

Live Foods for Juveniles' Production of Blue Swimming Crab, *Portunus pelagicus* (Linnaeus, 1766)

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ABSTRACT

The study were aim to demonstrate the affects of live food type's i.e., mixed diatom, *Artemia* nauplii and rotifer on survival rate and molt time of larvae stage till 1st day juvenile crabs (C1) of *P. pelagicus*. Three types of feeding regimes given to the crab larvae through out the study trials are with and without mixed diatom, with and without *Artemia* nauplii and with and without rotifer. The study shows that zoea fed with rotifer alone was not enough to sustain survival in the next zoea stages and to promote metamorphosis up to megalopa stage. Survival of zoea fed with *Artemia* nauplii alone shows that this type of food is not suitable for the very early zoea stages. The study also shows that the adding of mixed diatom to larvae rearing system where rotifer and *Artemia* nauplii is main food items did not produced high survival rate as compared to larvae rearing fed on rotifer and *Artemia* nauplii alone. The results of the study demonstrated that the food types not only effect survival rate but also the growth of crab larvae. The study generally ended that the combination diet of rotifer and *Artemia* nauplii alone is enough to produced C1.

Key words: *Artemia* nauplii, blue swimming crab, juvenile crab, live foods, *Portunus pelagicus*

INTRODUCTION

Blue swimming crab, *Portunus pelagicus* (Portunidae) is becoming a commercially important species, especially as a possible alternative culture species to prawns. The crab fishery and culture operations are expected to continue to grow in the future. The present investigation shows that there are no appropriate techniques established for the commercial production of juvenile crabs for *P. pelagicus*. Larvae rearing of *P. pelagicus* zoea stages till 1st day juvenile crab (C1) has been achieved but the hatchery technologies are not yet consistent enough to be adapted seriously by the commercial sector (Fielder, 2004). The recent attend to developed the commercial production technique of juvenile crabs for *P. pelagicus* was done by Soundarapandian *et al.* (2007) with survival rate of 4.3% for megalopa metamorphosed into 1st day juvenile crabs. Live food is still a major constraint to the crab hatchery practice where the live food cultures are difficult and expensive to maintain and live food is a disease vector (Allan and Fielder, 2004). Baylon and Failaman (1999) also show that inappropriate food and feeding density is one major factors

attributed to high mortalities in larvae rearing of mud crab (*Scylla serrata*). Feeding management may be one area which has to be investigated and modified to improve larval survival rate till C1 of Portunidae crab. Moreover, larval rearing may be simplified and production costs reduced by partial replacement of natural food with an artificial diet.

Hatchery works on Portunidae crab larvae show that rotifer and *Artemia* nauplii are the two most common live food used (Kanazawa *et al.*, 1983; Cowan, 1985; Marichamy and Rajapackiam, 1992; Zainoddin, 1992; Li *et al.*, 1999; Qunitio *et al.*, 1999; Baylon and Failaman, 1999; Hoang, 1999; Mann *et al.*, 1999; Zeng and Li, 1999; Suprayudi *et al.*, 2002; Parado-Estepa *et al.*, 2002, 2007; Fielder, 2004; Nguyen and Truong, 2004; Qunitio, 2004; Suprayudi *et al.*, 2004; Ruscoe *et al.*, 2004; Bryars and Havenhand, 2006; Baylon and Suzuki, 2007; Soundarapandian *et al.*, 2007; Baylon, 2009). Studies shows other than rotifer and *Artemia* nauplii, green phytoplankton and mixed diatom were also used to feed Portunidae crab larvae (Cowan, 1985; Marichamy and Rajapackiam, 1992; Zainoddin, 1992; Qunitio *et al.*, 1999; Hamasaki, 2003; Cowan, 1985; Hoang, 1999; Bryars and Havenhand, 2006; Baylon and Suzuki, 2007; Parado-Estepa *et al.*, 2007; Baylon, 2009). Commercial artificial encapsulated larvae feed were also used to feed *Portunidae* crab larvae (Kanazawa *et al.*, 1983; Zainoddin, 1992; Qunitio *et al.*, 1999). Recent hatchery works by Soundarapandian *et al.* (2007) on *P. pelagicus* used rotifer at 5-20 inds mL⁻¹ day⁻¹ to feed the zoea stages and *Artemia* nauplii at 5-25 inds mL⁻¹ to feed zoea 3 to megalopa. Other than work by Soundarapandian *et al.* (2007), literature review shows that there are no specific studies on *P. pelagicus* feeding regimes for the mass production of C1.

