A Description of Laboratory-reared Larvae of the Pinnotherid Crab *Sakaina japonica* Serène (Decapoda, Brachyura)[1)]

By

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(With 5 Text-figures, 2 Tables and 2 Plates)

Up to the present, the larval development of the pinnotherid crabs has been described in 27 species ranging in nine genera since Thompson's pioneering work on the zoea of the European pea crab *Pinnotheres pisum* (L.) (Thompson, 1835). However, the complete larval development of the pinnotherid crabs has been unknown yet in a half of these larval descriptions. Furthermore, the previous papers have concerned mostly the zoeae of the parasitic pinnotherids belonging to the genus *Pinnotheres*, so that the larval development of the non-parasitic or free-living crabs, such as the members of the genus *Xenophthalmus* and *Sakaina*, remains to be analysed.

In the present paper, the complete larval development of the non-parasitic pinnotherid crab *Sakaina japonica* Serène is described in detail and the larval characters of the present species are compared with those of the parasitic crabs.

Material and Methods

The pinnotherid crabs of *Sakaina japonica* are dwellers associated usually with the polychaete worms; sometimes they are free-living in the sea. They are found on the coasts of Kyushu, Sagami Bay, and Hokkaido, showing a wide range of distribution in Japan. In spite of their commensal life in the sea, the exoskeleton of this crab is well calcified and the extreme sexual dimorphism found in the parasitic species is not recognizable.

On 28 March 1979, six adult crabs (5♂♂ and 1♀) were found in the tubes of the polychaete worm *Loimia medusa* (Savigny) between the tide marks at Birohjima in the Ariake Bay, Kyushu. They were then brought to the laboratory of our university in Sapporo and reared in the glass tank with sea water kept at 18°C.

1) Contribution No. 39 from the Aitsu Marine Biological Station, Kumamoto University.

One ovigerous female with the carapace width of 7.9 mm was isolated in a compartment tray.

The first zoeae of the present species were hatched out on 10 April 1979. They were incubated in the culture vessels containing filtered sea water of 200 ml. The antibiotics were added in the sea water with salinity of 33‰. The freshly hatched *Artemia* nauplii were given as food every other day. The dead larvae and the exuviae were daily exmained with careful notice. The larvae were fixed in 5% buffered formalin and then were preserved in 70% ethanol.

The specimens used for the scanning electron microscopy were fixed in 2.5% glutaraldehyde in 0.2 M cacodylate buffer for 2 hrs and then post-fixed in 1% OsO_4 in the same buffer for 1 hr at 0°C. After washing in distilled water, they were dehydrated through a graded ethanol series to isoamylacetate. These materials were dried by critical point method with CO_2. The specimens were affixed to the specimen stubs with double-coated tape and coated with gold. They were examined in JSM–T20 at gun potentials of 5 to 20 kV.

Results

The larvae of *Sakaina japonica* pass through three zoeal stages and a megalopa. Each zoeal stage had 5 days for intermolt respectively. About 20 days after hatching, they molted into the first crab. A detailed description of each larval stage is given below.

Prezoea: Several prezoeae were found among the first zoeae, but all of them were inactive and eventually died within a few days.

First zoea: The carapace is provided with a rostral spine (Fig. 1, A). The carapace from the tip of the rostral spine to the posterior border measures 0.85 to 0.94 mm in length. The body is dark reddish brown under the light condition, while it is transparent under the dark one. The carapace has 2 setules on the mid-drosal portion. Three or 4 plumose setae are arranged on the ventrolateral margin of the carapace. The eyes are sessile. The rudiments of the third maxilliped and other throacic appendages are recognizable as a bunch of small buds situated under the carapace. The abdomen (Pl. IV, 1 and 1') consists of 5 somites and a bifurcated telson. From second to fifth abdominal somites have also five pairs of the setules on their posterodorsal border. The abdomen becomes broader towards the end of the body with the laterally expanded wings of the fifth somite, which are overlapped onto the telson. Each furca of the telson possesses 3 serrate spines on its inner margin. This character is unchanged throughout three zoeal stages.

The antennule, conical in shape, has 3 aesthetes and short seta (Fig. 1, B). The antenna is a long pointed process with a row of minute denticules (Fig. 1, C). The mandibles, composed of molar and incisor processes differ slightly in shape in both side of the body (Fig. 1, D). The endopodite of the maxillule has 4 setae on its distal end (Fig. 1, E). The basal endite has 6 (occasionally 5) bristly spines and

