Article

Taxonomical study of laboratory reared first to eight zoeal stages of *Lysmata vittata* (Stimpson, 1860) (Crustacea: Decapoda: Hippolytidae)

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Abstract

The larvae of Hippolytidae show such diversity that it is impossible to frame any definition which will distinguish them as a whole from other Caridea (Gurney, 1942). The present information is based on the morpho-taxonomic study of the zoeal stages of *Lysmata vittata* (Stimpson, 1860). The ovigerous females of *L. vittata* was collected from Buleji. Larvae were hatched at room temperature 23-25°C, in filtered seawater of a salinity of 40-37 ppt and pH 7.8. Eight zoeal stages of *L. vittata* are described along with their illustrations, and compared with the available descriptions of its congener's larvae given earlier.

Keywords Decapoda; Hippolytidae; taxonomic study; Lysmata vittata, Pakistan.

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1 Introduction

The family Hippolytidae Dana, 1852 is distributed worldwide (Bauer, 2004) and consists of 318 species divided in 36 genera (De Grave et al., 2009). The larval morphology of the family Hippolytidae or some hippolytid genera have been reviewed by several authors (Lebour, 1931; Gurney, 1937; Gurney, 1942; Haynes, 1985).

The larvae of the family Hippolytidae exhibit an immense diversity in larval forms, which makes it impossible to define any larval characters typical for the entire family (Gurney, 1942; Yang et al., 2001). There are some characters that are always present in a specific genus for example *Lysmata* has a scale which is segmented distally, no exopod seta on the basis of the maxillule and 5 setae on the scaphognathite (Terossi et al., 2010).

The larvae can be identified with the help of following characters: Supraorbital spines when present without spinules; pereiopod V develops before pereiopods III and IV, terminal spine of dactylus extremely long (extends at least beyond eyes and provided with spinules distally); protopod of maxilla with 3 endites only, exopod shorter than endopod in early larvae. Endopod of maxillule small and unsegmented. Endopod of

maxilliped I with two or three incomplete segments (as indicated by setation), never with indication of four segments. Maxillipeds II - III and pereiopods raptorial in form, with spiniform serrate and simple setae, dactylus produced into a strong spine.

2 Materials and Methods

2.1 Study area

An ovigerous female of *Lysmata vittata* (Stimpson, 1860) was collected from Buleji near Karachi (Long. 66°49'E, Lat. 24°59'N). Buleji is a rocky ledge at a distance of 30 km from Karachi.

2.2 Methodology

Meteorological parameters, air and water temperature (°C), salinity (0%), dissolved oxygen (ml/1), pH and tide (m) were noted. The ovigerous female was kept in unfiltered seawater of a salinity of 40-35 ppt under the laboratory conditions at room temperature: 23° C - 25° C until hatching occurred.

The newly hatched larvae were segregated and divided among five beakers (ten in each beaker, 500 ml) filled with filtered seawater of the same salinity and temperature. Each beaker was examined daily for mortality and next developmental stage. The exuviae were preserved and the live larvae were transferred to clean beakers filled with freshly filtered seawater, and at the same time offered newly hatched *Artemia* nauplii as food.

2.3 Fixation and preservation of material

Temporary slides of each stage were made using glycerin and 5% formalin (3 : 1). Measurements of each stage were made with the aid of a micrometer. The total length (TL) was determined by adding the carapace length (CL) (measured from the tip of the rostral spine to the midposterior margin of the telson). Measurements are in millimeter (mm) (Table 1).

2.4 Microscopic observations

The specimens were dissected through tungsten needle by using a Nikon binocular microscope ($4 \times 10/21$ magnification). Olympus BH2 microscope (1.25×10 , 20 and 40 magnifications) with Nomarski Differential Interference Contrast (D/C) and camera lucida attachment.

The spent female and the remaining larvae were deposited in the Marine Reference Collection and Resource Centre, University of Karachi.



Fig. 1 Lysmata vittata (Stimpson, 1860).

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3 Synopsis. -Not *Hippolysmata vittata* Pillai (1966):152 – 158(egg – zoea III); *Hippolysmata vittata* Kurien (1951): 416-417 (first stage); Romimohtarto & Srijuwana (1992): 32-42 (Protozoea II).

Stage	Days elapsed after hatching	Total length
		$TL \pm SD (mm)$
Zoea I	6	1.72 ± 1.73
Zoea II	1	1.73 ± 1.76
Zoea III	4	1.77 ±1.79
Zoea IV	3	1.87 ±1.88
Zoea V	1	2.10 ± 2.14
Zoea VI	1	2.43 ± 2.45
Zoea VII	5	2.46 ± 2.47
Zoea VIII	1	2.47 ± 2.49

3.1 Table 1 Time of the first appearance and measurements of each larval stage of Lysmata vittata (Stimpson, 1860).

4 Results

The following are the description of the larvae.

