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Title	Morphology of the Copepodid Stages of <i>Zaus robustus</i> Itô and <i>Paratigriopus hoshidei</i> Itô from Japan, with Reference to Some Biological Observations (Harpacticoida: Harpacticidae) (With 14 Text-figures and 1 Table)
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**Morphology of the Copepodid Stages of *Zaus robustus* Itô
and *Paratigriopus hoshidei* Itô from Japan, with
Reference to Some Biological Observations
(Harpacticoida: Harpacticidae)¹⁾²⁾**

By

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(With 14 Text-figures and 1 Table)

The present paper deals with the morphology of the copepodid stages of two harpacticoid copepods, *Zaus robustus* Itô, 1974, and *Paratigriopus hoshidei* Itô, 1969, both belonging to the Family Harpacticidae, as a report of the studies of marine harpacticoids in Hokkaido. Since biological aspect of the latter species has so far been scarcely known, a note on some biological observations is also given.

Collecting data for each species are given in the text. This paper was based upon a part of my D.S. thesis submitted to Hokkaido University, carried out under the direction of Professor Mayumi Yamada, to whom I express my cordial thanks.

1. *Zaus robustus* Itô

Following description of copepodid stages is based upon the specimens collected from Akkeshi (15-VII-1973). They were selected from a large number of individuals of various stages attached onto a small piece of a brown alga found at the low tide level of a rocky shore near the Akkeshi Marine Biological Station.

1-1. *The first copepodid stage. Female.* Body (Fig. 1-1) consisting of five somites, about 0.24 mm long. Cephalothorax much wider than long, almost as long as all succeeding somites combined, clearly swelling laterally and maximum width locating at two-thirds the length. Pleurotergite of second somite somewhat differentiated. Otherwise as in male.

Male. Body (Fig. 1-4) about 0.22 mm long. Rostrum (Fig. 2-1) as shown in figure. Cephalothorax not swelling laterally, almost rectangular in dorsal view, ornamented with at least three hairs along each lateral margin. Fourth somite

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2) Studies on marine harpacticoid copepods from Hokkaido, VII.

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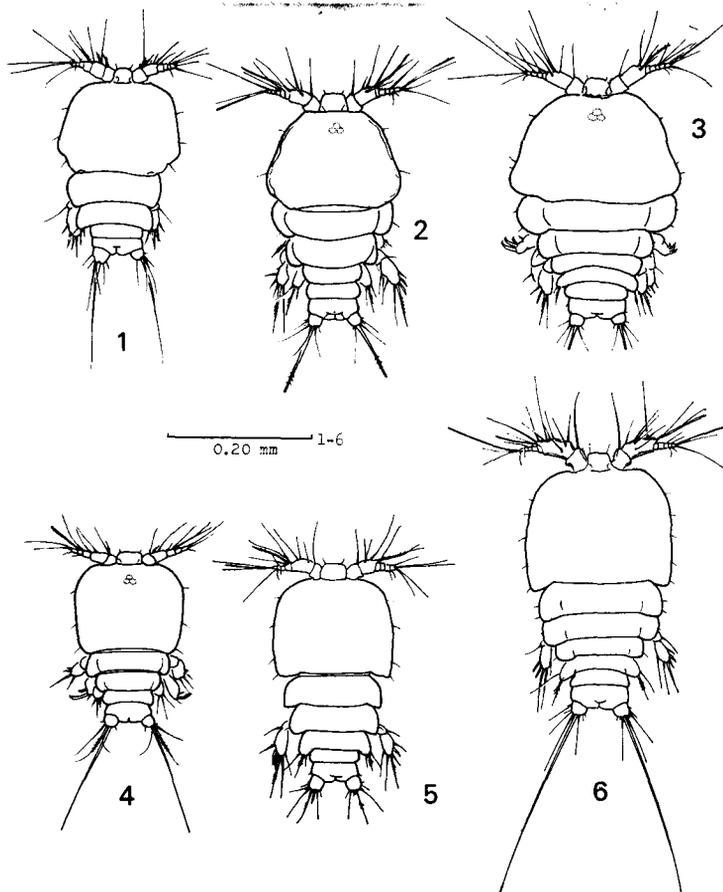


Fig. 1. *Zaus robustus*. Female. 1. first copepodid; 2. second cop.; 3. third cop. Male. 4. first cop.; 5. second cop.; 6. third cop.

(Fig. 2-4) short and unornamented. Last somite much longer than preceding one, somewhat widened behind, and ornamented with several spinules on lateral side near each furcal ramus. Furcal rami widely separated from each other; each ramus almost as long as wide, ornamented with some spinules near posterior end; principal terminal setae confluent to each other basally; one setula arising from middle of outer edge; outer distal corner with one elongate seta and one setula; one basally geniculate setula arising from dorsal side near posterior distal end; one slender seta on distal end close to dorsal side of principal terminal setae. *Antennule* (Fig. 2-1) six-segmented; first two segments remarkably thicker than others; first segment somewhat shorter than wide, furnished with one spinulose

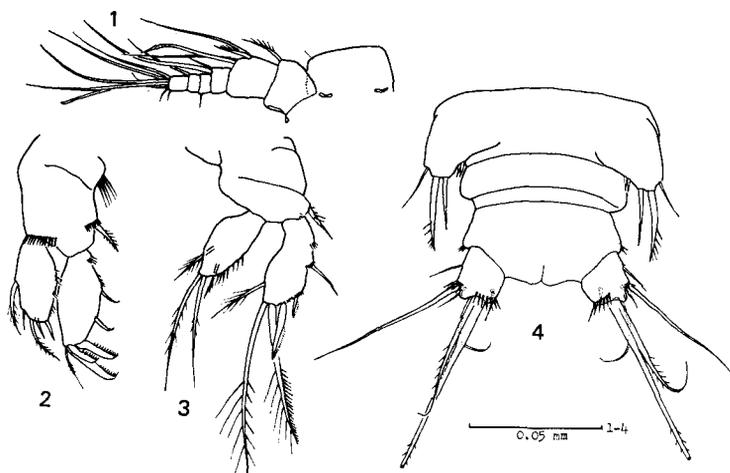


Fig. 2. *Zaus robustus*. The first copepodid stage. Male. 1. rostrum and antennule; 2. leg 1; 3. leg 2; 4. leg 3 and abdomen, ventral.

