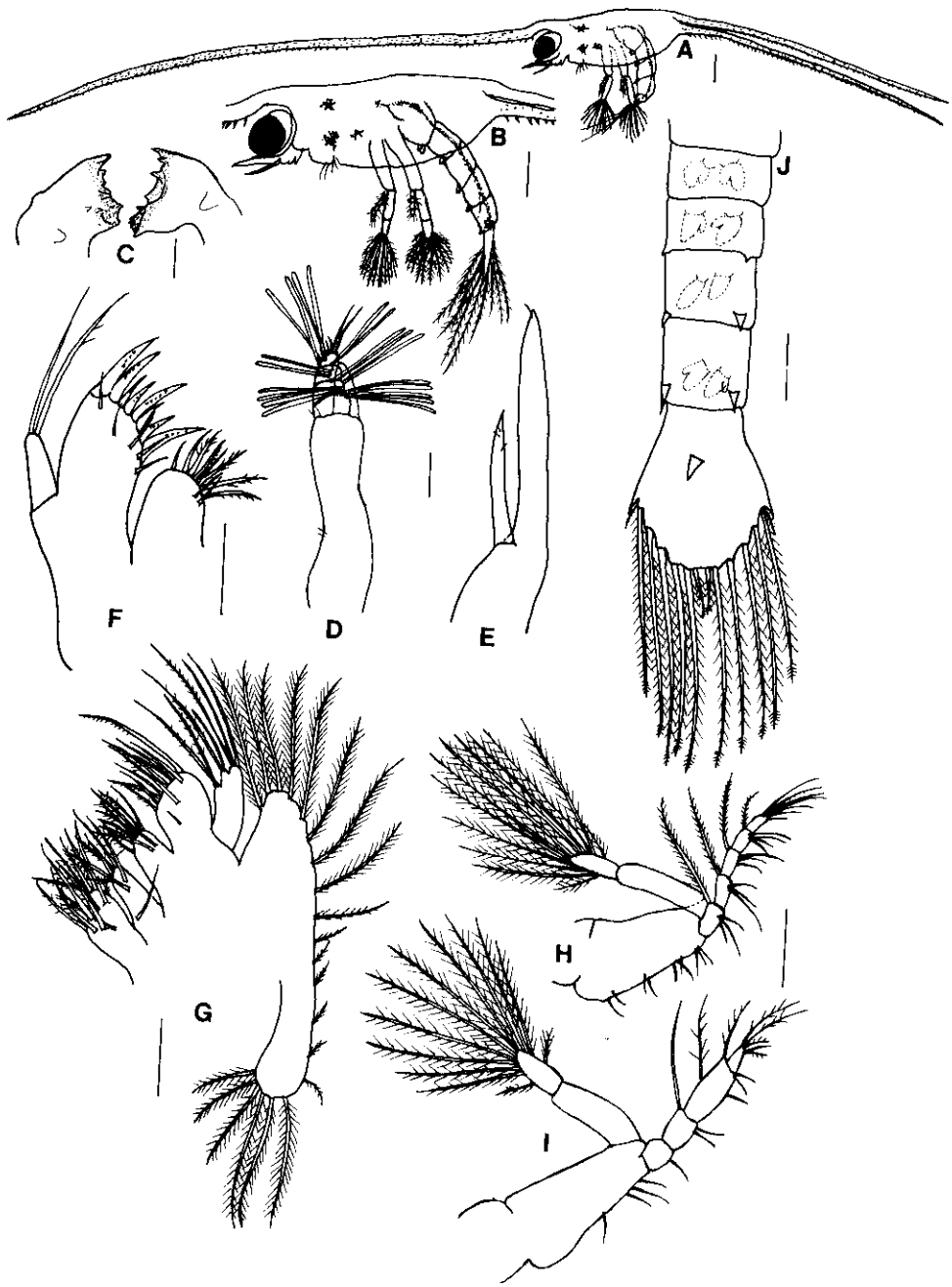

Fig. 2. *Petrolisthes japonicus* (De Haan, 1849), second zoeal appendages. A, B, lateral view; C, mandibles; D, antennule; E, antenna; F, maxillule; G, maxilla; H, first maxilliped; I, second maxilliped; J, abdomen and telson. Scale line A – B = 0.5 mm, C – J = 0.1 mm.

