THE LARVAL DEVELOPMENT OF PALAEMONID SHRIMPS FROM THE AMAZON REGION REARED IN THE LABORATORY. V. THE ABBREVIATED DEVELOPMENT OF Pseudopalaemon chryseus KENSLEY & WALKER, 1982 (CRUSTACEA: DECAPODA: PALAEMONIDAE). (*)

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SUMMARY

Larval development of the freshwater palaemonid shrimp Pseudopalaemon chryseus Kensley & Walker, 1982 was studied in the laboratory from the offspring of females collected in a lake of the lower Negro River system. Females carry few (14 to 43), large (1.86 ± 0.13 x 1.29 ± 0.06 mm), yolk-rich eggs. The species goes through three larval stages without feeding and the main feature of its larval development is the presence of functional walking legs on hatching (3rd, 4th and 5th pairs). Metamorphosis occurs five or seven days after hatching. Descriptions and illustrations of the three larval and first juvenile stages are presented.

INTRODUCTION

The genus **Pseudopalaemon** is endemic to South America, being distributed mainly in the Amazon basin; four of the five known species are reported for this region (Kensley & Walker, 1982). **Pseudopalaemon chryseus** is a common species in the blackwater river systems of Central Amazonia. Several aspects of its biology, feeding habits, population dynamics and reproduction are known from the works of Kensley & Walker (1982) and Walker & Ferreira (1985).

In the Amazon Region, the only shrimps which have their larval life history fully described are **Macrobrachium amazonicum** (Magalhães, 1985), and the three species of **Euryrhynchus** (Magalhães, in press). For species of the genus **Pseudopalaemon**, information on the larval development was only known from a brief account by Sollaud (1923) on **Pseudopalaemon bouvieri** and by a preliminary communication dealing with several Amazonian

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shrimps, in which **P. chryseus** was included (Magalhães & Walker, 1984). The aim of this paper is to provide a complete description, along with illustrations, of the three larval and first juvenile stages of **Pseudopalaemon chryseus**, and to present data on some of its life history characteristics.

MATERIAL E MÉTODOS

Several specimens of **Pseudopalaemon chryseus** were collected on April 13 and June 16, 1983 in the Caju lake, situated on the left bank of the Negro River, a few kilometers upriver from Manaus. About 20 ovigerous females were kept alive for this study and the remainder of the shrimps were preserved. The transportation of the females, their maintenance in the laboratory, rearing of the larvae, dissection and preparation of the larvae for illustrations, measuring of eggs and shrimps, follow the same procedures as explained in Magalhães (in press), except for the fact that food was not offered before metamorphosis. Temperature of the water in the aquaria ranged between 28°C and 33°C (measured during the day); pH was approximately 5.5. For greater clarity, plumose setae have been in the drawings of the whole larva. Where plumes are represented, they can be denser and longer than is indicated.

After they released their clutch, the females were preserved and, together with the other specimens from the Caiu lake, deposited in the "Coleção Sistemática de Invertebrados, Seção Crustacea" of the Instituto Nacional de Pesquisas da Amazônia, with catalogue numbers INPA-CR 051 and INPA-CR 125. Seven juveniles reared in the laboratory are deposited also in this collection (INPA-CR 435).

RESULTS

The mean total length (TL) of 20 preserved ovigerous females was 30.9 ± 2.1 mm. These females carried 14 to 43 eggs (mean: 26 ± 08). The eggs were eliptical, large and yolk-rich; 14 fresh eggs removed from 3 females measured 1.86 ± 0.13 x 1.29 ± 0.06 mm. Usually, two nights were needed for a female to release its whole clutch.

The development is abbreviated and consists of three larval stages. The larvae do not need to feed since their yolk supply is enough to nourish them until metamorphosis. In most cases, the first, second and third larval stages lasted, respectively, two, two and three days, but other patterns were also observed (Fig. 1).

Descriptions of the larval stages and juvenile 1:

Body

Larva 1 (TL 4.66 ± 0.13 mm; n = 17; 4.39 to 4.90 mm) (Figs. 2, 3): Rostrum unarmed, curved downwards. Antero-lateral region of the carapace with 2 spines, the lower only slightly removed from the anterior border (these teeth correspond, in the adult, to the

antennal and hepatic spines). Eyes sessile. Abdomen 6-seqmented, smooth; pleuron of the 2nd, 4th and 5th abdominal somites with a median notch on the latero-posterior border.

Larva II (TL 4.91 ± 0.20 mm); n = 15; 4.50 to 5.14 mm) (Figs. 19, 20): Rostrum straight and longer, armed with 4-6 dorsal and 0-1 ventral teeth. Carapace with a small supra-orbital spine. Eyes stalked.

Larva III (TL 5.09 ± 0.19 mm; n = 4.70 to 5.30 mm) (Figs. 28, 29): Similar to the preceding stage. Rostral formula 6-7/1.

Juvenile I (TL 5.42 ± 0.36; n = 24; 4.74 to 6.12 mm) (Figs. 38, 39): Rostral formula 6-8/1-2. Carapace without supra-orbital spine.

