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ADULT MORPHOLOGY AND LARVAL DEVELOPMENT OF *PARAMPHIASCELLA FULVOFASCIATA* N. SP. (COPEPODA, HARPACTICOIDA) *

by

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Résumé

Paramphiascella fulvofasciata n. sp. (Copépode, Harpacticoïde), morphologie de l'adulte et développement larvaire.

Une espèce nouvelle de Copépode Harpacticoïde, *Paramphiascella fulvofasciata*, est décrite de la baie de Massachusetts (U.S.A.). *P. fulvofasciata* se rapproche beaucoup de *P. pacifica* Vervoort, mais les deux espèces diffèrent spécifiquement par le P_2 mâle. Le développement des états larvaires (nauplius et copépodites) de cette nouvelle espèce est également décrit. Il existe six stades nauplius et six stades copépodites (le sixième étant le stade adulte), comme chez les autres Harpacticoïdes. Le développement du corps et de chaque appendice est figuré et discuté. Le cycle complet, d'une éclosion de l'œuf à la suivante, dure 29 jours à 17 °C et est comparé à celui de plusieurs autres espèces.

Introduction

Collections from suspended sediment in tidal creeks and wood bored by the Isopod *Limnoria tripunctata* in Massachusetts Bay, U.S.A., have revealed the presence of a new harpacticoid copepod (*Paramphiascella fulvofasciata*) to be described herewith. The tidal creek specimens were collected from Blacks Creek, Quincy, Massachusetts, in the fall of 1961, and the specimens associated with *Limnoria* from Duxbury, Massachusetts, in the fall of 1972. The original Quincy collection consisted of 8 females and 2 males, whereas the *Limnoria* collections consisted of 73 females and 36 males.

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Cahiers de Biologie Marine
Tome XV - 1974 - pp. 295-317

Three ovigerous females from the 1961 Quincy collections were the source of the developmental material also to be described here. Each developmental series was started using laboratory reared F_1 generations. Each series consisted of a male and a female in an individual Syracuse watch glass with filtered sea water at 17 °C. Females were observed every 1-2 days and as the females produced a brood, the adult pair was transferred to a new culture dish. Emerging nauplii were either isolated in similar watch glasses or reared in group culture. Nauplii and copepodites were observed at regular intervals and fed on dry yeast suspended in deionized water (to allow starch particles to settle out). Exuviae were removed with a glass pipette, under a dissecting microscope. It was thus possible to obtain complete series of the developmental stages of separate, individual copepods. Dissection and mounting were as described by Humes and Gooding (1964). Drawings were made with the aid of a *camera lucida.*

The nomenclature, phylogeny and descriptive terminology used throughout are adopted from Lang (1948, 1965). The abbreviations used throughout the paper are: A_1 = antennule, A_2 = antenna, Md. = mandible, Mx. = maxilla, Mxl. = maxillula, Mxp. = maxilliped, P_1 - P_6 = leg 1 - leg 6.

The letter after each figure explanation refers to the scale at which that figure was drawn.

SPECIES DESCRIPTION AND ADULT MORPHOLOGY

PARAMPHIASCELLA FULVOFASCIATA n. sp.

Material: 81 ♀♀, 38 ♂♂. Holotype 1 ♀, U.S.N.M. No. 142962. Paratypes 5 ♀♀, 3 ♂♂, U.S.N.M. No. 142963.

Type locality: Blacks Creek, Quincy, Massachusetts, U.S.A. (42°16.0'N ; 71°59.50'W).

Other localities: Duxbury, Massachusetts. Additional specimens were found inhabiting marine aquaria at Quinnipiac College, Hamden, Connecticut, but their origin is unknown.

Female:

Based on adult female, 0.83 mm. Table 1 gives dimensions of adults (female and male). Body equally wide through most of its length (Figs 1, 2). Rostrum as in Fig. 3. Numerous very fine hair-like sensillae on body (Figs 4, 5). The genital somite is double, representing urosome somites 2 and 3 (Figs 4, 5, 6) and ornamented with a ventrolateral row of spinules on each side as well as by various chitinous knobs and sensillae as figured (Figs 5, 6). Distad of the genital field each somite is laterally ornamented with ventrolateral spinules and sensillae (Fig. 7). The posterior portion of the prosome and the anterior edges of each urosomal somite are transversely banded with a yellow-brown pigment. The yellow-brown pigment also occurs on the bases of the swimming legs. Caudal rami (Figs 1, 2, 8, 9) are slightly wider than long, dimensions as in Table 1.

A_1 (Fig. 10), 8 segmented, aesthetasc on segments 4 and 8.

A_2 (Fig. 11), with allobasis, 1-segmented endopod and 3-segmented exopod. Endopod with 8 terminal spines and setae. Exopod with one seta on the first, none on the second and 3 setae on terminal segment.

Md. (Fig. 12), cutting edge with bi-dentate pars incisiva, each with 3 cusps; 6 dentate lacinia and a seta. Coxa-basis with 3 terminal setae. Exopod 2-segmented, with 1 seta on first and 3 setae on second segment. Endopod 1-segmented with 5 setae, one of which is bifurcate.

TABLE 1.
Adult dimensions, *Paramphiascella fulvofasciata* n. sp.*

Part Measured	Male	Female
length from base of rostrum to tip of caudal rami, greatest width	780μ, 160μ	830μ, 176μ
rostre length, width at base	69μ, 41μ	64μ, 41μ
cephalic shield length, width	204μ, 155μ	226μ, 173μ
metasome segment 1 length, width	77μ, 159μ	80μ, 176μ
metasome segment 2 length, width	72μ, 148μ	76μ, 173μ
metasome segment 3 length, width	63μ, 144μ	71μ, 170μ
urosome segment 1 length, width	39μ, 142μ	48μ, 163μ
urosome segment 2 length, width	69μ, 144μ	genital segment
urosome segment 3 length, width	80μ, 144μ	127μ, 165μ
urosome segment 4 length, width	85μ, 137μ	87μ, 155μ
urosome segment 5 length, width	117μ, 124μ	118μ, 136μ
urosome segment 6 length, width	57μ, 104μ	63μ, 115μ
caudal ramus length, width	28μ, 39μ	32μ, 42μ
caudal setae lengths: inner, outer	360μ, 180μ	380μ, 230μ

(*) Body segments measured dorsally; measurements based on 1 male, 4 females.