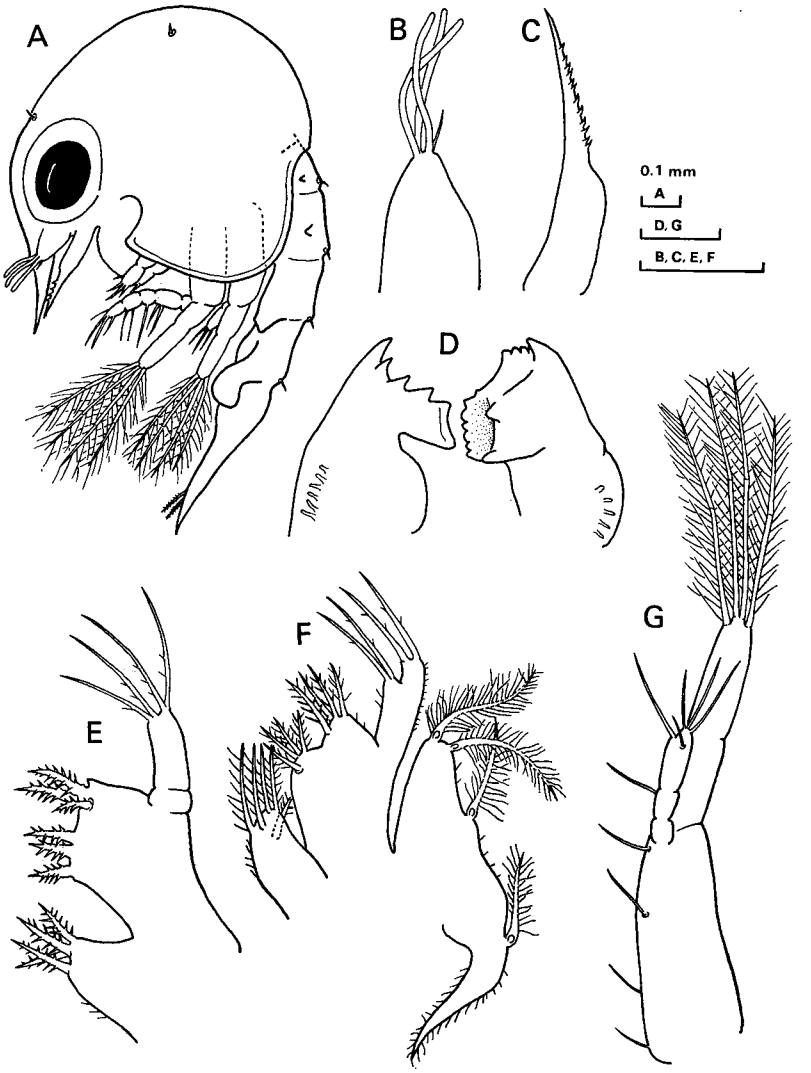

Fig. 1. First zoea of *Sakaina japonica* Serène. A. lateral view, B. antennule, C. antenna, D. mandibles, E. maxillule, F. maxilla, G. second maxilliped.

the coxal endite has 4 ones. The bilobed endopodite of the maxilla has 2 setae on each distal end (Fig. 1, F). The bilobed basal endite has the spinal arrangement 4–4, while the non-lobed coxal endite bears 5 spines. The scaphognathite carries 4 soft plumose setae on its margin and a long posterior projection. The protopodite of the first maxilliped has 8 setae. The five-segmented endopodite has the setal

arrangement 5, 2, 1, 2, 2 from distal to proximal. The exopodite is slightly constricted in the middle portion and carries 4 long natatory setae which are sparsely plumose. The protopodite of the second maxilliped bears 4 setae (Fig. 1, G). The three-segmented endopodite has the setation 5, 1, 0 from distal to proximal. The exopodite carries 4 long natatory setae as in the first maxilliped.

Second zoea: The carapace measures 1.00 to 1.06 mm in length from the tip of the rostral spine to the posterior border. It has three pairs of setules on the drosal surface (Fig. 2, A). The eyes are now stalked. The buds of the third maxilliped, cheliped and ambulatory legs are visible outside the caparace. The sixth abdominal somite comes to appear in shape on the telson, but its posterior margin runs only on the ventral side of the telson (Pl. IV, 2 and 2'). The pleopod buds come to appear on the second through fifth abdominal somites.

The antennule bears 4 to 6 aesthetes, a seta and an additional short setule (Fig. 2, B). The endopodite bud of the antenna is recognizable at the root of the protopodite (Fig. 2, C). The mandibles become somewhat larger than those of the first zoea, but otherwise unchanged (Fig. 2, D). The endopodite of the maxillule has 4 setae on its distal end as in the first zoea (Fig. 2, E). The basal and coxal endites have 7 and 4 spines respectively. On the dorsal margin of the maxillule, there are found 2 setae, of which the distal one is plumose. The endopodite of the maxilla has 4 setae as in the first zoea (Fig. 2, F). The basal endite has the spinal arrangement 4, 5 from distal to proximal and the coxal endite has 6 spines. The scaphognathite carries 9 to 12 soft plumose setae on its dorsal margin and 3 pulmose ones on its posterior projection. The long natatory setae on the exopodite of both the first and second maxillipeds have increased to 6, but otherwise as in the first zoea.

