

**On the Development of Parasitic Copepoda. IV. Ten Species
of Poecilostome Cyclopoids, Belonging to Taeniacanthidae,
Tegobomolochidae, Lichomolgidae, Philoblennidae,
Mycolidae, and Chondracanthidae**

By

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With Text-figures 1-49 and Tables 1-13

As the fourth report from my serial works on the development of parasitic Copepoda (see Izawa, 1973, 1975, 1986), this paper describes developmental stages of following 10 species of the poecilostome Cyclopoida as follows: 1) *Anchistrotos pleuronichthydis* Yamaguti, 1939 (Taeniacanthidae Wilson, 1911); 2) *Tegobomolochus nasicola* Izawa, 1967 (Tegobomolochidae Avdeev, 1978); 3) *Doridicola sepiae* (Izawa, 1976) and 4) *Nasomolgus firmus* Humes & Ho, 1967 (Lichomolgidae Kossmann, 1877); 5) *Philoblenna arabici* Izawa, 1976 (Philoblennidae Izawa, 1976); 6) *Neanthessius renicolis* Izawa, 1976 and 7) *Panaietis yamagutii* Izawa, 1976 (Mycolidae Yamaguti, 1936); 8) *Pseudacanthocanthopsis apogonis* Yamaguti & Yamasu, 1959; 9) *Prae-cidochondria setoensis* Izawa, 1975 and 10) *Acanthochondria yui* Shiino, 1964 (Chondracanthidae Milne Edwards, 1840).

Methods of Rearing Larvae

All the rearing larvae was carried out at the Seto Marine Biological Laboratory, Kyoto University, during my stay of April 1971-March 1972, excepting that of *Panaietis yamagutii* which was carried out in my laboratory of Mie University in September-October 1975. Each of egg sacs removed from the females was reared in a glass bowl with sea water filtered through cotton. The bowls were kept in a water bath filled with running sea water at water temperature ranging 16-26°C with seasons. Neither aeration nor circulation of the water was made, but the water was renewed two or three times a day. No consideration for the food supply was made usually, except for some cases in which unidentified unicellular green algae were fed.

The larvae reared and copepodites collected from hosts were fixed with formalin and preserved in alcohol. The preserved specimens, and exuviae as occasion demands, were measured and examined in lactic acid by using the wooden slide of Humes & Gooding, in some case being stained with Chlorazol Black E. Drawing and measurements were made respectively by using Abbe's drawing apparatus and ocular micrometer.

1. *Anchistrotos pleuronichthydis* Yamaguti, 1939

(Figs 1-14)

Material. Egg strings from 4 ovigerous females obtained from a flounder, *Pseudorhombus cinnamomeus* (Temminck & Schlegel) collected in Tanabe Bay, Wakayama Prefecture, on the Pacific coast of the middle Japan in April 1971, were used for rearing nauplii. In addition to these females, copepodites studied here were obtained from 2 species of flounder, *Kareius bicoloratus* (Basilewsky) and *Limanda yokohamae* (Gunther) fished in Ise Bay, Mie Prefecture, on the Pacific coast of the middle Japan, in Oct. 1971.

Eggs are about 80 μm in diameter. They gradually become translucent as they draw near hatching. Hatched nauplii moulted into the second nauplius stage within one day at 16-17°C, but no further moult occurred. No pigment spots appeared during these stages. Body length is shown in Fig. 1. The sexes are distinguishable at the fourth copepodid stage by body length and dimorphism of maxillipeds. Later copepodites including adults are found on the body surface of hosts, while the early copepodites are mostly found on the inner walls of the branchial cavity and the gill filaments.

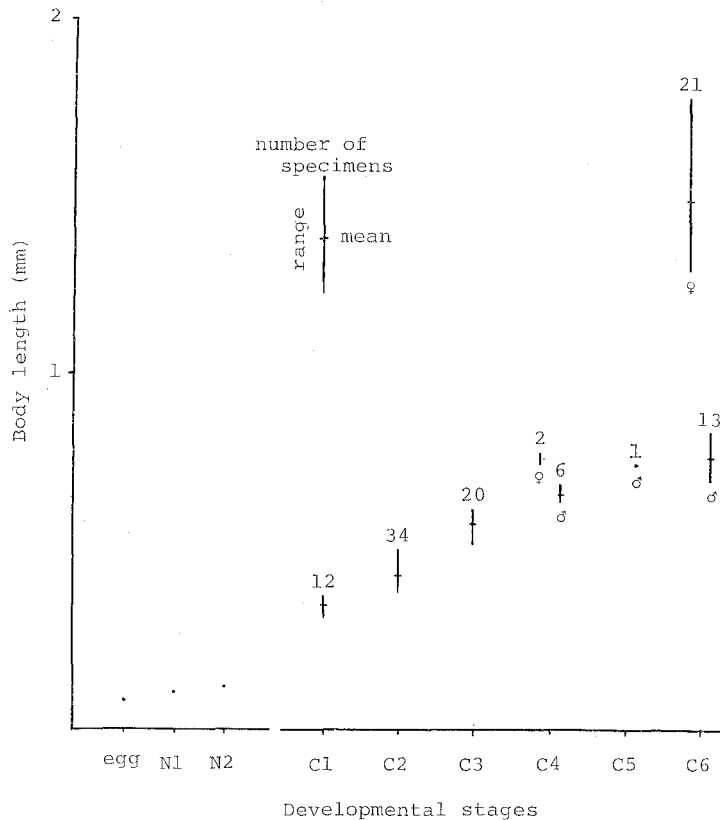


Fig. 1. Growth in body length excluding caudal rami of *Anchistrotos pleuronichthydis* Yamaguti. Abbreviations: N1-2, nauplius stage 1-2; C1-6, copepodite stage 1-6.

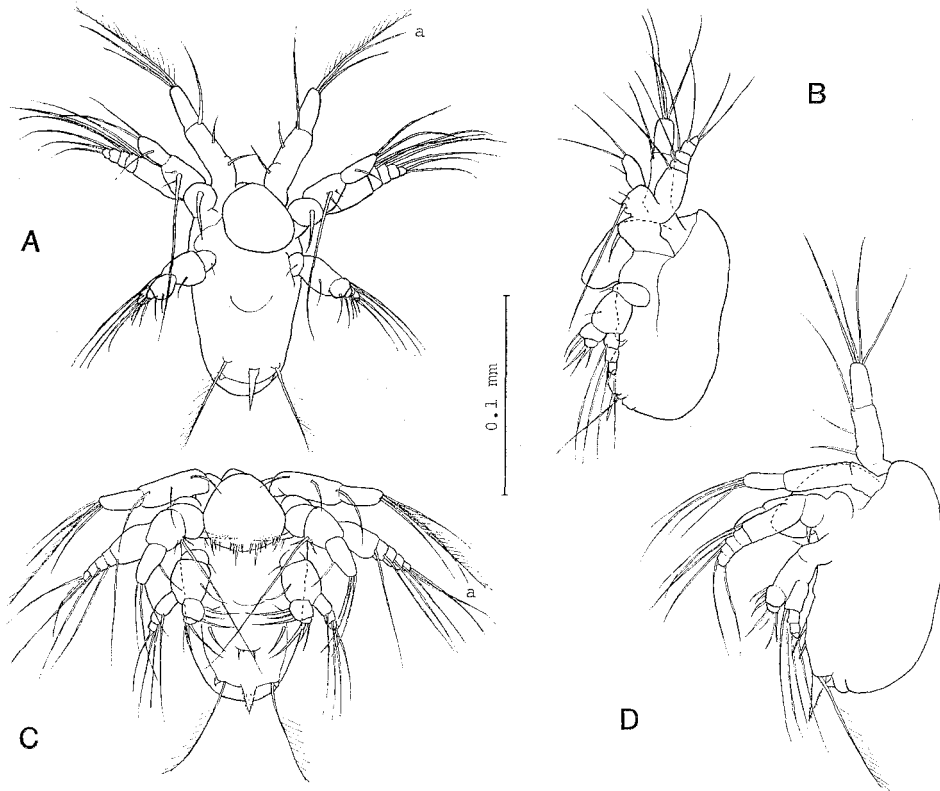


Fig. 2. First two nauplii of *Anchistrotos pleuronichthydis* Yamaguti. A, B. First nauplius, ventral and lateral; C, D. Second nauplius, ventral and lateral.

First Nauplius Stage (Fig. 2A, B).

Body length $104\ \mu\text{m}$ and width $56\ \mu\text{m}$ on an average. Body slim; furcal armature consisting of a median process, a pair of hairy setae and small ridges of lamellar denticles. Labrum usual, but naked. Labium represented as a slight bulge of the sternal surface, naked.

First antenna ca. $56\ \mu\text{m}$ long excluding setae and 3-segmented; the first indistinctly separated from the second, short and naked; the second long, with 3 simple setae on the ventral margin, each placed basally, medially and terminally, of which the basal and middle setae relatively short; the third about one third of the appendage in length, ending in a hairy seta accompanied at the base with a seta-like aesthete and a simple seta. *Second antenna* ca. $60\ \mu\text{m}$ long excluding setae; segments more or less flattened. Coxa short, with a stout spine on the medial expansion. Basis as long as coxa, furnished with a long and 2 short spines on the rounded medial margin, the long spine attaining to about $74\ \mu\text{m}$. Endopodite 1-segmented, somewhat smaller than first exopodite segment, with a spine at the middle of the medial margin and tipped by 2 setae. Exopodite longer than protopodite, 5-segmented; the first longer than distal 4 segments combined together; each segment with a

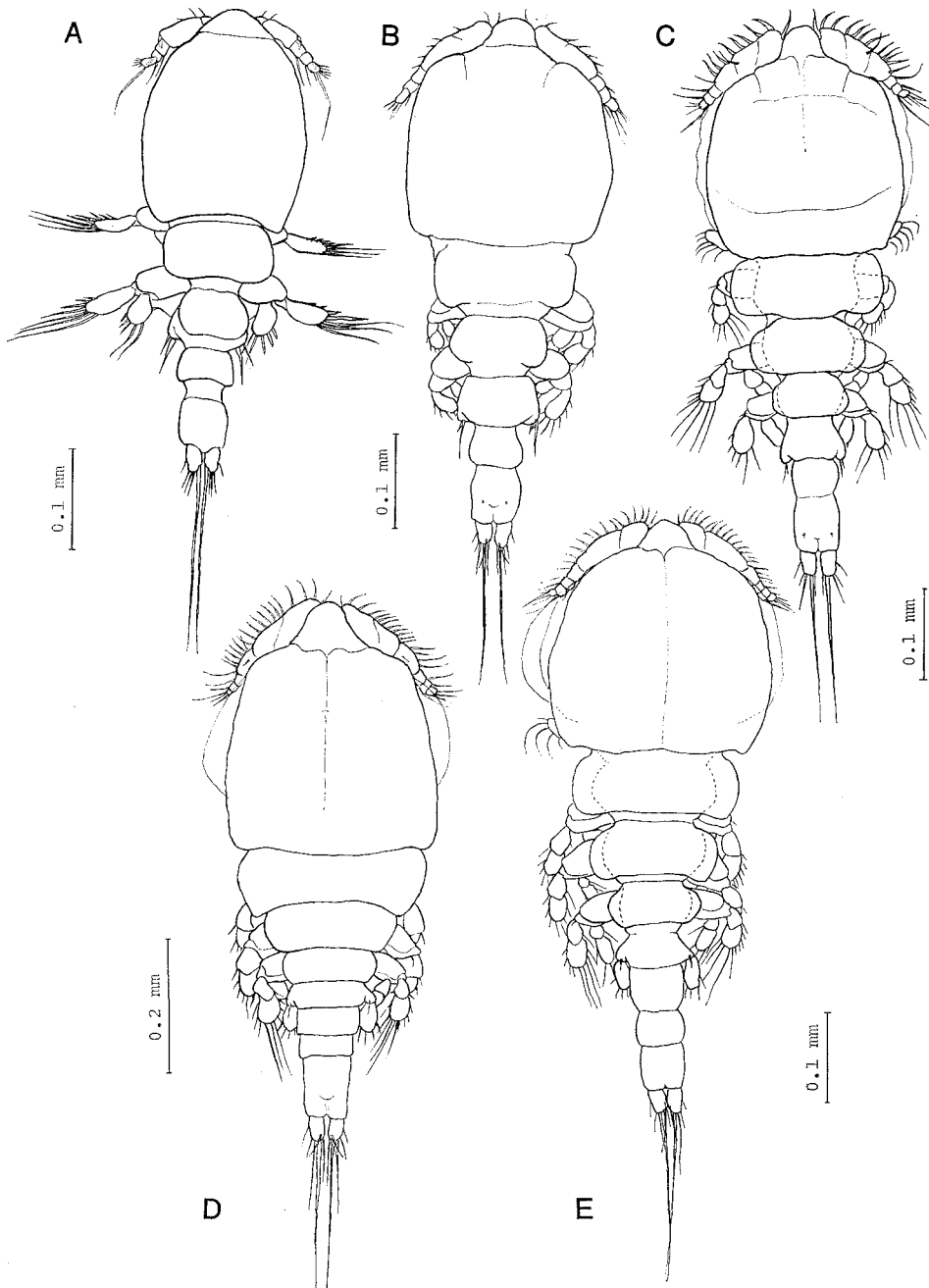


Fig. 3. Copepodites of *Anchiistrotois pleuronichthydis* Yamaguti, dorsal view. A. First copepodite; B. Second copepodite; C. Third copepodite; D. Fourth copepodite, female; E. Fourth copepodite, male.

plumose seta at the medio-distal corner, only the terminal segment additionally with a simple seta at the dorso-distal corner. *Mandible* ca. 43 μm long excluding setae, flattened. Coxa short, with a small spine on the medial margin. Basis very broad, but yet slightly longer than wide, with a spine on the medial margin. Endopodite stumpy, 2-segmented; the first expanded medially and about 2 times as wide as long, with 2 spines on the medial margin; the second small, with a spine and 2 setae. Exopodite narrow, 4-segmented; each segment furnished with a plumose seta at the medio-distal corner in proximal 3 but at the tip in the terminal segment.

Second Nauplius Stage (Fig. 2C, D).

Body length 117 μm and width 60 μm on an average. Body ornamented with 2 thin and 2 minute spinules arranged on an indistinct transverse ridge of the sternal surface of the posterior portion; rudimentary first maxillae emerged as a pair of spines on the ventral side posterior to labium; furcal armature as in the preceding stage, but a median process spinulate in this stage. Labrum with ca. 14 unequal spinules arranged symmetrically in 4 groups along the distal free margin.

First antenna ca. 58 μm long excluding setae, with an addition of a simple seta

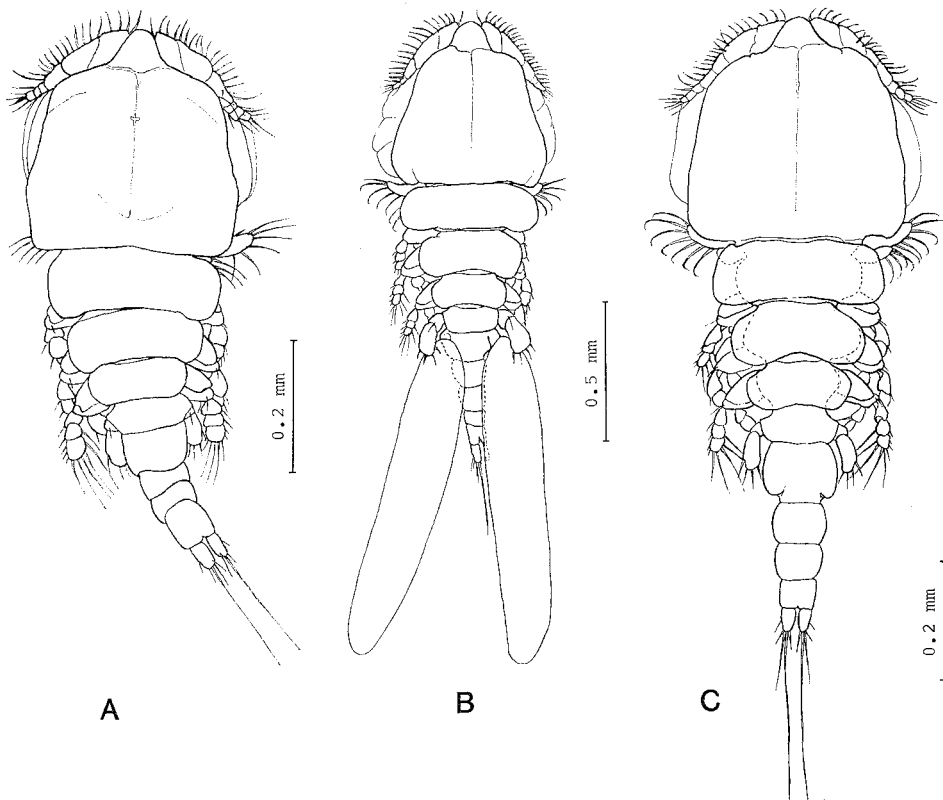


Fig. 4. Copepodites of *Anchistrotos pleuronichthydis* Yamaguti, dorsal view. A. Fifth copepodite, male; B. Sixth copepodite (adult), ovigerous female; C. Sixth copepodite, male.

at the tip. *Second antenna* ca. $71\ \mu\text{m}$ long excluding setae. *Coxal spine* with 2 fine hairs on the proximal one third of the posterior side and some fine hairs along the

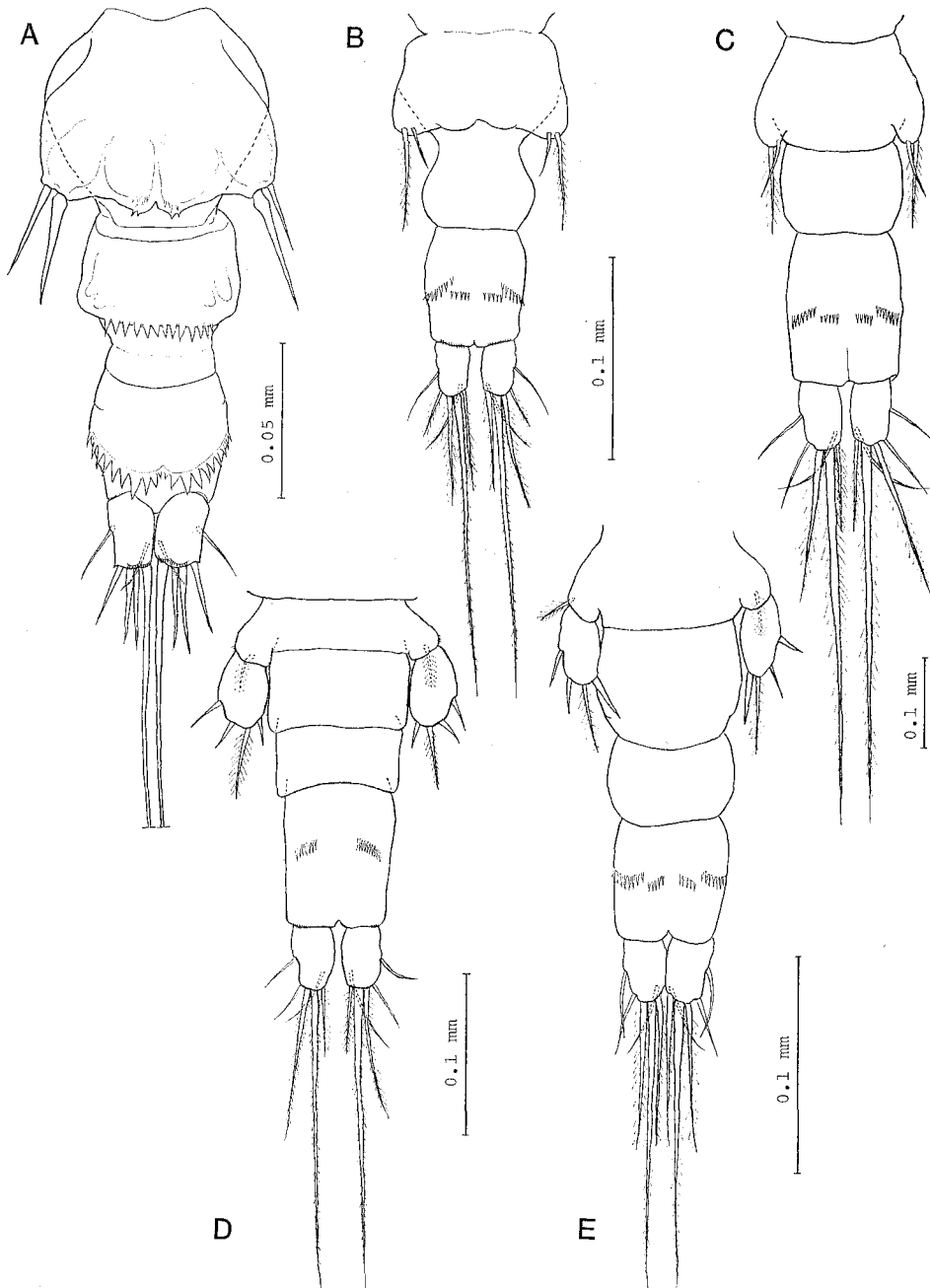


Fig. 5. Urosomes of first to fourth copepodites of *Anchistrotos pleuronichthydis* Yamaguti, ventral view. A. First copepodite; B. Second copepodite; C. Third copepodite; D. Fourth copepodite, female; E. Fourth copepodite, male.

opposite side of the distal half. Basis as in the preceding stage. Endopodite with an addition of a seta-like spine at the medio-distal corner. Exopodite maintaining the same setation as in the first stage, but all apical setae plumose in this stage. *Mandible* ca. $47\ \mu\text{m}$ long excluding setae. Coxa, basis and exopodite unchanged. Endopodite somewhat stouter than in preceding stage; first segment furnished with 3 spines on the medial margin, proximal one of these with a fine branch at the proximal one third on the anterior side.

First copepodid Stage (Figs 3A, 5A, 7).

Body length excluding caudal ramus $353\ \mu\text{m}$ on the average of 12 specimens, ranging $318\text{--}373\ \mu\text{m}$; cephalothorax $184\ \mu\text{m}$ in length and $154\ \mu\text{m}$ in width on the average. Cephalothorax, metasome and urosome clearly demarcated. Cephalothorax slightly shorter than the combined length of following somites; first pedigerous segment included completely in it; the rostral area distinct by a suture on the dorsal surface. Metasome of second pedigerous segment slightly narrower than the posterior portion of cephalothorax and about half as long as wide. Urosome

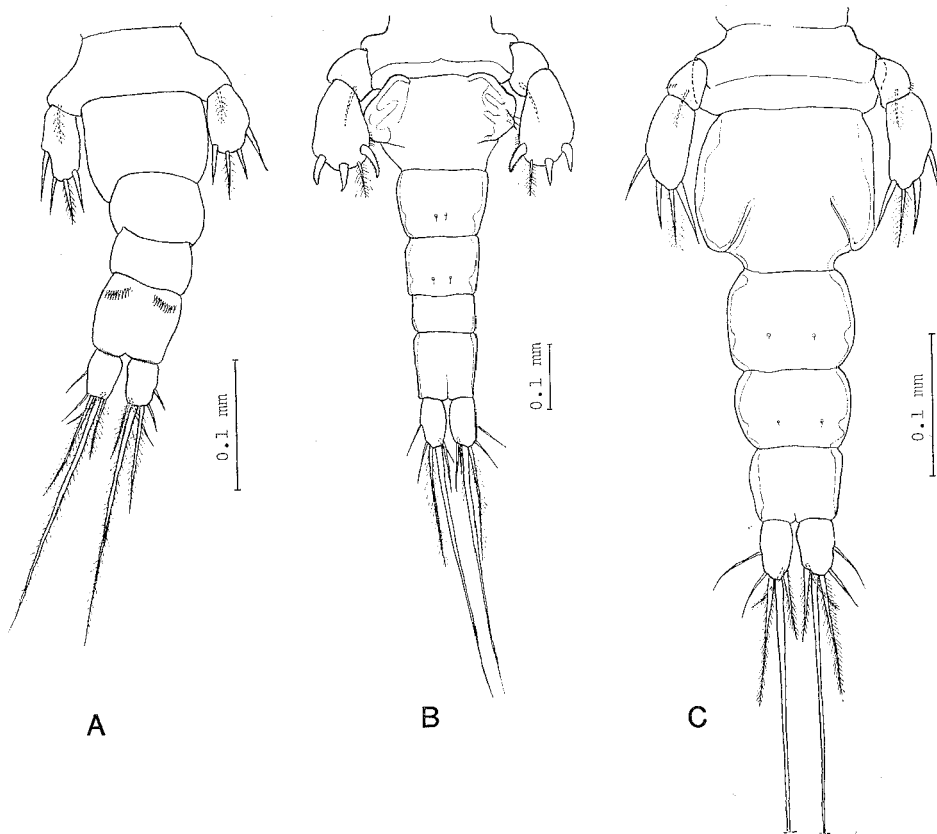


Fig. 6. Urosomes of fifth and sixth copepodites of *Anchistrotos plewonichthydis* Yamaguti, ventral view. A. Fifth copepodite, male; B. Sixth copepodite (adult), female; C. Sixth copepodite, male.

(Fig. 5A) much narrower than metasome and 3-segmented; the first with rudimentary third legs represented by a distally broadened, ventral plate with 2 spines at the tip of each postero-lateral expansion and 2 slight swellings tipped by 2 denticles at the middle of the posterior margin, exopodites and endopodites of this legs of the next stage seen through cuticle respectively in the postero-lateral expansions and medial swellings; the second wider than long, ornamented along the posterior margin of sternum with a row of some 13 lamellar teeth; the last longer than wide, ending in a pair of caudal rami, and ornamented across the ventral surface with a parabolic row of some 20 lamellar teeth.

Rostrum (Fig. 7A; R) moderate, with a hook on the ventral side. *First antenna* (Fig. 7A; A'; 7B) 5-segmented, though separation between first and second segments indistinct, with a stout claw on the second at the distal margin of the ventral side; setal formula of segments 2, 2+1 claw, 2, 2+1 aesthete, 7+1 aesthete; aesthete lamellate and long, somewhat broadened proximally with a narrow base and narrowed distally. *Second antenna* (Fig. 7A; A"; 7C) 5-segmented; the first short, but broad, naked; the second long, with a seta at the dorso-distal corner and a digitiform tissue mass tipped by 2 setules at the end of the ventral side, representing rudimentary exopodite; the third short, with a seta on the posterior side; the fourth almost as long as the second, narrowed distally into a process ending in 3 small claws, with a claw at the base of the terminal process, a transverse row of 6 spines about the middle on the posterior side, and a longitudinal, intermittent row of some 19 narrow laminae and about 3 longitudinal rows of similar laminae on the anterior and ventral surfaces respectively; terminal segment small, arising from a point at distal one third the length of the dorsal side of penultimate segment, with 2 claws at the tip and 3 setae on the dorsal side.

Labrum (Fig. 7D; Lr) semicircular with a rounded distal free margin, ornamented ventrally with 2 arciform rows of some 13 lamellar spinules which surround the antero-lateral corner. *Mandible* (Fig. 7D; Md) 2-segmented; the first stout, with a tissue mass representing the remnant, probably, of basis and rami; the second tapered distally and tipped by 2 blades. *Paragnath* (Fig. 7D; P) small, divided into a flat basal portion and a lobe-like distal portion perpendicular to the former. *First maxilla* (Fig. 7D; Mx') 2-segmented; the first short, but extended laterally, with a seta on the medial margin; the second lobe-like, with 2 setae on the distal margin. *Second maxilla* (Fig. 7D; Mx") 2-segmented; the first stout, thickened at the base; the second tapered distally and tipped with 2 pectinate processes and a simple spine. *Maxilliped* (Fig. 7C; Mxp) feeble, 2-segmented; the first short, but elongated medially; the second long, flattened and slightly broadened distally, with a membranous rim along the distal edge and 2 fine setae at the tip of a small distal projection. An inter-coxal plate between maxillipeds distinct.

First and second legs (Fig. 7E; P1, P2) biramous, almost the same in size and structure; each consisting of flattened 2-segmented protopodite and 1-segmented rami; coxa unarmed; basis with a seta on the outside and a row of hairs along the medio-distal corner. Exopodite spines of both legs with a membrane on each

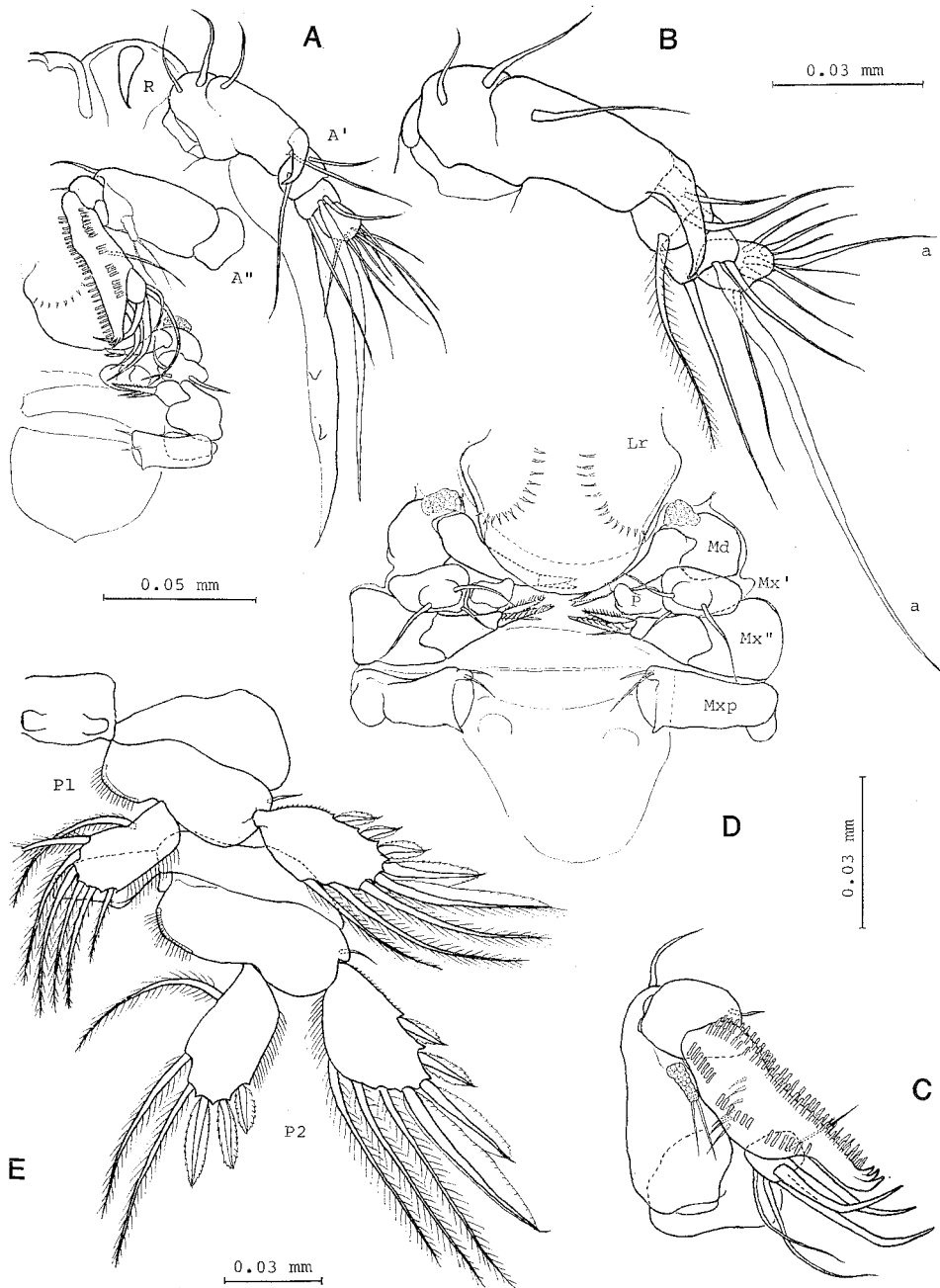


Fig. 7. Appendages of first copepodite of *Anchistrotos pleuronichthydis* Yamaguti. A. Cephalic appendages in situ, ventral; B. First antenna, ventral; C. Second antenna, ventral; D. Labrum and oral appendages in situ, ventral; E. First and second legs in situ, ventral. Abbreviations: R, rostrum; A', first antenna; a, aesthete; A'', second antenna; Lr, labrum; Md, mandible; P, paragnath; Mx', first maxilla; Mx'', second maxilla; Mxp, maxilliped; P1, first leg; P2, second leg.

Table 1. Setal formulae of first 2 legs of the first copepodid stage of *Anchistrotos pleuronichthydis* Yamaguti. Number of spines in Roman and that of setae in Arabic numerals.

	Protopodite coxa; basis	Endopodite seg. 1	Exopodite seg. 1
Leg 1	0-0; 0-1	7, 0	3, V
Leg 2	0-0; 0-1	3, III	3, IV

edge and a fine terminal blade, but the apical spine in first leg with hairs on its inner edge, instead of a membrane. Each of three endopodite spines of second leg also with a similar membrane on both edges, but lacking terminal blade. Setal formulae of first 2 legs shown in Table 1. Caudal ramus (Fig. 5A) longer than wide, with a row of fine spinules along the distal margin of the central side, and armed with 6 spines and setae in all, a short seta at the middle of the outer margin and another short seta at the distal one third of the inner dorsal margin, and 4 spines on the distal margin, of which the innermost is much longer than the others.

Second Copepodid Stage (Figs 3B, 5B, 8).