seta anteriorly; second one furnished with one bare seta close to one spinulose seta on middle anterior edge and an aesthetasc subdistally; apical four segments combined apparently shorter than basal two segments combined; third one somewhat longer than fourth one. *Leg 1* (Fig. 2-2). Demarcation between coxa and basis obscure. Outer edge of coxa with some longer spinules. Basis remarkably longer than coxa, furnished with one spinulose seta accompanied with some delicate spinules around base on middle outer edge; a transverse row of some spinules on anterior side of inner distal part. Both rami one-segmented. Exopodite elongate oval in outline, almost twice as long as greatest width, ornamented with an oblique spinular row on anterior side near inner proximal edge, and with two small spines each on a point a third and two-thirds the length of outer margin; three serrate claws and one hairy setula on and near distal end. Endopodite fairly shorter than exopodite, ornamented with some groups of spinules on outer margin; one hairy short seta arising from middle inner edge; one setula on subdistal inner edge, two small spiniform setae and one hairy setula on distal end. *Leg 2* (Fig. 2-3). Coxa bare. Basis furnished with one somewhat spinulose outer seta. Both rami one-segmented. Exopodite more than twice as long as greatest width, somewhat swelling inwards at two-thirds the length; a short spinular row on subproximal outer edge; one bare slender spine arising from middle outer edge; two serrate spines on subdistal outer edge; distal end with one elongate spine and one seta which is spinulose along outer margin and hairy along inner margin; one short hairy seta arising from a point three-fourths the length of inner margin. Endopodite shorter than exopodite, furnished with one spiniform seta on subdistal outer edge, two terminal setae and one inner seta subdistally.

Leg 3 (Fig. 2-4) represented by a small protuberance furnished with two close small spiniform setae on inner edge, one bare seta and one somewhat spinulose seta terminally, and one bare small outer seta subdistally.

1-2. *The second copepodid stage. Female.* Body (Fig. 1-2) consisting of six somites, about 0.3 mm long. Rostrum (Fig. 3-1) as shown in figure. Cephalothorax remarkably wider than long, narrowed anteriorly, almost as long as four succeeding somites combined. Pleurotergite of second and third somites apparently expanding laterally. Fifth somite (Fig. 3-5) unornamented. Last somite as in previous stage. Principal terminal setae of furcal ramus clearly separated from each other. *Antennule* (Fig. 3-1) seven-segmented, without any spinulose seta; first segment with one elongate bare seta instead of one spinulose short seta in previous stage; second one remarkably elongated, about 1.5 times as long as thick, and with an aesthetasc on a small process; third one short, with one elongate seta anteriorly; fourth one somewhat longer than preceding one; apical three segments small. *Leg 1* (Fig. 3-2). Coxa fairly developed, some spinules added to subproximal outer edge. Basis ornamented with some rather

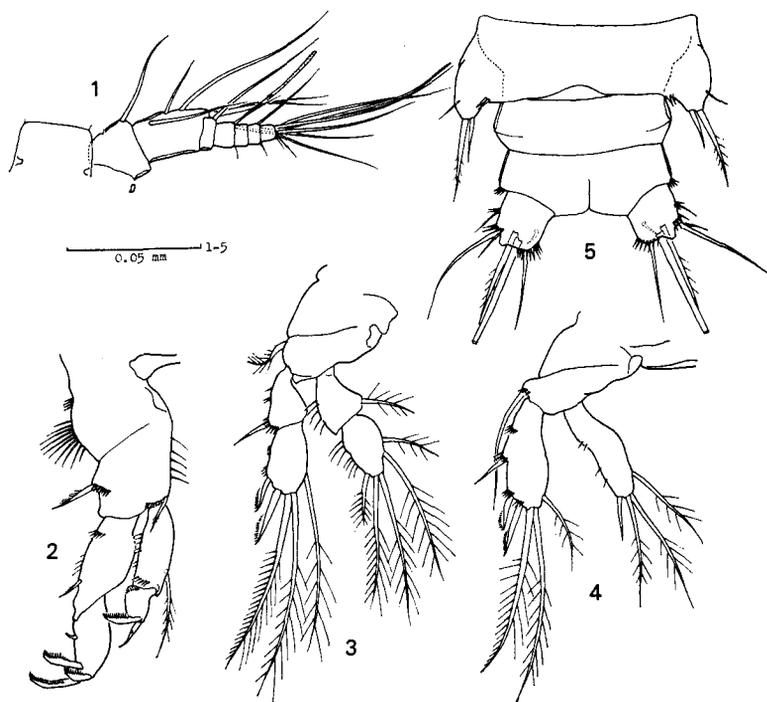


Fig. 3. *Zaus robustus*. The second copepodid stage. Female. 1. rostrum and antennule; 2. leg 1; 3. leg 2; 4. leg 3; 5. leg 4 and abdomen, ventral.

flexible spinules along inner margin; one inner seta differentiated. Both rami two-segmented. Exopodite almost same as long as basal two segments combined; first segment ending in an apically narrowed membranous formation, more than twice as long as wide, ornamented with a transverse spinular row subproximally, some slender spinules on middle part of outer margin and one somewhat spinulose outer seta at a point two-thirds the length; a short length of proximal part fairly narrowed especially at inner side. Second exopodite segment a little shorter than preceding one and furnished with three serrate claws distally or subdistally and one small seta on subproximal outer edge. Endopodite reaching distal end of first exopodite segment, fairly thinner than exopodite; first segment about three times as long as second, ornamented with some spinules along outer margin, a transverse spinular row on anterior side near distal end, and one hairy inner seta arising from a point two-thirds the length; second one protruded at inner proximal corner, ornamented with a row of some very delicate spinules on anterior side near outer proximal corner, one serrate claw and one midst geniculate spine on distal end. *Leg 2* (Fig. 3-3). Coxa unornamented. Outer seta of basis somewhat elongated. Both rami two-segmented. Exopodite almost as long as endopodite; first segment remarkably narrowed proximally, ornamented with some spinules on outer margin and near base of one bare outer spine; second one slightly longer than preceding one, elongate oval in outline, ornamented with two groups of spinules along outer margin, two serrate outer spines subdistally, one elongate spine and one seta, which is spinulose along outer margin and hairy along inner margin, on distal end and one hairy inner seta at a point two-thirds the length. First endopodite segment widened distally, furnished with one short hairy inner seta. Second endopodite segment almost as long as preceding one, oval in outline, with a notch at middle outer edge, and furnished with one spinulose outer spine subdistally, two hairy terminal setae, outer one of which is spinulose along outer margin, and two inner setae. Outer margins of endopodite segments sparsely spinulose. *Leg 3* (Fig. 3-4). Distal border of coxa strikingly inclined. Outer seta of basis elongate, reaching distal end of exopodite segment. Both rami one-segmented, of an equal length. Exopodite somewhat narrowed proximally, more than twice as long as greatest width, ornamented with a spinular row at a fourth the length of outer edge, one bare outer spine at middle edge, two serrate outer spines subdistally, one elongate spine and one hairy seta on distal end, and one rather small inner seta subdistally; all outer spines accompanied with several spinules basally; a small notch at middle inner edge. Endopodite slender, more than three times as long as greatest width, furnished with one outer spine subdistally, two terminal setae and one inner seta arising from a point three-fourths the length. *Leg 4* (Fig. 3-5) almost as in leg 3 in preceding stage.

