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Studies on the effect of delayed initial feeding on survival of *Macrobrachium dayanum* (Henderson) larvae under laboratory conditions

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Abstract
The present study was carried out to evaluate the effect of initial starvation and subsequent refeeding or delayed initial feeding on the survival of newly hatched larvae of *Macrobrachium dayanum* under laboratory conditions. In the delayed initial feeding experiments, the feeding rate of the starved newly hatched larvae of *M. dayanum* increased with the age up to 4th dph (day post hatching) when first food was offered. After a period of 5th dph the percentage of larvae feeding decreased sharply up to 9th dph and on 10th dph, no larva was found to feed and were very weak to accept the food. During the experiment, the point of no return (PNR_{50}) (when 50% of the unfed larvae are unable to feed when offered food) was reached in *M. dayanum* at 6th dph. Before PNR was reached, starved larvae of *M. dayanum* were able to capture their prey. Even when the larvae were provided food regularly after PNR_{50} was reached, they were too weak to capture food and showed 100% (PNR_{100}) mortality ultimately on day 8th in case of *M. dayanum*.

Keywords: *Macrobrachium dayanum*, starvation, point-of-no-return (PNR), survival

1. Introduction

Economically important prawns are members of the Penaeid and Palaemonid groups, the former dominating the seas and estuaries while the latter are abundant in riverine and lacustrine fresh-water environment. In the fresh water, the species of *Macrobrachium* dominate the catches from the major rivers. The genus *Macrobrachium* is circumtropical and is native to all continents except Europe, but presently most important and commercially cultured species is *Macrobrachium rosenbergii*. A number of other species of *Macrobrachium* have been used for aquaculture experimental work. Most of the species belonging to genus *Macrobrachium* are not cultured anymore but only a small number are cultured on very small scale. The three species of *Macrobrachium* viz., *M. dayanum*, *M. kistensis* and *M. lamarrei* have been recorded from Jammu region of Jammu and Kashmir State [1, 2]. None of these three species is presently cultured though *M. dayanum* and *M. lamarrei* are the ones that qualify criteria laid for edibility [3]. The absolute uniqueness of *M. dayanum* lies in the fact that it completes whole of its life cycle in freshwater as compared to its counterparts who have to spend a part of their life cycle in brackish or sea water thus, making the culture of *M. dayanum* practically convenient and economically notable.

Nevertheless, before any species is subjected to commercial aquaculture it is very important and essential to have complete knowledge about its life cycle, particularly maturation and reproduction [4] and apart from these factors the effect of starvation on the life cycle and mortality is a major concern.

Starvation, unfavorable environmental conditions, predation and pathogens are considered to be the main factors which are responsible for crustacean mortality during their early life stages [5, 6]. Starvation can lead to a severe deficiency of nutrients. Therefore, starvation studies may be useful predictors to determine energetic and metabolic requirements [7]. Since crustaceans experience starvation periods during their growing process, artificially induced fasting and starvation may help to determine the metabolic routes used in hierarchical order during molt and may describe novel biochemical and physiological adaptation mechanisms [8].

The capacity to withstand and recover from nutritional stress or starvation is an important adaptation for survival, growth, development and reproduction of any organism that must sporadically endure periods of limited food supply [9-11]. The ability of an organism to survive and recover from long periods of starvation is vital. Changes in food intake during development may have important consequences on the life history [12].

Anger and Dawirs (1981) [13] have demonstrated the existence of a critical period in the larval development of crustacean decapods termed as 'point- of-no-return' (PNR). Briefly, PNR represents the average time, which the larvae remain alive after exposure to starvation. Subsequently, feeding cannot reverse the nutritional stress imposed and further development is not possible [14]. Understanding these critical points on early larval feeding should be a valuable tool for the establishment of successful aquaculture protocols for commercially valuable decapods [15] and will help to minimize mortality in the early stages.