Third zoea: The carapace measures 1.09 to 1.29 mm in length. The buds of the third maxilliped, cheliped and ambulatory legs are well developed and their segmentation is clearly recognizable in feature (Fig. 3, A). The sixth abdominal somite is now complete in from (Pl. IV, 3 and 3'). The first abdominal somite carries a pair of long setae on the dorsal side. The pleopod buds are more elongated than those of the second zoea.

The antennule bears two tiers of aesthetes; 2 or 3 on the lower tier and 6 to 8 on the terminal tier (Fig. 3, B). A simple seta and a short setule are also present on the terminal end. The small endopodite bud on the antennule comes to appear in this stage. The endopodite bud of the antenna is elongated more than a half length of the protopodite (Fig. 3, C). The mandibles become larger in size than those of the previous stage, but otherwise unchanged (Fig. 3, D). The setations of the endopodites of the maxillule, maxilla and maxillipeds are the same as in the previous stages. The basal and coxal endites of the maxillule bear 8 and 4 spines respectively (Fig. 3, E). The bilobed basal endite of the maxilla has the spinal arrangement 4, 5 from distal to proximal, while the non-lobed coxal endite has 5 spines (Fig. 3, F). The scaphognathite bears 18 to 20 soft plumose setae.

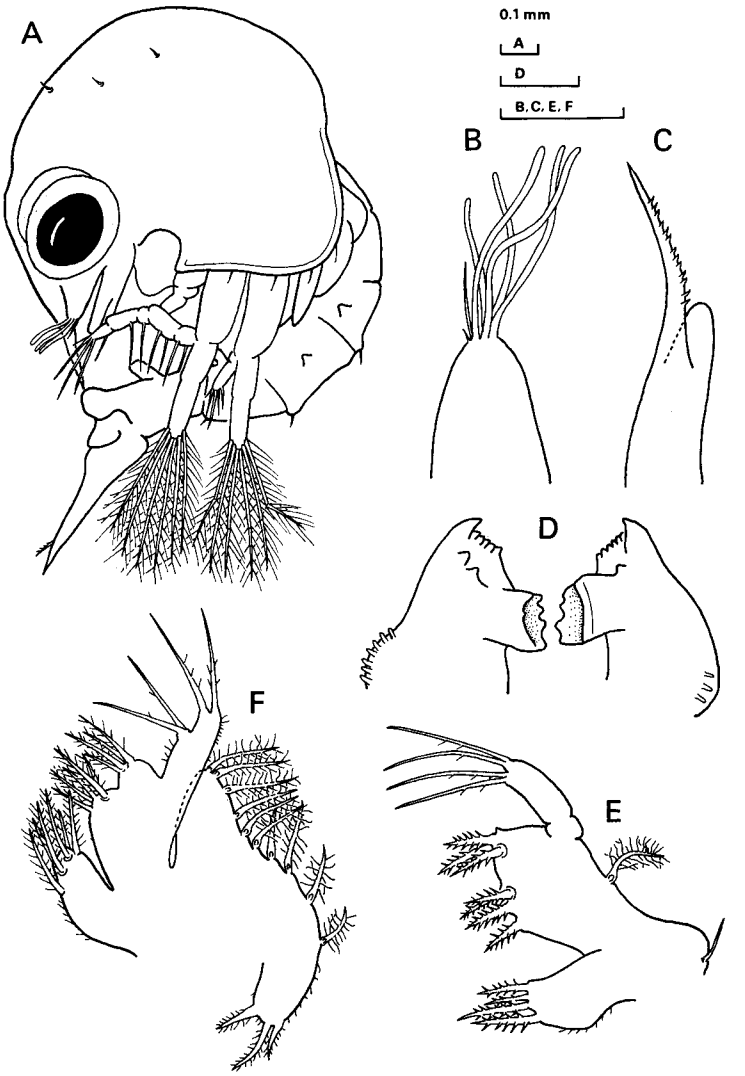

Fig. 2. Second zoea of *Sakaina japonica* Serène. A. lateral view, B. atennule, C. antenna, D. mandibles, E. maxillule, F. maxilla.

The exopodites of both maxillipeds have 8 (occasionally 7) long natatory setae, but otherwise as in the previous stage.

Megalopa: The carapace is far longer in the antero-posterior size than in the width, measuring 1.18 to 1.36 mm in length and 1.02 to 1.10 mm in width.

From the dorsal view, it is triangular in shape with broader posterior margin. The rostrum triangular in shape has a pair of horns beside it (Pl. V, 1). The eyes are well developed. The cheliped and ambulatory legs bear a lot of small setules. On the sternum of the third ambulatory legs, there are found a pair of conical projections with blunted ends (Pl. V, 2'). The fourth ambulatory leg carries 3

