

IV

Larval development -- III

PENAEUS SEMISULCATUS DE HAAN

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The larvae of *Penaeus semisulcatus* reared from eggs spawned in the laboratory are described and illustrated for the first time. At a rearing temperature of 31.0°C the nauplii hatched out 12 to 13 hours after spawning; the duration of the nauplius, protozoa and mysis stages was 42 hours, 154 hours and 96 hours respectively. The larvae passed through 6 nauplius substages, 3 protozoa substages and 3 mysis substages before transforming into postlarva I.

The green tiger prawn *Penaeus semisulcatus* which is commercially important on the Tamilnadu coast, spawned during September 1977 in the Kovalam Field Laboratory of the Central Marine Fisheries Research Institute, Madras Research Centre and the larvae were successfully reared to the postlarval stage. Though some information on the spawning and larval forms of *P. semisulcatus* from Taiwan (Liao and Huang, 1973, *In Coastal Aquaculture in the Indo-Pacific Region*, Fishing News (Books) Ltd., London, 328-354) and from Madagascar (Courties, 1976, *Cah. O. R. S. T. O. M. Ser. Oceanoger*, 14 (1); 49-70.) are available, detailed morphology of various larval stages of the species are not known. Hence, a complete description of different larval stages of *P. semisulcatus* along with necessary illustrations are given for the first time in this paper. Temperature of the water in the rearing basins was 31.0°C and the salinity 35.2‰.

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DESCRIPTION OF LARVAL STAGES

EGG

Spherical, diameter ranging from 0.27 to 0.29mm (mean 0.28 mm) (Fig.1,a). The nauplius hatches out of the egg 12-13 hours after spawning.

NAUPLIUS I

MTL: 0.30 mm (0.28-0.31 mm); MW: 0.16 mm (0.15-0.17 mm) MFS: 0.12 mm (0.11-0.13).

Typical penaeid nauplius with pyriform unsegmented body having ventrally projecting labrum, ocellus present as dark spot in anterior median region, persisting in all nauplius substages (Fig. 1,b), body smooth except for a small denticle on posterior margin dorsally, a pair of caudal setae present.

A1 uniramous, having terminally 1 small spike-like seta and 2 long setae, 1 long seta on distal outer margin as long as terminal setae, and 2 small setae on inner margin in distal half, in some specimens, an additional small seta seen at middle of proximal half; A2 biramous, endopod with 1 rudimentary and 2 long setae

distally and 2 short setae on inner margin, exopod with 5 long setae along inner and distal margin; Md biramous, exopod and endopod

(0.17 mm-0.18 mm); MFS: 0.20 mm(0.17-0.21 mm).

Posterior margin of body with 3+3 furcal setae (Fig.1,d); distally A1 bears 3 setae, of which 1 is small, a small distolateral seta present in some specimens, of the 2 inner lateral setae, distal one is longer; endopod of A2 with 3 distal and 2 lateral setae; exopod with 6 long setae. Duration of this substage was 4 hours.

NAUPLIUS IV

MTL: 0.34 mm (0.32-0.35 mm); MW: 0.17 mm (0.17-0.18 mm); MFS: 0.20mm (0.18-0.21mm).

4+4 furcal setae; 1 short proximal seta added to inner lateral margin of A1; endopod of A2 with 3 long distal and 2 short ventrolateral setae, exopod with 6 long setae and 1 short seta (Fig.1,e); base of Md slightly swollen, small buds of Mx and Mxp seen developing behind Md. Duration of this substage was 6 hours.

NAUPLIUS V

MTL: 0.39 mm (0.38-0.39 mm); MW: 0.18 mm (0.17-0.18mm);MFS: 0.26 mm (0.24-0.27 mm).

Furcal lobes with 6+6 setae (Fig.2,a); A1 without change; endopod of A2 with 3 long setae and 1 small seta distally and 2 inner lateral setae, exopod with 7 long and 2 short setae. Duration of this substage was 6 hours.

NAUPLIUS VI

MTL: 0.46 mm (0.42-0.49 mm); MW: 0.18 mm (0.17-0.18 mm);MFS: 0.31 mm (0.29-0.32 mm)

Outline of the developing carapace clearly seen (Fig.2,b), caudal furcae with 7+7 setae; partial segmentation seen on A1 and A2; buds of Mx and Mxp further developed; A1 with 1 short and 2 long setae terminally and 3 setae on inner lateral margin, of which distal one very long, 2 distolateral setae added on outer margin; endopod of A2 with 4 distal and 2 inner lateral setae, exopod with 11 setae of which 2 small; swelling at base of Md