Though number of studies have been carried out on the feeding aspects of *M. dayanum* in nature [16] feeding in laboratory [17, 18], formulation of artificial feed and proximate body composition [17-21] but the studies regarding the starvation and its effect and survival is very less. In the present investigation an attempt has been made to study the effect of starvation, delayed feeding on survival of locally available freshwater prawn of Jammu, Northern India so that these studies will help us to have the knowledge of starvation impact and resistance so as to culture of *M. dayanum* on commercial scale. It will also help in the optimization of feeding schedule of the animals in aqua hatcheries and will be useful in designing the feeding experiment of the species under study.

2. Materials and Methods

Larvae during the period of present investigation were obtained from the gravid females collected from Gho-Manhasa stream (32.5600 °N, 74.9500 °E), about 14 to 15 Kms from Jammu city. The gravid females were reared in 20L plastic troughs with only one gravid female per trough to avoid cannibalism. Experiment was started in the month of October with the fresh batch of *M. dayanum* larvae hatched in plastic troughs where brooders were kept.

A total of 12 rearing troughs were set up each having 20 newly hatched *M. dayanum* larvae. Ten troughs (TD1-TD10) were used to determine the effect of delayed initial feeding on growth and survival of *M. dayanum* larvae. For this experiment feeding was initiated in trough TD1 at the very first day of the hatching of larvae. In TD2 the feeding was initiated on day 2 of hatching of larvae with one day starvation, in TD3 the feeding was initiated the 3rd day of larval hatching with two days starvation and the same trend was followed in subsequent seven troughs up to TD10. The fasting-feeding mode was carried out to evaluate the effect of food deprivation on the survival of the larvae of *M. dayanum*. While the larvae in trough (TD11) were not fed and served as negative control while the larvae in trough 12 (TD12) were regularly fed (Positive control) and served as "supply containers" for the experiment. The larvae from both "unfed" (TD11) and "fed" (TD12) supply containers were also used to determine quantitative experiments on the aspects of feeding.

For stocking as well as rearing of animals during the period of experimentation dechlorinated water was used (sodium thiosulphate was added to the tap water with vigorous aeration for 5-6 hours). The larval density in each trough was adjusted taking into consideration the volume of water, age and size of fish and food concentration. More than half of the water was changed daily with the help of flexible PVC pipe fitted with 50 µm silk bolting mesh tied at the suction end to prevent suction of larvae as well as food organisms offered to them. Dead larvae if present were recorded and siphoned out before adding fresh food.

In order to minimize the chances of cannibalism and offer shelter to the larvae, stones, pebbles and PVC pipes were kept in the troughs.

3. Results and Discussion

In the delayed initial feeding experiments, the feeding rate of the starved newly hatched larvae of *M. dayanum* increased with the age up to 4th dph (day post hatching) when first food was offered. After a period of 5th dph the percentage of larvae feeding decreased sharply up to 9th dph and on 10th dph no larva was found to feed and were very weak to accept the food (Fig-1). Since *M. dayanum* is not supplied with any kind of endogenous source of energy, it has to depend entirely on the exogenous food source soon after hatching. The *M. dayanum* during the present study showed highest percentage of feeding on 2nd, 3rd and 4th day post hatching, consuming maximum prey items on day 4 after which consumption of prey as well as the percentage feeding declined progressively. When the first feeding was delayed beyond 4th day in case of *M. dayanum* subsequent weight gains and survival rates showed a progressive decline, though their feeding abilities were not adversely affected until the 5th day.

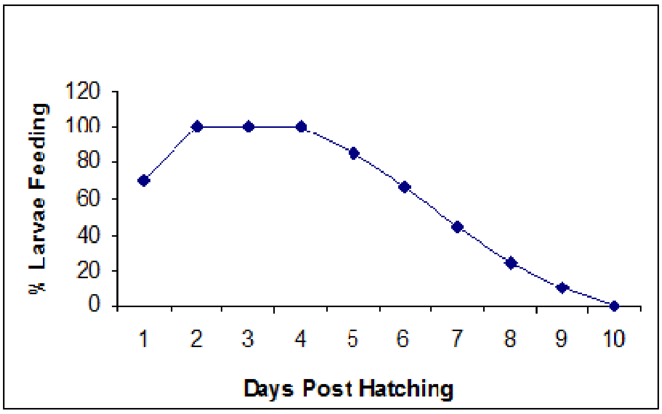

Fig 1: Percentage number of larvae of *M. dayanum* feeding during delayed feeding experiment