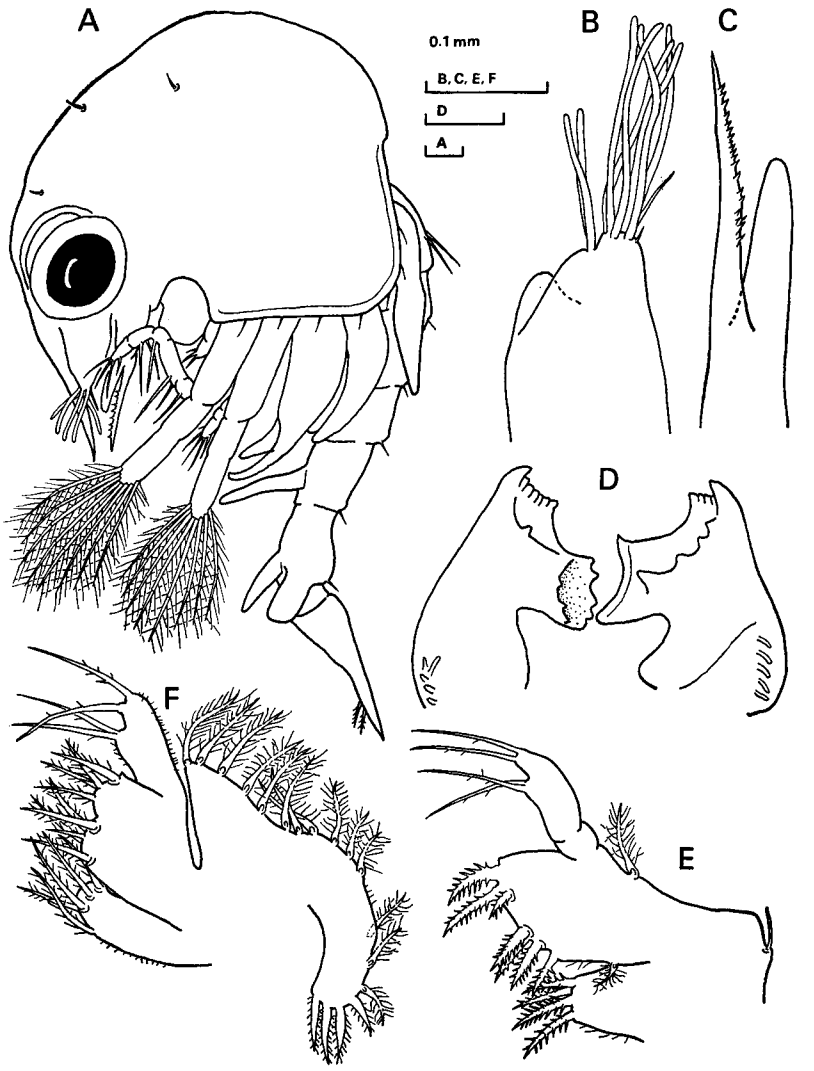

Fig. 3. Third zoea of *Sakaina japonica* Serène. A. lateral view, B. antennule, C. antenna, D. mandibles, E. maxillule, F. maxilla.

long feelers near the tip of the dactylus. The abdomen consists of 6 somites and telson. The pleopods are present on the second through fifth abdominal somites (Pl, V, 2), and the uropods on the sixth somite. The pelopods on the second through fifth somites have 12, 13, 13 and 10 plumose setae respectively. The uropod has not endopodite, bearing 5 plumose setae. The endopodite of the pleopods