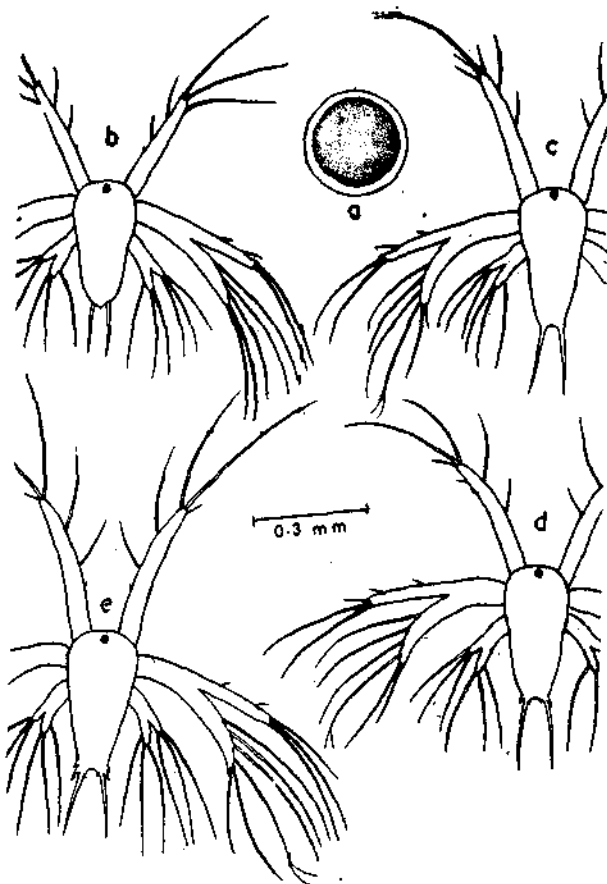


Fig. 1 *Penaeus semisulcatus*: a - egg; b - Nauplius I; c - Nauplius II; d - Nauplius III; e - Nauplius IV.

bearing 3 long setae terminally; setae on all appendages nonplumose. Duration of this substage was 5½ hours.

NAUPLIUS II

MTL: 0.33 mm (0.31-0.34 mm); MW: 0.17 mm; MFS: 0.16 mm (0.14-0.17 mm).

Setae on all appendages plumose; 1+1 furcal setae., A1 with 3 distal setae of which 1 is long, 1 distolateral and 2 inner lateral setae; A2 with 1 short seta added terminally in exopod, 4th seta from proximal end with bifurcated tip, a feature which is retained in all subsequent nauplius substages (Fig.1,c). Duration of this substage was 4 hours.

NAUPLIUS III

MTL: 0.34 mm (0.32-0.35 mm); MW: 0.17 mm

(Fig.2,c) prominent. Duration of this substage was 16 hours.

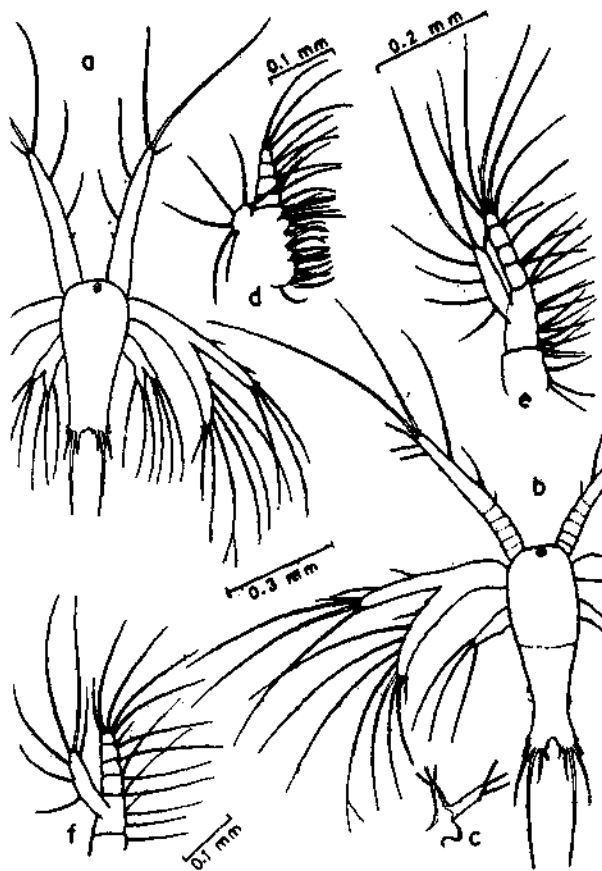


Fig. 2 *Penaeus semisulcatus*: a - Nauplius V; b - Nauplius VI; c - Md of Nauplius VI; Protozoa I: d - Mx2; e - Mxp1; f - Mxp2.

PROTOZOEIA I

MTL: 0.96 mm (0.95-0.98 mm); MCL: 0.44 mm (0.42 -0.47 mm).