The study of the survival rates under different starvation regimes with subsequent feeding (delayed initial feeding) helped to analyse that delayed initial feeding had significant influence on the survival rates with the age of *M. dayanum*. Mortality *of M. dayanum* gradually increased as the feeding was delayed from 0-15 days (PNR experiment). Larvae from group TD1 which was not deprived of food showed only 5% mortality by the end of the experiment. The rate of mortality showed a gradual increase with delay in feeding/starvation. The larvae in TD2 where feeding was delayed beyond 1 day showed 15% mortality, the mortality rate increased to 50% by the end of experiment in TD6 where feeding was delayed up to 6th day with 5 days of starvation and 100% mortality rate was observed by the end of the experiment in TD8 wherein larvae were starved for 7 consecutive days and were fed on 8th days post hatching (dph).

The PNR_{50} (Point of no return when 50% of the unfed larvae are unable to feed when offered food) was reached in *M. dayanum* at 6th dph. Before PNR_{50} was reached, starved larvae of *M. dayanum* were able to capture their prey. Even when the larvae were provided food regularly after PNR was reached, they were too weak to capture food and showed 100% mortality ultimately on day 8th in case of *M. dayanum*. In *M. dayanum* as the nature has deprived the animal of any kind of endogenous source of food, they had to rely completely on exogenous food. During the present study period it was observed that about 70% of the guts showed exogenous food item on the very day 1st day of post hatching and later on 100% guts showed food items. The percentage number of guts was observed to decrease from day 5 post hatching when their initial feeding was delayed and subsequently were unable to feed beyond 10 dph. In the present study PNR_{100} was noticed to be 8th dph (in case of *M. dayanum* larvae). It was further recorded that after 8th dph (in case of *M. dayanum*) the larvae failed to survive though they were provided with food on daily basis (Tables-1, Fig I-III).