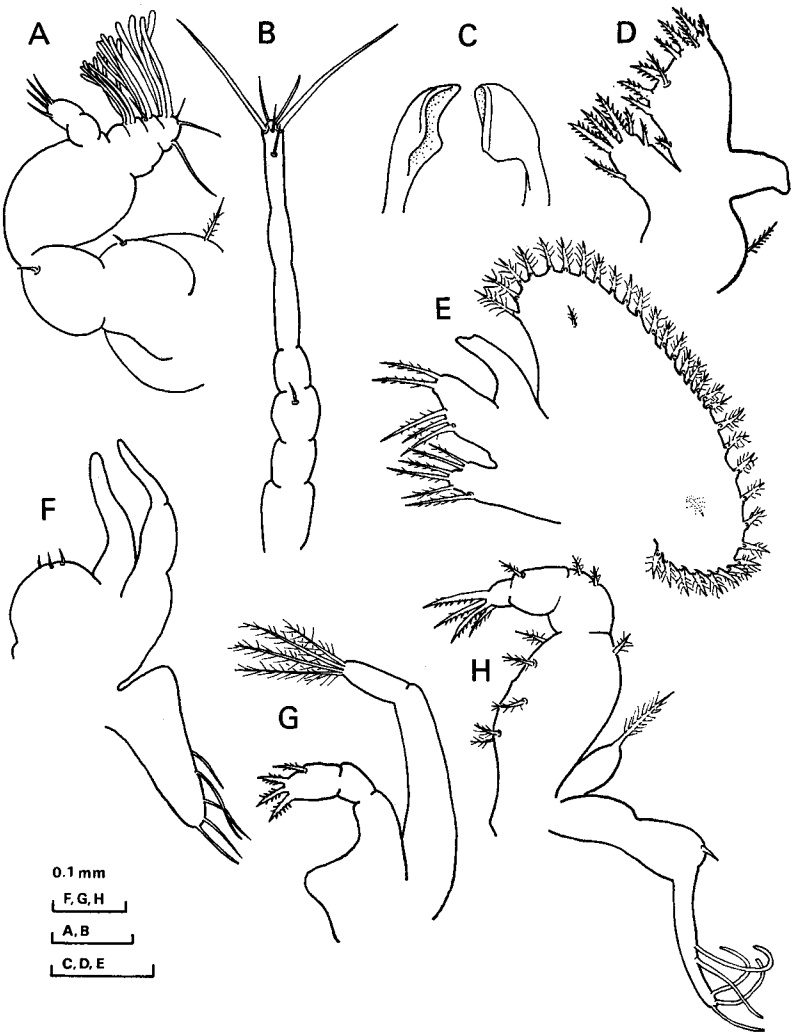

Fig. 4. Mouth parts of megalopa of *Sakaina japonica* Serène. A. antennule, B. antenna, C. mandibles, D. maxillule, E. maxilla, F. first maxilliped, G. second maxilliped, H. third maxilliped.

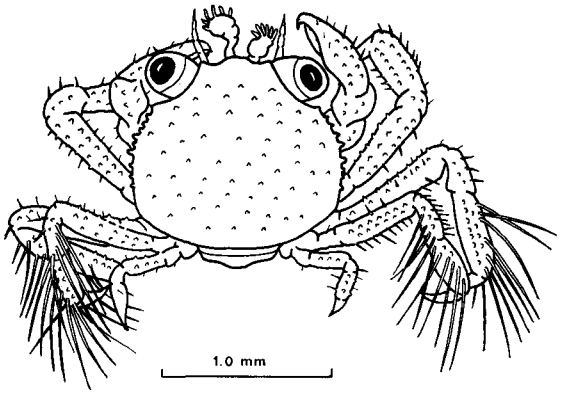

Fig. 5. Dorsal view of first crab of *Sakaina japonica* Serène.

has 2 hooks on its distal end. The telson has transformed to a half-round plate in shape.

The antennule consists of three-segmented peduncle and 2 flagella, of which the inner flagellum is two-segmented and the outer larger one is four-segmented (Fig. 4, A). The inner flagellum carries 4 terminal setae, while the outer one bears 3 terminal setae and three tiers of aesthetes; 4 to 5 on the distal tier, 6 to 8 on the middle tier, and 7 to 8 on the proximal tier. The antenna is composed of 5 segments; the terminal segment is slightly constricted at two portions with 2 long and 4 short setae on its distal end (Fig. 4, B). It has the setation of 6,0,1,0,0 from distal to proximal. The mandibles, transformed into spoon-shaped bodies, have no palps (Fig. 4, C). The endopodite of the maxillule has no armature (Fig. 4, D). The setations of the basal and coxal endites are 9 to 12 and 7 to 8 respectively. On the dorsal side of the maxillule, there is found one plumose seta. The endopodite of the maxilla has changed to a flattened and single-lobed process without seta (Fig. 4, E). The slightly bilobed basal endite carries 5 or 6 setae, while the coxal endite bears 6 or 7 ones. The scaphognathite has 30 to 34 soft pulmose setae and an additional plumose seta on each lateral surface. The protopodite of the first maxilliped bears 3 setules on its inner side (Fig. 4, F). Both endo- and exopodite have no armature. The epipodite, triangular in shape, is provided with 5 to 7 marginal setae. The two-segmented expodite of the second maxilliped bears 4 long plumose setae on the distal end (Fig. 4, G). The three-segmented endopodite is provided with 3 terminal serrate setae and a subterminal seta. The endopodite of the third maxilliped is four-segmented with the spinal arrangement 4,1,2,6 from distal to proximal (Fig. 4, H). The exopodite carries a terminal pulmose seta. The epipodite bears 5 marginal setae and a short seta.

First crab: The first crab molted from the megalopa was obtained only in one

case in the present study. The ambulatory legs of the first crab thus obtained was sometimes used for swimming.

The triangular-shaped carapace of the megalopa becomes oval in shape in the first crab as usual in the adult. The carapace in this stage measures 1.13 mm in length and 1.27 mm in width. Numerous tubercules and setules are scattered on the carapace and thoracic appendages. The second and third ambulatory legs have long natatory hairs and the fourth ones are smaller than the others as in the adult crabs.

Discussion

In the present study, it is confirmed that the setations of the endopodites of the maxillule, maxilla and maxillipeds and the number of spines on the furca of the telson are constant throughout the zoeal stages (Table 1). According to the zoeal classification by Aikawa (1933), the antenna and telson of the zoeae of *Sakaina japonica* belong to D- and B-type respectively; these types are specific to *Dissodactylozoea* in his definition. The main characters of the zoeae of the present species are different from those of the parasitic species in 3 points as follows (Table 2):

1) *Size of body*: The carapace of the first zoea of *S. japonica* measures 0.79 mm in a distance between the anterior margin of the eyes and the posterior margin

Table 1. A synopsis of the main zoeal characters of *Sakaina japonica* Serène.