Food types not only effect survival rate but also the growth of larvae i.e., moult times of the mud crab (*S. paramamosain*) (Nguyen and Truong, 2004). So the objectives of this present study were to determine the effects of live food type's i.e., diatom, *Artemia* nauplii and rotifer on survival rate and moult time of larvae stage till C1 of *P. pelagicus*.

MATERIALS AND METHODS

The raw sea water used were passed through cotton bag filter (50 µm) after settling overnight in the sedimentation tanks. In the hatchery, the water was disinfected with 25 ppm of active chlorine (calcium hypochloride) before use. *P. pelagicus* berried female used in the present study were caught from the wild using gill net. The berried females were kept in a circular fiberglass holding tank with stocking density of one crab per tones of water. Chopped fish meat was given once daily as food. Seawater within the holding tanks were exchange daily at 100% exchange rate. Moderate aeration was provided through the incubation period. When the berried female has matured with black eggs, the crab was transfers to the circular PE hatching tanks (0.5 tones capacity) with stocking density of one crab per tank. The hatching tank holds 400 L of water with daily water exchange of 100% using disinfected seawater till the crab hatched. Moderate aeration was also provided through this period. To reduce the exposure of larvae to high bacterial levels, the larvae were removed from the hatching tank within the second hour of hatching. After hatching, the aeration in the hatching tank is turn-off for 10 to 15 min to allow the vigorously swimming, photo-positive larvae to aggregate at the surface, where they are collected. To ensure crab larvae are stocked into the culture tank at a required density, counts are made for larval density. The required volume of larvae concentrate was then transferred directly to the culture tank. All the culture tanks used are circular fiberglass tank and were located indoors under transparent roofs. The larvae culture tanks used was estimated 5 tones capacity with tank dimension of 1.4 m radius,

80 cm high and 1.2 mm thickness, grey background color and with outflow of 5.10 cm diameter at the centre with the total volume of water culture medium used at 4,000 l and the stocking density at 50 larvae L⁻¹, total crab larvae stocked per each larvae culture tank of 5 tones capacity is 200,000 larvae tank⁻¹.

Three types of live foods, mixed diatoms, *Artemia* nauplii and rotifer are given to the crab larvae through out the study trials with different combination of these live foods. The feeding schedule for the larval stages of *P. pelagicus* during the study is as in Table 1. The composition of mixed diatom culture used in the present studies are *Skeletonema* spp. (\approx 80%), *Chaetoceros* spp. (\approx 19%) and the remainder is taken by other species of diatom (\approx 1%) which included *Stephanopyxis* spp., *Lauderia* spp. and *Nitzschia* spp. *Artemia* nauplii used were packed from Great Salt Lake, United State of America.

Management tactics used in the larvae rearing are designed to maintain stability of the culture environment and reduce the potential for opportunistic pathogens to invade the system. While cultures are running well, water exchanges are done daily at 100% exchange rate. After the crab larvae have metamorphosed to the megalopa stage, additional substrate is suspended within the larvae culture tank to provide a surface for settlement of megalopa and juvenile crabs. The substrate is constructed of strips of nylon strings which is suspended vertically from the tank bottom with weighted at one end. The settlement substrate added to the larvae culture tank during the megalopa stage also act as a convenient way to harvest settled megalopa and juvenile crabs from the tank. Megalopa and juvenile crabs tend to remain clinging to the fibres as the substrate is gently removed from the tank and placed in a nursery tank. The remaining megalopa or juvenile crabs are drain harvested into a mesh scoop net. Dead larvae are removed daily to prevent contamination. Larval numbers are estimated and monitored daily through volumetric using 5 mL pipette from the rearing tanks. The details used to determine the morphological characters for the larvae development stage of *P. pelagicus* are as described by Arshad *et al.* (2006). The larvae rearing trial will end when all the crab larvae within the culture rearing tank metamorphosed to 1st day juvenile crabs (C1).

