Comparative study on larval days and survival rates of selected ornamental shrimps in captive conditions

Ornamental shrimps are bizarrely valued resources in the aquarium industry, due to their striking colouration, size, hardiness and cleaning behaviour[1,2]. The popularity of reef tanks in the past decades has led to an increased demand for marine ornamental decapods. The vast majority of them in the aquarium trade are still harvested from the wild, mainly from the coral reef ecosystems[1]. Unreliability of supply to meet market demand leads to overexploitation and inadvertent introduction of parasites or diseases from wild animals. Furthermore, the removal of certain species of shrimps that display associations with various sea creatures results in long-term ecological imbalances[1]. Besides, wild shrimps show less adaptability to the captive environment, resulting in high mortality during acclimatization. In recent years investigators, dealers, collectors and hobbyists have begun a global effort to alleviate the growing pressure on the natural population of marine ornamental species by promoting its captive breeding and rearing[1,2]. In recent decades, many attempts have been directed to standardize the culture methodologies of the marine ornamental shrimps[3,4]. Larviculture methods have been employed in some ornamental species, but are still in their infancy[2]. Proper larval rearing protocols must be established utilizing proper culture systems and manipulating biotic and abiotic factors for producing high-quality organisms, viably as an alternative to wild-harvested counterparts[3,4].

A knowledge gap exists concerning the complete larval developments of many ornamental shrimps. The culture of many decapods is not commercially viable due to long larval duration and difficulties in maintaining broodstock[4]. The dearth of knowledge on complete larval biology for different marine decapods is one of the bottlenecks, still impairing aquariculture[1]. Studying the reproductive biology of a species is a prerequisite for developing broodstock, hatchery technology and grow-out system. In the present study, we have documented the fecundity, larval duration and survival rates (%) of selected marine ornamental shrimps in captivity (Table 1, Figure 1), which will help in standardizing the larviculture techniques under captivity and thus the commercial production of marine crustaceans.

Highly demanded marine ornamental shrimps such as *Gnathophyllum americanum*, *Lysmata hochi*, *Saron marmoratus*, *S. neglectus*, *Ancylocaris brevicarpalis*, *Periclimenella agattii* and *Thor hainanensis* were collected from the lagoons and rocky intertidal areas of Agatti Island, Lakshadweep, India, during the night explorations conducted at a depth of 0.5–2 m, using scoop nets and hand picking. After collection, the shrimps were quarantined for 7 days in the hatchery. Later, male and female shrimps of each species were accommodated at 1 : 1 ratio in 250 litre FRP tanks, filled with filtered seawater (salinity of 35–36 ppt, pH 8.2–8.5 and temperature 27.5–28.5°C). Live rocks and coral boulders were provided as shelter, which also imitated the natural habitat. *Artemia* biomass, boiled clam meat and chopped polychaetes were fed thrice daily at a rate of 5% body weight. Broodstock development was attained within 2–4 months of rearing in captivity. Fecundity was calculated by counting the number of embryos brooded in the abdomen of the animal. After hatched out, the larvae were transferred to separate FRP tanks of 250 litre capacity with the similar water quality parameters as that of the broodstock tank. Larvae produced by each animal were manually counted and noted. Larvae were fed with ad-libitum of *Brachionus plicatilis* enriched with *Nannochloropsis salina* at a density of 5 nos/ml, for 3 days. From the 4th day, the rotifer density was reduced to 25%, and freshly hatched brine shrimps (*Artemia salina*) were fed at a concentration of 8–10 nauplii/ml till they reached the juvenile stage. The larval duration was calculated by the number of days taken to complete the metamorphosis. Larval survival rate was estimated by the average number of zoea obtained from the egg clutch and the juvenile survival rate was calculated by the average number of larvae turned into miniature adults after metamorphosis.

In the present study, it was observed that the larval duration of *G. americanum* was the longest, consisting of 110–120 days, with a low larval survival rate (40%). The highest fecundity was observed in *A. brevicarpalis* (800–1000 nos) and lowest in *G. americanum* (100–150 nos). *A. brevicarpalis* exhibited the lowest larval duration, consisting of 21–25 days with a 60% larval survival rate. Larval duration of *L. hochi* was 90–110 days with 45% survival rate and the lowest juvenile survivability (40%). The larval survivability of *T. hainanensis* was highest (80%) among all the species studied, with 85% juvenile survivability, whereas *S. marmoratus* exhibited the lowest larval survivability (35%) with 99% juvenile survivability. *G. americanum*, *S. marmoratus* and *A. brevicarpalis* exhibited 99% juvenile survival rates.