Body length excluding caudal ramus 388 μm to 511 μm and 429 μm on the average of 34 specimens; cephalothorax 217 μm in length and 203 μm in width on the average. Body (Fig. 3B) consisting of roundish cephalothorax and succeeding slender body part; metamerism distinct. Cephalothorax (Fig. 8A) slightly

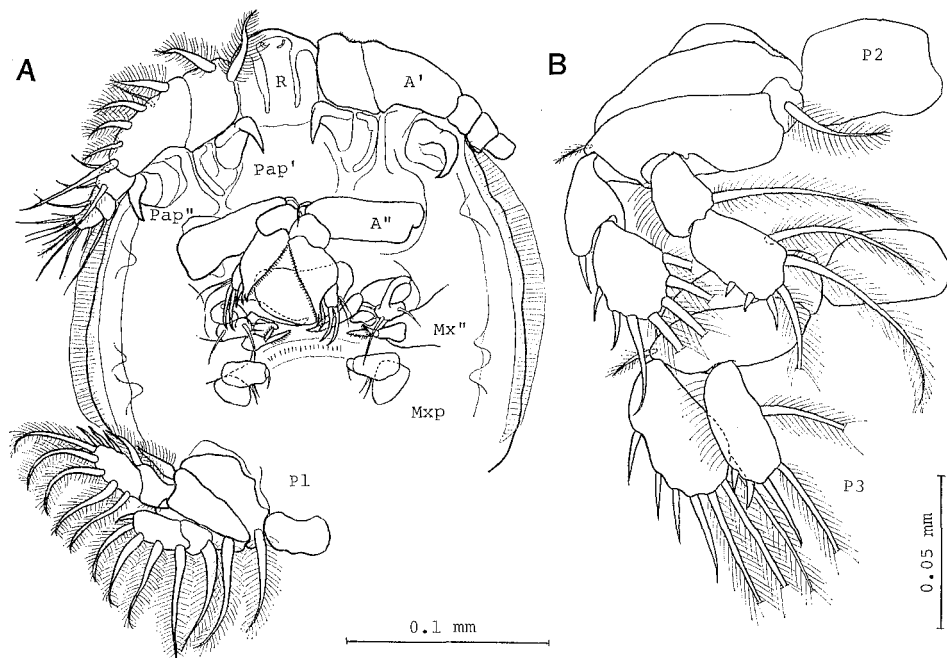


Fig. 8. Appendages of second copepodite of *Anchistrotos pleuronichthydis* Yamaguti. A. Cephalothorax, ventral side; B. Second and third legs in situ, ventral. Abbreviations: Pap', first postantennal process; Pap'', second postantennal process; P3, third leg.

longer than wide, depressed; the ventral side concaved, equipped with a pair of marginal membranes, which completely fill the wide space between first antennae and first legs, and function as a suction cup together with these structures as in adult. The posterior body part consisting of 2 metasomal and 3 urosomal segments, narrower posteriorly, about two-thirds as wide as cephalothorax at the level of widest first metasomal segment. Two metasomal segments with second and third legs respectively. Urosome (Fig. 5B) slightly longer than metasome; first segment with rudimentary third legs, each represented by a postero-lateral expansion on the ventral side and tipped with 2 spines, outer one of which longer than the other and with fine hairs; the second naked; anal segment longer than wide, with 2 transverse, medially interrupted, rows of spinules at the middle on the ventral surface and fine spinules along the distal margin of the same surface.

Rostrum (Fig. 8A; R) lost a hook on the ventral side, but with 2 small chitinous ridges near the anterior end. *First antenna* (Fig. 8A; A') 5-segmented, with first and second segments broadened, but a hook on second segment disappeared in this stage; setal formula of segments 2, 6, 3, 2, 8; setae on the anterior margin of first 2 segments relatively thick and hairy, aesthete indiscernible. Two pairs of postantennal processes (Fig. 8A; Pap' & Pap'') appeared in this stage just posterior and lateral to the first antenna base. *Second antenna* (Fig. 8A; A'') 5-segmented, almost as in first copepodite, but rudimentary exopodite dropped; in penultimate segment, a longitudinal row of lamellar teeth disappeared from the anterior surface, ventral rows of similar teeth replaced by those of fine spinules in this stage, and a claw-like spine at the base of distal process shortened.

Labrum missing ornamentation of spinules. *Mandible* almost as in first copepodite, but a tissue mass representing rudimentary basis and rami disappeared. *Paragnath* as in first copepodite. *First maxilla* with a digitiform process projected ventrally and curved outward near the tip, and 4 setae around the process base. *Second maxilla* (Fig. 8A; Mx'') almost as in preceding stage, but a terminal spine disappeared. Sternal surface between first maxillae of both sides slightly elevated and with a transverse row of spinules. *Maxilliped* (Fig. 8A; Mxp) 3-segmented; the first short, but broad; the second with 2 medial setae; the third small, with a seta-like fine lamella, probably representing a rudiment of fourth segment.

First leg (Fig. 8A; P1) assuming and functioning almost the same as in adult, with 2-segmented rami; coxa and basis with an additional plumose seta on the

Table 2. Setal formulae of first 3 legs of the second copepodid stage of *Anchistrotopleuronichthydis* Yamaguti.

	Protopodite coxa; basis	Endopodite seg. 1; 2	Exopodite seg. 1; 2
Leg 1	1-0; 1-1	1-0; 4, I	0-1; 5, III
Leg 2	1-0; 0-1	1-0; 3, III	0-I; 4, III
Leg 3	0-0; 0-1	2, III	3, IV

medio-distal margin. Second leg (Fig. 8B; P2) with 2-segmented rami; coxa with an addition of a plumose seta on the medio-distal margin. Third leg (Fig. 8B; P3) with 1-segmented rami; basis with a seta on the outer margin. Setal formulae of 3 legs shown in Table 2. Caudal ramus (Fig. 5B) almost the same as in adult; longest spine on the distal margin spinulate, other distal spines hairy, but spine on the outer lateral margin simple.

Third Copepodid Stage (Figs. 3C, 5C, 9).

Body length excluding caudal ramus $522\ \mu\text{m}$ to $623\ \mu\text{m}$, $576\ \mu\text{m}$ on the average of 20 specimens; cephalothorax $277\ \mu\text{m}$ in length and $239\ \mu\text{m}$ in width on the average. Body (Fig. 3C) with metasome and urosome both 3-segmented. Third metasomal segment with biramous fourth legs. Urosome (Fig. 5C) shorter than metasome; the first with rudimentary fifth legs represented by a pair of postero-lateral bulges tipped with 2 setae; the second naked; anal segment the same as in the preceding stage.

Cephalic appendages (Fig. 9A) related more closely to those of adult. *Rostrum* with a small sclerotized projection on the anterior ventral margin. *First antenna*

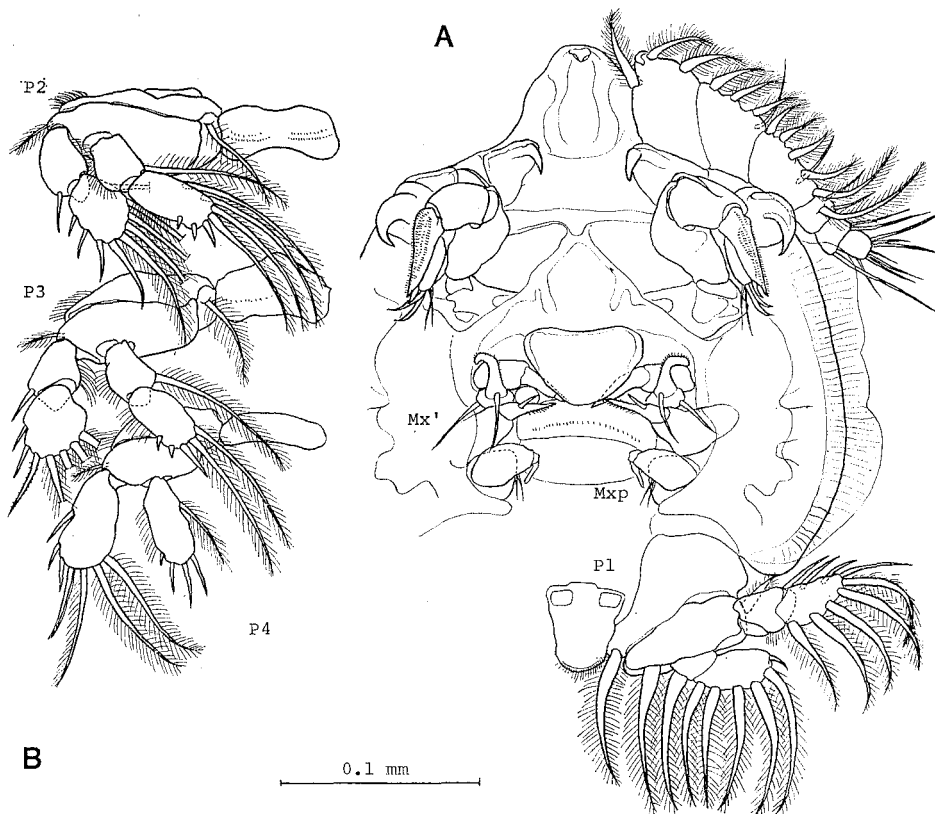


Fig. 9. Appendages of third copepodite of *Anchistrotos pleuronichthydis* Yamaguti. A. Cephalothorax, ventral; B. Second to fourth legs in situ, ventral. Abbreviation: P4, fourth leg.

Table 3. Setal formulae of first 4 legs of the third copepodid stage of *Anchistrotos pleuronichthydis* Yamaguti.

	Protopodite coxa; basis	Endopodite seg. 1; 2	Exopodite seg. 1; 2
Leg 1	1-0; 1-1	1-0; 5, I	0-I; 5, III
Leg 2	1-0; 0-1	1-0; 4, III	0-I; 5, IV
Leg 3	1-0; 0-1	1-0; 2, III	0-I; 4, III
Leg 4	0-0; 0-1	2, III	3, IV

6-segmented; first segment with a small sclerotized projection at the medio-anterior corner; setal formula of segments 3, 4, 6, 3, 3, 7; aesthete indiscernible. *Second antenna* densely covered with spinules on the ventral surface of fourth segment as in adult. *First maxilla* (Fig. 9A; Mx') with fine spinules on the digitiform process. *Second maxilla* developed more stouter than in the preceding stage. *Maxilliped* (Fig. 9A; Mxp) 4-segmented; fourth segment represented by a lamellar process.

Anterior 4 pairs of legs (Fig. 9A; P1; 9B; P2-4) appear all biramous; rami 2-segmented in legs 1-3, but 1-segmented in leg 4; coxa with hairs on the outer distal margin in legs 2-4; inter-coxal plate with hairs along the distal margin in leg 1, but a few transverse rows of spinules in legs 2-3. Setal formulae of 4 legs shown in Table 3.

Fourth Copepodid Stage (Female: Figs 3D, 5D, 10. Male: Figs 3E, 5E, 11).

Sexes definable by body length and claw shape of maxilliped. Body length excluding caudal ramus 755 and 780 μm in 2 females, while 645 to 686 μm and 666 μm on the average of 6 males; cephalothorax 373 μm and 288 μm in length, and 306 μm and 255 μm in width on an average in female and male respectively.

Body (Female: 3D, E. Male: Fig. 5D, E) with 4-segmented urosome in both sexes; first urosomal segment with fifth legs. Cephalic appendages of female and male given in Figs 10A and 11A respectively. *First antenna* (Figs 10A, 11A) 6-segmented increased in number of setae; setal formula of segment 4, 8, 6, 4(3), 2+1 aesthete, 7, aesthete seta-like. *Second antenna* acquires a short seta on the posterior side of third segment; a medio-distal seta on second segment with hairs in this stage; ventro-distal process of fourth segment ending in 2 claw-like points and a claw-like spine which is inserted between the formers. *Mandible* (Figs 10A, Md; B; 11A) with 2 similar terminal blades (Fig. 10B). *Paragnath* (Figs 10A, 11A; P) narrowed distally and bent medially in male. *First maxilla* (Figs 10A; Mx'; 11A) almost the same as in preceding stage. *Second maxilla* (Figs 10A; Mx"; 10C; 11A) ending in 2 spinulate processes, longer one with a membrane on the anterior edge (Fig. 10C). *Maxilliped* exhibits sexual dimorphism. In female (Fig. 10A; Mxp), the terminal process longer and stronger than that in male, recurved and bifurcated apically and with a small seta near the middle. In male (Fig. 11A; Mxp), the terminal process half as long as second segment, rod-like, and with fine teeth along the inside of distal portion.

Anterior 4 pairs of legs (Female: Fig. 10D, E. Male: Fig. 11A, B; P1-P4)

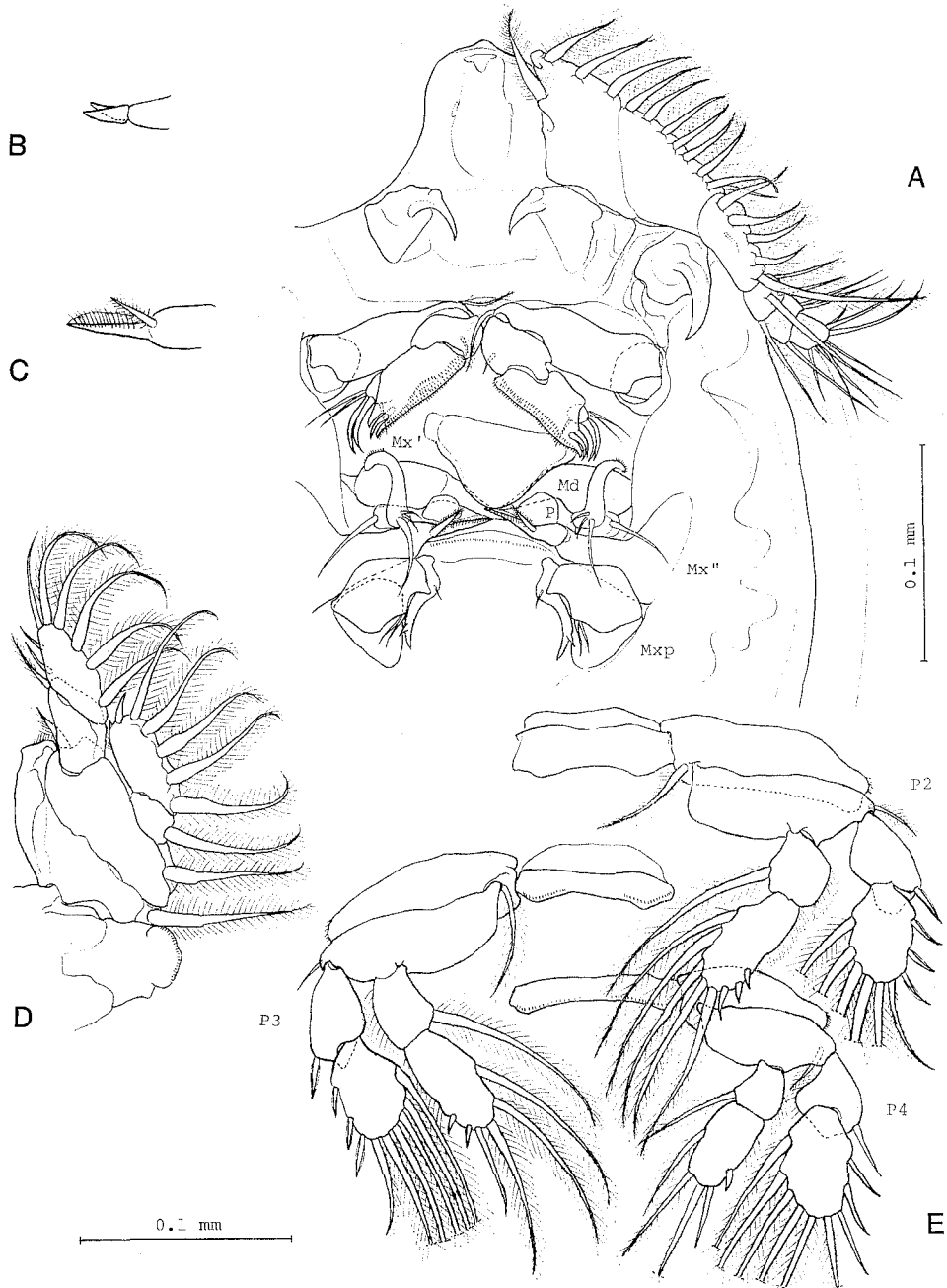


Fig. 10. Appendages of fourth copepodite of *Anchistrotos pleuronichthydis* Yamaguti, female. A. Cephalic appendages in situ, ventral; B. Terminal blades of mandible, ventral; C. Distal end of first maxilla, ventral; D. First leg, ventral; E. Second to fourth legs in situ, ventral.

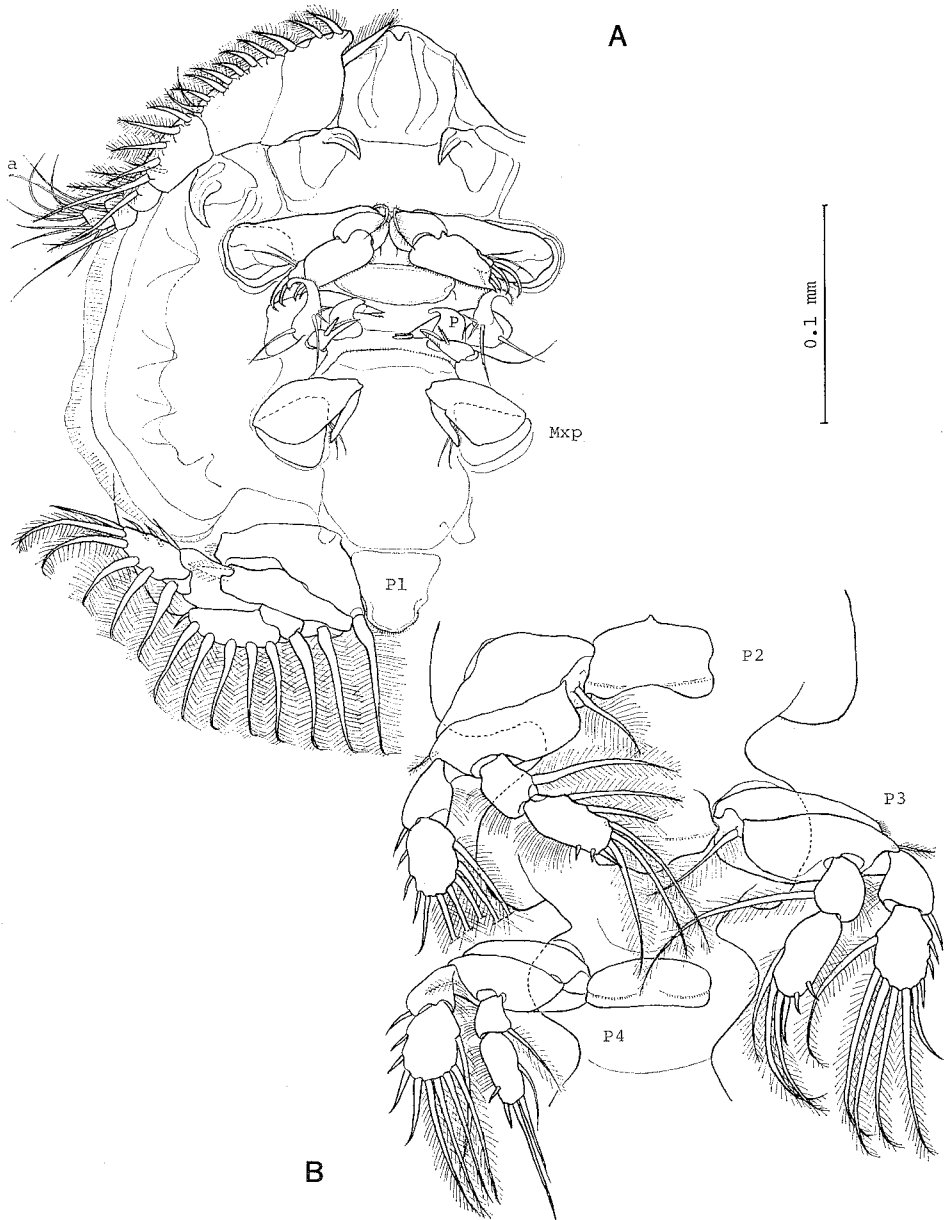


Fig. 11. Appendages of fourth copepodite of *Anchistrotos pleuronichthydis* Yamaguti, male. A. Cephalothorax, ventral; B. Second to fourth legs in situ, ventral, magnified as in A.

all with 2-segmented rami; setal formulae of legs shown in Table 4. Fifth leg (Fig. 5D, E) as a uniramous 2-segmented appendage as in adult, though first segment fused to somite; first segment with a plumose seta on the dorso-distal margin; second segment ovoid and flattened, with 4 setae along the distal margin, of which the

Table 4. Setal formulae of first 4 legs of the fourth copepodid stage of *Anchistrotos pleuronichthydis* Yamaguti.

	Protopodite coxa; basis	Endopodite seg. 1; 2	Exopodite seg. 1; 2
Leg 1	1-0; 1-1	1-0; 5, II	0-I; 6, II
Leg 2	1-0; 0-1	1-0; 5, III	0-I; 5, IV
Leg 3	1-0; 0-1	1-0; 3, III	0-I; 5, IV
Leg 4	0-0; 0-1	1-0; 3, II	0-I; 5, IV

distalmost one is plumose.

Fifth Copepodid Stage (Male) (Figs 4A, 6A, 12, 13A).

Body length excluding caudal ramus 745 μm , cephalothorax 318 μm long,

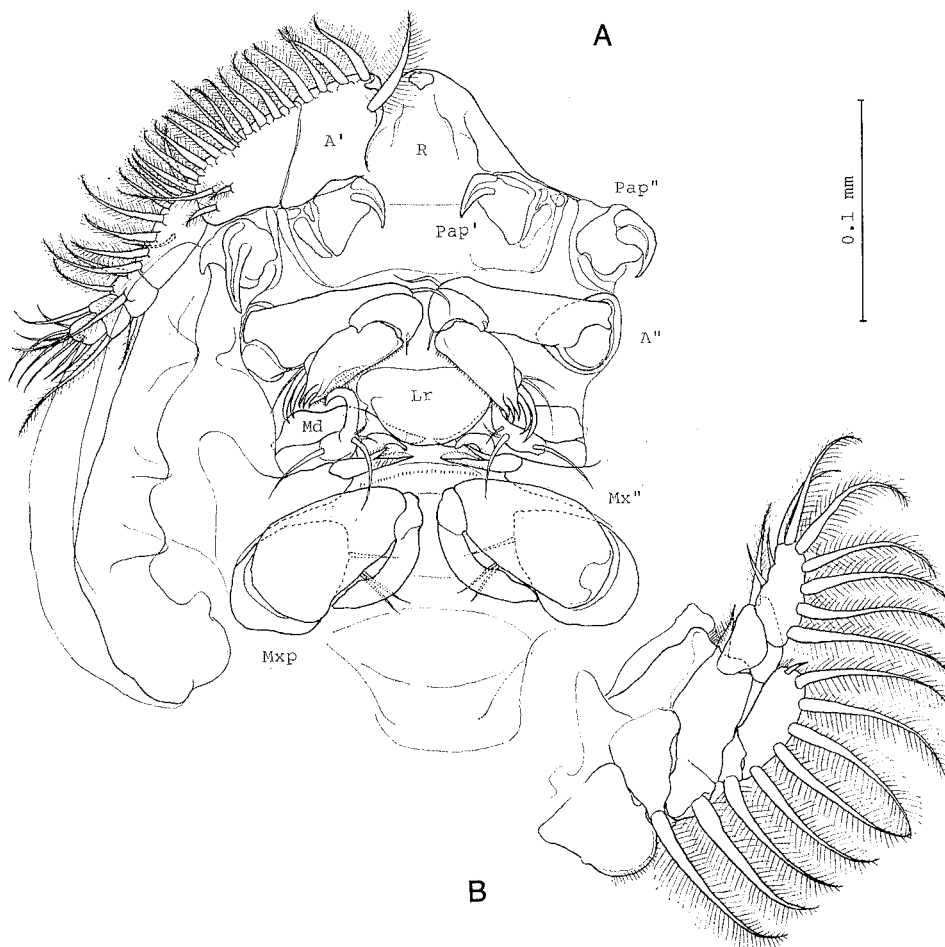


Fig. 12. Appendages of fifth copepodite of *Anchistrotos pleuronichthydis* Yamaguti, male. A. Cephalothorax, ventral side; B. First leg, ventral, magnified as in A.

Table 5. Setal formulae of first 4 legs of the fifth copepodid stage of *Anchistrotos pleuronichthydis* Yamaguti.

	Protopodite coxa; basis	Endopodite seg. 1; 2; 3	Exopodite seg. 1; 2; 3
Leg 1	1-0; 1-1	1-0; 5, II	0-1; 6, III
Leg 2	1-0; 0-1	1-0; 2-0; 3, II	0-I; 1-I; 5, IV
Leg 3	1-0; 0-1	1-0; 2-0; 2, III	0-I; 1-I; 5, III
Leg 4	0-0; 0-1	1-0; 1-0; 2, II	0-I; 1-I; 5, III

308 μm wide in a male. Body (Figs 4A, 6A) with 5-segmented urosome as in adult; the first with a transverse, interrupted row of ca. 26 spinules across the ventral surface at the middle.

Cephalic appendages through maxillipeds given in Fig. 12A, almost the same as in adult, though segmentation of first antenna lesser, and terminal claw of maxilliped not yet matured. *First antenna* (12A; A') 6-segmented; setal formula of segments 5, 15, 8, 4, 2, 7; aesthete indiscernible. *Maxilliped* (Fig. 12A; Mxp) stouter than in preceding stage, 4-segmented; the first stumpy, with a medial seta; the second voluminous, with 2 medial setae; the third indistinctly definable at the base of terminal claw, short and naked; the terminal claw thickened and bent inward.

First 4 pairs of legs (Figs 12B; 13A; P2-4) structured as in adult; legs 2-4 with 3-segmented rami; second endopodite segment with a spine-like process at the outer distal corner in legs 2, 3. Setal formulae of legs 1-4 shown in Table 5. Sixth Copepodid Stage (Adult) (Female: Figs 4B, 6B, 13B, C. Male: Figs 4C, 6C, 14).

Body length 1488 and 766 μm on the average of 21 females and 13 males respectively, ranging 1293-1777 and 706-835 μm ; cephalothorax 537 and 289 μm in length, and 537 and 270 μm in width on the average in female and male respectively.

Female: Egg sac about 890 μm in length and 180 μm in diameter. Urosome 6-segmented; the first a half as long as wide, with powerful fifth legs; the second genital, slightly shorter than wide, with a lateral swelling on each side, accompanied by 3 small setae representing sixth leg near the genital pore; the third and fourth each with a pair of fine tubercles tipped with a hair on the ventral surface; the fifth and anal segments naked.

Cephalic appendages through maxillipeds given in Fig. 13B. *First antenna* 6-segmented, though 7-segmented in male; setal formula of segments 5, 14, 8, 2, 2, 7; aesthete indiscernible.

Anterior four legs given in Fig. 13C (P1-P4). Setal formulae of legs 1-4 shown in Table 6. Fifth leg 2-segmented; the first separated from somite, with a dorsal seta on the distal margin; the second broadened distally, with 3 stout and a thin hairy spines.

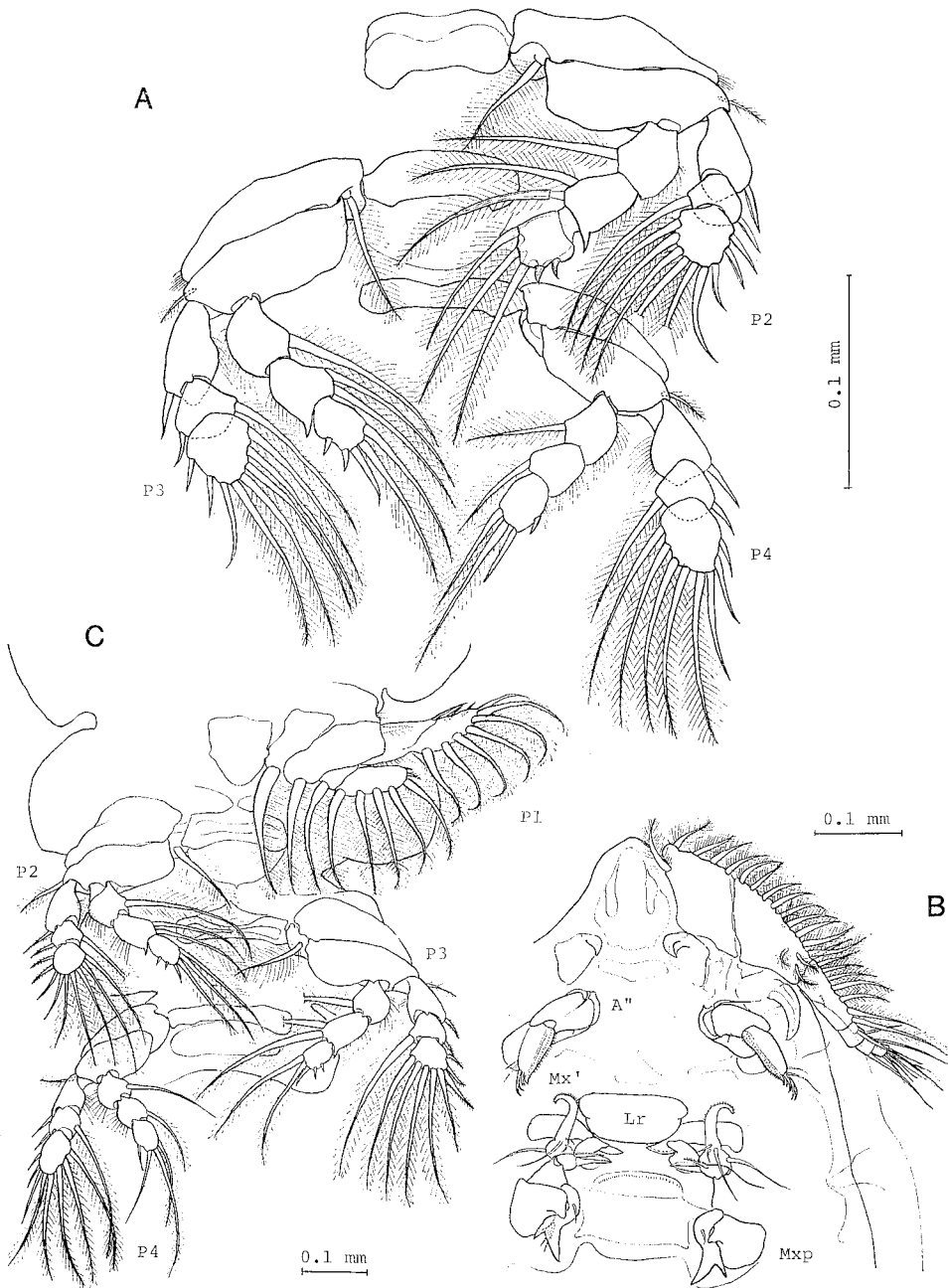


Fig. 13. Appendages of fifth copepodite (male) and sixth copepodite (female) of *Anchistrotos pleuronichthydis* Yamaguti. A. Second to fourth legs of fifth copepodite (male) in situ, ventral; B & C. Sixth copepodite (female); B. Cephalic appendages in situ, ventral; C. First to fourth legs in situ, ventral.

Table 6. Setal formulae of first 4 legs of the sixth copepodid stage of *Anchistrotos pleuronichthydis* Yamaguti.

	Protopodite coxa; basis	Endopodite seg. 1; 2; 3	Exopodite seg. 1; 2; 3
Leg 1	1-0; 1-1	1-0; 7, 0	0-I; 6, III
Leg 2	1-0; 0-1	1-0; 2-0; 3, III	0-I; 1-I; 5, IV
Leg 3	1-0; 0-1	1-0; 2-0; 2, III	0-I; 1-I; 5, III
Leg 4	0-0; 0-1	1-0; 1-0; 2, II	0-I; 1-I; 5, III

Male (Figs 4C, 6C, 14): Urosome 5-segmented as in preceding stage; the second genital, slightly longer than the first with fifth legs, with a pair of genital slits on ventral side; the third and fourth each with a pair of fine tubercles tipped with a hair on the ventral side; anal segment naked.

First antenna (Fig. 14A) 7-segmented; first segment with a small projection at the medio-distal corner; setal formula of segments 5, 16, 4, 4, 4, 2+1 aesthete, 7; aesthete of terminal segment indiscernible. *Maxilliped* (Fig. 14A; Mxp; 14B) powerful, 5-segmented; the first short, naked, almost fused to the sternal surface; the second narrower than the first and next segments, with a medial seta; the third thickened abruptly at the base and narrowed distally, ornamented with 2 medial setae and a longitudinal row of teeth accompanied by a granular area near the middle along the medial margin; the fourth short and naked, forming into a joint; terminal claw longer than third segment, curved deeply and indented along the inner margin at about distal half.

First to fourth legs given in Fig. 14A (P1), 14C (P2-4); setal formulae the same as in female. Fifth leg (Fig. 6C) almost the same as in female, but second segment narrower and 3 simple spines on this segment thinner and sharply pointed than in female.

Remarks. *Anchistrotos pleuronichthydis* is the second species of the Taeniacanthidae, of which developmental stages are described, as far as I am aware. The first is *Taeniacanthus lagocephali* in the previous paper (Izawa, 1986). In this paper, the early two nauplii and all of the copepodid stages except female of fifth copepodid stage of the species are described. Nauplii of this species are very similar to those of *T. lagocephali*, but slight difference in ornamentation of body is noticeable between them, *viz.* the second nauplius is ornamented with 2 thin spinules on an indistinct transverse ridge of the sternal surface of the posterior portion in this species, while the second nauplius of *T. lagocephali* has a transverse row of ca. 7 thin spinules on the same portion. The first copepodite of this species is unique in having a hook on the ventral side of rostrum and the distal margin of the same side of the first antenna respectively, which are disappeared at the second copepodid stage and 2 pairs of postantennal processes appear by way of compensation. The first copepodite of this species is quite different from that of *T. lagocephali* in structure of mandible and maxilliped. Mandible is similar in shape and structure throughout

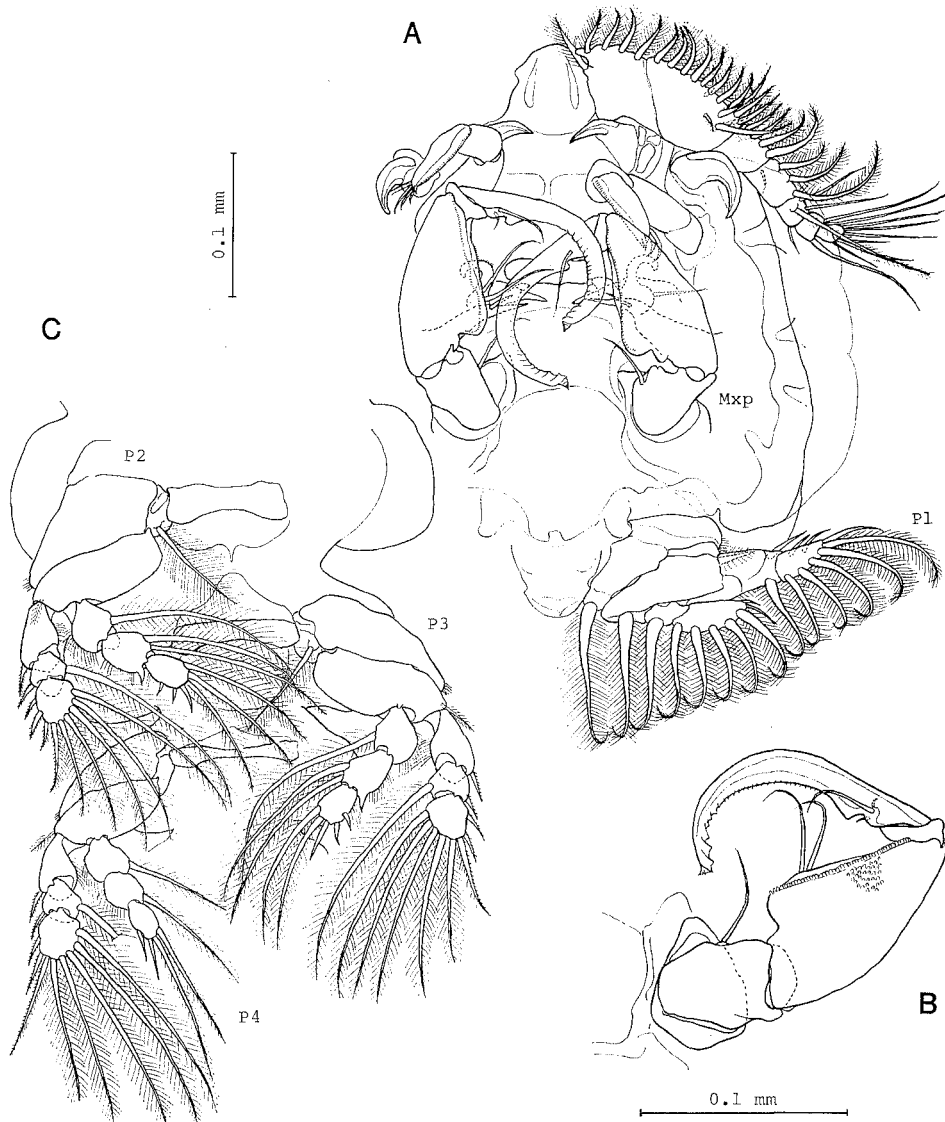


Fig. 14. Appendages of sixth copepodite of *Anchistrotos pleuronichthydis* Yamaguti, male. A. Cephalothorax, ventral side; B. Maxilliped, posterior; C. Second to fourth legs in situ, ventral, magnified as in A.

all the copepodid stages in this species, but in *T. lagocephali*, as shown in my previous paper (Izawa, 1986, Fig. 5D), the counterpart of the first copepodite is peculiar in having an gnathobase-like process, which reminds me of a gnathostome mandible. Maxilliped of the first copepodite of this species is quite different from that of the same stage of *T. lagocephali*; it is a degenerative prehensile appendage in this species (Fig. 7D; Mxp), while that of the latter (Izawa, 1986, Fig. 5G) well develops to assume an aspect of the feeding appendage, as seen in the filter feeding

copepods. The sexes are distinct at the fourth copepodid stage in body length and sexual dimorphism of maxillipeds in this species, while in *T. lagocephali* the sexes are distinguishable one stage earlier than in the former at the third copepodid stage by size and subtle habit of body, though sexual dimorphism of maxillipeds appears one stage later than in the former at the fifth copepodid stage.