Antennule

Larva I (Fig. 4): Peduncle unsegmented. Distally with 2 flagella: inner flagellum with 4 longitudinal rows of plumes and 2 apical naked setae; outer flagellum, at distal half, long and fine and bearing 2 naked setae, 1 aesthete and 1 weakly plumose seta.

Larva II (Fig. 21): Peduncle 3-segmented, bearing several naked and plumose setae as illustrated. Proximal segment with a ventral spine, a developing stylocerite and a small spine on the distal-lateral corner. Distal segment with a developed antennular lobe tipped with 4 weakly plumose setae. Inner flagellum 3-segmented; outer flagellum subdivided, basal part unsegmented, inner branch tipped with 2 aesthetes and shorter than the 3-segmented outer branch. Both flagella bearing small setae, but minute aesthetes present only on the inner one.

Larva III (Fig. 30): Stylocerite more developed. Inner flagellum longer, 6-segmented. outer branch longer, 5-segmented.

Juvenile I (Fig. 40) Statocyst developed.

Antenna

Larva I (Fig. 5): Protopod unsegmented, with a sharp spine on the distal-ventral border. Scale large, with 26-30 plumose setae along the inner and distal margins, and a spine on the disto-lateral corner. Endopod as a long, multi-articulated flagellum about 6 times as long as the scale.

Larvae II, III and Juvenile I: Similar to that of the preceding stage, except for the bisegmented protopod.

Mandibles

Larvae I (Fig. 6), II (Fig. 22) and III (Fig. 31): Rudimentary. Cleft between incisor and molar processes increases from first to third larval stage, but neither have developed teeth.

Juvenile I (Figs. 41, 42): Fully developed, strong. Incisor process with 3 teeth; molar process subquadrate, with several sharp and rounded teeth.

Maxillule

Larvae I (Fig. 7), II and III: Rudimentary. Coxal and basal endites smooth or with some terminal protuberances. Endopod bilobed, lower lobe always tipped with a minute spine; upper lobe with a minute spine in the first larval stage and smooth in the others.

Juvenile I (Fig. 43): Fully developed. Coxal endite with 8, naked and weakly plumose, setae terminally and subterminally. Basal endite with 11 spinose setae terminally and subterminally, and 2 plumose setae on the inner margin. Endopod with a curved spine on the lower lobe.

Maxilla

Larvae I (Fig. 8), II and III: Protopod bilobed, both endites smooth. Endopod smooth. Scaphognathite developed, fringed by 34-35 plumose setae.

Juvenile I (Fig. 44): Protopod with lower and upper endites elongated and bearing, respectively, 2 and 3 naked setae.

Maxilliped 1

Larva I (Fig. 9): Protopod with a small epipod and the inner margin simple, bearing 4 plumose setae distally. Endopod short, with 4-5 plumose setae. Exopod long, with 4 terminal plumose setae.

Larva II (Fig. 23): Protopod slightly bilobed.

Larva III (Fig. 32): Protopod with basal endite bearing 1 naked and 5-6 plumose setae. Exopod slightly bulged in its proximal outer border.

Juvenile I (Fig. 45): Protopod with coxal endite bearing 1 plumose and 2 naked setae, and basal endite showing several, naked and weakly plumose, setae terminally and subterminally; epipod distinctly bilobed. Endopod with 1 naked and 1 plumose seta. Exopodal lobe developed, with 5 plumose setae.

Maxilliped 2

Larvae I (Fig. 10) and II: Protopod segmented, coxa slightly bulged on the outer margin. Endopod 4-segmented, segmentation between the penultimate and the last segments faint; penultimate segment with 1 plumose seta, last segment with 2-3 subapical plumose setae and 1 apical plumose spine. Exopod long, with 5 plumose setae distally.

Larva III (Fig. 33): Coxa with inner margin distinctly enlarged. Last two segments of the endopod wider, last segment with 5, short and long, plumose setae and some protuberances distally.

Juvenile I (Fig. 46): Coxa with enlargement of the inner margin bearing 1 weakly plumose and 2 naked setae. Endopod 5-segmented, strongly incurved, with the last two segments wider than the others; penultimate segment with 5 setae, being 3 (1 naked and 2 weakly plumose) on the inner side and 2 naked on the distal margin; last segment with several naked and weakly plumose setae terminally and subterminally.

Maxilliped 3

Larvae I (Fig. 11), II and III: Protopod segmented, basis with 2 naked setae. Endopod 4-segments, with 4-5, 3-4, 4-7, 2-3, naked and weakly plumose, setae from proximal to distal segment; distal segment also with an apical plumose spine. Exopod about half of the endopod in length, with 1 subterminal naked seta and 4 terminal plumose setae.

Juvenile I (Fig. 47): Both coxa and basis with 2 naked setae each. Endopod 3-segmented, with several naked and weakly plumose setae scattered mainly on the inner side

of the segments, and the apical plumose spine. Exopod unchanged.

