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The Larval Stages of the Swimming Crabs, *Portunus pelagicus* and *P. sanguinolentus* Reared in the Laboratory

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Certain of the members of the swimming crabs support fairly important local fisheries in the Seto Inland Sea and increasing attempts have been undertaken in recent years to improve fishery resources in the sea by releasing a large number of young crabs reared from egg in the hatcheries. Identification of planktonic larval crabs is of prime importance to study in nature early life histories of these crabs and to develop suitable releasing methods which guarantee high rates of survival of seed crabs introduced in the sea.

This paper presents detailed descriptions and line drawings of the larvae of *P. pelagicus* and *P. sanguinolentus* which are very common in the coastal and offshore waters of Wakayama Prefecture.

Berried crabs were obtained from regular commercial catches by local fishermen and were kept in an aerated plastic 0.5 ton aquarium until eggs hatched out. The newly hatched zoeae were transferred into rearing tanks containing filtered sea water and unicellular green algae, *Chlorella* sp., at a medium concentration. Zoeae were fed with rotifers, *Brachionus* sp., and newly hatched *Artemia* nauplii in succession. Samples were taken at intervals, fixed and preserved in 5% sea water formaline for the later examinations. Measurements of the larvae were taken according to KURATA (1975).

Portunus pelagicus (Linnaeus)

The "TAIWAN GAZAMI" ranges from Sagami Bay to Kyushu in Japan, further extending widely in offshore waters of tropical Indo-West Pacific and East Africa. (SAKAI, 1939). This is the most important commercial crabs in Wakayama Prefecture keeping the highest prices in the local markets (300-700 yen per crab in 1974). It is somewhat smaller than the estuarine relative, *P. trituberculatus,* attaining about 170 mm. across carapace and 400 grams in wet weight, and prefers higher temperatures and higher salinities than does the latter.

Berried crabs were obtained in August, 1974 from the gill-net catches from 5-6 meter deep, and the hatched larvae were reared in 7 ton concrete tanks. Some of them survived beyond metamorphosis. Four zoeal stages and one megalopa were recognized.

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ZOEA (Fig. 1)

Carapace has all the spines, which are all smooth. Rostral spine is long and almost straight. Dorsal spine curves, ending in a hook. It is distinctly longer than carapace as well as rostral spine in all stages. Lateral spines are less than 1/4 as long as carapace. Eyes are large, maximum diameter of cornea being almost 1/2 the length of carapace in early stages. Ventral margin of carapace is denticulated, and, in later stages, is fringed with sparse setae. There is an inconspicuous dorsal knob on the carapace above stomach.

Abdomen is much shorter than distance from spine to spine. There are lateral hooks on somites 2 and 3, and postero-lateral spines on somites 3-5. These are distinct in all stages. Postero-lateral spines of somite 3 are somewhat longer than those of somite 4.

Telson is slender and typically forked, with 2 outer spines, lacking the second. Forks are smooth. Outer spines 1 and 3 are spinous. Spine 1 is almost as long as or slightly longer than spine 3, and its insertion is almost level with that of inner seta 1 in early stages, but moves behind the latter in later stages. Spine 3 is inserted about 1/3 way down on the fork and inner dorsal in position, bending inward distally in early stages. Inner setae are somewhat less than 1/2 the length of fork, seta 1 reaching only slightly behind tip of outer spine 3. There is a pair of extra inner setae inside in later stages.

Antennule in all but the last stage is simple and unjointed. It is jointed and biramous in the last stage. Antenna is much shorter than rostral spine with two rows of spinules along spinous proccess. The spinules, in later stages, are arranged in more than two rows at proximal portion. Exopod is about 1/3 as long as spinous process ending in a short spine with an apical inner spine which is almost as long as the rest of exopod less terminal spine. Endopod appears from stage 3.

Mandible is well developed with a palp in the last stage. Endopod of maxillule is of 2 segments with 1 and 6 setae on proximal and distal segment respectively. A feathered seta and a simple seta is present on outer edge of basis and coxa respectively in later stages. Endopod of maxilla is unsegmented but bilobed with 6 setae in 3 pairs of which the terminal pair tends to be suppressed. Endopod of maxilliped 1 is of 5 segments and that of maxilliped 2 is of 3 segments. Maxilliped 3 is seen as minute rudiments from stage 1, while legs become free from stage 2.

