

On the Development of Parasitic Copepoda
III. *Taeniacanthus lagocephali* Pearse
(Cyclopoida : Taeniacanthidae)

By

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With Text-figures 1-9

Taeniacanthidae Wilson, 1911, is a family flourishing as fish parasites. It makes a distinct group of the parasitic copepods of marine fishes together with the closely related and also flourished family, Bomolochidae Sumpf, 1871, and three small families; *i.e.* Tuccidae Vervoort, 1962, Telsidae Ho, 1967, and Tegobomolochidae Avdeev, 1978. Of these families, the Taeniacanthidae which includes some 70 species tends to be rather more variable as mentioned by Kabata (1979) and is peculiar in containing a few genera parasitic on marine invertebrates.

As far as I am aware, ontogeny of this group has so far been unknown at all though the first nauplii of two bomolochid species were described by Kabata (1976). In this paper the development of *Taeniacanthus lagocephali* Pearse, 1952, is dealt with, describing the first two nauplius stages reared and the all copepodid stages collected from a puffer, *Lagocephalus gloveri* Abe & Tabeta.

Specimens used for the following descriptions were obtained from some individuals of *Lagocephalus gloveri* fished in Tanabe Bay, Wakayama Prefecture, Japan, in April, 1971. A large number of individuals of *Taeniacanthus lagocephali*, including ovigerous females, were taken out from the branchial cavity and gills of the hosts. Rearing nauplii was carried out at the Seto Marine Biological Laboratory where I stayed. Egg sacs removed from the females were reared each in a glass bowl with sea water filtered through cotton. The bowls were kept in water bath at 16-17°C. Neither aeration nor circulation of the water was made, but the water was renewed two or three times a day. No consideration was made as to the food supply.

The nauplii reared and copepodites collected from the host were fixed with formalin and preserved in alcohol. The preserved specimens were then measured and examined in lactic acid by using the wooden slide of Humes & Gooding, in some cases being stained with Chlorazol Black E. Drawings and measurements were made respectively by using Abbe's drawing apparatus and ocular micrometer.

Development

Eggs are small, 68 μm in diameter on an average, though an enormous number of them are brooded; they become translucent near hatching. Hatched nauplii passed into the second nauplius stage within 2 days at 16-17°C, but any further

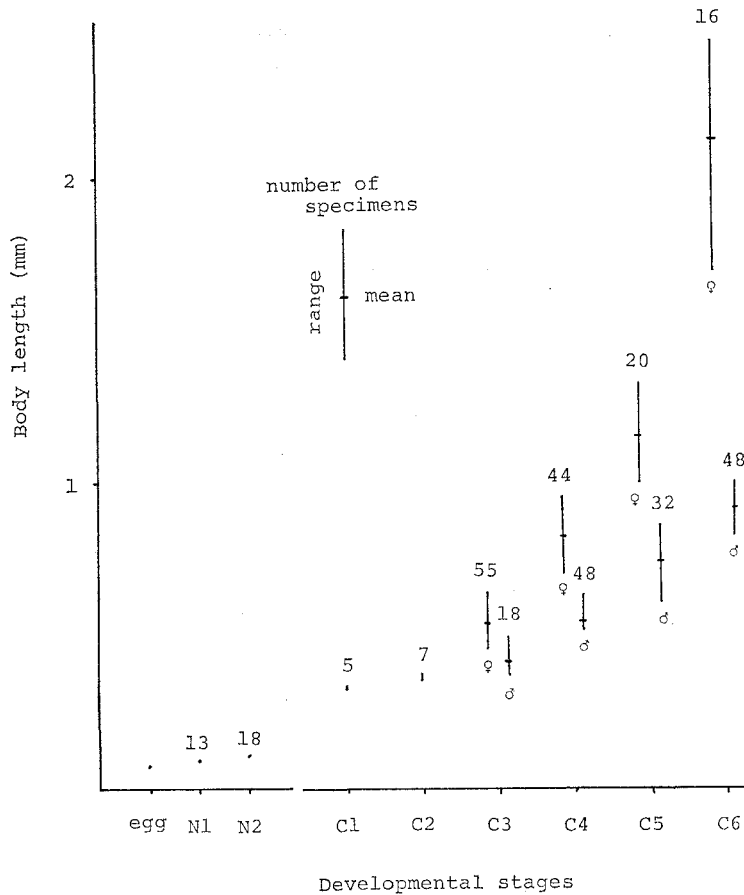


Fig. 1. Growth in body length excluding caudal rami of *Taeniacanthus lagocephali* Pearse. Abbreviation: N1-2, nauplius stage 1-2; C1-6, copepodid stage 1-6.

moult did not proceed.

Growth of body length is shown in Fig. 1. Sexual dimorphism of maxillipeds appears at the fifth copepodid stage. The sexes, however, are distinguishable before the fifth copepodid stage by body length. The females are larger than the males. Ranges of body length of the both sexes separate completely after the fourth copepodid stage. Most females of the fifth copepodid stage are accompanied with an adult male in each, which holds genital segment of the female from the back by powerful maxillipeds, but the females of this stage are not yet given with spermatophores. Adults are found rather on the inner walls of the branchial cavity, while the larvae are mostly found on the gill filaments. Matured females are pale yellow due to the gonads and have red eyes. Adult males and larvae are translucent with silvery red eyes.

First Nauplius Stage (Figs. 2A; 3A, C, E).

Body length $85\mu\text{m}$ and width $39\mu\text{m}$ on an average. Body (Fig. 2A) slim, slightly