Pereiopods 1 and 2

Larvae I (Figs. 12, 13) and II (Figs. 24, 25): Well developed, chelate, uniramous buds anteriorly directed under the cephalothorax. Segmentation between palm and dactylus undistinguished; a few naked setae present.

Larva III (Figs. 34, 35): More developed than the preceding stages, with segmentation between palm and dactylus clearly distinct.

Juvenile I (Fig. 48, 49): Fully developed and functional. Pereiopod 2 longer than pereiopod 1. Both with several short, naked and/or weakly plumose, setae scattered on all segments and a tuft at the tip of the movable and fixed fingers. Pereiopod 1 with a typical oblique subterminal row of 4 plumose setae on the inner side of the carpus and 3 plumose spiniform setae on the inner proximal side of the palm.

Pereiopods 3, 4 and 5

Larvae I (Figs. 14, 15, 16), II, III and Juvenile I (Fig. 50): Uniramous and fully developed on hatching, with several short, naked and weakly plumose setae scattered on the segments, mainly on the propodus. Dactylus with a terminal spine.

Pleopods 1 to 5

Larva I (Fig. 17a-e): Well-developed, biramous buds; pleopods 2 to 5 bearing rudimentary appendices internae. In some individuals, the endopod of the pleopods 2, 3 and 4 already bears some plumose setae.

Larva II (Fig. 26a-e): Endopod and exopod now with marginal plumose setae (except for the endopod of the pleopod 1).

Larva III (Fig. 36a-e) and Juvenile I: Appendices internae more developed than in the preceding stages, bearing minute hooks.

Uropod

Larvae I (Fig. 18) and II (Fig. 27): Buds visible through the telsonal cuticle.

Larva III (Fig. 37): Exopod with a disto-lateral spine, 23-24 plumose setae on the inner and distal borders, 2 short plumose setae on the outer proximal border and some short, naked and plumose, setae on the ventral surfaces (these setae, as well as those of the inner border of the exopod which lay under the endopod, were not represented in the drawings). Endopod rudimentary, but with 3 and 4 plumose setae, respectively, on the outer proximal border and the dorsal surface.

Juvenile I (Fig. 51): Endopod with a fixed and an articulated spine on the disto-lateral corner, and 23-25 plumose setae on the inner and distal borders. Endopod developed, with 14-19 plumose setae on the inner and distal borders.

Telson

Larvae I (Fig. 18) and II (Fig. 27): Fan-like; posterior border strongly convex, with 21-24 plumose setae.

Larva III (Fig. 37): Narrower and longer than in the preceding stages, wider on its posterior part, bearing a pair of spines on the disto-lateral corners and 20-23

plumose setae on the convex posterior border.

Juvenile I (Fig. 51): Enlogated, a little narrower posteriorly, bearing 12-16 plumose setae on the still convex posterior border and 4 pairs of spines: 3 pairs on the disto-lateral corners and 1 pair a little more proximally, on the lateral borders; the distal-most pair is the largest.

Color of the larvae

To the naked eye, the larvae exhibit only a slight greenish hue in the cephalo-torax. Under a microscope, red dendritic chromatophores can be noted in the lateral region of the carapace, the ocular and antennular peduncles, the antenna (protopod and scale), the buccal region and base of all thoracic appendages (mainly in the 3rd pair of maxillipeds), the dorsal of the abdominal somites and the telson. Black chromatophores are scattered in the carapace and are also present in the ocular peduncle, the antennular and antennal flagella, the antennal scale, in the joints of the thoracic appendages, along the posterior margin of the abdominal somites and the telson. A difuse bluish hue is sometimes noted ventrally in the anterior part of the cephalothorax.

DISCUSSION

Like to other palaemonid shrimps with abbreviated development, **Pseudopalaemon chryseus** has a short larval phase of only three stages. Its uropods are freed at the third larval stage; furthermore, its newly-hatched larvae show the scaphognathite of the maxilla with many setae and a broad telson with more than 7 + 7 setae. Such characters are usually associated with abbreviated development in Decapoda (Williamson, 1982); particularly in those species of Palaemoninae from Sollaud's (1923) second group. However, even within this group of abbreviated developers there are species hatching in a more or less advanced stage. **P. chryseus** has a very advanced larval development, since its newly-hatched larvae, besides being benthic, show characters such as long, multi-articulated antennal flagellum, chelipeds as well-developed, uniramous buds, and walking legs fully formed and functional. In this context, the larval development of **P. chryseus** is similar to those of **Macrobrachium shokitai** Fujino et Baba (Shokita, 1973), **M. asperelum** (von Martens) (Shokita, 1977), their interspecific hybrid (Shokita, 1978), **M. potiuna** (Müller) (Müller, 1892; Bueno, 1981) and **M. brasiliense** (Heller) (Vega, 1984). However, in all these species the pereiopods 3 to 5 are still rudimentary on hatching, becoming functional at the second larval stage only. The possession of functional walking legs is, therefore, the remarkable characteristic of the larval development of **P. chryseus**.