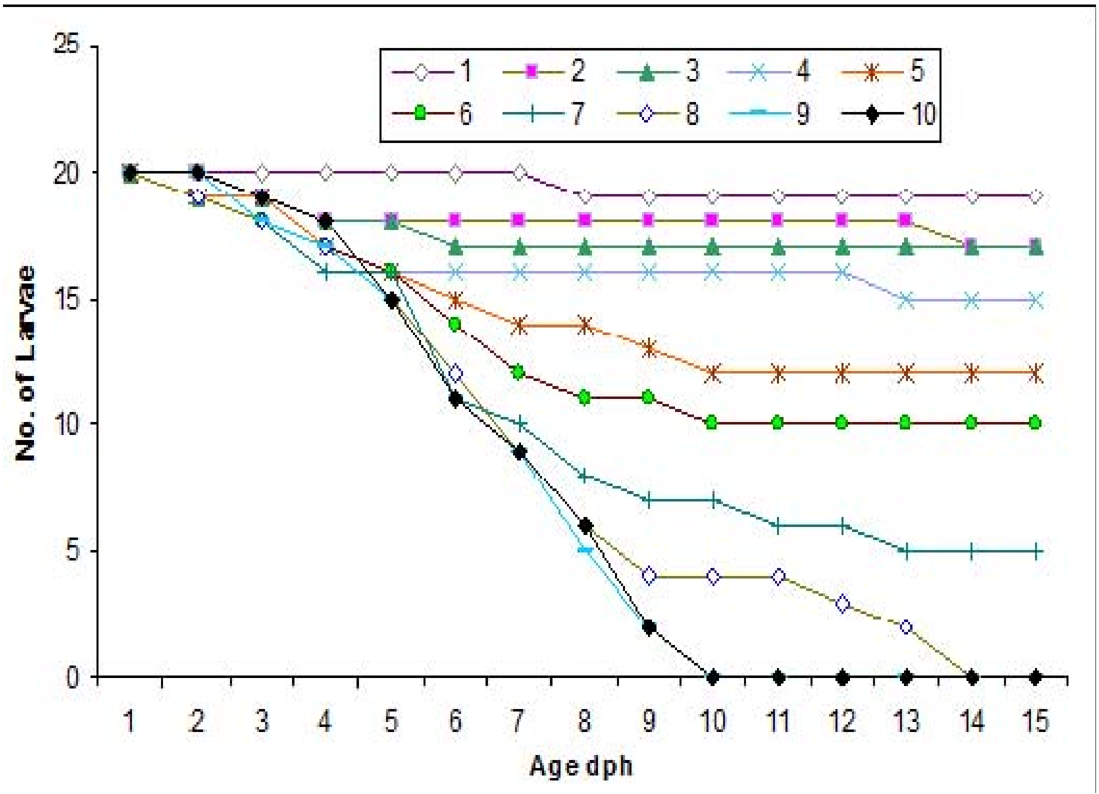

Fig 2: Survival curves for larvae of *M. dayanum* with different times of initial feeding (different colour indicates the day of initial feeding)

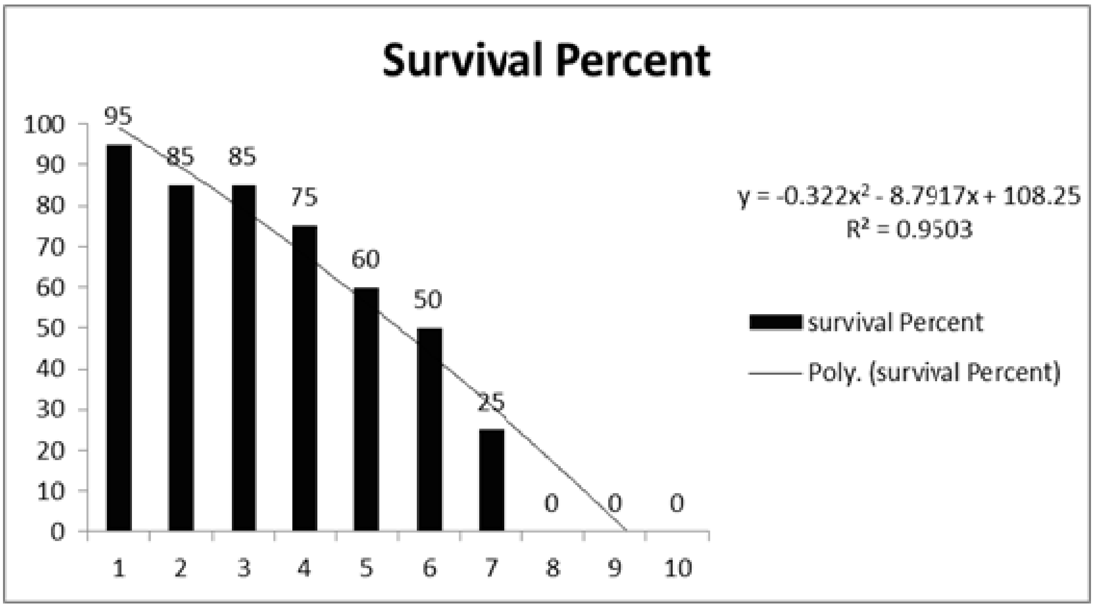

Fig 3: Survival percentage of *M. dayanum* larvae from 1 dph to 10 dph

Table 1: The effect of delayed initial feeding and mortality rates in *M. dayanum* larvae

Age/Days of first feeding	Original number of larvae	Number of larvae alive on first feeding	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	Percent survival to day 15
1	20	20	20	20	20	20	20	20	20	19	19	19	19	19	19	19	19	95
2	20	20	20	20	19	18	18	18	18	18	18	18	18	18	18	17	17	85
3	20	19	20	19	19	18	18	17	17	17	17	17	17	17	17	17	17	85
4	20	17	20	19	19	17	16	16	16	16	16	16	16	16	15	15	15	75
5	20	16	20	19	19	17	16	15	14	14	13	12	12	12	12	12	12	60
6	20	14	20	20	18	17	16	14	12	11	11	10	10	10	10	10	10	50
7	20	10	20	20	18	16	16	11	10	8	7	7	6	6	5	5	5	25
8	20	6	20	19	18	17	15	12	9	6	4	4	4	3	2	0	0	0
9	20	2	20	20	18	17	15	11	9	5	2	0	0	0	0	0	0	0
10	20	0	20	20	19	18	15	11	9	6	2	0	0	0	0	0	0	0