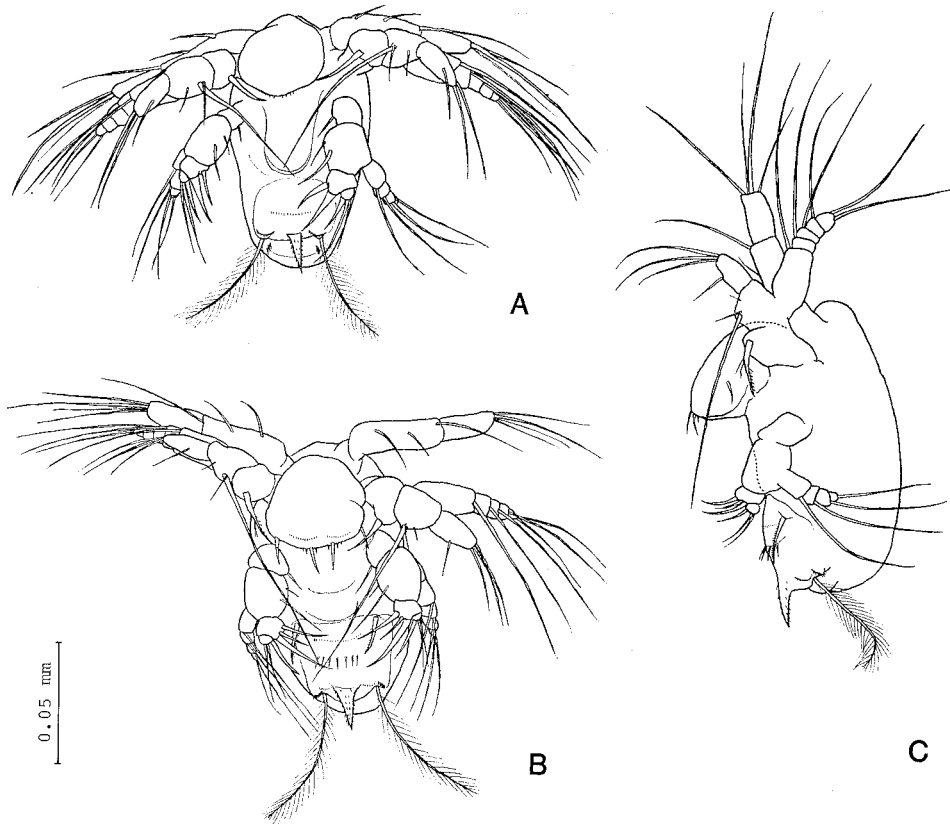


Fig. 2. First two nauplii of *Taeniacanthus lagocephali* Pearse. A. first nauplius, ventral; B. second nauplius, ventral; C. the same, lateral.

constricted on the ventral side at the posterior one third just posterior to labium, with a transverse row of fine spinules on the ventral surface on the posterior portion; furcal armature consisting of a spinulate median process and a pair of hairy setae accompanied with 2 small spinulate ridges at each base. Labrum moderate, with fine spinules on the distal free margin. Labium represented as a slight bulge of the sternal surface, naked.

First antenna (Fig. 3A) ca. $55\ \mu\text{m}$ long excluding setae; segments more or less flattened and 3-segmented; the first short, naked; the second long, with 3 relatively long simple setae on the ventral margin respectively at the base, middle and the end; the third about half as long as the second, ending in a long simple seta and a hairy one accompanied at the base with a thin, but long aesthete.

Second antenna (Fig. 3C) $55\ \mu\text{m}$ long excluding setae; segments more or less flattened. Coxa short, the medial margin projected into a knob tipped by a stout spine. Basis slightly longer than wide, furnished with 3 spines around the middle on the rounded medial margin, the median one of these very long, attaining to about $55\ \mu\text{m}$. Endopodite 1-segmented, slightly shorter than the first exopodite segment,

with a spine at the middle of the medial margin and tipped by a simple inner seta and a sparsely hairy outer one. Exopodite issuing from the outside of basis, 5-segmented; the first almost as long as either basis or distal 4 segments combined together; each segment with a plumose seta at the medio-distal corner, only the terminal segment additionally with a simple seta at the outer distal corner.

Mandible (Fig. 3E) ca. 40 μm long excluding setae, flattened. Coxa short, with a short spine on the rounded medial margin. Basis very broad, but yet slightly longer than wide, with 2 unequal spines on the medial margin about the middle. Endopodite 2-segmented; the first expanded medially and 2 times as wide as long, with 2 stout spines on the medial margin; the second small, with a stout spine on the medial margin and a simple seta and a sparsely hairy one on the distal margin. Exopodite narrow, issued from the distal margin of basis and 4-segmented; segments diminishing the size distally and each with a plumose seta at the medio-distal corner in proximal 3 but at the distal end in terminal segment.

Second Nauplius Stage (Figs 2B, C; 3B, D, F).

Length 112 μm and width 58 μm on an average. Body (Fig. 2B, C) ornamented markedly on the ventral surface in the posterior portion with a transverse row of ca. 7 thin spinules; rudimentary first maxillae emerged on the ventral side posterior to labium as a pair of spines spinulated only along the medial side; furcal armature as in the preceding stage. Labrum armed with 4 spines on the distal free margin, medial 2 of these accompanied with a few spinules around the base. Labium as in the first stage. Three pairs of appendages more or less stronger than in the first nauplius.

First antenna (Fig. 3B) ca 65 μm long excluding setae, with an addition of a simple seta at the distal end of terminal segment.

Second antenna (Fig. 3D) ca. 60 μm long excluding setae. Coxa covered with a few transverse rows of fine spinules on the anterior surface; the medial spine with 2 fine branches at the proximal one third of posterior side, while hairy in the distal half on the outside. Basis furnished with a transverse row of fine spinules and a short basal spine on the anterior surface; the longest one of the 3 medial spines attaining nearly 85 μm , while the distal one much diminished. Endopodite with an addition of a seta-like spine at the medio-distal corner; the outer distal margin fringed with fine spinules. Exopodite maintaining the same setation as in the first stage, but all apical setae plumose in this stage.

Mandible (Fig. 3F) with protopodite and endopodite somewhat stouter than in the first stage, though spines on coxa and basis diminished the size a little. First endopodite segment with an addition of 2 more spines between the 2 stout ones on the medial margin, the proximalmost one of these 4 spines with a few hairs along the proximal edge of the anterior side. Second endopodite segment with the same setation as in the preceding stage, though 2 apical setae diminished the size. Exopodite moved from the distal margin to the subterminal site on the outer margin of basis, with an addition of a setule proximally on the medial margin of first segment.

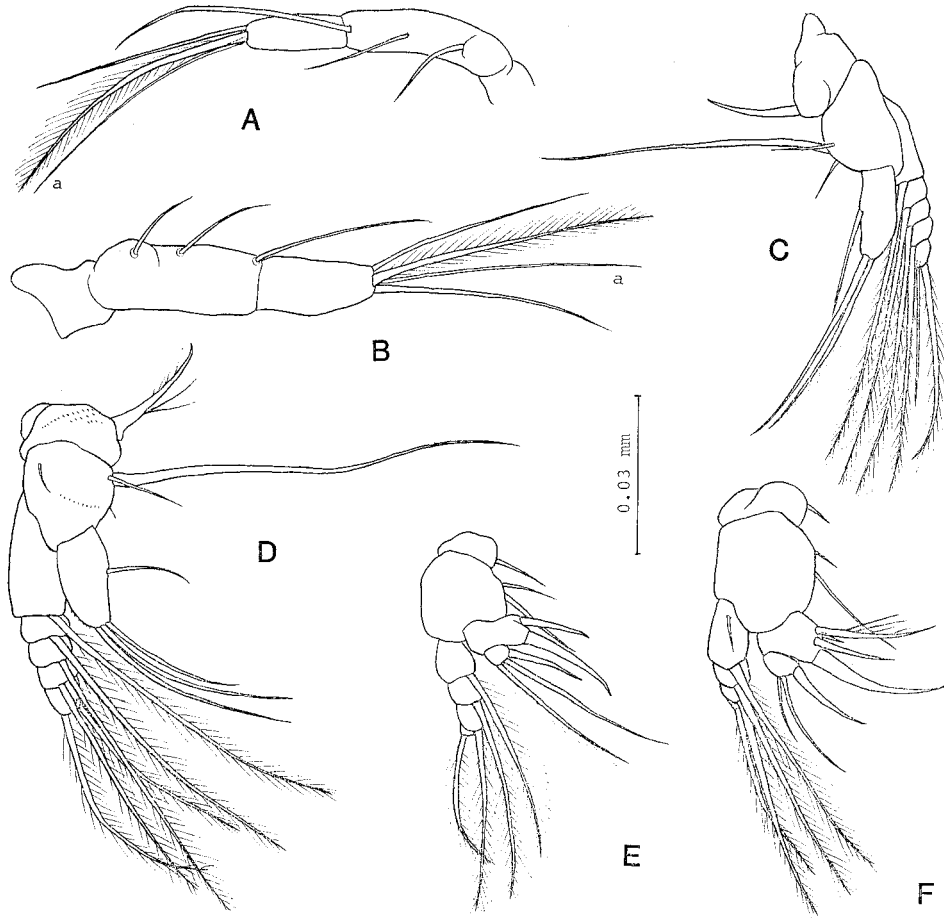


Fig. 3. Naupliar appendages of *Taeniacanthus lagocephali* Pearse. A & B. first antenna of first nauplius (A, ventral) & second nauplius (B, postero-ventral); C & D. second antennae of first (C) & second (D) nauplii, antero-ventral; E & F. mandibles of first (E) & second (F) nauplii, anterior. Abbreviation: a, aesthete.