4.1 Zoea I (Fig. 2A – J)

Size.- TL= 1.72mm – 1.73mm

Duration.- 6 days.

Diagnostic Features.-

Carapace (Fig. 2 A).- Rostrum long, distally pointed; eyes sessile.

Antennule (Fig. 2B).- Peduncle 2-segmented, distal segment with 1 long plumose seta (endopod); outer ramus (exopod) with 4 aesthetascs and 1 seta.

Antenna (Fig. 2C).-Biramous; endopod with 1 long plumose seta; exopod (scaphocerite) with 10 setae.

Mandible (Fig. 2D).- Well developed.

Maxillule (Fig. 2E).-Coxal endite with 3 plumodenticulate setae; basial endite with 3 cuspidate and 2 setae; endopod with 3 terminal and 2 subterminal plumodenticulate setae.

Maxilla (Fig. 2F).-Coxal and basial endites bilobed with 5 + 4 and 2 + 4 plumodenticulte setae, respectively; endopod with 6 plumodenticulate setae; exopod with 5 setae.

Maxilliped I (Fig. 2G).-Coxal endite with 6 plumodenticulate setae; basial endite with 7 plumodenticulate setae; endopod 4-segmented with 3,1,2 and 6 plumodenticulate setae, respectively; exopod with 3 terminal and 1 subterminal plumose natatory setae.

Maxilliped II (Fig. 2H).-Coxopod broken; basipod with 1plumodenticulate seta; endopod 3-segmented, with 8,1 and 5 plumodenticulate setae, respectively; exopod with 2 terminal and 6 subterminal long plumose natatory setae.

Maxilliped III (Fig. 2I).-Coxopod naked; basipod with 4 plumodenticulate setae; endopod 4-segmented with 0,2,4 and 3 plumodenticulate setae, respectively; exopod with 2 terminal and 6 subterminal long plumose natatory setae.

Abdomen (Fig. 2A).- 5-somites.

Telson (Fig. 2J).- Triangular; posterior margin with 7 long plumose setae.



Fig. 2 *Lysmata vittata* (Stimpson, 1860). Zoea I: A, entire, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G - I, maxillipeds I - III; J, telson.

4.2 Zoea II (Fig. 2A - J)

Size.- TL= 1.73mm - 1.76mm

Duration.- 1 day.

Diagnostic Features.-

Carapace (Fig. 2A).-Smooth, rostrum long distally pointed; eyes stalked.

Antennule (Fig. 2B).- Peduncle 2-segmented; outer ramous with 3 aesthetscs and 2 setae.

Antenna (Fig. 2C).-Biramous; endopod with 1 long plumose seta; exopod (scaphocerite) number of setae increase.

Mandible (Fig. 2D).- Incisor and molar processes well developed.

Maxillule (Fig. 2E).- Coxal endite with 4 plumodenticulate setae; basial endite with 2 cuspidate and 2 plumodenticulate setae; endopod with 3 terminal and 2 subterminal plumodenticulate setae.

Maxilla (Fig. 2F).-Coxal and basial endites bilobed with 5 + 4 and 3 + 2 plumodenticulate setae, respectively; endopod with 7 plumodenticulate setae; scaphognathite with 5 setae.

Maxilliped I (Fig. 2G).-Coxopod naked; basipod with 5 plumodenticulate setae; endopod 4-segmented with 3,2,1 and 2 plumodenticulate setae, respectively; exopod with 3 terminal and 1 subterminal plumose setae.

Maxilliped II (Fig. 2H).-Coxopod broken; basipod naked; endopod 5-segmented with 0,2,1,0 and 6 plumodenticulate setae, respectively; exopod with 2 terminal and 6 subterminal plumose setae.

Maxilliped III (Fig. 2I).-Coxopod broken; basipod naked; endopod 4-segmented with 2,1,2 and 2 plumodenticulate setae, respectively; exopod with 3 terminal and 8 subterminal long plumose natatory setae. Abdomen (Fig. 2A).-5-somites.

Telson (Fig. 2J).-Triangular; posterior margin with 7 setae.



Fig. 2 *Lysmata vittata* (Stimpson, 1860). Zoea II: A,entire, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G - I, maxillipedsI - III; J, telson.

4.3 Zoea III (Fig. 3A – J)

Size.- TL= 1.77mm – 1.79mm

Duration.- 4 days.

Diagnostic Features.-

Carapace (Fig. 3A).- Rostrum increase in size; eyes stalked.