Occasional under nutrition or starvation is experienced during the life cycle of prawn due to spatial and temporal and patchiness of food resources Food plays a pivotal role and influences growth, survival and life cycle of aquatic invertebrates [9, 22] and so the starvation which also affects the same in a negative way. The periods of starvation if do not affect the first stage can cause a slower development in Zoea II and these delayed effects differ from response patterns that are known from planktotrophic marine decapod larvae and also moult cycle is affected in the same [23, 24]. While carrying out the preliminary studies on the feeding and starvation of the larvae of *Macrobrachium rosenbergii* Gang and Jiandong (1996) [25] found that significant effect of starvation on metamorphosis and survival of larvae was observed. At temperature 27±2 ^oC, the PNR_{100} (point of no return) for Zoea-I was about 4 days. Insufficient supply of food is also associated with decrease in survival rate besides increase in duration of larval stage [26]. The effect of starvation on the zoea of *Metapenaeus affinis* PNR_{50} and PRS_{50} were estimated to be 12 h and 20-24 h [27], for zoea of *Scylla serrata* PNR_{50} and PRS_{50} was found to be 1.3 to 2.3 days at 27 ^0C [28], for PNR_{50} and PRS_{50} was found to be 7.86 and 11.75 days [11], the PNR_{50} and PRS_{50} for was found to be 3.85 and 4.81 days [29], for instar I of Phyllosoma of *Panulirus cygnus* the PNR_{50} and PRS_{50} values were found to be 3.6 and 4.6 days respectively and the difference in PNR_{50} and PRS_{50} values between species may be due to genetic variation and condition of brood stock, temperature, egg incubation and larval rearing [30]. Our studies are also in close range to the studies of Zhang *et al*., (2009) [11] and Zhang *et al*., (2014) [29] on *F. chinensis* juveniles and *E. caricauda* larvae. Newly hatched larvae of *E. caricauda* (M1) stage under total food deprivation could develop to M2 stage but all individuals died by 10 dph whereas 50% survival was observed on 6.89dph [29]. Marine fish larvae are known to be generally more sensitive to food deprivation than freshwater species and more so starvation effects in them appears to be temperature dependent [31-33]. When the physiological effects of starvation became irreversible, i.e. when feeding cannot revive fish to normalcy, a 'Point-Of-No-Return' (PNR) is reached [34, 35]. The time of PNR is an indicator of the maximum duration for which a given species can withstand starvation. The PNR values are generally lower for marine and brackish water fish larvae, reflecting their greater susceptibility to starvation [36, 37]. PNR is related to metabolic rate and is temperature dependent as stated earlier and therefore forms the central theme of critical period concept. The importance of PNR for freshwater fishes in nature has not been critically evaluated, but available data indicates that transition period (from endogenous to exogenous sources of nutrition) entailing the threat of irreversible starvation is probably not as critical as in marine fishes with planktonic egg and larval stages and is further observed to lose its significance for cultured fishes like rohu. Nevertheless, PNR studies provide an estimate of tolerance of culturable fishes to food deprivation in their larval stages. Such information might prove useful under certain hatchery conditions of unpredictable or inadequate live food levels in the pond, or during transportation of larvae from the hatchery to distant fish farms [38]. Thus the studies on the starvation conducted on the *M. dayanum* in terms of PNR_{50} and PNR_{100} will definitely help in culture aspects of this fresh water prawn from Jammu region.