First Copepodid Stage (Figs 4A, F; 5A-G; 6A).

Body length excluding caudal rami $326\ \mu\text{m}$ to $333\ \mu\text{m}$ and $330\ \mu\text{m}$ on an average, cephalothorax $175\ \mu\text{m}$ in length and $120\ \mu\text{m}$ in width on an average in 5 specimens. Cephalothorax, metasome and urosome clearly demarcated (Fig. 4A). Cephalothorax slightly longer than the combined length of metasome and urosome; first pedigerous segment included in it. Pleura of cephalothorax at the portion from the second antennae to posterior to maxillipeds protrude ventrally and flank the bases of these appendages (Fig. 5A). Metasome of second pedigerous segment narrower than the posterior portion of cephalothorax and about half as long as wide. Urosome (Fig. 4F) much narrower than anterior body portions, 3-segmented; the first broader distally, with rudimentary third legs each represented by 2 spines of a hairy one at the postero-lateral margin on the ventral side and a shorter simple one

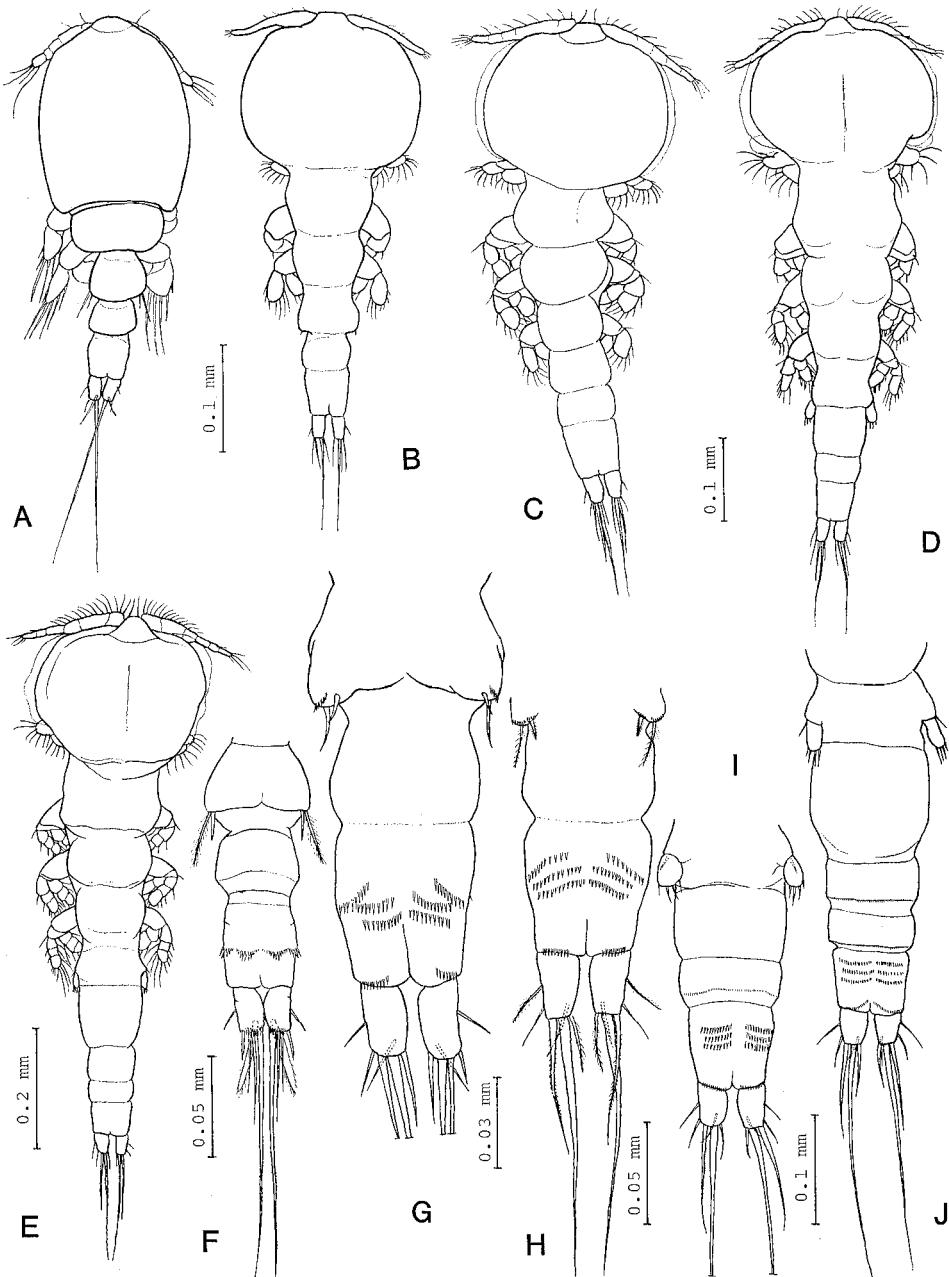


Fig. 4. Copepodites of *Taeniacanthus lagocephali* Pearse. A. first copepodite, dorsal; B. second copepodite, dorsal; C. third copepodite, dorsal; D. fourth copepodite (female), dorsal; E. fifth copepodite (male), dorsal; F-J. urosomes of first (F) to fifth (J, male) copepodites, ventral.

at its inner base; the second wider than long, too, naked; anal segment longer than wide, ornamented around the middle on the ventral surface with a transverse row of 4 groups of lamellate spinules of different lengths.

Rostrum (Fig. 5A; R) moderate, folded back on the ventral side of cephalothorax, with the rounded distal margin.

First antenna (Fig. 5B) 5-segmented; setal formula of segments 2, 2, 3, 2+1 aesthete, 7+1 aesthete; aesthetes filiform.

Second antenna (Fig. 5A; A"; 5C) 5-segmented; the first short, unarmed; the second elongate, about 3 times as long as wide, with a seta at the dorso-distal corner and a digitiform structure tipped by 2 setules at the end of the ventral side, representing rudimentary exopodite; the third about half as long as the second, with a seta almost at the middle on the posterior side; the fourth almost as long as the third, narrowed distally into a knob-like spinulate process, with 4 longitudinal rows of spinules on the postero-ventral surface and a seta and an articulate claw on the dorsal side; the fifth issuing from the middle of the dorsal side of the fourth, smaller, furnished with 2 articulate claws on the distal margin and 4 setae around the dorso-distal corner, 2 of them much shorter than the other ones.