The only other species of this genus for which information on the larval development is available is **P. bouvieri** Sollaud. The account given by Sollaud (1923: 579-581, fig. XXI) is brief but, even so, it is easy to note that the larval development of **P. chryseus** and **P. bouvieri** differ in one basic aspect: the stage of development of the pereiopods on hatching. According to Sollaud (1923), the late embryos of **P. bouvieri** show

exopods on cheliped's buds but these exopods, though a little variable, are very rudimentary and destined to disappear. The other pereiopods are considered by Sollaud (op. cit.) to be similar to those he described for the newly-hatched larvae of **Palaemonetes antennarius** (von Martens) (as **P. varians lacustris**), and this means that the walking legs of **P. bouvieri** are not functional, at least on the first larval stage. In addition, the posterior margin of the telson, in **P. bouvieri**, has 14 plumose setae while it has 21-24 in **P. chryseus**. The larval development of the other species of **Pseudopalaemon**, all occuring in the Amazon basin, is still unknown.

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RESUMO

O desenvolvimento larval em laboratório do camarão dulcícola ***Pseudopalaemon chryseus*** *foi estudado a partir da prole de aproximadamente 20 fêmeas ovadas coletadas em um lago do sistema do baixo rio Negro. As fêmeas carregavam poucos ovos (14 a 43), sendo os mesmos grandes (1,86 ± 0,13 x 1,29 ± 0,06 mm) e ricos em vitelo. A espécie apresenta três estágios larvais e não ingere alimento durante essa fase. A principal característica do seu desenvolvimento larval é o fato de os terceiro, quarto e quinto pares de pereiópodos estarem totalmente desenvolvidos e funcionais desde o primeiro estágio larval. A metamorfose ocorre entre cinco a sete dias após a eclosão. A descrição e ilustrações dos três estágios larvais e do primeiro estágio de juvenil são fornecidas.*