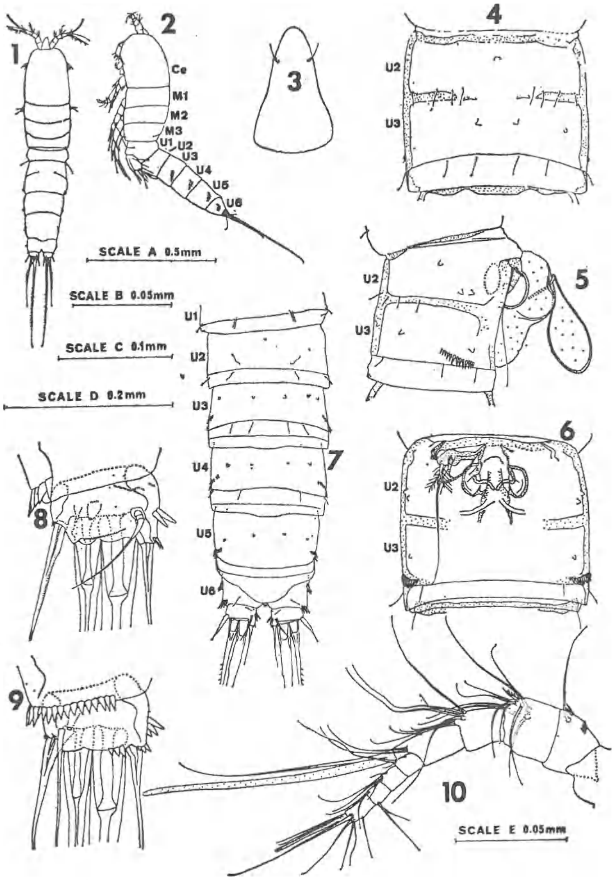
Mxl. (Fig. 13), praecoxa arthrite with 4 compound spines an adjacent seta terminally and 2 surface setae. Coxa with 2 terminal setae. Basis with 2 lateral and 3 terminal setae. Exopod and endopod each 1-segmented with 2 and 3 setae respectively.

Mx. (Fig. 14), syncoxa with 3 endites: the proximal one with 1 seta, the middle one with 2 setae and the distal one with 3 setae. Basis terminally with a large double claw. Endopod with 7 setae. Exopod absent.

Mxp. (Fig. 15), coxa short with fine setules on posterio-lateral surface; basis, 2-1/2 times as long as wide, with 4 setae at inner distal corner. First endopod segment with one row of spinules on the antero-ventral surface, one row of very small spinules on the postero-ventral surface and 2 setae on the posterior surface. Second endopod segment with 2 inner setae, one surface spine and terminating in a claw.

P_1 (Fig. 16), P_2 (Fig. 17), P_3 (Fig. 18), P_4 (Fig. 19) all with 3-segmented rami. Setation as figured and listed below:

	Exp.	End.
P_1	0.0.022	1.1.120
P_2	0.1.023	1.1.121
P_3	0.1.123	1.1.221
P_4	0.1.223	1.1.121



FIGS 1-10.
P. fulvofasciata n. sp. female.

1. habitus, dorsal (A); 2. habitus, lateral (A); 3. rostrum (B); 4. genital somite, dorsal (C); 5. genital somite, lateral with spermatophore (C); 6. genital somite, ventral (C); 7. urosome, dorsal (D); 8. caudal ramus, dorsal (F); 9. caudal ramus, ventral (F); 10. A_1 (B).

P_5 (Fig. 20), rami separate. Baseoendopodite reaching half the length of the exopod with 2 terminal, 1 sub-terminal and 2 inner setae. Exopod with 5 setae on margin.

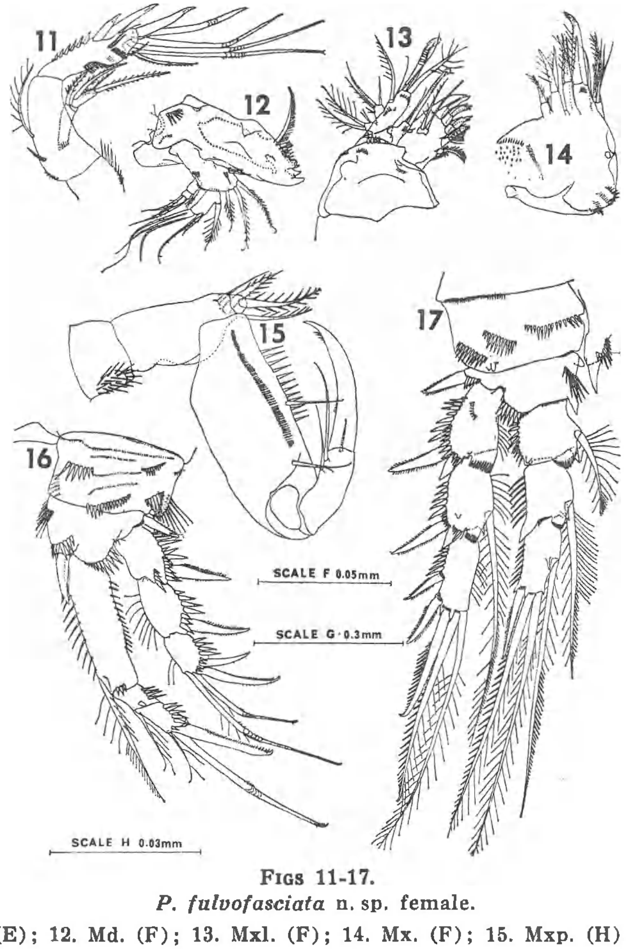
Male:

Based on a mature male 0.78 mm. Only body size, A_1, P_1 basis, P_2 and P_5 differ from the female.

Habitus (Fig. 21), slightly smaller and more slender than the female.

A_1 (Fig. 22), 9-10 segmented and haplocer. Large aesthetasc on segment 5 and small aesthetasc on last segment.

P_1 basis (Fig. 23), inner basis spine curved outward and displaced somewhat medially from that of the female (Fig. 16). The spinules located just above the spine in the female are replaced by