Antennule (Fig. 3B).-Peduncle 2-segmented; outer ramous with 3 aesthetscs and 2 setae.

Antenna (Fig. 3C).-Biramous; endopod with 1 long plumose seta; exopod (scaphocerite) number of setae increase.

Mandible (Fig. 3D).-Incisor and molar processes well developed.

Maxillule (Fig. 3E).-Coxal endite with 5 plumodenticulate setae; basial endite with 2 cuspidate and 3 plumodenticulate setae; endopod with 3 terminal and 2 subterminal plumodenticulate setae.

Maxilla (Fig. 3F).-Coxal and basial endites bilobed with 6 + 4 and 4 + 3 plumodenticulate setae, respectively; endopod with 8 plumodenticulate setae; scaphognathite with 5 setae.

Maxilliped I (Fig. 3G).-Coxopod broken; basipod with 8 plumodenticulate setae; endopod 4-segmented with 2,1,1 and 3 plumodenticulate setae, respectively; exopod with 3 long plumose natatory setae.

Maxilliped II (Fig. 3H).-Coxopod broken; basipod with 3 plumodenticulate setae; endopod 4-segmented with 1,2,2 and 6 plumodenticulate setae, respectively; exopod with 3 terminal and 6 subterminal long plumose natatory setae.

Maxilliped III (Fig. 3I).-Coxopod and basipod naked; endopod 3-segmented with 3,2 and 3 plumodenticulatesetae, respectively; exopod with 3 terminal and 8 subterminal long plumose natatory setae.

Pereiopods I-V (Fig. 3J).- Rudimentary.

Abdomen (Fig. 3A).-5-somites.

Telson (Fig. 3A).- Triangular; posterior margin with 7 long plumose setae.

4.4 Zoea IV (Figs. 4A – 5E)

Size.- TL= 1.87mm - 1.88mm

Duration.- 3 days.

Diagnostic Features.-

Carapace (Fig. 4A).-With few minute setae; eyes stalked.

Antennule (Fig. 4B).-Biramous; peduncle 2-segmented, with 2 and 5 plumodenticulate setae, respectively; inner ramus (endopod) with 1 long plumose seta; outer ramus (exopod) with 2 aesthetascs and 1 seta.

Antenna (Fig. 4C).-Biramous; peduncle with a distal spine on inner margin; endopod absent; scaphocerite number of setae increase.

Mandible (Fig. 4D).- More developed.

Maxillule (Fig. 4E).-Coxal endite with 5 plumodenticulate setae; basial endite with 4 cuspidate setae; endopod with 3 terminal and 1 subterminal setae.

Maxilla (Fig. 4F).-Coxal and basial endites bilobed with 6 + 4 and 3 + 3 plumodenticulate setae, respectively; endopod with 7 plumodenticulate setae; scaphognathite with 6 setae.

Maxilliped I (Fig. 4G).-Coxopod with 7 plumodenticulate setae; basipod with 9 plumodenticulate setae; endopod 4-segmented with 2,2,1 and 2 plumodenticulate setae, respectively; exopod with 3 terminal and 1 subterminal plumose natatory setae.

Maxilliped II (Fig. 5A).-Coxopod broken; basipod with 1 plumodenticulate seta; endopod 3-segmented with 6,2 and 5 plumodenticulate setae, respectively; exopod 4-segmented with 2,2,2 and 4 long plumose natatory setae, respectively.

Maxilliped III (Fig. 5B).-Coxopod broken; basipod naked; endopod 4-segmented with 5,0,5 and 3

plumodenticulate setae, respectively; exopod 5-segmented with 2,2,2,2 and 4 plumose natatory setae, respectively.

Pereiopods I-V (Figs. 5C, D).-Pereiopod I (Fig. 5C) biramous; coxopod broken; basipod naked; endopod 4-segmented, distal segment with 5 plumodenticulate setae; exopod with 6 plumose natatory setae; pereiopod II-V (Fig. 5D) biramous, rudimentary.

Abdomen (Fig. 4A).-5-somites.

Telson (Fig. 5E).- Posterior margin with 7 plumose setae and lateral margin with 1 simple seta; uropod biramous; endopod with 1 seta; exopod with 7 setae.



Fig. 3 *Lysmata vittata* (Stimpson, 1860). Zoea III: A, entire, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla, G - I, maxillipeds I - III; J, pereiopods I-V.

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Fig. 4 *Lysmata vittata* (Stimpson, 1860). Zoea IV: A, entire, lateral view; B, antennule;C, antenna; D, mandible; E, maxillule; F, maxilla, G, maxilliped I.



Fig. 5 Lysmata vittata (Stimpson, 1860). Zoea IV: A, B, maxillipeds II, III; C, pereiopodsI; D, pereiopods II-V; E, telson with uropods.