2. *Tegobomolochus nasicola* Izawa, 1967

(Figs 16 & 17)

Material. Egg sacs from 2 ovigerous females obtained from the nasal cavity of a goatfish, *Pseudopeneus spilurus* (Bleeker), fished in Tanabe Bay in January 1972, were used for rearing nauplii.

Eggs are $104 \times 92 \mu\text{m}$ on an average, fairly larger than in the previous taeniacanthids. First nauplii, reared at ca. 16°C in the so-called green water with the culture of uncertain algae, reached the third nauplius stage within 5–6 days after hatching, though unfortunately the batch of larvae was destroyed by an accident on the 11th day after hatching before the next moult. Long stay in the third nauplius stage was probably attributable to inadequate food supply.

First Nauplius Stage (Figs 15A, B; 16A, D, G).

Length $158 \mu\text{m}$ and width $82 \mu\text{m}$ on an average. Body structure (Fig. 15A, B) closely related to those of the preceding species, though much larger; slightly constricted on the ventral side almost at the middle just posterior to labium, with a transverse row of fine spinules on the ventral surface in the posterior portion; furcal armature consisting of a median spinulate process and paired hairy setae and patches of fine spinules. *Labrum* moderate, unarmed. *Labium* represented by a round swelling of the sternal surface, unarmed.

First antenna (Fig. 16A) ca. $80 \mu\text{m}$ long excluding setae, covered sparsely with short transverse rows of fine spinules on the anterior surface, 3-segmented; the first short, without any seta; the second long, with 3 relatively long setae on the ventral margin; the third moderate in length, ending in a simple seta and a plumose one accompanied with a slender aesthete at the base. *Second antenna* (Fig. 16D) ca. $80 \mu\text{m}$ excluding setae; segments more or less flattened and covered sparsely with transverse rows of fine spinules on the anterior surface. Coxa short, with a simple spine on the rounded medial margin. Basis slightly wider than long, with 2 spines, ca. $80 \mu\text{m}$ long and much shorter ones, at the medio-proximal corner and a short spine at the medio-distal corner. Endopodite 1-segmented, as long as basis, with a spine at the middle on the medial margin and 2 plumose setae on the distal margin. Exopodite issuing from the outer proximal part of basis, 5-segmented; the first slightly longer than either basis or distal 4 segments combined together; each segment with a plumose seta at the medio-distal corner, but the terminal segment additionally with a simple apical seta at the outer distal corner. *Mandible* (Fig. 16G) ca. $60 \mu\text{m}$ long excluding setae; the anterior surface covered sparsely with fine spinules. Coxa short, with a spine on the slightly expanded medial margin. Basis broad, almost

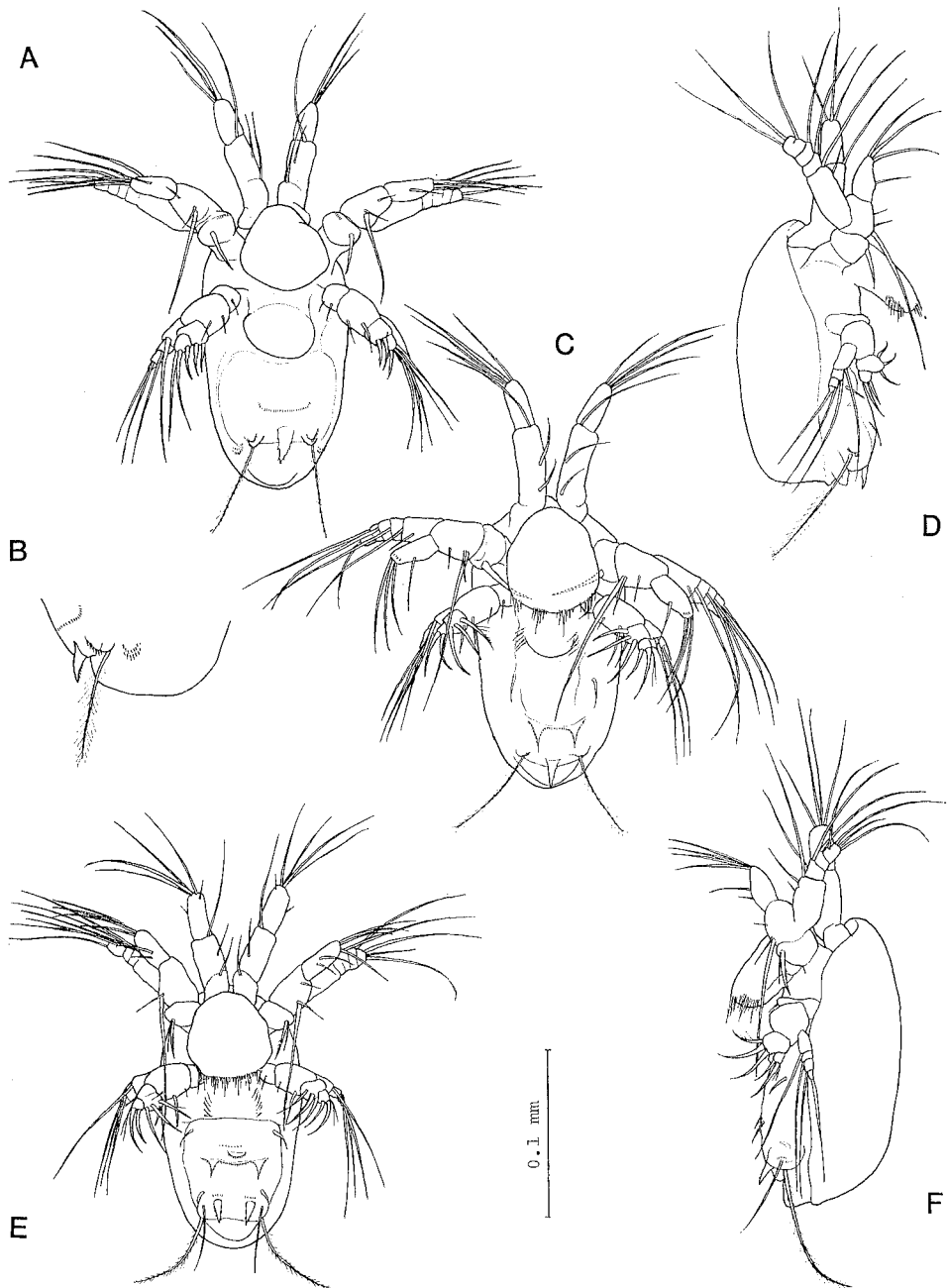


Fig. 15. First three nauplii of *Tegobomolochus nasicola* Izawa. A. First nauplius, ventral; B. Posterior portion of first nauplius, ventral; C, D. Second nauplius, ventral and lateral; E, F. Third nauplius, ventral and lateral.

as long as wide, with 2 short spines arranged proximally and distally on the medial margin. Endopodite broad, 2-segmented; the first expanded medio-distally, with 2 spines on the distal margin of the expansion; the second small, with a spine at the medio-distal corner and apically with a simple seta and a plumose one. Exopodite issuing around the middle of the outer margin of basis, nearly perpendicular to the axis of the latter, narrow and 4-segmented; segments diminishing the size distally and each with a plumose seta.

Second Nauplius Stage (Figs 15C, D; 16B, E, H).

Length $161\ \mu\text{m}$ and width $83\ \mu\text{m}$ on an average. Body (Fig. 15C, D) ornamented transversely on the ventral side in the posterior portion with a membrane acutely pointed at each end and marginally pectinated; rudimentary first maxillae as a pair of spines on the ventral side posterior to labium; patches of fine spinules

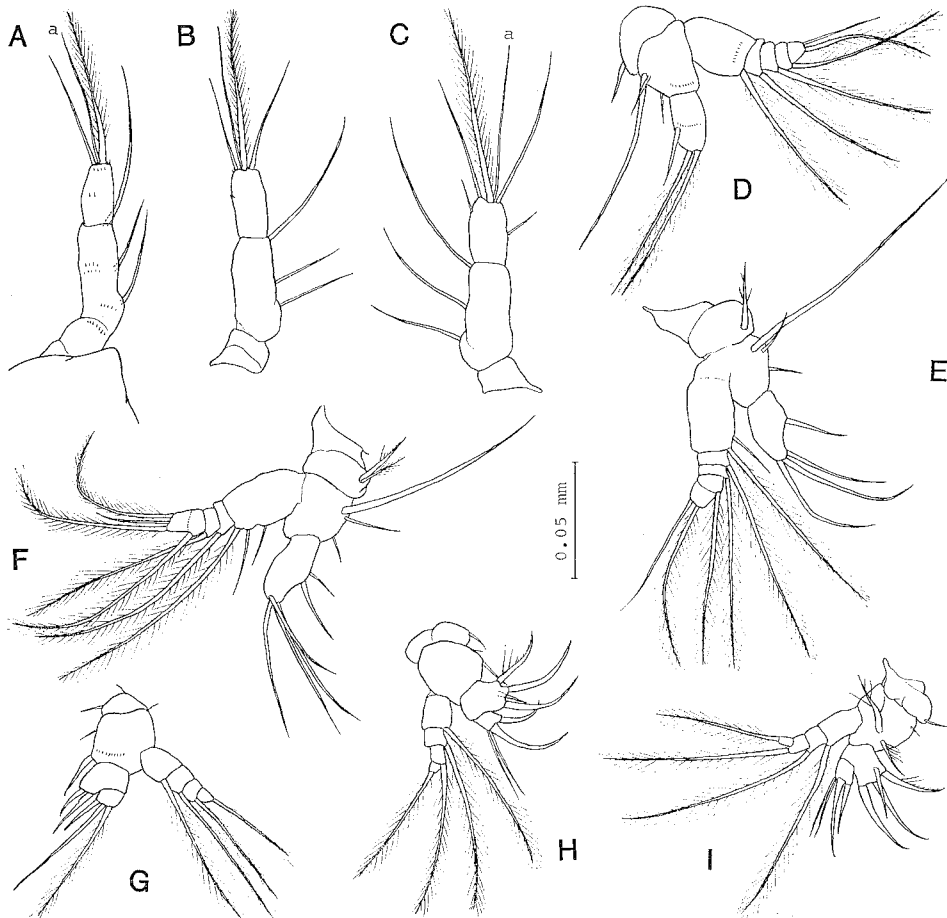


Fig. 16. Naupliar appendages of *Tegobomolochus nasicola* Izawa. A-C. First antennae of first (A) to third (C) nauplii, dorsal; D-F. Second antenna of first (D) to third (F) nauplii, D, anterior, E & F, posterior; G-I. Mandibles of first (G) to third (I) nauplii, G & H, anterior, I, posterior.

disappeared from furcal armature. *Labrum* pectinated with several spinules of different sizes at 4 sites along the distal free margin. *Labium* with a row of some 5 hairs on each lateral side.

First antenna (Fig. 17B) with addition of a simple apical seta in third segment, no fine spinules on the surface. *Second antenna* (Fig. 16E) with addition of a subterminal setule on the medial margin of first exopodite segment and a spine at the medio-distal corner of endopodite; no fine spinules on the surface; the long spine of basis attaining to about $110\ \mu\text{m}$, the coxal spine with a few fine branches and 2 apical setae of endopodite naked in this stage. *Mandible* (Fig. 16) with endopodite reinforced by increasing and growing spines; though protopodite and exopodite the same as in the first stage; fine spinules disappeared from the surface. First endopodite segment armed with a spine near the middle of the medial margin and with 3 stout spines on the same margin, the proximal one of the latter furnished with fine branches. Second endopodite segment distally with 2 stout spines and 2 feeble simple setae.

Third Nauplius Stage (Figs 15E, F; 16C, F, I).

Length $169\ \mu\text{m}$ and width $87\ \mu\text{m}$ on an average. Body (Fig. 16E, F) with a small crescent-shaped additional membrane marginally fringed with fine spinules on the posterior ventral surface just in front of the prominent membrane appeared in the second stage; furcal armature additionally with a pair of feeble setae, the median process seen in first and second nauplii replaced by a pair of similar process. *Labrum* fringed more densely with thin spinules on the distal free margin than in the preceding stage. *Labium* rather indiscernible, though lateral hairs being left.

First antenna (Fig. 16C); third segment newly with a subterminal spinule on the ventral margin and a middle one on the dorsal margin. *Second antenna* (Fig. 16F) almost the same as in the preceding stage, though ornamental elements increased; the joint between distal 2 exopodite segments obscure in this stage. Coxa newly with a feeble hairy seta at the base of the medial spine. Endopodite newly with a short spine proximally to the middle one on the medial margin and a seta-like long spine at the medio-distal corner. Exopodite with addition of a setule almost at the middle on the medial margin of first segment and another one between 2 apical plumose setae of the terminal segment. *Mandible* (Fig. 16I) additionally with a stout spine furnished with fine branches on the posterior side of basis; the spine near the medio-distal corner of the same segment furnished with fine branches in this stage.

Remarks. This species was described as the type species of a new genus *Tegobomolochus* belonging to the family Bomolochidae at the first. Avdeev (1978) erected a new family Tegobomolochidae closely related to but distinct from the Bomolochidae to accommodate this species. Then, at present the Tegobomolochidae is monotypic. As for development of the Bomolochidae, Kabata's (1976) description of the first nauplii of *Bomolochus cuneatus* and *Holobomolochus spinulus* is sole. In this

paper, the early three nauplius stages of *T. nasicola* are described. It seems to be worthy of note that a caudal process disappears at the third nauplius stage in this species.

3. *Doridicola sepioe* (Izawa, 1976)

(Fig. 17)

Material. Egg sacs of a female taken from the ctenidium of a cuttle-fish (cephalopod mollusk), *Sepia esculenta* Hoyle, caught in Tanabe Bay in April, 1971, were used for rearing nauplii.

Eggs are about 50 μm in diameter on an average and gradually become translucent as they draw near hatching. Hatched nauplii moulted into the second nauplius stage within 1 or 2 days at 16–17°C, but no further moult occurred in the starved state. No pigment spots appeared during these stages.

First Nauplius Stage (Fig. 17A, C, E, G).

Length 82 μm and width 40 μm on an average. Body (Fig. 17A) slim, broadest at the anterior one third, ornamented on the postero-ventral surface with 3 crescent-shaped narrow membranes finely serrated marginally; furcal armature consisting of a very delicate lamella, somewhat looking like a median process, a pair of hairy setae and a pair of small conical projections. *Labrum* distinct, with ca. 8 spinules on the distal free margin. *Labium* represented as a small bulge on the sternal surface, bearing ca. 4 pairs on each lateral margin.

First antenna (Fig. 17C) about 40 μm long excluding setae, 3-segmented; the first short, unarmed; the second long, with 3 relatively long simple setae on the ventral margin respectively at the base, middle and the distal end; the third about half as long as the second, ending in a simple seta and a plumose one accompanied with a slender aesthete at the base. *Second antenna* (Fig. 17E) ca. 50 μm long excluding setae, biramous; segments more or less flattened. Coxa short, swollen on the medial margin into a knob furnished on the tip with a stout spine slightly curved and issuing 2 fine branches near the base. Basis longer than wide, slightly expanded at the middle, bearing a simple setule on the antero-proximal surface and 3 simple spines at the middle of the medial margin, the largest one ca. 35 μm long. Endopodite consisting of only a simple segment about half as long as basis, with 2 spines at the middle of the medial margin and 2 simple setae on the distal margin. Exopodite jointed to the outer distal margins of basis and 5-segmented; the first as long as basis and longer than combined length of distal 4 segments; each of five segments with a plumose seta at the medio-distal corner, but terminal segment with an additional simple seta on the dorso-distal corner. *Mandible* (Fig. 17G) ca. 40 μm long excluding setae, biramous; segments of protopodite and endopodite flattened. Coxa short, expanded medially into a round knob which bears an apical spine with 2 fine branches. Basis broad, though slightly longer than wide, provided at the middle of the rounded medial margin with 2 spines, one of which is furnished with 2 fine branches. Endopodite 2-segmented; first segment much wider than long, expanding

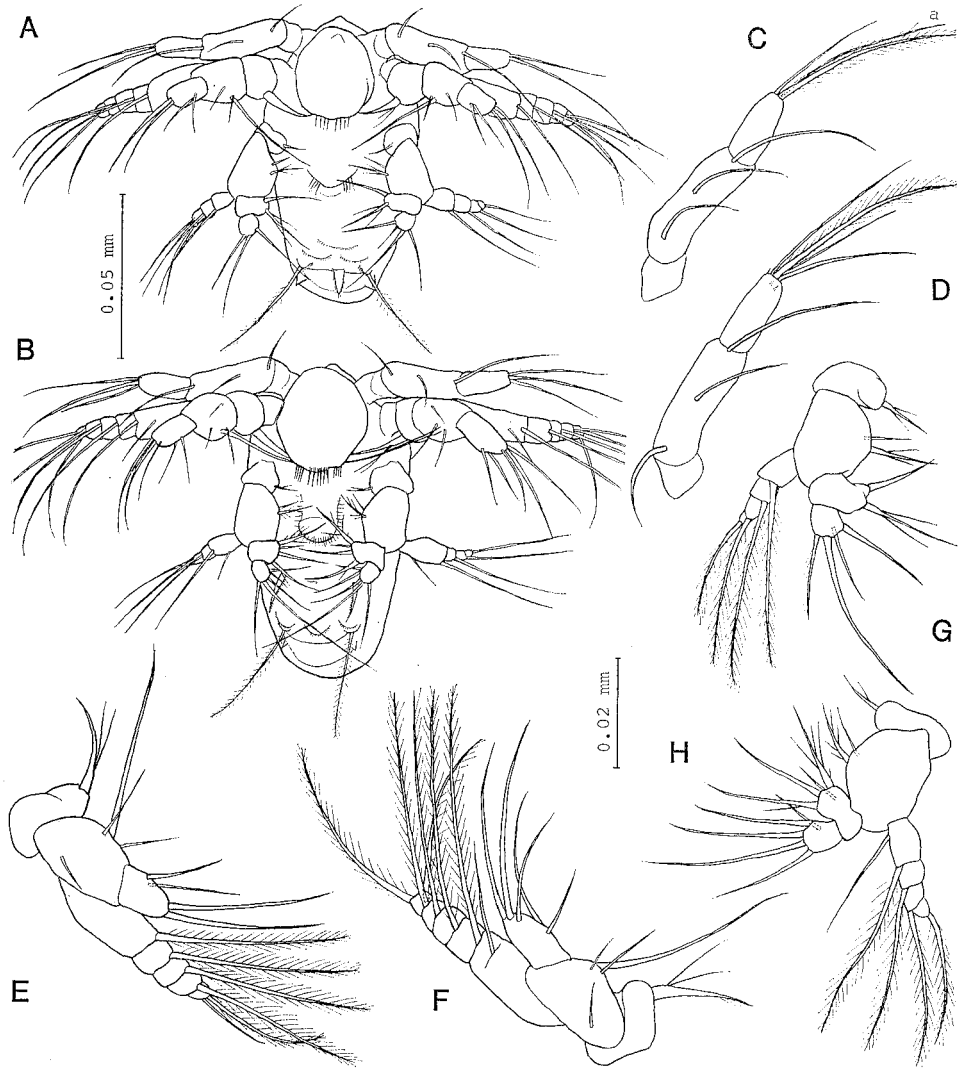


Fig. 17. First two nauplii of *Doridicola sepiæ* (Izawa). A. First nauplius, ventral; B. Second nauplius, ventral; C & D. First antennae of first (C) & second (D) nauplii, ventral; E & F. Second antennae of first (E) & second nauplii, antero-ventral; G & H. Mandibles of first (G) & second (H) nauplii, anterior.

medially into a lobe furnished at the medio-proximal corner with a simple spine and at the middle of the medial margin with a spine armed with 2 fine branches; the second almost as long as the first, but half as wide as the latter, furnished with 2 spines at both middle and posterior sides of the medial margin and 2 apical setae, the longer one simple and placed at the median, while the shorter one plumose and placed at the outer border. Exopodite issuing perpendicular to the axis of the appendage from the subterminal dorsal margin of basis, rather thin and 4-segmented; segments diminishing distally, each with a plumose seta at the medio-distal corner in proximal

3 but at the distal end in terminal segment.

Second Nauplius Stage (Fig. 17B, D, F, H).

Length 92 μm and width 46 μm on an average. Body (Fig. 17B) slightly larger than in the first stage, with rudimentary first maxillae represented as a pair of spines spinulated on the inner side on the sternal surface somewhat posterior to labium; a structure alike median caudal process disappeared in this. *Labrum* and *labium* bearing much more hairs.

First antenna (Fig. 17D); terminal segment additionally with a simple apical seta and 3 spinules on the dorso-distal margin. *Second antenna* (Fig. 17F); first exopodite segment indistinctly divided into 2 subjoints by a faint striation accompanied with a simple setule on the subterminal medial surface; endopodite with an additional simple spine at the medio-distal corner. Spine of coxa furnished newly with some fine hairs on the anterior side of the apical portion; a short simple seta on the outer distal margin of terminal exopodite segment in the first stage replaced by a plumose seta in this stage. *Mandible* (Fig. 17H); endopodite with 3 additional spines, 2 between the 2 stouter transmitted spines on the medial margin of first segment and 1 on the medio-distal corner of second segment; exopodite with an additional simple seta on the medio-proximal margin of first segment.

4. *Nasomolgus firmus* Humes & Ho, 1967

(Fig. 18)

Material. Two egg sacs of an ovigerous female taken from the nest tube of a plumed worm (Polychaeta), *Sabellastarte indica* (Savigny), at Seto, in April 1971, were reared.

Eggs are 75–80 μm in diameter. The first nauplii lived only for 6 days without food at 16–17°C, but did not moult into the second nauplius stage.

First Nauplius Stage (Fig. 18A–E).

Length 88 μm on an average. Body (Fig. 18A) slightly depressed between labrum and labium and ornamented on the sternal surface of the posterior portion with a transverse row of fine spinules and a lunate narrow membrane finely serrated marginally; furcal armature as in *Doridicola sepiacae*, consisting of a delicate lamella looking like caudal process and paired hairy setae and small conical projections. *Labrum* somewhat larger than in the previous species, fringed along the distal free margin with ca. 9 spinules. *Labium* represented as a slight bulge of the sternal surface accompanied with a longitudinal row of hairs on each lateral side.

First antenna (Fig. 18C) ca. 40 μm long excluding setae, more or less flattened and 3-segmented; the first short, unarmed; the second with 3 relatively long simple setae on each of the proximal, middle and distal portions of the ventral margin; the third with 2 fine spinules on the dorsal margin and 2 apical setae consisting of a shorter simple seta and a longer plumose one accompanied with a thin, but long, aesthete basally. *Second antenna* (Fig. 18D) ca. 50 μm long excluding setae;

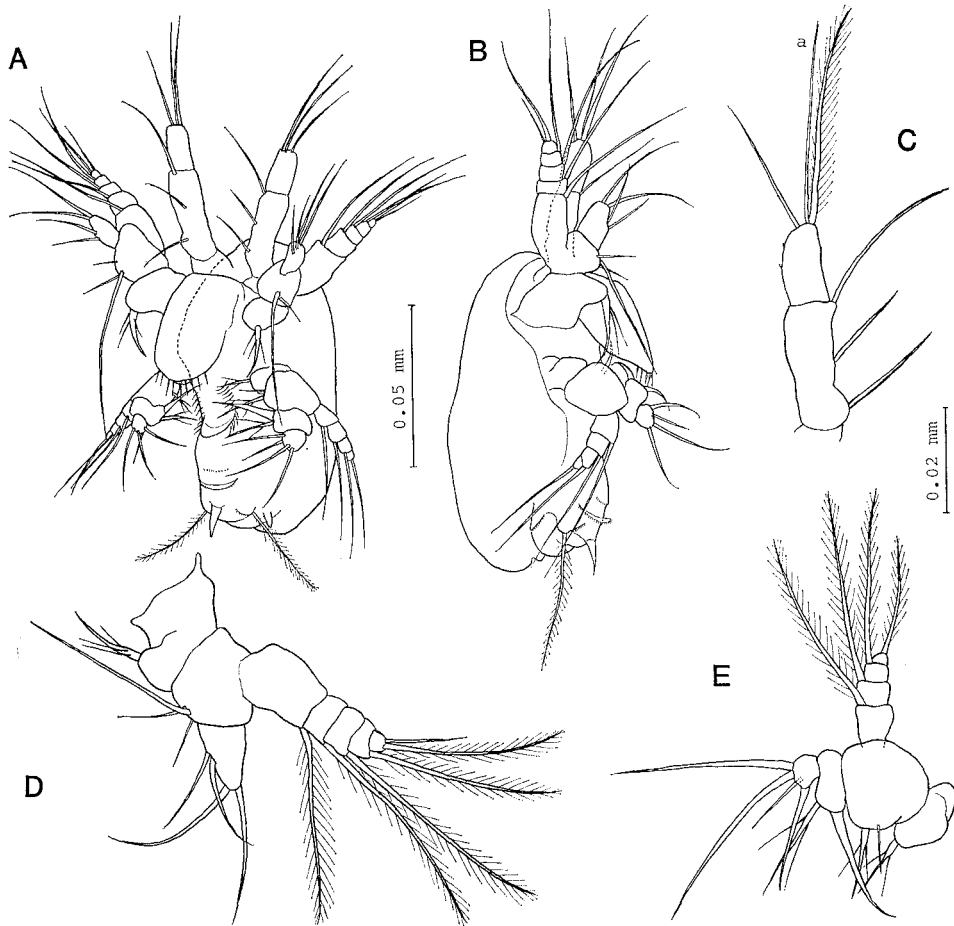


Fig. 18. First nauplius of *Nasomolgus firmus* Humes & Ho. A, B. First nauplius, ventro-lateral and lateral; C. First antenna, posterior; D. Second antenna, posterior; E. Mandible, anterior.

segments more or less flattened. Coxa wider than long, the medio-distal portion projected into a knob tipped with a stout spine furnished with 3 fine branches. Basis almost as long as wide, with 3 spines on the medial margin, one of which is much longer than the rest and attains ca. $35\ \mu\text{m}$. Endopodite 1-segmented, shorter than basis and narrower distally, with 2 spines at the middle of the medial margin and 2 simple setae at the distal end. Exopodite issuing from almost the middle of the outer margin of basis, 5-segmented; the first as long as basis and slightly diminishing the size; respective segments with a plumose seta at the medio-distal corner, in addition terminal segment with a simple seta at the outer distal corner. *Mandible* (Fig. 18E) ca. $40\ \mu\text{m}$ long excluding setae, flattened. Coxa short; the expanded medial margin bearing a spine with 2 fine branches. Basis broad, almost as long as wide, with 2 spines, one simple and the other furnished with 2 fine branches. Endopodite broad and 2-segmented; the first short but very broad,

with a stout spine at the medio-proximal corner and a spine furnished with 2 fine branches at the medio-distal corner; the second as long as the first but much narrower, with 2 spines on the medial margin and 2 simple spine-like setae on the distal margin. Exopodite issuing from a subterminal point of the outer margin of basis, perpendicular to the axis of the appendage, narrow and 4-segmented; segments diminishing the size distally and each with a plumose seta at the medio-distal corner.

Remarks. Developmental stages of the Lichomolgidae and its closest relative, Sabelliphilidae, are well known (see Pesta, 1909; Valle, 1880; Lang, 1949; Costanzo, 1968, 1969; Briggs, 1977). Though only the first two nauplius stages of *Doridicola sepiiae* and the first nauplius stage of *Nasomolgus firmus* were obtained from rearing, these stages are described here in detail. A delicate lamellar structure which resembles the caudal process found in the first two nauplius stages of taeniacanthidiforms is discovered in both two lichomolgids here dealt with, though only at the first nauplius stage. No structure like this has been noted by any workers mentioned above thus far. From delicacy of this structure, its homology is unknown at present.

5. *Philoblenna arabici* Izawa, 1976

(Figs 19–21)

Material: Egg sacs of 2 ovigerous females taken from the mantle surface of an arabic cowry (gastropod mollusk), *Peribolus (Arabica) arabica* (Linne), at Seto in September 1971, were reared.

Eggs are $130 \times 120 \mu\text{m}$ on an average, becoming translucent near hatching. Nauplii reached the first copepodid stage within 4 days through probably 6 nauplius stages without food and at $24\text{--}25^\circ\text{C}$. Nauplii and the first copepodites were capable of active swimming. No pigment spots appeared throughout the observed stages. As only a few nauplii were available, none of the nauplii after the fourth stages were fixed, further the examination of the casts molted by nauplii of these stages was unsuccessful. Thus, the morphology of the late nauplii remains unknown.

First Nauplius Stage (Figs 19A; 20A, D, G).

Much larger than in the previous lichomolgids, but slightly smaller than in the mycolids dealt with here; body length $153 \mu\text{m}$, width $87 \mu\text{m}$ and length of dorsal shield $152 \mu\text{m}$ on an average. Body (Fig. 19A) somewhat plump, constricted on the ventral side at the middle just behind labium, with 2 transverse rows of fine spinules on the posterior ventral surface; furcal armature consisting of paired small conical projections and hairy setae accompanied with a lunar narrow membrane finely serrated marginally and laid between their bases. *Labrum* moderate, fringed along the distal free margin with hairs. *Labium* represented as a slight bulge of the sternal surface, covered with hairs along the lateral and posterior margins. Second antenna and mandible furnished with well-developed spines on the medial margin

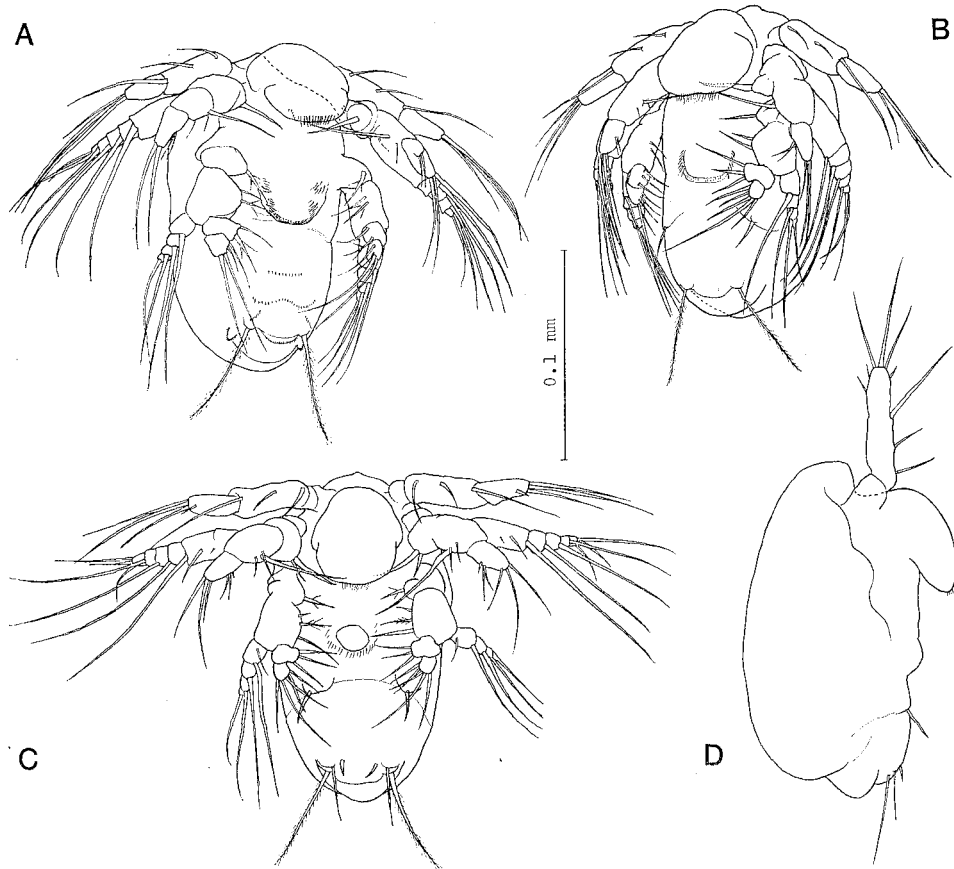


Fig. 19. First three nauplii of *Philoblenna arabici* Izawa. A. First nauplius, ventro-lateral; B. Second nauplius, ventro-lateral; C. Third nauplius, ventral; D. Third nauplius, lateral (second antenna and mandible omitted).

as seen generally in the feeding nauplii.

