

First Zoea of *Pagurus japonicus* (Crustacea: Decapoda: Anomura: Paguridae) Reared in the Laboratory

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The first zoeal stage of *Pagurus japonicus* is described and illustrated. Its morphological characteristics are compared with those of other known species of the genus *Pagurus*. The first zoea of *P. japonicus* was very similar to that of *P. similis*. The zoeas of the two species could be distinguished from other pagurid zoeas by morphological characteristics of the carapace without posterolateral spine, two setae on the endopod of the antenna, and 3+3 setae on the endopod of the maxilla. They show affinities more to the species of the family Diogenidae than to the species of the genus *Pagurus* in respect of zoeal morphology.

There are currently nineteen species of the family Paguridae recognized in Korea. They belong to four genera (Kim, 1973; The Korean Journal of Systematic Zoology, 1997). The genus *Pagurus* is the largest group among them and comprises sixteen species.

Larval descriptions in the genus *Pagurus* are limited to only nine species from Korea and the adjacent waters: *P. middendorffii* Brandt (Kurata, 1964; Konishi and Quintana, 1988), *P. brachiomastus* (Thalwitzer) (Konishi and Quintana, 1987), *P. ochotensis* Brandt (McLaughlin et al., 1992), *P. trigonocheirus* (Stimpson) (Quintana and Iwata, 1987), *P. dubius* (Ortmann) (Hong, 1981), *P. geminus* McLaughlin (Kurata, 1968a; Konishi and Quintana, 1988), *P. similis* Ortmann (Lee and Hong, 1970), *P. constans* (Stimpson) (Hong and Kim, 2002) as *Parapagurodes constans*, and *P. lanuginosus* De Haan (Hong, 1969; Konishi and Quintana, 1988). However, any larval stages of *P. japonicus* has not been described yet.

The aims of the present study are to describe and illustrate the first zoeal stage of *P. japonicus* and compare with those from other known species in the genus *Pagurus*.

Materials and Methods

An ovigerous female of *Pagurus japonicus* was collected by SCUBA diving into the sea of about 20 meter depth from Jeju Island in Korea on July 3, 2002. The larvae collected among those hatched in the laboratory were reared using the methods described by Ko (1995), at a

constant water temperature of 25°C. The larvae were fixed and preserved in 10% neutral formalin for further studies. Dissected appendages were examined using a Leitz laborlux S microscope and drawings were made with the aid of camera lucida. Setal counts on appendages and measurements were based on the mean of ten specimens for zoeal stage. Setal armature on appendages was described from proximal to distal segments and in order of endopod to exopod. The remaining zoeas and the spent females were deposited in Silla University, Korea.

Results

First Zoea (Figs. 1, 2)

Carapace length (from tip of rostral spine to posterior margin of carapace). 1.71 ± 0.03 mm.

Duration. 3 days.

Carapace (Fig. 1A). Rostrum slightly shorter than antennae; posterolateral carapace spine absent; eyes sessile.

Antennule (Fig. 1B). Subcylindrical, distinctly bilobed; exopod fused to protopod, with 3 (2 stout and 1 thinner) aesthetascs and 3 (1 smaller) simple setae; rudimentary endopodal bud with 1 long plumose terminal seta.

Antenna (Fig. 1C). Scaphocerite with elongate distal spine; inner margin with 8 plumose setae and short simple seta; endopod slightly shorter than scaphocerite, with 2 long terminal setae; protopod with a strong spine bearing tiny denticles.

Mandible (Fig. 1D). Asymmetrically dentate; incisor process with strong teeth and a few smaller teeth; molar process with a few strong teeth and a few acute small teeth; no palp bud.