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References

1. Jyoti MK, Kailoo UC. Spawning season of *M. dayanum* Henderson Inhabiting Jammu waters, India. Zoologica Orientalis 1985; Z: 45-48.
2. Bakhtiyar Y. Food preferences of *Macrobrachium dayanum* (Henderson) and *Labeo rohita* (Hamilton) and Nutritional status and culture of food organisms. Ph.D. Thesis submitted to University of Jammu, 2008.
3. Jhingran VG. Fish and Fisheries of India. Hindustan Publishing Corporation, India, 1982.
4. Mourente G, Rodríguez A. 1 Variation in the lipid content of wild-caught females of the marine shrimp *Penaeus kerathurus* during sexual maturation. Mar. Biol 1991; 110(1):21-28.
5. Anger K. The biology of decapod crustacean larvae. Lisse: AA Balkema Publishers 2001; 14:1-420
6. Wahle RA. Revealing stock–recruitment relationships in lobsters and crabs: is experimental ecology the key? Fisheries Research 2003; 65:3-32.
7. Guderley H, Lapointe D, Bedard M, Dutil JD. Metabolic priorities during starvation: enzyme sparing in liver and white muscle of Atlantic cod, *Gadus morhua* L. Comp. Biochem. Physiol 2003; 2(A):347-356.
8. Barclay MC, Dall W, Smith DM. Changes in lipid and protein during starvation and the moulting cycle in the tiger prawn, *Penaeus esculentus* Haswell, Journal of Experimental Marine Biology and Ecology. 1983; 68:229-244.
9. Hervant F, Mathieu J, Barré H, Simon K, Pinon C. Comparative study on the behavioral, ventilatory, and respiratory responses of hypogean and epigean

