

Starvation resistance of early zoeal stages of marine ornamental shrimps *Lysmata* spp. (Decapoda: Hippolytidae) from different habitats

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Abstract

The genus *Lysmata* is present worldwide in a variety of habitats and newly hatched larvae from different species may display variable tolerance to starvation. This work evaluates the effect of starvation on survival of newly hatched and zoea II larvae of *Lysmata amboinensis*, *Lysmata boggessi*, *L. debelius* and *L. seticaudata*. Survival of newly hatched larvae was influenced by the period of starvation and by parental species. *L. boggessi* and *L. seticaudata* newly hatched larvae displayed facultative primary lecithotrophy (FPL), with all continuously starved larvae molting to zoea II. In general, when starved for similar periods, *L. debelius* larvae displayed significantly higher survival to zoea II than *L. amboinensis*. However, no *L. debelius* or *L. amboinensis* larvae endured starvation for more than 24 h. Survival from zoea II to zoea III was affected by the duration of starvation period, by parental species and by starvation of the first zoeal stage (for *L. boggessi* and *L. seticaudata*). Zoea II from all tested species, produced from starved or fed zoea I, displayed similar survival when larval preys were always available. However, when starved for only 24 h, zoea II of *L. boggessi* and *L. seticaudata* originating from continuously starved zoea I displayed significantly lower survival than those produced from fed larvae. Only zoea II originating from fed zoea I displayed facultative secondary lecithotrophy (FSL) and larvae from all tested species were able to successfully molt to the third zoeal stage in the total absence of food. This feature has never been previously recorded among caridean shrimps. Larval preys ingested in zoea I contribute to the build up of energetic reserves that latter are catabolized during starvation in zoea II, allowing some larvae to molt to zoea III. Since differences were recorded among the survival displayed by starved zoea II of *Lysmata* with FPL (*L. boggessi* and *L. seticaudata*) and those without such feature (*L. amboinensis* and *L. debelius*), it seems that egg yolk reserves are totally depleted in starved larvae and that energy accumulated through larval preys ingestion plays the crucial role. Future studies may help to confirm the current informal division of genus *Lysmata*: “crowd” species (*L. boggessi* and *L. seticaudata*) displaying FPL vs “pairs” species (*L. amboinensis* and *L. debelius*) without FPL. Additionally, it may also be confirmed that “pairs” species are ancestral to “crowd” species, since it is unlikely that FPL would have regressed to full planktotrophy.

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1. Introduction

Newly hatched decapod crustacean larvae are known to display dietary requirements varying intra and interspecifically, seasonally and annually (Anger, 2001). Such dietary requirements are dependent on the qualitative and quantitative aspects of energetic reserves stored in the egg yolk (Kattner et al., 1994). In general, since yolk reserves are rapidly catabolized, decapod larvae must start feeding immediately after hatching and avoid the deleterious effects induced by starvation. Anger and Dawirs (1981) demonstrated the existence of a critical period in the larval development of crustacean decapods termed as “point of no return” (PNR). Briefly, PNR represents a threshold where larvae which were exposed to starvation and were subsequently fed may remain alive for a variable period of time, although being incapable to recover from the nutritional stress early imposed, not developing further and finally dying. The understanding of these critical points on early larval feeding can be a valuable tool for the establishment of successful aquaculture protocols for commercially valuable decapods (Paschke et al., 2004), helping to minimize early zoeal stages mortality and increasing survival to metamorphosis. The importance of such studies is even more relevant if we take into account that PNR can be quantified experimentally, helping to clarify the nutritional flexibility of planktotrophic decapod larvae (Sulkin and van Heukelem, 1980; Sulkin et al., 1998; Gimenez and Anger, 2005).

In the latest years, the culture of marine ornamental shrimps of the genus *Lysmata* has been frequently addressed, in an attempt to establish commercial scale culture protocols that minimize the growing fishing efforts for these highly valuable organisms (Calado et al., 2003a,b). Early and late zoeal stages feeding have been pointed as the main bottlenecks impairing the successful culture of these ornamental shrimps (Rhyne and Lin, 2004). However, growing experimental evidence seem to indicate that late zoeal stage mortality and metamorphosis delay are heavily influenced by nutritional stress induced to early larval stages of ornamental shrimps (Simões et al., 2002; Calado et al., 2005a,b). Marine ornamental shrimp's larvae commonly hatch during the night and are left in the absence of food until the next morning. Therefore, newly hatched larvae are commonly exposed to starvation periods that may range at least from 6 to 12 h. In extreme cases, due to the wrong believe that all marine shrimps hatch with enough yolk reserves to allow them to molt from zoea I to zoea II in the absence of food (facultative primary lecithotrophy (FPL), see Anger, 1995, 2001; Thessalou-

Legaki et al., 1999), newly hatched larvae can be starved for up to 48 h.

Since shrimps from the genus *Lysmata* occur worldwide in habitats ranging from coral reefs in tropical areas to rocky shores in warm-temperate seas (Debelius, 2001), it is possible that newly hatched larvae may display different tolerance levels to variable starvation periods. The present work evaluates the effect of different periods of starvation on survival and stage duration of newly hatched and zoea II larvae of marine ornamental shrimps of the genus *Lysmata* occurring in different habitats: *Lysmata amboinensis* (De Man, 1888), from the shallower areas of coral reefs through the Indo-Pacific (Debelius, 2001); *Lysmata boggessi* Rhyne and Lin, 2006, mainly living under rocky ledges at depths up to 15 m in the Gulf of Mexico (Rhyne and Lin, 2006); *L. debelius* Bruce, 1983, commonly occurring at depths greater than 10 m in the coral reefs of the Indo-Pacific (Debelius, 2001); and *L. seticaudata* (Risso, 1816), inhabiting rocky bottoms of the warm-temperate waters of the north-eastern Atlantic and the Mediterranean sea, being present from the lower intertidal area to depths up to 60 m (Udekem d'Acoz, 1999).

2. Materials and methods

2.1. Parental broodstock keeping

Ten specimens of *L. amboinensis*, *L. boggessi*, *L. debelius* and *L. seticaudata* in simultaneous hermaphrodite sexual phase and displaying average total lengths (TL — measured from the anterior tip of the rostrum to the posterior end of the telson) of 50 ± 2 mm, were used to form five randomly assembled breeding pairs for each species. Each breeding pair was kept in a rectangular glass tank (0.60 m long \times 0.30 m wide \times 0.30 m high, total volume 54 L) connected to a recirculated maturation system for ornamental decapods described in detail by Calado et al. (2007). A photoperiod of 12 h light:12 h dark was used, with breeding tanks being illuminated from above with fluorescent white lights. Artificial seawater was prepared using freshwater purified by a reverse osmosis unit and mixed with the salt Crystal Sea[®] produced by Marine Enterprises International[®] (Baltimore, MD, USA), following the instructions of the manufacturer. Salinity was daily checked and maintained at 35 ± 1 , while temperature was kept at 25 ± 1 °C through the use of a heating/cooling unit. Ammonia and nitrite were maintained below detectable levels and nitrate and pH showed average values (\pm standard deviation, S.D.) of $3.1 (\pm 2.2)$ mg L⁻¹ and $8.0 (\pm 0.1)$, respectively.

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