Labrum (Fig. 5A; Lr) broadened and flattened distally, unarmed.

Mandible (Fig. 5A, E; Md; 5D) strong, biparted and unique in structure; the first thick, with a tissue mass representing rudimentary exopodite at the anterior distal corner; the second narrowed and recurved distally to form a horn-like process, furnished basally on the medial margin with a narrow lamellar process and a gnathobase-like strong process curved and flattened distally and fringed along the truncate distal edge with ca. 7 teeth.

Paragnath (Fig. 5A, E; P) naked, divided into a flat basal portion and a lobe-like distal portion perpendicular to the former.

First maxilla (Fig. 5A, E; Mx') 2-segmented; the first expanded laterally, with 2 spinulate setae on the medial margin; the second lobe-like, with 2 setae on the outer and 3 ones on the medial margin.

Second maxilla (Fig. 5A; Mx"; 5F) 2-segmented; the first stout, thickened at the base, furnished on the medio-distal margin with a thick plumose seta; the second small, narrowed distally and tipped by a spinulate claw and 3 feeble spines including 2 spinulate and a hairy ones.

Maxilliped (Fig. 5A; Mxp; 5G) well developed, probably 4-segmented; the first short, furnished at the medio-distal corner with a spine bearing hairs in the distal portion; the second elongated, about 3 times as long as wide, with a simple spine at the proximal one third on the medial margin and an additional spine bearing 2 spine-like branches almost at the middle and the distal one fourth on the anterior side; the third very small, carrying 2 long spiny processes branched complicated as seen in the figure, the terminal one gently curved and furnished with 3 branches on the outer side probably representing terminal segment.

Anterior 2 pairs of legs (Fig. 6A; P1, P2) biramous, almost the same in size and structure; each consisting of flattened 2-segmented protopodite and 1-segmented

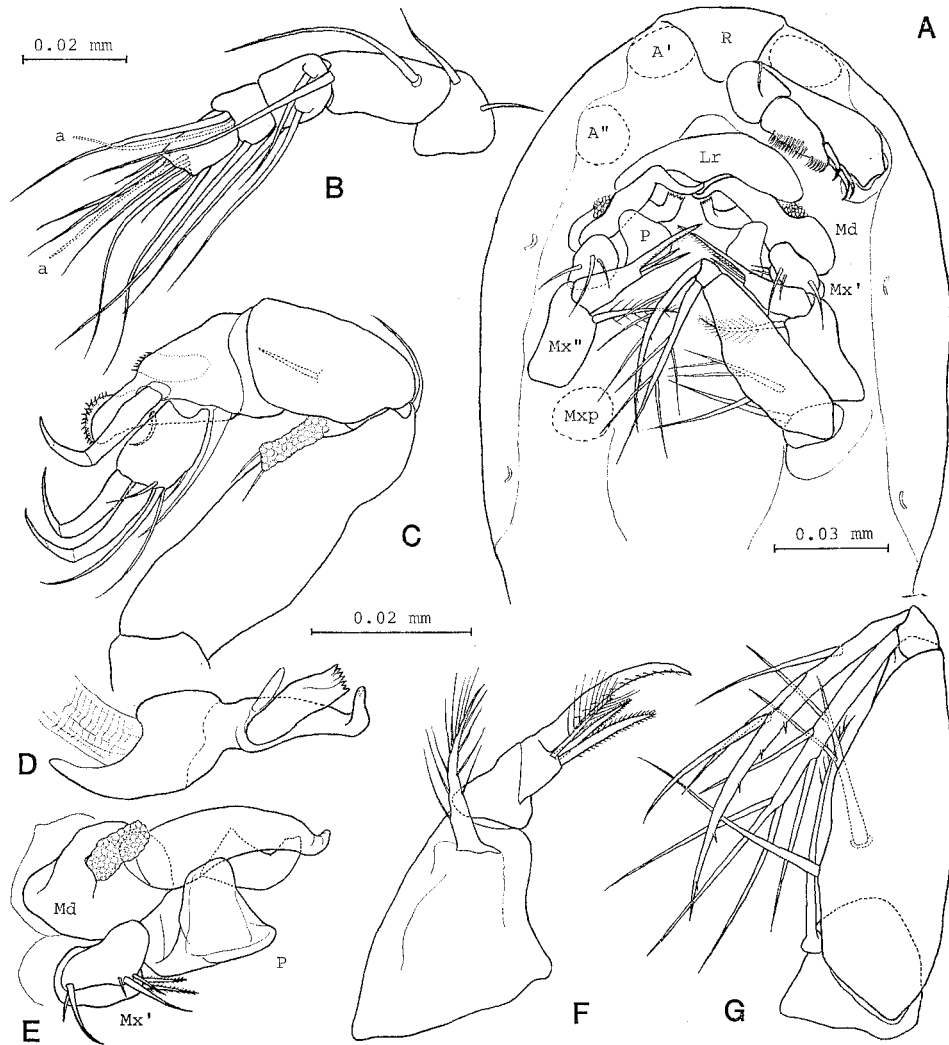


Fig. 5. Appendages of first copepodite of *Taeniacanthus lagocephali* Pearse. A. appendages on cephalothorax in situ, with first antennae removed, ventral; B. first antenna, ventral; C. second antenna, antero-lateral; D. mandible, dorsal; E. mandible, first maxilla and paragnath in situ, ventral; F. second maxilla, medial; G. maxilliped, lateral. Magnification of D-G as in C. Abbreviations: R, rostrum; A', first antenna; A'', second antenna; Lr, labrum; Md, mandible; P, paragnath; Mx', first maxilla; Mx'', second maxilla; Mxp, maxilliped.

rami; coxa of first leg with fine spinules along the distal edge on the anterior side; basis with a distal seta on the outside. Exopodites ornamented with spinules along the outer margin, but endopodites with hairs along the same margin; first leg exopodite furnished with in addition to 3 plumose setae on the medial margin 5 spines on the outer margin, the proximal 4 of these with a membrane or pectination on each edge and a fine terminal blade, while the distalmost one with hairs on the inside but a membrane on the outside and terminally with a fine blade; 3 spines on the distal

margin of second leg endopodite respectively with a narrow membrane on both edges, too, but lacking terminal blade, the middle one of these much longer than others. Setal formulae of legs as follows (number of spines in Roman and that of setae in Arabic numerals):

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

Caudal ramus (Fig. 4F) longer than wide, with a short transverse ridge at the proximal one fourth on the outer side, a row of 7-10 fine spinules along the distal margin on the ventral side and 6 spines, a short one at the middle on the outer margin and 5 on the distal margin, the innermost one of the latter much longer than others and medio-distal one on the dorsal side lamellate.

Second Copepodid Stage (Figs 4B, G; 6B-H).