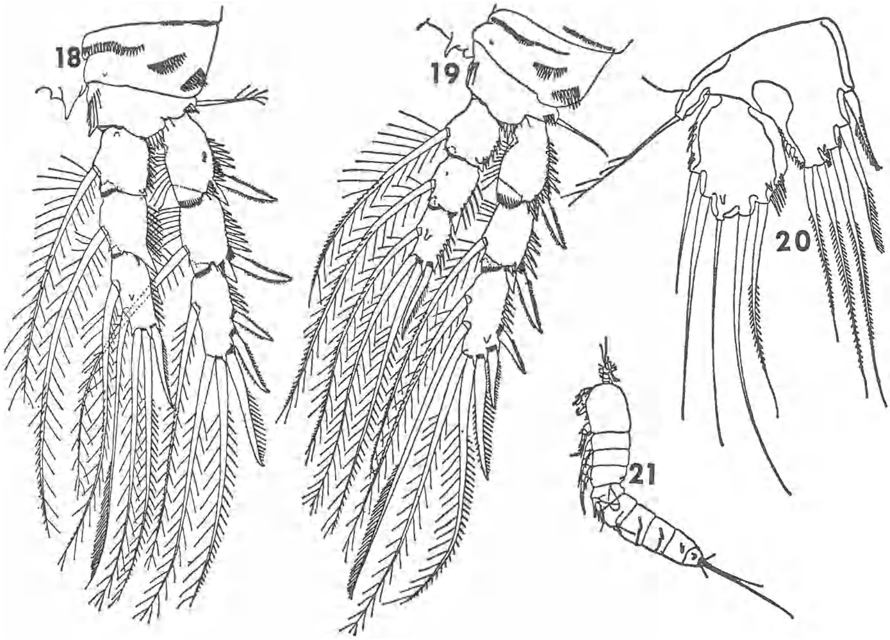


Figs 11-17.
***P. fulvofasciata* n. sp. female.**

11. A_1 (E); 12. Md. (F); 13. Mxl. (F); 14. Mx. (F); 15. Mxp. (H); 16. P_1 (E); 17. P_2 (E).

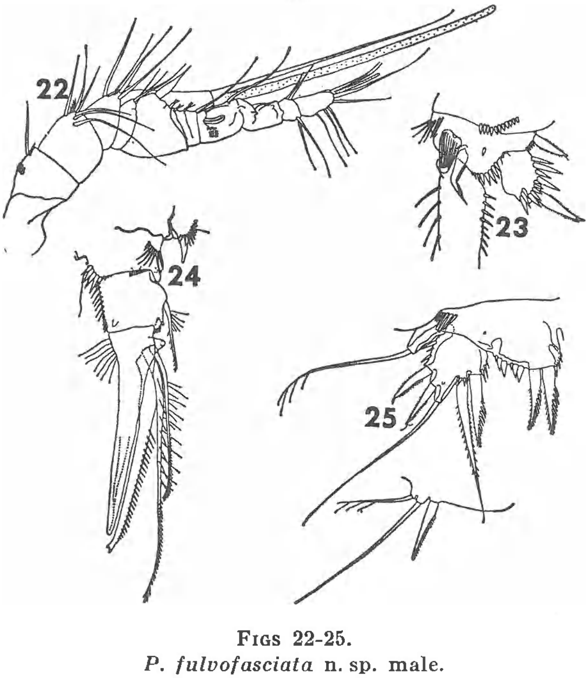
a striated blunt knob in the male, apparently representing the fusion of the female spinules.

P_2 (Fig. 24), exopod same as female. Inner basis process modified into a knob. First endopod segment like that of the female. Second and third endopodite segments fused into a stout heavy spine (spatulate in apical half and tapering distally to a slit, slit bounded by raised chitin ridges along either side), bearing an inner spine, 2 inner setae and an inner medially directed knob. The inner spine, arises



FIGS 18-21.
P. fulvofasciata n. sp.

18. P_3 female (E); 19. P_4 female (E); 20. P_5 female (E); 21. Habitus male lateral (A).



FIGS 22-25.
P. fulvofasciata n. sp. male.

22. A_1 (E); 23. P_1 basis (E); 24. P_2 endopod (E); 25. P_5 and P_6 (E).

from the base of the first as a stout bar with spinules on the inner edge and extends beyond the large stout spine terminating in a tri-dentate lobe.

P_5 (Fig. 25), rami separate. Inner expansion baseoendopodite with 2 stout setae, exopod with 2 stout inner setae, 1 slender terminal seta and 2 short outer setae.

P_6 (Fig. 25), left and right legs indistinctly separate, each represented by 3 setae.

Etymology: The specific name « *fulvofasciata* » refers to the yellow-brown transverse banding across the posterior edge of the prosome and the anterior edges of the urosomal segments.

Species justification: *P. fulvofasciata* n. sp. is most closely related to *P. pacifica* Vervoort. These two species are almost identical in every aspect except the P_2 ♂ endopod which has long been used as a species specific character. In *P. pacifica* the outer portion of the P_2 ♂ endopod claw apparatus is tuberculate and longer than the inner portion and has but one accessory seta, whereas in *P. fulvofasciata* the inner portion of the claw apparatus is longer than the outer, is not tuberculate and bears 2 accessory setae.

LARVAL DEVELOPMENT

We shall discuss and figure individual structures through their development from N1, N2 ... N6 (nauplii stages 1-6) and C1 to C5 (copepodite 1 - copepodite 5). (Adult structures are figured and discussed previously along with the species description.) This will allow the reader to follow individual structure throughout its entire development.

General body shape: body dimensions of nauplii and copepodites are given in Table 2.

TABLE 2.

Dimensions of larval stages of *Paramphiascella fulvofasciata* n. sp.

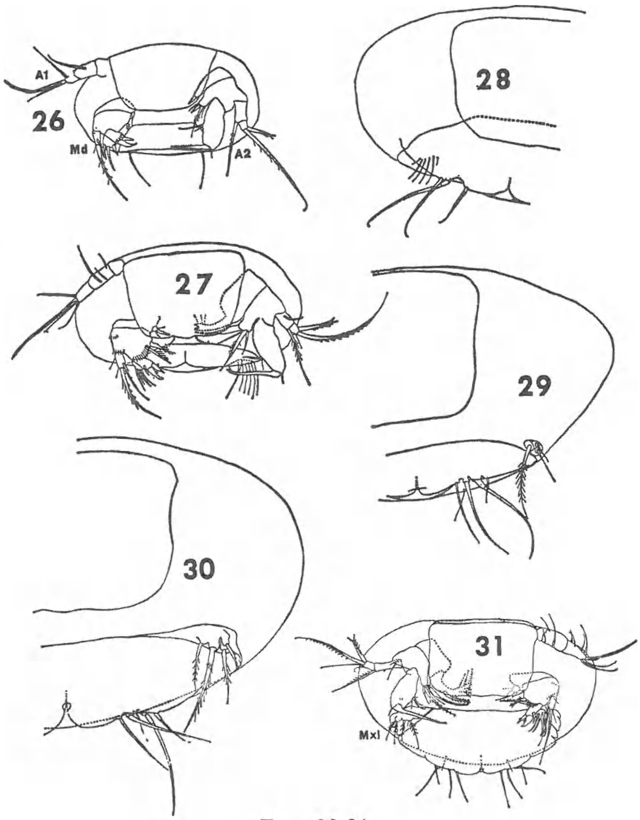
Nauplii	N1	N2	N3	N4	N5	N6
body length	50μ	55μ	70μ	80μ	100μ	125μ
body width	80μ	100μ	125μ	150μ	170μ	190μ
Copepodites		**C1**	**C2**	**C3**	**C4**	**C5**
length (as in adult)		270μ	360μ	430μ	540μ	700μ

N1 (Fig. 26), broadly oval, with 3 appendages, A_1, A_2, Md. Labrum broad, lacking ornamentation. Single short seta on either side of anal area.

N2 (Fig. 27), more heavily chitinized than N1. Labrum adorned with hairs and spinules but omitted from figure. 5-7 hairs and single seta on either side anal opening. Medial anal suture and depression appears.

N3 (Fig. 28), proportions the same as N2 except that anal hairs are smaller and displaced anteriorly. Two new setae have been added to either side of the anal area, so that there are now 3 setae on each side.

N4 (Fig. 29), proportions as in N3. Maxillae appear (separate discussion). Posteriorly 5 setae now present on each side. Lateral hairs on N2 and N3 no longer present.