4.5 Zoea V (Figs. 6A - 7H)

Size.- TL= 2.10mm - 2.14mm

Duration.- 1 day.

Diagnostic Features.-

Carapace (Figs. 6A,B).- Spines enlarged; eyes stalked.

Antennule (Fig. 6C).-Biramous; peduncle 2-segmented, with 2 and 3 plumodenticulate setae, respectively; inner ramus (endopod) with 1 plumose seta; outer ramus (exopod) with 2 aesthetascs and 1 plumodenticulate seta.

Antenna (Fig. 6D).- Peduncle with a distal spine on inner margin; scaphocerite with 9 setae and 1 pointed distolateral spine.

Mandible (Fig. 6E).-More developed.

Maxillule (Fig. 6F).-Coxal endite with 6 plumodenticulate setae; basial endite with 6 cuspidate and 1 plumodenticulate seta; endopod with 2 terminal and 1 subterminal plumodenticulate setae.

Maxilla (Fig. 6G).-Coxal and basial endites with 5 + 2 and 2 + 4 plumodenticulate setae; endopod with 6 plumodenticulate setae; scaphognathite with 6 setae.

Maxilliped I (Fig. 6H).-Coxopod with 4 plumodenticulate setae; basipod with 9 plumodenticulate setae;

endopod 3-segmented with 1,1 and 3 plumodenticulate setae, respectively; exopod with 4 long plumose natatory setae terminally.

Maxilliped II (Fig. 7A).-Coxopod broken; basipod naked; endopod 3-segmented with 6,1 and 5 plumodenticulate setae, respectively; exopod 4-segmented with 2,2,2 and 4 long plumose natatory setae, respectively.

Maxilliped III (Fig. 7B).-Coxopod broken; basipod with 1 seta; endopod 4-segmented with 1,0,5 and 3 plumodenticulate setae, respectively; exopod 5-segmented with 2,2,2,2 and 3 plumose setae, respectively.

Pereiopods I-V (Figs. 7C-G).-Pereiopod I (Fig. 7C) biramous; endopod 4-segmented with 2,0,3 and 3 plumodenticulate setae, respectively; exopod 3-segmented with 2,2 and 4 plumose natatory setae, respectively; pereiopods II – V (Figs. 7D-G) biramous, rudimentary.

Abdomen (Fig. 6A).-5-somites.

Telson (Fig. 7H).-Posterior margin with 7 plumose setae and lateral margin with 1 simple seta; uropod biramous; endopod with 1 plumose seta; exopod with 8 long plumose setae.



Fig. 6 *Lysmata vittata* (Stimpson, 1860). Zoea V: A, entire, lateral view; B, carapace, dorsal view; C, antennule; D, antenna; E, mandible; F, maxillule; G, maxilla; H, maxilliped I.



Fig. 7 Lysmata vittata (Stimpson, 1860). Zoea V: A, B, maxillipeds II, III; C - G, pereiopods I - V; H, telson with uropods.

4.6 Zoea VI (Figs. 8A - 9H)

Size.- TL= 2.43mm - 2.45mm

Duration.- 1 day.

Diagnostic Features.-

Carapace (Fig. 8A).-Spines enlarged; eyes stalked.

Antennule (Fig. 8B).-Biramous; peduncle 2-segmented, with 3 and 4 plumodenticulate setae, respectively; inner ramus (endopod) with 1 long plumose seta; outer ramus (exopod) with 2 aesthetascs and 2 setae.

Antenna (Fig. 8C).-Peduncle with a distal spine on inner margin; scaphocerite with 10 long plumose setae. Mandible (Fig. 8D).-More developed.

Maxillule (Fig. 8E).-Coxal endite with 6 plumodenticulate setae; basial endite with 3 cuspidate and 3 plumodenticulate setae; endopod with 3 terminal and 2 subterminal plumodenticulate setae.

Maxilla (Fig. 8F).-Coxal endite with 6 plumodenticulate setae; basial endites bilobed with 3, 3

plumodenticulate setae, respectively; endopod with 7 plumodenticulate setae; scaphognathite with 6 setae.

Maxilliped I (Fig. 8G).-Coxopod with 4 plumodenticulate setae; basipod with 11 plumodenticulate setae; endopod 4-segmented with 2,1,1 and 3 plumodenticulate setae, respectively; exopod with 4 terminal and 1 subterminal plumose natatory setae.

Maxilliped II (Fig. 9A).-Coxopod and basipod naked; endopod 3- segmented with 6,2 and 6 plumodenticulate setae, respectively; exopod 4-segmented with 2,2,2 and 4 long plumose natatory setae, respectively.