Stage 1. From spine to spine : 1.38-1.50 mm. in 20 specimens.

Eyes are sessile. Rostral spine is about 4/5 as long as carapace, while dorsal spine is somewhat longer than the latter. Abdomen is of 5 somites plus telson. Telson is twice as long as wide. Fork is somewhat longer than the rest of telson. There are 3+3 inner setae. Postero-lateral spines on abdominal somite 3 are about 1/3 as long as somite 4. Antenna is 5/6 as long as rostral spine without endopod. Maxillipeds bear 4 swimming setae.

Stage 2. From spine to spine : 1.92-2.10 mm. 15 specimens.

Eyes are stalked. Telson is 1/3 times more than twice as long as wide, with a

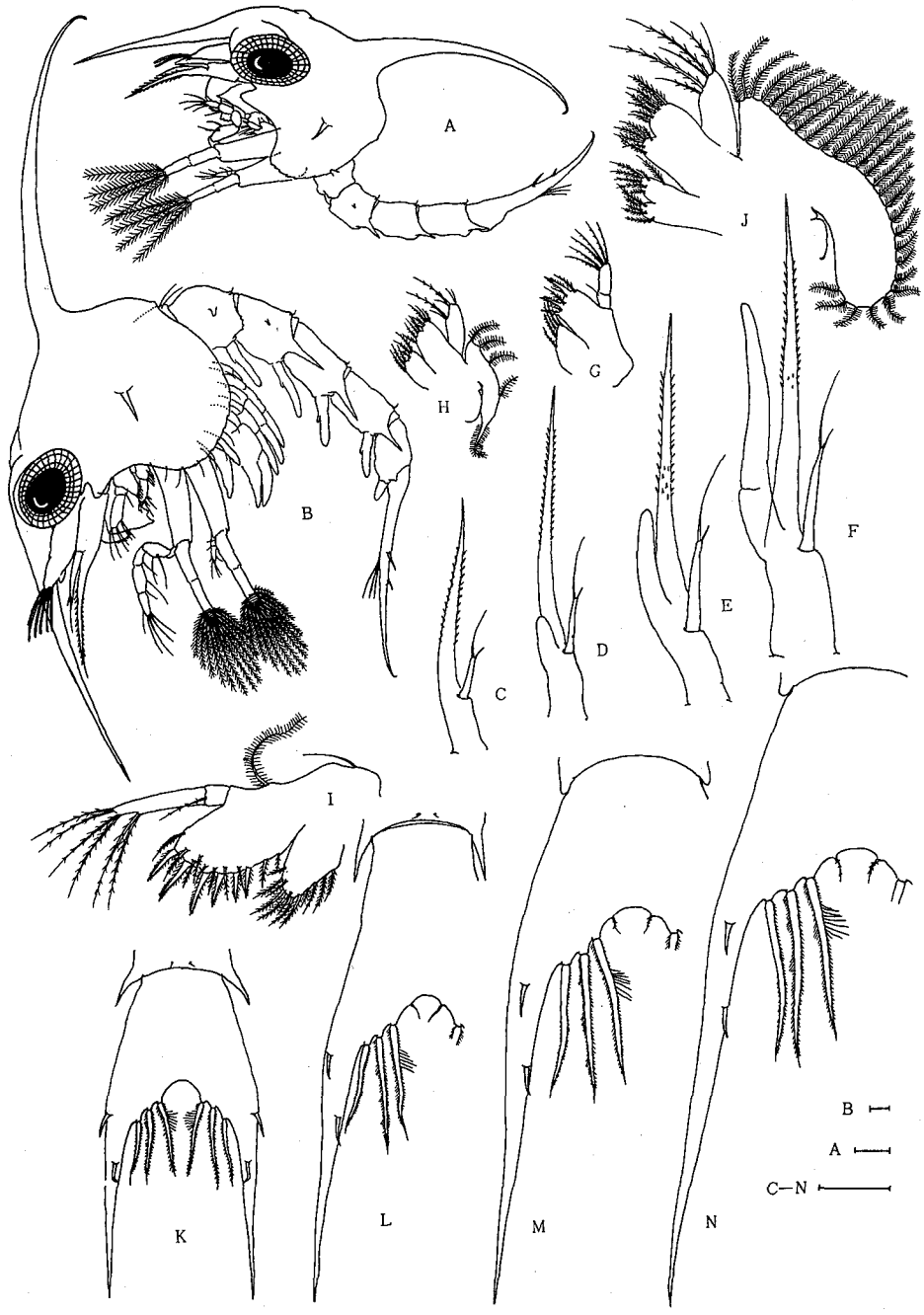

Fig. 1. *Portunus pelagicus*: zoeal stages 1–4. A, stage 1, lateral; B, stage 4, lateral; C–F, antenna, stages 1–4; G,H, stage 1, maxillule and maxilla; I,J, stage 4, maxillule and maxilla; K–N, telson, dorsal, stages 1–4. Scales indicate 0.1 mm.

pair of extra inner setae inside. Fork is 1/4 times longer than the rest of telson. Antenna is 3/4 as long as rostral spine with a short endopod. Leg buds are free but no pleopods are present. Maxillipeds bear 8, instead of 6, swimming setae.

Stage 3. From spine to spine : 2.88-3.12mm. in 5 specimens.

Rostral spine is 1/5 times longer than carapace. Abdominal somite 6 is segmented off from telson, which is now slightly more than twice as long as wide. Outer spine 1 moves behind insertion of inner seta 1. Postero-lateral spines of abdominal somite 3 are about 1/3 as long as somite 4. Antenna is about 2/3 as long as rostral spine, endopod is somewhat longer than exopod less spines. Pleopods appear, simple and unjointed, and are about 1/2 as long as their respective somite. Maxillipeds bear 10-11 swimming setae.

