

Larval Development of the Caridean Shrimp *Exopalaemon styliferus* (H. Milne Edwards, 1840) (Decapoda, Caridea, Palaemonidae) from the South of Iraq Reared in the Laboratory

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Abstract: The complete series of larval development of the caridean shrimp *Exopalaemon styliferus* (H. Milne Edwards, 1840) was determined from the laboratory hatching of ovigerous females. There were 6 zoeal stages followed by a megalopa. The distinctive features of zoea I are as follows: total length 2.72 mm, rostrum shorter than peduncle of antennules, scaphognathite of maxilla with 5 setose marginal setae and there are 3 rudiments of pereopods. These stages were described in detail. A comparison was made with larvae of closely related species.

Key Words: *Exopalaemon styliferus*, Decapoda, Caridea, larval development

Introduction

The first record of the Palaemonid shrimp, *Exopalaemon styliferus*, from the Arabian Gulf and the Iraqi inland waters was in mid 1983 (Salman and Bishop, 1990). The occurrence of the species in these areas represents a significant range of extension of approximately 2000 km from the nearest recorded location at the Indus River delta (Ahmed, 1985). *E. styliferus* occurred here in salinity from less than 1‰ to 36-44‰ (Salman and Bishop, 1990). *E. styliferus* inhabits shallow marine and brackish waters from the north coast of Borneo and Indonesia westward through Thailand and India to Pakistan (Fischer and Bianchi, 1984). Although the species cited ranges widely in coastal waters, it appears to occur in abundance only in or near estuaries of major rivers.

To the author's knowledge, larval stages of *E. styliferus* have not previously been described. Therefore, the present article presents a description of 6 zoeal stages and a megalopa (Williamson, 1969), which were obtained from ovigerous females.

Materials and Methods

Ovigerous females (4 individuals) of *E. styliferus* were collected from Shatt Al-Arab, at Al-Fao town, south of Basrah, Iraq, during September 2000. The females were brought to the laboratory and kept in a 50-l glass tank and fed with boiled fish meat. Hatching occurred 5 days after collection, and the newly hatched larvae were transferred into small plastic containers of about 100 ml. The larvae were reared singly and fed with newly hatched *Artemia* nauplii every day. The water was replaced every other day. Water temperature during the experiment ranged from 24 to 28 °C. The containers were checked every day for exuviae. After each moult some of the larvae and their exuviae were preserved in 4% formaldehyde.

Results

Six zoeal stages and a megalopa were obtained in the laboratory.

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Descriptions

The first stage is described in detail and only the changes in the preceding stages are noted. Total length (mm) of 10 larvae of each stage was measured from the tip of the rostrum to the end of the telson.

Zoea I (Figure 1)

Duration. 1-2 days.

Size. Total length 2.72 mm (range 2.5-3.0 mm).

Carapace (Figure 1a, b), without spines; rostrum short, straight, directed slightly downward. Eyes sessile.

Abdomen (Figure 1 a, b), with 5 somites, somite 5 without posterolateral spines.

Antennule (Figure 1c). Peduncle of a single segment, with a long setose seta; flagellar segment with 2 long aesthetascs and 2 short setae.

Antenna (Figure 1d). Exopod broad, with 4 short distal segments plus long proximal one and with 10 plumose setae. Endopod shorter than exopod, with long plumose apical seta.

Mandible (Figure 1e). Incisor process with 2 teeth, molar process well developed, a gap between molar and incisor processes with 2 spines.