Maxilliped III (Fig. 9B).-Coxopod broken; basipod with 1 seta; endopod 4-segmented with 4,1,5 and 3 plumodenticulate setae, respectively; exopod 5-segmented with 2,2,2,2 and 3 plumose setae, respectively.

Pereiopods I-V (Figs. 9C-G).-Pereiopod I (Fig. 9C) biramous, endopod 4-segmented with 2,0,3 and 3 plumodenticulate setae, respectively; exopod 3-segmented with 2,2 and 2 plumos natatory setae, respectively; pereiopods II-V (Figs. 9D-G) biramous, partially segmented.

Abdomen (Fig. 8A).- 5-somites.

Telson (Fig. 9H).-Posterior margin with 7 plumose setae and lateral margin with 1 simple seta; uropod biramous; endopod with 2 plumose setae; exopod with 8 long plumose setae.



Fig. 8 *Lysmata vittata* (Stimpson, 1860). Zoea VI: A, entire, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla;G, maxilliped I.



Fig. 9 Lysmata vittata (Stimpson, 1860). Zoea VI: A, B, maxillipeds II, III; C - G, pereiopods I - V; H, telson with uropods.

4.7 Zoea VII (Figs. 10A - 11H)

Size.- TL= 2.46mm - 2.47mm

Duration.- 5 days.

Diagnostic Features.-

Carapace (Fig. 10A).-Spines enlarged; eyes stalked.

Antennule (Fig. 10B).-Biramous; peduncle 2-segmented with 3 and 5 plumodenticulate setae, respectively; inner ramus (endopod) with 2 setae; outer ramus (exopod) with 2 aesthetascs and 1 seta.

Antenna (Fig. 10C).-Peduncle with a distal spine on inner margin; scaphocerite with 10 long plumose setae. Mandible (Fig. 10D).- More developed.

Maxillule (Fig. 10E).-Coxal endite with 6 plumodenticulate setae; basial endite with 5 cuspidate and 1 plumodenticulate seta; endopod with 2 terminal and 2 subterminal plumodenticulate setae.

Maxilla (Fig. 10F).-Coxopod with 7 plumodenticulate setae; basipod bilobed with 2,4 plumodenticulate setae, respectively; endopod with 10 plumodenticulate setae; scaphognathite with 8 setae.

Maxilliped I (Fig. 10G).-Coxopod with 1 seta; basipod with 8 plumodenticulate setae; endopod 4-segmented with 2,1,2 and 3 plumodenticulate setae, respectively; exopod with 4 plumose natatory setae.

Maxilliped II (Fig. 11A).-Coxopod and basipod naked; endopod 4-segmented with 1,3,2 and 7 plumodenticulate setae, respectively; exopod 4-segmented with 2,2,2 and 4 long plumose natatory setae, respectively.

Maxilliped III (Fig. 11B).-Coxopod broken; basipod with 1 seta; endopod 4-segmented with 3,1,6 and 3 plumodenticulate setae, respectively; exopod 5-segmented with 2,2,2,2 and 3 plumose setae, respectively.

Pereiopods I-V (Figs. 11C-G).-Pereiopod I (Fig. 11C) biramous, endopod 3-segmented with 2+2,3 and 3 plumodenticulate setae, respectively; exopod 3-segmented with 2,2 and 2 plumose natatory setae, respectively; pereiopods II-V (Figs. 11D-G) biramous, partially segmented.

Abdomen (Fig. 10A).- 5-somites.

Telson (Fig. 11H).- Posterior margin with 6 pairs of setae; lateral margin with 2 pairs of spines, endopod and exopod with 4 and 11 plumose setae, respectively.



Fig. 10 *Lysmata vittata* (Stimpson, 1860). Zoea VII: A, entire, lateral view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla; G, maxilliped I.



Fig. 11 Lysmata vittata (Stimpson, 1860). Zoea VII: A, B, maxillipeds II, III; C - G, pereiopods I - V; H, telson with uropods.

4.8 Zoea VIII (Figs. 12A - 13I)

Size.- TL= 2.47mm - 2.49mm

Duration.- 1 day (died).

Diagnostic Features.-

Carapace (Fig. 12A).-Spines enlarged; eyes stalked.

Antennule (Fig. 12B).-Biramous; peduncle 2-segmented with 4 and 6 setae, respectively; outer and inner ramus enlarged; inner ramus (endopod) with 1 seta and outer ramus (exopod) with 2 aesthetascs and 1 seta.

Antenna (Fig. 12C).-peduncle with a distal spine on inner margin; scaphocerite with 14 setae.

Mandible (Fig.12D).-More developed.