Carapace rounded anteriorly with median concavity (Fig.3,a) and 2 small rounded frontal organs, naupliar eye persists, developing compound eyes covered by carapace, thorax 6 segmented, abdomen unsegmented, telson not demarcated from abdominal segment, each lobe of telson with 7 setae, of which outermost one shortest originating from dorsolateral aspect of telson.

A1 (Fig.3.a) with 3 segments, basal segment with 5 indistinct divisions, 2nd segment bears 3 setae on inner side, distal segment with 2 aesthaetes and 3 setae of which one is more than twice length of A1; A2 (Fig.3,a)

2segmented, endopod with 5 terminal setae of which inner one very small, and 1+1+2 inner lateral setae, exopod 10 segmented, with 11 plumose setae along inner and distal margin and 2 on outer margin; Md (Fig.3,b) exopod and endopod absent, incisor

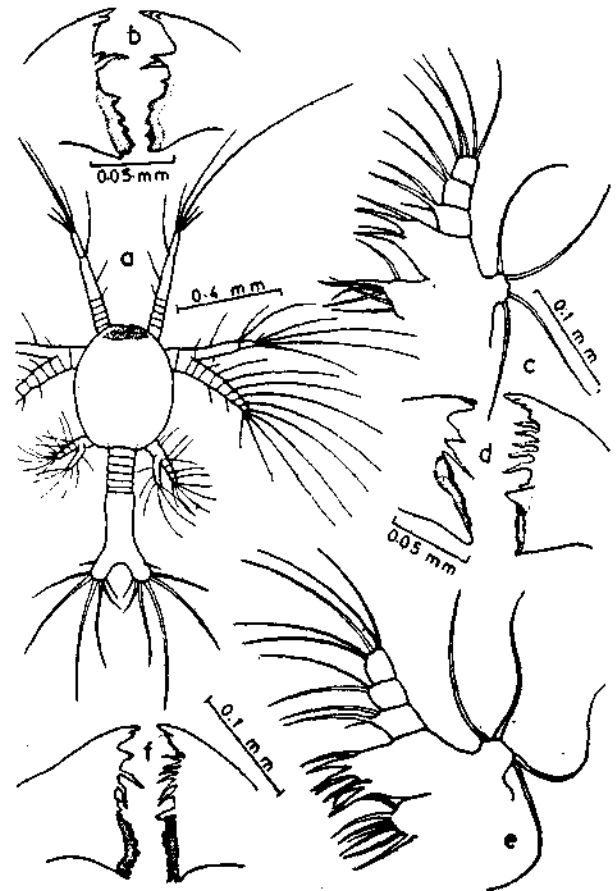


Fig. 3 *Penaeus semisulcatus*: Protozoa I: a - dorsal view; b - Md; c - Mx1; Protozoa II: d - Md; e - Mx1; Protozoa III: f - Md.

process with 3 teeth and molar with a number of transverse rows of small grinding teeth, 1 serrated tooth and a shorter tooth present in between molar and incisor processes, Mx1 (Fig.3,c) exopod small, knob-like, bearing 4 long feathery setae, endopod 3 segmented bearing 5, 2, 3 setae respectively on distal, middle and proximal segments, distal endite with 4 stout setae and proximal with 6 setae; Mx2 (Fig.2,d) exopod knob-like with 5 long feathery setae, endopod 3 segmented, middle segment showing a partial division, distal segment carries 3 setae and other segments with 2 long setae on inner distal margin,

protopod with 5 endites, proximal one semicircular bearing 7 to 8 setae, other endites with 4 to 5 setae; Mxp1 (Fig.2,e) biramous, exopod unsegmented with 7 plumose setae, endopod 4 segmented with 5 long setae on distal segment, 1st, 2nd and 3rd segments with 3, 1 and 2 setae respectively on inner side, protopod 2 jointed, basis with 12 and coxa with 5 setae on inner side; Mxp2 (Fig.2,f) shorter than Mxp1, exopod unsegmented with 6 long plumose setae of which 3 are outer, 2 terminal and 1 inner distal, endopod 4 segmented, 1st, 2nd, 3rd and 4th segments with 2, 1, 2 and 5 setae respectively, basis with 5 setae; Mxp3 absent. Duration of this substage was 50 hours.

PROTOZOEAE II

MTL: 1.74 mm (1.61-1.85 mm); MCL: 0.70 mm (0.67-0.73 mm).