First antenna (Fig. 20A) ca. $75\ \mu\text{m}$ long excluding setae, 3-segmented; segments somewhat flattened and sparsely furnished with short transverse rows of fine spinules on the anterior surface; the first short, almost completely coalesced with the second, without any seta; the second long, with 3 simple setae on the ventral margin, each located on the proximal, middle and distal portions; the third about half as long as the second, apically with a simple seta and a plumose one accompanied with a slender aesthete at its base. *Second antenna* (Fig. 20D) ca. $80\ \mu\text{m}$ long excluding setae; segments more or less flattened and covered sparsely with fine spinules on the anterior surface. The medial margin of coxa projected into a knob tipped with a stout spine. Basis relatively small, almost as long as coxa, with 2 shorter and longer spines at the middle of the medial margin. Endopodite 1-segmented, shorter than basis, with 2 spines at the middle of the medial margin and 2 simple setae at the distal end. Exopodite issued from the outer proximal margin

of basis and 5-segmented; the first slightly longer than either basis or distal 4 segments combined together; each segment with a plumose seta at the medio-distal corner, only the terminal with an additional simple seta at the tip. *Mandible* (Fig. 20G) ca. 75 μm long excluding setae, more or less flattened and covered sparsely with fine spinules on the anterior surface. Coxa short; the medial margin projected into a knob tipped by a spine with fine branches. Basis broad, but slightly longer than wide, the medial margin furnished around the middle with a simple spine and one furnished with 3 fine branches. Endopodite 2-segmented; the first expanded medially, about 2 times as wide as long, the medial margin with two spines, one of which is simple, the other is furnished with 2 fine branches; the second as long as the first, but narrower than the latter, with 2 spines on the medial margin and 2 simple setae at the distal end. Exopodite issuing from the distal margin of basis, as long as basis and 4-segmented; segments diminishing the size distally and each with a plumose seta.

Second Nauplius Stage (Figs 19B; 20B, E, H).

Body length 164 μm , width 94 μm , and length of dorsal shield 157 μm on an average. Body (Fig. 19B) with a pair of simple spines foreshowing first maxillae at the posterior one third on the ventral side; transverse rows of fine spinules on the posterior ventral surface and a pair of small conical projections in furcal armature, both seen in the first stage, disappeared. *Labrum* and *labium* almost the same as in the preceding stage.

First antenna (Fig. 20B) with addition of a simple seta at the distal end of terminal segment; fine spinules on the surface disappeared. *Second antenna* (Fig. 20E); a subterminal setule appeared on the medial margin of first exopodite segment and a spine at the medio-distal corner of endopodite; fine spinules on the surface disappeared. Both apical setae of exopodite bearing hair in this stage. *Mandible* (Fig. 20H) with addition of a short setule at the middle on the medial margin of first exopodite segment, 2 spines between the two on the medial margin of first endopodite segment, and a simple one at the medio-distal corner of second endopodite segment; the proximal one of the 4 medial spines of first endopodite segment stouter and with several fine branches, while the distal one a little thinner and simple as compared with that in the preceding stage; fine spinules on the surface of segments disappeared.

Third Nauplius Stage (Figs 19C, D; 20C, F, I).

Body length 164 μm , width 95 μm , and length of dorsal shield 157 μm on an average. Paired short spines and simple setae joined the caudal armature; rudimentary first maxilla as a small lobe protruded from the sternal surface and tipped by a spine (Fig. 19C, D). *Labrum* as in the second stage. *Labium* becomes slightly smaller.

First antenna (Fig. 20C) with addition of a spinule near the ventro-distal corner and 2 spinules on the dorso-distal margin of terminal segment. *Second antenna* (Fig. 20F); coxa with a short additional spine on the medial margin at the base of a stout

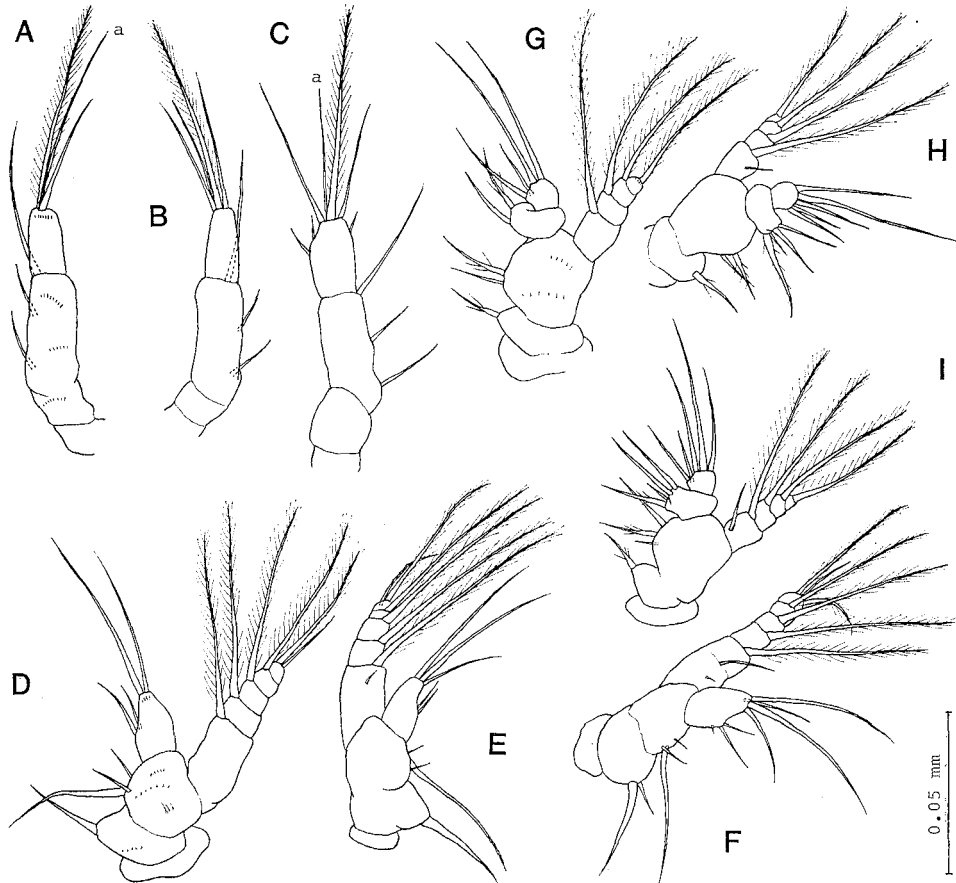


Fig. 20. Naupliar appendages of *Philoblenia arabici* Izawa. A-C. First antennae of first (A) to third (C); A (1st) & B (2nd), dorsal; C (3rd), lateral; D-F. Second antennae of first (D) to third (F) nauplii; D (1st), anterior; E (2nd) & F (3rd), antero-ventral; G-I. Mandibles of first (G) to third (I) nauplii, anterior.

one. Basis as in the second stage. Endopodite newly with a minute spinule proximally to the base of 2 middle spines on the medial margin and a simple seta at the outer distal corner on the posterior side. *Mandible* (Fig. 20I) with an additional small spine about the middle on the medial margin of basis; the setule on the medioproximal margin of first exopodite segment slightly larger than in the preceding stage.

Later Nauplius Stages.

Probably 6 nauplius stages were there in all, but detailed morphology of the later nauplius stages are unknown as no nauplii of these stages were fixed.

First Copepodite Stage (Fig. 21A-H).

Body length 246 μm , width 86 μm , and length of cephalothorax 133 μm on an average. Body (Fig. 21A) slim, composed of elongate cephalothorax, metasome of second pedigerous segment and narrower urosome. Cephalothorax longer than

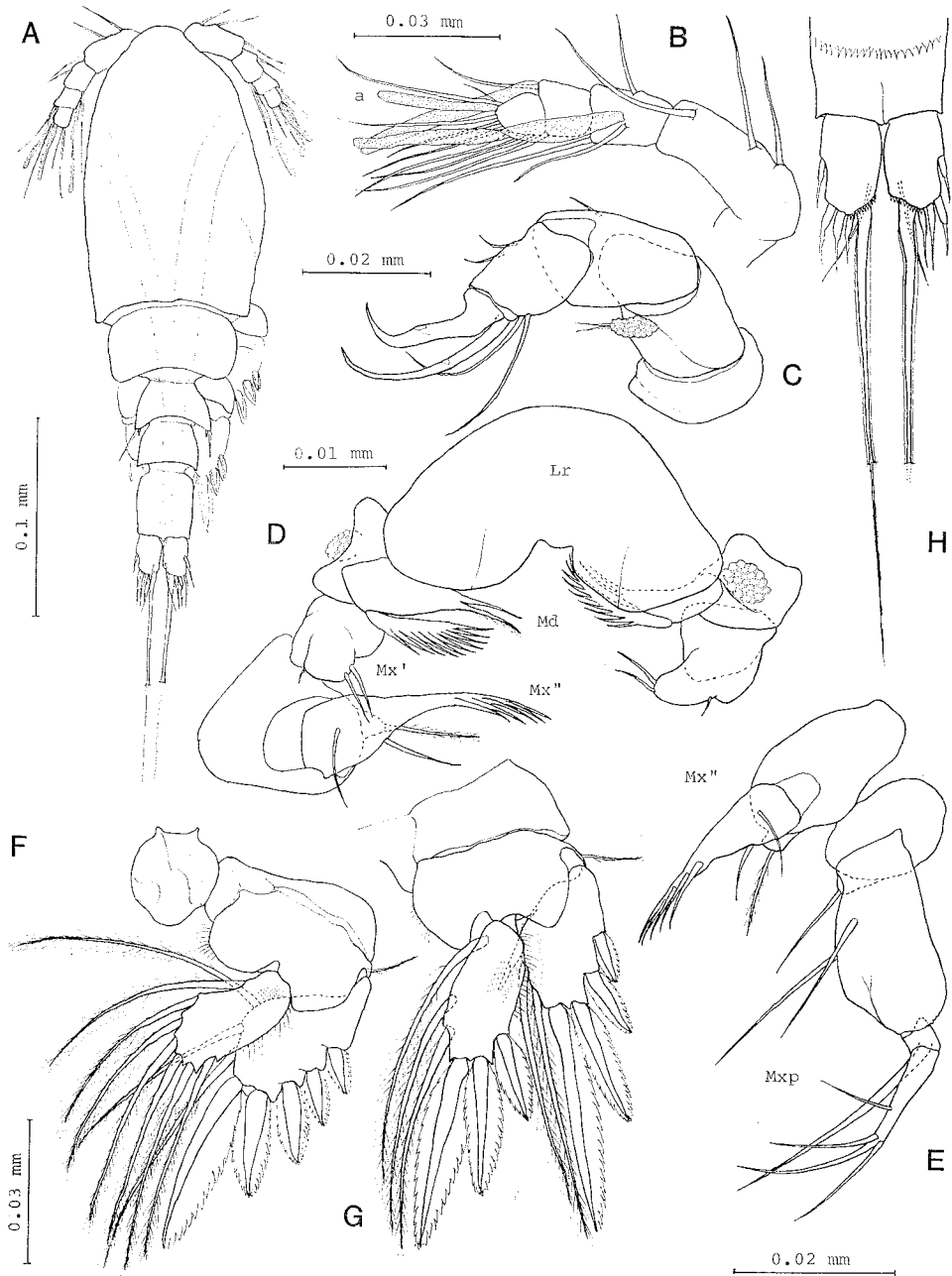


Fig. 21. First copepodite of *Philoblenia arabici* Izawa. A. Total individual, dorsal; B. First antenna, ventral; C. Second antenna, ventro-lateral; D. Labrum and oral appendages in situ, ventral; E. Second maxilla and maxilliped in situ, ventral; F. First leg, ventral; G. Second leg, ventral; H. Anal segment and caudal rami in situ, ventral, magnified as in F.

a half of body length, first pedigerous portion included in it not clearly demarcated from cephalic portion, though slight line-like constriction noticed on the both sides. Metasome slightly narrower than the posterior portion of cephalothorax, about 2 times as wide as long. Urosome about half as wide as metasome, 3-segmented; the first wider distally, with 2 spines of different sizes representing rudimentary third leg at each postero-lateral corner; the second slightly wider than long, naked; anal segment longer than wide, ornamented with a transverse row of lamellate denticles on the ventral side.

First antenna (Fig. 21B) ca. 70 μm long excluding setae, more or less depressed and 5-segmented; the first short, almost completely coalesced with the long second; distal 3 segments combined together as long as the second; setal formula of segments 0, 3, 3+1 aesthete, 2+1 aesthete, 7+1 aesthete; aesthetes lamellate. *Second antenna* (Fig. 21C) 5-segmented; the first broad, but short, unarmed; the second with a digitiform structure tipped by 2 short setae and representing rudimentary exopodite on the postero-distal margin; the third longer than wide, with a short seta on the ventral side; the fourth shorter than the third, with 2 short setae around the middle on the ventral surface and 2 longer setae at the dorso-distal corner; the fifth very short, plate-like, with 2 claws on the distal margin, longer one thinner than the shorter.

Labrum (Fig. 21D; Lr) wider than long, broadened distally and concaved at the middle of the distal margin to form 2 lateral lobes, unarmed. *Mandible* (Fig. 21D; Md) 2-segmented; basal segment broad, laid on the sternal surface, with a tissue mass representing degenerated basis and rami; distal segment lamellate, tapering distally into 2 short lashes and carrying a lamellate process near the base of its posterior margin; the lamellate process fringed with ca. 9 teeth along its posterior margin. *First maxilla* (Fig. 21D; Mx') composed of a broad basal portion, which is unarmed, and a knob-like distal portion which is armed with 3 setae, one on the outer proximal margin and 2 on the distal margin. *Second maxilla* (Fig. 21D; Mx'') 2-segmented; the first stout, thickened at the base, with a small projection tipped by a hairy seta on the medial margin; the second acuminate, with 4 spine-like teeth on the ventral side in the distal portion and 2 setae in the basal portion. *Maxilliped* (Fig. 21E; Mxp) in the form of a prominent appendage, 4-segmented; the first short, but broad, with a small projection tipped by a spine on the medial margin; the second long, about 2 times as long as wide, with 2 spines about the middle on the medial margin; the third very small, with a long spine at the postero-distal corner; the fourth forming a long spine-like process, with 2 spines at the middle and one spine on a point at proximal one-third.

First and second legs (Fig. 21F, G) biramous, almost equal in size and structure; each consisting of flattened, 2-segmented protopodite and 1-segmented rami; basis with a hairy seta on the outside and hairs on the medio-distal margin; rami longer than wide, with hairs on the medial margin of exopodite and the outer margin of endopodite in addition to plumose setae and spatulate spines with serrated membranes. Setal formulae of legs shown in Table 7. The fifth spine of exopodite

Table 7. Setal formulae of first 2 legs of the first copepodite of *Philoblenna arabici* Izawa.

	Protopodite coxa; basis	Endopodite seg. 1	Exopodite seg. 1
Leg 1	0-0; 0-1	7, 0	3, V
Leg 2	0-0; 0-1	3, III	3, IV

in first leg and the fourth exopodite spine in second leg lacking the membrane on the inside. Caudal ramus (Fig. 21H) longer than wide, fringed with fine spinules along the medio-distal margin and furnished with 6 spines; the longest one at the medio-distal corner ca. 100 μm long, longer than urosome, with a narrow membrane along each side and a joint near the middle; 3 spines on the distal margin and a spine at the middle on the outside somewhat degenerative, but each with an indistinct terminal blade.

Remarks. Though lecithotrophic, the nauplii of this species, which are probably consisting of 6 stages, are less simplified in spite of profound deformation in the adult female (the male is unknown). As seen from the descriptions dealt with here, both the nauplii and first copepodite of this species bear similarity with those of lichomolgids described here and described by Costanzo (1969) in many respects. This supports my suggestion of relationship between this species and the lichomolgid complex (Izawa, 1976c).

6. *Neanthessius renicolis* Izawa, 1976

(Figs 22-26)

Material. Egg sacs of several females taken out from the renal sacs of some individuals of a spindle whelk (gastropod mollusk), *Pleuroploca trapezium audouini* (Jonas), collected at Seto on October 1971, were used for rearing experiments.

The number of eggs per one sac is relatively small, about 30-50, but the eggs are larger, ca. $170 \times 130 \mu\text{m}$ on an average, and colored pale yellow due to a considerable amount of yolk. Eggs near hatching become translucent. Nauplii just hatched were able to swim and reached the first copepodid stage through five nauplius stages within 3 days without food and at 24-25°C. The survival rate of the first nauplii to the first copepodite was rather high. No pigment spots appeared throughout the observed stage. The first copepodites were capable of active swimming. As they still retained some yolk, many of them survived more than a week in the unfed state without showing any morphological changes, but gradually becoming almost transparent. This stage is clearly the infective stage as all of about 100 individuals, that were 2-3 days old, went into the host snails in a short time when the latters were introduced in the same container holding these copepodites.

First Nauplius Stage (Figs 22A; 23D; 24A, F).

Body length 182 μm , width 104 μm , depth or thickness 104 μm and length

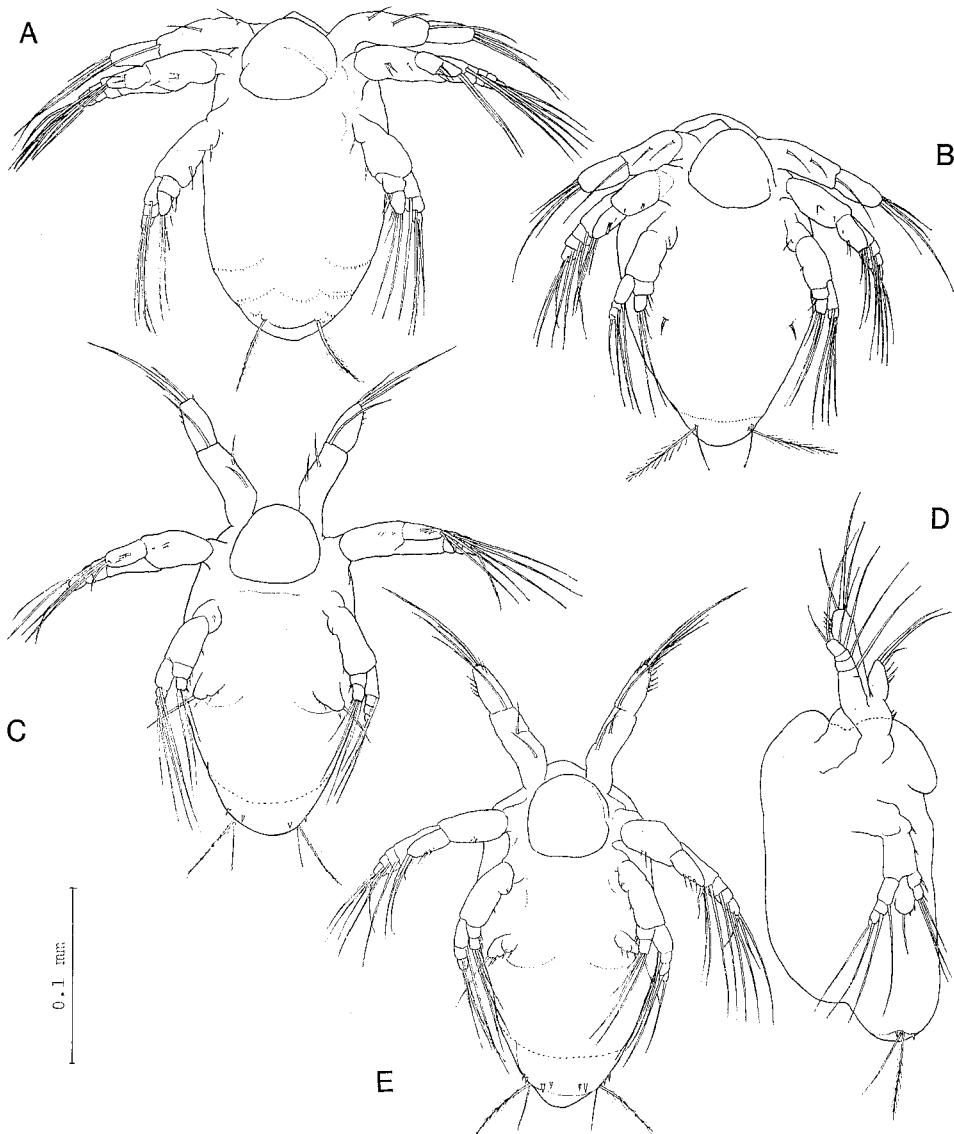


Fig. 22. Nauplii of *Neanthessius renicolis* Izawa. A. First nauplius, ventral; B. Second nauplius, ventral; C, D. Third nauplius, ventral and lateral; E. Fourth nauplius, ventral.

of dorsal shield $177\ \mu\text{m}$ on an average; much larger than in the corresponding stage of the previous species. Plump body (Fig. 22A) ovoid, a little elongated, ornamented with fine spinules which are roughly arranged in 2 transverse rows on the posterior ventral surface; furcal armature on the caudal margin consisting of a pair of hairy setae and a narrow membrane extended between the bases of setae and finely serrated marginally; no caudal process. *Labrum* not prominent, unarmed. *Labium* indiscernible.

First antenna (Fig. 23D) ca. $90\ \mu\text{m}$ long excluding setae, 3-segmented, some-

what flattened and furnished with short transverse rows of fine denticles on the anterior surface; the first short, unarmed; the second with 3 spinulate setae on the ventral margin, each arising from the proximal, middle and distal portions; the third slightly longer than a half of the second, apically with a shorter simple seta and a longer plumose one which is accompanied with a thin, but long, aesthete at the base. *Second antenna* (Fig. 24A) ca. 100 μm long excluding setae; segments more or less flattened and furnished with short transverse rows of fine denticles on the anterior surface; spines on the medial margin of protopodite and endopodite less developed. Coxa indistinctly separated from both of the sternal surface and basis, with a slight spinulose bulge near the medial margin on the posterior surface,

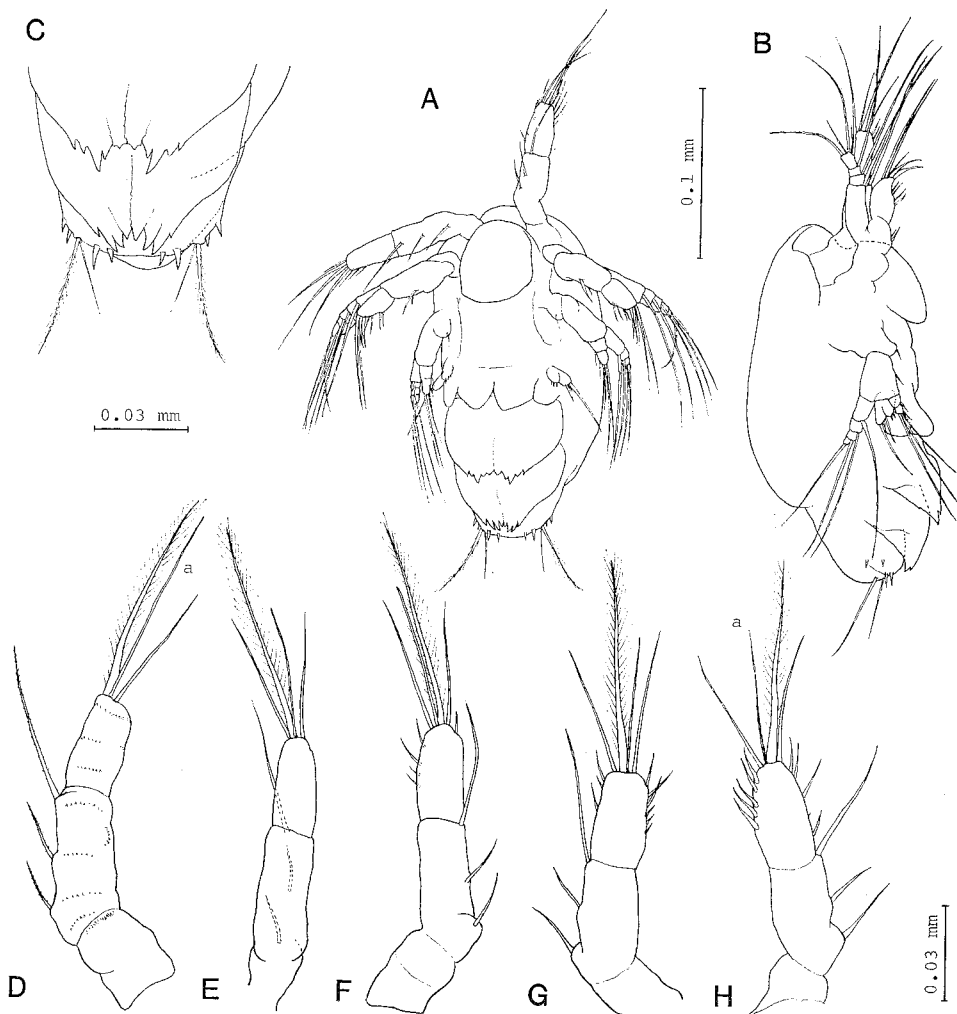


Fig. 23. Nauplii of *Neanthessius venicolis* Izawa. A, B. Fifth nauplius, ventral and lateral; C. Posterior portion of the fifth nauplius, ventral; D-H. First antennae of first (D) to fifth (H) nauplii; D (1st) & G (4th), anterior; E (2nd), dorsal; F (3rd) & H (5th), posterior.

but without any other spine. Basis almost as long as wide, with 3 short spines on the medial margin, 2 of which are placed almost at the middle and the other near the distal end. Endopodite unsegmented, almost as long as basis, with 2 spines at the middle of the medial margin and 2 simple setae at the distal end. Exopodite issuing from the outer half of the dented distal margin of basis, 5-segmented; the first indistinctly separated from basis, as long as the latter and slightly shorter than combined length of distal 4; each segment with a plumose seta at the medio-distal corner, only terminal segment with an additional simple seta at the outer-distal corner. *Mandible* (Fig. 24F) ca. 80 μm long excluding setae; segments more or less flattened and furnished sparsely with short transverse rows of fine denticles on the anterior surface; spines on the medial margin of protopodite and endopodite less developed. Coxa short, with the medial margin rounded and tipped with a short spine. Basis longer than wide, with 2 spinules of different lengths at the middle of the medial margin. Endopodite 2-segmented; the first wider than long, with a simple spine and a spinulate one at the medio-distal corner; the second slightly longer, but narrower than the first, with a short simple spine and a longer spinulate one about the middle on the medial margin and 2 apical setae, the inner one spinulated and the outer plumose. Exopodite issuing from the distal margin of basis, almost as long as basis and relatively broad, 4-segmented; each segment with a plumose seta at the medio-distal corner.

Second Nauplius Stage (Figs 22B; 23E; 24B, G).

Body length 177 μm , width 92 μm , and length of dorsal shield 166 μm on an average. Body (Fig. 22B) slightly narrower in the posterior portion than in the first stage; transverse rows of fine spinules disappeared on the posterior ventral surface, instead with a pair of spines representing rudimentary first maxillae near the middle of the sternal surface; an additional pair of feeble simple setae in furcal armature.

First antenna (Fig. 23E) with an additional simple seta on the distal margin of terminal segment; transverse rows of fine denticles disappeared from the anterior surface. *Second antenna* (Fig. 24B), as in the first antenna, missing similar rows of fine denticles on the anterior surface. Two spinules and a spine newly appeared on endopodite, the formers are placed proximal to the base of 2 spines at the middle of the medial margin and the latter at the medio-distal corner. First segment of exopodite of this appendage indistinctly divided into 2 subjoints and with a simple setule on the medial margin at the distal end of the proximal subjoint; the border between fourth and terminal segments rather obscure; terminal segment with an additional setule between 2 apical setae, both plumose now. *Mandible* (Fig. 24G) slightly narrower than in the preceding stage, with an additional spine at the medio-distal corner on second endopodite segment; fine denticles on the anterior surface and one of the 2 spines on the medial margin of basis disappeared. Setation of exopodite the same as in the first stage.

Third Nauplius Stage (Figs 22C, D; 23F; 24C, H, K).

Body length $191\ \mu\text{m}$, width $106\ \mu\text{m}$ and length of dorsal shield $167\ \mu\text{m}$ on an average. Body (Fig. 22C, D) somewhat slenderer than in previous stages, with rudimentary first maxilla which is represented by a small prominence on the sternal surface and armed with spines; 2 pairs of spinules appeared newly in furcal armature. *Labrum* as in the second stage.

First antenna (Fig. 23F) with 5 additional spinules on terminal segment, one

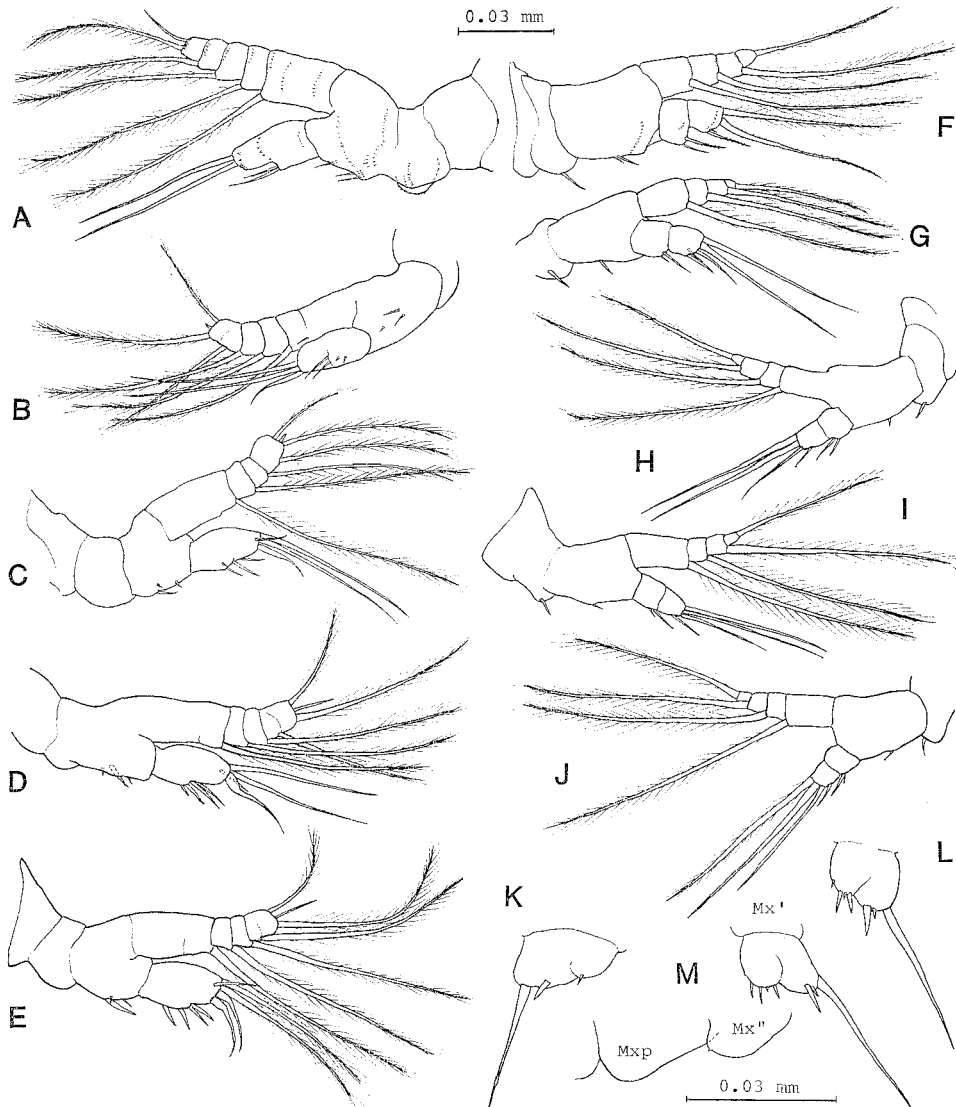


Fig. 24. Naupliar appendages of *Neanthessius renicolis* Izawa. A-E. Second antennae of first (A) to fifth (E) nauplii; A (1st) & D (4th), anterior; B (2nd), anteroventral; C (3rd) & E (5th), posterior; F-J. Mandibles of first (F) to fifth (J) nauplii, anterior; D-M. First maxillae of third (K) to fifth (M) nauplii, ventral; M, with rudimentary second maxilla and maxillipeds in situ.

of them placed at the ventrodistal corner, the rest arranged on the dorsal margin longitudinally. *Second antenna* (Fig. 24C) with a thin additional setule at the postero-distal corner of endopodite; the subterminal setule found in the second stage on the medial margin of first exopodite segment disappeared. *Mandible* (Fig. 24H) slightly altered; 2 spines on protopodite diminished the size, smaller one of the 2 spines at the middle of second endopodite segment disappeared. *First maxilla* (Fig. 24K) wider than long, indistinctly divided into 2 lobes by a slight constriction on the posterior margin, armed with a spine on the inner lobe and 2 spines on the outer lobe.

Fourth Nauplius Stage (Figs 22E; 23G; 24D, I, L).

Body length 188 μm , width 102 μm and length of dorsal shield 166 μm on an average. Body (Fig. 22E); this stage is definable clearly by an addition of 2 pairs of spinules along the caudal margin.

First antenna (Fig. 23G); lateral spinules of terminal segment increased to 3 on the ventral and to 5 or 6 on the dorsal margin. *Second antenna* (Fig. 24D); setation roughly as in the third stage, though the simple setule between the 2 plumose setae on the distal margin of terminal exopodite segment growing larger and the spine at the medio-distal corner of endopodite becoming stouter than in preceding stage. *Mandible* (Fig. 24I) as in the third stage. *First maxilla* (Fig. 24L) somewhat narrowed at the base; lobation clearer than in the preceding stage with deepening of the distal constriction; spinules on the distal margin increased to 7 inclusive of longer one.

Fifth Nauplius Stage (Figs 23A-C, H; 24E, J, M).

Body length 205 μm , width 98 μm and length of dorsal shield 164 μm on an average. Body (Fig. 23A-C) longer than in the preceding stage for elongation of the caudal portion protruded beyond the posterior edge of dorsal shield; furcal armature as in the fourth stage. Rudiments of second maxilla, maxilliped and anterior 2 legs appeared on the posterior ventral side, each as a cuticular sac protruded from sternal surface and partly overlapping posteriorly one another. *Labrum* retaining the same feature through the five nauplius stages, but *labium* undefined throughout.

First antenna (Fig. 23H) with 2 additional spinules on the ventro-proximal margin of terminal segment; all spinules on the distal half of the ventral margin and on the dorsal margin of terminal segment nearly equal in size. *Second antenna* (Fig. 24E) with 2 claw-like spines at the medio-distal corner of endopodite, representing the precursors of 2 apical claws of second antenna in first copepodite. *Mandible* (Fig. 24J) almost the same as in the fourth stage, but one of the 2 medio-distal spinules of first endopodite segment reduced. *First maxilla* (Fig. 24M; Mx'); ornamentation as in the preceding stage, though the lobation clearer. Rudiment of *second maxilla* (Fig. 24M; Mx'') situated laterally to that of *maxilliped* (Fig. 24M; Mxp); smaller than the latter, with minute projection at the medio-distal corner; rudimentary maxilliped broadened basally and thus both components touching

each other medially.

Each of first two legs (Fig. 23C) represented by a similar broad cuticular sac which is indented distally and divided into two parts (paired legs) by an indistinct suture; each part split further by a suture into 2 areas that show endopodite and exopodite. In a later phase of this stage, second maxilla, maxilliped and 2 pairs of legs of first copepodite are seen through the cutilce inside respective rudiments.

First Copepodid Stage (Figs 25A-E; 26A-D).