Telson (Fig. 2A, B, J).-With a pair of setae on posterior median margin. Anal spine present.

Colour.-Similar to first stage.

Megalopa

Carapace length × width 1.5 mm × 1.2 mm. N 5.

Carapace (Fig. 4A).-Length longer than width, oval and naked. Frontal region enlarged, extending anterior to eyes. Eyes stalked.

Antennule (Fig. 3B).-Biramous, unsegmented peduncle with 2 setae. Upper ramus 6-segmented; aesthetascs on segments 2-5, usually in groups of 7, 6, 6, 2. A long and a short setae on tip of distal segment and other setae as shown. Lower ramus

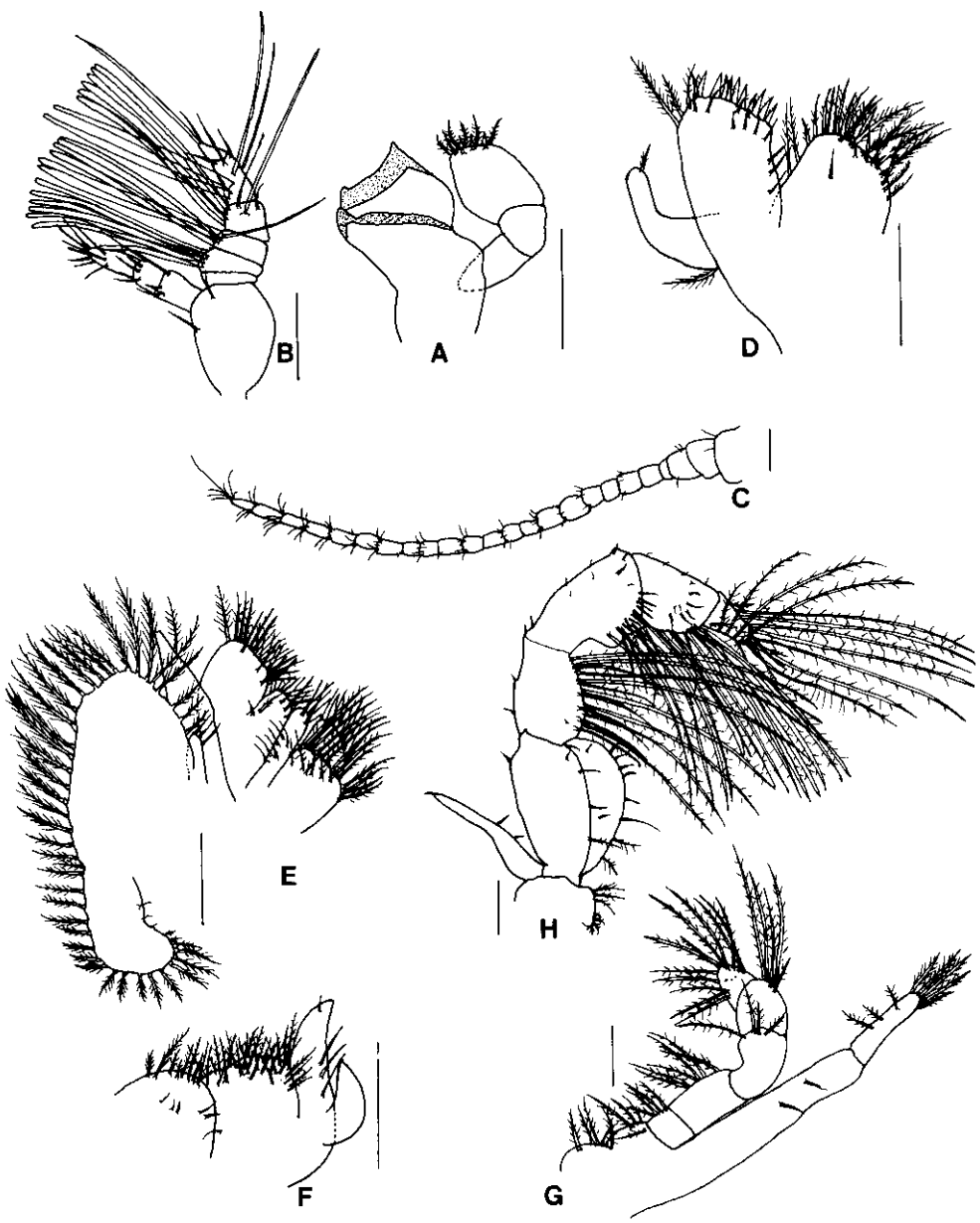

Fig. 3. *Petrolisthes japonicus* (De Haan, 1849), megalopal appendages. A, mandible; B, antennule; C, antenna; D, maxillule; E, maxilla; F, first maxillipd; G, second maxilliped; H, third maxilliped. Scale line A – H = 0.1 mm.

3-segmented, all with setae, as shown.

Antenna (Fig. 3C).-Peduncle 3-segmented, flagellum with 21 segments. Terminal segment with 1 long and 6 short setae.

Mandible (Fig. 3A).-Palp 3-segmented, first and second segments naked and distal segment with 9 setae.

Maxillule (Fig. 3D).-With endopodite unsegmented, bearing 1 terminal and 1 basal seta. Basal endite with 11 spines and 14 setae. Coxal endite with 25 setae.

Maxilla (Fig. 3E).-With endopodite unsegmented, bearing 1 subterminal seta. Basal and coxal endites bilobed, heavily setose on distal margins. Scaphognathite with 47 setae around margin.

Maxilliped 1 (Fig. 3F).-Endopodite naked. Exopodite with 3 lateral and 1 small subterminal setae. Basal endite bearing about 28 setae. Coxal endite with 8 marginal and 5 small internal setae.

Maxilliped 2 (Fig. 3G).-Coxopodite and basipodite with 5 and 4 setae, respectively. Endopodite 5-segmented with 4, 6, 4, 5 and 17 setae, respectively. Exopodite 2-segmented, distal segment with 5 terminal and 3 marginal setae, basal segment with 2 setae.

Maxilliped 3 (Fig. 3H).-Basipodite with 7 setae.