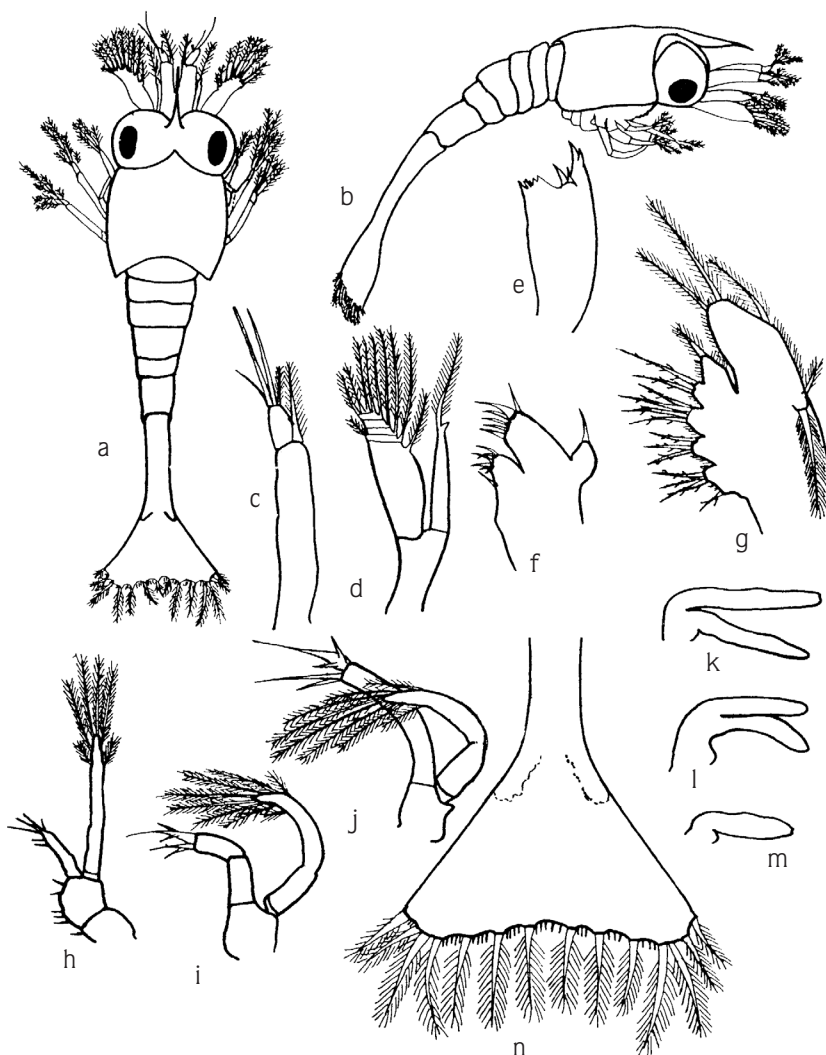


Figure 1. *Exopalaemon styliferus*, zoea I (TL = 2.60 mm): a, dorsal view; b, ventral view; c, antennule; d, antenna ; e, mandible; f, maxillule; g, maxilla; h-j, maxillipeds 1-3; k-m, pereopods 1-3; n, telson.

Maxillule (Figure 1f). Coxal and basal endites each with 6 processes (spines and setae). Endopod unsegmented, with 1 terminal seta.

Maxilla (Figure 1g). Coxal endite with 3+1 setae, proximal and distal lobes of basal endite with 3 and 4 setae, respectively. Endopod with 2+1 setae. Scaphognathite with 5 plumose setae.

Maxilliped 1 (Figure 1h), protopod with 1 + 5 setae, endopod unsegmented, exopod with 4 long natatory setae plus 2 small ones.

Maxillipeds 2 and 3 (Figure 1i, j). Endopods 3-segmented, exopods with 6 long + 2 short natatory setae.

Peraeopods 1 and 2 (Figure 1k, l), biramous rudiments.

Peraeopod 3 (Figure 1m), uniramous rudiment.

Telson (Figure 1n) very broad distally, posterior margin with 7 + 7 plumose spines, with minute spinules between 4 innermost pairs of spines.

Zoea II (Figure 2)

Duration, 2-3 days. Total length 3.0 mm. (2.9-3.2 mm).

Carapace (Figure 2a, b), a pair of supraorbital spine, one on each side of carapace. Eyes stalked.

Abdomen (Figure 2a, b), somite 5 with posterolateral margins produced into a pair of spines.