Genetical characteristics and environmental conditions such as water quality parameters, particularly temperature influences the period of incubation and embryonic development in marine shrimps[5]. Larval stages of most carideans are still

Table 1. Fecundity, larval duration, larval and juvenile survival rates of shrimps in captivity

Species	Fecundity (nos)	Larval duration (days)	Larval survival rate (mean) (%)	Juvenile survival rate (mean) (%)
Gnathophyllum americanum	100–150	110–120	40	99
Lysmata hochi	400–500	90–110	45	40
Saron marmoratus	250–300	81–85	35	99
Saron neglectus	200–250	50–55	50	90
Ancylocaris brevicarpalis	800–1000	21–25	60	99
Periclimenella agattii	150–160	40–45	40	70
Thor hainanensis	150–200	39–45	80	85

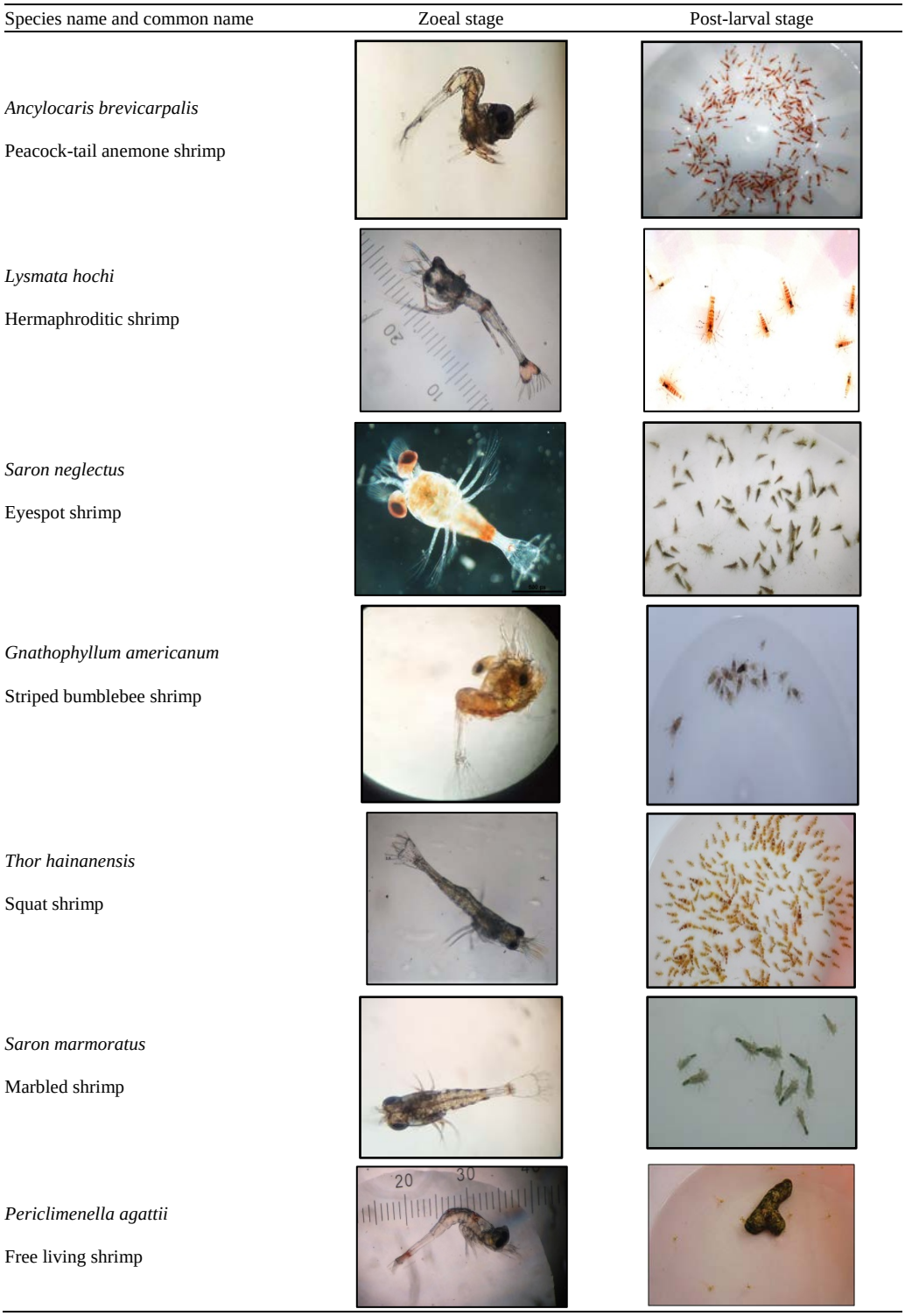

Figure 1. Zoeal and post-larval stages of Caridean shrimps.

unclear and have not been described in detail. The number of larval stages is different within the species of the same genus and also variation in larval duration is observed even among the individuals of the same batches of a species.

Under unfavourable rearing conditions, larval stages may last longer and mark time moulting (a series of moults where small or no morphological changes occur) which delays larval development[1,5], was noticed in the present study also. As the zoea stage of shrimps is the most difficult larval stage to rear, giving suitable feed guarantees high survival of zoea and subsequent stages. Larviculture is also affected by prey availability, unsuitable feeding protocols and fluctuations in water quality parameters[1,5].

Egg quality, health and survival of larvae are closely related to the physiological condition of a spawner[5,6].

The constraints for aquaculture of marine ornamental decapods are lack of information on life-history traits, poor larval survival and lack of standardized breeding and seed production protocols. Additionally, larval settlement of marine decapods is also triggered by chemical cues, especially exudates of host anemone and conspecifics of symbiotic decapods[7], which in turn results in variable and lengthy