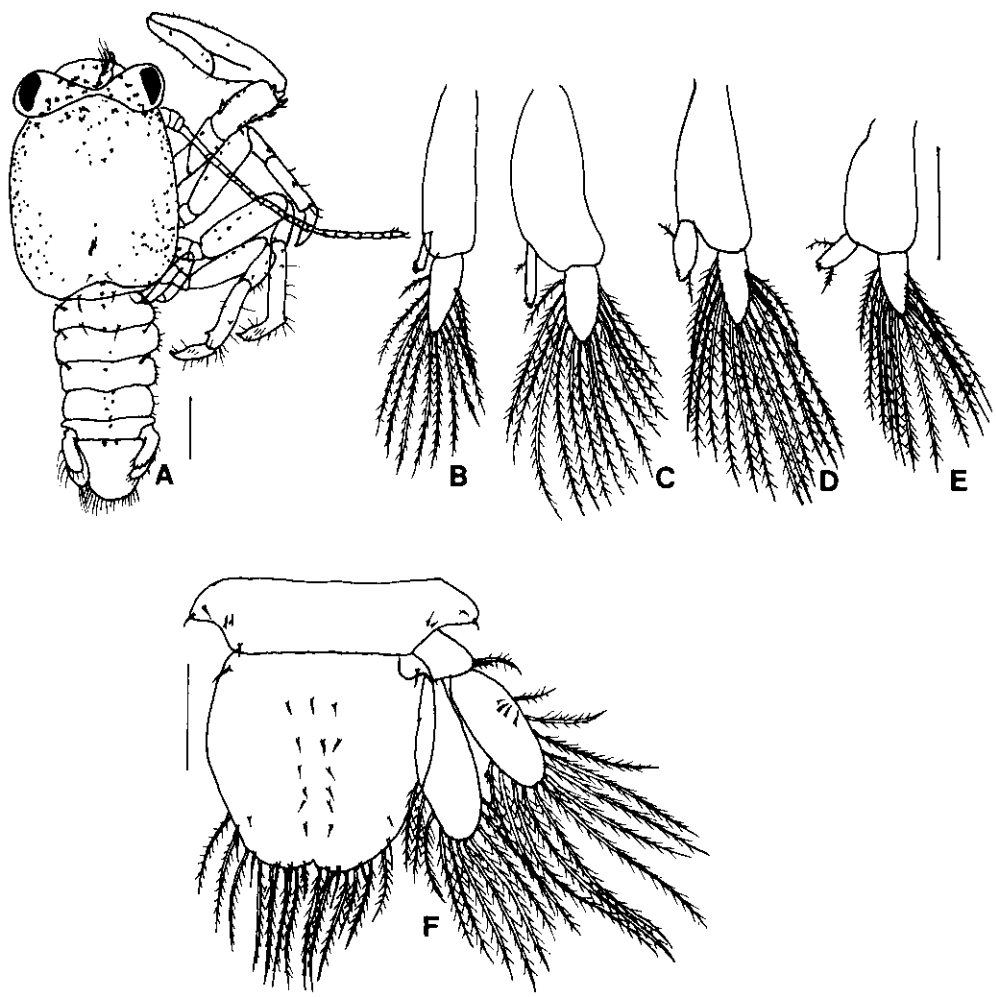

Fig. 4. *Petrolisthes japonicus* (De Haan, 1849), megalopal appendages. A, dorsal view; B-E, pleopod 1-4; F, tail fan. Scale line A – F = 0.2 mm.

Exopodite with a terminal and 2 marginal setae. Endopodite 5-segmented, first with lateral blade-like projections. All segments profusely setose.

Pereiopods (Fig. 4A).-Cheliped with small setae marginally, carpus with 6 acute spines on margin. With several setae marginally, on propodus of 2nd pereiopod, on propodus and dactylus of 3rd pereiopod, and on carpus, propodus and dactylus of 4th pereiopod.

Pleopods (Fig. 4B-E).-Four pairs on abdominal segments 2-5, biramous. Exopodite with 11 to 14 long natatory setae. Endopodite with rudimentary setae progressing toward telson usually: 0, 1, 2, 2. All pleopods with 3 or 4 appendix interna.

Tail fan (Fig. 4F).-Telson plate wide, fringed with 13 long setae and 9 simple setae arranged among longer setae. Uropods biramous, exopodite with 12 long setae, endopodite with 11 setae.

Colour.-Transparent. Red chromatophores as follows: on merus, carpus, propodus and dactyla of cheliped, and on merus, carpus and propodus of pereiopods 2-4, along lateral surface and on frontal region of carapace, in each abdominal segment and tail fan.

Discussion

Petrolisthes japonicus has two zoeal stages and one megalopal stage. A detailed comparison of four *Petrolisthes* species including *P. japonicus* with the great resemblance among the reported species of the genus *Petrolisthes* is presented in Tables 1 to 3.