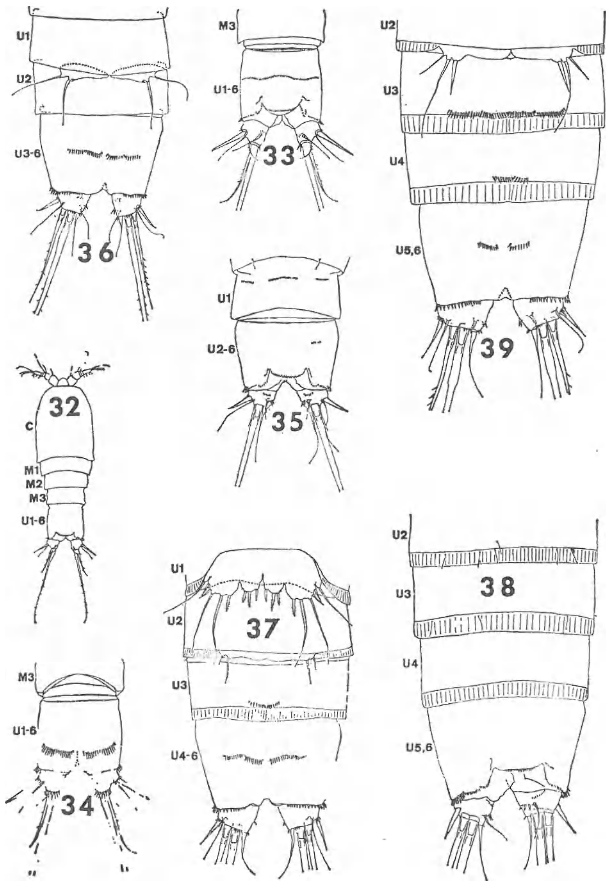
FIGS 26-31.
P. fulvofasciata n. sp., nauplii, body form.
26. Nauplius 1 (E); 27. N2 (E); 28. N3 (F); 29. N4 (F); 30. N5 (F); 31. N6 (C).

N5 (Fig. 30), body more elongate than N4. Number of setae on each anal side same as N4; setae are larger than in N4.

N6 (Fig. 31), last naupliar stage. Animal now square in appearance. Anlagen copepodite structures visible through body wall. Setation same as N5; but anal area with prominent indentations and sutures (Fig. 34).

C1 (Figs 32, 33, 34), body typical harpacticoid form, with cephalosome (includes segment with P_1), 3-segmented metasome (with P_2

and P_3; P_4 is absent) and a single elongate urosome segment (Figs 33, 34). Second and third metasomal somites and urosomal somite, dorsally with spinule row near anterior end (Fig. 33). Cephalosome and each metasomal segment with posterior hyaline membrane which overlaps following segment and terminates in fine dentations, as in adult. Anal operculum with row of spinules across free, posterior edge. These spinules continuing laterally and distally toward anterior



Figs 32-39.
P. fulvofasciata n. sp. copepodites, body form.

32. C1, habitus (G); 33. C1, urosome, dorsal (C); 34. C1, urosome, ventral (C); 35. C2 (C); 36. C3, urosome, ventral (C); 37. C4 female, urosome, ventral (C); 38. C5 female, urosome, ventral (C); 39. C5 male, urosome, ventral (C).

edge of anal segment branches. Ventral surfaces of urosome with row of large spinules (Fig. 34).

C2 (Fig. 35), like C1 except urosome segment 1 (U1) is now segmented off (will later bear P_5). P_4 present as uniarticulate flaps on last metasome segment.

C3 (Fig. 36), like C2 except urosome segment 2 (U2) is now segmented off (will later bear P_6) and P_5 appears.

C4 (Fig. 37) urosome segment 3 (U3) is now segmented off. P_6 now present. U3 bears row of subterminal ventral spinules. No sexual dimorphic differences except in P_5.

C5 (Figs 38, 39), another urosomal segment (U4) has been added. Spinules on U3 expanded laterally. U4 with small row subterminal ventral spinules. (There is much variation between individuals regarding this spinulation; that figured illustrates maximum conditions of spinulation.) Last urosomal somite (U5, 6) bears only the more medial spinules as compared to the preceding stage (C4). Only sexual differences are in appendage morphology (female, Fig. 38; male, Fig. 39).

C6 (Adult), see species description earlier in this paper (Figs. 1, 2, 21).

Caudal ramus:

N1-N6-Caudal rami absent.

C1 (Figs. 32, 33, 34), elongate compared to adult with a single bifurcated terminal seta (inner caudal seta). An outer spine and outer seta originate at 1/3 the length, and a dorsal pedicellated seta at 1/2 the length.

C2 (Fig. 35), principal terminal seta no longer bifurcate; outer branch is lost. Just medial to principal terminal seta a fine terminal seta arises from distal extension of ramus.

C3 (Fig. 36), outer principal terminal seta appears.

C4 (Fig. 37), same as C3; with increase in chitinization and size.

C5 (Figs 38, 39), same as C4, with increase in chitinization and size.

C6 (Adult), see Figs 1, 2, 8, 9.

Antennule, (A_1):

N1 (Fig. 40), 3-segmented. First segment naked, second segment with 1 large and 2 small ventral naked setae, third segment with an anterior seta, and terminal aesthetasc and seta with common base.

N2 (Fig. 41), same as N1 except for addition of latero-posterior seta at terminus (see arrow).

N3 (Fig. 42), differes from N2 in addition of 2 setae on segment 3 (see arrows), one on anterior border, one just proximal to posterior subterminal seta.

N4 (Fig. 43), like N3 but with addition of short seta on anterior border of segment 3 (see arrow).

N5 (Fig. 44), another seta (see arrow) is added to third segment and spinules appear on segment 2 and 3.

N6 (Fig. 45), same as N5.

The setation of the copepodite A_1 is listed in Table 3.

C1 (Fig. 46), 5-segmented. The first segment corresponds to the adult first segment, the second segment to the segments 2-5 of the adult, and the last three to segments 6, 7, and 8 of the adult. Segment 2 and 5 each bear an aesthetasc. Remainder of setation as figured and listed (Table 3).

C2 (Fig. 47), 6-segmented. Segment 5 of the adult is now separate as segment 3 here. Setation as figured and listed (Table 3).

C3 (Figs 48, 49), same segmentation as in C2. This is first stage in which the male and female differ, but only in setation. The female

TABLE 3.

Segmentation and setation of A_1 during copepodite stages of *P. fulvofasciata* n. sp. The brackets indicate the fusion of several segments, and the numbers refer to the number of setae on each segment or pro-segment. Total number of setae for any fused segment can be obtained by adding number of setae in bracket.

Segment	Female					
	C1	C2	C3	C4	C5	Ad.
1	1	1	1	1	1	1
2	0	1	3	7	10	11
3	2	2	4	6	8	8
4*	0	2	4	4	4	4
5	1	1	2	2	2	2
6	2	3	4	4	4	4
7	3	4	4	4	4	4
8*	7	7	7	7	7	7
	Male					
1	like female	→	→	→	→	→
2	»	→	→	→	→	→
3	»	→	→	7	11	10 divided
4*	»	→	3	3	3	10 semi-divided
5	»	→	→	→		2
6	»	→	→	→		1
7	»	→	→	→	→	→
8*	»	→	→	→	→	→

(*) Segment area 4 and segment 8 each bear an aesthetasc at all stages.

(Fig. 48) adds a seta at the base of the aesthetasc that is not found in the male (Fig. 49).

C4 (Figs 50, 51), 7-segmented. Adult segment 2 is now separate. There are again setation differences between the female (Fig. 50) and the male (Fig. 51).

C5 (Figs 52, 53), female (Fig. 52) and male (Fig. 53) very much similar in general shape. Female as in adult except for setation (see Table 3). Male like female except in segment proportions and setation.