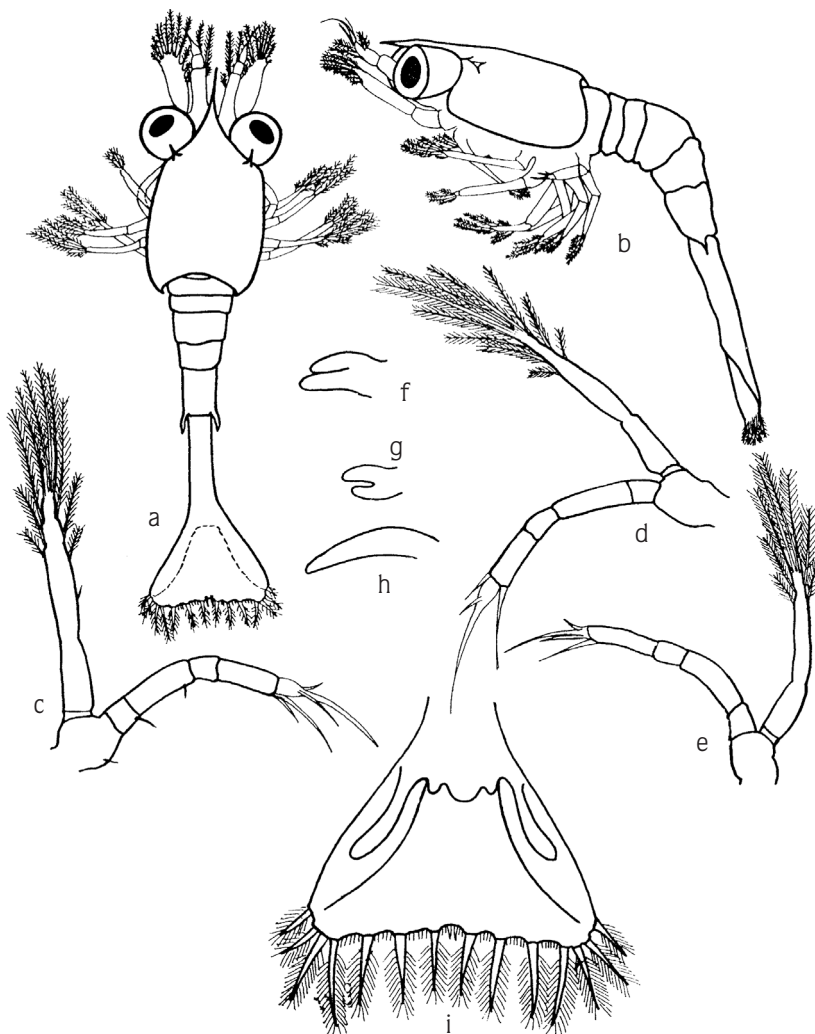


Figure 2. *Exopalaemon styliferus*, zoea II (T.L. = 3.00 mm). a & b, general aspects. c, maxilliped 3. d & e, peraeopods 1 & 2. f-h, peraeopods 3-5, respectively. i, telson.

Antennule, peduncle 2-segmented.
 Antenna, exopod with 14 plumose setae.
 Maxilla, scaphognathite with 7 plumose setae.
 Maxilliped 3 (Figure 2c), endopod 5-segmented.
 Peraeopods 1 and 2 (Figure 2d, e), exopods 2-segmented, endopods 5-segmented.
 Peraeopods 3 and 4 (Figure 2f, g), biramous rudiments.
 Peraeopod 5 (Figure 2h), uniramous rudiment.
 Telson (Figure 2i), slightly narrow distally. Uropods, rudimentary.
 Zoea III (Figure 3)
 Duration, 2-3 days. Total length, 3.2 mm (3.1-3.3 mm).
 Carapace (Figure 3a, b), with one dorsomedian spine, rostrum with minute ventrodistal retrose spines.
 Abdomen (Figure 3a, b), with 6 somites.

Antennule, first segment of peduncle with a median spine.
 Antenna, endopod 3-segmented, exopod with 18 plumose setae.
 Peraeopods 3 and 4 (Figure 3c, d), still biramous rudiments.
 Peraeopod 5 (Figure 3e), uniramous, 5-segmented.
 Uropods free, exopod of uropod with 13 plumose setae, endopod rudimentary, devoid of setae. Telson (Figure 3f), posterior margin concave with 6 + 6 plumose spines.
 Zoea IV (Figure 4)
 Duration, 2-3 days. Total length, 3.7 mm (3.2-4.2 mm).
 Carapace (Figure 4a, b), with 2 dorsomedian spines.
 Antennule (Figure 4c), peduncle 3-segmented, stylocerite developed on basal segment, distal segment bearing first segment of internal and of external flagella.