Stage 4. From spine to spine : 3.48-3.55mm. in 3 specimens.

Postero-lateral spines of abdominal somite 3 are 2/3 as long as somite 4. Telson is very selnder, much more than twice as long as wide. There is still a pair of extra inner setae. Antennule is jointed and biramous with 2 groups of aesthetascs on outer flagellum. Antenna is about 1/2 as long as rostral spine. Endopod is about 3/4 as long as spinous process with a basal articulation. Maxilliped 3 and legs are very large and more or less jointed, emerging from carapace cover. Maxillipeds bear 12-13 swimming setae. Pleopods are nearly as long as their respective somite.

MEGALOPA (Fig. 2)

Total length ranges 3.8-4.0mm. and carapace length 2.1-2.4mm. Carapace has no conspicuous protuberances or dorsal spines, but has a pointed rostrum sticking out foreward almost horizontally. The rostral spine is slightly shorter than the rest of rostrum. Rostrum as a whole constitutes somewhat less than 1/2 the length of carapace and is almost 1/2 as wide as carapace. Abdomen is of 6 somites plus telson and is about 2/3 as long as carapace. Sides of somite 5 stick out behind into a pair of lateral spines, reaching to proximal 1/3 of telson. Telson is almost as long as wide. There are well developed, biramous pleopods on abdominal somites 2-5, and uniramous uropod on somite 6 bearing 9-10 setae on exopod and with or without a seta on protopod.

Antenna is consisted of a protopod of 4 segments and a flagellum of 8 segments, exceeding tip of rostrum by its distal 3-4 segments. Segment 5 of flagellum has a pair of long setae at distal end. Mouth parts assume general characters of the genus (KURATA, 1975).