In the first zoeal stage, some similarities of the larval characters of *P. japonicus* to other species are: 1 rostral spine and 2 posterior spines, the number of setae on the endopodite of the

Table 1. Comparison of the first zoeal characters in four species of *Petrolisthes*

Species References	*P. japonicus* (Present study)	*P. ornatus* (Yaqoob, 1977)	*P. elongatus* (Greenwood, 1965)	*P. armatus* (Gore, 1970)
Carapace				
Length	1.42 mm	1.8 mm	1.4 mm	1.6 mm
Rostal spine	4X	3.8X	4.6X	4X
Posterial spine	2.4X	2.9X	2.5X	1X
Antennule	3.3 setae	3.3 setae	3.3 setae	3.3 setae
Antenna				
Endopodite	1 seta	1 seta	1 seta	1 seta
Exopodite	2 setae	0 seta	3 setae	2 setae
Maxillule				
Endopodite	3+1 setae	4-5+1-2 setae	4+1 setae	3+1 setae
Maxilla				
Endopodite	4,2,3 setae	4,2,3 setae	5,3 setae	5,3 setae
Scaphognathite	10+5 setae	11+5 setae	8+5 setae	5+1 setae
Maxilliped 1				
Basipodite	2,2,3,3, setae	2,2,3,3, setae	1,2,2 setae	1,2,2,3 setae
Endopodite	3,3,3,6,9+1 setae	3-4,4,4,6,7+1 setae	2,4,3,6+1,7 setae	3,3,2+4,9+1 setae
(Segment)	5	5	5	4
Maxilliped 2				
Basipodite	1,2 setae	1,3 setae	1,1,1 setae	1,1 setae
Endopodite	2,2,1+2,5+1 setae	3-4,3-4,2+4,6+1 setae	3,2,1+3+1,6 setae	2,2,1+2,5+1 setae
(Segment)	4	4	4	4
Abdomen				
Lateral spine	Somites 3,4,5	Somites 4,5	Somites 4,5	Somites 4,5
Telson		5th. pair setae on prominence		

X: the ratio of rostral or posterior spine to carapace length

Table 2. Comparison of the second zoeal characters in four species of *Petrolisthes*

Species References	*P. japonicus* (Present study)	*P. ornatus* (Yaqoob, 1977)	*P. elongatus* (Greenwood, 1965)	*P. armatus* (Gore, 1970)
Carapace				
Length	2.3 mm	2.2 mm	2.3 mm	2.0 mm
Rostal spine	4.4X	3.9X	3.8X	5X
Posterial spine	2.3X	2.5X	2X	1X
Antennule				
Exopodite	18+4 setae	12+2+2 setae	20+1+2 setae	20+2 setae
Antenna				
Exopodite	1/2>endo.	5/6 endo.	1/2 endo.	1/2 endo.
Maxillule				
Endopodite	2 setae	4-5+1-2 setae	5 setae	3 setae
Maxilla				
Scaphognathite	15+6 setae	16+7 setae	15+6 setae	16-20+1 setae
Maxilliped 1				
Basipodite	2,2,3,3 setae	2,2,3,3 setae	2,1,1,2 setae	1,1,2,3 setae
Endopodite	3+1,3+1,3+1,4+1,7	3-4+1,4+1,4+1,6,7+1	3+1,3+1,4+1,6,8+1	3+1,3+1,2+5+1,11+1
Maxilliped 2				
Basipodite	1,3 setae	1,3 setae	2,3 setae	1,1 setae
Exopodite	12 setae	15 setae	12 setae	12-15 setae
Telson	with 2 setae on the central prominence with median seta			

X: the ratio of rostral or posterior spine to carapace length
endo.: endopodite

antenna, the number of segments in the endopodite of the second maxilliped, and 5 pairs of long plumose setae on the central prominence of the telson. In the scaphognathite of most all Porcellanidae species including *Petrolisthes armatus* and *Petrolisthes granulosus*, the anterior lobe bears 6 or 7 marginal setae, while the posterior lobe is naked, except for an apical seta (Van Dover *et al.*, 1982). According to Van Dover *et al.* (1982), these characteristics belong to the type 3, but the shape of *P. japonicus*, *P. ornatus* and *P. elongatus* may belong to the type 4, the anterior lobe bears 7-11 marginal setae and posterior lobe bears 5 setae.