Body length excluding caudal ramus 359 to 375 μm and 365 μm on an average, cephalothorax 150 μm in length and 161 μm in width on an average in 7 specimens. Body (Fig. 4B) consisting of roundish cephalothorax and succeeding slender body part; metamerism somewhat indistinct. Cephalothorax (Fig. 6B) slightly wider than long, depressed; the ventral side concaved, equipped with a membrane along each lateral margin, and functioning as a suction cup as in adult. The posterior body part consisting of 2 metasomal and 3 urosomal segments, narrower posteriorly, about half as wide as cephalothorax at the level of widest first metasomal segment. The two metasomal segments with second and third legs respectively. Urosome (Fig. 4G) slightly longer than metasome; first segment wider distally, with rudimentary third legs each represented by a postero-lateral expansion on the ventral side and tipped by 2 spines and fine spinules set near their base; the second naked; anal segment longer than wide, with 4 transverse, medially interrupted rows of spinules on the ventral surface, 3 rows around the middle and one along the distal margin.

Rostrum (Fig. 6B; R) relatively small.

First antenna (Fig. 6B; A') 5-segmented; setal formula of segments 2, 6, 3, 2+1 aesthete, 7+1 aesthete; setae on first 2 segments hairy.

Second antenna (Fig. 6B; A"; 6C) 5-segmented, structured essentially almost the same as in first copepodite, but rudimentary exopodite dropped. Fourth segment newly furnished at the ventro-distal corner with a blade-like lamellate process serrated along the ventral edge with ca. 22 teeth, and throughout the ventral surface with 2 longitudinal rows of denticles; the proximal seta on the dorsal side in first copepodite disappeared in this stage. Terminal segment incompletely coalesced with the fourth on the dorsal side and furnished distally with 2 claws and 2 setae, one of the latter much shorter than the other.

Postantennal process (Fig. 6B; Pap) appeared just lateral to the second antenna base; forming a stout hook as in adult.

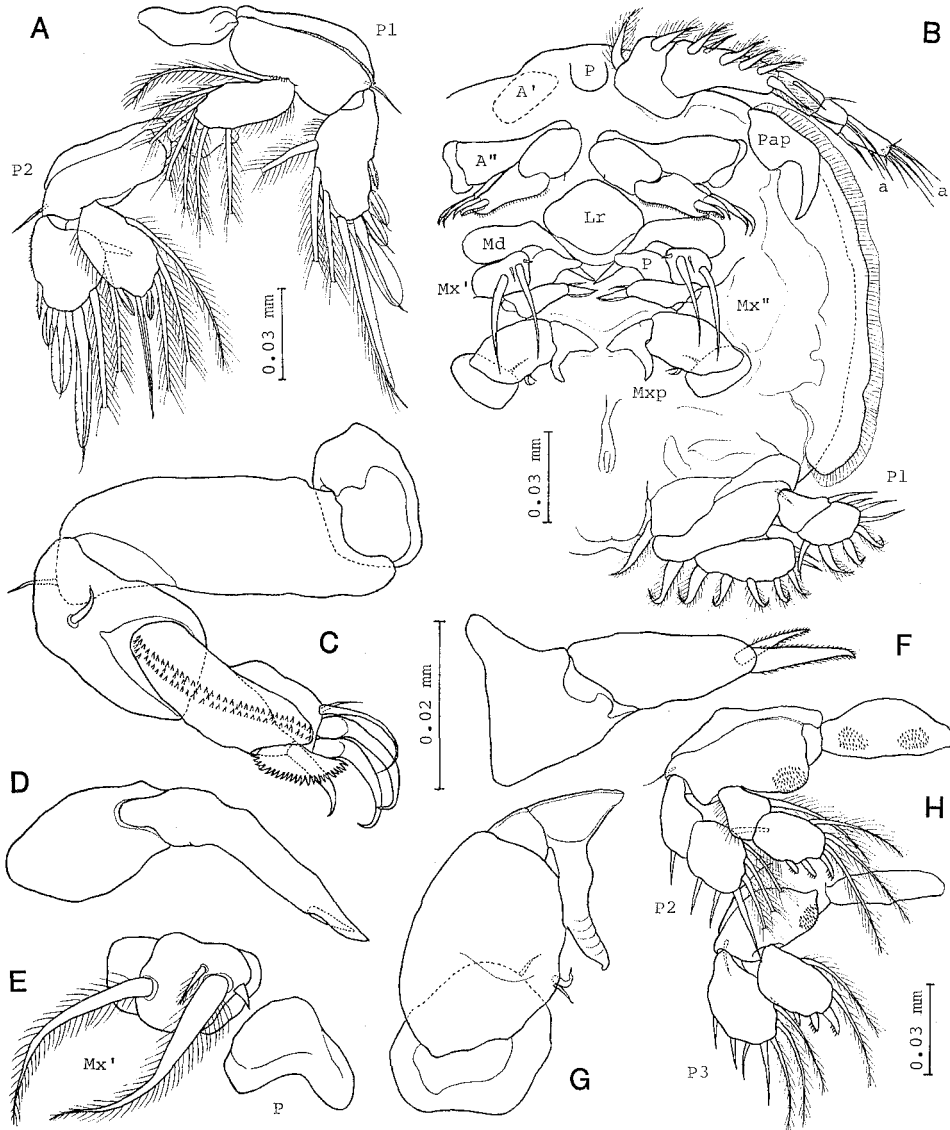


Fig. 6. Appendages of first and second copepodites of *Taeniacanthus lagocephali* Pearse. A. First copepodite: first and second legs in situ, ventral; B-H. Second copepodites: B. cephalothorax, ventral side; C. second antenna, postero-ventral; D. mandible, postero-ventral; E. first maxilla and paragnath in situ, ventral; F. second maxilla, ventral; G. maxilliped, postero-ventral. Magnification of D-G as in C; H. second and third legs in situ, ventral. Abbreviations: Pap, postantennal process; P1-3, leg 1-3.

Labrum (Fig. 6B; Lr) relatively smaller than in preceding stage, still unarmed. Mandible (Fig. 6B; Md; 6C) essentially almost the same as in adult, 2-segmented; the first devoid of rudimentary exopodite; the second forming distally a lanceolate process accompanied with a subterminal accessory blade instead of a strong, gnathobase-like process in first copepodite.

Paragnath (Fig. 6B, E; P) with the distal portion narrowed and medially bent. First maxilla (Fig. 6B, E; Mx'). First segment stripped of setae, 2 hairy setae of second segment developed markedly.

Second maxilla (Fig. 6B; Mx'', 6F). First segment stripped of a stout plumose seta from the medial margin; the second longer than the first, more than 2 times as long as wide, ending in 2 unequal spine-like, spinulate processes.

Maxilliped (Fig. 6B; Mxp; 6G) essentially almost the same as in adult female, 4-segmented; the first still short, but broad, with a medial spine reduced; the second massive, with 2 rudimentary spines on the medial margin; the third still small; the fourth forming distally a strong bifurcate process.