Male. Body (Fig. 1-5) fairly flattened rather than that in female, about 0.29 mm long. Both lateral margins of cephalothorax entirely parallel to each other. Otherwise as in female.

1-3. *The third copepodid stage.* Female. Body (Fig. 1-3) consisting of

seven somites, about 0.31 mm long. Cephalothorax much more widened, 0.25 mm in greatest width, tapering anteriorly, and ornamented with a few delicate hairs marginally. Succeeding somites tapering posteriorly. Pleurotergites of second and third somites fairly expanded at lateral parts, and that of fourth somite differentiated. Sixth somite short and unornamented. Last somite differentiated. Last somite and furcal rami ornamented as in preceding stage. *Antennule* (Fig. 4-1) seven-segmented; first segment somewhat spinulose anteriorly; second one extremely elongated, more longer than apical five segments combined, and with at least two dorsal setae. *Leg 1* (Fig. 4-2). Coxa and basis ornamented as in preceding stage. Exopodite fairly lengthened; inner edge of first segment clearly protruded. *Leg 2* (Fig. 4-3). Coxa ornamented with some spinules on outer edge. Exopodite; first segment still lacking in inner seta; one serrate outer spine and one hairy inner seta added to second segment. Endopodite; outer end

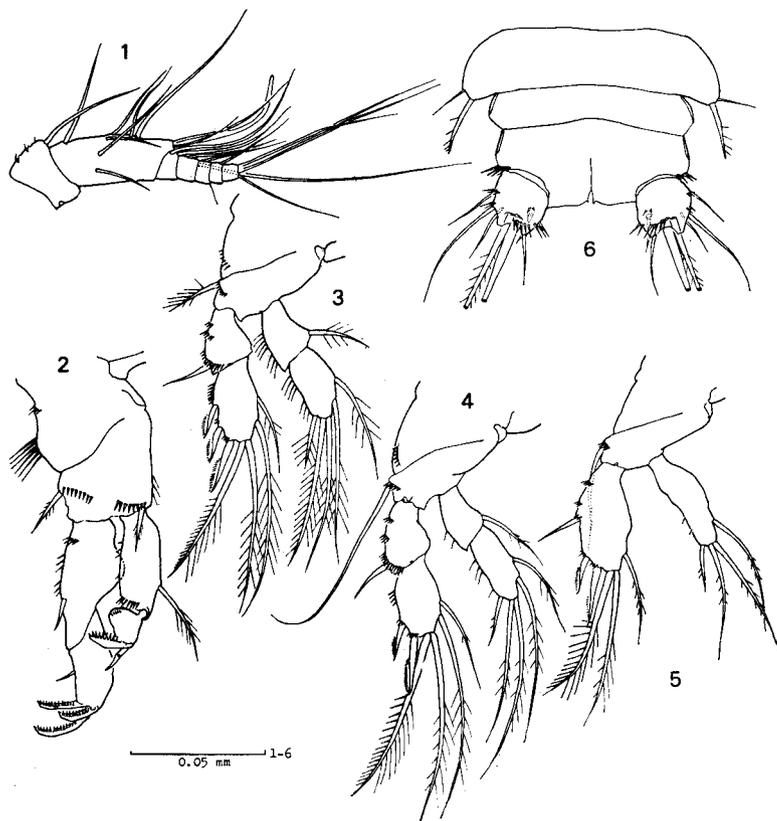


Fig. 4. *Zaus robustus*. The third copepodid stage. Female. 1. antennule; 2. leg 1; 3. leg 2; 4. leg 3; 5. leg 4; 6. leg 5 and abdomen, ventral.

of first segment pointed; second one somewhat elongated. *Leg 3* (Fig. 4-4). Coxa ornamented with some spinules near outer margin. Outer seta of basis extremely elongated, extending beyond distal end of last exopodite segment. Both rami two-segmented. Exopodite ornamented almost as in leg 2, except for distal segment with two outer spines instead of three. Endopodite rather slender and less spinulose along outer edges; all setae sparsely hairy; otherwise as in leg 2. *Leg 4* (Fig. 4-5). Coxa unornamented. Outer seta of basis not extending beyond distal end of exopodite segment. Both rami one-segmented, and fairly alike to those in leg 3 in preceding stage; exopodite almost twice as long as greatest width. *Leg 5* (Fig. 4-6) represented by one spinulose seta and one bare setula on each lateral hind corner of sixth somite.

Male. Body (Fig. 1-6) about 0.32 mm long. Both lateral edges of cephalothorax almost parallel to each other. Cephalothorax and succeeding two or three somites thinner than those of female. Otherwise as in female.

1-4. *The fourth copepodid stage. Female*. Body (Fig. 5-1) consisting of eight somites, about 0.42 mm long. Rostrum (Fig. 6-1) as in figure. Cephalothorax further more widened, and still tapering anteriorly. Sixth and seventh somites short and unornamented. Last somite and furcal rami ornamented as in preceding stage. *Antennule* (Fig. 6-1) eight-segmented; second and third segments derived from second segment in preceding stage; second segment with dorsal setae; third one about 1.5 times as long as second. *Leg 1* (Fig. 6-2). Coxa as in preceding stage. Basis ornamented with an oblique row of some spinules on anterior side near inner proximal corner. Both rami ornamented as in preceding stage. *Leg 2* (Fig. 6-3). Outer seta of basis fairly developed. Spur-shaped process on distal edge of basis prominent. Both rami still two-segmented. One small inner seta on first exopodite segment differentiated. One additional inner seta arising from a point a third the length of second exopodite segment. Second endopodite segment bearing one additional seta at a point a third the length of inner margin. *Leg 3* (Fig. 6-4). Coxa and basis almost as in preceding stage. Inner seta of first exopodite segment differentiated. One serrate outer spine and two hairy inner setae added onto second exopodite segment. Second endopodite segment tapering distally, and two setae added to proximal half of inner edge. *Leg 4* (Fig. 6-5). Outer seta of basis not so elongated. Both rami two-segmented, ornamented with almost as in leg 3, except for size, absence of inner seta of first exopodite segment and presence of three inner setae instead of four on second endopodite segment. *Leg 5* (Fig. 6-6). Baseoendopodites not defined from each other. Inner expansion represented by a small protuberance ending in two close bare setae. Exopodite indistinctly bordered basally, somewhat longer than wide, furnished with five setae in all; outermost seta elongate and entirely bare.