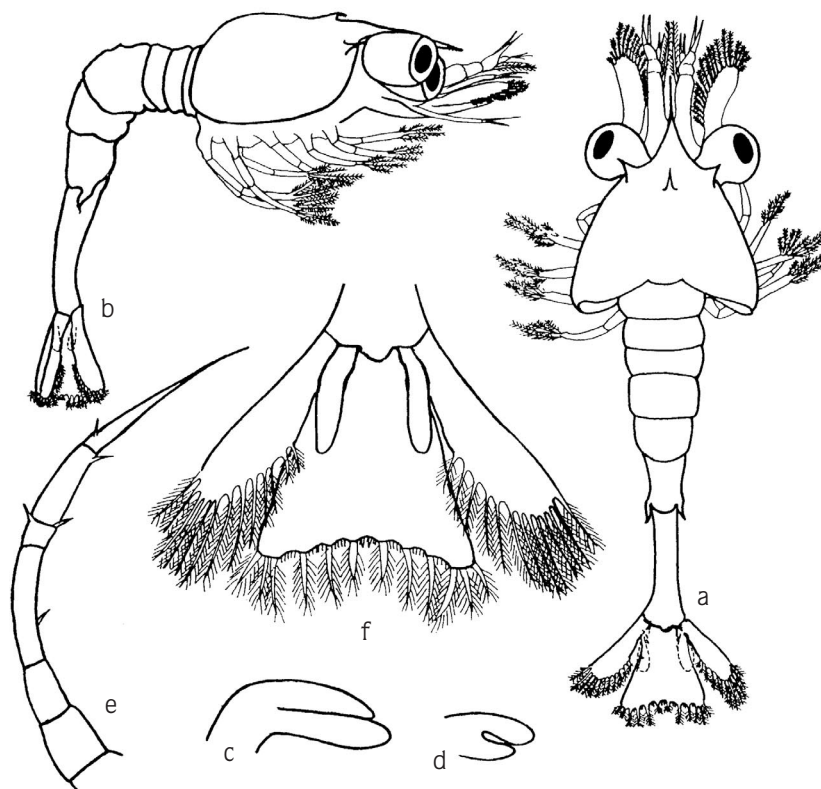


Figure 3. *Exopalaemon styliferus*, zoea III (T.L.= 3.15 mm). a & b, general aspects. c & d, peraeopods 3 & 4. e, peraeopod 5. f, telson and uropods.

Antenna (Figure 4d), endopod slightly shorter than exopod, latter with about 20 plumose setae.

Maxilla (Figure 4e), scaphognathite with 11 plumose setae.

Maxilliped 1, endopod 2-segmented.

Peraeopod 3 (Figure 4f), biramous, endopod 5-segmented.

Peraeopod 4 (Figure 4g), biramous rudiments.

Peraeopod 5 (Figure 4h), uniramous, 7-segmented.

Pleopods (Figure 4b) minute buds.

Uropods (Figure 4i), exopod and endopod of uropods with 17 and 11 plumose setae, respectively.

Telson (Figure 4i), posterior width slightly more than 2 times anterior width. Posterior margin of telson more concave and with 4 + 4 plumose spines.

Zoea V (Figure 5)

Duration 3-5 days. Total length, 4.5 mm (4.1-4.9 mm).

Antennule, external flagellum with 4 distal and 1 subterminal aesthetascs.

Antenna, exopod with 24 plumose setae, endopod 6-segmented, as long as exopod.

Maxilla, scaphognathite with 20 plumose setae.

Peraeopods 1 and 2 (Figure 5c, d), endopod with internal distal margin of propodus produced forward to over $\frac{1}{2}$ length of dactyl indicating start of formation of chela.

Peraeopod 3 (Figure 5e), endopod ultimate segment with claw.

Peraeopod 4 (Figure 5f), exopod nearly as long as $\frac{1}{2}$ length of endopod (excluding setae), latter 4-segmented.

Pleopods 1-5 (Figure 5g-k), biramous rudiments.

Telson (Figure 5l), posterior width slightly more than anterior width, posterior margin of telson with 4 + 4 plumose spines. Exopod and endopod of uropods with 21 and 17 marginal plumose setae, respectively.

Zoea VI (Figure 6)

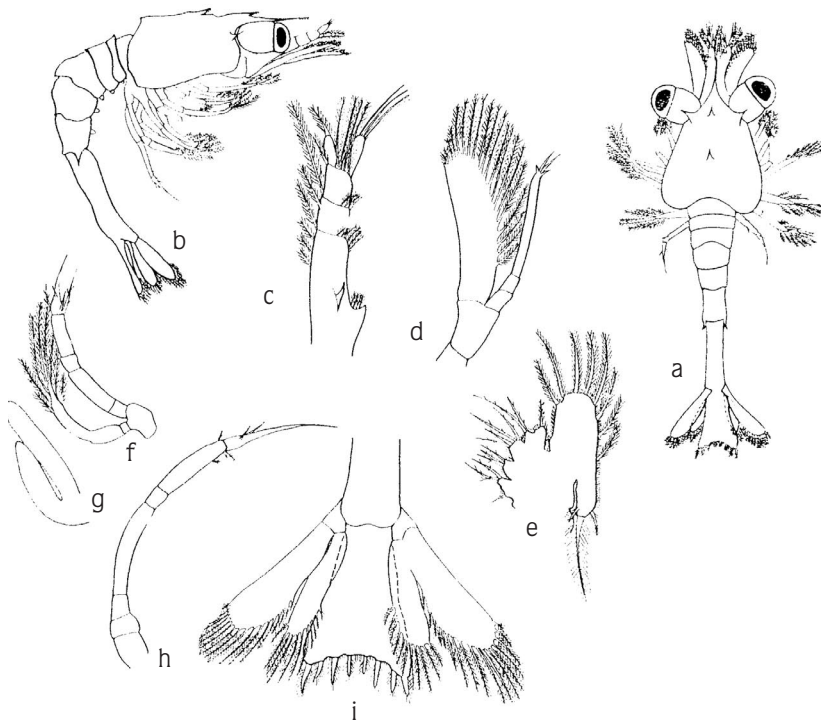


Figure 4. *Exopalaemon styliferus*, zoea IV (T.L.= 3.85 mm). a & b, general aspects. c & d, antennule & antenna. e, maxilla. f-h, peraeopods 3-5, respectively. i, telson and uropods.