First leg (Fig. 6B; P1) assuming and functioning almost the same as in adult, with 2-segmented exopodite; coxa and basis each with an additional stout plumose seta at the medio-distal corner. Second leg (Fig. 6H; P2) with 2-segmented rami; basis with rounded patches of fine spinules near the medio-distal corner as well as on the sternal plate. Third leg (Fig. 6H; P3) with 1-segmented rami; basis with a seta on the outer margin and a patch of fine spinules near the medio-distal corner. Setal formulae of 3 legs as follows:

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

Exopodite spines simple in all legs, while those of endopodite in second and third legs with a few fine spinules distally only on the outer margin.

Caudal ramus (Fig. 4G) almost the same as in adult.

Third Copepodid Stage (Figs 4C, H; 7A, B).

Sexes definable by body size, though structural difference in appendages indiscernible. Body length excluding caudal ramus 455 to 646 μm and 542 μm on an average in 55 females, while 364 to 495 μm and 407 μm on an average in 18 males; cephalothorax in female and male respectively 210 μm and 160 μm in length and 208 μm and 168 μm in width on an average. Body (Fig. 4C) with metasome and urosome, both 3-segmented. Third metasomal segment with biramous fourth legs. Urosome (Fig. 4H) shorter than metasome; first segment newly with rudimentary fifth legs as a pair of small bulges tipped by 2 spines respectively at each ventro-posterior corner; the second wider than long, naked; anal segment the same as in the preceding stage.

Cephalic appendages (Fig. 7A) related more closely to those of adult. First antenna 6-segmented; setal formula of segments 3, 7, 4, 4, 2+1 aesthete, 7+1 aesthete. Second antenna densely covered with spinules on the ventro-posterior surface of fourth segment as in adult. Maxilliped with terminal process longer than in the preceding stage.

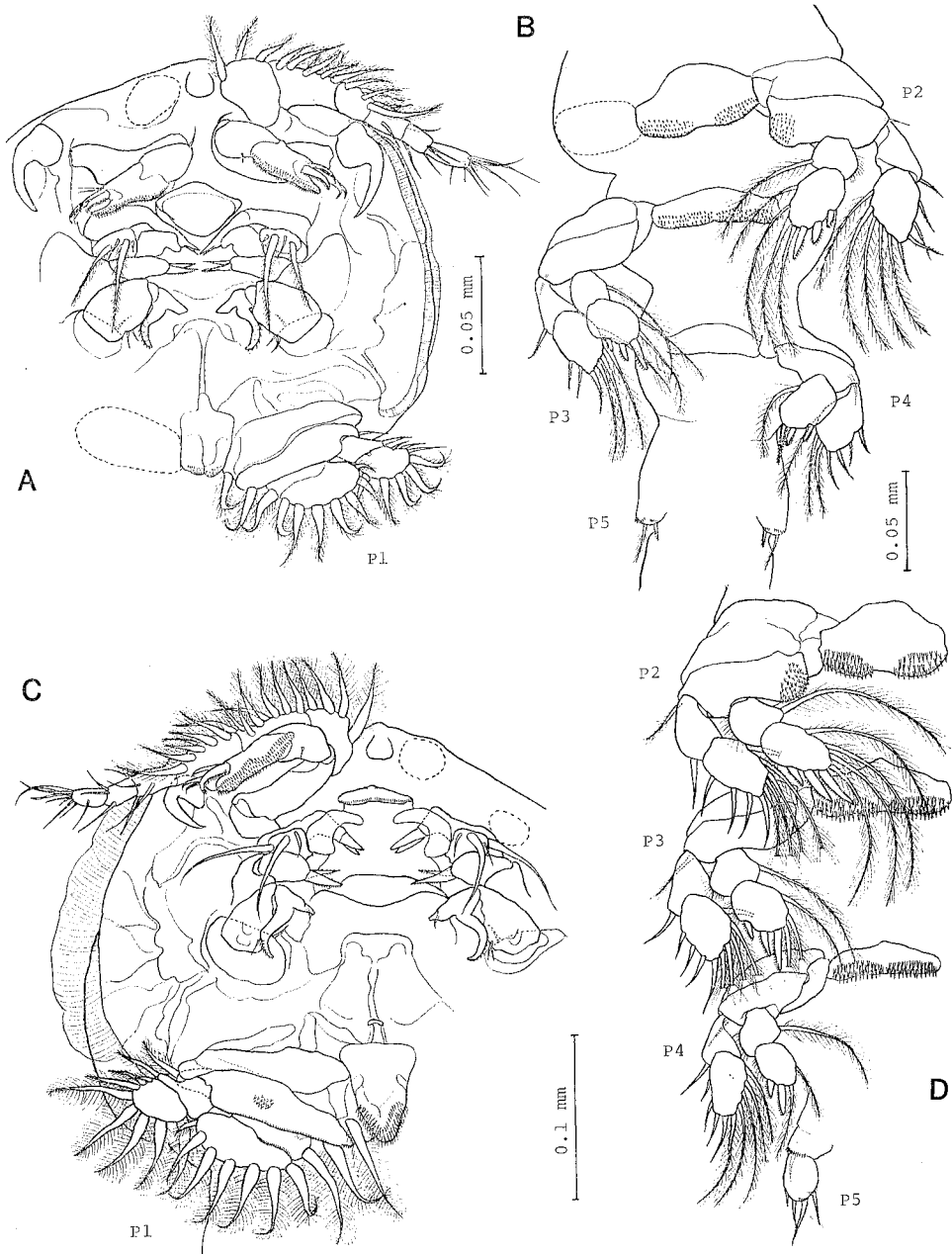


Fig. 7. Appendages of third and fourth copepodites of *Taeniacanthus lagocephali* Pearse. A & B. Third copepodite: A. cephalothorax, ventral side; B. legs 2-5 in situ, ventral; C & D. Fourth copepodite: C. cephalothorax, ventral side; D. legs 2-5 in situ, ventral. Abbreviation: P4 & 5, leg 4 & 5.

Anterior 4 pairs of legs appear all biramous; rami 2-segmented in legs 1-3, but 1-segmented in leg 4. Setal formulae of legs as follows:

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

Fourth Copepodid Stage (Female: Figs 4D, I; 7C, D).

Body length excluding caudal ramus 737 to 955 μm and 824 μm on an average in 44 females, while 515 to 636 μm and 544 μm on an average in 48 males; cephalothorax 269 μm and 193 μm in length and 298 μm and 198 μm in width on an average respectively in female and male. Body (Fig. 4D, I) with 4-segmented urosome; first urosomal segment with fifth legs.

Cephalic appendages to first legs given in Fig. 7C. First antenna 6-segmented; setal formula of segments 4, 8, 6, 4, 2+1 aesthete, 7+1 aesthete. Terminal processes of mandible more developed than in the preceding stage. Paragnath narrower than in the third stage. Maxilliped with 2 distal segment coalesced with each other to form a bifurcate process; sexual dimorphism noticeable, though slight, in length of process, two branches of process shorter in male than in female; with 2 small swellings at the proximal portion on the posterior side of second segment.