Male. Body (Fig. 5-3) almost as long as female, but fairly thinned particularly in apical four somites. Both lateral edges of cephalothorax moderately rounded. *Antennule* (Fig. 7-1) eight-segmented; third segment not so longer than second

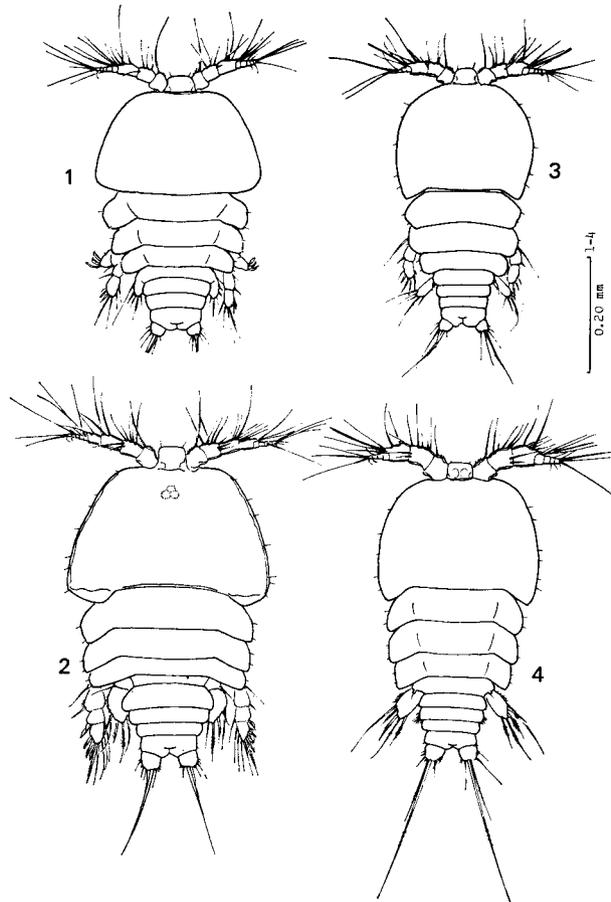


Fig. 5. *Zaus robustus*. Female. 1. fourth copepod; 2. fifth cop. Male. 3. fourth cop.; 4. fifth cop.

rather than in female. First four pairs of *thoracic legs* as in female. *Leg 5* (Fig. 7-2). Inner expansion of baseoendopodite absent. Exopodite fairly longer than wide, furnished with five setae in all.

1-5. *The fifth copepodid stage. Female.* Body (Fig. 5-2) consisting of nine somites, about 0.52 mm long. Rostrum (Fig. 8-1) ornamented with two pairs of sensillae. Cephalothorax more than 1.5 times as wide as long, almost trapezoid in dorsal view. Fifth somite remarkably smaller than preceding somite and also succeeding one. Sixth and seventh somites (Fig. 9-2) clearly bordered dorsally, but ventral border between them not so distinct; both unornamented. Posterior four somites gradually tapering behind. Ventral posterior edge of last somite

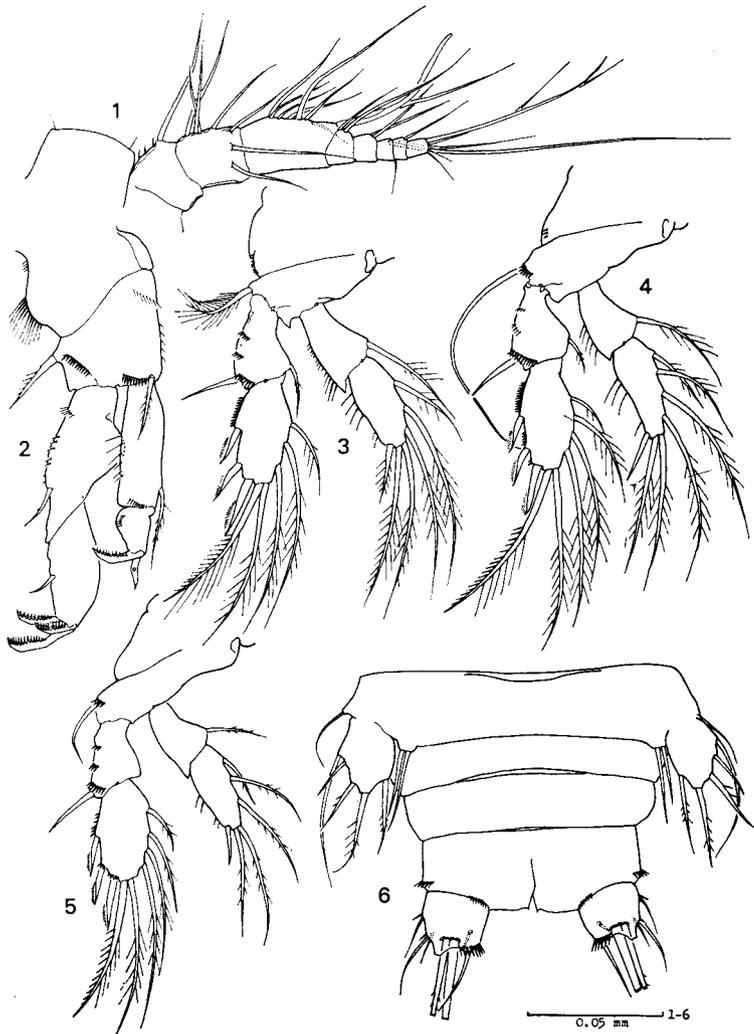


Fig. 6. *Zaus robustus*. The fourth copepodid stage. Female. 1. rostrum and antennule; 2. leg 1; 3. leg 2; 4. leg 3; 5. leg 4; 6. leg 5 and abdomen, ventral.

ornamented with some spinules. *Antennule* (Fig. 8-1) nine-segmented; third and fourth segments derived from third segment in preceding stage. *Leg 1* (Fig. 8-2). Coxa and basis almost as in adult. Both rami three-segmented, separation of distal two segments not so clear. Exopodite; outer seta of first segment apparently spinulose; second segment furnished with one small outer seta subdistally and one bare setula on inner distal end; third one as long as wide,