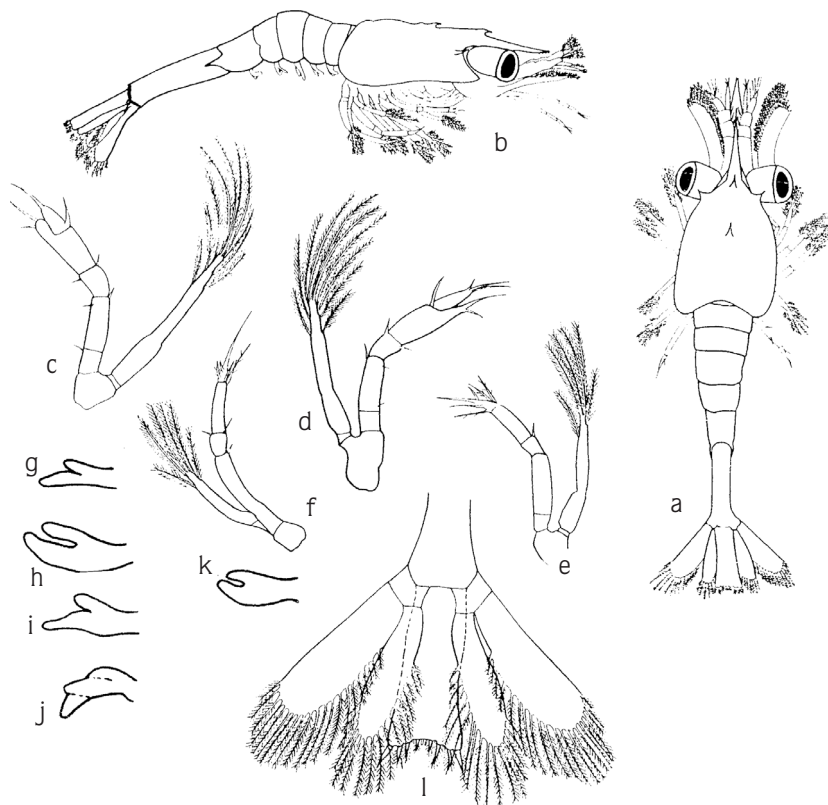


Figure 5. *Exopalaemon styliferus* zoea V (T.L. = 4.50 mm). a & b, general aspects. c-e, pereopods 1-3, respectively. f, pereopod 4. g-k, pleopods 1-5, respectively. l, telson and uropods.

Duration, 3-5 days. Total length, 5.6 mm (5.4-5.9 mm).

Carapace (Figure 6a, b), suborbital and pterygostomian spines well developed.

Antennule (Figure 6c), stylocerite well developed.

Antenna (Figure 6d), exopod with about 28 plumose setae, endopod longer than exopod, many-segmented.

Maxilla (Figure 6e), scaphognathite with 28 plumose marginal setae.

Pereopods 1 and 2, endopod with immovable finger of propodus produced forward to almost length of dactyl excluding terminal setae.

Pereopod 5, still uniramous.

Pleopods (Figure 6f-j), functionless, endopod with appendix interna.

Telson (Figure 6k), posterior width nearly $\frac{1}{2}$ anterior width. Posterior margin straight with 1 long outermost

and 3 short spines on each side. Exopod and endopod of uropod with 27 and 23 plumose marginal setae, respectively,

Megalopa (Figure 7)

Duration, 3-5 days. Total length, 6.00 mm (5.8-6.3 mm).

Carapace (Figure 7a), rostrum with 5 dorsal teeth, supraorbital spines missing.

Abdomen (Figure 7a), somite 5 with rounded lateral margins.

Antennule (Figure 7b), peduncle 3-segmented, outer and inner flagellum 6-segmented each, latter with 3 short aesthetascs.

Antenna (Figure 7c), flagellum (endopod) about 3 times length of exopod.

Mandible (Figure 7d), incisor with 3 strong teeth, molar well developed, movable spines absent.