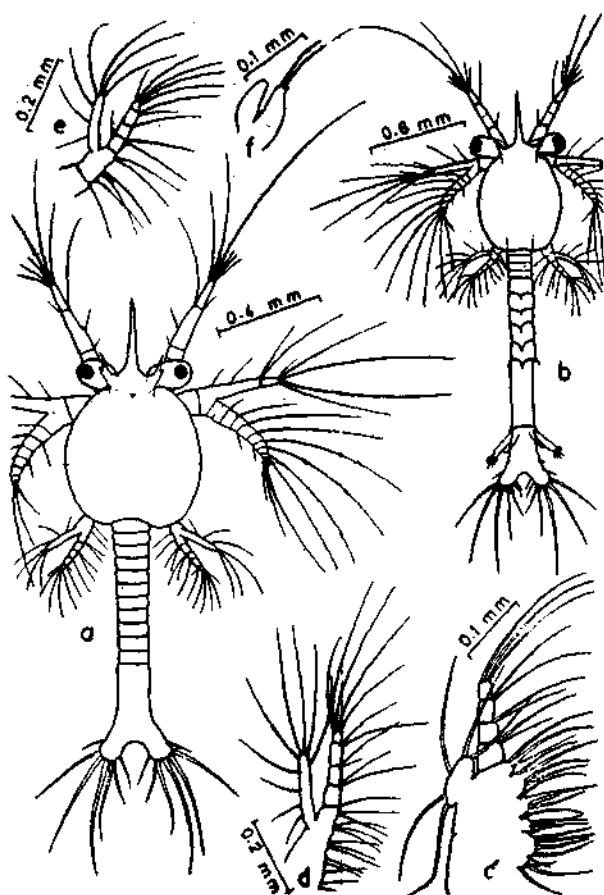


Fig. 4 *Penaeus semisulcatus*: Protozoaea II: a - dorsal view; Protozoaea III: b - dorsal view; c - Mx2; d - Mxp1; e - Mxp2; f - Mxp3.

Major changes from protozoaea I are the development of stalked compound eyes, rostrum, bifurcated supraorbital spines and 6 segmented abdomen (Fig.4, a).

A1 distal segment with 3 setae and 3 aesthaetes; A2 same as in the previous stage; Md (Fig. 3,d) asymmetrical, left Md with 5 and right with 1 free standing teeth; Mx1 (Fig.3,e proximal and distal endites each with 7 to 8 setae; no appreciable change in Mxp1 and Mxp2. Duration of this substage was 60 hours.

PROTOZOEAE III

MTL: 2.47 mm (2.41-2.57 mm); MCL: 0.87 mm (0.84-0.91 mm).

Supraorbital spine simple, telson demarcated from last abdominal segment by articulating joint, dorsomedian spine present on posterior border of first 5 abdominal segments, 5th and 6th abdominal segments with a pair of posterolateral spines; biramous buds of Mxp3 and uropods develop and telson with 8 + 8 setae (Fig. 4,b).

Subdivisions on basal segment of A1 disappear, distal segment with 3 setae and 4 aesthaetes; Md (Fig.3,f) left Md with 6 free standing teeth and right with 2; Mx1, no appreciable change; Mx2 (Fig.4,c) number of setae on endites increased; Mxp1 (Fig.4,d) exopod with 9 plumose setae, 1 seta added to 2nd segment of endopod; Mxp2 (Fig.4,e) exopod with 7 setae, 1st segment of endopod with 1 seta on outer margin; Mxp3 (Fig.4,f) biramous, with 2 setae and a small setal rudiment at distal end of one ramus. Duration of this substage was 44 hours.

MYSIS I

MTL: 3.15 mm (2.99 - 3.29 mm); MCL: 1.10 mm (1.00-1.15 mm).

Rostrum long, extending beyond eye and devoid of spines (Fig.5,a); carapace with hepatic, supraorbital and pterygostomial spines; P1 to P5 developed and functional; 4th, 5th and 6th abdominal segments with dorsal spine on posterior margin, 5th and 6th with a pair of lateral spines and 6th in addition bears a ventromedian curved

spine at junction with telson; uropod biramous (Fig. 5, k), exopod with 14 plumose setae, a prominent posterolateral spine on outer border and a short non-plumose seta between the posterolateral fixed spine and the plumose setae, endopod with 13 plumose setae along inner and