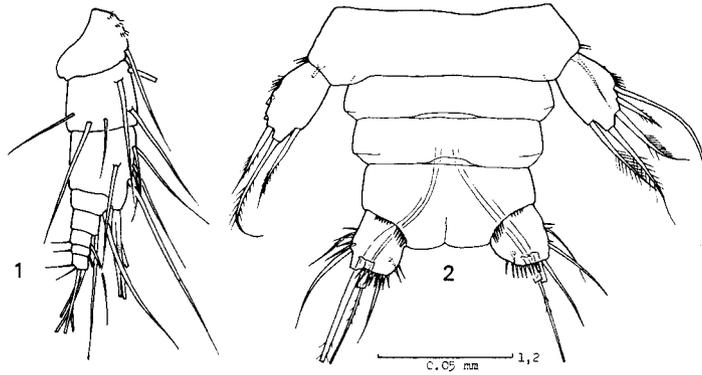


Fig. 7. *Zaus robustus*. The fourth copepodid stage. Male. 1. antennule; 2. leg 5 and abdomen, ventral.

furnished with four serrate claws and one setula. Endopodite; second segment ornamented with a vertical spinular row near outer margin; third one somewhat longer than preceding and furnished with one serrate claw and one midst geniculate spine. *Leg 2* (Fig. 8-3), *leg 3* (Fig. 8-4) and *leg 4* (Fig. 9-1). Both rami three-segmented. Setal and spinal numbers of all segments entirely same as in adult. Each outer distal corner of first two endopodite segments remarkably pointed. Outer seta of basis in leg 3 far exceeding beyond second exopodite segment. Distal end of last endopodite segment in leg 4 reaching mid way of last exopodite segment. *Leg 5* (Fig. 9-2). Both baseoendopodites confluent to each other; each inner expansion area furnished with two short setae and two close elongate setae, all entirely bare; outer seta arising from dorsal side. Distal end of exopodite reaching posterior end of seventh somite. Exopodite directing posteriorly, furnished with five setae in all.

Male. Body (Fig. 5-4) somewhat smaller and narrower than female. Sixth somite (Fig. 9-4) ornamented with some spinules laterally. *Antennule* (Fig. 9-3) eight-segmented as in preceding stage; second and third segments fairly thickened. First four pairs of *thoracic legs* as in female. *Leg 5* (Fig. 9-4). Both legs divergent. Exopodite spinulose along both lateral edges, and furnished with five setae in all. *Leg 6* not yet differentiated.

1-6. *Remarks*. The morphology of the last copepodid stage (adult) was already described fully by Itô (1974). In the first three copepodid stages, each sex is determinable based upon the shape of cephalothorax, though no structural difference in appendages occurs between sexes. The antennular differentiation through the six copepodid stages in the present species principally accords with those of *Tigriopus japonicus* Mori (Itô, 1970) and *Harpacticus uniremis* Kröyer (Itô, 1971).

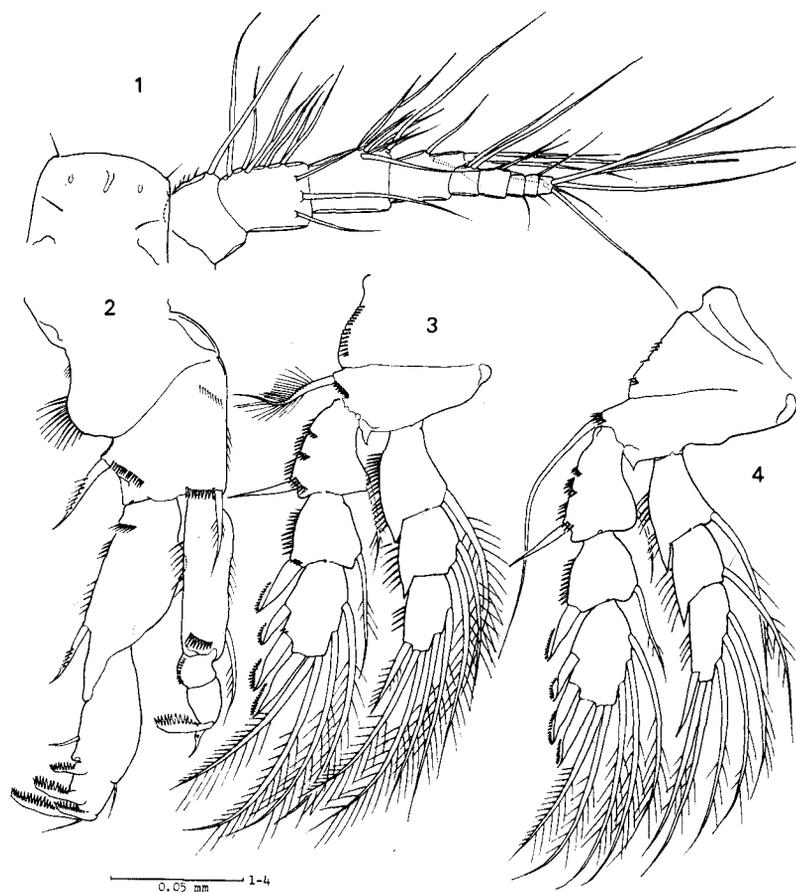


Fig. 8. *Zaus robustus*. The fifth copepodid stage. Female. 1. rostrum and antennule; 2. leg 1; 3. leg 2; 4. leg 3.

2. *Paratigriopus hoshidei* Itô

Since the present species lives commensal with barnacles as it was previously described (Itô, 1969), no individual has been so far found outside barnacles. During warmer months in Oshoro, ovigerous females are occasionally found inside the barnacle shells. Younger copepodids found, however, are remarkably fewer than adults. More younger ones before the fourth copepodid stage and nauplius larvae have not been hitherto collected. Further, an attempt to culture the individuals isolated from the host animal has been unsuccessful though they have been kept in alive without any breeding or development at least several days.