Leg 1 has a hook-shaped spine on ventral edge of ischium and on antero-ventral edge of carpus. Palm is 1/2 times longer than wide. Fingers are almost as long as palm with 4 teeth each along inner edges of movable and immovable ones. Tip of fingers deeply crosses each other when chela is closed. Leg 2 has a spine on ventral edge of coxa. There is a large sternal spine (cornua) each side at the base of leg 4, sticking out behind and reaching slightly beyond hind end of abdominal somite 2. Last segment of leg 5 is paddle-shaped, ending in a short spine with 2 feathered setae and 6 feelers, of which two are saw like, along

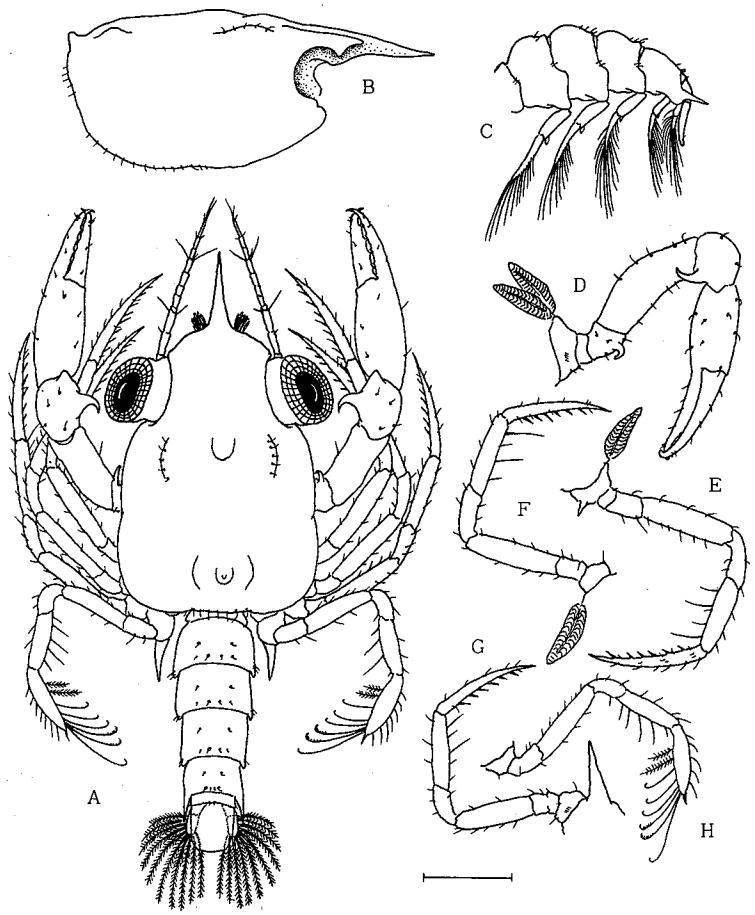

Fig. 2. *Portunus pelagicus*: megalopa. A, dorsal view; B, carapace, lateral; C, abdomen, lateral; D–H, legs 1–5. Scale indicates 0.5 mm.

ventral margin.

There is 1 long mastigobranch with filamentous setae on maxillipeds 1 and 3, 2 arthrobranchs each on maxillipeds 2, 3 and leg 1, and an arthrobranch on legs 2 and 3. Gill formula is thus completed as in the adult except a mastigobranch on maxilliped 2.

Remarks Zoeae and megalopa of this crab reared from egg in the laboratory have been briefly described and figured by YATSUZUKA (1957, 1962). He found that they changed into megalopa from either stage 4 or 5. Those reared under favourable conditions usually changed into megalopa from stage 4.

Zoea of *P. pelagicus* is unique among Portuninae in bearing 8, instead of 6, swimming setae in stage 2. This is also confirmed by YATSUZUKA (1962). The fact, together with the character having very long rostral and dorsal spines on carapace, seems to be an adaptation of the zoea keeping up the surface layers.

Portunus sanguinolentus (Herbst)

The "JANOME GAZAMI" is very common in oceanic littoral areas from Tokyo Bay to Kyushu and elsewhere in the tropical Indo-West Pacific. It is much more abundant than *P. pelagicus* in Wakayama Prefecture. Commercially, however, it is less important than the latter owing to its smaller size attaining only 130 mm. across carapace.

At Arasaki, Sagami Bay, berried crabs are found as early as June, while in Harima Nada, Seto Inland Sea, period of egg carriage is limited to the later half of the year, August-December (HAMADA *et al*, 1975).