Body length excluding caudal ramus $281 \mu\text{m}$; length of cephalothorax $159 \mu\text{m}$, width $91 \mu\text{m}$ and thickness $85 \mu\text{m}$ on an average. Body (Fig. 25A-C) slim, consisting of elongate cephalothorax, metasome of second pedigerous segment and urosome sharply narrowed. Cephalothorax including first pedigerous segment distinctly separated from the other portion by a dorsal suture, longer than a half of body; posterior pedigerous portion about one third as long as anterior cephalic portion. Metasome wider than long, but slightly narrower than in pedigerous

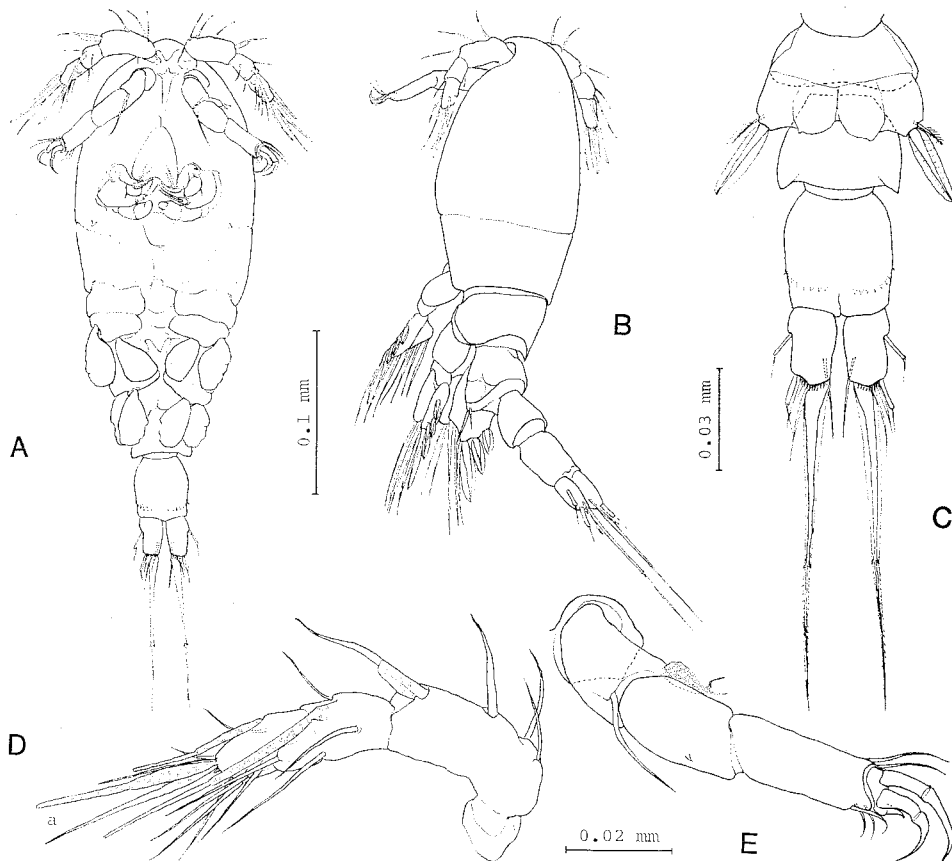


Fig. 25. First copepodite of *Neanthessius renicolis* Izawa. A, B. Total individual, ventral (ornamentation of legs omitted) and lateral; C. Urosome, ventral; D. First antenna, ventral; E. Second antenna, medio-ventral.

portion of cephalothorax. Urosome (Fig. 25C) 3-segmented; anterior 2 wider than long and broader distally; the first with rudimentary third leg; the second naked; anal segment longer than wide, ornamented with a transverse row of denticles on the posterior ventral surface but near the median line.

Rostrum small, with the distal margin bluntly pointed. *First antenna* (Fig. 25D) somewhat flattened and 4-segmented; the first short; the second broad and as long as distal 2 combined together; setal formula of segments 0, 4+1 aesthete, 3+1 aesthete, ca. 8+1 aesthete; aesthete lamellate. *Second antenna* (Fig. 25E) 5-segmented; proximal 2 and distal 3 segments probably representing protopodite and endopodite respectively; the first short, almost completely coalesced with the sternal surface, unarmed; the second longer than wide, provided at the outer-distal corner with a small digitiform structure tipped with 2 setules, probably representing rudimentary exopodite, with a long seta at the ventro-distal corner; the third almost as long as the second, with a spinule on the ventral side; the fourth longer, but narrower than proximal 3, with 3 setules at the medio-distal corner and 2 feeble

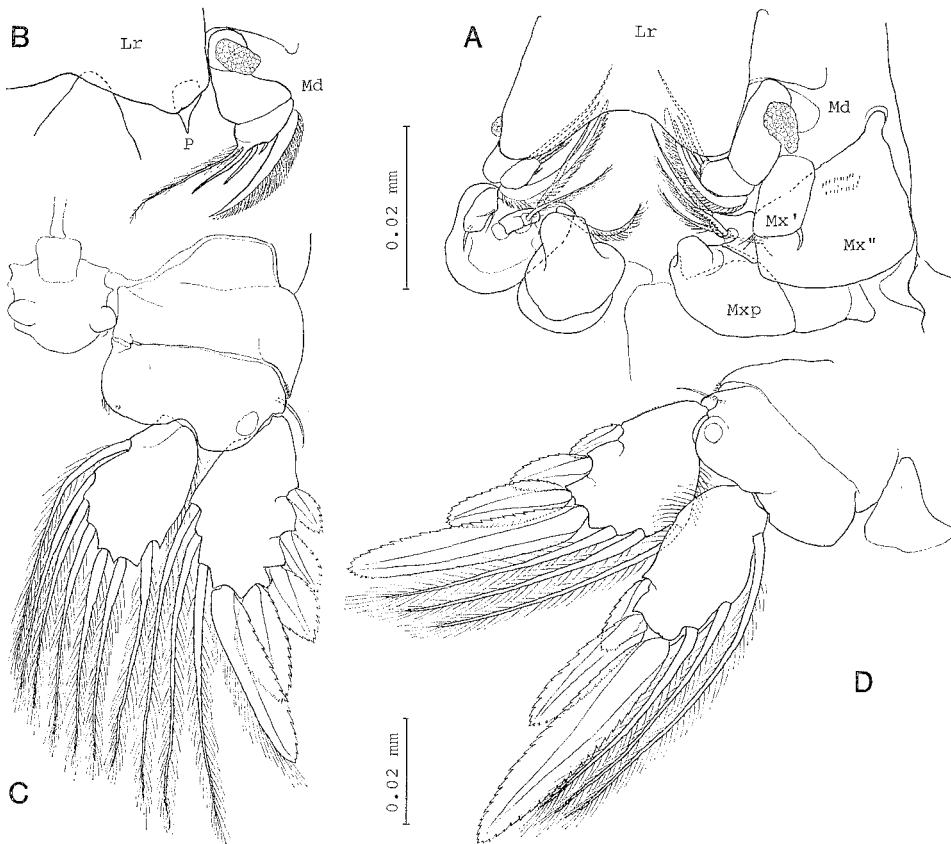


Fig. 26. First copepodite of *Neanthessius venicolis* Izawa. A. Labrum and oral appendages in situ, ventral; B. Mandible and paragnath in situ, ventral; C. First leg, ventral; D. Second leg, ventral.

setae at the outer-distal corner; the fifth very short, ending in 2 articulate claws and a small, sharply pointed claw-like projection.

Labrum (Fig. 26A; Lr) longer than wide, broader distally and concaved at the middle on the distal margin, unarmed. *Mandible* (Fig. 26A, B; Md) lamellate, composed of 2 portions; proximal portion elongate, with a tissue mass (rudimentary basis and rami) near its base; distal portion as wide as the proximal at the base, but soon narrowed distally and ending in 4 unequal lashes, the posteriormost short and setule-like, while the anteriormost longest and with hairs; distal portion further with a lamellar process which arises from the posterior edge near its base and extends along the posterior margin; the lamellar process pectinate, with ca. 30 thin teeth posteriorly. *Paragnath* (Fig. 26B; P) represented as a small, posteriorly pointed unarmed process. *First maxilla* (Fig. 26A; Mx') 1-segmented, oblong and more or less flattened antero-posteriorly, with a small slightly sclerotized setiform process at the outer-distal corner and 2 setules at the medio-distal corner. *Second maxilla* (Fig. 26A; Mx'') 2-segmented; the first massive, with a subterminal hairy seta on the medial margin and a patch of fine spinules basally on the antero-lateral margin; the second small, narrowed distally, with a simple spine at the tip and a hairy seta about the middle of the posterior margin. *Maxilliped* (Fig. 26A; Mxp) digitiform, 3-segmented and unarmed; proximal 2 almost equal in length, the third small and almost completely coalesced with the second, looking like a terminal knob of the latter.

Anterior 2 pairs of legs (Fig. 26C, D) biramous, almost the same in size and structure; each consisting of flat protopodite and 2-segmented and 1-segmented rami. Coxa with fine spinules at the distal edge of the outside. Basis with a seta on the outer side; basis of first leg with some hairs around the medio-distal corner. Rami longer than wide; with hairs on the medial margin of exopodite and on the outer margin of endopodite and spatulate spines on the exopodite of first leg and both rami of second leg in addition to plumose setae; setal formulae shown in Table 8. Only the fifth spine of exopodite of first leg with hairs instead of a membrane along the inside. Rudimentary third legs (Fig. 25C) represented as a pair of ventro-posterior protrusions from first urosomal segment each furnished with a small hairy seta and a spatulate spine at the postero-lateral corner; 2 portions respectively corresponding to exopodite and endopodite clearly demarcated on the ventral side.

Caudal ramus (Fig. 25C) longer than wide, fringed with fine spinules along the

Table 8. Setal formulae of first 2 legs of the first copepodid stage of *Neanthesius renicolis* Izawa.

	Protopodite coxa; basis	Endopodite seg. 1	Exopodite seg. 1
Leg 1	0-0; 0-1	7, 0	3, V
Leg 2	0-0; 0-1	3, III	3, IV

distal margin of the ventral side, furnished with 6 spines in all; the longest one placed at the medio-distal corner, as long as urosome, with a narrow membrane along each side and a joint near the middle; two spines, one placed near the base of the outside and the other at the outer distal corner, armed with a fine blade terminally.

7. *Panaietis yamagutii* Izawa, 1976

(Figs 27–33)

Material. Egg sacs of several females taken out from the buccal cavities of some individuals of a horned turban (gastropod mollusk), *Batillus cornutus* (Lightfoot), collected at Kiinagashima, Mie Prefecture, in September 1975, were used for rearing larvae. The third copepodid larvae described here were collected from the same individuals of host.

Eggs large, $145 \times 134 \mu\text{m}$ on an average, containing a large amount of yolk; colored pale orange, but becoming translucent just before hatching. Hatched nauplii were able to swim and reached the first copepodid stage within 5 days through 5 nauplius stages at 18° – 24°C , without feeding as in *Neanthessius renicolis*. The rate of nauplii attained to the first copepodid stage was rather high. No pigment spots appeared throughout these stages except for red eye pigments of the first copepodite. The first copepodites were swimming actively. They still retained a considerable amount of yolk and survived for 1–3 weeks unfed, without showing any morphological changes, but finally became almost transparent.

First Nauplius Stage (Figs 27A, B; 29A, B, G; 30A).

Body length $164 \mu\text{m}$, width $99 \mu\text{m}$ and length of dorsal shield $160 \mu\text{m}$ on an average. Body (Fig. 27A, B) plump and ovoid, furnished with a few transverse rows of fine spinules on the postero-ventral surface; furcal armature consisting of a pair of hairy setae and a crescent-shaped membrane laid between these setae and marginally pectinated. *Labrum* not prominent, unarmed. *Labium* indiscernible.

First antenna (Fig. 29A, B) ca. $90 \mu\text{m}$ long excluding setae, somewhat flattened and covered with short transverse rows of fine denticles on the surface, 3-segmented; the first short, without seta; the second long, with 3 spinulate setae on the ventral margin, each placed basally, medially and distally; the third about two third as long as the second, ending in 2 setae, longer one of which is spinulated and accompanied with a thin, but long aesthete at the base. *Second antenna* (Fig. 29G) $100 \mu\text{m}$ long excluding setae; segments more or less flattened and covered on the anterior surface with short transverse rows of fine denticles; spines on the medial margin of protopodite less developed. The medial margin of coxa rounded and tipped with a short spine; the border between coxa and sternal surface indistinct. Basis slightly wider than long, provided with 2 short spines on the medial margin proximally and a similar one distally. Endopodite 1-segmented, almost as long as basis, with a simple spine and a spinulate one at the middle of the medial margin and 2 spinulate setae at the distal end. Exopodite 5-segmented; the first slightly longer than either basis or distal 4 combined together; each segment with a plumose seta at the medio-

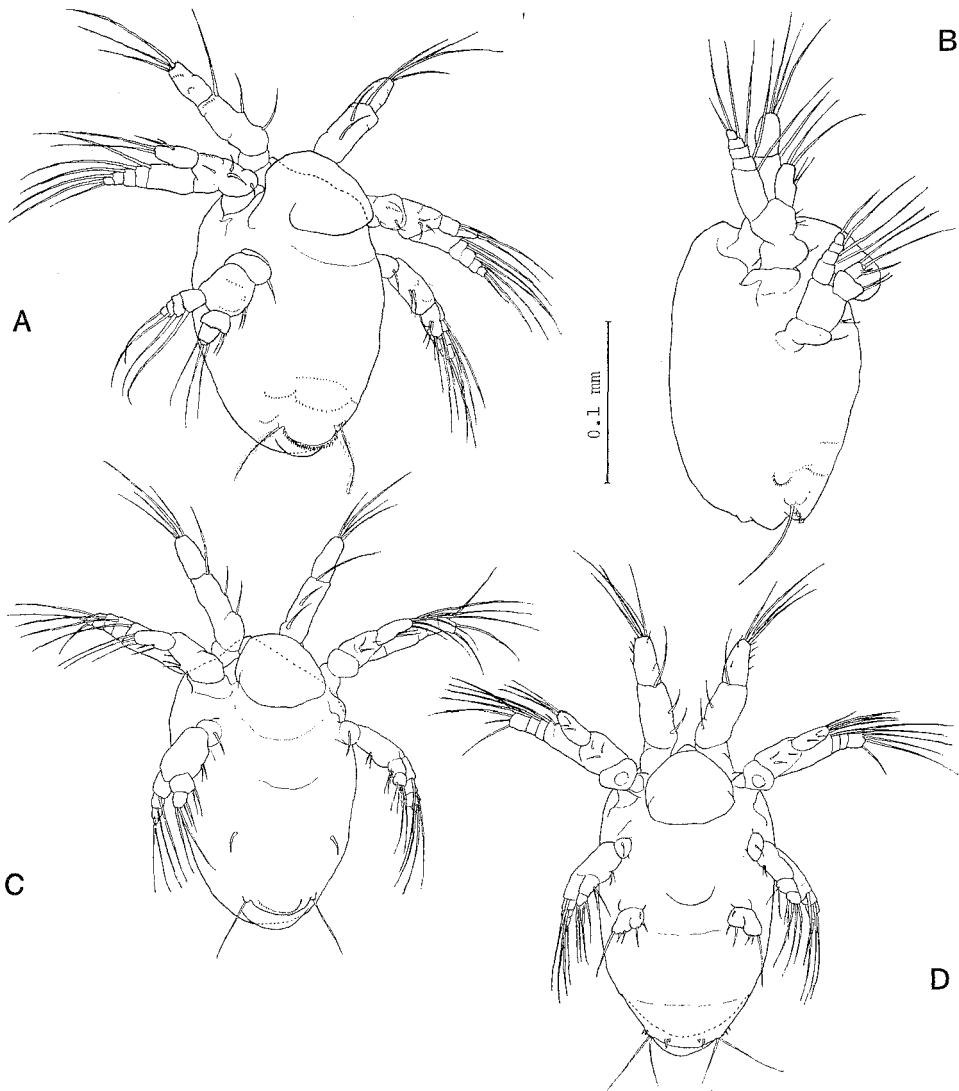


Fig. 27. First to third nauplii of *Panaietis yamagutii* Izawa. A. First nauplius, ventro-lateral; B. The same, lateral; C. Second nauplius, ventral; D. Third nauplius, ventral.

distal corner, but terminal segment with an additional short spinulate seta at the outer distal corner. *Mandible* (Fig. 30A) ca. $80\ \mu\text{m}$ long excluding setae; segments more or less flattened and furnished on the anterior surface with fine denticles as in antennae; spines on the medial margin of protopodite and endopodite less developed. Coxa short, with a spine on the slightly expanded medial margin. Basis broad, but slightly longer than wide, with 2 short spines at the middle on the medial margin. Endopodite 2-segmented; the first almost 2 times as wide as long, with 2 spinulate spines at the medio-distal corner; the second jointed to the distal margin of the first but biasing outwards, longer than the first and about half as wide as the

latter, with a spinulate spine and a short simple one subterminally on the medial margin and 2 apical setae, the medial one spinulate, while the other plumose. Exopodite issued from the distal margin of basis, 4-segmented and as long as basis; first three segments with a plumose seta on each medio-distal corner, the terminal segment with a plumose seta apically.

Second Nauplius Stage (Figs 27C; 29C, H; 30B).

Body length $157\ \mu\text{m}$, width $94\ \mu\text{m}$ and length of dorsal shield $154\ \mu\text{m}$ on an average. Body (Fig. 27C) ovoid, with rudimentary labium as a slight bulge on the sternal surface, armed with a pair of spines which are situated posterior to the labium and foreshow first maxillae; transverse rows of fine spinules on the

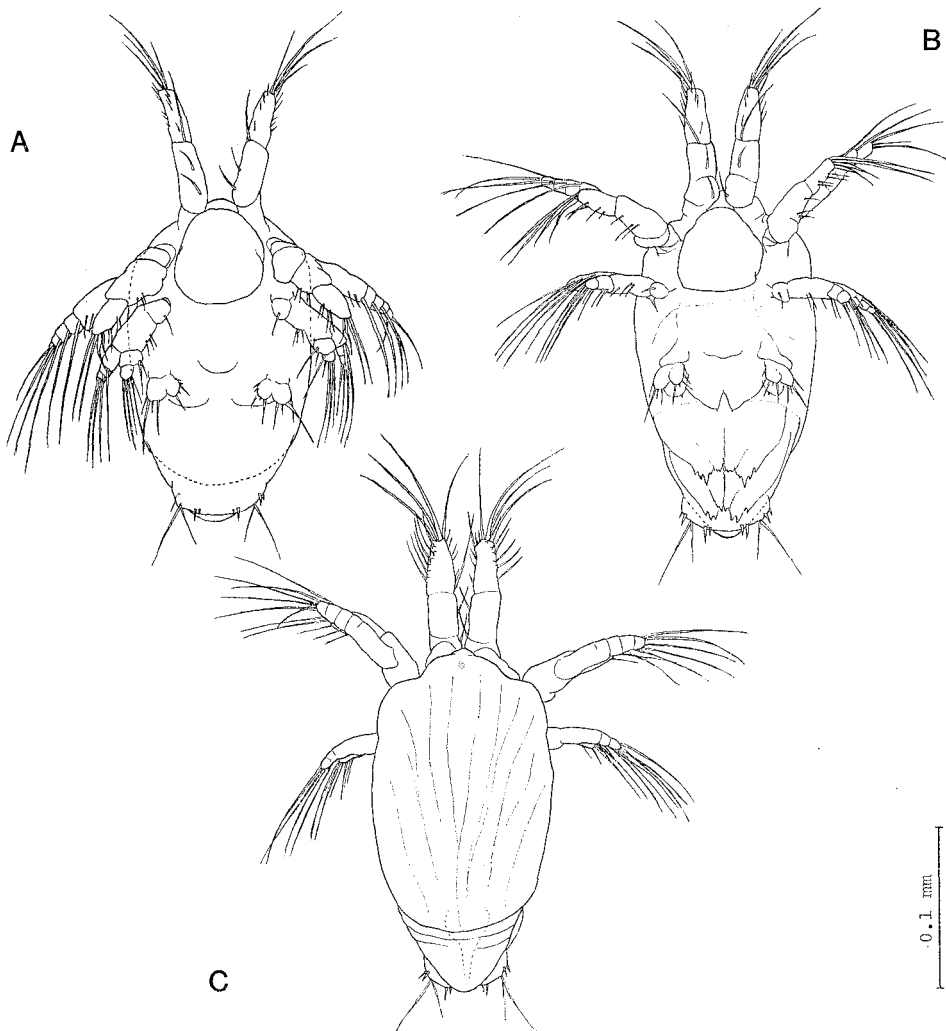


Fig. 28. Fourth and fifth nauplii of *Panaietis yamagutii* Izawa. A. Fourth nauplius, ventral; B, C. Fifth nauplius, dorsal and ventral.

posteroventral surface disappeared. Labrum and furcal armature almost as in the first stage.

First antenna (Fig. 29H) with addition of a simple apical seta; transverse rows

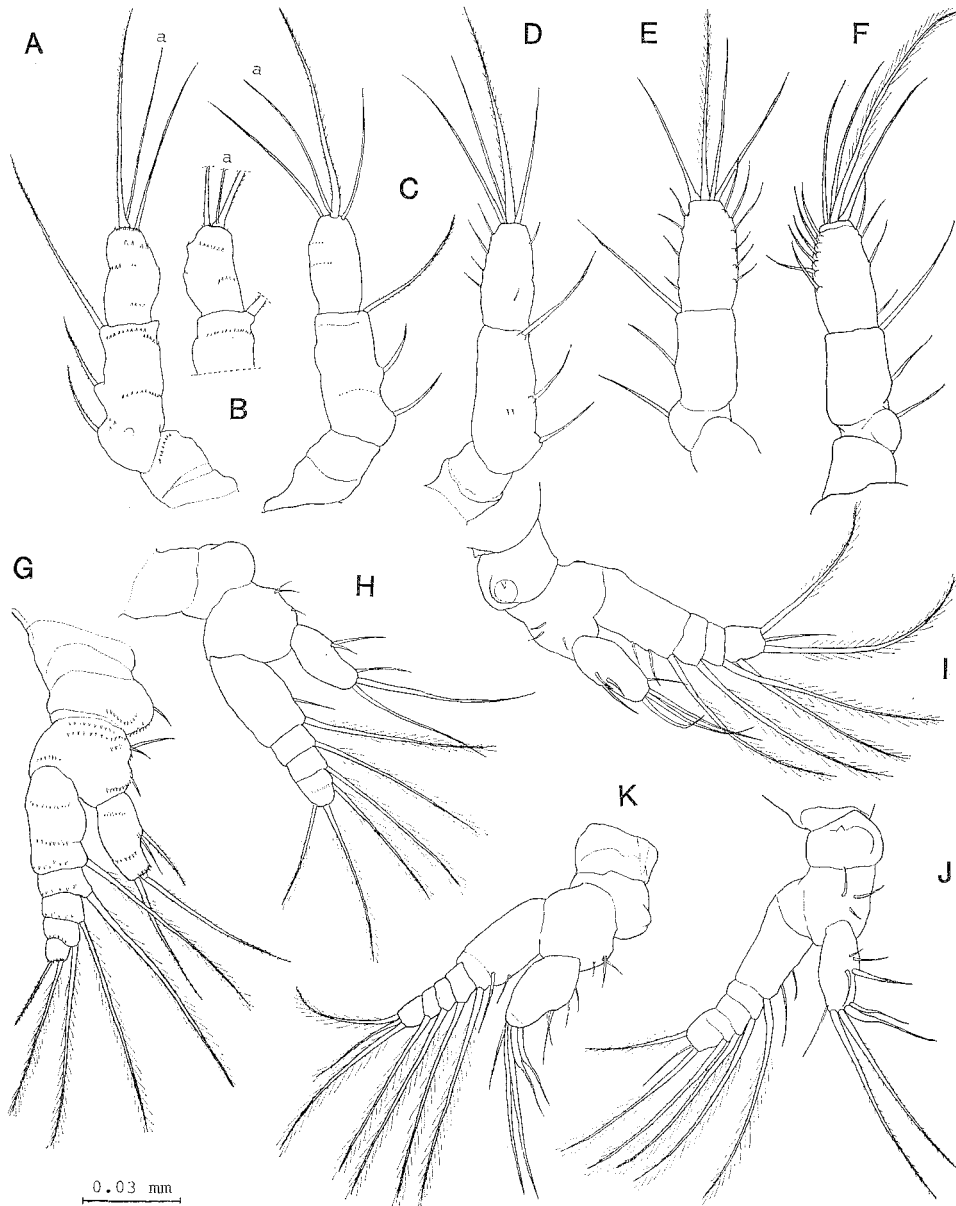


Fig. 29. Naupliar appendages of *Panaietis yamagutii* Izawa. A. First antenna of first nauplius, anterior; B. Distal portion of the first antenna of first nauplius, posterior; C-F. First antennae of second (C) to fifth (F) nauplii, posterior; G-K. Second antennae of first (G) to fifth (K) nauplii; G (1st) & K (5th), anterior; H (2nd) & I (3rd), posterior; J (4th), ventro-posterior.

of fine denticles disappeared. *Second antenna* (Fig. 29H) with addition of a sub-terminal setule on the medial margin of first exopodite segment and a spine at the medio-distal corner of endopodite, but missing fine denticles on the surface and a spine on coxa; joint between distal 2 exopodite segments obsolete, all spines and setae of endopodite simple. *Mandible* (Fig. 30B) missing fine denticles on the surface, but with addition of a setule at the middle of the medial margin of first exopodite segment and a seta-like spine at the medio-distal corner of second endopodite segment now as long as the first segment; all spines and setae, but except for an apical seta, of endopodite simple in this stage.

Third Nauplius Stage (Figs 27D; 29D, I; 30C, F).

Body length 185 μm , width 106 μm and length of dorsal shield 175 μm on an average. Body (Fig. 27D) slightly more elongated than in the preceding stage; furcal armature with addition of a pair of thin setae and 4 pairs of spinules, a crescent-shaped membrane between the hairy setae in previous stage disappeared. First maxilla as a small appendage with a free segment. *Labrum* and *labium* as in second stage.

First antenna (Fig. 29D) with 6 additional spinules on terminal segment, 4 along the dorsal margin, one near the ventro-distal corner and one on the posterior side near the base. *Second antenna* (Fig. 29I): A setule added onto the middle of the medial margin of first exopodite segment, between 2 plumose setae on the distal end of terminal exopodite segment, and the outer distal corner of endopodite; a short spine added onto the middle of the medial margin of endopodite, proximal to 2 spines. *Mandible* (Fig. 30C) almost the same as in the second stage. *First maxilla* (Fig. 30F) ca. 20 μm long excluding setae, indistinctly 2-segmented; the first very short, almost completely fused to the sternal surface; the second wider than long, divided into smaller medial and larger lateral lobes by a constriction; the medial lobe with 2 short stout spines on the medial margin, while the lateral with 2 short spines and a long one on the distal margin.

Fourth Nauplius Stage (Figs 28A; 29E, J; 30D, G).

Body length 199 μm , width 106 μm and length of dorsal shield 173 μm on an average. General body appearance very similar to that of the third stage. Rudimentary second maxillae (Fig. 28A) represented by a pair of faint bulges of the sternal surface just posterior to first maxilla; the caudal portion, protruded beyond dorsal shield, a little more elongated than in third nauplius; furcal armature as in the preceding stage.

First antenna (Fig. 29E); spinules of terminal segment increased to 4 on the ventral and to 6 on the dorsal margin. *Second antenna* (Fig. 29J); endopodite with addition of 2 spines, a short one at basal one third on the medial margin and the other at the distal end of the same margin basally to the apical tuft; 2 medial spines of apical tuft thickened in the basal half. *Mandible* (Fig. 30D) with a short additional spine distally on the medial margin of basis. Four more spinules appeared in *first maxilla* (Fig. 30G), one of them placed on the outside of lateral lobe, the rest on the medial margin of

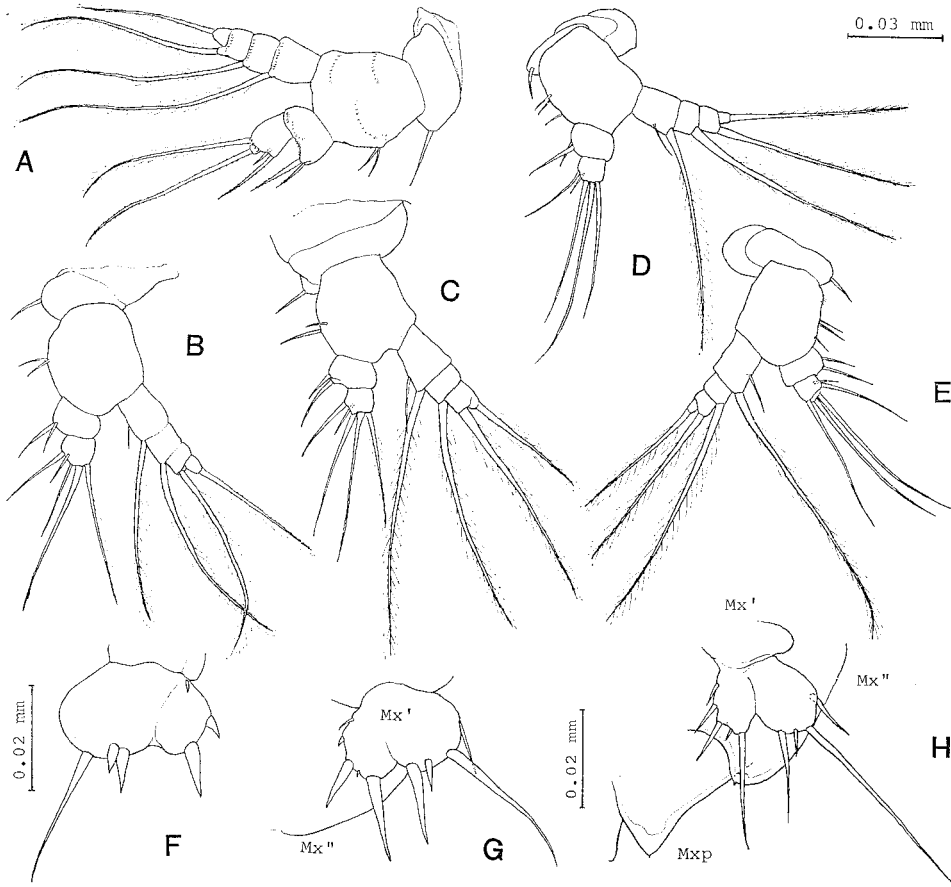


Fig. 30. Naupliar appendages of *Panaietis yamagutii* Izawa. A–E. Mandibles of first(A) to fifth(E) nauplii; A(1st), C(3rd), D(4th) & E(5th), anterior; B(2nd), posterior; F–H. First maxillae of third(F) to fifth(H) nauplii, ventral; G, together with rudiments of second maxilla in situ; H, together with rudiments of second maxilla and maxilliped in situ.

medial lobe.

Fifth Nauplius Stage (Figs 28B, C; 29D, K; 30E, H).

Body length 208 μm , width 105 μm and length of dorsal shield 170 μm on an average. Body (Fig. 28B, C) a little more elongated than in the preceding stage with elongation of the caudal portion protruded beyond dorsal shield; with four pairs of cuticular sacs on the sternal surface, which represent rudiments of second maxillae, maxilliped and anterior 2 legs; furcal armature as in fourth nauplius. Labrum and rudimentary labium as in the preceding stage.

First antenna (Fig. 29F); setation as in the preceding stage, but spinules on the dorsal and ventral sides of terminal segment almost the same in size. *Second antenna* (Fig. 29K); setation also as in the preceding stage; distal part of first exopodite segment defined as a short subsegment by a subterminal suture at the level of the

penultimate seta on the medial margin; in old individuals, 2 terminal claws of second antenna of first copepodite seen inside 2 medial spines with the base thickened, of apical tuft. *Mandible* (Fig. 30E) as in fourth nauplius. *First maxilla* (Fig. 30H; Mx') with a knob-like lateral projection on first segment; lobation of second segment more distinct than in the fourth stage; spinulation as in the preceding stage, though all elements a little more developed. Rudiments of *second maxilla, maxilliped* (Fig. 30H; Mx'' & Mxp) and anterior 2 pairs of legs (Fig. 28C) structured principally the same as in *Neanthesius renicolis*.

First Copepodid Stage (Figs 31A–C; 32A–F).

Body length excluding caudal ramus 276 μm , cephalothorax 153 μm in length and 97 μm in width on an average. Cephalothorax, metasome and urosome demarcated clearly as in the previous species (Fig. 31A–C). Cephalothorax inclusive of distinctly definable first pedigerous segment, longer than metasome plus urosome; first pedigerous portion occupying about a quarter of the length of cephalothorax and slightly narrower than cephalic portion. Metasome, the second pedigerous segment, much wider than long, slightly narrower than the first pedigerous portion of cephalothorax. Urosome sharply narrowed, 3-segmented; the first wider distally, with rudimentary third legs; the second naked; anal segment longer than wide, with a transverse row of fine denticles on the ventral surface.

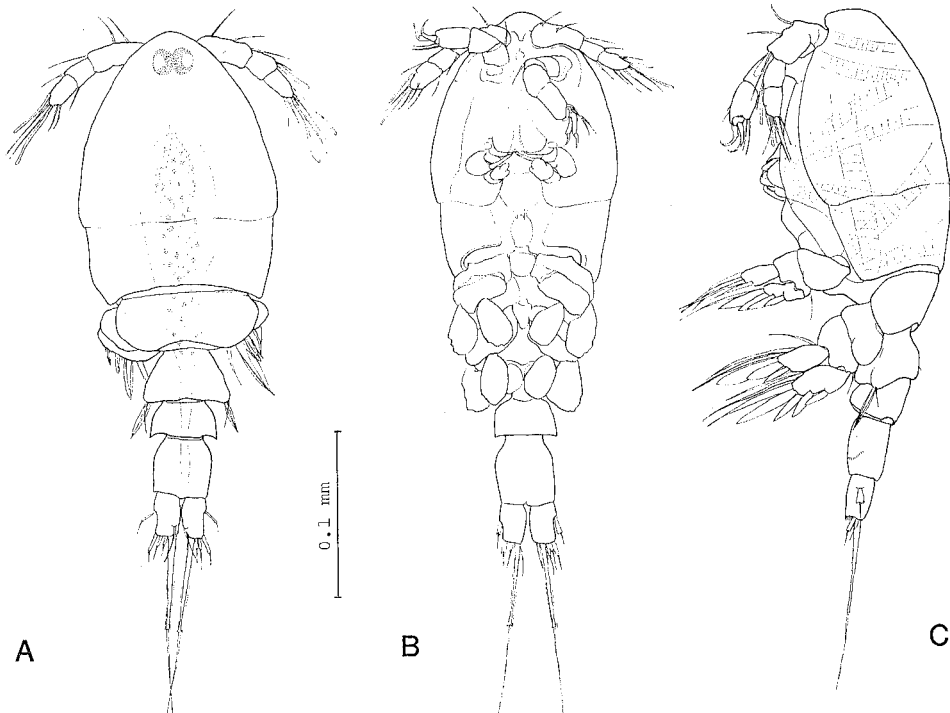


Fig. 31. First copepodite of *Panaietis yamagutii* Izawa. A–C. Total individual, dorsal, ventral (ornamentation of legs omitted) and lateral.