Six treatments were conducted through the study period with three replicates for each treatment for different combination of the three live food types. The summary of the feeding regimes experimental design is as in Table 2. Larvae were fed once daily in the morning about 1000 h. through out the study trials. Moderate aeration was provided in the larval rearing tanks. Throughout the study trials, all other parameters were maintained as in Table 3. The water culture medium temperature was maintained at 30°C using 3 phase thermostat water heater.

The main data collected during the study trial were survival rate and molt time of larvae stage till C1. Any C1 present was removed from the larvae rearing tanks at the time of the daily count. Trials were ended when all the larvae had metamorphosed to crabs or died. The survival rates to C1 were expressed as percent of the initial number of larvae at zoea 1 stage stocked into the larvae

Table 1: Feeding scheme used for rearing *P. pelagicus* larvae till C1

Food types	Crab larvae stages					
	Z1	Z2	Z3	Z4	M	C1
Mixed diatoms; 2×10 ⁴ -5×10 ⁴ cells mL ⁻¹	✓	✓	✓	✓		
Rotifers (<i>Brachionus</i> spp.); 35 rotifer mL ⁻¹	✓	✓	✓	✓		
<i>Artemia</i> nauplii; 5 nauplii mL ⁻¹		✓	✓	✓	✓	✓

Z1: Zoea 1, Z2: Zoea 2, Z3: Zoea 3, Z4: Zoea 4, M: Megalopa, C1: 1st day juvenile crab

Table 2: Summary of the different feeding regimes experimental design

Larvae rearing batch No.	Larvae feed treatment	Other feeds given
1	Mixed diatom	Rotifer and <i>Artemia</i> nauplii
2	Without mixed diatom (control)	Rotifer and <i>Artemia</i> nauplii
3	<i>Artemia</i> nauplii	Rotifer
4	Without <i>Artemia</i> nauplii (control)	Rotifer
5	Rotifer	<i>Artemia</i> nauplii
6	Without rotifer (control)	<i>Artemia</i> nauplii

Table 3: Parameters which was maintained throughout the study trials

Parameters	Constant variables
Water culture media parameter	
Salinity	30 ppt
Temperature	30°C
pH	8.0-8.7
Dissolved oxygen	>6 mg L ⁻¹
Water exchange	100% daily
Stocking rate	50 larvae L ⁻¹
Background colour of larvae culture tank	Grey

rearing tank. Physico-chemical of water parameter (i.e., water temperature, pH, salinity and dissolved oxygen) readings was also recorded daily before water exchange among 08:00-10:00 h. Electronic water checker unit is used to measure the water parameter reading for dissolved oxygen (mg L⁻¹), salinity (ppt) and temperature (°C) through out the present study. The electronic water checker unit model is YSI 85, produce by YSI Incorporated, Ohio, USA. Data are presented as Mean±standard deviation. Statistical significance of differences between treatments for survival rate from zoea 1 stage to C1 was determined using analysis of variance. The analysis of variance of data was used to test for; (1) larvae rearing treated with mixed diatom (batches No. 1) and without mixed diatom (batches No. 2), (2) larvae rearing treated with *Artemia* (batches No. 3) and without *Artemia* (batches No. 4) and (3) larvae rearing treated with rotifer (batches No. 5) and without rotifer (batches No. 6). A fixed-ratio hypothesis of Chi-square test was used to test for; (1) the number of larvae rearing batches reached megalopa stage within 12 days as compared to other days of 11, 13 and 14 days and (2) the number of larvae rearing batches reached C1 within 17 days as compared to other days.