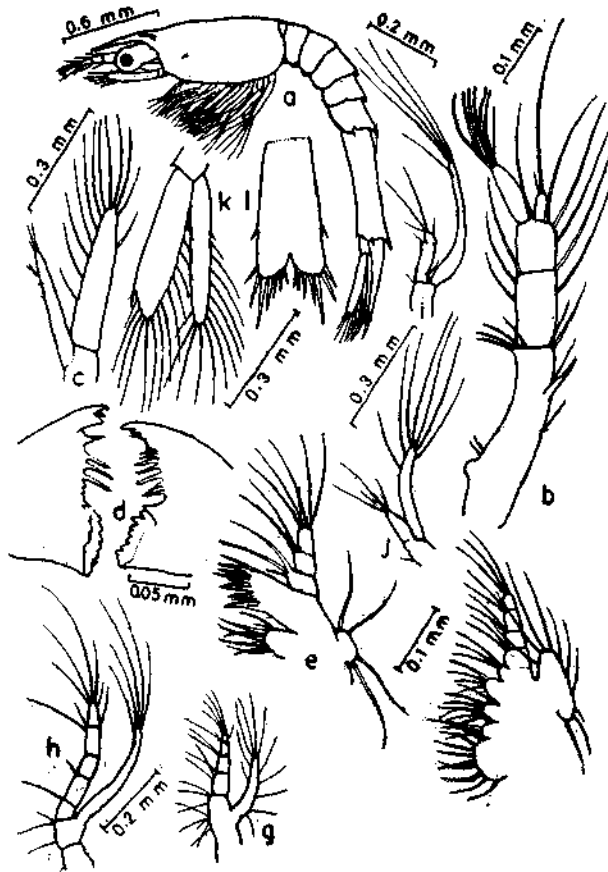


Fig. 5 *Penaeus semisulcatus*: Mysis I: a - lateral view; b - A1; c - A2; d - Md; e - Mx1; f - Mx2; g - Mxp1; h - Mxp3; i - P1; j - P4; k - uropod; l - telson.

distal margin, telson (Fig. 5,l) broader distally with median notch, each lobe with 1 lateral and 7 terminal setae.

A1 (Fig. 5,b) 3 segmented, basal segment with anteromedian spine and 2 setae above stylocerite rudiment, distal segment with 2 flagellar rudiments, outer rudiment with 6 aesthaetes and 1 seta, inner only half size of outer, bearing 1 long and 1 short seta terminally; A2 (Fig. 5,c) exopod unsegmented, leaf like with a distolateral seta on outer margin and 11 setae along inner and distal margin, endopod unsegmented carrying 3 terminal seta and 2 distolateral setae

placed on a minute projection; Md (Fig. 5, d) asymmetrical, right and left Md with 3 and 7 free standing teeth respectively between incisor and molar processes; Mx1 (Fig. 5, e) distal and proximal endites with 11 and 8 setae respectively, knob-like exopod with 4 long feathery setae; Mx2 (Fig. 5, f) exopod expanded to form scaphognathite, with 10 plumose setae; Mxp1 (Fig. 5, g) exopod with 11 plumose setae, 1 seta added to 1st segment of endopod along outer margin; Mxp2 basis with 7 setae on inner side, exopod with 6 long plumose setae distally, endopod 4 segmented, terminal segment with 5 long setae; Mxp3 [Fig.5,h] biramous, coxa and basis bearing 1 and 3 setae on inner side respectively, exopod as long as endopod bearing 4 apical and 2 subapical plumose setae, endopod 5 segmented, terminal segment with 5 setae, 1st, 2nd and 4th segments bearing 1, 1, 3 setae respectively, 3rd segment without any seta; P1 to P3 almost identical (Fig 5, i) endopod unsegmented, developing chela seen with 5 terminal setae, exopod longer than endopod bearing 4 apical and 3-4 subapical long plumose setae; P4 and P5 identical (Fig.5,j) endopod unsegmented, half length of exopod, bearing 4 apical setae, exopod with 7 to 8 long plumose setae distally. Duration of this substage was 22 hours.

MYSIS II

MTL: 3.50 mm (3.48 - 3.52 mm); MCL: 1.13 mm (1.10-1.16 mm).

Rostrum extending to tip of eye or slightly beyond, devoid of any spine (Fig.6,a), carapace with spination as in the previous substage; exopod of uropod (Fig.6,h) with 16 plumose setae and 1 non-plumose seta (Fig.6, i) in addition to posterolateral fixed spine, endopod with 14 plumose setae; telson (Fig.6,j) almost rectangular, middle cleft extending to level of origin of penultimate lateral setae, telson with 2 pairs of lateral and 6 pairs of distal setae.

A1 (Fig.6,b) number of setae on A1 segments increased, basal segment with swollen base showing the developing statocyst and carries 3 plumose short setae; A2 (Fig.6,c) exopod with 18 plumose setae along inner and distal margin, a spine replaces the seta on distolateral outer margin, endopod unsegmented and devoid of setae; Md (Fig.6,d) unsegmented, small palp developed; Mx1, except for absence

of exopod no other change in appendage; Mxp2 (Fig.6,e) endopod 5 segmented, distal segment with 6 long setae, 1st, and 2nd segments carry 1 seta each on outer distal margin; Mxp3, 3rd segment of endopod with 2 setae; p1 to p3



Fig. 6 *Penaeus semisulcatus*: Mysis II: a - lateral view; b - A1; c - A2; d - Md; e - Mxp2; f - P1; g - P5; h - uropod; i - distolateral tip of exopod of uropod; j - telson. Mysis III: k - Md.

almost identical (Fig.6,f) endopod 4 segmented, chela developed bearing 5 setae, exopod almost of same size as endopod, bearing 7-8 long setae distally; p4 and p5 (Fig.6,g) similar, endopod 4 segmented, 3rd and 4th segments bearing 2 and 3 setae respectively. Duration of this substage was 56 hours.