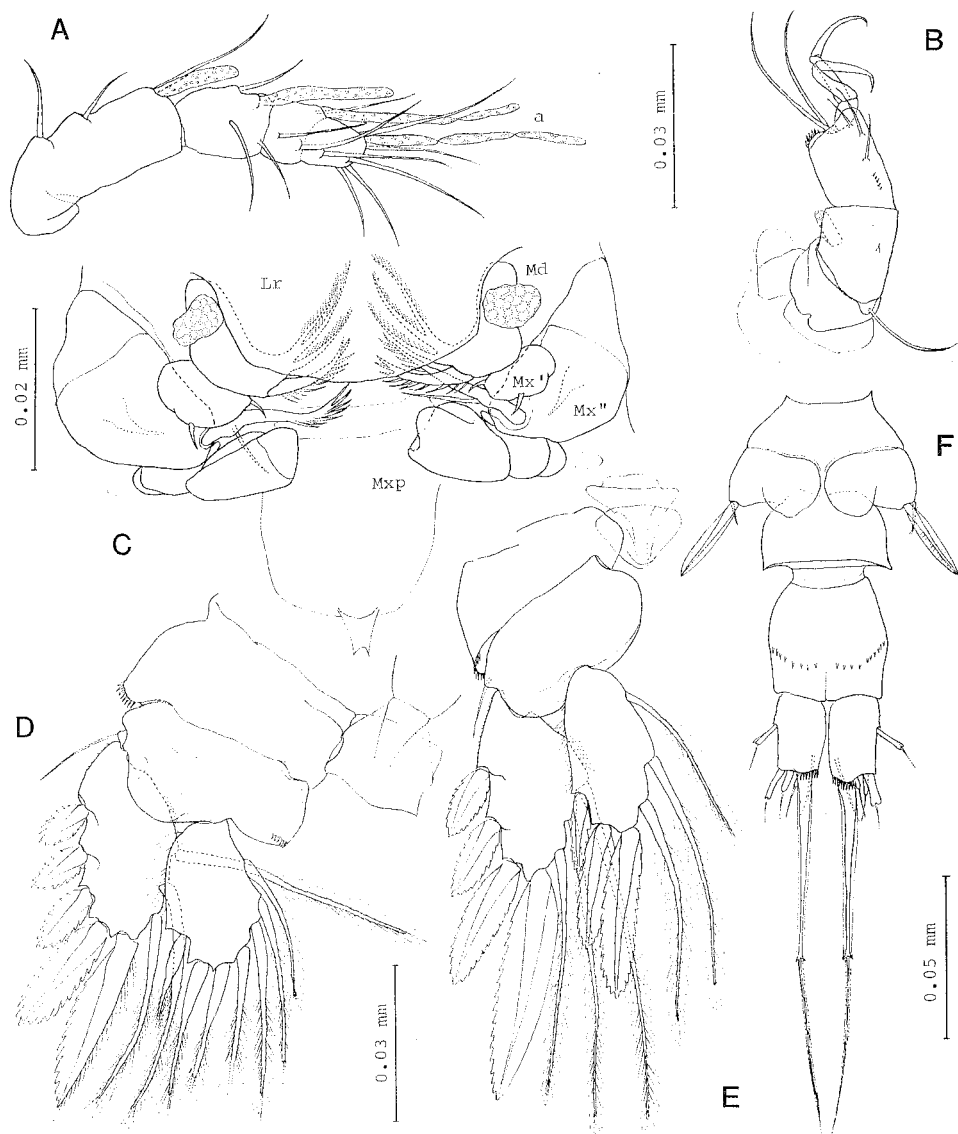


Fig. 32. First copepodite of *Panaietis yamagutii* Izawa. A. First antenna, ventral; B. Second antenna, medio-ventral, magnified as in A; C. Labrum and oral appendages in situ, ventral; D. First leg, ventral; E. Second leg, ventral; F. Urosome, ventral.

Rostrum with the bluntly pointed posterior margin. *First antenna* (Fig. 32A) more or less flattened, 5-segmented, but borders respectively between first and second segments and fourth and fifth segments indistinct; setal formula throughout segments 0, 3+1 aesthete, 3+1 aesthete, 3+1 aesthete, 3+1 aesthete and 6+1 aesthete; aesthete lamellate. *Second antenna* (Fig. 32B) 5-segmented; the first short, but broad, almost completely fused to the sternal surface, unarmed; the second with a small digitiform structure representing rudimentary exopodite at the outer

distal corner and a seta at the medio-distal corner; the third almost as long as the second, with a spinule near the middle on the ventral margin; the fourth slightly longer than the third, furnished with several fine spinules and 2 setae around the dorso-distal corner, 3 short setae on the distal half of ventral margin, and a row of some 5 fine spinules on the rest of ventral margin; the fifth very small, more or less flattened dorso-ventrally, with 2 articulate claws on the distal margin.

Labrum (Fig. 32C; Lr) about 2 times as wide as long, with the posterior margin slightly rounded, unarmed. *Mandible* (Fig. 32C; Md) lamellate and 1-segmented; the proximal half with a structure representing rudiment of basis and rami combined together; the distal half bent sharply and narrowed into 3 hairy lashes, furnished postero-basally with a lamellate process fringed with ca. 9 thin teeth along the posterior margin. *First maxilla* (Fig. 32C; Mx') lobular, somewhat flattened antero-posteriorly, with one setule on both medial and distal margins. *Second maxilla* (Fig. 32C; Mx'') 2-segmented; the first stout, broadened basally, with a setiform process on the medial margin near the base; the second in the form of a narrow tapering process furnished with ca. 6 thin teeth distally and a seta proximally. *Maxilliped* (Fig. 32C; Mxp) indistinctly 3-segmented, unarmed; the first somewhat compressed antero-posteriorly; the second thicker distally; the third small, almost completely coalesced with the second to form a terminal knob of the latter.

Anterior 2 pairs of legs (Fig. 32D, E) biramous, almost the same in size and structure; each consisting of flattened 2-segmented protopodite and 1-segmented rami. Coxa with spinules around the outer distal corner. Basis with a seta on the outer margin; in first leg, with spinules at the medio-distal corner. Endopodite with hairs on the outer margin; exopodite with hairs on the medial margin and fine spinules in addition to plumose setae and spatulate spines with serrated membranes on the outer margin; setal formulae of legs shown in Table 9. Only the fifth spine of exopodite in first leg with hairs instead of membrane along the inside. Rudimentary third legs (Fig. 32F) represented as a pair of ventro-posterior lobular expansions of first urosomal segment; each indistinctly divided into medial and lateral lobes which represent endopodite and exopodite respectively, the latter with a short hairy seta and a spatulate spine at the outer distal corner.

Caudal ramus (Fig. 32F) longer than wide, fringed with a row of fine spinules on the inner distal margin on the ventral side and armed with 6 spines; the innermost one of distal spines longest, jointed about the middle, furnished with a narrow membrane on both lateral sides of the basal half and accompanied with a simple seta at the dorsal base; the other 4 spines somewhat lamellate and with a fine ter-

Table 9. Setal formulae of the first 2 legs of first copepodite of *Panaetis yamagutii* Izawa.

	Protopodite coxa; basis	Endopodite seg. 1	Exopodite seg. 1
Leg 1	0-0; 0-1	7, 0	3, V
Leg 2	0-0; 0-1	3, III	3, IV

minal blade.

Third Copepodid Stage (Fig. 33A-F).

Length 910 μm and width 300 μm on an average. Body (Fig. 33A) elongate, consisting of roundish cephalothorax and following slender portion composed of 3-segmented metasome and 4-segmented urosome; metamerism more or less indistinct. Cephalothorax ca. 300 μm long, almost as long as wide, included definable first pedigerous segment. Following 7 segments gradually narrowed posteriorly; each metasomal segment with paired legs on the anterior border of the ventral side. First urosomal segment with a pair of rudimentary fifth legs, each represented as a small knob tipped with 2 setules at the postero-lateral corner on the ventral side. Following 2 segments naked. Anal segment indistinctly separated from the preceding one, with elongated caudal rami.

Rostrum indistinct. First antenna (Fig. 35B; A') 7-segmented; joint between

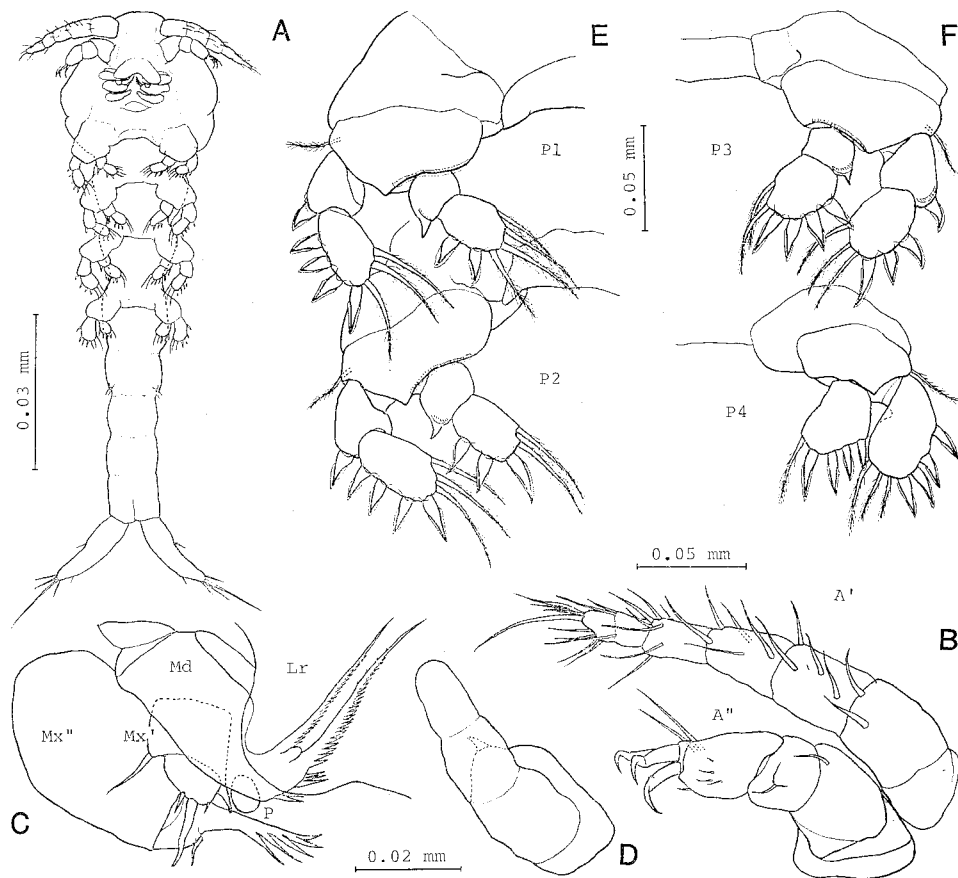


Fig. 33. Third copepodite of *Panaietis yamagutii* Izawa. A. Total individual, ventral; B. First and second antennae in situ, ventral; C. Labrum and oral appendages in situ, ventral; D. Maxilliped, ventral; E. First and second legs in situ, ventral; F. Third and fourth legs in situ, ventral.

the first 2 segments indistinct; setal formula throughout segments 0, 2, 4, 5, 7, 3, 8; aesthete indistinguishable. *Second antenna* (Fig. 35B; A'') 5-segmented; the first short, but broad, unarmed; the second somewhat long, with seta at the ventro-distal corner; the third shorter, with a seta on the ventral side; the fourth almost as long as the second, with 2 setae at the outer distal corner and 5 setules in the medio-distal portion; the fifth very small, with 3 articulate claws at the tip.

Labrum broader distally, concaved at the middle of the posterior margin. *Mandible* (Fig. 33C; Md) structured almost the same as in adults; ending in 2 subequal lashes which are serrated along each medial margin with ca. 20 teeth; a small process inserted between the bases of these lashes; with 2 teeth on the medial margin near the base of terminal lash, respectively bi- and tricuspidate. *Paragnath* (Fig. 33C; P) represented as a small lobe which is oval and unarmed. *First maxilla* (Fig. 33C; Mx') flattened antero-posteriorly and 2-segmented; the first wider than long, with a spine-like projection at the medio-distal corner and a seta at the outer distal corner; the second smaller, with a seta basally accompanied with 2 setules on the distal margin. *Second maxilla* (Fig. 33C; Mx'') 2-segmented; the first massive, longer than wide, unarmed; the second represented by a narrow process which is armed with 5 acute teeth, inclusive of its apex, along the distal half of its medial margin and is accompanied with a setule basally. *Maxilliped* (Fig. 33D) digitiform and 4-segmented; the first broad, with a small setiform projection on the medial margin; distal 3 indistinctly defined, unarmed.

Anterior 4 pairs of legs (Fig. 33E, F; P1-4) biramous; each protopodite flattened and 2-segmented; rami 2-segmented in anterior 3 legs, 1-segmented in fourth leg; basis with a hairy seta on the outside; first endopodite segment in legs 1-3 with a spine-like conical projection at the outer distal corner; setal formulae of legs shown in Table 10. Abnormal setation was observed as follows: 3, III on second exopodite segment in left second leg; 3, IV on second exopodite segment in left third leg.

Caudal ramus ca. 180 μ m long excluding setae, about 3.5 times as long as wide, slightly bent outward; with 6 spines in all, one near the middle of the outer margin, another on a subterminal portion of the medial margin, and the rest on the distal edge; one of the distal spines long and setiform.

Remarks. The family Myicolidae is a family flourishing mainly as parasites of gastropod and pelecypod mollusks. As for the developmental stages of the Myi-

Table 10. Setal formulae of four legs of the third copepodite of *Panaetis yamagutii* Izawa.

	Protopodite coxa; basis	Endopodite seg. 1; 2	Exopodite seg. 1; 2
Leg 1	0-0; 0-1	0-0; 4, II	0-I; 3, IV
Leg 2	0-0; 0-1	0-0; 2, III	0-I; 3, IV
Leg 3	0-0; 0-1	0-0; 2, IV	0-I; 3, III
Leg 4	0-0; 0-1	1, IV	3, IV

colidae, all of the five nauplius and six copepodid stages of *Ostrincola koe* were described by Kô et al. (1974) and Kô (1969) respectively, and all of the six nauplius and six copepodid stages of *Midicola pontica* were described by Nakamura et al. (1979, as *Pseudomyicola ostreae*) and Do et al. (1984, as *Pseudomyicola spinosus*) respectively. In this paper, two other species belonging to different genera are dealt with, describing all of the five nauplius and the first copepodid stages of *Neanthessius renicolis* and all of the five nauplius and first and third copepodid stages of *Panaietis yamagutii*. The nauplii and first copepodites are very similar between these two species in many respects. All the nauplii are lecithotrophic and rather degenerative especially in feeding apparatus in the above mentioned four species of Myicolidae.

8. *Pseudacanthocanthopsis apogonis* Yamaguti & Yamasu, 1959

(Figs 34–36)

Material. Egg sacs of several females taken from the branchial cavities of some individuals of a cardinal fish, *Apogon semilineatus* T. et S., collected at Seto in June and October, 1971, were used for rearing larvae.

Eggs are relatively small, ca. 120 μm in diameter on an average, colored pale yellow, as the amount of yolk is rather large; they become translucent near hatching in the same coloration without forming any pigment spots. The first nauplii reached the first copepodid stage within 2–3 days after hatching through 3 nauplius stages lecithotrophically at 23–24°C. The first copepodites were active swimmers and survived about a week without feeding. Any pigment spots did not appear throughout the larval stage except silvery luster of eyes in the first copepodites.

First Nauplius Stage (Figs 34A; 35A, D, H).

Length 128 μm and width 83 μm on an average. Body (Fig. 34A) plump and ovoid; furcal armature simple, consisting of a pair of hairy setae. Labrum less developed, unarmed. Labium indiscernible. Three pairs of appendages rather short as compared with the body size, spines on the medial margin of second antenna and mandible less developed.

First antenna (Fig. 35A) ca. 45 μm long excluding setae, indistinctly 3-segmented; the first short, unarmed; the second elongate, with 3 simple setae on the ventral margin, each placed proximally, medially and distally; the third slightly longer than the second, distally with a short simple seta and a long plumose seta which is accompanied with a fine aesthete at the base. *Second antenna* (Fig. 35D) ca. 60 μm long excluding setae; segments more or less flattened. Protopodite without any spine; coxa short, with a short transverse row of fine spinules on the anterior surface; basis slightly longer than wide. Endopodite 1-segmented, as long as basis, with a spinule at the middle of the medial margin and 2 plumose setae distally. Exopodite issuing from the distal margin of basis, 5-segmented; the first shorter than basis; each segment with a plumose seta at the medio-distal corner, the penultimate seta perpendicular to the axis of ramus. *Mandible* (Fig. 35G) ca. 60 μm long

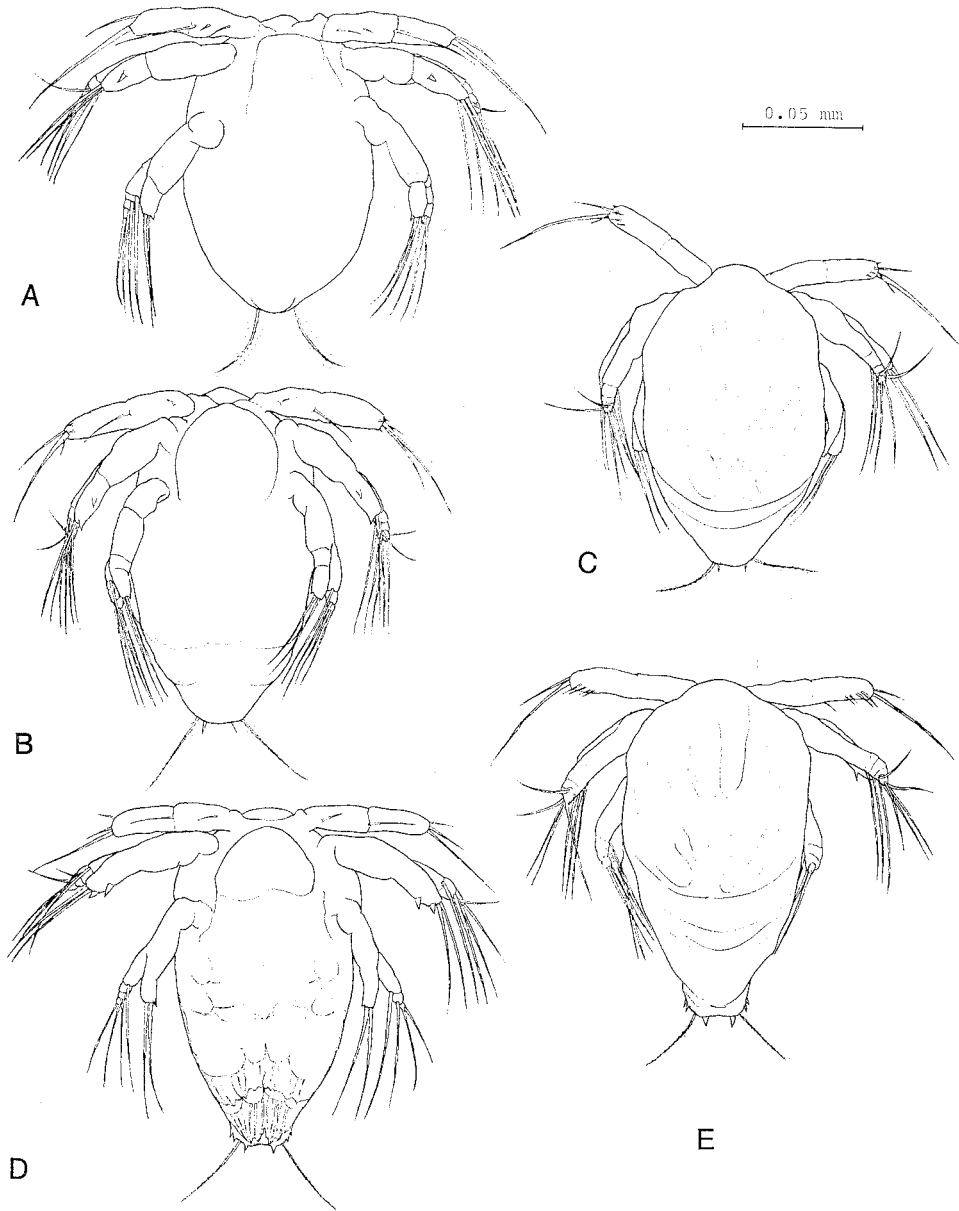


Fig. 34. Nauplii of *Pseudacanthocanthopsis apogonis* Yamaguti & Yamasu. A. First nauplius, ventral; B, C. Second nauplius, ventral and dorsal; D. Third nauplius, ventral; E. The same, dorsal.

excluding setae; protopodite rather thin, without any spine; coxa short, its medial margin somewhat rounded; basis longer than wide. Endopodite issuing obliquely from the medio-distal corner of basis, 2-segmented; the first short, without spine; the second somewhat elongate, with a spinule at the medio-distal corner and apically with 2 plumose setae.

Second Nauplius Stage (Figs 34B, C; 35B, E, H).

Length 126 μm and width 76 μm on an average. Body (Fig. 34B, C) slightly narrower than in first nauplius, with addition of a pair of spinules on the caudal margin. Two segment-like structures seen through the cuticle on the ventral side, respectively referable to first and second pedigerous segments of first copepodite.

First antenna (Fig. 35B) with addition of 5 spinules on terminal segment, 3 of which are placed around the dorso-distal, the rest near the ventro-distal corners; setae on the ventral margin of second segment diminished the size, the middle one

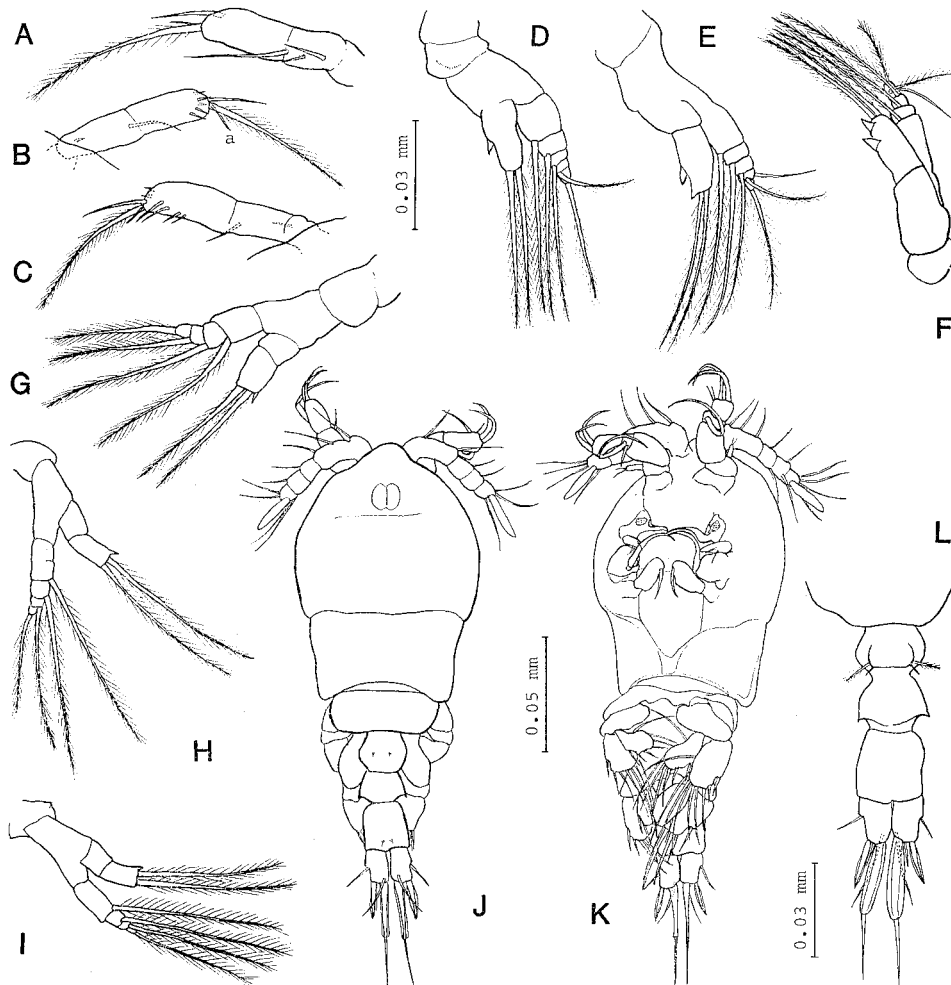


Fig. 35. Naupliar appendages and first copepodite of *Pseudacanthocanthopsis apogonis* Yamaguti & Yamasu. A-C. First antennae of first to third nauplii; A(1st), ventral; B(2nd) & C(3rd), dorsal; D-F. Second antennae of first to third nauplii; D(1st) & E(2nd), antero-ventral; F(3rd), ventral; G-I, mandibles of first to third nauplii; G(1st), posterior; H(2nd) & I(3rd), anterior; J-L. First copepodite; J. Total individual, dorsal; K. The same, ventral; L. Urosome, ventral.

of the 3 setae in the first stage completely disappeared. *Second antenna* (Fig. 35E); joints indistinct between coxa and basis and between basis and exopodite. Coxa without any ornamentation of fine spinules on the anterior surface. Endopodite with addition of a spinule at the medio-distal corner. Exopodite with addition of a simple setule which issues from the outer proximal corner of the terminal segment and is perpendicular to the axis of this ramus. *Mandible* (Fig. 35H) thinner than in the preceding stage; first exopodite segment with a slight constriction at the middle on the medial margin; ornamentation the same as in the first stage.

Third Nauplius Stage (Figs 34D, E; 35C, F, I).

Body length 135 μm and width 70 μm on an average. Body (Fig. 34D, E) a little more elongated than in second nauplius; the caudal portion narrow and protruded beyond dorsal shield, the distal margin slightly concaved at the middle and armed with 4 more spinules in addition to a pair of hairy setae. Each rudiment of first 2 pairs of legs represented by a cuticular sac on the postero-ventral surface; each posterior margin serrated. Labrum the same as in the second stage. No signs of postmandibular oral appendages seen on the ventral surface, though first and second maxillae, maxilliped, and first 2 pairs of legs of first copepodite already ready inside the body and visible through the cuticle.

First antenna (Fig. 35C) with addition of a spinule around the dorso-distal corner of terminal segment. *Second antenna* (Fig. 35F) with setation the same as in the preceding stage, though the 2 spinules on endopodite stouter than in second nauplius. *Mandible* (Fig. 35I) unaltered in setation; the slight constriction in first exopodite segment seen in second nauplius disappeared.

First Copepodid Stage (Figs 35J-I; 36A-G).

Body length excluding caudal ramus 177 μm , cephalothorax 104 μm in length and 74 μm in width on an average. Body (Fig. 35J, K) consisting of relatively broad cephalothorax, metasome of second pedigerous segment and narrow urosome. Cephalothorax including first pedigerous segment clearly distinguishable from the anterior cephalic portion, longer than metasome plus urosome; pedigerous portion half as long as and narrower than cephalic portion. Metasome slightly narrower than the width at the posterior end of pedigerous portion of cephalothorax, much wider than long. Urosome (Fig. 35L) 3-segmented; the first with rudimentary third legs each represented by a plumose seta and a short simple spine, borne at each end of the posterior margin of a ventral bulge; the second wider distally and pointed at the postero-lateral corner; anal segment slightly longer than wide.

First antenna (Fig. 36A) almost even in width throughout the whole length, 5-segmented; setal formula of segments 0, 3, 3, 2+1 aesthete; 7+2 aesthetes; aesthete of fourth segment lamellate, while longer and shorter ones of terminal segment setiform. *Second antenna* (Fig. 36B) 5-segmented; the first stout, unarmed; the second as long as, but narrower than the first, with rudimentary exopodite at the outer distal corner, represented by a digitiform structure tipped with 2 setae; the third long, unarmed; the fourth small, distally with a long articulate claw on

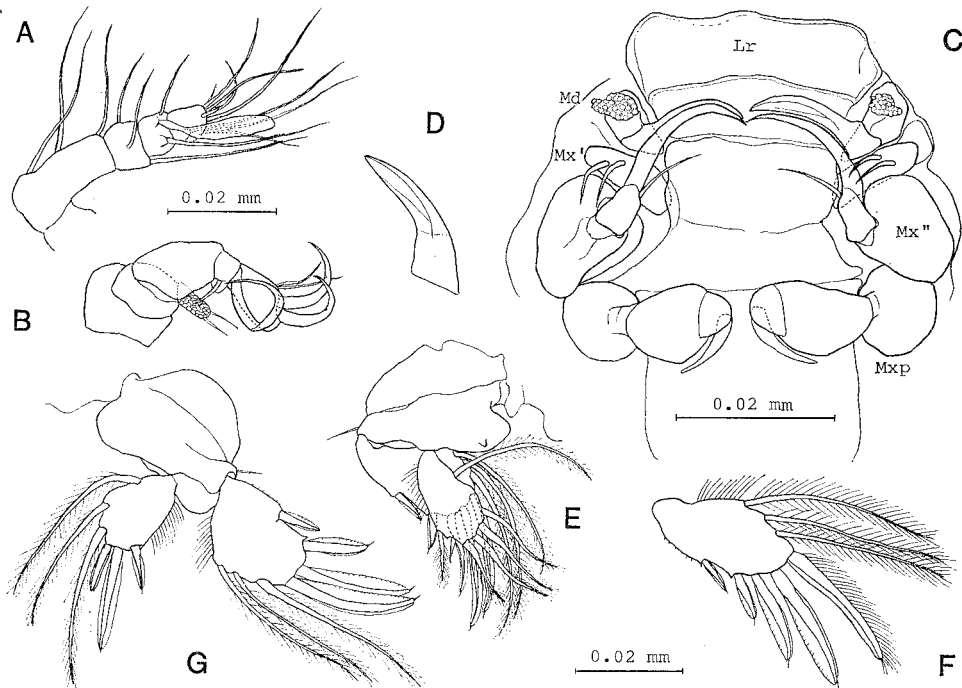


Fig. 36. Appendages of first copepodite of *Pseudacanthocanthopsis apogonis* Yamaguti & Yamasu. A. First antenna, ventral; B. Second antenna, ventral; C. Labrum and oral appendages in situ, ventral; D. Distal portion of mandible, posterior; E. First leg, ventral; F. Exopodite of first leg, ventral; G. Second leg, ventral.

the ventral border and with a seta on the medial margin; terminal segment somewhat elongate and wider distally, with 2 claws on the distal margin and 2 feeble subterminal setae on the outer margin. *Mandible* (Fig. 36C, Md; D) indistinctly 2-segmented; basal segment with a structure probably representing rudiment of basis and rami combined together; distal segment forming a claw-like lamellar process somewhat thickened along both concave and convex edges. *Paragnath* indiscernible. *First maxilla* (Fig. 36C; Mx') elongated and laid on the sternal surface, with 2 simple setae on the ventral side. *Second maxilla* (Fig. 36C; Mx'') 2-segmented, the first stout, broadened at the base, unarmed; the second small, ending in a relatively long claw furnished with a simple seta near the base on the medial margin. *Maxilliped* (Fig. 36C; Mxp) somewhat feeble, indistinctly 4-segmented; the first roundish, unarmed; the second longer than wide, narrowed at the base, unarmed; the third small, indistinctly separated from the second; terminal segment forming a claw turned back along the medial margin of third segment and the distal half of the second.

Two pairs of legs (Fig. 36E-G) biramous and almost the same in size and structure; each consisting of flattened, 2-segmented protopodite and 1-segmented rami. Basis with a seta on the outside. Endopodite with hairs on the outer margin, while

Table 11. Setal formulae of first 2 legs of first copepodite of *Pseudacanthocephalus apogonis* Yamaguti & Yamasu.

	Protopodite coxa; basis	Endopodite seg. 1	Exopodite seg. 1
Leg 1	0-0; 0-1	7, 0	3, V
Leg 2	0-0; 0-1	3, III	3, IV

exopodite with fine spinules and hairs on the outer margin and the medial margin respectively. Setal formulae of these legs shown in Table 11; spine with a membrane on both edges and a fine terminal blade, but fifth spine of exopodite in first leg with hairs along the medial edge and a membrane along the outer edge.

Caudal ramus (Fig. 35L) slightly longer than wide, furnished with 6 setae, the innermost one on the distal margin longest and with a membrane along each edge and a thin terminal blade, the outermost one on the same margin shorter and with membranes but without a terminal blade.

9. *Praeicodondria setoensis* Izawa, 1975

(Figs 37-39)

Material. Egg sacs of a female taken from the buccal cavity of a serranid fish, *Epinephelus fasciatus* (Forskål), fished in Tanabe Bay, in November 1971, were used for rearing larvae.

Eggs are 145 μm in diameter on an average. Hatched nauplii reached the first copepodid stage within 4-5 days through 3 nauplius stages wholly lecithotrophically at 16-17°C. Nauplii and first copepodites were able to swim, though not so actively in the nauplius stages. No pigment spots appeared throughout these larval stages, except a silvery luster of eyes in the first copepodites.

First Nauplius Stage (Figs 37A; 38A, D, G).

Larger than in the preceding species, body length 160 μm and width 102 μm on an average. Body (Fig. 37A) plump and ovoid, with a pair of hairy setae and a small median projection at the caudal end. Labrum less developed, unarmed. Labium indiscernible.