RESULTS

Treatment with and without mixed diatom: There was a significant reduction in the survival of zoea 1 three days after stocking in all the three replicates (1a, 1b, 1c) of the larvae rearing batches fed with combination of mixed diatom, rotifer and *Artemia* nauplii as shown in Fig. 1. At zoea 2, survival rate was reduced further to less than 50%. All the three run with mixed diatom produced 1st day juvenile crabs with survival rate of 0.1, 0.03 and 0.01% for larvae rearing replicate No. 1a, b and c, respectively (Fig. 1). At zoea 2 of the 5th day, survival rate was reduced to 26.381, 0.624 and 8.105% for larvae rearing replicate No. 2a, b and c, respectively (Fig. 2). All the three replicates for the control where larvae fed without mixed diatom but fed with only rotifer and *Artemia* nauplii (2a, 2b and 2c), also survived till 1st day juvenile crab with survival rate of 0.002, 0.001 and 0.001% for larvae rearing replicate No. 2a, b and c, respectively (Fig. 2). For both the treatments, analysis of variance showed there was no significant difference ($p>0.05$) in the

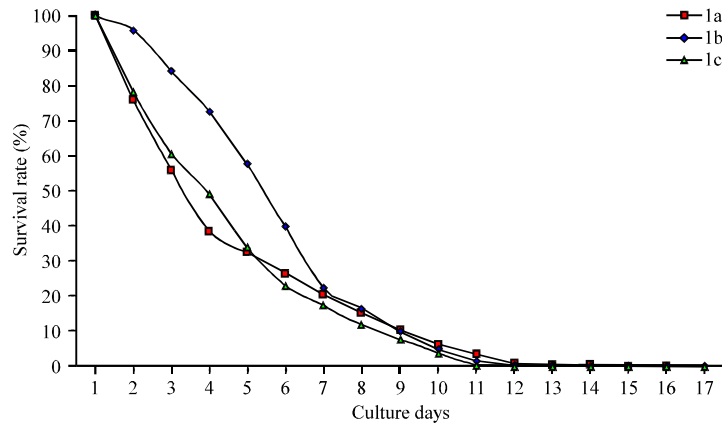


Fig. 1: Survival rate of *P. pelagicus* larvae feed with combination of mixed diatom, rotifer and *Artemia* nauplii of larvae rearing batch No. 1 with three replicates (1a-c)

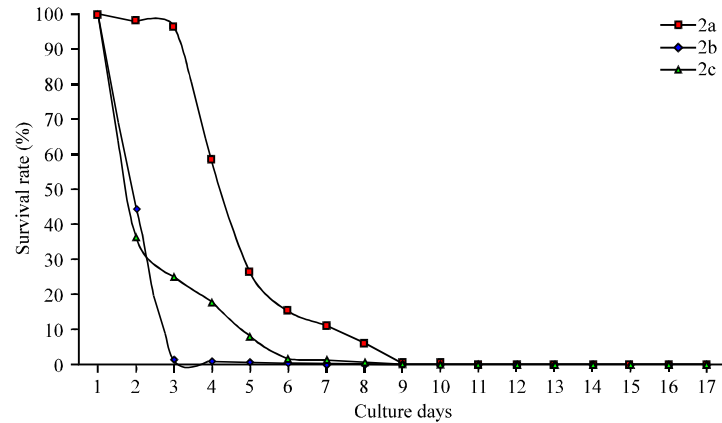


Fig. 2: Survival rate of *P. pelagicus* larvae feed without mixed diatom but fed only with rotifer and *Artemia* nauplii of larvae rearing batch No. 2 with three replicates (2a-c)

Table 4: Survival rate from zoea 1 (Z1) until the 1st day juvenile crab (C1) of *P. pelagicus* and analysis of variance (CRD with equal Replication) of the larvae rearing with different treatments

Treatment combination	Computed F	Tabular F	
		5 (%)	1 (%)
Batch No. 1 vs. No. 2	2.88 ^{ns}	7.71	21.2
Batch No. 3 vs. No. 4	7.75*	7.71	21.2
Batch No. 5 vs. No. 6	7.73*	7.71	21.2

NS: Not significant, *: Significant at 5% level. Batch No. 1: With mixed diatom, Batch No. 2: Without mixed diatom, Batch No. 3: With *Artemia* nauplii, Batch No. 4: Without *Artemia* nauplii, Batch No. 5: With rotifer, Batch No. 6: Without rotifer

survival rate of zoea 1 to 1st day juvenile crab when testing the mean survival rate affect of the larvae feed with mixed diatom and without mixed diatom (Table 4). In larvae rearing treated with mixed diatom, the study shows that the zoea reached the megalopa stage in 12-13 days and reached the C1 in 16-17 days. For larvae rearing treated without mixed diatom, the study shows that the zoea reached the megalopa stage in 13 days and reached the C1 in 17 days. Study also

shows that the molting was not synchronous even within mixed diatom treatments as compare to the larvae feed without mixed diatom.