Maxillule (Fig. 12E).-Coxal endite with 6 plumodenticulate setae; basial endite with 5 cuspidate and 1 seta; endopod with 3 terminal and 2 subterminal plumodenticulate setae.

Maxilla (Fig. 12F).-Coxal endite with 8 plumodenticulate setae; basial endite bilobed with 4 and 3 plumodenticulate setae, respectively; endopod with 6 plumodenticulate setae; scaphognathite with 7 plumose setae.

Maxilliped I (Fig. 13A).-Coxopod with 1 seta; basipod with 9 plumodenticulate setae; endopod 4-segmented

with 2,1,2 and 4 plumodenticulate setae, respectively; exopod unsegmented with 4 terminal plumose natatory setae and 1 simple seta.

Maxilliped II (Fig. 13B).-Coxopod broken; basipod with 1 seta; endopod 4-segmented with 3,2,0 and 6 plumodenticulate setae, respectively; exopod 4-segmented with 2,2,2,4 (2 subterminal and 2 terminal) plumose setae, respectively.

Maxilliped III (Fig. 13C).-Coxopod broken; basipod naked; endopod 4-segmented with 2,0,5 and 4 plumodenticulate setae, respectively; exopod 5-segmented with 2,2,2,2,4 (2 subterminal and 2 terminal) plumose setae, respectively.

Pereiopods I-V (Figs. 13D-H).-Pereiopod I (Fig. 13D) biramous, basipod with 1 seta, endopod 5-segmented with 0,2,1,4 and 4 plumodenticulate setae, respectively; exopod4-segmented with 2,2,2 and 4 (2 subterminal and 2 terminal) plumose natatory setae, respectively; pereiopods II-V (Figs. 13E-H) biramous, partially segmented.

Abdomen (Fig. 12A).- 5-somites.

Telson (Fig. 13I).-Posterior margin with 6 pairs of setae; lateral margin with 2 pairs of spines, endopod with 7 plumose setae; exopod with 11 plumose setae.



Fig. 12 *Lysmata vittata* (Stimpson, 1860). Zoea VIII: A, entire, dorsal view; B, antennule; C, antenna; D, mandible; E, maxillule; F, maxilla.



Fig. 13 Lysmata vittata (Stimpson, 1860). Zoea VIII: A - C, maxillipeds II-III; D - H, pereiopods I - V; I, telson with uropods.

4.9 Comparison between laboratory reared zoea I - VIII of *Lysmata vittata* (present study) and zoea I - III of *Hippolysmata vittata* (now *L. vittata*) and zoea I - VIII of *H. (Exhippolysmata) ensirostris* (Table 2).

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Characters	L.vittata	L.vittata	H.(E.) ensirostris	H.(E.) ensirostris
	present study	Pillai	Bensam & Kartha	Pillai (1974)
		(1966)	(1967)	
Eyes	short & unarmed	short & unarmed	elongated	elongated
Maxillule:				
coxalendite	3 setae	no mention	4 setae	7 setae
basialendite	3 spine, 2 setae	no mention	3 spines	4 setae
endopod	5 setae	no mention	4 setae	5 setae
Maxilla:				
exopod	unsegmented	no mention	unsegmented	segmented

Zoea I:

Maxilliped I:				
endopod	4-segmented	4-segmented	no mention	no mention
	with 3,1,2,6 setae	with 4,2,1,2		
		setae		
Maxilliped II:				
endopod	3-segmented with	3-segmented	no mention	3-segmented
	8,1,5 setae	with 4,2,1 setae		with 3,4,3 setae
Maxilliped III:				
endopod	4-segmented with	no mention	no mention	3-segmented
	0,2,4,3 setae			with 5,2,4 setae
Abdomen:				
posterior margin of 5 th	with spine	with spine	without spine	with spine
abdominal segment				
Time taken of moulting to next	6 days	3 days	3 days	2 days
stage				

Zoea II:

Characters	L. vittata present	L. vittata	L. vittata Pillai	H. (E.)	H.(E.) ensirostris
	study	Romimohtarto	(1966)	ensirostris	Pillai (1974)
		& Juwana		Bensam &	
		(1992)		Kartha (1967)	
supra-orbital	absent	present	present	absent	present
spine					
Antennule:					
peduncle	2-segmented	unsegmented	no mention	feebly segmented	unsegmented
Antenna:					
scaphocerite	distally with 6-	faintly 3-	no mention	distally without	distally with 3-
	segmented	segmented		segmented	segmented
endopod	1 seta	no mention	no mention	without seta	1 seta
Pleopod:	absent	no mention	Absent	absent	biramous bud
					present
Maxilliped I:					
coxopod	setae absent	3 setae	no mention	no mention	4setae
basipod	5 setae	9 setae	no mention	no mention	9setae
endopod	4-segmented	5-segmented	4-segmented	no mention	4-segmented
	with 3,2,1,2 setae	with 2 + 2 + 1	with 4,3,1,2 setae		with 3,1,2,3 setae
		+ 1 +2 setae			
Maxilliped II:					
endopod	4-segmented	5-segmented	4-segmented	nomention	no mention
	with 2,1,0,6	with 5,3,1,1,6	with 3,2,1,2 setae		

	setae	setae			
Pereiopod	not developed	rudimentary	rudimentary	no mention	paddle shape
V:propodus					