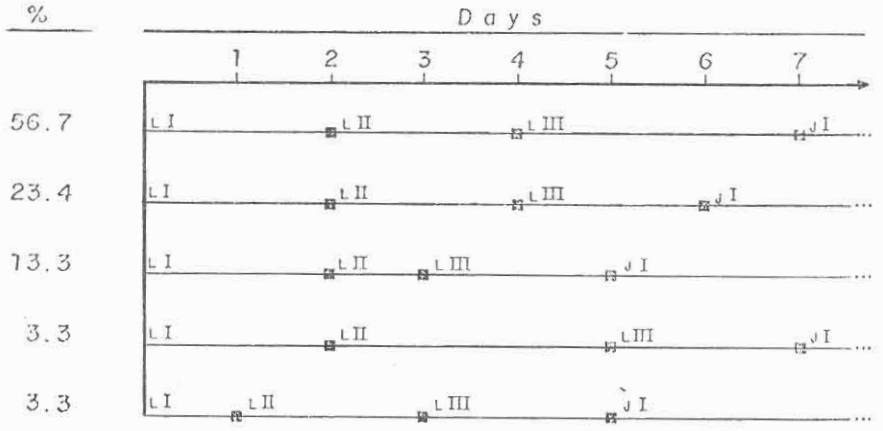
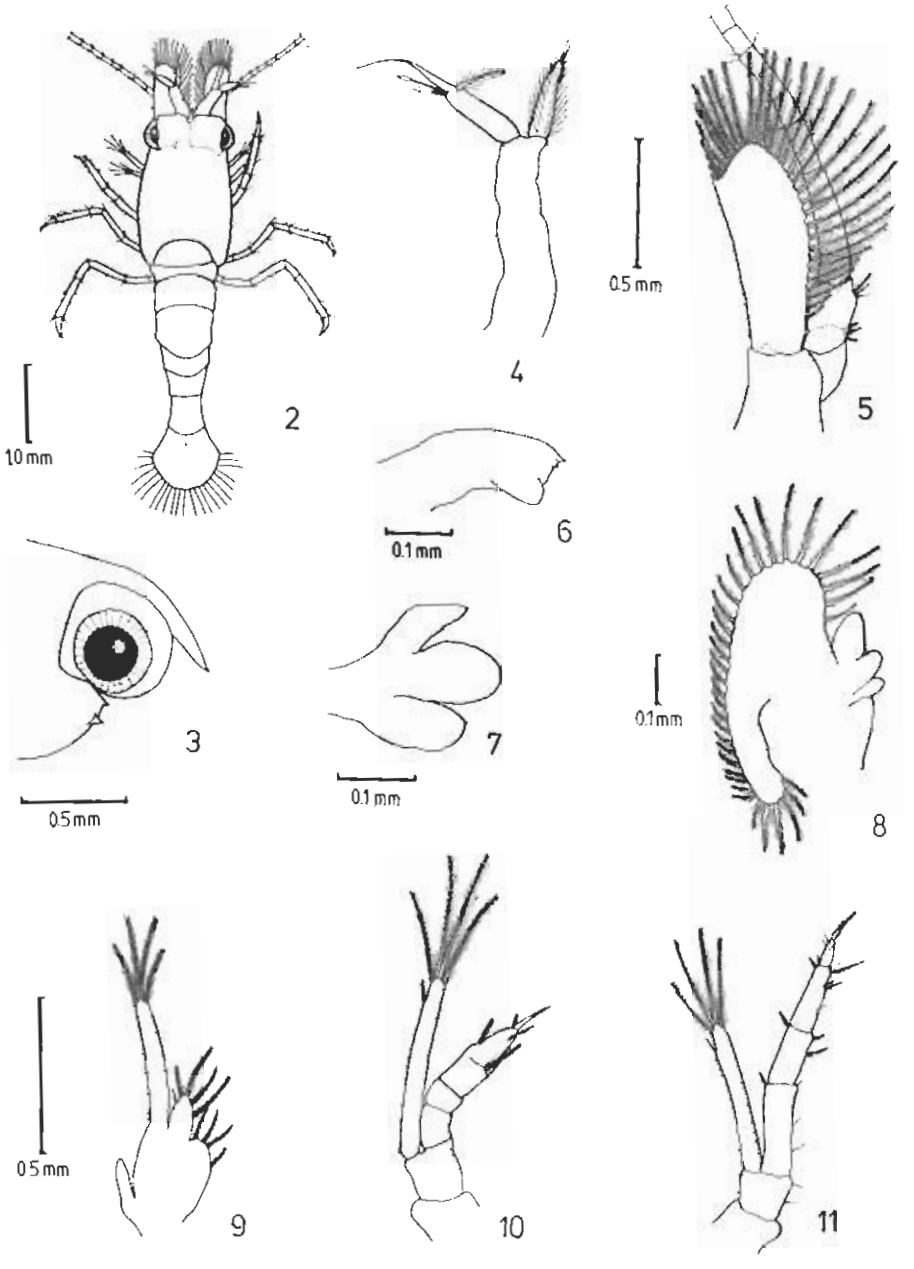
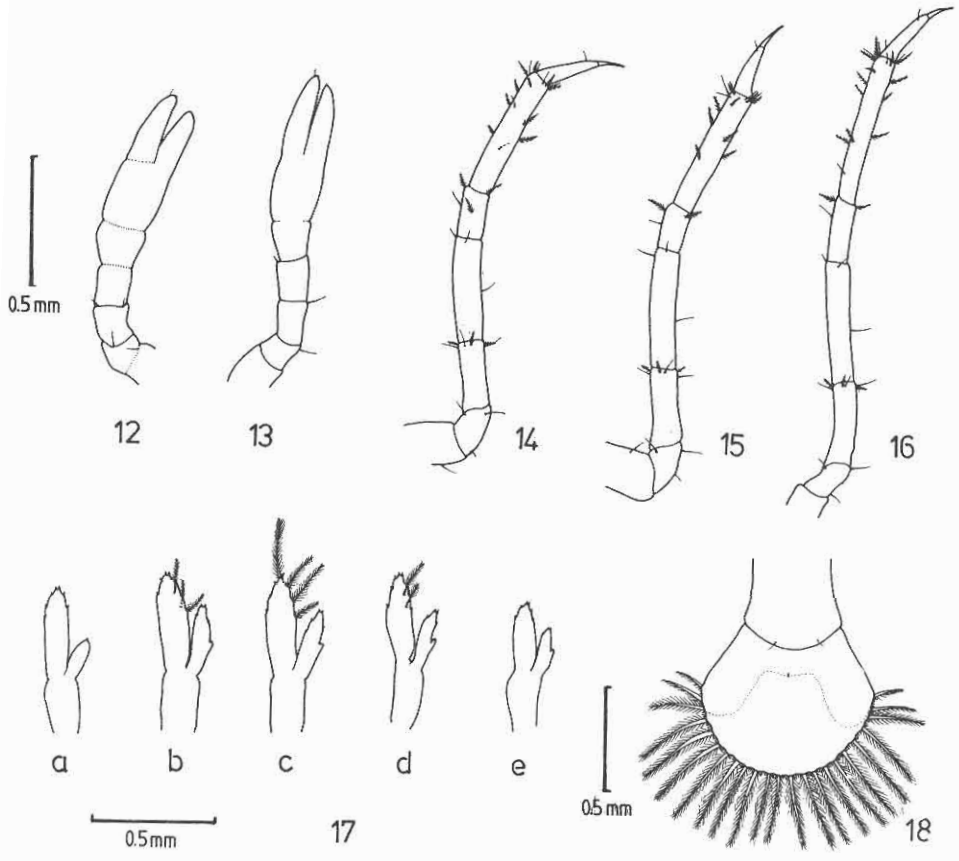