Newly hatched zoeae were obtained from berried crabs separated in August, 1974 from regular trawl catches in Tanabe Bay, Wakayama Prefecture. They were reared in an aerated 0.5 ton plastic aquarium by the similar method as in *P. pelagicus*. Unfortunately, however, they did not live beyond stage 4.

ZOEA (Fig. 3)

Zoea is very like *P. pelagicus* in essential characters, but differs from it in smaller size and rudimentary antennal exopod. Rostral spine is shorter than carapace in all stages. Dorsal spine curves without terminal hook, and is almost as long as carapace. Lateral spines are 1/3-1/4 the length of rostral spine.

Telson is forked and bears 3 outer spines. Spines 1 and 3 are large and spinous in all stages, while spine 2 is minute and hair-like disappearing in later stages. Spine 1 is much larger than spine 3, and its insertion is almost level with that of inner seta 1. Spine 3 is at about proximal 1/4 of fork and bends inward distally. Inner seta 1 is about 2/3 as long as fork, well exceeding tip of outer spine 3. There is a pair of extra inner setae in later stages. Telson fork is rather short. It is nearly as long as the rest of telson and abdominal somite 6 combined in early stages but distinctly shorter than the latter in later stages.

Antenna is more or less shorter than rostral spine with two rows of spinules along spinous process. Exopod is very small, less than 1/7 as long as spinous process, ending in a short spine which is as long as the rest of exopod. Apical inner spine is about twice as long as exopod including terminal spine. Endopod of maxillule is of 2 segments with 6 aetae on distal segment. No seta is present on proximal one. Endopod of maxilla is unsegmented but bilobed with 6 setae in 3 pairs, of which the terminal pair tends to be suppressed. Endopod of maxilliped 1 is of 5 segments and that of maxilliped 2 is of 3 segments.

Stage 1. From spine to spine : 0.81-0.93mm. in 15 specimens.

Eyes are sessile. Maximum diameter of cornea much exceeds 1/2 the length of carapace. Rostral spine is about 2/3 as long as carapace. Abdomen is of 5 somites plus telson. Postero-lateral spines on abdominal somites 3-5 are very short with minute accessory denticles dorsally. Telson is 3/4 times longer than wide. Fork is almost as long as the rest of telson. There are 3+3 inner setae. Outer spine 2 is minute but distinct in all specimens examined. There are neither antennal endopod nor legs nor pleopods. Maxillipeds bear 4 swimming setae.