Zoea III:

Characters	L. vittata	L. vittata	H.(E.) ensirostri
	present study	Pillai (1966)	Pillai (1974)
Eye peduncle	short & unarmed	long	long with a spine
Antennule:	2-segmented, distal segment	2-segmented, distal segment	2-segmented, distal segment
peduncle	without setae	with 3,4 setae	with 5,4 setae
exopod	3 aesthetascs+ 2 setae	4 aesthetascs	2 aesthetascs + 1 seta
Antenna:			
scaphocerite	distally with 4- segmented 10	unsegmented with 11 setae	distally with 2- segmented
	setae		with 13 setae
Maxillule:			
coxal endite	5 setae	5 setae	7 setae
basial endite	2 spine, 3 setae	7 setae	6 setae
Maxilla:			
coxal endite	6+4 setae	6+3 setae	9-10 setae
basial endite	4+3 setae	3+3 setae	3,3-4 setae
endopod	8 setae	5 setae	9 setae
Maxilliped I:			
basipod	8 setae	10 setae	10-11 setae
endopod	4-segmented with 2,1,1,3	feebly 4-segmented with	4-segmented with 3,2,2,3
	setae	2,2,2,3 setae	setae
exopod	8 setae	5 setae	6 setae
Maxilliped II:			
exopod	9 setae	10 setae	10 setae
Pereiopods I-V:	rudimentary	I & II developed III-V	developed
		rudimentary	

Zoea IV:

2000 2 1 0		
Characters	L. vittata	H.(E.) ensirostris
	present study	Pillai (1974)
Eye peduncle	short, unarmed	long with a spine
Antennule:		
endopod	1 seta	4 setae
exopod	2 aesthetascs + 1 seta	2 aesthetascs $+ 1$ seta
Maxillule:		
coxal endite	5 setae	7 -8 setae
basial endite	4 setae	6-7 setae
Maxilla:		
scaphognathite	6 setae	9 setae

Maxilliped III:		
endopod	4-segmented, segment 3 with	4-segmented, segment 3 with
	5 setae	6 setae
Pereiopods II-V:	rudimentary	developed

Zoea V:

Characters	L. vittata	H.(E.) ensirostris
	present study	Pillai (1974)
Eye peduncle	short, unarmed	long with a spine
Antennule:		
endopod & exopod	lobe like	long flagellum
Maxilla:		
scaphognathite	6 setae	14 setae
Maxilliped III: exopod	4 terminal setae	4 terminal and 5 pairs of subterminal
		setae
Pereiopod I:		
exopod	2 terminal and 3 pairs subterminal setae	4 terminal and 7 pairs subterminal setae
Pereiopods II-V:	rudimentary	developed

Zoea VI:

Characters	L. vittata	H.(E.) ensirostris
	present study	Pillai (1974)
Eye peduncle	short, unarmed	long with a spine
Antennule:		
endopod & exopod	lobe like	long flagellum
Antenna:		
scaphocerite	10 setae	25 setae
Pereiopod I:		
endopod	unsegmented	segmented
exopod	2 terminal and 3 pairs subterminal setae	4 terminal and 7 pairs subterminal setae
Pereiopods III-V:	rudimentary	developed

Zoea VII:

Characters	L. vittata	H.(E.) ensirostris
	present study	Pillai (1974)
Eye peduncle	short	long with a spine on stalk
Antennule:		
endopod & exopod	lobe like	long flagellum
Maxillule:		
coxal endite	6 setae	10-12 setae
basial endite	6 setae	7 setae
endopod	4 setae	5 setae
Maxilla:		
scaphognathite	8 setae	25-26 setae

Maxilliped I:		
coxopod	1 seta	4-5 setae
basipod	8 setae	10-13 setae
endopod	4-segmented with 2,1,2,3 setae	2-segmented with 4,7 setae
exopod	4 setae	7 setae
Maxilliped II:		
endopod	4-segmented with1,3,2,7 setae	3-segmented with4-5,4,2 setae
Telson:	2 pairs of lateral and 6 pairs of posterior	2 pairs of lateral and 5 pairs of posterior
	setae	setae