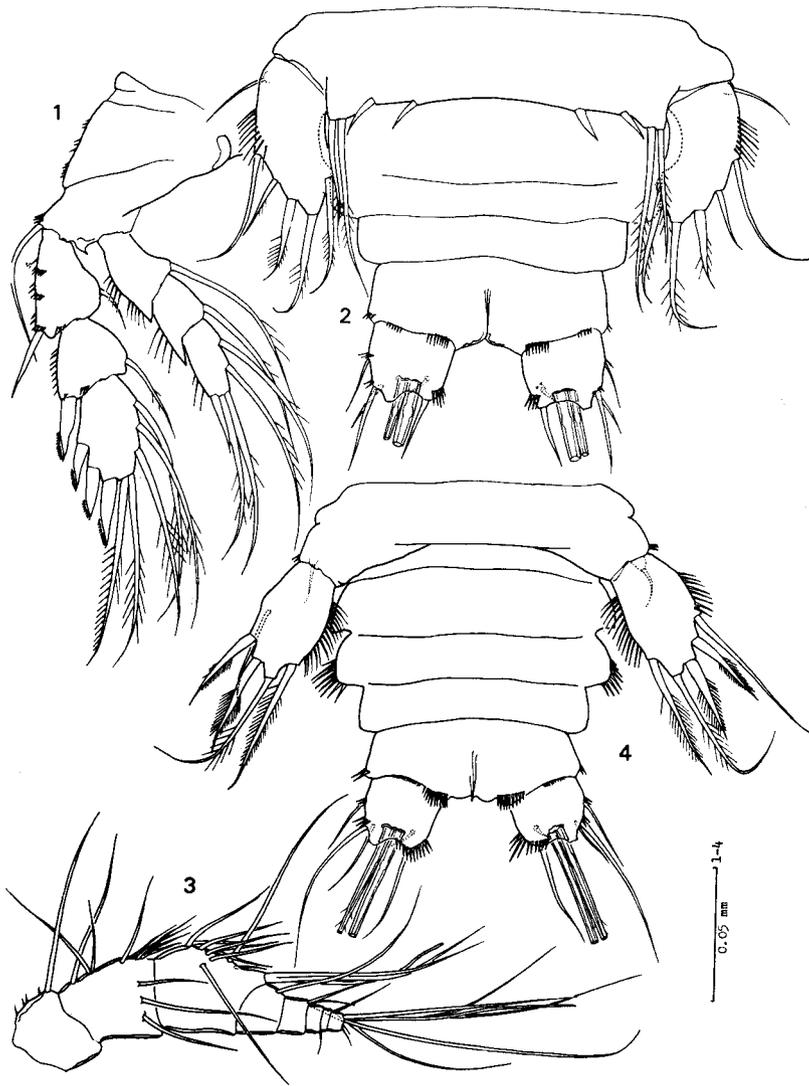


Fig. 9. *Zaus robustus*. The fifth copepodid stage. Female. 1. leg 4; 2. leg 5 and abdomen, ventral. Male. 3. antennule; 4. leg 5 and abdomen, ventral.

Only two developmental stages presumable as the fourth and fifth copepodids are now available and will be described, based upon the specimens collected from Oshoro (29-VIII-'72, 3-X-'72).

2-1. *The fourth copepodid stage. Female.* Body (Fig. 10-1) consisting of

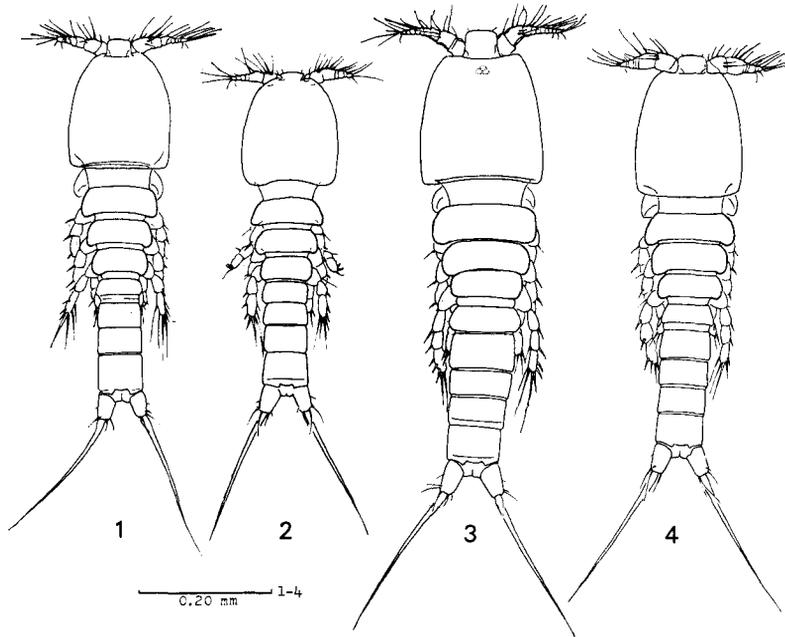


Fig. 10. *Paratigriopus hoshidei*. 1. fourth copepodid female; 2. fourth cop. male; 3. fifth cop. female; 4. fifth cop. male.

eight somites, about 0.54 mm long. Rostrum well recognized in dorsal aspect. Cephalothorax fairly depressed dorso-ventrally, 0.15 mm wide, somewhat longer than wide, and tapering anteriorly. Thorax tapering behind. Pleurotergites of second, third and fourth somites well differentiated. Sixth and seventh somites (Fig. 12-1) unornamented. Last somite about twice as long as preceding somite, ornamented with two transverse rows of some delicate spinules on ventral side near posterior end, and some spinules along base of furcal rami. Furcal ramus somewhat longer than wide, tapering distally, ornamented as in adult. *Antennule* (Fig. 11-1) nine-segmented; aesthetasc on fourth segment not so thickened. *Leg 1* (Fig. 11-2). Coxa and basis fairly alike to those in adult. Both rami two-segmented. First exopodite segment much longer than second, ornamented almost as in corresponding segment in adult. First endopodite segment ornamented with some spinules along both margins, and a transverse spinular row on anterior side near distal end; inner seta arising from a point three-fourths the length. Second endopodite segment ornamented with two short rows of some delicate spinules on outer edge, one arched claw and one geniculate spine on distal end. *Leg 2* (Fig. 11-3). Coxa and basis almost same as in adult. Both rami two-segmented. First exopodite segment furnished with one outer spine and one inner seta; second segment about 1.5 times as long as preceding one, furnished