		First zoea	Second zoea	Third zoea
Antennule:	aesthetes	3	4-6	8-10
	endopodite bud	-	—	+
Antenna:	endopodite but	-	+	++
Mandible:	bud of palp	-	—	—
Maxillule:	endopodite	4	4	4
	basal endite	6	7	9
	coxal endite	4	4	4-5
	dorsal side	-	2	2
Maxilla:	endopodite	4	4	4
	basal endite	8	9	9
	coxal endite	5	5	6
	scaphognathite	4	12-15	18-22
Mxp. I:	protopodite	8	8	8
	endopodite	5, 2, 1, 2, 2	5, 2, 1, 2, 2	5, 2, 1, 2, 2
	exopodite	4	6	7-8
Mxp. II:	protopodite	4	4	4
	endopodite	5, 1, 0	5, 1, 0	5, 1, 0
	exopodite	4	6	8
Abdomen:	no. of somite	5	(6)	6
Telson:	inner spines	6	6	6

—: absent, +: emerges, ++: elongates.

Table 2. A comparison of the main zoeal characters of 10 pinnotherid species with *Sakaina japonica* Serène.

Species	Carapace spine			Antenna type	Setation of endopodite		Telson type	No. of instars	Sixth abdominal somite	Authors
	Rostral	Dorsal	Lateral		Mx.	Mxp. II				
'Dissodactylozoea singularis'	+	−	−	D	4	5, 1, 0	B	?	?	Aikawa, 1933
Sakaina japonica	+	−	−	D	4	5, 1, 0	B	3	(II)	present work
Xenophthalmus garthii	+	+	+	B	5	4, 1, 0	B	?	?	Sankarankutty, 1970
Asthenognathus atlanticus	+	+	+	B	?	?	B	5	III	Bocquet, 1965
Pinnixa rathbuni	+	+	+	D	3	5, 0	B	5	—	Sekiguchi, 1978
Pinnotheres maculatus	+	+	+	D	3	5, 0	B	5	IV	Costlow & Bookhout, 1966
P. ostreum	+	−	−	D	3	4, 0	F	4	—	Sandoz & Hopkins, 1947
P. chamae	+	−	−	D	3	5, 0	F	3	—	Roberts, 1975
P. boninensis	−	−	−	D	3	4, 0	F	3	—	Muraoka, 1977
P. aff. *sinensis*	−	−	−	D	3	4, 0	F	3	—	Yatsuzuka & Iwasaki, 1979
P. taylori	+	+	−	D	3	5, 0	B	2	—	Hart, 1935

+: present, —: absent
Mx.: maxilla, Mxp. II: second maxilliped

of the carapace, while that of the *Pinnotheres* species has a range between 0.34 mm (*P.* aff. *sinensis* Shen) and 0.57 mm (*P. taylori* Rathbun).

2) *Setation on endopodite*: The endopodites of the maxilla and second maxilliped of the present zoeae have 4 terminal setae in the former and the setation 5,1,0 from the distal to proximal segments in the latter, while those of the zoeae of the *Pinnotheres* species have 3 terminal setae and the setation 5,0 or 4,0 from the distal to proximal segments. Most of the parasitic pinnotherids generally show some regressive features in their larvae as well as their adults; a reduction in the number of segments and the setation of their appendages. In this respect, the zoeae of the present species resemble those of the non-parasitic *Xenophthalmus garthii* Sankarankutty and *Asthenognathus atlanticus* Monod.

3) *Abdominal segmentation*: In the present species, the sixth abdominal somite comes to appear even in the second zoea, although it has completed in the third zoeal stage. Most of the parasitic species have only 5 somites throughout the zoeal stages. If any, the segmentation of the sixth somite occurs in the fourth zoeal stage as in the case of *P. maculatus* Say (Costlow and Bookhout, 1966).

In addition, the bud of mandibular palp is absent in all zoeal stages, even in the megalopa stage. Most of the other pinnotherid larvae emerge from it before megalopa stage.

In his zoeal classification based on the planktons, Aikawa (1933) described

Dissodactylozoea singularis, of which adult crab could not be ascertained. It is noticeable that Aikawa's *D. singularis* closely resembles in feature the third zoea of the present species. Furthermore, in Korea Strait where *D. singularis* was collected, the adult crab of *Sakaina* has been known (Sakai, 1976). It is, therefore, very possible that Aikawa's *D. singularis* at least belongs to the genus *Sakaina* in the adult stage.

Besides Glassell (1933) figured the first zoea of *Parapinnixa affinis* Holmes. Since the genus *Parapinnixa* is the nearest kin of *Sakaina*, it should be necessary to compare the larvae of these allies. In his paper, however, he gave only a lateral view of the first zoea and no detailed description was presented; from his figure it can be seen that the carapace, 0.66 mm in length, possesses only a rostral spine, and that the endopodite of the second maxilliped consists of 3 segments as in the present case. In spite of the limited data, the first zoea of *P. affinis* resembles that of the present species in general feature.