Zoea VIII:

Characters	L. vittata	H.(E.) ensirostris
	present study	Pillai (1974)
Eye peduncle	short	long with a spine on stalk
Antennule:		
endopod & exopod	lobe like	long flagellum
Maxilla:		
scaphognathite	7 setae	40-45 setae
Pereiopod III-V:	rudimentary	developed
Telson:	2 pairs of lateral and 6 pairs of posterior	2 pairs of lateral and 5 pairs of posterior
	setae	setae

5 Discussion

Terossi et al. (2010) revised the morphology of zoea in the family Hippolytidae. The larval morphology of the family and some genera have been reviewed by Haynes (1985). In total 666 species larvae have been published. Complete larval series are known for only three of the 39 valid species worldwide in the genus *Lysmata*. *L.vittata* is grouped in second kind of larval pattern when the larvae hatch without buds and a long zoeal development with amaximum of 11 zoeal stages (Bartiliotti et al., 2012).

The mother shrimp was identified as *L.vittata* with certainty, the extended larval development (8 zoeae, figs. 2-13) supported the identification. Following Gurney (1937) who have summarized larval characters of this genus and using Santos et al. (2004) key it also runs down to *Lysmata*. All species of *Lysmata* pass through the same number of instars (Knowlton and Alavi,1995), extended larval development pattern (13-25 instars) is the norm in this genus. But the zoeal stages of present *Lysmata vittata* having eyes with short peduncle onward from zoea VII, 1st pereiopod developing before the 2nd, 3rd, 4th and 5th pereiopods, 5th leg with not enlarged, flattened and paddle-like propodus on any stage till last zoea is quite puzzling. The earliest description of the species by Kuriyan (1951) differs in several characters from present larvae such as shorter rostrum, presence of dorsal tubercle on carapace and difference of setal count in maxilliped 1 endopod. Even the size of his protozoeae and that given in another study from Indonesia by Romomohmarto and Sri-juwana (1992) is bigger than the Pakistani zoeae and appearance of supra orbital is found in early stages as compared to Pakistani larvae (Table 2). A comparison cannot be made with other *Lysmata* whose larval morphology is known as all of them have paddle shape 5th pereiopods. Pillai (1966) for early larval stages did not display morphological characters typically attributed to larva of species (Calado et al., 2004). Such differences seem to indicate that Pillai (1966) was dealing with a larval series that cannot be allocated to *Lysmata vittata*. There is

a probability of mixing up of materials of two similar families obtained with the same data as reported for the palaemonid *Periclimenes* larvae which were wrongly assigned to Hippolytidae as several characters are common like five setae on exopod of the second maxilla is common with *Periclimenes* (Alkholy, 1963).

In the present case the evident differences are the shape of propodus of 5th pereiopods and tempo of morphogenesis with regard to maturation of pereiopods in later stage, a diagnostic characteristic, by most of the authors, is the appearance of long club like fifth pereiopod before pereiopod 2-4 but after pereiopod I in present *L. vittata*. In the present case the first leg appeared in zoea IV, second in zoea VI third to fifth pereiopods are rudimentary up to zoea VIII (last stage obtained) and not in ways given in Knowlton and Alavi (1995, table). These authors consider that descriptions given by Kuriyan, 1951, and Pillai, 1966 suggest that *L.vittata* is morphologically more advanced at hatching than their *L.anchisteus*, not observed here. Such differences do not allow the present *Lysmata vittata* larvae to fit in the zoeae of *Lysmata* spp. which can be differentiated from other hippolytid genera by the presence of greatly elongated 5th pereiopod with greatly expanded propodi in late stage (cf. Williamson, 1957). The issue was discussed with Dr. R.Knowlton. He replied "I'm not sure that this is a generic characteristic. I assume that you were not able to keep the zoeae to the later stages (as we could not). It looks to me like *Lysmata* typically goes through a lot of stages and that the tempo of development is very variable among individuals". However, a larva of *Lysmata* described by Bano (1999) from offshore waters of Pakistan possesses this structure. Apart from this larval stage described nothing is known of the developmental history of the genus from Pakistan coast.

Only 3 of the 31 species in the genus *Lysmata* have their complete larval series known. Therefore further studies are needed to establish the general pattern in larval development in the laboratory and to remove the bottle necks impairing the commercial production of these highly priced shrimp. It is known that in recent years, the genus Lysmata has received special attention in ornamental world trade. However, the inaccuracy of the few existing larval descriptions for the genus, and the lack of knowledge on the larval morphology and development of the majority of Lysmata species is one of the problems faced by the aquarists.

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