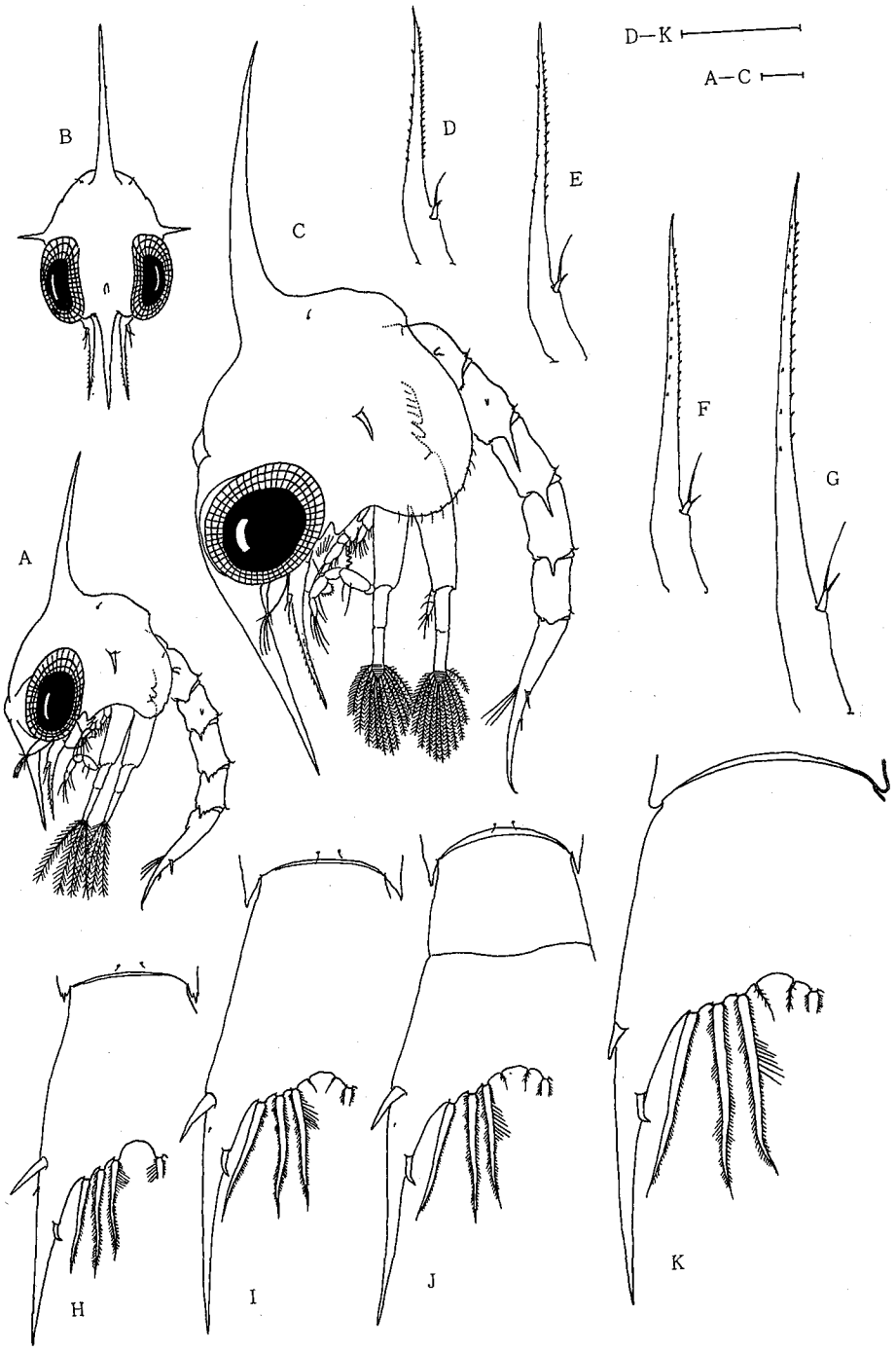

Fig. 3. *Portunus sanguinolentus*: zoeal stages 1–4. A, stage 1, lateral; B, the same, carapace, dorsal; C, stage 4, lateral; D–G, antenna, stages 1–4; H–K, telson, dorsal, stages 1–4. Scales indicate 0.1 mm.

Stage 2. From spine to spine : 1.05-1.14mm. in 15 specimens.

Eyes are stalked. Telson is twice as long as wide. Fork is only 1/6 times longer than the rest of telson. There is a pair of extra inner setae. Postero-lateral spines on abdominal somites 3-5 are simple without accessory spines, and are about 1/3 as long as their succeding somites. Maxillipeds bear 6 swimming setae.

Stage 3. From spine to spine : 1.38-1.68mm. in 6 specimens.

Abdomen is of 6 somites plus telson. Telson is now somewhat less than 1/2 times longer than wide. Fork is 1/2 times longer than the rest of telson but somewhat shorter than combined length of somite 6 and the latter. Insertion of outer spine 1 is almost level with or slightly anterior to that of inner seta 1. Inner seta 1 reaches about 2/3 the length of fork. Antenna has no endopod and is about 2/3 as long as rostral spine. Maxillipeds bear 8 swimming setae.

Stage 4. From spine to spine : 1.82-1.91mm. in 2 specimens.

Telson fork is about 1/2 times longer than the rest of telson, and is nearly equals to width of telson. Outer spine 1 is slightly behind to inner seta 1 at insertion. Outer spine 2 disappears in all the specimens examined. Postero-lateral spines on abdominal somite 3 reach to about 2/3 the length of somite 4. Rudiments of legs are still folded. There are no antennal endopod or pleopods. Maxillipeds bear 10-11 swimming setae.