First antenna (Fig. 38A) ca. 65 μm long excluding setae, indistinctly 3-segmented; the first short, unarmed; the second elongate, with 3 hairy setae on the ventral margin, each placed basally, medially and distally; the third as long as the second, distally with 2 plumose setae, the longer one accompanied with a fine aesthete at the base. *Second antenna* (Fig. 38D) 75 μm long excluding setae; segments more or less flattened and covered sparsely with short transverse rows of fine spinules on the anterior surface; spines on the medial margin of protopodite and endopodite less developed. Coxa short, the medial margin somewhat expanded but without any spines. Basis almost as long as wide, with 2 spinules on the medial margin, each placed medially and near the distal corner. Endopodite 1-segmented, as

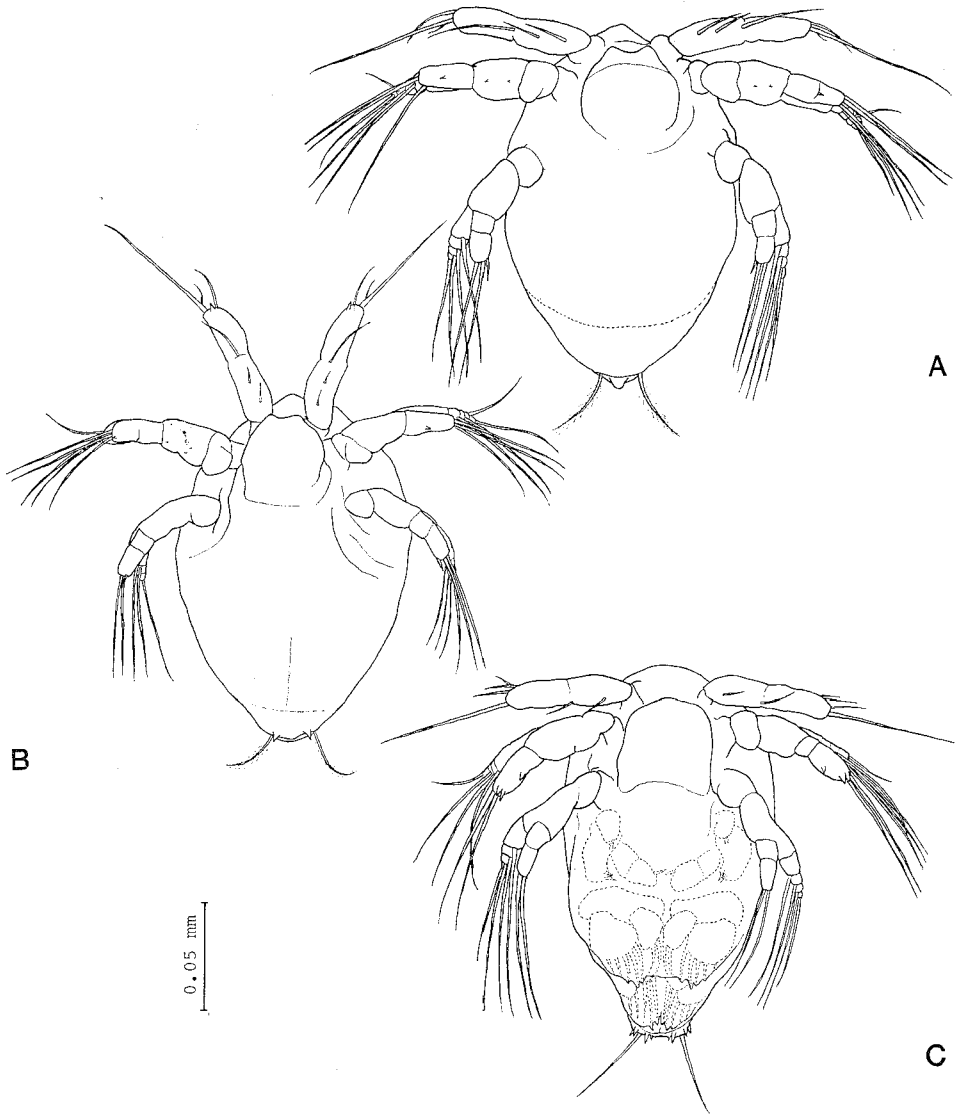


Fig. 37. Nauplii of *Praecidochondria setoensis* Izawa. A. First nauplius, ventral; B. Second nauplius, ventral; C. Third nauplius, ventral.

long as basis, with a spinule at the middle of the medial margin and distally with 2 plumose setae. Exopodite issued from the distal margin of basis and 5-segmented; the first slightly shorter than basis, but longer than distal 4 segments combined together; each segment with a seta at the medio-distal corner; setae plumose but the penultimate one simple and arising perpendicular to the axis of ramus. *Mandible* (Fig. 38G) ca. $70\ \mu\text{m}$ long excluding setae, rather thin; spines on the medial margin of protopodite and endopodite less developed. Protopodite unarmed; coxa short, with the rounded medial margin; the second longer than wide. Endopodite

issued from the subterminal site of the medial margin of basis, 2-segmented; the first as long as wide, without spine; the second somewhat elongate and slightly thinner than the first, with a spinule at the medio-distal corner and 2 plumose setae on the distal margin. Exopodite issued from the distal end of basis, 4-segmented; the first almost as long as basis; each segment with a plumose seta.

Second Nauplius Stage (Fig. 37B, 38B, E, H).

Length 160 μm and width 101 μm on an average. Body (Fig. 37B) almost the same as in first nauplius; a small median projection at the caudal end in first nauplius disappeared and replaced by a pair of spinules.

First antenna (Fig. 38B) with an additional subterminal spinule on the ventral margin of terminal segment; 2 proximal hairy setae on the ventral margin of second segment in first nauplius replaced in this stage by 2 minute simple ones; shorter apical seta of terminal segment simple. *Second antenna* (Fig. 38E) without any fine spinules on the surface; endopodite divided indistinctly into 2 subsegments by a slight marginal constriction at the middle and with addition of a spinule at the medio-distal corner; the penultimate seta of exopodite furnished with plumes. *Mandible* (Fig. 38H) the same as in the first stage.

Third Nauplius Stage (Figs 37C; 38C, F, I).

Length 171 μm and width 94 μm on an average. Body (Fig. 37C) slightly slenderer than in second nauplius, the caudal portion elongated and protruded beyond dorsal shield; the caudal margin truncated and the furcal armature with 6 more spinules. A pair of rudimentary legs each represented as an apically serrated cuticular sac on the posterior ventral surface. Labrum the same as in the second stage. No signs of post-mandibular oral appendages definable on the surface, although first and second maxillae and maxillipeds of first copepodite already formed within the body and seen through the sternal cuticle.

First antenna (Fig. 38C) with a longitudinal row of 5 short spines newly appeared in the distal half of the dorsal margin of terminal segment, the middle setule on the ventral margin of second segment in second nauplius completely disappeared in this stage. *Second antenna* (Fig. 38F); endopodite elongated by about 50% of the length in the second stage and furnished additionally with a spinule near the distal stout spinules on the medial margin; exopodite with addition of a simple setule issuing perpendicular to the axis of ramus from the outer proximal corner of terminal segment; the perpendicular seta of penultimate segment simple in this stage; proximal one of the 2 medial spinules on basis disappeared. *Mandible* (Fig. 38I) slightly altered; the medio-distal spine of second endopodite segment diminished the size further.

First Copepodid Stage (Figs 38J-L; 39A-F).

Body length excluding caudal ramus 235 μm , cephalothorax 137 μm in length and 100 μm in width on an average. In broad cephalothorax (Fig. 38J, K) first pedigerous segment clearly distinguishable from the anterior cephalic portion, almost half as long as but slightly narrower than cephalic portion. Metasome of

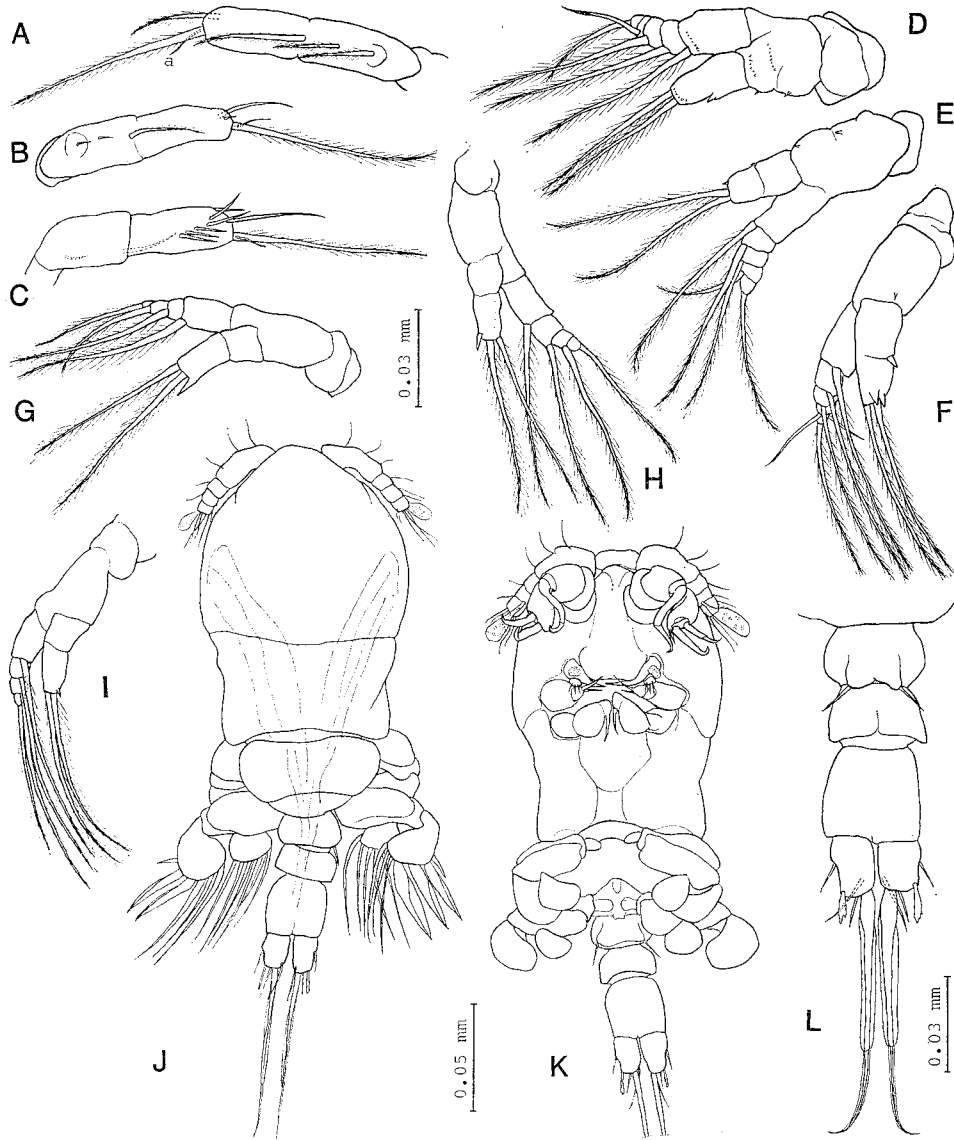


Fig. 38. Naupliar appendages and first copepodite of *Praeichondria setoensis* Izawa. A-C. First antennae of first to third nauplii. A(1st) & B(2nd), ventral; C(3rd), dorsal. D-F. Second antennae of first to third nauplii. D(1st), antero-ventral; E(2nd), postero-ventral; F(3rd), ventral. G-I. Mandibles of first to third nauplii. G(1st) & I(3rd), antero-ventral. H(2nd), postero-ventral. J-L. First copepodite. J, K. Total individual, dorsal and ventral (ornamentation of legs omitted); L. Urosome, ventral.

second pedigerous segment short and slightly narrower than first pedigerous portion of cephalothorax. Urosome (Fig. 38L) sharply narrowed and 3-segmented; the first wider than long, with rudimentary third legs represented by a ventral bulge slightly concaved on the posterior margin at the middle and furnished with a simple

seta at each postero-lateral corner; the second wider than long, slightly broader distally, naked; anal segment as wide as long, without any ornamentation but caudal rami.

First antenna (Fig. 39A) more or less flattened and indistinctly 5-segmented; the first small, almost completely coalesced with the sternal surface; the second longer than distal 3 segments combined together and slightly thicker than those; setal formula of segments 0, 3, 4, 2+1 aesthete, 7+2 aesthetes; the aesthete of penultimate segment lamellate, broadened distally, with narrow base; the two aesthetes of terminal segment unequal in length, both setiform. *Second antenna* (Fig. 39B, C) 5-segmented; the first short and broad, almost completely coalesced with the sternal surface, unarmed; the second wider than long, constricted at the middle

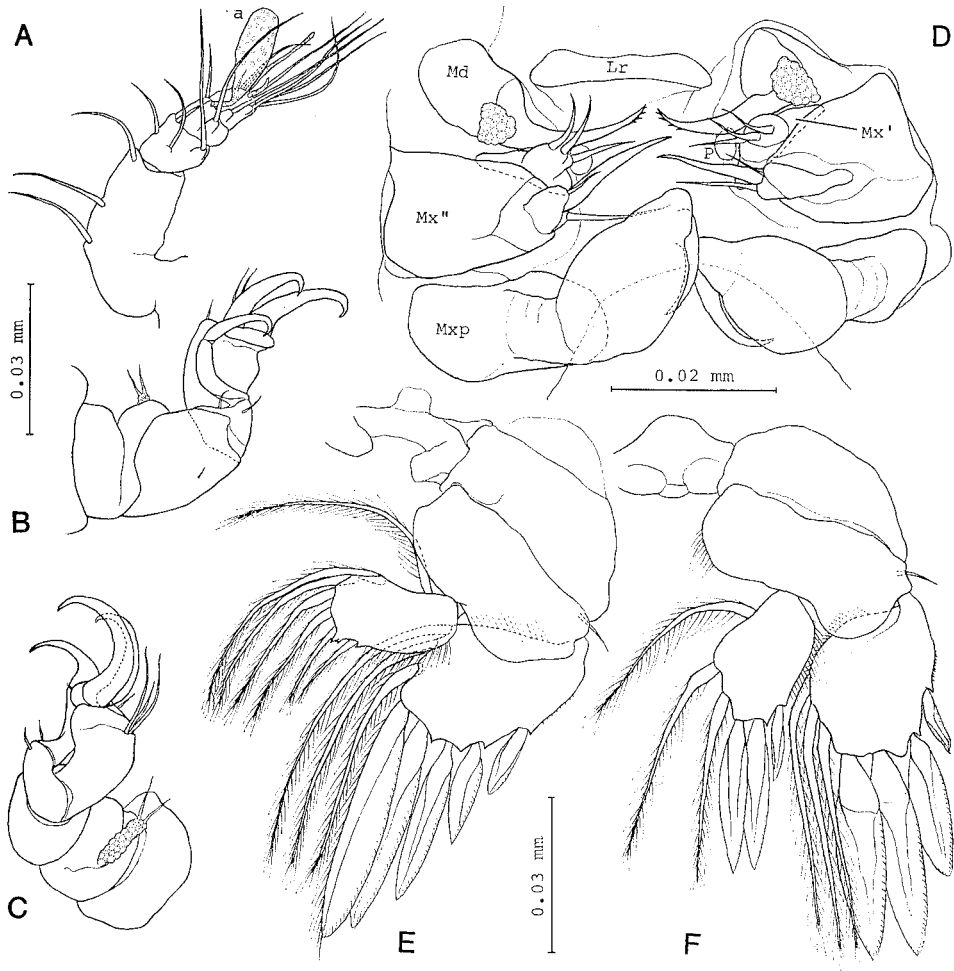


Fig. 39. Appendages of first copepodite of *Praecidochondria setoensis* Izawa. A. First antenna, ventral; B. Second antenna, medial; C. Second antenna, outer-lateral, magnified as in B; D. Labrum and oral appendages in situ, ventral; E. First leg, ventral; F. Second leg, ventral.

of the postero-lateral side, with rudimentary exopodite represented by a digitiform structure tipped with 2 setules on the outer distal margin; the third longer than wide, with a fine setule on the ventral side; the fourth small and narrowed distally, with an articulated strong claw at the ventral distal corner and 2 subterminal setules on the medio-ventral margin; the fifth issuing from a dorso-basal portion of the fourth, elongate and widened distally, with 2 claws and a setule on the distal margin and 3 feeble subterminal setae on the outer margin.

Labrum (Fig. 39D; Lr) relatively small as compared with other oral appendages, wider than long, the distal margin almost straight, unarmed. *Mandible* (Fig. 39D; Md) indistinctly 2-segmented; basal segment laid on the sternal surface, broad, with a tissue mass representing rudiment of basis and rami combined together; distal segment sharply narrowed at the base, attenuated distally into a claw-like process with 4 denticles along the convex edge in the apical portion. *Paragnath* (Fig. 39D; P) represented by a small ovoid swelling of the sternal surface, unarmed. *First maxilla* (Fig. 39D; Mx') composed of the basal portion laterally expanded and the lobe-like distal portion apically with 3 simple setae. *Second maxilla* (Fig. 39D; Mx'') 2-segmented; the first stout, thickened at the base, unarmed; the second small, but furnished with a long lanceolate process at the tip and two unequal setae, the longer one at the medio-proximal corner and the shorter at the ventro-distal edge near the base of apical process. *Maxilliped* (Fig. 39D; Mxp) indistinctly 4-segmented, ending apically in a feeble claw formed by terminal segment; proximal 2 segments relatively large, though less sclerotized and unarmed, the third small and almost completely coalesced with the second.

Two pairs of legs (Fig. 39E, F) biramous and almost the same in size and structure; each consisting of flattened 2-segmented protopodite and 1-segmented rami. Basis with a seta on the outside in each leg, with additional hairs on the medio-distal margin in first leg. Rami with fine spinules and hairs on the outer and the medial margins of exopodite respectively, and hairs on the outer margin of endopodite in addition to the plumose setae and spatulate spines with a broad membrane on each edge in respective rami; setal formulae shown in Table 12. The fifth spine of first leg exopodite with hairs on the medial edge, but a membrane on the other edge.

Caudal ramus (Fig. 38L) slightly longer than wide, with 5 setae in all; the longest one at the medial end of the distal margin with a membrane along each edge and tipped with a terminal blade; the short lamellate seta at the outer distal corner serrated along both edges.

Table 12. Setal formulae of first 2 legs of first copepodite of *Praeicodochondria setoensis* Izawa.

	Protopodite coxa; basis	Endopodite seg. 1	Exopodite seg. 1
Leg 1	0-0; 0-1	7, 0	3, V
Leg 2	0-0; 0-1	3, III	3, IV

10. *Acanthochondria yui* Shiino, 1964

(Figs 40–49)

Material. 194 individuals of copepodites including adult females obtained from a few individuals of a goby, *Acanthogobius flavimanus* (Temminck et Schlegel), collected at the estuary of the River Kushida in Ise Bay in May, 1985.

Eggs are $175 \times 201 \mu\text{m}$ on an average. No rearing of the eggs was carried out. Growth of body length of the copepodites is shown in Fig. 40. The sexes are distinguishable at the second copepodid stage by shape of the terminal claw of second antennae. Ranges of body length of the both sexes separate completely after the third copepodid stage. Younger copepodites are found exclusively on the gill filaments of host, while matured adult females accompanied with an adult male are found rather on the inner walls of the branchial cavity.

First Copepodid Stage (Fig. 41).

Body length excluding caudal ramus $310 \mu\text{m}$ on the average of 12 specimens, ranging $299\text{--}330 \mu\text{m}$; cephalothorax including first pedigerous segment $170 \mu\text{m}$

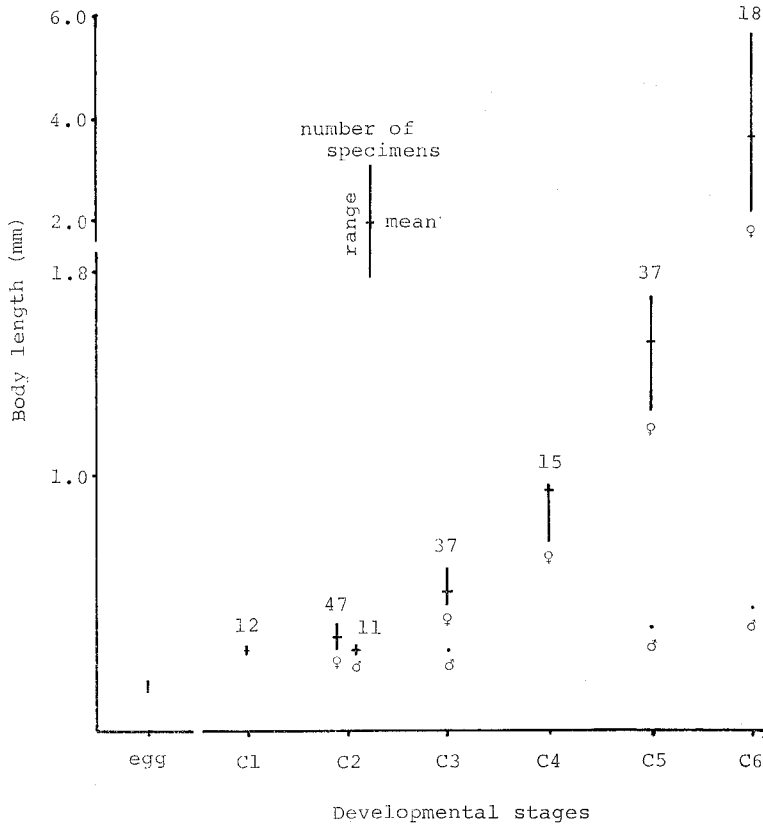


Fig. 40. Growth in body length excluding caudal rami of *Acanthochondria yui* Shiino.

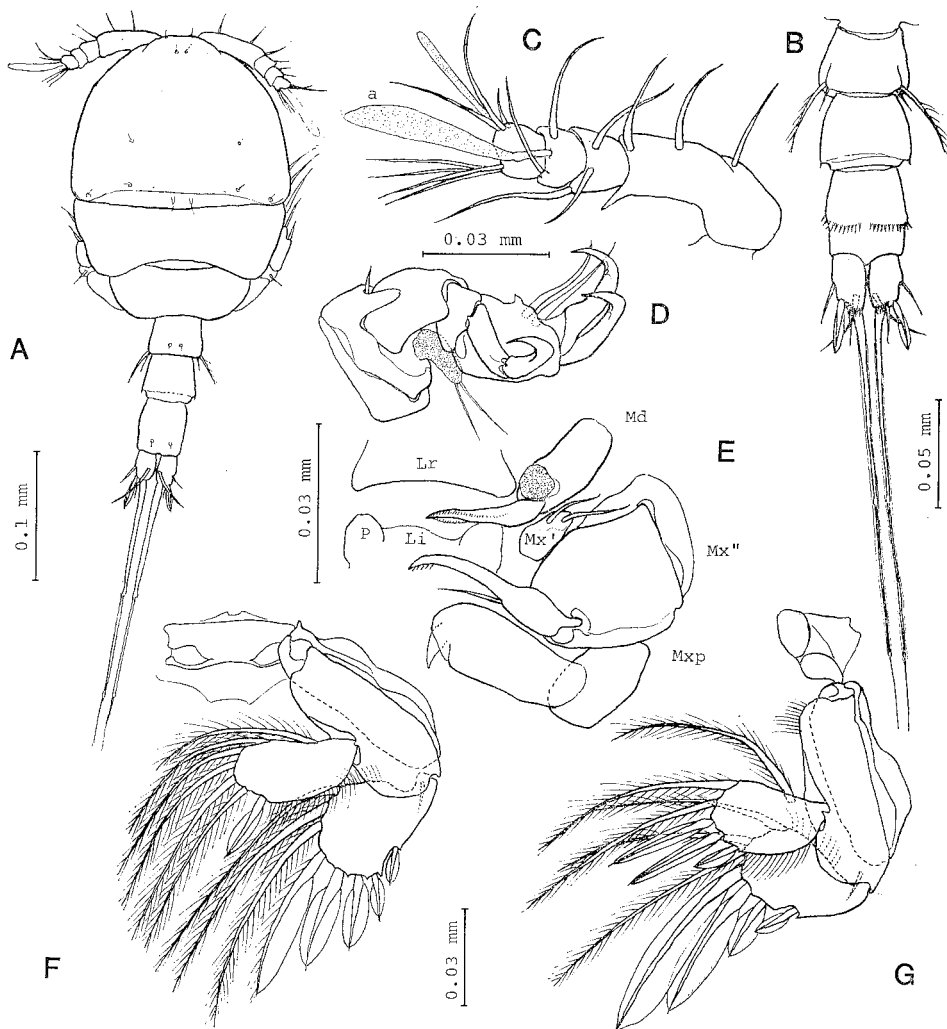


Fig. 41. First copepodite of *Acanthochondria yui* Shiino. A. Total individual, dorsal; B. Urosome, ventral; C. First antenna, ventral; D. Second antenna, medio-ventral; E. Labrum and oral appendages in situ, ventral; F. First leg, ventral; G. Second leg, ventral.

in length and $140\ \mu\text{m}$ in width on the average. Body (Fig. 41A) composed of ovoid prosome and narrow urosome; segmentation distinct. Prosome consisting of cephalothorax including first pedigerous segment, though distinctly defined from anterior cephalon by a dorsal suture, and second pedigerous segment. Cephalon with some six pairs of fine tubercles tipped by a hair, probably with sensory function, on the dorsal surface. First pedigerous segment concaved on the distal margin. Urosome (Fig. 41A, B) 3-segmented, about a quarter as wide as prosome; the length excluding caudal rami measuring a half of prosome length. First urosomal segment bearing a pair of fine tubercles tipped by a hair on the dorsal side and

rudimentary third legs represented by a ventral plate furnished with 2 unequal setae; each seta placed at the postero-lateral corners, the longer one hairy. Second urosomal segment almost as long as the first, naked. The last segment somewhat longer than the anterior 2 segments, ornamented with a pair of fine tubercles tipped by a hair on the posterior dorsal side and a transverse, medially interrupted row of about 22 spinules on the ventral surface, and ending with caudal rami; caudal ramus furnished with spines, one of which is extremely elongate, almost as long as prosome.

First antenna (Fig. 41C) 5-segmented; the first short, almost completely coalesced with sternal surface; the second thickened at the base, longer than distal 3 segments combined together, and with a sharply pointed process at the distal posterior corner of the ventral side; setal formula of segments 0, 3, 3, 2+1 aesthete, 7+1 aesthete; aesthetes lamellate, that of the penultimate segment wider than that of the terminal segment. *Second antenna* (Fig. 41D) powerful, 5-segmented; first 2 segments corresponding to protopodite short but broad, with a digitiform tissue mass tipped by 2 setae representing rudimentary exopodite on the distal margin at the lateral side and with a seta at the medio-distal corner; the third somewhat flattened owing to be compressed laterally, naked; the fourth small but with a strong, articulated claw on the distal margin at the ventral side; the terminal segment almost as long as the third and fourth segments combined together, furnished with 2 strong claws and 2 setae on the distal margin.

Labrum (Fig. 41E; Lr) with broadened and gently concaved posterior margin, naked. *Labium* (Fig. 41E; Li) with a pair of globular paragnathes (P) at the antero-lateral corner. *Mandible* (Fig. 41E; Md) consisting of a basal segment and a masticatory process; basal segment, probably coxa, 2 times as long as wide, laid along the sternal surface at the lateral to labrum, and with a globular tissue mass probably corresponding to rudiment of basis and rami; masticatory process falcate almost as long as the basal segment, indented along on both concave and convex margins. *First maxilla* (Fig. 41E; Mx') represented by a small lobe-like segment perpendicular to the sternal surface, ending in 2 setae. *Second maxilla* (Fig. 41E; Mx'') 2-segmented; the first stout, unarmed; the second forming itself a process tapered distally and curved gently, with a seta at the middle of medial margin and a row of spinules along the medial side of a distal portion. *Maxilliped* (Fig. 41E; Mxp) feebler than second maxilla, 2-segmented; the first longer than wide, unarmed; the second longer than the first, slightly broadened distally, with a feeble hook-like process at a medio-distal portion.

First and second legs (Fig. 41F & G) biramous swimming legs, almost the same in structure and size, consisting of flattened, 2-segmented protopodite and 1-segmented rami; intercoxal plate distinct, without ornamentation; coxa unarmed; basis with a seta on the lateral margin in both legs and a row of hairs along the medio-distal margin in second leg; exopodite somewhat longer than endopodite, with a row of hairs along the medial margin, while exopodite with the same along the lateral margin. Setal formulae of these legs shown in Table 13. Spines of rami with a

Table 13. Setal formulae of first 2 legs of first copepodite of *Acanthochondria yui* Shiino.

	Protopodite coxa; basis	Endopodite seg. 1	Exopodite seg. 1
Leg 1	0-0; 0-1	6, I	3, V
Leg 2	0-0; 0-1	3, III	3, IV

membrane on both sides and a fine terminal blade, but the longest one of first leg exopodite, followed by a row of setae, hairy on the medial side while with a membrane on the opposite side.

Caudal ramus (Fig. 41B) longer than wide, furnished with a simple seta at the middle of outer margin and a seta on a medio-distal portion of the dorsal side; 2 spines arising from the terminal edge, accompanied with a fine seta between them; the outer one of terminal spines as long as furcal ramus, fringed with a membrane bilaterally; the medial terminal spine elongate, about 200 μm long, with 2 joints, fringed with a narrow membrane bilaterally except for the apical part represented by a thin terminal blade; a short transverse row of spinules occurring on the ventral surface close to the bases of terminal armatures.

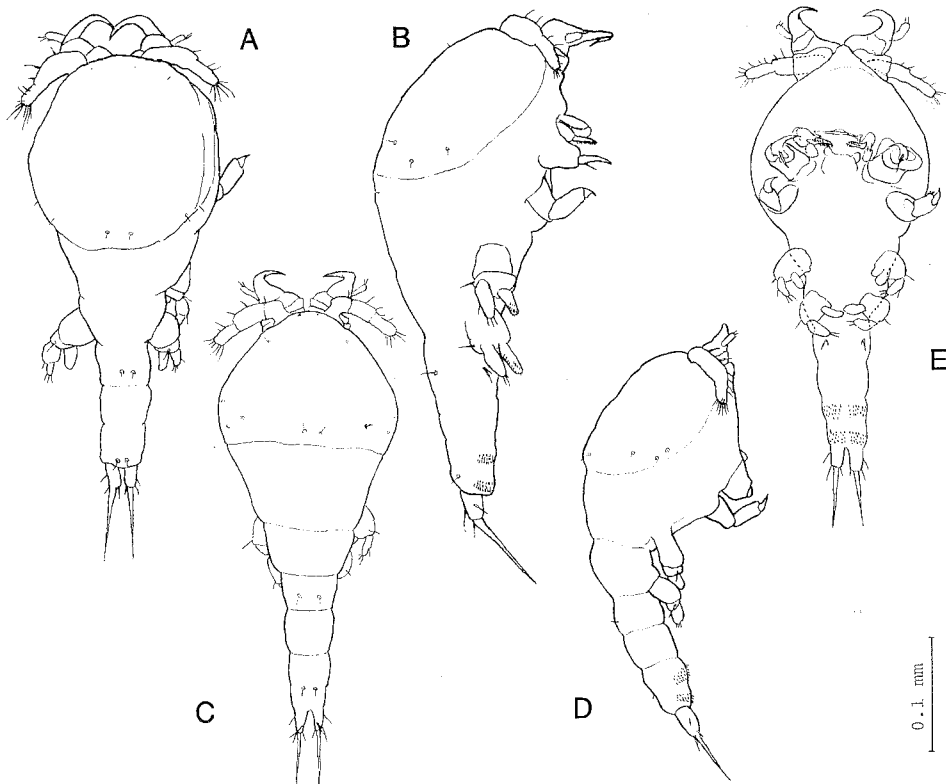


Fig. 42. Second copepodites of *Acanthochondria yui* Shiino. A, B. Female, dorsal and lateral; C-E. Male, dorsal, lateral and ventral.

Second Copepodid Stage (Figs 42 & 43).

Body becomes fleshy. Sexes definable by size and shape of terminal claw of second antenna. Body length excluding caudal ramus 320 to 420 μm and 368 μm on the average of 47 females, while 300 to 340 μm and 325 μm on the average of 11 males; average lengths of dorsal shield 155 and 145 μm in female and male respectively; average depths of cephalothorax 138 and 115 μm in female and male respectively.

Female (Figs 42A, B; 43A-H): Body broadened and narrowed distally. Segmentation of body indistinct but segments definable by constrictions of body. Dorsal shield more or less distinct on the portion of cephalon, with some pairs of tubercles tipped by a fine hair. Segment following to second pedigerous one bearing rudimentary third legs on the ventral side. A similar pair of sensory hairs found

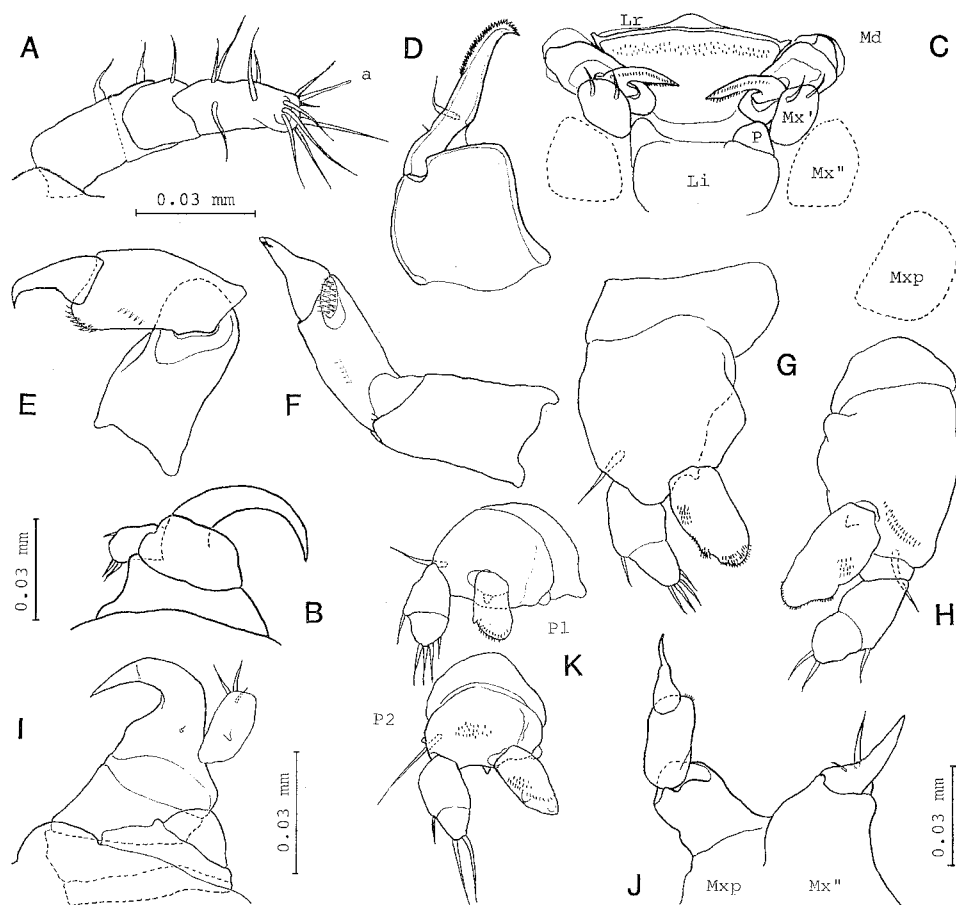


Fig. 43. Appendages of second copepodite of *Achanthochondria yui* Shiino. A-H: female. C-H, magnified as in A. A. First antenna, ventral; B. Second antenna, dorsal; C. Labrum and oral appendages in situ, ventral; D. Second maxilla, lateral; E, F. Maxilliped, medial and medio-posterior; G. First leg, ventral; H. Second leg, ventral. I-K: male. I. Second antenna, ventral; J. Second maxilla and maxilliped in situ, lateral; K. First and second legs in situ, ventral, magnified as in I.

on the dorsal side of third pedigerous and last segments. Penultimate and last segments delimited by ventral swellings of sternal surface covered with spinules in addition to body constriction.

First antenna (Fig. 43A) indistinctly 3- or 4-segmented; terminal segment probably corresponding to distal 3 segments in first copepodid stage; setal formula of segments 1, 1, 1, 12+1 aesthete. *Second antenna* (Fig. 41B) altered thoroughly, consisting of a 2-segmented broad, but short, base and a strong terminal claw accompanied by a so-called accessory antennule tipped by 3 small setae corresponding to original distal segment of this appendage.