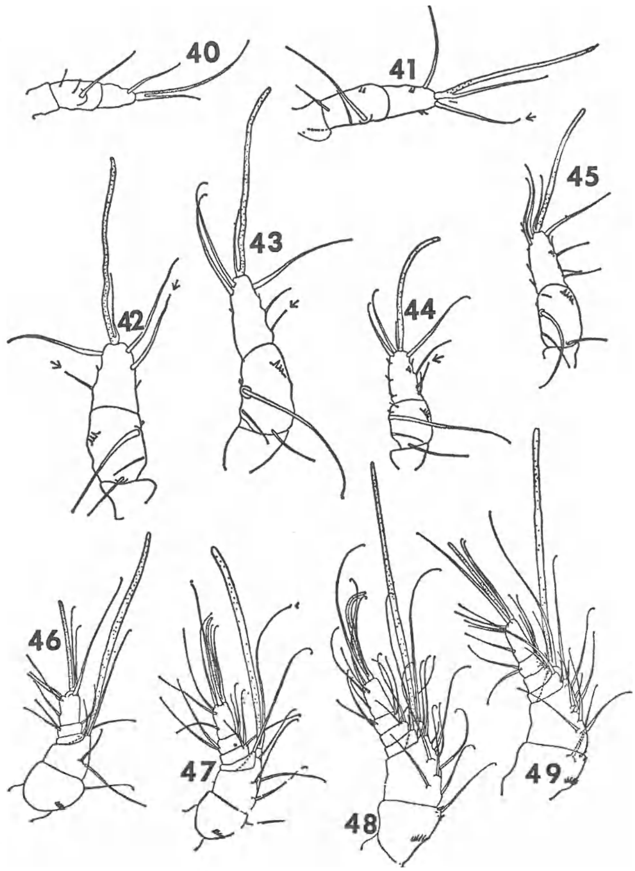
C6 (Adult) - see Figs. 10 (female) and 22 (male).

Antenna, (A_2):

N1 (Fig. 54). A_2 with coxa, basis, 2-segmented exopod and 1-segmented endopod. Coxa medially with short pro-gnathobasic projection. Basis medially with 2 spines and 2 setae, laterally with fine spinule row. First exopod segment with long subterminal seta, second segment with a long seta, a club-like spine and a short fine hair. Endopod with 2 small medial setae 1/2 the endopod length, terminally with a claw and a small seta at base of claw.

N2 (Fig. 55), a true functional gnathobase arises from the coxa. The basis setae have enlarged and additional small setae have been added to the exopod and the endopod (see arrows).

N3 (Fig. 56), 4 setae have been added as indicated by the arrows.



Figs 40-49.
P. fulvofasciata, A_1.

40. N1 (H); 41. N2 (H); 42. N3 (H); 43. N4 (H); 44. N5 (F); 45. N6 (F); 46. C1 (F); 47. C2 (F); 48. C3 female (F); 49. C3 male (F).

N4 (Fig. 57), no major additions or changes from N3.

N5 (Fig. 58), one seta is added to the endopod as indicated by the arrow.

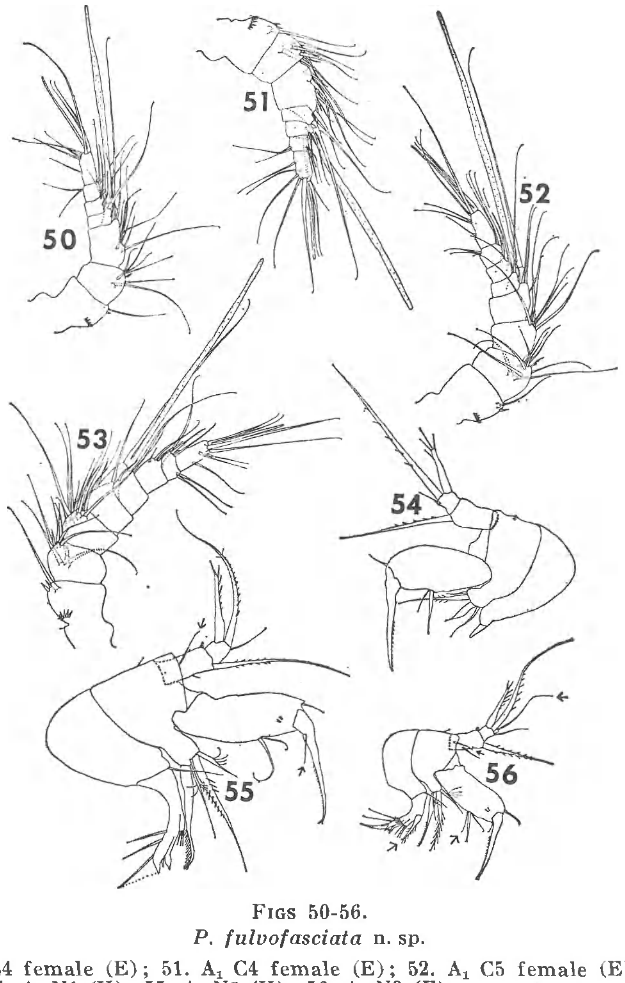
N6 (Fig. 59), same as N5 except for size.

C1 (Fig. 60), gone are the gnathobases, basis spines and seta and the endopodal claw. Endopod has become much larger and general structure resembles that of the adult except for size and spinule setation. Endopod lacks one geniculate terminal seta of the adult.

C2-C5—not figured—generally similar to C1 and adult except for general graduations in spinule rows and size.

Mandible (*Md.*)*:*

N1 (Fig. 61), mandible with coxa, basis, 1-segmented exopod and 1-segmented endopod. Coxa with medial seta; basis with short medial



FIGS 50-56.
P. fulvofasciata n. sp.

50. A_1 C4 female (E); 51. A_1 C4 female (E); 52. A_1 C5 female (E); 53. A_1 C5 male (E); 54. A_2 N1 (H); 55. A_2 N2 (H); 56. A_2 N3 (F).

seta and lateral row of spinules; exopod with stout surface seta and long seta, a short seta and a hair terminally. Endopod with 2 strong terminal setae, and a dorso-lateral hillock with 3 setae and a hair.

N2 (Fig. 62), same as N1 except size and addition of setae (arrows) and spinulose ornamentation.

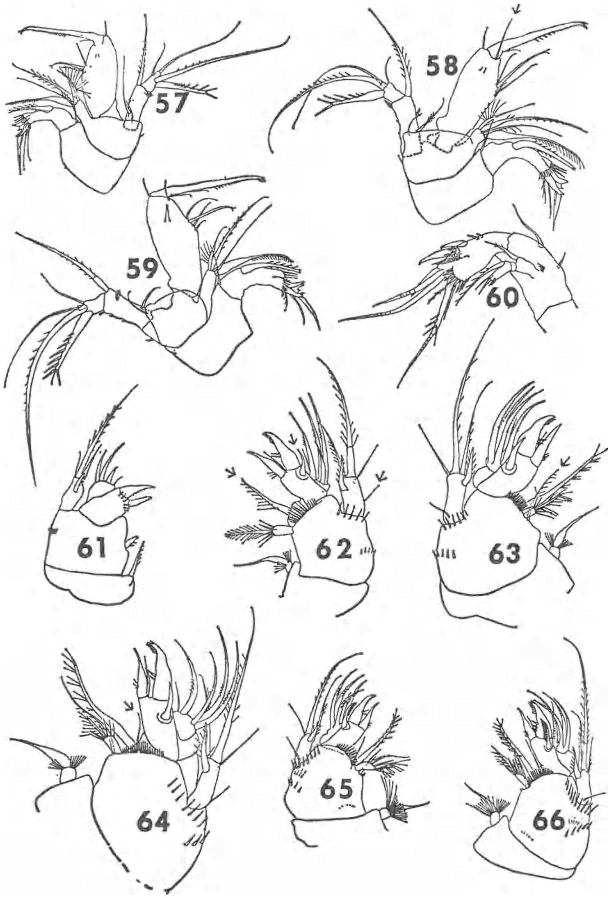
N3 (Fig. 63), same as N2 with a new seta (arrow).