Anterior 4 pairs of legs (Fig. 7C; P1; 7D; P2-4) all with 2-segmented rami; setal formulae of legs as follows:

	Protopodite coxa; basis	Endopodite seg. 1; 2	Exopodite seg. 1; 2
Leg 1	1-0; 1-1	1-0; 7,0	0-1; 8,0
Leg 2	0-0; 0-1	1-0; 4,III	0-I; 5,IV
Leg 3	0-0; 0-1	1-0; 3,III	0-I; 5,IV
Leg 4	0-0; 0-1	1-0; 2,II	0-I; 5,IV

Fifth leg (Fig. 7D; P5) as uniramous 2-segmented appendage as in adult; the first short, almost completely fused to somite, with a simple seta at the dorso-distal corner and a row of fine spinules along the distal edge on the ventral side; the second ovoid, distally with 4 setae accompanied each with a short fringe of fine spinules at the base.

Fifth Copepodid Stage (Female: Fig. 8B; Male: Figs. 4E, J; 8A, C).

Sexual dimorphism distinct in maxilliped in addition to body size. Females mostly found in mating, though spermatophores not yet received; held at urosome by adult male from the back with powerful maxillipeds.

Body length excluding caudal ramus 1150 μm and 740 μm on an average in 20 females and 33 males respectively, ranging 1000-1325 μm and 606-864 μm ; cephalothorax 376 μm and 232 μm in length, and 419 μm and 239 μm in width on an average

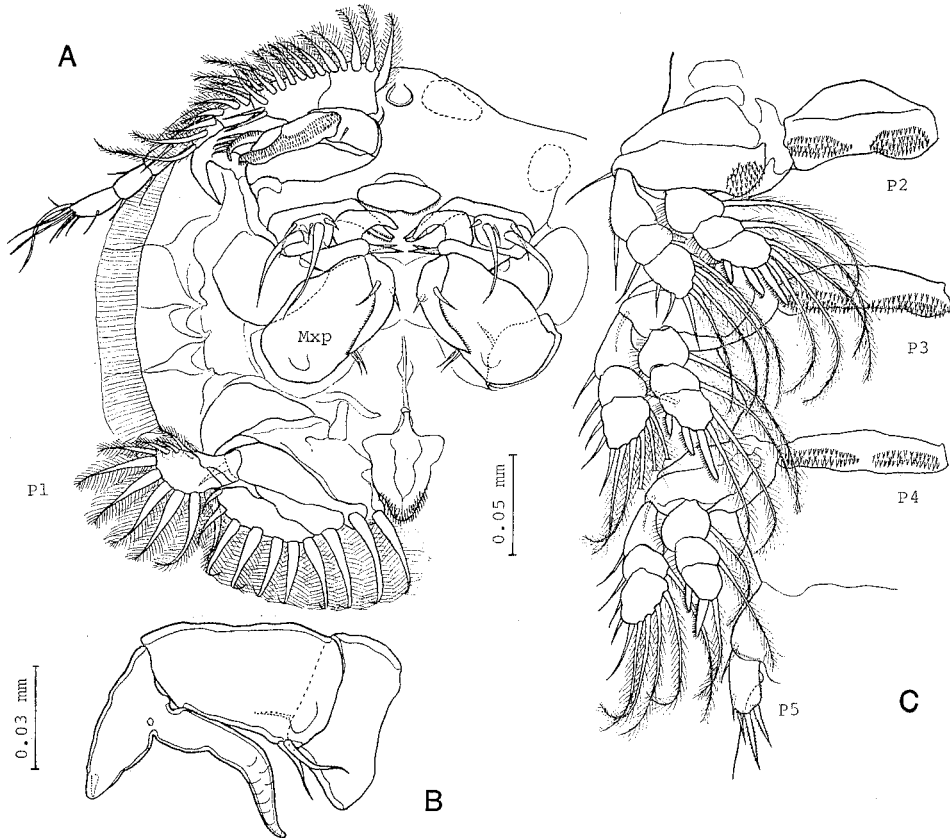


Fig. 8. Appendages of fifth copepodite of *Taeniacanthus lagocephali* Pearse. A. cephalothorax, ventral side, male; B. maxilliped of female, posterior; C. legs 2-5 in situ, ventral, male.

in female and male respectively.

Female: Body enlarged in cephalothorax and metasome, with 5-segmented stumpy urosome. Appendages but maxilliped almost the same as in male. Maxilliped (Fig. 8B) structured essentially the same as in adult female, though terminal process still less powerful. Setal formulae of segments of first antenna and all legs the same as in male.

Male: Body (Fig. 4E, J) slender, with 5-segmented urosome as in adult male.

Appendages (Fig. 8A, C) almost the same as in adult. First antenna 7-segmented; setal formula of segments 5, 15, 5, 3, 4, 2+1 aesthete, 7+1 aesthete. Maxilliped (Fig. 8A; Mxp) developed into a prehensile appendage, 3-segmented; the first short, with a seta at the medio-distal corner; the second massive, with 2 setae on the medial margin near the middle; the third forming a claw, stout but slightly shorter and feebler than in adult, fringed with fine spinules almost wholly along the concave margin and armed dorso-ventrally with 2 setae in the basal portion.

All the five legs (Fig. 8A; P1; 8C; P2-5) structured as in adult; rami 2-segmented in first leg and 3-segmented in second-fourth ones; ornamentation of rami as

in adult, too, though spines still less powerful especially those on terminal endopodite segment in legs 2-4, curved in adult, still straight. Setal formulae of legs as follows:

	Protopodite coxa; basis	Endopodite seg. 1; 2; 3	Exopodite seg. 1; 2; 3
Leg 1	1-0; 1-1	1-0; 7,0	0-1; 9(10),0
Leg 2	0-0; 0-1	1-0; 1-0; 3,III	0-1; 1-I; 4,III
Leg 3	0-0; 0-1	1-0; 1-0; 2,III	0-1; 1-I; 5,III
Leg 4	0-0; 0-0	1-0; 1-0; 1,II	0-1; 1-I; 4,III

Sixth Copepodid Stage (Adult) (Male: Fig. 9A-D).