Labrum (Fig. 43C; Lr) with spinulose posterior surface. *Labium* and *paragnath* (Fig. 43C; Li, P) almost the same as in preceding stage. *Mandible* (Fig. 43C; Md) deprived of tissue mass found in the preceding stage from basal segment. *First maxilla* (Fig. 43C; Mx'); construction as in preceding stage, though 2 setae relatively diminished in size. *Second maxilla* (Fig. 43D); unaltered in structure, but the terminal process becomes stouter than in preceding stage, and with a pectinated fringe along convex margin of distal half and a seta and a spinule on the base. *Maxilliped* (Fig. 43E, F) developed as a 3-segmented, prehensile appendage; the first as long as distal 2 segments combined together, unarmed; the second armed with an elliptic area covered with spinules on the medio-distal corner and a row of some 5 spinules near the middle of posterior surface; the third represented by a stout claw with thick base.

First and second legs (Fig. 43G, H) fleshy, with ornamentation much reduced though construction of segments almost unaltered; inter-coxal plates unnoticed, and each of paired legs well separate to locate at ventro-lateral portions of body. Coxa short, almost fused with sternal surface. Basis lengthened and thickened, with a small conical process on the posterior side near the base of endopodite in addition to a lateral seta and an indistinct round swelling on the medial margin. basis of second leg with 2 transverse rows of spinules on the distal margin of anterior surface. Rami lobe-like; endopodite 1-segmented, longer than wide, deprived of setae and spines, but with a slight projection on the outer-distal corner and patches of spinules on the surface; exopodite indistinctly 2-segmented, with a seta on the distal end of outer edge of first segment; second exopodite segment of the first leg with 4 setae on the distal margin, while only 2 on the counter part of the second leg. Caudal ramus (Fig. 43A & B) more or less fused with last segment of body; armature reduced, especially the longest spine much reduced in size.

Male (Figs 42C-E; 43I-K): Body somewhat slim and shorter than in female, though range of body length overlaps partly to that of female; construction and shape of body almost the same as in female. All appendages, except for the followings, almost the same in shape and size as in female. *Second antenna* (Fig. 43I) with a terminal claw which is more thicker and curved more sharply than in female. *Second maxilla* (Fig. 43J; Mx"); terminal claw also stouter than in female and deprived of indentation. First and second legs (Fig. 43K; P1, 2) almost as in female.

Third Copepodid Stage (Fig. 44).

Sexes distinct in size and shape; male dwarf. In female, body length excluding caudal ramus ranging 495 to 640 μm and 570 μm on the average of 37 individuals; dorsal shield 240 μm in length, cephalothorax 210 μm in width and 220 μm in depth

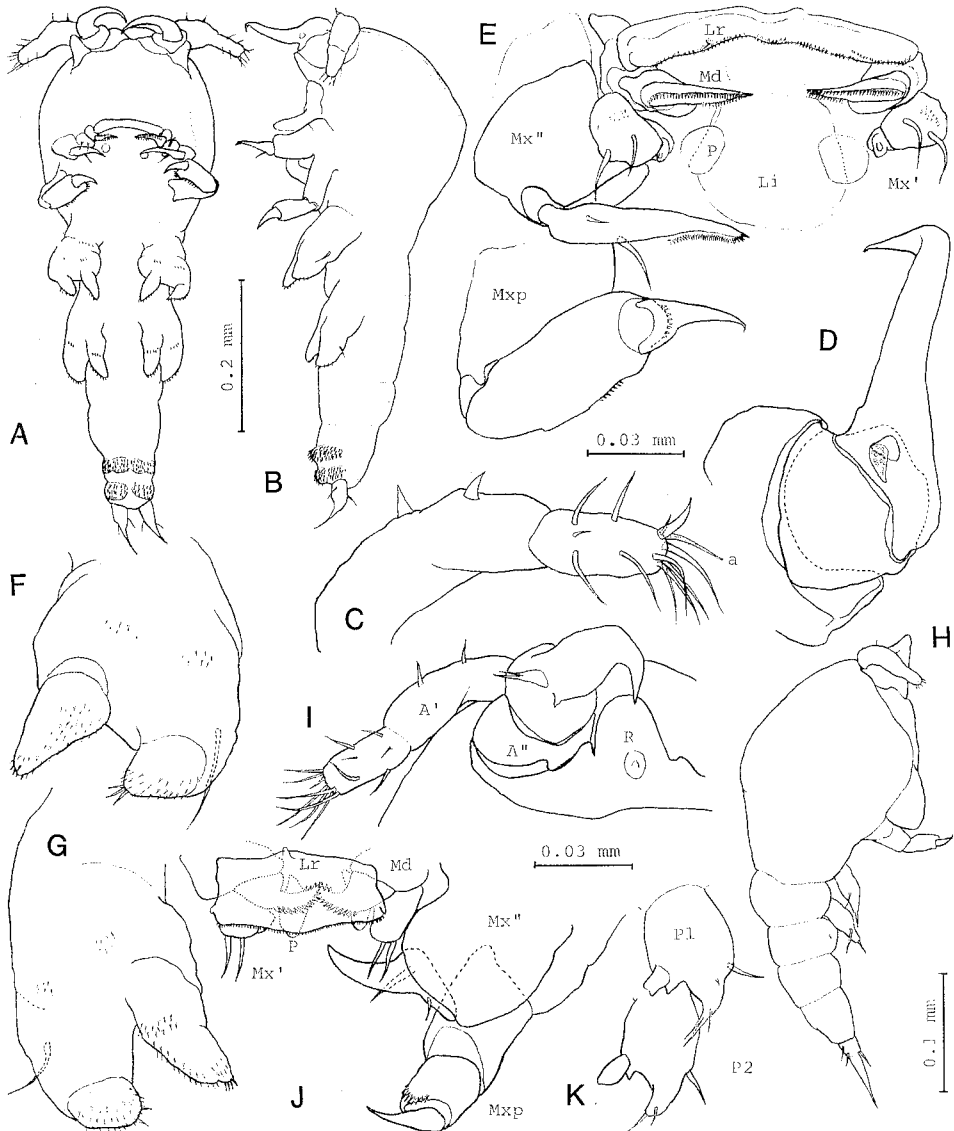


Fig. 44. Third copepodite of *Acanthochondria yui* Shiino. A-G: female. A. Total individual, ventral; B. Same, lateral; C. First antenna, ventral; D. Second antenna, lateral; E. Labrum and oral appendages in situ, ventral; F. First leg, ventral; G. Second leg, ventral. D-G, magnified as in C. H-K: male. H. Total animal, lateral; I. First and second antennae and rostrum in situ, ventral; J. Labrum and oral appendages in situ, ventral; K. First and second legs in situ, ventral. J & K, magnified as in I.

on the average. In a male, body length excluding caudal ramus $323\ \mu\text{m}$, length of dorsal shield $149\ \mu\text{m}$ and cephalothorax $109\ \mu\text{m}$ in width.

Female: Body (Fig. 44A, B) stouter than in preceding stage especially in meta-urosomal portion. Increase of body segments unnoticed, and segmentation more indistinct than in preceding stage. Posterior portion corresponding to last two segments narrower than preceding portion, with 2 transverse ridges covered with spinules more prominent than in preceding stage.

Appendages altered though slightly. *First antenna* (Fig. 44C) fleshy, 2-segmented; the first more than twice as long as the second, with 2 stout setae on the antero-ventral margin; the second with about 12 setae and a seta-like aesthete. *Second antenna* (Fig. 44D); accessory antennule representing rudiment of original terminal segment much more reduced into a small tissue mass on the base of terminal claw. *Labrum* and *oral appendages* (Fig. 44E; Lr, Md, Mx', Mx'', Mxp) somewhat stronger than in previous stage; *first maxilla* (Mx') indistinctly 2-segmented and with a small projection on the medial margin of the first and a few transverse rows of spinules on the anterior surface of the second in addition to 2 terminal setae in this stage.

First 2 legs (Fig. 44F, G) more massive and deformed than in previous stage; segmentation indistinct, with spinose patches on the portions of basis and rami in addition to a lateral seta of basis and a few rudimentary seta at the tip of rami. Caudal furca forming itself into a horn-like process by fusing with the longest terminal spine of the preceding stage.

Male (Fig. 44H-K): Body almost the same as in preceding stage in size and structure, but clearly distinguishable by shape of 2 pairs of legs. Dorsal shield of cephalothorax distinct. Last urosomal segment with neither transverse ridges nor spinose areas on the ventral side. *Second antenna* (Fig. 44I; A'') different from that of female in shape of terminal claw. *Mandible* (Fig. 44J; Md) with lesser number of teeth on the terminal blade than in female. *Second maxilla* (the same; Mx'') more strongly developed than *maxilliped* (Mxp); first segment very much thickened. First two pairs of legs (Fig. 44K; P1, 2) degenerative; endopodite diminished in size to form a simple small plate; exopodite almost completely fused to basis to form a process ending in 3 setae and 2 setae in first and second legs respectively.

Fourth Copepodid Stage (Female) (Fig. 45).

Body length excluding caudal ramus 750 to $970\ \mu\text{m}$ and $950\ \mu\text{m}$ on the average of 15 females; dorsal shield $370\ \mu\text{m}$ in length on the average, cephalothorax $320\ \mu\text{m}$ in both width and depth on the average.

Body similar to third copepodite in shape and structure though size distinctly larger than it. *First antenna* (Fig. 45C) lost segmentation, represented by a rod-shaped fleshy structure which consists of a thick proximal part and slender distal part; proximal part twice as long as distal part, armed with three stout setae on its antero-ventral face; distal part armed with about 11 setae together with an apical aesthete. *Second antenna* (Fig. 45D) consisting of 2 broad basal segments and a terminal claw; an antennary gland noticeable, its opening located on the lateral side

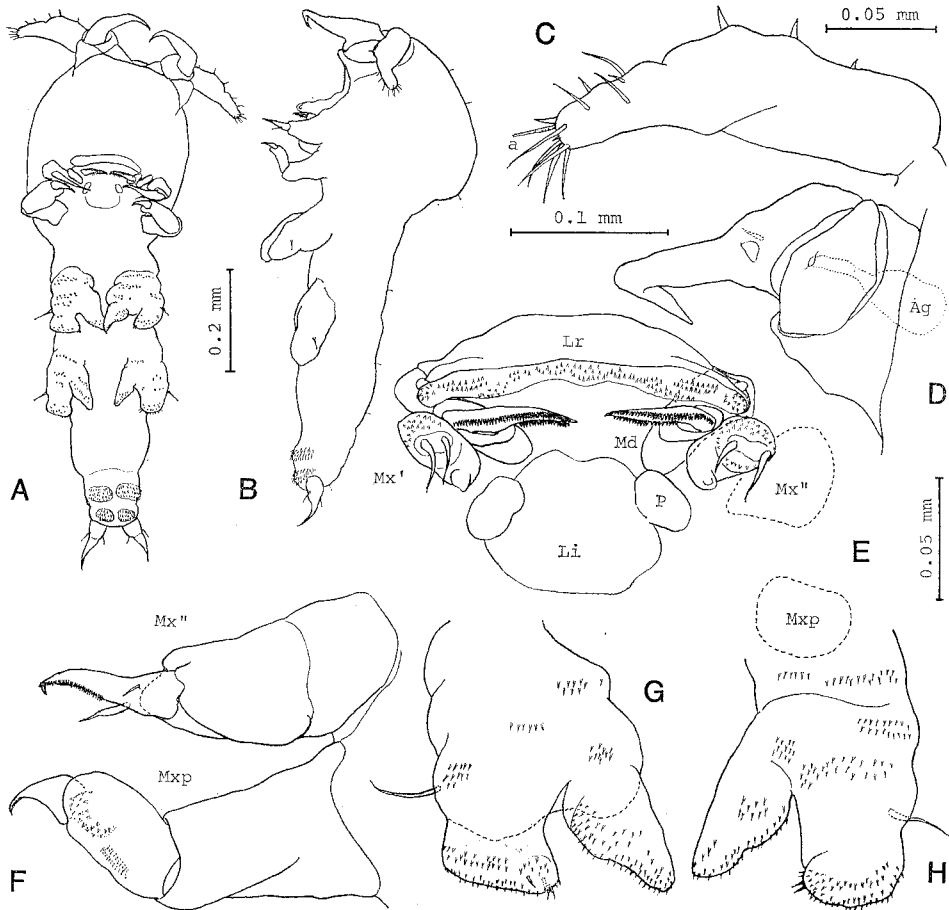


Fig. 45. Fourth copepodite of *Acanthochondria yui* Shiino, female. A, B. Total individual, ventral and lateral; C. First antenna, ventral; D. Second antenna, lateral; E. Labrum and oral appendages in situ, ventral; F. Second maxilla and maxilliped in situ, lateral; G. First leg, ventral; H. Second leg, ventral. F-H, magnified as in C. Abbreviation: Ag, antennary gland.

of second segment; terminal claw with a seta near the base on the medial side; rudiment of original terminal segment completely disappeared leaving a small unsclerotized area on lateral side of the basal portion. *Labrum* and *oral appendages* (Figs 45E; Lr, P, Li, Md, Mx', Mx'', Mxp; 45F; Mx'', Mxp) almost as in preceding stage, though developed a little more strongly. First two pairs of legs (Fig. 45G, H), a little more strongly developed than in preceding stage, forming into a mitten-like shape as in adult female.

Male: unknown.

Fifth Copepodid Stage (Figs 46 & 47).

Body length of female, excluding caudal ramus, 1260 to 1710 μm and 1528 μm on the average of 37 individuals; dorsal shield 518 μm in length on the average,

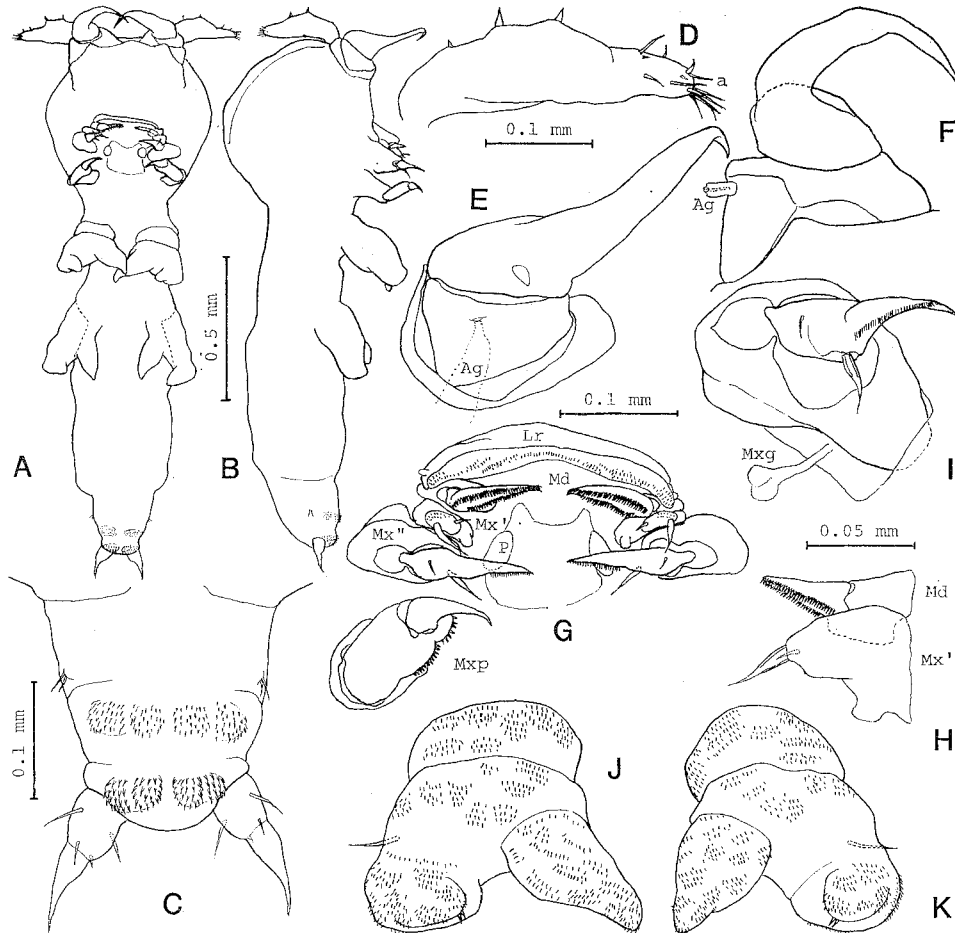


Fig. 46. Fifth copepodite of *Acanthochondria yui* Shiino, female. A, B. Total individual, ventral and lateral; C. Urosome, ventral; D. First antenna, ventral; E. Second antenna, lateral; F. Second antenna with a part of duct of antennary gland extruded, lateral; G. Labrum and oral appendages in situ, ventral; H. Mandible and first maxilla, lateral; I. Second maxilla with a maxillary gland extruded, ventral, magnified as in H; J. First leg, ventral; K. Second leg, ventral; J & K magnified as in E. Abbreviation: Mxg, maxillary gland.

cephalothorax 470 and 422 μm in width and depth respectively on the average. A male 417 μm in length excluding caudal ramus and 199 μm in width at the broadest portion.

Female (Fig. 46): Body (Fig. 46A, B) similar to preceding stage in shape and structure though distinctly larger than in the latter and with urosome more thickened than metasome of first and second pedigerous portion. Distal portion of urosome (Fig. 46C) abruptly narrowed and divisible into 3 segments by constrictions; the first with 2 setae on the ventro-lateral margin of both sides, probably representing rudimentary 6th legs, then this segment regarded as genital segment; following

2 segments with pads covered with spinules on the ventral side.

All appendages (Fig. 46D–L) similar to those of preceding stage in shape and structure but not in size. *Second antenna* (Fig. 46E, F) with an antennary gland. In rare case probably owing to condition during preparation of specimens, a part of duct of an antennary gland turned inside out accidentally and extruded out from its opening. *First maxilla* (Fig. 46G, H; Mx'); 2 terminal setae different in size. *Second maxilla* (Fig. 46G; Mx''; I) with a maxillary gland opened on the posterior side of the first segment almost completely fused with sternal surface. In a rare case also probably by the same reason as in antennary gland, the maxillary gland turned inside out accidentally and extruded out from its opening as shown in Fig. 46I. First and second legs (Fig. 46J, K) covered with spinules more densely than in preceding stage.

Male (Fig. 47): Body (Fig. 47A, B) thickened at the cephalic portion and

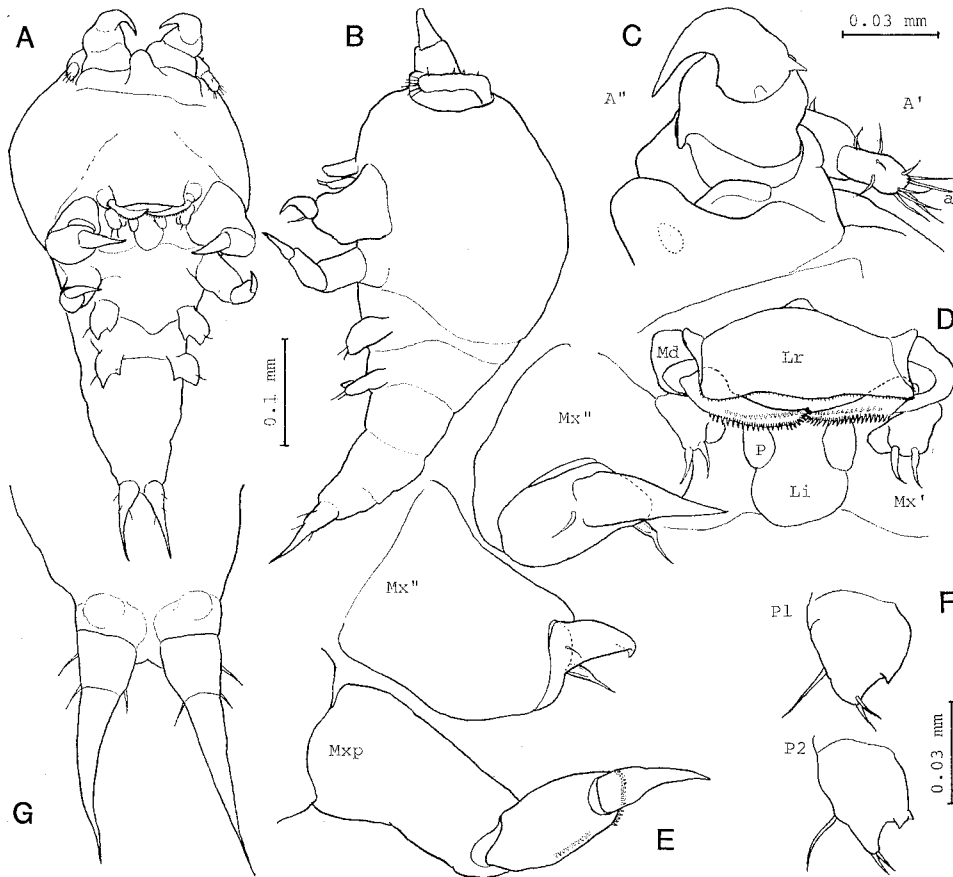


Fig. 47. Fifth copepodite of *Acanthochondria yui* Shiino, male. A, B. Total individual, ventral and lateral; C. First and second antennae in situ, ventral; D. Labrum and oral appendages in situ, ventral; E. Second maxilla and maxilliped in situ, lateral; F. First and second legs in situ, ventral; G. Caudal rami in situ, ventral, magnified as in E.

tapered distally. *First antenna* (Fig. 47C; A') fleshy, indistinctly 2-segmented; the first with 3 stout setae on the ventro-anterior margin; the second narrowed and with about 10 setae and a setiform aesthete. *Second antenna* (Fig. 47C; A'') strong; the terminal claw with a small conical process on the lateral side of the base. *Mandible* (Fig. 47D; Md) stronger than in third copepodid stage, increasing in number of teeth. *First maxilla* (Fig. 47D; Mx') with 2 equal setae. *Second maxilla* (Fig. 47E; Mx'') with thickened basal segment, stronger than *maxilliped* (Fig. 47E; Mxp).

First and second legs (Fig. 47F; P1 & P2) similar to each other in shape and size, more simplified than in third copepodid stage; endopodite fused to basis to form a small conical process; exopodite ending in 2 setae.

Sixth Copepodid Stage (Adult) (Figs 48 & 49).

Of 18 females examined, 7 individuals bore egg sacs and 8 individuals were accompanied by a male. Almost all the females larger than ca. 3800 μm in body length had egg sacs and were accompanied by a male. All males mating with female were adult.

Body length of female 2200 to 5700 μm and 3700 μm on the average of 18 individuals, but 4500 μm on the average of 7 ovigerous females; dorsal shield 750 to 1455 μm and 1070 μm on the average in length and 800 to 1550 μm and 1050 μm on the average in width. A male 507 μm in length in natural form and 318 μm in depth at cephalic portion.

Female (young adult, Fig. 48): Body begins to grow at the posterior portion, which follows after a narrow neck-like portion of first and second pedigerous segments, and to develop a pair of posterior processes; then head, neck, and trunk with genito-abdomen definable. Trunk armed with a pair of knob-like pads on the ventral face between the bases of posterior processes and just in front of genital segment (Fig. 48B). These pads are probably deformed fifth legs and used for mating, in which the male grasps them with his second antennae. Genital segment (Fig. 48B) globoid, with a pair of genital slits opened along the lateral sides; a seta found arising from inside of the posterior end of each genital slit, probably rudimentary sixth leg; a pair of small, somewhat pointed processes found at the middle of ventral side. The last-mentioned processes seem to be some structure belonging to the reproductive system, as far as judging from the fact that they were connected with each the genital slit by a duct-like structure. Abdomen small globoid, probably composed of fused 2 abdominal segments, and ending in a pair of caudal rami armed with a stout horn-like process which originated from the longest terminal spine of first copepodid stage, 2 setae on the ventral face, and 1 seta on the dorsal face near the base of the horn-like process.

First antenna (Fig. 48C; A') swollen about the middle, with a terminal tuft of setae. *Second antenna* (Fig. 48C; A'') stronger than in preceding stage, an antennary gland found yet. *Labrum* and *oral appendages* (Fig. 48D; Lr, Md, P, Mx', Mx'', Mxp) stronger than in preceding stage. *Labrum* (Lr) with spinules on the

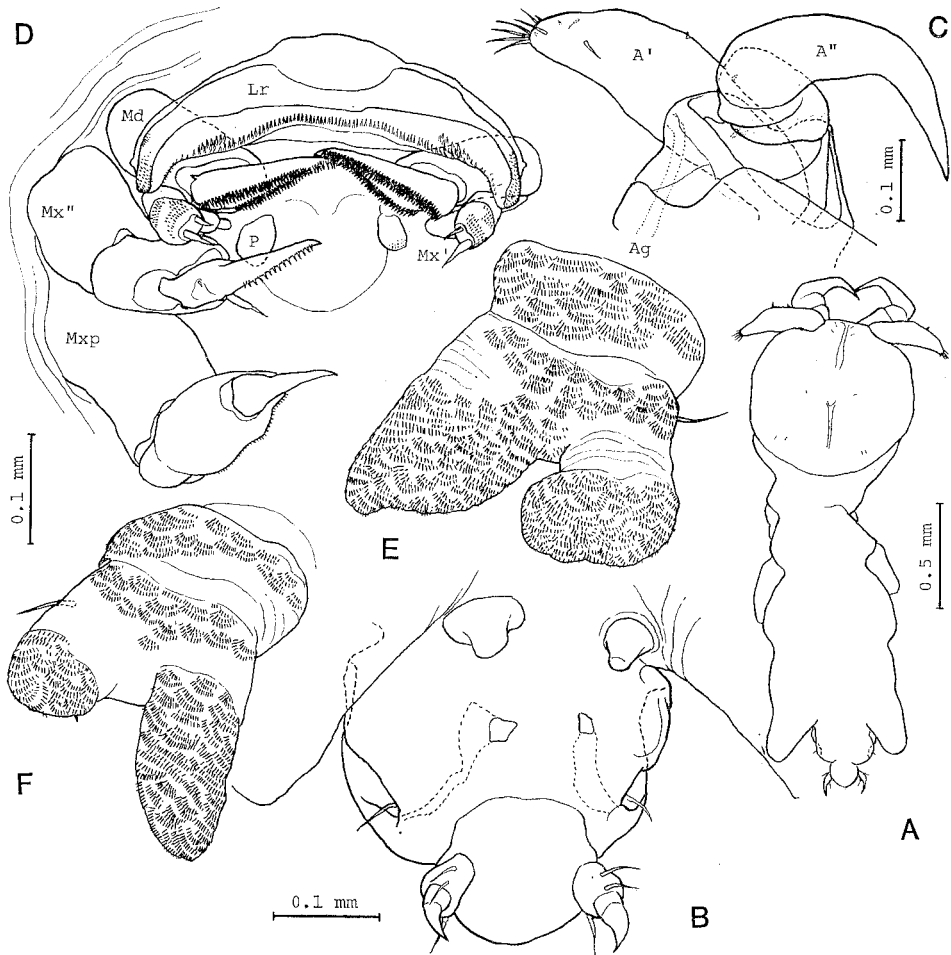


Fig. 48. Sixth copepodite (young adult) of *Acanthochondria yui* Shiino, female. A. Total individual, dorsal; B. Abdomen, ventral; C. First and second antennae in situ, ventral; D. Labrum and oral appendages in situ, ventral; E. First leg, ventral; F. Second leg, ventral.

posterior surface and fine spinules on the outside of lateral portion which is somewhat expanded posteriorly. *Mandible* (Md) with basal segment laid on the sternal surface and seemingly fused or sank into the latter, across which the lateral portion of labrum overlaid; terminal blade with rows of some 40 and 30 teeth on the ventral (convex) and dorsal (concave) margins respectively. *Paragnath* (P) with fine spinules on the terminal surface. *First maxilla* (Mx') 2-segmented; the first elongated laterally and laid on the sternal surface along the posterior side of mandibular basal segment, with a blunt projection on the medial side; the second somewhat flattened laterally and perpendicular, with 2 unequal setae on the tip and fine spinules on the lateral surface. *Second maxilla* (Mx'') 3-segmented; the first thickened but almost fused to the sternal surface; the second flattened antero-posteriorly;

terminal claw armed with a row of ca. 15 teeth along the convex side distally, and a seta and a spinule at the base. *Maxilliped* (Mxp) 3-segmented; the first stout but longer than wide; the second somewhat flattened antero-posteriorly, swollen at the medio-distal corner, and covered with spinules on the swelling and medio-posterior margin; terminal claw simple.

First and second legs (Fig. 48E, F) flattened and covered densely with spinules which are arranged like scales, with constrictions or naked areas dividing coxa, basis and rami, and with a seta on the lateral side of basis.

Male (Fig. 49): Dwarf. Body (Fig. 49A) drop-shape; prosome globular, more thickened than in the preceding stage; urosome less than a half of prosome in either dimensions, gently vent ventrally. Portion of second pedigerous segment narrowed; following portion indistinctly 3-segmented, thicker than second pedigerous portion; first 2 segments naked, the last segment with a pair of genital slits each accompanied with a lateral flap along the outer margin of slit, and ending in caudal rami.

Rostrum and antennae (Fig. 49B; R, A', A''): *Rostrum* (R) with a round swelling on the ventral surface at the middle. *First antenna* (A') indistinctly 3-

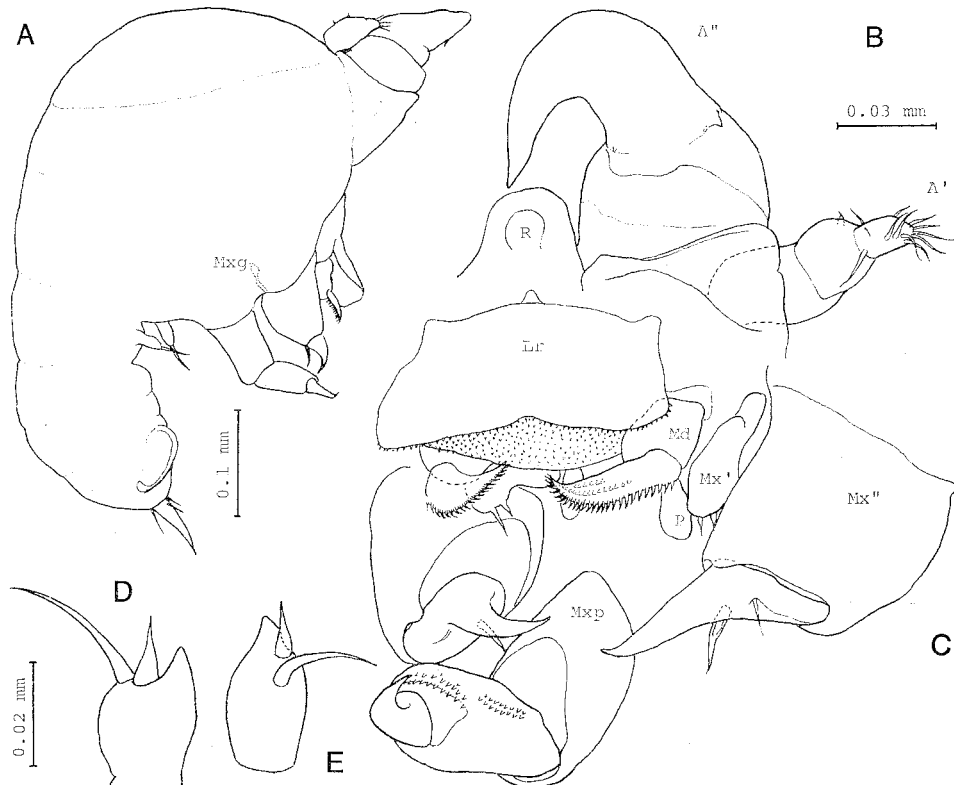


Fig. 49. Sixth copepodite (adult) of *Acanthochondria yui* Shiino, male. A. Total individual, lateral; B. First and second antennae in situ, ventral; C. Labrum and oral appendages in situ, ventral; D. First leg, anterior; E. Second leg, lateral.

segmented, with a few short but thick setae on the anterior side of proximal 2 segments and some 12 setae on distal segment. *Second antenna* (A'') much more stronger than in the preceding stage; basal portion very much thickened and indistinctly segmented; terminal claw, too, very thickened and deeply curved. Labrum and oral appendage (Fig. 49C; Lr, Md, P, Mx', Mx'', Mxp): *Labrum* (Lr) rectangular, wider than long, slightly curved posteriorly at both of the lateral margins, covered with spinules posteriorly. *Mandible* (Md) probably with 3 rows of teeth; a row of ca. 25 teeth along the whole of the convex ventral margin, a row of ca. 16 teeth on the posterior surface, and a row of ca. 6 teeth along a distal portion of the concave dorsal margin. *Paragnath* (P) simple pouch-like, elongated antero-posteriorly. *First maxilla* (Mx') indistinctly 2-segmented, ending in 2 setae. *Second maxilla* (Mx'') becomes stronger than maxilliped; the first segment completely fused into the sternal surface though retained an opening of maxillary gland just posterior to the base of voluminous second segment (see Fig. 49A; Mxg); terminal claw strong, with 2 unequal setae at the base, but without teeth. *Maxilliped* (Mxp) 3-segmented; the first almost as long as the second with a few rows of spinules along the medial margin about the middle and medio-distal margin; the third a simple stout claw.

First and second legs (Fig. 49D, E) simpler than in preceding stage, similar in shape and size; lobe-like, with a conical terminal process and 2 setae, a terminal conical process at the medial side and a stout seta-like structure correspond to endopodite and exopodite respectively, and a long lateral seta representing the original seta of basis. Caudal ramus horn-shape, with 3 setae at the base.

Remarks. As to larvae of the Chondracanthidae, the first nauplii have been described in the first by Claus (1858) in *Chondracanthus lophii*, then Heegaard (1947) followed after him in describing the larvae of *Acanthochondria cornuta* and *Chondracanthus gracilis*. Though Heegaard (*l.c.*) suggested that there was only one naupliar stage in the Chondracanthidae, I think that all the chondracanthids develop into the first copepodid stage through 3 naupliar stages as shown here, as this family is very homogeneous. As far as I am aware, Heegaard (*l.c.*) was the sole worker who described chondracanthid copepodid larvae. He described, following to the first nauplius, the first copepodid and succeeding stages. However, some misidentification of stages are included in his paper, though his identification on the first copepodid and young adult female are right; *viz.* his second copepodid and the appendages (Heegaard, *op. cit.*, figs 119–124), too, are clearly of the first copepodid stage; his third, fourth, fifth and adult males (Heegaard, *op. cit.*, figs 125–135) can be regarded as the second, third, fourth and fifth males respectively in high probability; his young and slightly older females (Figs. 136–140) are probably fourth and fifth females respectively. As seen in *Acanthochondria yui* described here, the sexes are definable as early as the second copepodid stage in the Chondracanthidae. This seems to be a feature characteristic to the forms with dwarf male.

Phylogenetic significance of some respective features which appeared during the ontogeny of these species will be examined in detail elsewhere.

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