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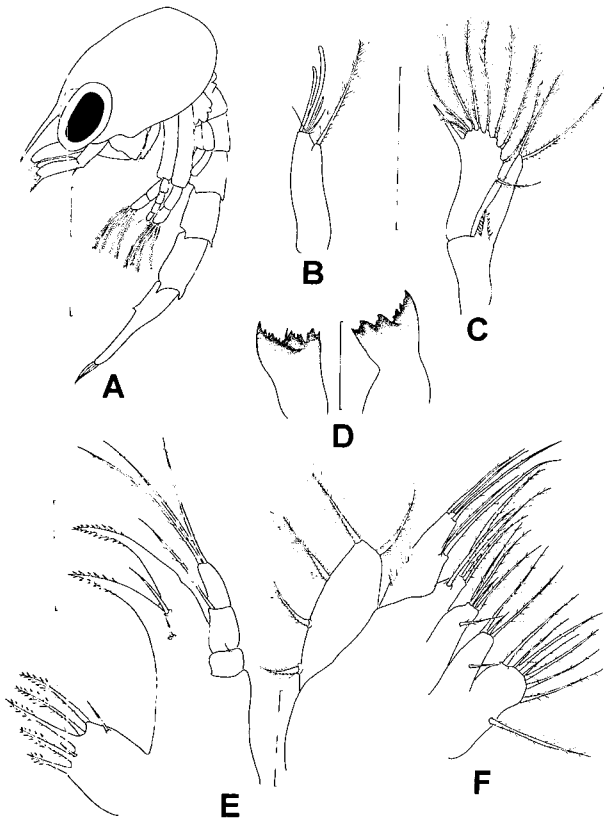


Fig. 1. *Pagurus japonicus*, first zoeal stage. A, Lateral view. B, Antennule. C, Antenna. D, Mandibles. E, Maxillule. F, Maxilla. Scale bars=0.1 mm (A, B, C, E, F), and 0.25 mm (D).

Maxillule (Fig. 1E). Endopod 3-segmented; setal formula progressing distally 1, 1, 3 of which proximal seta very short; coxal endite with 5 plumodenticulate setae marginally and 2 short simple setae submarginally; basal endite with 2 strong elongate spine-like teeth armed with a few small denticles and 2 short simple setae submarginally.

Maxilla (Fig. 1F). Endopod bilobed weakly, with 3 marginal plumose setae (2 long and 1 shorter) on proximal lobe and 3 marginal plumose setae on distal lobe; bilobed-coxal endite with 1 submarginal and 7 marginal plumose setae on proximal lobe, 3 marginal and 1 submarginal plumose setae on distal lobe; bilobed-basal endite with 4 marginal and 1 submarginal plumose setae on proximal lobe. Three marginal and 1 submarginal plumose setae on distal lobe; scaphognathite with 5 marginal plumose setae.

First maxilliped (Fig. 2A). Coxopod with 1 simple marginal seta; basipod with setal formula progressing distally 1, 2, 3, 3; endopod 5-segmented, segmental setation proximal to distal 3, 2, 1, 2, 4+1 (1=dorsal plumose seta) and additional fine setules on lateral margins of segments 1-3; exopod with 4 terminal natatory setae.

Second maxilliped (Fig. 2B). Coxopod without seta; basipod with 1 short simple marginal seta near to distal half, Two plumose setae at distal angle; endopod 4-