N4 (Fig. 64), one seta (see arrow) is added.

N5 (Fig. 65), changes only in size and spinule ornamentation.

N6 (Fig. 66), no change except size.

C1-C5 - same as adult (Fig. 12) except for size.



FIGS 57-66.
P. fulvofasciata n. sp.

57. A_2 N4 (F); 58. A_2 N5 (F); 59. A_2 N6 (F); 60. A_2 C1 (F); 61. Md. N1 (H); 62. Md. N2 (H); 63. Md. N3 (H); 64. Md. N4 (H); 65. Md. N5 (F); 66. Md. N6 (F).

Maxillula (Mxl.):

N1-N3, not present.

N4 (Fig. 29), first appearance of Mxl. as bilobed structure bearing 3 setae at the lateral edges of the ventral body wall.

N5 (Fig. 30), now Mxl. is represented by 4 setae.

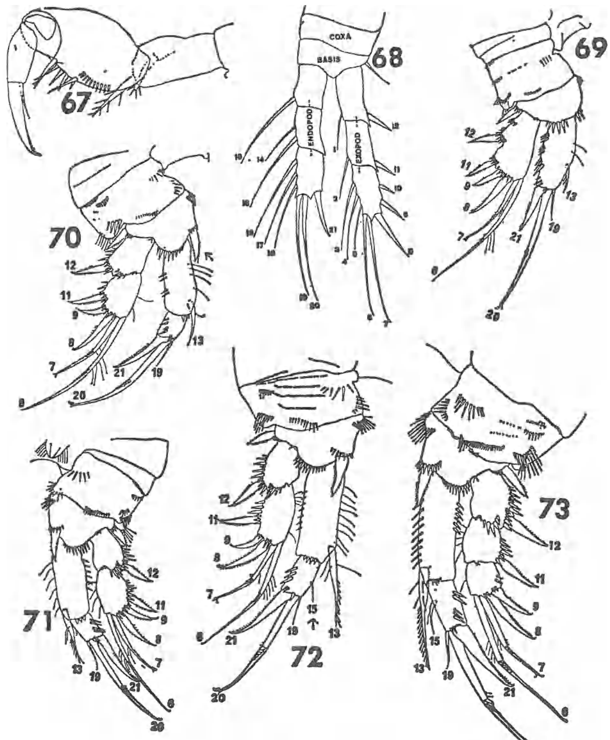
N6 (Fig. 31), now with 4 setae, a hair and inner lobe.

C1-C5, not figured; very much like adult (see Fig. 13) with addition of setae at each stage so that by C4 it is exactly like the adult appendage except for size. It was not possible to determine which setae additions occurred at what stage.

Maxilla (*Mx.*):

N1-N5, not present.

N6, a naked lobe just posterior to the Mxl. presumed to be the pro-maxilla.



FIGS 67-73.
P. fulvofasciata n. sp.

67. Mxp. C1; 68. Generalize copepod leg to illustrate the coding used for the setae and spines; 69. P_1 C1 (F); 70. P_1 C2 (F); 71. P_1 C3 (E). 72. P_1 C4 (E); 73. P_1 C5 (E).

C1-C5 maxilla differs from the adult (Fig. 14) only in size and is, therefore, not figured.

Maxilliped (*Mxp.*):

N1-N6, not present.

C1 (Fig. 67), basically the same as the adult (Fig. 15), differing in size and ornamentation.

C2-C5, like adult except for size and ornamentation (not figured).

P_1-P_4:

In order to follow the armature development of each leg from C1 to adult (no swimming legs appear in the nauplii), a coding system is used. In this system each possible seta and spine has been assigned a number. This then allows the reader to note homologies between copepodite setae and adult setae as well as being able to determine at what stage a particular seta originates. Fig. 68 illustrates these setation numbers as found on a typical adult leg. Table 4 lists the leg armature and segmentation for each stage as well as indicating at what stage an increase in segmentation and armature occurs.

TABLE 4.

Leg armature and setation, copepodites and adults, *P. fulvofasciata* n. sp. The numbers in each column refer to the individual leg setae. Fig. 68 illustrates the coding for the setae. Once a seta originates, it continues to be present in every succeeding stage. New setae are added where noted.

Stage	P1		P2		P3		P4		P5	P6
	exopod	endopod	exopod	endopod	exopod	endopod	exopod	endopod		
C1	1 seg. 6, 7 8, 9 11, 12	1 seg. 13, 19 20, 21	1 seg. 6, 7 8, 9 12	1 seg. 13, 17 19, 20 21	1 lobe 3 setae		—		—	—
C2	2 seg.	2 seg.	2 seg.	2 seg.	1 seg. 6, 7 8, 9 12	1 seg. 13, 17 19, 20 21	1 lobe 3 setae		—	—
C3			+ 2, 11	+ 15	2 seg. + 4	2 seg. + 16	1 seg. 4, 6 7, 8 9, 12	1 seg. 13, 17 19, 20 21	1 lobe 2 setae	—
C4		+ 15			+ 2, 11	+ 15	2 seg. + 2, 3, 11	2 seg. + 15	setae male 5/2 fem. 5/3	2 setae
C5	3 seg.		3 seg. + 10	3 seg.	3 seg. + 10	3 seg.	3 seg. + 10	3 seg.	setae male 5/2 fem. 5/5	3 setae
Adult		3 seg.		(male modified)					distal seg. separate	

P_1:

C1 (Fig. 69), both rami one-segmented, numbered setae as figured.

C2 (Fig. 70), both rami 2-segmented, same armature as in C1 except inner basis spine has been added (see arrow).