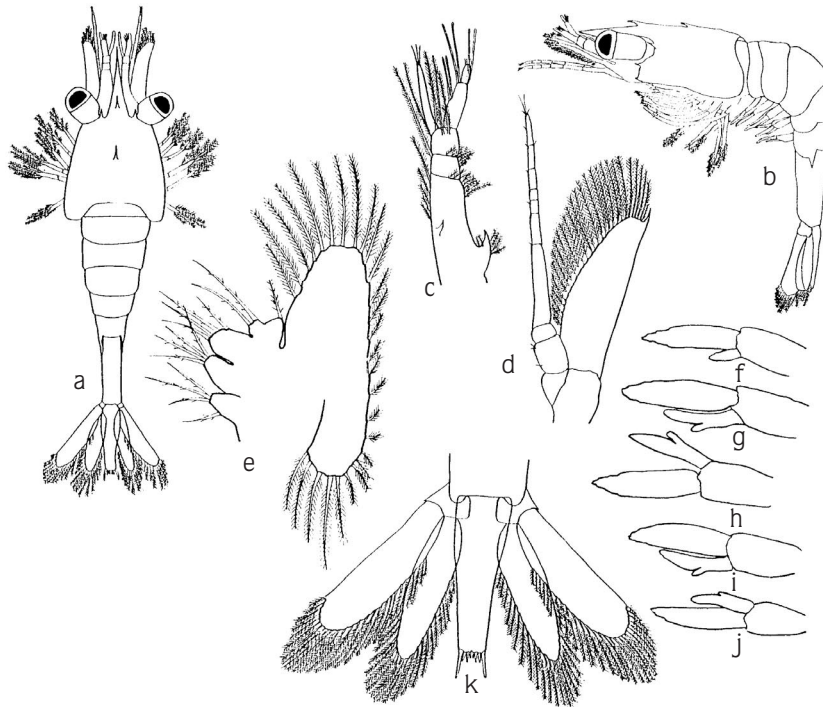


Figure 6. *Exopalaemon styliiferus* zoea VI (T.L. = 5.70 mm). a & b, general aspects. c & d, antennule & antenna, respectively. e, maxilla. f-j, pleopods 1-5, respectively. k, telson and uropods.

Maxillule (Figure 7e), endopod rudimentary.

Maxilla (Figure 7f), endopod rudimentary, scaphognathite with 32 plumose setae.

Maxilliped 1 (Figure 7g), endopod rudimentary, exopod with 5 plumose setae.

Maxilliped 2 (Figure 7h), endopod with propodus and dactyl flattened, exopod with 4 plumose setae.

Maxilliped 3 (Figure 7i), exopod with 5 plumose setae.

Peraeopods 1 and 2 (Figure 7j, k), endopod chelate, merus and carpus long, exopod rudimentary.

Peraeopods 3-5 (Figure 7l-n), ischium and carpus short, merus, propodus, dactyl long, latter sickle-shaped. Exopod of peraeopods 3 and 4 rudimentary, peraeopod 5 uniramous.

Pleopods (Figure 7o-q) functional.

Telson (Figure 7r), with a distinct posterior margin tapering to a sharp point and bearing a pair of small outermost and a pair of long plumose setae and minute ones. Two pairs of small lateral spines on each side of

telson. Exopod and endopod of uropod with 29 and 27 marginal plumose setae, respectively.

Discussion

The present study indicates that the number of zoeal stages of *E. styliiferus* was occasionally variable. Although 6 zoeal stages were usual, 5 and 7 zoeal stages were also observed and formed 10% and 4% of the cases, respectively. Reduction in the numbers of zoeal stages always occurred at the moult between the third and fourth stages, whereas the addition of the stage occurred at the moult between the fourth and fifth stages. The additional stage possesses features that are always intermediate between the original 2 stages. These characters are the total length, the shape of the telson and the number of spines on its posterior margin, the state of development of the first peraeopods and the pleopods. Variations in the number of zoeal stages are common among decapod crustaceans, particularly in shrimps with prolonged development (Knowlton, 1974; Fincham and Figueras, 1986), and numerous accounts of variation in instar numbers, both in laboratory and