MYSIS III

MTL: 4.43 mm (4.38-4.48 mm); MCL: 1.50 mm (1.48 - 1.51 mm).

Rostrum extends beyond eye (Fig.7,a), in some specimens a rudimentary rostral

tooth may be present, supraorbital, hepatic and pterygostomial spines present; pleopods 2 segmented; exopod and endopod of uropod with 19 and 23 setae respectively (Fig. 7,f), median cleft of telson (Fig.7,g) reduced.

A1 (Fig.7,b) statocyst seen at base of 1st segment, flagella of equal size, outer flagellum 2 segmented with 7 aesthaetes in 3 groups of 3 + 2+2 and 2 terminal seta, inner flagellum indistinctly 2 segmented with 4 apical setae; A2 (Fig.7,c) exopod with 22 plumose setae and 1 outer lateral spine, endopod 2 segmented bear-

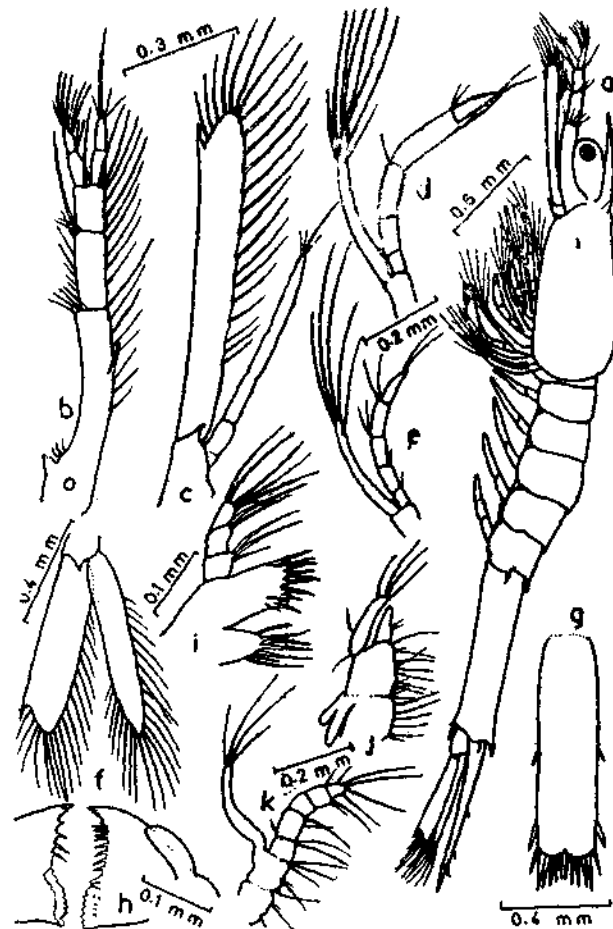


Fig. 7 *Penaeus semisulcatus*: Mysis III: a - lateral view; b - A1; c - A2; d - P1; e - P5; f - uropod; g - telson. Intermediate stage: h - Md; i - Mx1; j - Mxp1; k - Mxp2;

ing 4 apical setae; Md (Fig.6,k) palp 2 segmented but devoid of setae; Mx1 no change from previous stage; Mxp2 rudiment of gill developed, exopod bears 4 long plumose setae apically; Mxp3 rudimentary gills present on coxa,

endopod longer than exopod and 5 segmented, distal segment with 4 setae; P1 to P3, although identical in appearance, show progressive increase in size from P1 to P3 (Fig.7,d) rudimentary gills developed, endopod 5 segmented, chela fully developed and dactylus with 2 apical setae; P4 and P5 (Fig.7,e) identical, endopod 5 segmented, 3rd and 5th segments each bearing 2 distal setae. Duration of this substage was 18 hours.