By the characters found on the feeler of the fourth ambulatory legs and the uropod, the megalopae of the pinnotherid crabs are separable into two main groups, such as the group A which shows absence of the feeler and uropod, and the group B which has these characters (Muraoka, 1977). However, it was reported that the megalopa of *Pinnotheres* aff. *sinensis* has the feeler without showing the presence of the uropod (Yatsuzuka and Iwasaki, 1979). In spite of this fact, it is sure that the megalopae of the parasitic pinnotherid crabs belong to the group A and those of the non-parasitic crabs, such as *Sakaina japonica* and *Asthenognathus atlanticus*, belong to the group B.

It may be concluded that the larval characters of the present species are more common with those of the non-parasitic crabs than with those of the parasitic ones.

Summary

Three zoeal and one megalopa stages of the non-parasitic pinnotherid crab *Sakaina japonica* Serène obtained under laboratory conditions are described in detail. The larvae of the present species are different in characters from those of the parasitic species of the genus *Pinnotheres*. It is also suggested that *Dissodactylozoea singularis* in the zoeal classification made by Aikawa (1933) belongs to the genus *Sakaina* in the adult stage.

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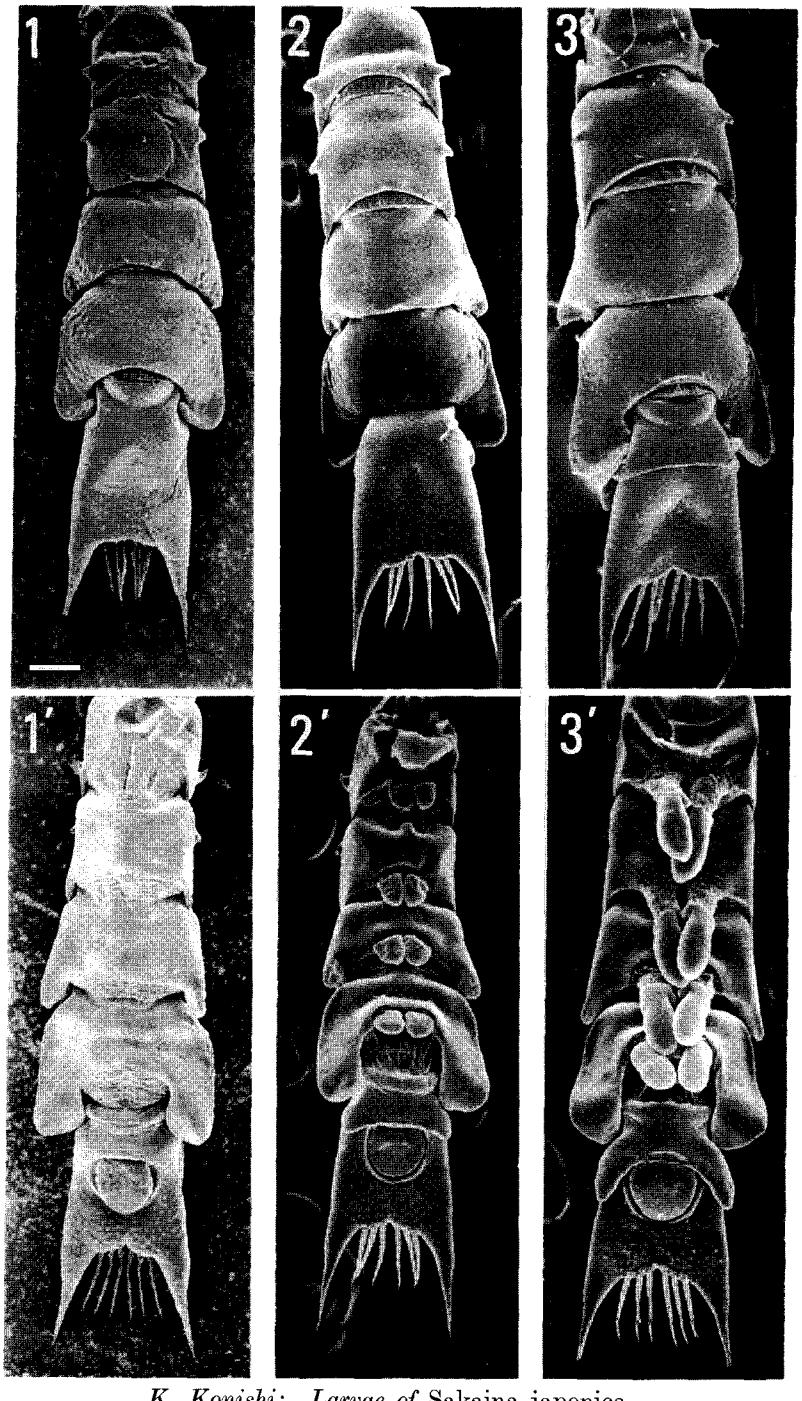
Explanation of Plates

Plate IV. Scanning electron micrograph of abdomens in each zoeal stage of *Sakaina japonica* Serène. 1. first zoea, dorsal view; 1′, first zoea, ventral view. 2. second zoea, dorsal view; 2′ second zoea, ventral view. 3. third zoea, dorsal view; 3′. third zoea, ventral view. Bar indicating 0.1 mm.