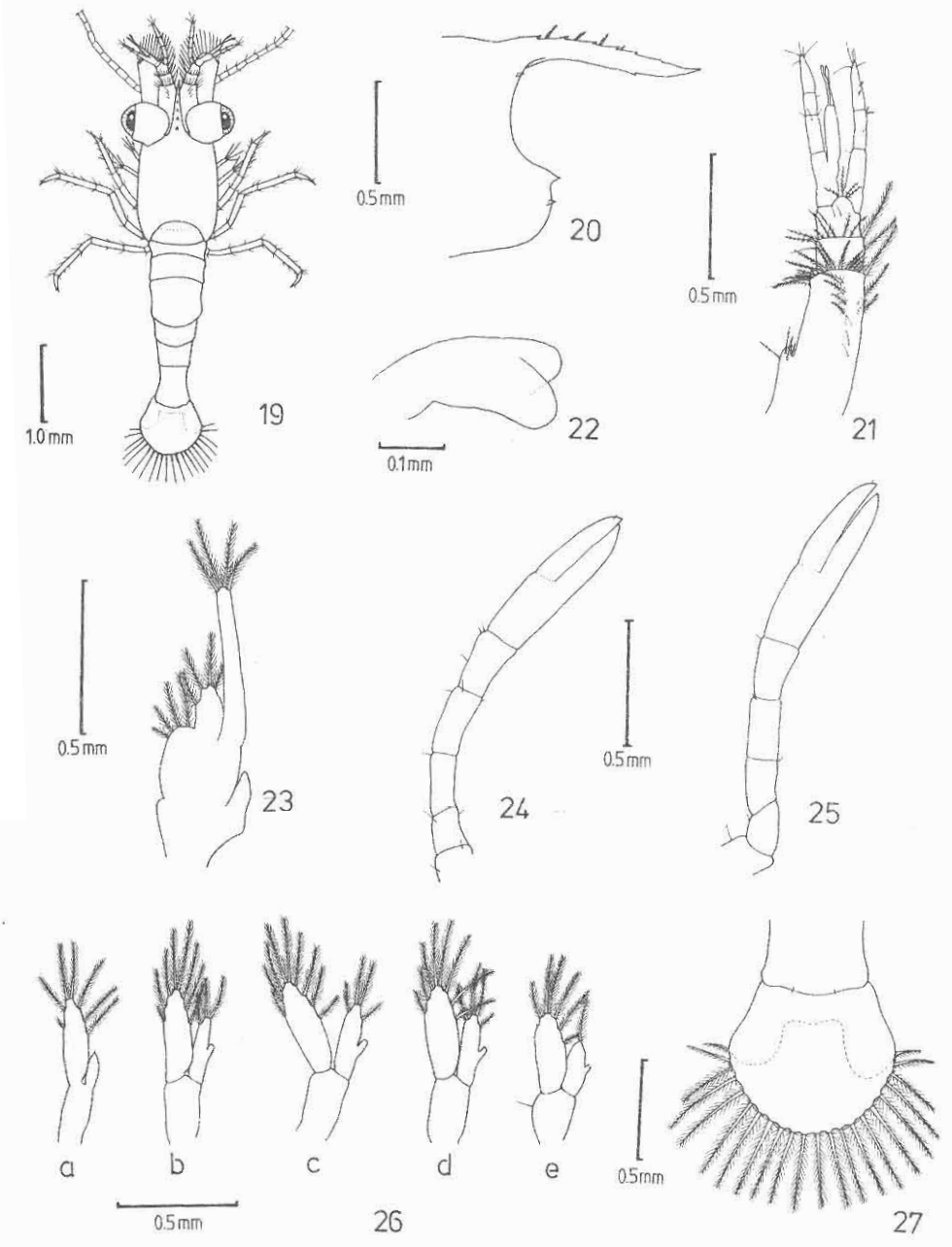
Fig. 1. Patterns of duration of the larval stages in **Pseudopalaemon chryseus** (n = 30 observations; L = larva; J = juvenile; square = molt).