INTERMEDIATE STAGE

MTL: 4.21 mm; MCL: 1.26 mm

Although pleopods (Fig.8,g) bear 5 short terminal setae, exopods of pereopods retain apical setae; spines on carapace, abdomen and telson same as in mysis stage (Fig.8,a),

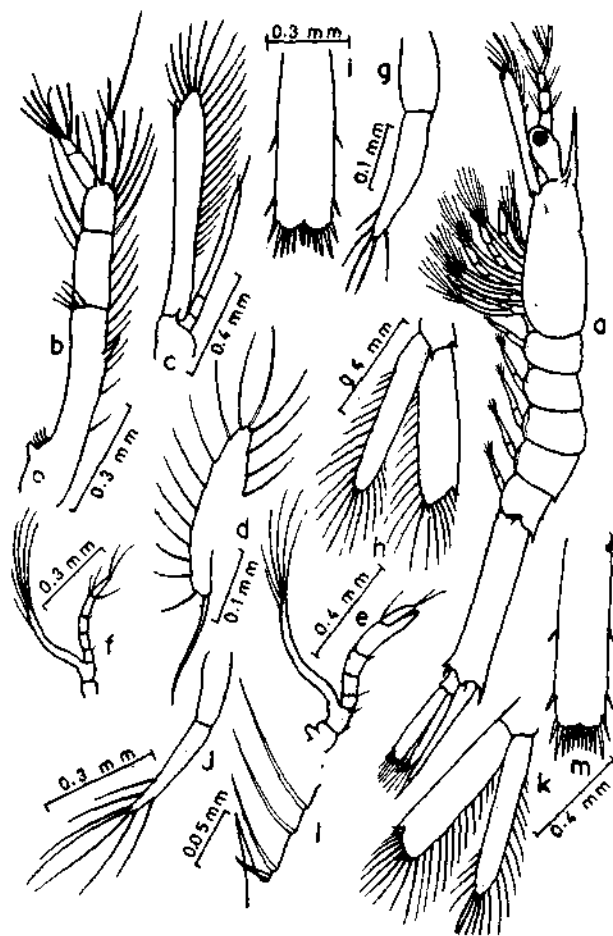


Fig 8 *Penaeus semisulcatus*: Intermediate stage: a - lateral view; b - A1; c - A2; d - exopod of Mx2; e - P1; f - P5; g - pleopod; h - uropod; i - telson. Postlarva I: j - pleopod; k - uropod; l - distolateral tip of exopod of uropod; m - telson.

exopod of uropod with 18 plumose setae and 1 non-plumose seta in addition to distolateral fixed spine (Fig.8,h), endopod with 20 plumose setae; telson (Fig.8,i) truncate with 5 pairs of distal and 3 pairs of lateral setae.

A1 (Fig.8,b) statocyst fully developed, number of setae on segments increase, flagella almost equal in size, outer with 7 to 8 aesthaetes and 1 seta, inner with 3 setae apically; A2 (Fig.8,c) exopod with 24 plumose setae and 1 distolateral spine, endopod with 2 clear segments and 2 indistinct segmentation, more than half length of exopod and beset with 2 apical setae; Md (Fig.7,h) and Mx1 (Fig.7,i) without any noticeable change; Mx2 (Fig.8,d) exopod with 16 plumose setae; Mxp1 (Fig.7,j) endopod and exopod reduced in size, protopod segments enlarged, gill rudiments well developed, endopod unsegmented bearing only 2 small setae on inner side, exopod with 6 setae; Mxp2 (Fig.7,k) endopod 5 segmented with a slight bent towards inner side, length of setae slightly reduced; Mxp3 without any noticeable change; P1 to P5 (Fig.7,e,f) rudimentary gill developed.

POSTLARVA I

MTL: 4.82 mm (4.76 - 4.87 mm); MCL: 1.50 mm (1.47 - 1.54 mm).

Rostrum longer than eye, bearing 1 dorsal spine (Fig.9,a), supraorbital, pterygostomial and hepatic spines present; 4th, 5th and 6th abdominal segments with a posteromedian dorsal spine, lateral spine present on 5th and 6th abdominal segments, anal spine persists, exopods of pereopod rudimentary, pleopods (Fig.8,j) fully developed bearing 3 to 4 pairs of plumose setae; telson (Fig.8,m) with 5 pairs of distal and 3 pairs of lateral setae; exopod of uropod (Fig.8,k,l) with 21 plumose setae and 2 short nonplumose setae, endopod with 20 plumose setae.