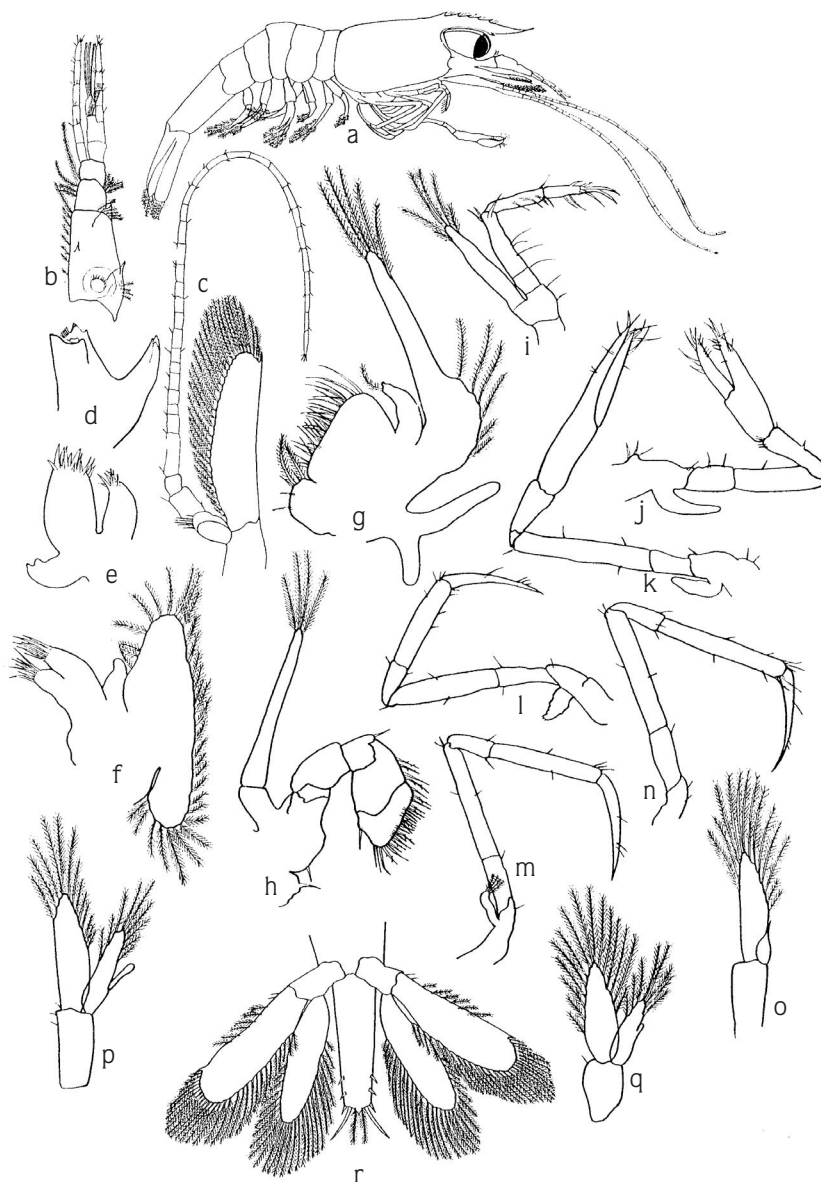


Figure 7. *Exopalaemon styliferus* megalopa. (T.L.= 6.00 mm.). a, general aspects. b&c, antennule & antenna. d, mandible. e & f, maxillae 1 & 2. g-i, maxillipeds 1-3, respectively. j-n, peraeopods 1-5, respectively. o-q, pleopods 1, 2 & 5, respectively. r, telson and uropods.

planktonic populations, attest to relative independence of moulting and morphogenesis. Moreover, these 2 processes are affected in different ways by diet (Broad, 1957), food quality, and temperature, as demonstrated experimentally in *Palaemonetes vulgaris* (Knowlton, 1974).

The present result indicates the loss of the proximal lobe of coxal endite of the maxilla, a feature apparently

usual in the family Palaemonidae (Benzie, 1982). In the family Atyidae, however, the loss of the distal lobe of the same appendage is usual.

It is evident that *P. semmelinkii* passes through 12 zoeal stages (Jagadisha and Sankolli, 1977); hence, it is more primitive than the rest of the species listed in the Table. Both *P. elegans* and *P. serratus* pass through 9 zoeal stages, *P. longirostris* passes through 7 zoeal

Table. Comparison of zoea I of *Exopalaemon styliferus* with those of palaemonid shrimps from various sources.

Species	Total length (range), mm	Rostrum length	Scaphognathite of maxilla, setal number	Rudimental peraeopods, pairs	Number of zoeal stages	Posterolateral abdominal spines	Reference
<i>Palaemon (Palaemon) elegans</i>	3.1 (2.8-3.2)	Slightly longer than antennule peduncle	5	2	9	+	Fincham (1977)
<i>Palaemonetes (Palaemonetes) varians</i>	3.8 (3.5-4.1)	As long as antennule peduncle	6	5	5	-	Fincham (1979a)
<i>Palaemon (Palaemon) longirostris</i>	3.5 (3.3-3.8)	Longer than antennule peduncle	5	5	7	-	Fincham (1979b)
<i>Palaemon (Palaemon) serratus</i>	3.3 (3.2-3.5)	Equal or longer than antennule peduncle	5	2	9	-	Fincham (1983)
<i>Palaemon (Palaemon) adspersus</i>	2.6 (2.5-2.7)	Shorter than antennule peduncle	5	2	6	-	Fincham (1985)
<i>Palaemon pacificus</i>	2.1 (2.10-2.28)	Longer than antennule peduncle	5	2	6	-	Han and Hong (1978)
<i>Palaemon (Palaemon) semmelinkii</i>	2.35	Longer than antennule peduncle	5	2	12	-	Jagadisha and Sankolli (1977)
<i>Exopalaemon styliferus</i>	2.72 (2.5-3.0)	Shorter than antennule peduncle	5	3	6	-	Present study

stages, and *P. adspersus*, *P. pacificus*, and *E. styliferus* pass through 6 zoeal stages, whereas *Palaemonetes varians* passes through 5 zoeal stages; therefore, it may be considered the most advanced species.