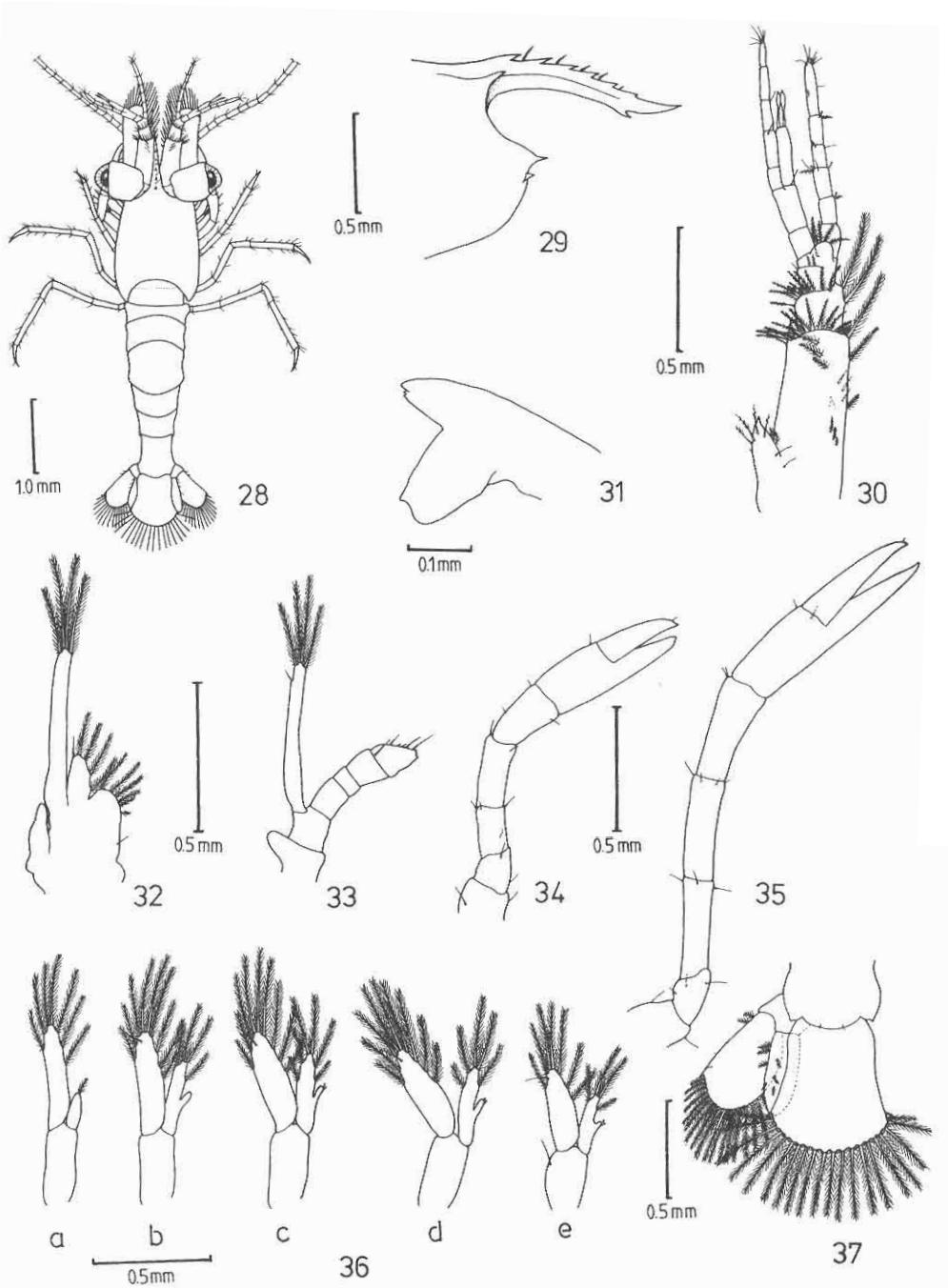
Figs. 2 - 11. **Pseudopalaemon chryseus**, larva I: 2, dorsal view; 3, lateral view of the anterior part of the carapace; 4, antennule; 5, antenna; 6, left mandible; 7; Maxillule; 8, maxilla; 9, maxilliped 1; 10, maxilliped 2; 11, maxilliped 3.



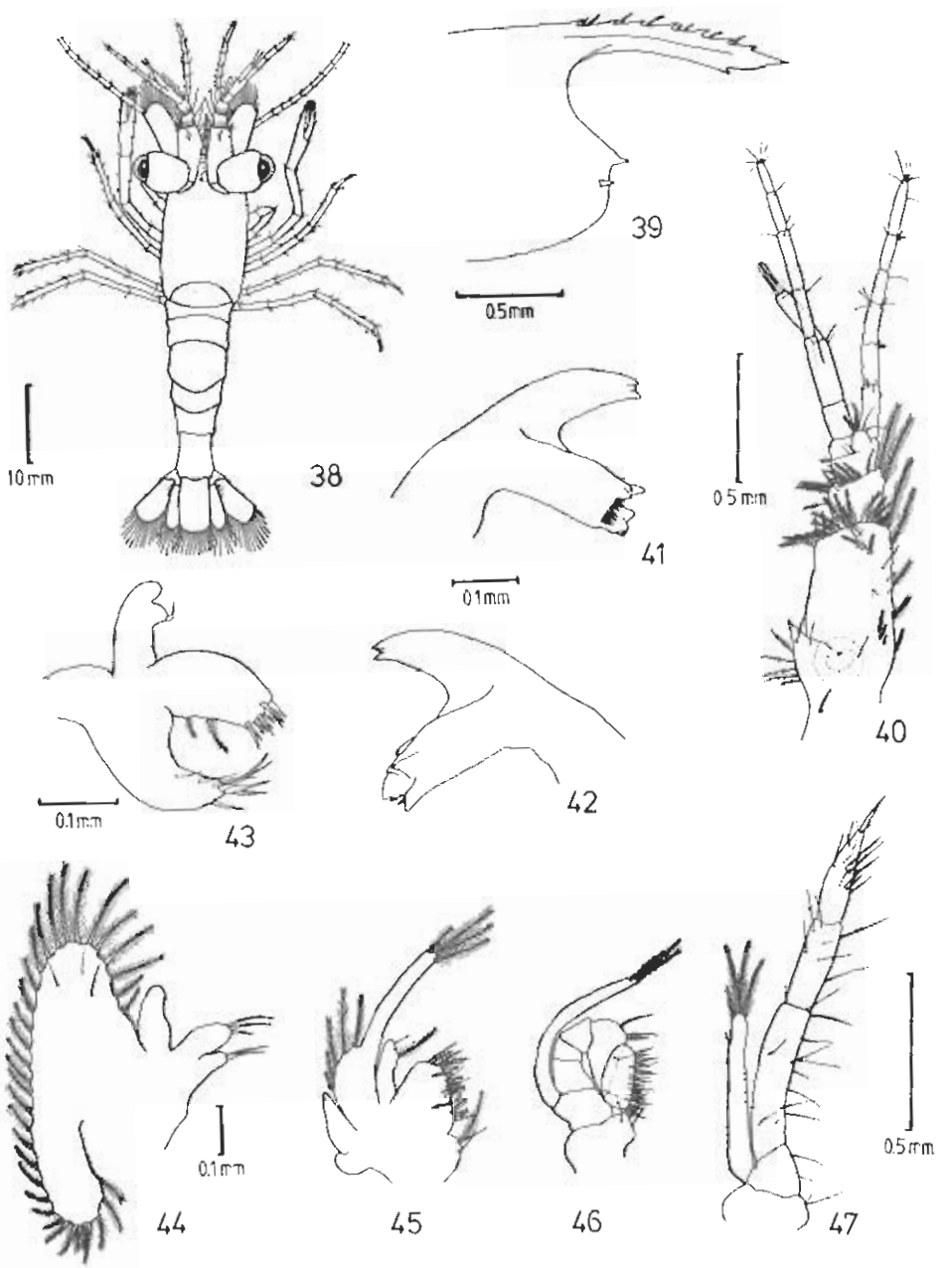
Figs. 12 - 18. **Pseudopalaemon**, larva I: 12, pereiopod 1; 13, pereiopod 2; 14, pereiopod 3; 15, pereiopod 4; 16, pereiopod 5; 17a-e pleopods 1 to 5; 18, telson.