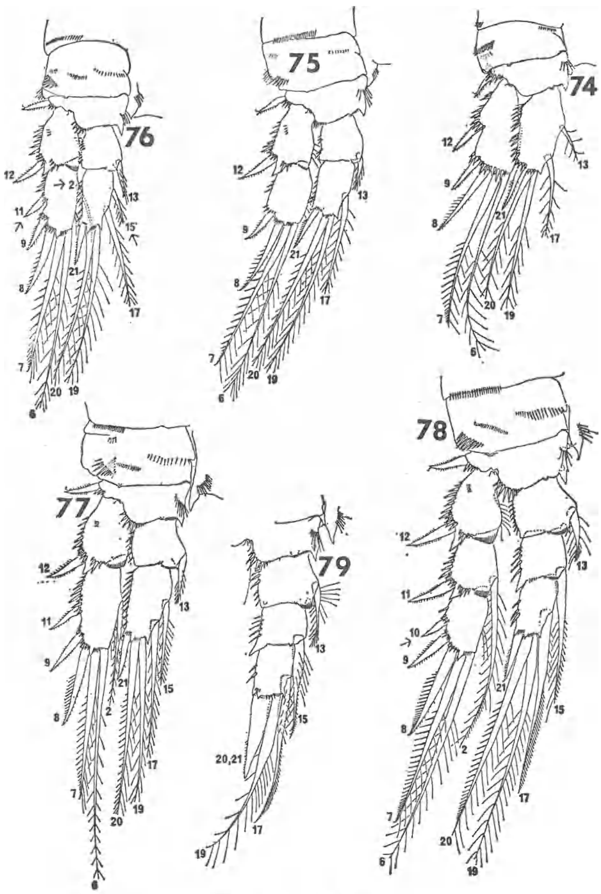
C3 (Fig. 71), except for size and spinule ornamentation no change from C2.

C4 (Fig. 72), little change from C3 except seta #15 (see arrow) is added.

C5 female (Fig. 73), endopod 2-segmented, exopod 3-segmented.

C5 male, same as female (Fig. 73), except for the width of the inner basis spine (6.5μ in female; 8μ in male).

Adult - see Figs 16, 23.



FIGS 74-79.
P. fulvofasciata n. sp. P_2.

74. C1 (F); 75. C2 (F); 76. C3 (E); 77. C4 (E); 78. C5 female (E); 79. Endopod C5 male (E).

P_2:

C1 (Fig. 74), both rami one-segmented.

C2 (Fig. 75), armature the same as C1, but now both rami are 2-segmented.

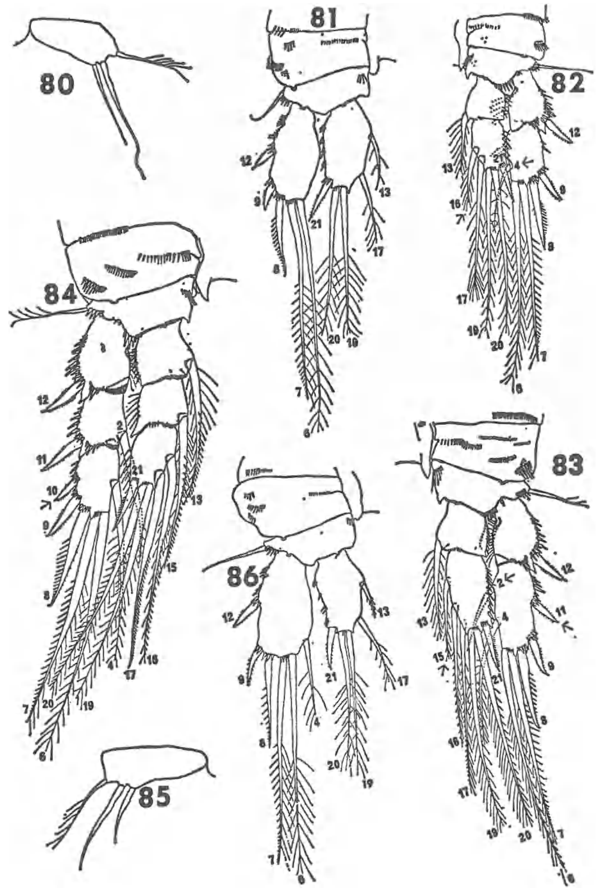
C3 (Fig. 76), 2 new setae are added to the exopod (#2, #11) and 1 new seta (#15) to the endopod (see arrows).

C4 (Fig. 77), same as C3 except size.

C5 female (Fig. 78), both rami 3-segmented. Seta #10 has been added to the terminal exopod segment (see arrow).

C5 male (Fig. 79). Exopod as in female. Endopod shows beginnings of modification in that setae #20 and #21 are fused into a very stout spine.

Adult - see Figs 17 and 24.



FIGS 80-86.
P. fulvofasciata n. sp.
80. P_3 C1 (F); 81. P_3 C2 (F); 82. P_3 C3 (E); 83. P_3 C3 (E); 84. P_3 C5 (E); 85. P_4 C2 (F); 86. P_4 C3 (F).

P_3:

C1 (Fig. 80), leg consists of flap with 3 setae.

C2 (Fig. 81), both rami 1-segmented. Setation as figured.

C3 (Fig. 82), 2-segmented rami, armature like C2 with addition of seta #4 on terminal exopod segment and seta #16 on terminal endopod segment (see arrows).

C4 (Fig. 83), rami 2-segmented. Seta #2 and #11 have been added to terminal exopod segment, and seta #15 to terminal endopod segment (see arrows).

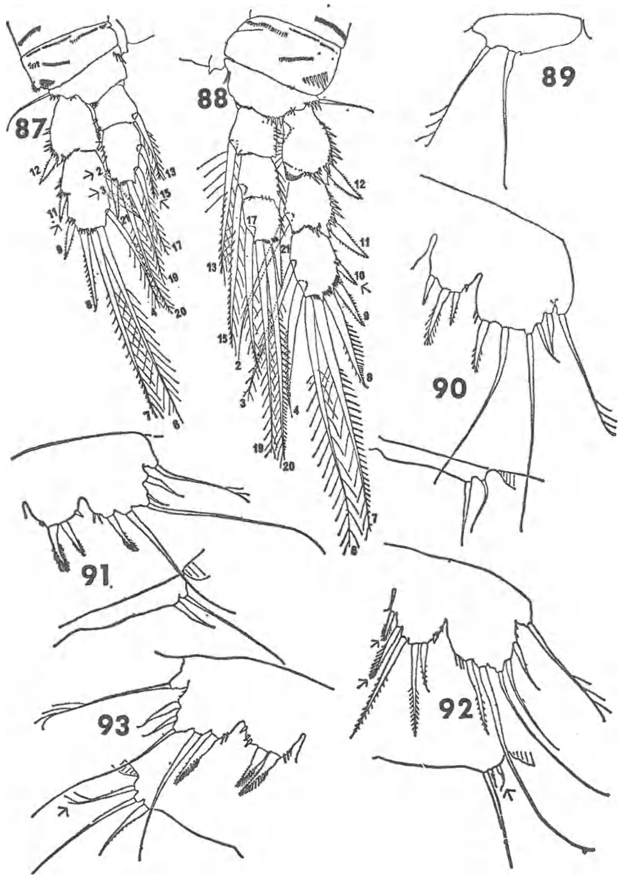
C5 (Fig. 84), 3-segmented rami. Seta #10 is added to last exopod segment.

Adult - see Fig. 18.

P_4:

C1 - P_4 is absent.

C2 (Fig. 85), like P_3 of C1, flap with 3 setae.



FIGS 87-93.
P. fulvofasciata n. sp.

87. P_4 C4 (E); 88. P_4 C5 (E); 89. P_5 C3 (F); 90. P_5 and P_6 C4 female (F); 91. P_5 and P_6 C4 male (F); 92. P_5 and P_6 C5 female (E); 93. P_5 and P_6 C5 male (E).

C3 (Fig. 86), rami 1-segmented. Setation as figured.