Body length excluding caudal ramus 2120 μm and 913 μm on an average in 16

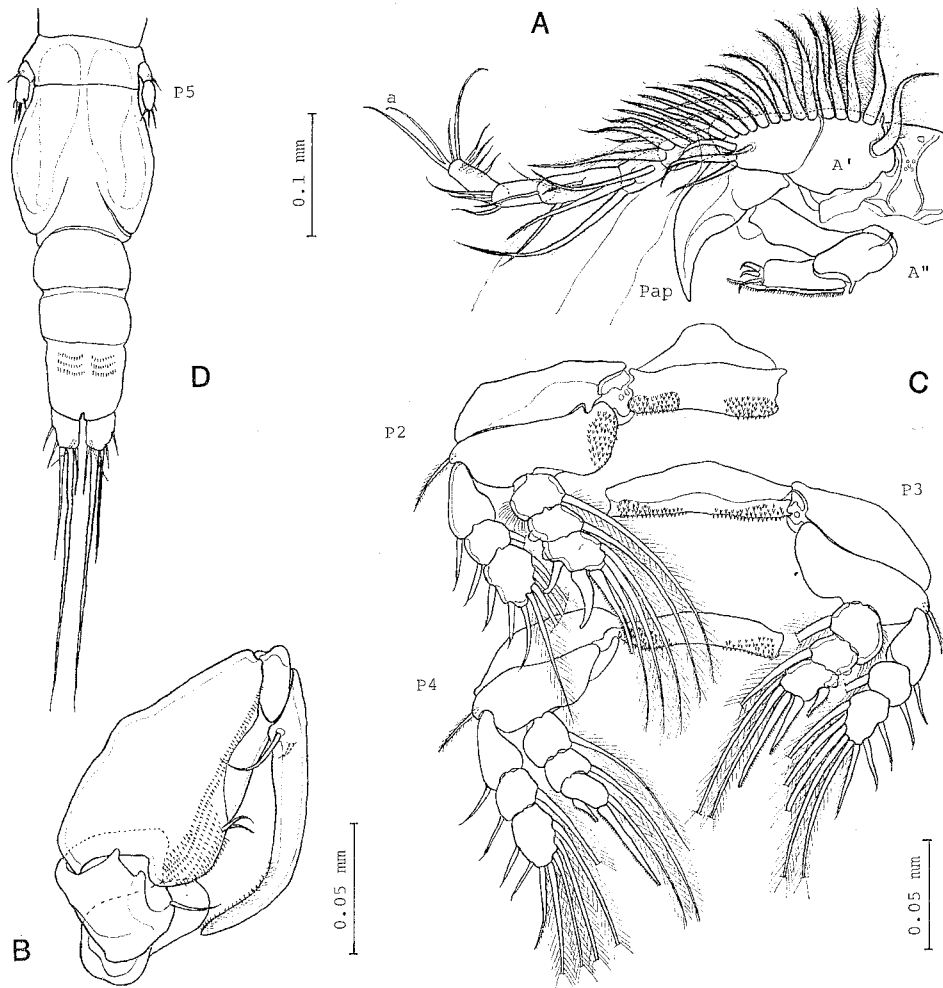


Fig. 9. Urosome and appendages of adult male of *Taeniacanthus lagocephali* Pearse. A. first and second antennae and postantennal process in situ, ventral; B. maxilliped, ventral; C. legs 2-4 in situ, ventral; D. urosome, ventral, magnified as in A.

females and 48 males, ranging 1690–2440 μm and 825–1000 μm respectively; width of cephalothorax 695 μm in female and 304 μm in male on an average.

Female: Body having cephalothorax and 3 metasomal segments swollen and subequal in length. Urosome 6-segmented, abruptly narrowed and short, almost as long as or slightly shorter than last metasomal segment; all segments much wider than long; first segment with fifth legs, the second genital, the third to fifth naked, anal segment with 3 transverse rows of spinules on the ventral side and ending in a pair of caudal rami.

Male: Body narrow, having 5-segmented urosome (Fig. 9D). First urosomal segment much wider than long, with fifth legs. Genital segment longer than wide and gently swollen at the middle, with a pair of cuticular slits representing genital pores. Third and fourth urosomal segments wider than long, naked. Anal segment longer than wide, ornamented with 3 transverse, intermitent at the middle, rows of spinules.

First antenna (Fig. 9A; A') 7-segmented, with a small spine-like projection of cuticle at the medio-anterior corner of first segment; setal formula of segments 5, 15, 5, 3, 4, 2+1 aesthete, 7+1 aesthete; setae on first 4 segments hairy. Postantennal process stouter than in the preceding stage. Maxilliped 5-segmented; first segment short and naked; the second with a medial seta; the third massive, with 2 medial seta, covered by longitudinal rows of fine spinules along the medial margin; fourth small, forming a joint; the fifth a long claw with 2 proximal setae and ridge-like teeth as a file along the distal concave margin. Second to fourth legs given in Fig. 9C (P2–P4); distal 2 endopodite segments in second and third legs each with a small, hemicyclic cuticular flange on the outer margin; spines of endopodites stouter than those of exopodites, while the latter with a fine terminal blade each. Setal formulae of legs 1–4 as follows:

	Protopodite coxa; basis	Endopodite seg. 1; 2; 3	Exopodite seg. 1; 2; 3
Leg 1	1-0; 1-1	1-0; 7,0	0-1; 9,0
Leg 2	0-0; 0-1	1-0; 1-0; 3,III	0-I; 1-I; 4,III
Leg 3	0-0; 0-1	1-0; 1-0; 2,III	0-I; 1-I; 5,III
Leg 4	0-0; 1-1	1-0; 1-0; 1,II	0-I; 1-I; 4,III

Fifth leg (Fig. 9D; P5) 2-segmented; first segment probably basis, separated from somite, with a seta on the dorso-distal margin; the second somewhat flattened and with 4 setae along the distal margin.

Discussion

Judging from egg size, 68 μm in diameter, of this species and a result of rearing nauplii, in that the hatched nauplii fail to moult into the third nauplius stage without food supply, it seems clear that feeding is indispensable for the nauplii to pass the later nauplius stages into the infective first copepodid stage. This seems to be confirmed by the fact that the second nauplii have well developed feeding apparatus,

i.e. a coxal masticatory spine of the second antenna (Fig. 3D) and medial spines of the mandibular endopodite (Fig. 3F). In this connection, medial spines on basis of the second antenna, too, are considered usually to take part in feeding, but the longest one of which seems clearly too long to feeding in this species. This extremely long spine is found also in other taeniacanthid nauplii studied by me but unpublished yet and in *Hemicyclops adharens* studied by Faber (1966, Figs. 31–33).

The nauplii of this species are characteristic in having a median process on the caudal margin besides paired furcal armature. Existence of such a median caudal process in early nauplii seems to be a feature common to the taeniacanthid-bomolochid group, since all the early nauplii of this group studied so far by me and the first nauplii of *Bomolochus cuneatus* and *Holobomolochus spinulus* studied by Kabata (1976, Figs. 5 & 10) are consistently provided with it, though Kabata has mentioned that the median caudal process probably can be used as distinguishing features of bomolochid nauplii in general.

As far as I am aware, this paper is the first in dealing with the whole copepodid stages of a taeniacanthid in detail. The first copepodite exhibits surprising uniformity in general body structure throughout all copepods, while the second copepodite shows significant changes towards parasitic life (Fig. 4A-E). The cephalothorax forms a suction cup in the second copepodid stage as in adult (Fig. 6B). The first copepodite of this species carries both unique mandibles and maxillipeds. The mandible is peculiar in having an additional gnathobase-like process, which remind me of a gnathostome mandible (Fig. 5D). The maxilliped well develops to assume an aspect of the feeding appendage as seen in the filter feeding copepods (Fig. 5G). This has a strong resemblance to those of the first copepodites of *Hemicyclops* sp. studied by Canu (1888, Pl. 28, Fig. 22; as *Giardella* sp.) and *H. adhaerens* by Gooding (1963, Pl. 3, Fig. h). Though remarkable features of these appendages of the first copepodite described here raise a little doubt as to its identify, I think true judging from that any other types of the first copepodite are not found among a series of many copepodites of this species examined. This is confirmed also in another lot of specimens including all the copepodid stages of this species obtained lately from the same host species of the East China Sea.

As for phylogenetic significance of the respective features found during the ontogeny will be examined in detail in future paper.

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