crustaceans to long-term starvation and subsequent feeding. Comparative Biochemistry and Physiology Part A: Physiology 1997; 118(4):1277-1283.
10. Wu L, Dong S, Wang F, Tian X. Compensatory growth response following periods of starvation in Chinese shrimp, *Penaeus chinensis* Osbeck, Journal of Shellfish Research. 2000; 19:717-722.
11. Zhang P, Zhang X, Li J, Gao T. Starvation resistance and metabolic response to food deprivation and recovery feeding in *Fenneropenaeus chinensis* juveniles. Aquaculture international 2009; 17(2):159-172.
12. Brzęk P, Konarzewski M. Effect of food shortage on the physiology and competitive abilities of sand martin (*Riparia riparia*) nestlings, Journal of Experimental Biology. 2001; 204(17):3065-3074.
13. Anger K, Dawirs RR. Influence of starvation on the larval development of *Hyas araneus* (Decapoda, Majidae). Helgoländer Meeresuntersuchungen 1981; 34(3):287-311.
14. Calodo R, Dionısio G, Dinis MT. Starvation resistance of early zoeal stages of marine ornamental shrimps Lysmata spp. (Decapoda; Hippolytidae) from different habitats, Journal of Experimental Marine Biology and Ecology. 2007; 351:226-233.
15. Paschke KA, Gebauer P, Buchholz F, Anger K. Seasonal variation on in starvation resistance of early larval North Sea shrimp *Crangon crangon* (Decapoda: Crangonidae). Marine Ecology Progress Series 2004; 279:183-191.
16. Bakhtiyar Y, Lakhnotra R, Langer S. Natural food and feeding habits of a locally available freshwater prawn *Macrobrachium dayanum* (Henderson) from Jammu waters, North India, International Journal of Fisheries and Aquatic Studies. 2014; 2(3):99-104.
17. Langer S, Bakhtiyar Y, Lakhnotra R. Replacement of fishmeal with locally available ingredients in diet composition of *Macrobrachium dayanum,* African Journal of Agricultural Research. 2011; 6(5):1080-1084.
18. Bakhtiyar Y, Samyal A, Kumari A, Langer S. Studies on the food preferences of *Macrobrachium dayanum* and *Labeo rohita* under laboratory condition, International Journal of Fisheries and Aquaculture Sciences. 2012; 2(3):199-206.
19. Langer S, Kour T, Bakhtiyar Y. Studies on the effect of varying levels of dietary protein on growth and survival of freshwater prawn *Macrobrachium dayanum,* J Aqua Biol. 2004; 19(1):187-191.
20. Langer S, Bakhtiyar Y, Malik N, Karlopia SK. Growth, Survival and Proximate Body Composition of *M. dayanum* Larvae Fed Artificial Food and Natural Food Organisms under Laboratory Conditions, International Journal of Biotechnology and Biochemistry. 2009; 5(3):213-221.
21. Samyal A, Bakhtiyar Y, Verma A, Langer S. Studies on the seasonal variation in lipid composition of muscles, hepatopancreas and ovary of freshwater prawn, *Macrobrachium dayanum* (Henderson) during reproductive cycle, Advance Journal of Food Science and Technology. 2011; 3(3):160-164.
22. Ciannelli D, Uttieri M, Strickler JR, Zambianchia E. Zooplankton encounters in patchy particle distributions. Ecological Model 2009; 220:596-604.
23. Anger K, Dawirs RR, Anger V, Costlow JD. Effects of early starvation periods on zoeal development of brachyuran crabs. Biological Bulletin 1981; 161:199-212.
24. Anger K. The DO threshold: a critical point in the larval development of decapod crustaceans, Journal of Experimental Marine Biology and Ecology. 1987; 108:15-30.
25. Gang C, Jiandong Z. Preliminary study on feeding and starvation of larvae of *Macrobrachium rosenbergii* (de Man). Journal of Zhanjiang Ocean University, 1996, 2.
26. Rotllant G, Moyano FJ, Andres M, Estevez A, Dıaz M, Gisbert E. Effect of delayed first feeding on larval performance of the spider crab *Maja brachydactyla* assessed by digestive enzyme activities and biometric parameters. Marine Biology 2010; 157:2215-2227.
27. Lin RC, Zhou LZ, Zhang JB. Starvation, feeding behavior and food of larvae (postlarvae) of *Metapenaeus affinis,* Journal of Fisheries of China. 1992; 16:189-201.
28. Li SJ, Zeng ZS. Effects of Starvation on Survival and Development of Zoea-1 Larvae of the Mud Crab, *Scylla serrate*, Journal of Xiamen University (Natural Sciences). 2001; 40:782-788.
29. Zhang C, Li Z, Li F, Xiang J. Effects of starvation on survival, growth and development of *Exopalaemon carinicauda* larvae. Aquaculture Research, 2014, 1-11.
30. Liddy GC, Phillips BF, Maguire GB. Survival and growth of instar 1 phyllosoma of the western rock lobster, *Panulirus cygnus*, starved before or after periods of feeding. Aquaculture International 2003; 11:53-67.
31. Lasker R. Efficiency and rate of yolk utilization by developing embryos and larvae of the Pacific sardine (*Sardinops caerulea*) (Guard), Journal of the Fisheries Research Board of Canada. 1962; 19:867-875.
32. Laurence GC. Influence of temperature on energy utilization of embryonic and prolarval tautog, (*Tautoga onitis*), Journal of the Fisheries Research Board of Canada 1973; 30:435-442.
33. Quantz G. Use of endogenous energy sources by larval turbot (*Scophthalmus maximus*). Trans. Amer. Fish. Soc 1985; 114:558-563.
34. Blaxter JHS, Hempel G. The influence of egg size on herring larvae (*Clupea harengus* L.), J Cons. Perm. Int. Explor. Mer. 1963; 28:211-240.
35. Lasker R, Feder HM, Theilacker GH, May RC. Feeding, growth, and survival of *Engraulis mordax* larvae reared in the laboratory. Mar. Biol 1970; 5:345-353.
36. Bagarinao T. Yolk resorption, onset of feeding and survival potential of larvae of three tropical marine fish species reared in hatchery. Marine Biology 1986: 91:449-459.
37. Yin MC, Blaxter JHS. Feeding ability and survival during starvation of marine larvae reared in the laboratory, Journal of Experimental Marine Biology and Ecology. 1987; 105:73-83.
38. Mookerji N, Rao TR. Rates of yolk utilization and effects of delayed initial feeding in the larvae of the freshwater fishes Rohu and Singhi. Aquaculture International 1999; 7:45-56.