Remarks Zoea of *P. sanguinolentus* is quite outstanding among Portuninae and is readily distinguished from the other known species of Portuninae by its rudimentary antennal exopod. Judging from the state of development in stage 4 zoea, 2 more stages at least should be passed before reaching megalopa.

RAJA BAI NAIDU (1955) described first zoea hatched from egg. Her first zoea is somewhat smaller than the present materials measuring only 0.75 mm. from spine to spine. She states and figures that the antennal exopod is spinous as a whole with a short seta at about half its length on the outer edge. In the present materials, however, antennal exopod has a general character of the genus, ending in a short spine with an apical inner spine. Her observation on the setation of endopods of maxillule and maxilla is also not entirely correct. These endopods, in the present materials, assume the character of the genus bearing 6 setae instead of 4 as she described. In compiling zoeal characters of the known species of *Portunus,* she cites zoea of *P. trituberculatus* from AIKAWA (1929) who, unfortunately, overlooked lateral spines on carapace, though revised in a later paper (AIKAWA, 1937).

DISCUSSION

Zoeae of the two species described here differ each other in many minor details as summarized in the following table, though resembling in every essentials.

Distinguishing characters between zoeae of P. pelagicus and P. sanguinolentus

Characters	*P. pelagicus*	*P. sanguinolentus*
Dorsal spine on carapace	Longer than carapace ending in a hook	As long as carapace without terminal hook
Rostral spine on carapace	Longer than carapace except in stage 1	Shorter than carapace in all stages.
Antennal exopod	Moderately long	Very short
Telson	Twice or more as long as wide	Not more than twice as long as wide
Inner setae of telson	Only slightly exceed hind end of outer spine 3	Well exceed hind end of outer spine 3
Outer spine of telson	Spine 1 is not much longer than spine 3	Spine 1 is much longer than spine 3

Characters of zoea which are essential and common to both are the presence of all the spines on carapace, of lateral hooks on abdominal somites 2 and 3, of postero-lateral spines on somites 3-5, and of 3 outer spines on telson including rudimentary second. Basic characters of antenna which are common to both seem to be most important since this is quite consistent among Portuninae so far known and is very usefull to distinguish them as a whole from the other groups of Brachyura. Comparison of characters between zoeae of the two species clearly indicates that we should refer to the minor details instead of essential characters as AIKAWA (1929, 1937) did in order to distinguish between the species of Portuninae.

SUMMARY

Zoea stages 1-4 and megalopa of *Portunus pelagicus* and zoea stages 1-4 of *P. sanguinolentus* were described and figured in detail based on the materials reared from egg in the laboratory. Larvae of *P. pelagicus* pass through 4 zoeal stages and one megalopa before changing into crab, while in *P. sanguinolentus* more than 4, probably 6, stages are assumed in the zoea. Zoeae of the two species are very like in every essentials but differ in minor details.

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タイワンガザミとジャノメガザミの飼育幼生について

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ガザミ類幼生の同定は，プランクトン期の生活史研究に不可欠であるが，この点に関する従来の知見は極めて不充分である。本報告では，タイワンガザミのゾエアとメガロパおよびジャノメガザミのゾエアについて，ほかのカニ類幼生との識別を目的として，外部形態の詳細を記載し図解した。観察材料は抱卵親ガニからふ化した幼生を実験室で飼育したものである。

タイワンガザミの幼生期にはゾエア4期とメガロパ1期とを認めた。ジャノメガザミは第4期ゾエアまで飼育したが，歩脚や腹肢の発達から判断すると，メガロパまでにさらに少くとも2期を経過するだろうと推測した。

両種のゾエアはすべての基本的な特徴において互いに一致する。主な違いは体の大きさのほか頭胸甲の棘，第2触角外肢，尾節の形と棘などの相対的な長さに認められる。いわゆる基本的な特徴はガザミ類幼生を一括してほかのカニ類幼生から識別するためには非常に有用であるが，ガザミ類相互間の識別にはほとんど役に立たない。恐らく，種，属，科など分類体系の水準に応じて，形態分化は違った部分に現われるからだと考えられる。

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