Based on the characters of zoea I, these species can be distinguished from each other as follows: *P. elegans* can readily be discriminated by possessing posterolateral spines on abdominal somite 5. *P. adspersus* and *E. styliferus* each have the rostrum shorter than the peduncle of the antennule. However, the larvae of the former species possess 2 pairs of rudimentary peraeopods, whereas the latter have 3 pairs. *Palaemonetes varians* larvae, although being the largest (3.8 mm; Fincham, 1979a), have 6 plumose setae on the

scaphognathite of the maxilla. *P. longirostris* larvae may be easily recognized by having 5 pairs of rudimentary peraeopods.

Larvae of *P. serratus* are larger than those of *P. pacificus* and *P. semmelinkii* and the rostrum is equal or slightly longer than the peduncle of the antennule. Larvae of *P. pacificus* are very similar to those of *P. semmelinkii*; however, the former are smaller than the latter.

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References

- Ahmed, M. 1985. Winter and spring abundances of juvenile penaeid and caridean shrimps in the Indus Delta (Pakistan: Northern Arabian Sea). *Pakistan J. Zool.* 17: 67-70.
- Benzie, J.A.H. 1982. The complete larval development of *Caridina mecullochi* Roux, 1926 (Decapoda Atyidae) reared in the laboratory. *J. Crust. Biol.* 2: 493-513.
- Broad, A.C. 1957. The relationship between diet and larval development of *Palaemonetes*. *Biol. Bull. (Woods Hole)*. 112: 162-170.
- Fincham, A.A. 1977. Larval development of British prawns and shrimps (Crustacea: Decapoda: Natantia). 1. Laboratory methods and a review of *Palaemon (Palaeander) elegans* Rathke 1837. *Bull. Br. Mus. Nat. Hist.* 32: 1-28.
- Fincham, A.A. 1979a. Larval development of British prawns and shrimps (Crustacea: Decapoda: Natantia) 2. *Palaemonetes (Palaemonetes) varians* (Leach, 1814) and morphological variation. *Bull. Br. Mus. Nat. Hist. (Zool.)*. 35: 127-200.
- Fincham, A.A. 1979b. Larval development of British prawns and shrimps (Crustacea: Decapoda: Natantia) 3. *Palaemon (Palaemon) longirostris* H. Milne Edwards, 1837 and the effect of antibiotic on morphogenesis. *Bull. Br. Mus. Nat. Hist. (Zool.)*. 37: 17-46.
- Fincham, A.A. 1983. Larval development of British prawns and shrimps (Crustacea: Decapoda: Natantia). 4. *Palaemon (Palaemon) serratus* (Pennant, 1777) and functional morphology of swimming. *Bull. Br. Mus. Nat. Hist. (Zool.)*. 44: 125-161.
- Fincham, A.A. 1985. Larval development of British prawns and shrimps (Crustacea: Decapoda: Natantia) 5. *Palaemon (Palaemon) adpersus* Rathke, 1837. *Bull. Br. Mus. Nat. Hist. (Zool.)*. 48: 215-231.
- Fincham, A.A. and Figueras, A.J. 1986. Larval keys and diagnoses for the subfamily Palaemoninae (Crustacea: Decapoda: Palaemonidae) in the north-east Atlantic and aspects of functional morphology. *J. Nat. Hist.* 20: 203-224.
- Fischer, W. and Bianchi, G. 1984. FAO species identification sheets for fishery purposes. Western Indian Ocean (fishing Area 51). In.: L.B. Holthuis. *Shrimps and Prawns*. FAO Rome, 5: 79-84.
- Han, C.H. and Hong, S.Y. 1978. The larval development of *Palaemon pacificus* Stimpson (Decapoda, Palaemonidae) under the laboratory conditions. *Publ. Inst. Mar. Sci. Nat. Fish. Univ. Busan*. 11: 1-17.
- Jagadisha, K. and Sankolli, K.N. 1977. Laboratory culture of the prawn *Palaemon (Palaeander) semmelinkii* (De Man) (Crustacea, Decapoda, Palaemonidae). In.: *Proc. Symp. Warm Water Zoopl.*, NIO, Goa, pp. 619-633.
- Knowlton, R.E. 1974. Larval development processes and controlling factors in decapod Crustacea, with emphasis on Caridae. *Thal. Jugos.* 10: 139-158.
- Salman, S.D. and Bishop, J.M. 1990. *Exopalaemon styliferus* (H. Milne Edwards, 1840) in the Northern Arabian Gulf and the inland waters of Iraq. (Decapoda, Caridea, Palaemonidae). *Crustaceana*. 95: 281-288.
- Williamson, D.I. 1969. Names of larvae in the Decapoda and Euphausiacea Crustaceana. 16: 210-213.