A1 (Fig.9,b) basal segment with well developed statocyst, ventromedian spine persists, outer flagellum 2 segmented carrying 8 aesthaetes in 3 groups of 4+2+2, apically 2 slender setae present, inner flagellum longer than outer, 3 segmented with 3 apical setae; A2 (Fig.9,c) scale with 22 long plumose setae and 1 distolateral spine, endopod 5

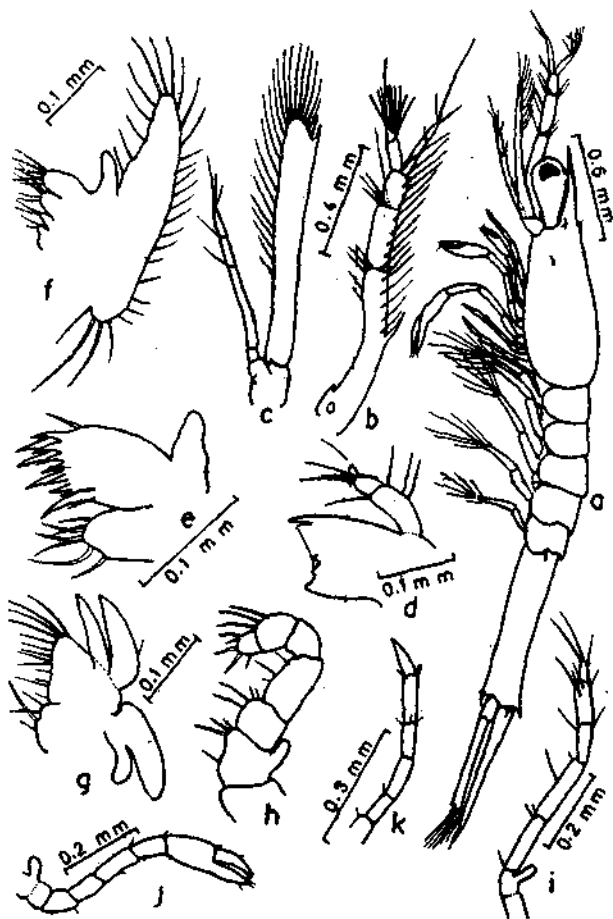


Fig. 9 *Penaeus semisulcatus*: Postlarva I: a - lateral view; b - A1; c - A2; d - Md; e - Mx1; f - Mx2; g - Mxp1; h - Mxp2; i - Mxp3; j - P1; k - P5.

segmented, almost same length as exopod; Md (Fig.9,d) symmetrical, standing teeth lacking, palp 2 segmented, proximal segment with 3 setae on outer margin, 1 seta on distal inner border and distal segment with 3 apical setae; Mx1 (Fig.9,e) endopod rudimentary, unsegmented and without setae, distal lobe longer than proximal and bears 13 setae, proximal lobe with 7 to 8 setae. Mx2 (Fig.9,f) 4 endites much reduced in size, proximal 2 endites each bearing 2 setae, distal 2 endites with 4 to 6 setae, endopod unsegmented and much reduced, exopod fairly large bearing 28 plumose setae; Mxp1 (Fig.9,g) endopod and exopod unsegmented and much reduced, gills fully developed, protopod broad carrying numerous setae; Mxp2 (Fig.9,h) acquires typical adult shape, exopod vestigial, endopod recurved, distal segment with 5 stout setae, 4th segment with 3 long setae, first 2 segments with 4 and 3 setae respectively; Mxp3 (Fig.9, i) protopod with gills, exopod vestigial, endopod 5 segmented, distal 2 segments with 3 to 4 long setae; P1 to P3 (Fig.9, j) rudimentary gill present, exopod absent or highly reduced and without setae; P3 longest, chela fully developed, tips beset with small brushlike setae; P4 and P5 (Fig.9, k) identical, exopod absent, endopod 5 segmented without many long setae.

REMARKS

Although *P. semisulcatus* has been reared from the egg to the juvenile stage under controlled conditions in Taiwan (Liao and

	<i>P. semisulcatus</i> (present material)	<i>P. semisulcatus</i> (Liao and Huang ¹)
Egg	0.28 mm	0.26 mm
Nauplius I	0.30 "
Nauplius II	0.33 "
Nauplius III	0.34 "
Nauplius IV	0.34 "
Nauplius V	0.39 "
Nauplius VI	0.46 "	0.53
Protozoa I	0.96 "	1.02
Protozoa II	1.74 "
Protozoa III	2.47 "	2.71
Mysis I	3.15 "	3.38
Mysis II	3.50 "
Mysis III	4.43 "	4.74
Postlarva I	4.82 "	5.22

Huang¹) only the length of some larval stages is given by them. The detailed structure of the various larval stages is described for the first time in this paper. The egg diameter and the length of the larvae of *P. semisulcatus* from India (present material) and Taiwan (Liao and Huang¹) are compared in the preceding table.

Although the present eggs are slightly larger than those from Taiwan, all the larval stages from Taiwan were a little larger than

the corresponding stages in the present material.

In addition to the 6 nauplius, 3 protozoa and 3 mysis substages, some times an intermediate substage between the last mysis and postlarva I was also observed during the present study. In the intermediate stage the pleopods have setae but the exopods of the pereopods remain fully functional and the Md, Mx1, Mx2, Mxp1 and Mxp2 retain the mysis stage characters. The specimens in the intermediate stage were however very rare.