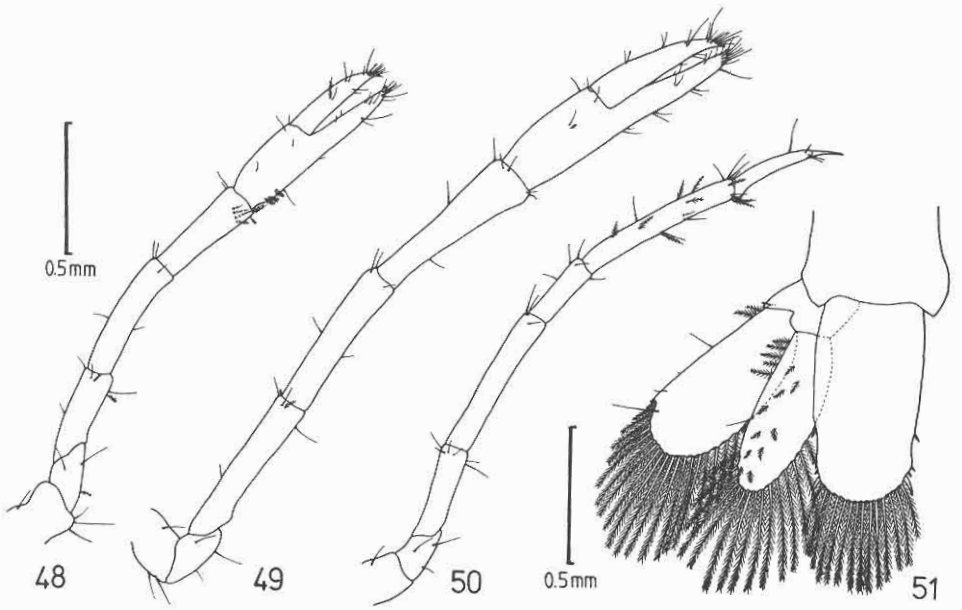
Figs. 19 - 27. **Pseudopalaemon chryseus**, larva II: 19, dorsal view; 20, lateral view of the anterior part of the carapace; 21, antennule; 22, left mandible; 23, maxilliped 1; 24, pereiopod 1; 25, pereiopod 2; 26a-e, pleopods 1 to 5; 27, telson.



Figs. 28 - 37. **Pseudopalaemon chryseus**, larva III: 28, dorsal view; 29, lateral view of the anterior part of the carapace; 30, antennule; 31, right mandible; 32, maxilliped 1; 33, maxilliped 2; 34, pereiopod 1; 35, pereiopod 2; 36a-e, pleopods 1 to 5; 37, left uropod and telson.



Figs. 38 - 47. **Pseudopalaemon chryseus**, juvenile I: 38, dorsal view; 39, lateral view of the anterior part of the carapace; 40, antennule; 41, left mandible; 42, right mandible; 43, maxillule; 44, maxilla; 45, maxilliped 1; 46, 46, maxilliped 2; 47, maxilliped 3.



Figs. 48 - 51. **Pseudopalaemon chryseus**, juvenile I: 48, pereiopod 1; 49, pereiopod 2; 50, pereiopod 5; 51, left uropod and telson.

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