larval phases. Further studies regarding larval response to the presence of settlement cues need to be carried out for standardizing larviculture. Broodstock development, larval rearing, juvenile rearing and grow-out practices are species-specific, which must be standardized to meet the growing demand for commercial-scale cultivation of marine decapod crustaceans. The results of the present study pave the foundation for future research on the refinement of protocols for captive production of these important species. So as to commercialize the culture of these marine decapods for the aquarium trade, future studies should address in more detail on features of larvae and the effect of different larval diets for increasing survivability.

1. Calado, R., Olivotto, I., Oliver, M. P. and Holt, J., *Marine Ornamental Species Aquaculture*, John Wiley, UK, 2017, pp. 1–677.
2. Jose, S., Purushothaman, P., Kumar, T. T. and Lal, K. K., *Curr. Sci.*, 2021, **121**(4), 476–478.
3. Olivotto, I., Planas, M., Simões, N., Holt, G. J., Avella, M. A. and Calado, R., *J. World Aquac. Soc.*, 2011, **42**(2), 135–166.
4. Figueiredo, J. and Narciso, L., *Aquaculture*, 2006, **261(**4), 1249–1258.
5. Tziouveli, V., Ph.D. thesis, James Cook University, Australia, 2011.
6. Brillon, S., Lambert, Y. and Dodson, J., *Mar. Biol.*, 2005, **147**(4), 895–911.
7. Dos Santos, A., Calado, R., Bartilotti, C. and Narciso, L., *Helgol. Mar. Res.*, 2004, **58**(2), 129–139.

ACKNOWLEDGEMENTS. We thank the Director, ICAR-NBFGR, Lucknow for providing the necessary facilities. We also thank the Department of Biotechnology, New Delhi for financial assistance and the Centre for Marine Living Resources and Ecology and the Lakshadweep Administration for local logistical support.

Received 3 January 2022; revised accepted 14 June 2022

MANU MADHAVAN[1,2]
T. K. TEENA JAYAKUMAR[1,2]
T. T. AJITH KUMAR[1,*]
KULDEEP K. LAL[1]

[1]*ICAR-National Bureau of Fish Genetic Resources,*
Lucknow 226 002, India
[2]*Kerala University of Fisheries and Ocean Studies,*
Kochi 682 506, India
**For correspondence.*
e-mail: ttajith87@gmail.com