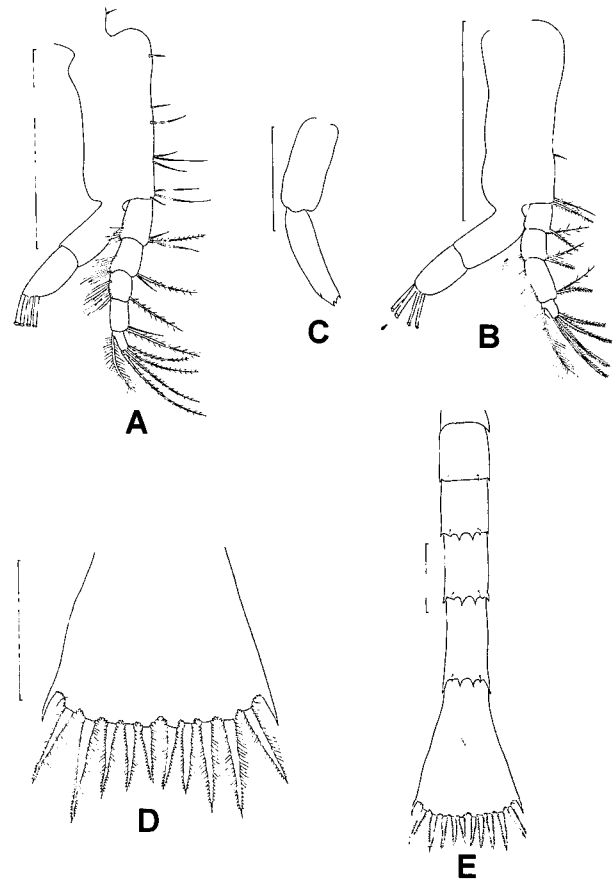


Fig. 2. *Pagurus japonicus*, first zoeal stage. A, First maxilliped. B, Second maxilliped. C, Third maxilliped. D, Dorsal view of telson. E, Dorsal view of abdomen and telson. Scale bars=0.5 mm (A, B, D), 0.25 mm (C), and 0.1 mm (E).

segmented, segments 1-3 each with 2 plumose setae, distal segment with 4+1 plumose setae (1=dorsal plumose seta) and additional fine setules on lateral margins of segments 2, 3; exopod with 4 terminal natatory setae.

Third maxilliped (Fig. 2C). Exopod completely segmented, weakly furcated terminally.

Abdomen (Fig. 2E). Five somites; somites 2-5 each with posterolateral processes increasing in size toward distal segment and each with 1 pair of posterodorsal setae, somites 3-5 each with 1 pair of spines at posterodorsal margin, spine pairs progressively increasing in size posteriorly.

Telson (Fig. 2D, E). Fan-shaped posteriorly; posterior margin with shallow median cleft and 7+7 processes, outermost immovable naked spine, second anomuran hair, third through seventh, plumodenticulate processes, of which the fourth longest; very short marginal setae between processes and on median cleft; anal spine present.

Discussion

The first zoea of *P. japonicus* strongly resembles that of

Table 1. Comparison of first zoeal characteristics in known pagurid species from Korea

Species	Carapace	Antenna		Maxillule	Maxilla	Sources
	Posterolateral spine	exo.	endo.	endo.	endo.	
<i>Pagurus lanuginosus</i>	+	5	simple	1, 1, 3	3+1+3	Hong, 1969
<i>Pagurus middendorffi</i>	+	6	simple	1, 1, 3	3+1+3	Konishi and Quintana, 1988
<i>Pagurus brachiomastus</i>	+	6	simple	1, 1, 3	3+1+3	Konishi and Quintana, 1987
<i>Pagurus ochotensis</i>	+	7	simple	1, 1, 3	3+1+3	McLaughlin et al., 1992
<i>Pagurus constans</i>	+	6	simple	2, 1, 3	3+1+3	Hong and Kim, 2002
<i>Pagurus dubius</i>	+	5	bifid	0, 1, 3	2+1+3	Hong, 1981
<i>Pagurus geminus</i>	+	6	bifid	1, 1, 3	3+1+3	Konishi and Quintana, 1988
<i>Pagurus trigenocheirus</i>	+	8	bifid	1, 1, 3	3+1+3	Quintana and Iwata, 1987
<i>Pagurus similis</i>	-	10	2 setae	1, 1, 3	3+3	Lee and Hong, 1970
<i>Pagurus japonicus</i>	-	10	2 setae	1, 1, 3	3+3	Present study

P. similis and significantly different from the zoeas of the other eight species by having a carapace without posterolateral spines, the exopod and the endopod of the antenna each with 10 and 2 setae, the endopod of the maxilla with 3+3 setae (Table 1). The carapace without posterolateral spines did not appear in any other known zoeas of the pagurid species and it only occurs in the zoeas of the family Diogenidae, such as *Paguristes digitalis* (Stimpson) (Kurata, 1968b), *Diogenes diogenes* (Herbst) (Navak and Kakati, 1977), *Diogenes bicristimanus* Alcock (Sarojini and Nagabushanam, 1968), and *Paguristes ortmanni* Miyake (Quintana and Iwata, 1987). Moreover, the zoeas of 4 diogenid species have 9 to 11 setae on the exopod and 2 or 3 long setae on the endopod of the antenna. Based on the characteristics of zoeal morphology, therefore, *P. japonicus* and *P. similis* seem to have more affinities to the diogenid species than the pagurid species.

The general morphology of the first zoeas of *P. japonicus* and *P. similis* is very similar, but they can be distinguished from each other by the minute differences in the antennule, the antenna, the coxal endite of the maxilla, and the endopod of the second maxilliped (Table 2). These differences may be useful for discriminating the first zoeas of two species from plankton collected materials.