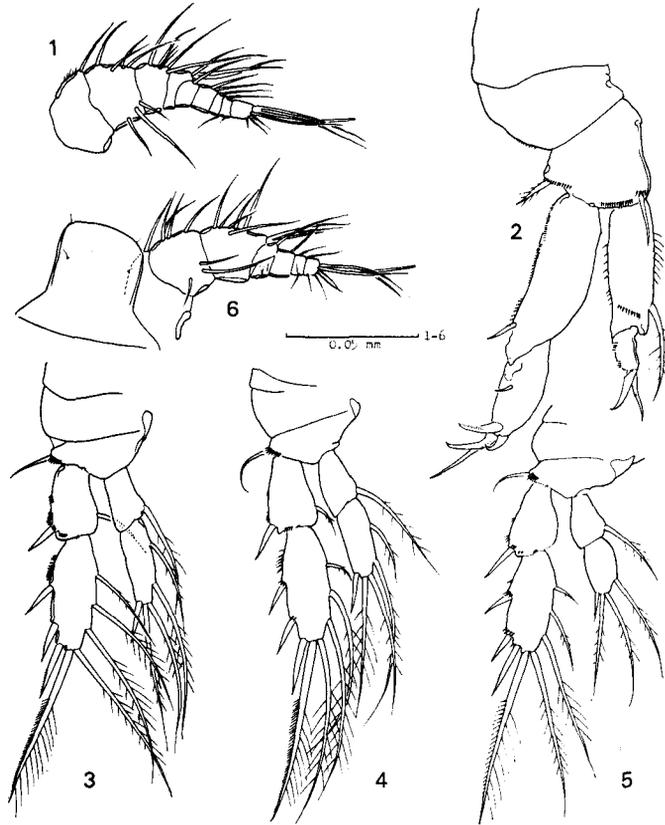


Fig. 11. *Paratigriopus hoshidei*. The fourth copepodid stage. Female. 1. antennule; 2. leg 1; 3. leg 2; 4. leg 3; 5. leg 4. Male. 6. rostrum and antennule.

with three outer spines, one elongate spine and one hairy seta on distal end, and three inner setae. Distal end of endopodite segment reaching a mid way of second exopodite segment; first endopodite segment furnished with one inner seta; second one 1.4 times as long as first one, furnished with one spiniform seta on outer subdistal ledge, two terminal setae and two widely separate inner setae. *Leg 3* (Fig. 11-4). Segmentation and ornamentation almost same as in leg 2, but some setae rather shortened. *Leg 4* (Fig. 11-5). Coxa and basis as in leg 3. First endopodite segment lacking in inner seta. Distal end of endopodite segment not reaching middle of second exopodite segment. Second endopodite segment oval in outline, as long as first segment, and furnished with one spiniform outer seta subdistally, two sparsely hairy setae terminally, and one inner seta at a point three-fourths the length. Otherwise as in leg 3. *Leg 5* (Fig. 12-1). Inner expansion

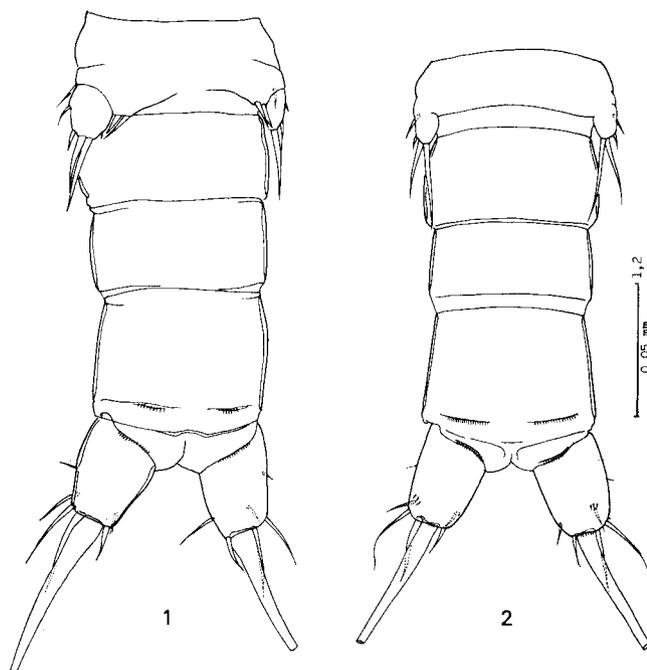


Fig. 12. *Paratigriopus hoshidei*. The fourth copepodid stage. Female. 1. leg 5 and abdomen, ventral. Male. 2. leg 5 and abdomen, ventral.

somewhat developed, terminating in two short spiniform setae. Exopodite rather round in outline, furnished with two terminal setae and two small setae outwards on outer edge; innermost seta longest, reaching posterior end of sixth somite.

Male. Body (Fig. 10-2) about 0.5 mm long, consisting of eight somites as in female. Abdominal somites (Fig. 12-2) somewhat slenderer rather than those in female; last somite widened posteriorly. Rostrum (Fig. 11-6) as shown in figure. *Antennule* (Fig. 11-6) probably seven-segmented (in fourth and sixth segments an indistinct trace of subdivision is recognizable); first three segments scarcely tapering apically; third one furnished with a rather short aesthetasc. *Leg 1*, *leg 2*, *leg 3* and *leg 4* ornamented as in female. *Leg 5* (Fig. 12-2). A pair of baseopodite segments represented by a narrow common plate, not defined at base. Exopodite small, furnished with two setae on distal end and one setula on outer edge.

2-2. *The fifth copepodid stage. Female*. Body (Fig. 10-3) consisting of nine somites, about 0.62 mm long. Rostrum (Fig. 13-1) as shown in figure. Abdomen somewhat tapering behind. Sixth, seventh and eighth somites unornamented. Last somite and furcal rami ornamented as in preceding stage. Genital doublesomite



Fig. 13. *Paratigriopus hoshidei*. The fifth copepodid stage. Female. 1. rostrum and antennule; 2. leg 1; 3. leg 2; 4. leg 3; 5. leg 4. Male. 6. rostrum and antennule; 7. leg 2.

not yet formed. *Antennule* (Fig. 13-1) nine-segmented, very much alike to that in adult. *Leg 1* (Fig. 13-2), *leg 2* (Fig. 13-3), *leg 3* (Fig. 13-4) and *leg 4* (Fig. 13-5). Segmentation and ornamentation same as in adult. *Leg 5* (Fig. 14-1). Distal end of inner expansion of baseoendopodite segment not extending beyond