Plate V. Scanning electron micrograph of megalopa of *Sakaina japonica* Serène. 1. dorsal view. 2. ventral view, arrow indicates a pair of conical projections on the thoracic sternum; 2′. conical projection, enlarged. Bar indicating 1.0 mm in 1 and 0.1 mm in 2′, respectively.



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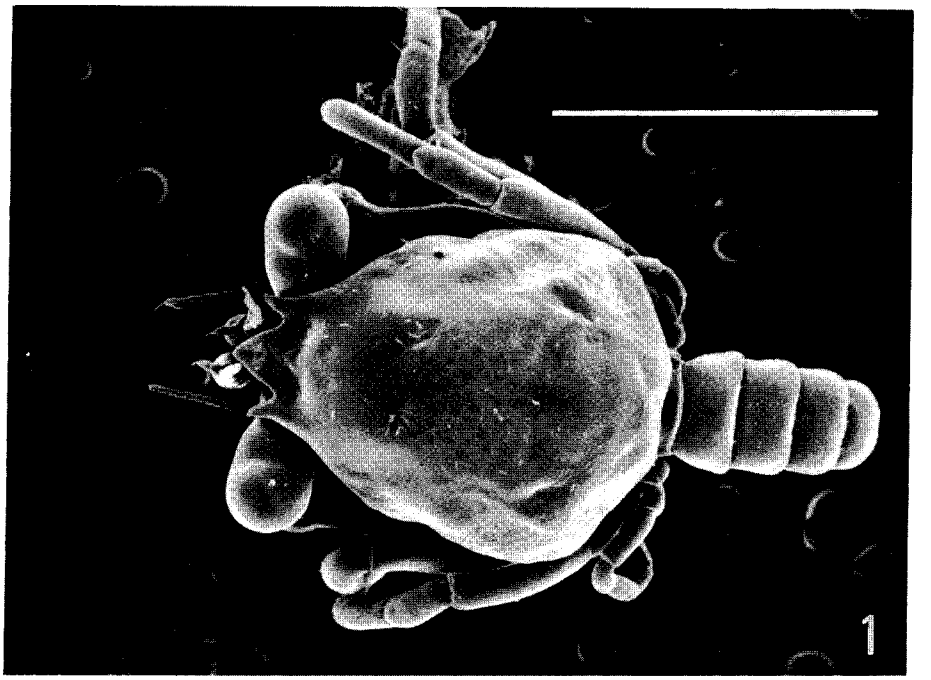

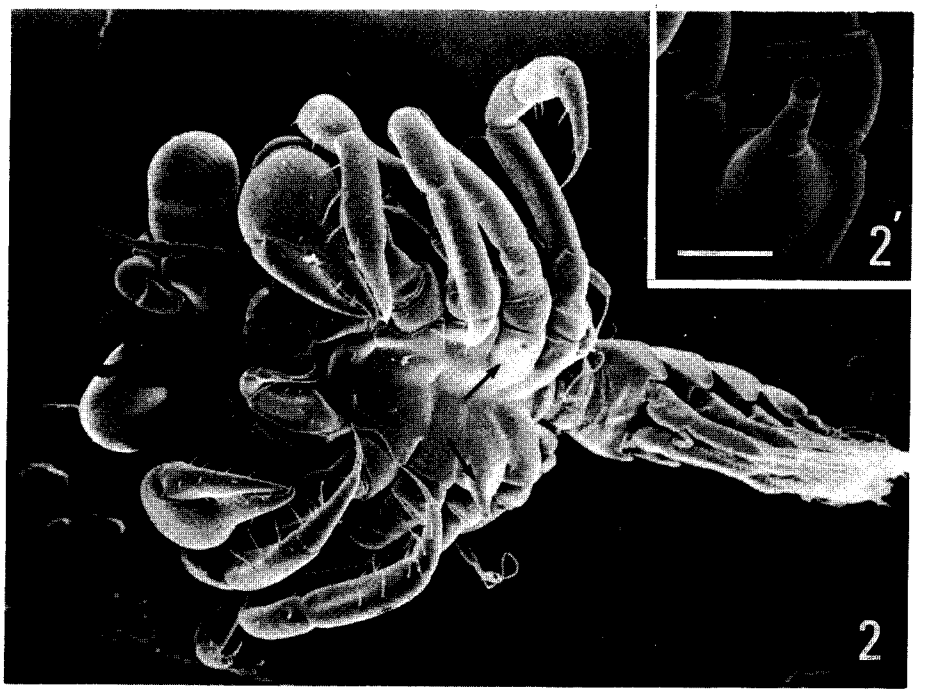

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