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References

- Hong SY (1969) The larval development of *Pagurus lanuginosus* de Haan (Crustacea, Anomura) reared in the laboratory. *Bull Korean Fish Soc* 2: 1-15.
- Hong SY (1981) The larvae of *Pagurus dubius* (Ortmann) (Decapoda, Paguridae) reared in the laboratory. *Bull Nat Fish Univ Busan* 21: 1-11.
- Hong SY and Kim MH (2002) Larval development of *Parapagurodes constans* (Decapoda: Anomura: Paguridae) reared in the laboratory. *J Crust Biol* 22: 882-893.
- Kim HS (1973) Anomura, Brachyura. Illustrated Encyclopedia of Fauna and Flora of Korea. Vol 14, The Ministry of Education, Korea, Seoul, pp 1-506.
- Ko HS (1995) Larval development of *Benthopanope indica* (De Man, 1887) (Decapoda: Brachyura: Pilumnidae) in the laboratory. *J Crust Biol* 15: 280-290.
- Konishi K and Quintana R (1987) The larval stages of *Pagurus brachiomastus* (Thalwitzer, 1892) (Crustacea: Anomura) reared

Table 2. Differences in first zoeal characteristics between *Pagurus similis* described by Lee and Hong (1970) and *P. japonicus* examined by the present study

Character	Species	
	<i>Pagurus similis</i>	<i>P. japonicus</i>
Antennule	5 aesthetascs and a seta	3 aesthetascs and 3 setae
Exopod of antenna	10 plumose setae	9 plumose setae and a simple seta
Coxal endite of maxilla	7+3 setae	8+4 setae
Endopodal setation of maxilliped 2	2, 2+1, 2+1, 4+1	2, 2, 2, 4+1

1=dorsal plumose seta

- in the laboratory. *Zool Sci* 4: 349-365.
- Konishi K and Quintana R (1988) The larval stages of three pagurid crabs (Crustacea: Anomura: Paguridae) from Hokkaido, Japan. *Zool Sci* 5: 463-482.
- Kurata H (1964) Larvae of decapod Crustacea of Hokkaido. 5. Paguridae (Anomura). *Bull Hokkaido Reg Fish Res Lab* 29: 24-48.
- Kurata H (1968a) Larvae of decapod Anomura of Arasaki, Sagami Bay-I. *Pagurus samuelis* (Stimpson) (Paguridae). *Bull Tokai Reg Fish Res Lab* 55: 265-269.
- Kurata H (1968b) Larvae of decapod Anomura of Arasaki, Sagami Bay. 3. *Paguristes digitalis* (Stimpson) (Diogenidae). *Bull Tokai Reg Fish Res Lab* 56: 181-185.
- Lee BD and Hong SY (1970) The larval development and growth of decapod crustaceans of Korean waters. I. *Pagurus similis* Ortmann (Paguridae, Anomura). *Pub Mar Lab Pusan Fish Coll* 3: 13-26.
- McLaughlin PA, Crain JA, and Gore RH (1992) Studies on the *provenzanoi* and other pagurid group. 6. Larval and early juvenile stages of *Pagurus ochotensis* Brandt (Decapoda; Anomura; Paguridae) from a northeastern Pacific population, reared under laboratory conditions. *J Nat Hist* 26: 507-531.
- Navak VN and Kakati VS (1977) Metamorphosis of the hermit crab *Diogenes diogenes* (Herbst) (Decapoda, Anomura) in the laboratory. *Indian J Mar Sci* 6: 31-34.
- Quintana R and Iwata F (1987) On the larval development of some hermit crabs from Hokkaido, Japan, reared under laboratory conditions (Decapoda: Anomura). *J Fac Sci Hokkaido Univ Ser VI Zool* 25: 25-85.
- Sarojini R and Nagabushanam R (1968) Larval development of *Diogenes bicristimanus* in the laboratory. *J Mar Biol Ass India* 10: 71-77.
- The Korean Society of Systematic Zoology (1997) Lists of Animals in Korea (Excluding Insects). Academy Publishing Co, Seoul, pp 1-489.

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