However, the first zoea of *P. japonicus* has 10 + 5 plumose setae formula on the scaphognathite of the maxilla, and 3, 3, 3, 6, 9 + 1 setae formula on 5-segmented endopodite of the first maxilliped. These seem to be the most useful criteria for distinguishing the zoea of *P. japonicus* from other *Petrolisthes* zoeae.

In the second zoeal stage, it shows that *P. japonicus* resembles *P. ornatus* and *P. elongatus* more than *P. armatus* in respects to the type of the scaphognathite of the maxilla, 5-segmented endopodite of the first maxilliped and occurrence of a pair of medial short plumose setae. The setal formula of basipodites of the first and second maxillipeds in *Petrolisthes* are 2, 2, 3, 3 and 1, 3 respectively, and these characters agree with those of *P. ornatus*.

In the megalopal stage, the exopodite of the second maxilliped and endopodite of the third maxilliped are suggested to be common in megalopal stage of the *Petrolisthes*. The setal formula of the endopodite of the maxillule and maxilla, segment number of the endopodite of the maxillule, and segment number of the endopodite and exopodite of the first and second maxilliped of *P. japonicus* agree well with those of *P. elongatus*.

Therefore, a comparison of the first and second zoeal characters of *P. japonicus* with other *Petrolisthes* species shows that *P. japonicus* is closer to *P. ornatus* than other species. However *P. japonicus* bears more resemblance to *P. elongatus* than *P. ornatus* in megalopal stage.

Table 3. Comparison of megalopal characters in four species of *Petrolisthes*

Species References	*P. japonicus* (Present study)	*P. ornatus* (Yaqoob, 1977)	*P. elongatus* (Greenwood, 1965)	*P. armatus* (Gore, 1970)
Carapace				
Length X Width	1.5 X 1.2 mm	1.85 X 1.40 mm	1.6-1.7 X 1.3 mm	1.5 X 1.2 mm
Antennule				
Upper ramus	6 segments	6 segments	6 segments	6 segments
Lower ramus	3 segments	4 segments	3 segments	3 segments
Antenna				
Last segment	1+6 setae	1+7 setae	1+2 setae	1 seta
Mandible				
Last segment	9 setae	12 setae	12 setae	14 setae
Maxillule				
Endopodite	unsegmented 1+1 setae	2-segmented 1 spine	unsegmented 1+1 setae	2-segmented 2 setae
Maxilla				
Endopodite	1 seta	3 setae	1 seta	1+2 setae
Maxilliped 1				
Endopodite	unsegmented	unsegmented	unsegmented	unsegmented
Exopodite	unsegmented	2-segmented	unsegmented	unsegmented
Maxilliped 2				
Endopodite	5 segments	4 segments	5 segments	4 segments
Exopodite	2 segments	2 segments	2 segments	2 segments
(Last segment)	5 setae	7 setae	5 setae	11 setae
Maxilliped 3				
Endopodite	5 segments	5 segments	5 segments	5 segments
Exopodite	1 segment	2 segments	2 segments	1 segment
Telson	divided	divided	undivided	undivided

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갯가게붙이(***Petrolisthes japonicus***)의 유생발생

이화자(제주대학교 자연과학대학 생물학과)

게붙이과(Porcellanidae)에 속하는 갯가게붙이(*Petrolisthes japonicus*)의 유생을 실험실내에서 부화시켜 사육한 후 각 유생단계를 기술, 도시하였다. 갯가게붙이의 유생단계는 2기의 zoea기와 1기의 megalopa기로 구성되며 제1zoea기에서 제2zoea기 까지는 약4일, 제2zoea기에서 megalopa기 까지는 약10일이 소요되었으며 이미 보고된 *Petrolisthes*속내의 여러 종과 각 유생단계의 형태적 특징을 비교하였다. 그 결과 본 종의 제1과 제2zoea기에 있어서는 *P. ornatus*와, megalopa기에서는 *P. elongatus*와 밀접히 관련됨을 보여주었다.