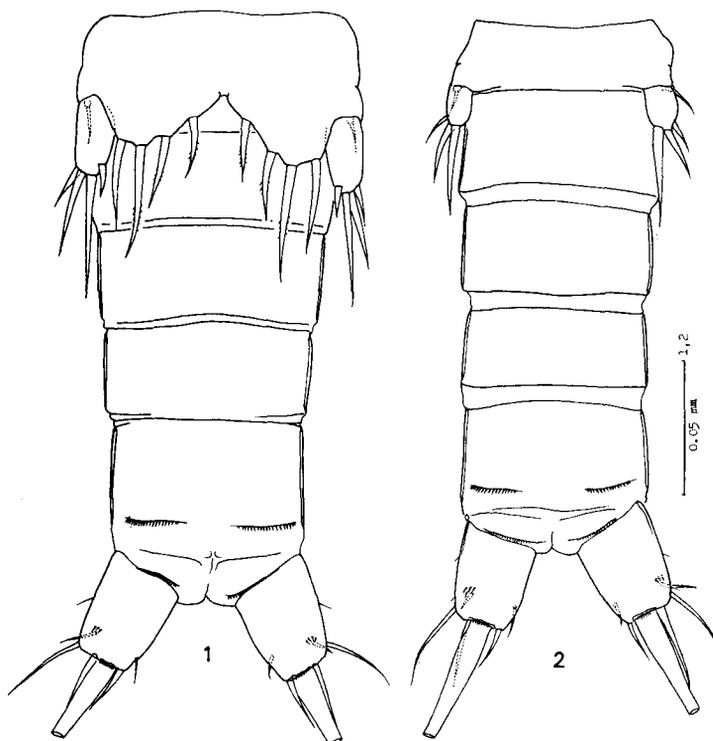


Fig. 14. *Paratigriopus hoshidei*. The fifth copepodid stage. Female. 1. leg 5 and abdomen, ventral. Male. 2. leg 5 and abdomen, ventral.

middle of exopodite segment. Outer seta of baseoendopodite arising from a small protuberance near dorsal base of exopodite segment. Four thick setae along inner expansion. Exopodite much longer than wide, furnished with four setae in all.

Male. Body (Fig. 10-4) about 0.6 mm long. Rostrum (Fig. 13-6) as shown in figure. Abdomen (Fig. 14-2) not tapering behind. Sixth, seventh and eighth somites unornamented. *Antennule* (Fig. 13-6) eight-segmented; first three segments much thickened; fourth and fifth ones thickened, but fairly shortened; sixth one somewhat elongated, almost as long as apical two segments combined. *Leg 1*, *leg 2* (Fig. 13-7), *leg 3* and *leg 4* entirely same as in female. Endopodite of leg 2 without any trace of transformation. *Leg 5* (Fig. 14-2). Baseoendopodite segment not defined at base, with one short outer seta. Exopodite small, somewhat longer than wide, furnished with three setae in all. *Leg 6* not yet differentiated.

2-3. *Biological observation*. This species is found inside the shells of *Cthamalus challenger* Hoek all the year round in Oshoro, and not small populations are maintained even in winter.

A single egg sac is fairly depressed dorso-ventrally, and contains from seven to nine eggs. The eggs are blue in color in those presumably as ones recently produced and rather reddish in those fairly developed. The breeding period represented by the presence of ovigerous females lasts some warmer months in Oshoro. Two examples for the population composition in the breeding season are given in Table 1.

Table 1. Population composition of *Paratigriopus hoshidei* collected from 200 individuals of barnacles in each sampling time in Oshoro.

	29-VIII-'72	3-X-'72
adult female, ovigerous	5	27
non-ovigerous	3	48
adult male	6	27
fourth and fifth copepodids	3	11
Total	17	113

While a number of samples were examined under a binocular microscope, they were easily detectable since they actively crept out the inside of barnacle shells removed from the substrata. They usually showed clear positive phototaxis in behavior. Through all the examinations, neither pairing nor copulation was detected.

2-4. *Remarks.* The fact that neither nauplius stage nor any younger copepodid before the fourth copepodid stage was found inside barnacles is fairly noteworthy. It is probably not impossible that these young develop outside barnacles. Each stage of the copepodid described was established having regard to the similarity of segmentation and ornamentation of appendages to those of the other genera of the family Harpacticidae previously mentioned in this paper and reported by several authors (Fraser, 1936; Pugliesi, 1914; Itô, 1970, 1971). Omission of any copepodid stage may be doubtful.

3. Discussion

The most essential difference in the developmental stages between the two species examined would be the antennular differentiation. The antennular proximal part (from the basalmost segment to the aesthetasc-bearing one) in the fourth copepodids of both sexes in *Zaus rubustus* consists of three segments as in *Tigriopus japonicus* and *Harpacticus uniremis* reported by Itô (1970, 1971). In the fourth copepodid stage of *Paratigriopus hoshidei*, however, the corresponding part is four-segmented in the female and three-segmented in the male. In this connection, the antennular proximal part of the third copepodid stage of *Harpacticus gracilis* Claus consists of three segments (Pugliesi, 1914), whereas

the corresponding part of the same stage is two-segmented in *Zaus robustus*, *Tigriopus japonicus* and *Harpacticus uniremis*. When the fact that their antennules in the adult females in these species are entirely identical with each other in the segmentation is considered, the significance of such discrepancy in the developmental stages becomes apparent. Most characters, some of which have been disregarded for the value or misconceived for the true taxonomic significance, not only specific but also generic, must be re-evaluated after critical examinations of the differentiation process through all the developmental stages in each the species, because further presence of other characters of such specific difference is presumable within the family.

Summary

1. The first five copepodid stages of *Zaus robustus* Itô were described. Clear sexual dimorphism in the body shape was detected even in the first copepodid stage.

2. The fourth and fifth copepodid stages of *Paratigriopus hoshidei* Itô were described. The antennular proximal part of the fourth copepodid female consists of four segments, whereas the corresponding part of *Zaus robustus* is three-segmented.

References

- Fraser, J.H. 1936. The occurrence, ecology and life history of *Tigriopus fulvus* (Fischer). *J. mar. biol. Ass. U.K.* **20**: 523-536.
- Itô, T. 1969. Descriptions and records of marine harpacticoid copepods from Hokkaido, II. *J. Fac. Sci. Hokkaido Univ. Ser. 6*, **17**: 58-77.
- 1970. The biology of a harpacticoid copepod, *Tigriopus japonicus* Mori. *Ibid.* **17**: 474-500, pl. 7-8.
- 1971. The biology of a harpacticoid copepod, *Harpacticus uniremis* Kröyer. *Ibid.* **18**: 235-255, pl. 11.
- 1974. Descriptions and records of marine harpacticoid copepods from Hokkaido, V. *Ibid.* **19**: 546-640.
- Pugliesi, E. 1914. Sullo sviluppo larvale di *Harpacticus gracilis* Cls. *Atti Acc. Ven. Trent.* **7**: 81-95.
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