C4 (Fig. 87), 2-segmented rami; setae added as indicated by arrows (#'s 2, 3, 11, 15).

C5 (Fig. 88), 3-segmented rami. Seta #10 is added.

Adult - see Fig. 19.

P_5:

C1-C2, P_5 is absent.

C3 (Fig. 89), P_5 is flap with 2 setae.

C4 female (Fig. 90), of typical harpacticoid form, but the rami are fused. Inner expansion Benp. portion with 3 setae, Exp. portion with. 5.

C4 male (Fig. 91), similar shape to female but with only 2 setae on inner expansion Benp.

C5 female (Fig. 92), rami still incompletely segmented. Inner expansion now with 5 setae.

C5 male (Fig. 93), like C4 but armature is better developed.

Adults as in Figs 20 and 25.

P_6:

C1-C3, P_6 not present.

C4 (Figs 90, 91), male and female very similar, except for relative length of the setae. Female (Fig. 90); male (Fig. 91).

C5 (Figs 92, 93), with 3 setae; female (Fig. 92) with 2 short outer and a long inner seta; male (Fig. 93) with a short outer and inner seta, with a long middle one.

BIOLOGICAL NOTES

A key for distinguishing the nauplii of *P. fulvofasciata* n. sp. is given in Table 5. One of use (Rosenfield, 1967) has cultured five other diosaccid harpacticoids; *Amphiascus minutus* (Claus), *Robertgurneya* sp., *Robertsonia propinquua* (T. Scott), *Amphiascoides debilis* (Giesbrecht) and *Schizopera knabeni* Lang. The characters listed in Table 5 were common to all 6 species therefore, we present the key as a general key for Diosoccidae nauplii.

The three isolated F_1 females produced 15, 17 and 21 broods of nauplii. In general, a new brood was produced every 5 days, the

TABLE 5.

Key to the stages of diosaccid nauplii.

1	Labrum naked, no second antennal gnathobase	*N1*
	Labrum haired, second antennal gnathobase present	2
2	Second antennal gnathobase lacks posterior spine	*N2*
	Second antennal gnathobase has a posterior spine	3
3	Maxillula setae absent	*N3*
	Maxillula setae present	4
4	Maxillula bears three setae	*N4*
	Maxillula bears four setae	5
5	Posterior surface of body lateral to posterior setae smooth	*N5*
	Posterior surface of body lateral to posterior setae deeply sutured	*N6*

new eggs being formed right after the old ones hatched. Occasionally, the old, empty egg sacs would remain attached to the female for a while, along with the new ones.

The number of nauplii per brood was not specifically determined, although the larger broods consisted of about 15 nauplii. No unhatched egg sacs were saved. After about 15 or so broods, to judge from the most productive of the three isolated F_1 females, the number of viable eggs dropped; the broods became smaller and smaller. By the end of the experiment, none of these females still produced viable eggs.

A total of 23 broods (from the 3 F_1 females) was carried until reproduction occurred, as evidenced by nauplii hatching out. Although a statistical treatment of the data obtained is unwarranted, the usual periods elapsing from naupliar hatching until certain easily-observed following events in the life cycle at 17°C were as follows:

to first copepodite ...... 9 days
to pairing (♂ + ♀) .... 23 days
to egg sac production .. 25 days
to nauplii hatching .... 29 days (the complete life cycle)

There is no comparable life cycle data in the literature on diosaccid harpacticoids, but Table 6 lists some aspects of *P. fulvofasciata*'s life cycle along with that of several other harpacticoids.

Except for Brian's (1921) and Bresciani's (1960) work where they briefly describe a few naupliar stages of several species, we are

TABLE 6.

Comparative developmental time for various harpacticoid copepods.

Spécies	Temp. °C of culture	Time (days) Nauplii stages	Time (days) Hatching to adult	Time (days) Complete cycle Hatch to hatch	Reference
Ectinosoma curticorne	18-20		10-12		Muus (1967)
Tachidius discipes	18-20	3-8	6-16	11-18	» »
» »	8-12	11-19		33-36	» »
Tisbe furcata	17-18	3-8	15-18	9-24	Johnson and Olson (1948)
Tisbe longicornis	30		9		Raibaut (1967)
» »	20		7-11		» »
» »	10		13		» »
Tisbe dilatata	10	6-10	19-28	29	Muus (1967)
» »	15	5-6	11-15	18	» »
» »	20	3	7-9	10	» »
» »	25	3	6-8	9	» »
Tisbe sp.	5.5-30		6-16	12-18	Vilela (1969)
Harpacticus littoralis	30		8		Raibaut (1967)
» »	20		9-10		» »
Tigriopus californicus	23	5-6	15-18	> 18	Huizinga (1971)
Nitocra lacustris	30	2	5-6		Raibaut (1967)
» »	20	6	11-12		» »
Nitocra spinipes	18-20	3-8	4-14	> 11	Muus (1967)
Arenopontia indica	26-31	11-15	25-30	> 30	Chandrasekhara Rao (67)
Cletocamptus retrogressus	30	3	7		Raibaut (1967)
» »	20	5	11		» »
Robertgurneya sp.	17	14	30-32	42	Rosenfield (1967)
Paramphiascella fulvofasciata	17	9	20-23	29	Present study

unaware of any developmental study of diosaccid harpacticoids. Our data, then, represent the first complete description of these larvae. Barnett (1966) and Carter and Bradford (1972), however, have given most complete descriptions of developing harpacticoids, but there is relatively little morphological similarity between the development of their species and *Paramphiascella.*

The larval development of harpacticoids is a most fruitful, though demanding, avenue of research. Hopefully with continued efforts some of the persistent problems in harpacticoid phylogeny can be elucidated using larval morphology.

Acknowledgement

This research was partially supported by NSF Grant GB-1809 to Dr. A. G. Humes of Boston University.

Summary

A new species of harpacticoid copepod, *Paramphiascella fulvofasciata,* is described from Massachusetts Bay, U.S.A. *P. fulvofasciata* is most closely related to *P. pacifica* Vervoort, but the two species differ significantly in the male P_2. The complete larval (nauplii and copepodite) development of the new species is also presented. There are six naupliar and six copepodite stages (the sixth copepodite being the adult) as in other harpacticoids. The development of the body and each appendage is figured and discussed. The complete life cycle (from hatch to hatch) takes 29 days at 17°C and is compared with that of several other species.

Zusammenfassung

Eine neue Gattung der harpacticoid Copepoden von Massachusetts Bay, U.S.A., *Paramphiascella fulvofasciata,* ist beschrieben. *P. fulvofasciata* und *P. pacifica* Vervoort, sind sehr ähnlich, nur die manliche Form des P_2 is bemerkenswert anders. Die ganze Entwichelung der larven Stadien sind beschrieben. Es sind sechs nauplien und sechs copepoditen in der Entwickelung wie in anderen Harpacticoiden. Der Körper und alle Extremitäten sind beschrieben und abgebildet. Der ganze Lebenslauf ist in 29 Tagen bein 17°C vollendet und wird mit denen anderen Gattungen vergleicht.

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Dr. G.R.F. Hicks of the University of Wellington, New Zealand has examined several of our *P. fulvofasciata* n. sp. and he informs me that he has collected this species at Norfolk, England.