Treatment with and without *Artemia* nauplii: The study shows that there was a significant reduction in the survival of zoea 1 three days after stocking in all the three replicates of the larvae rearing batches feed with combination of *Artemia* nauplii and rotifer (3a, 3b and 3c) as shown in Fig. 3. At zoea 2 of the 4th day, survival rate was reduced further to less than 50%. All the three run with *Artemia* nauplii produced 1st day juvenile crabs with survival rate of 0.09, 0.35 and 0.2% for larvae rearing replicate No. 3a, b and c, respectively (Fig. 3). Two of the three replicates for the control (larvae rearing replicate No. 4a and b) did not survival till 1st day juvenile crab, where larvae feed without *Artemia* nauplii but feed with only rotifer (Fig. 4). The results show that the zoea fed with rotifer along was not enough to sustain survival in the earlier zoea 1 stages and all the larvae died within three days of the zoea 1 stage. Only one replicate for the control, larvae rearing replicate No. 4c did produced 1st day juvenile crabs with survival rate of 0.01% (Fig. 4). For both the treatments, analysis of variance showed there was significant difference ($p < 0.05$) in the

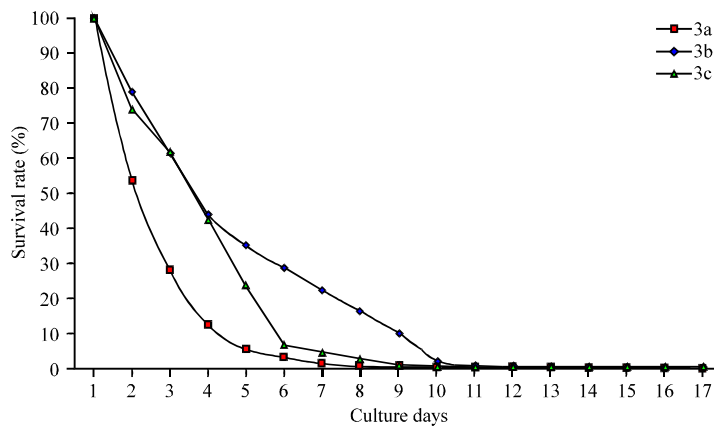


Fig. 3: Survival rate of *P. pelagicus* larvae feed with combination of *Artemia* nauplii and rotifer of larvae rearing batch No. 3 with three replicates (3a-c)

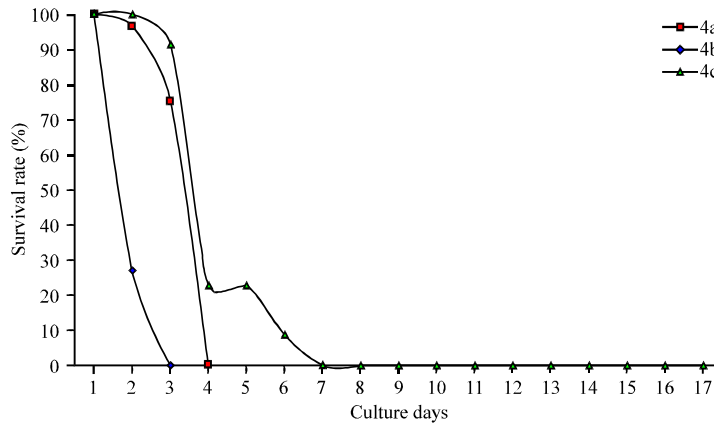


Fig. 4: Survival rate of *P. pelagicus* larvae feed without *Artemia* nauplii but feed only with rotifer of larvae rearing batch No. 4 with three replicates (4a-c)

survival rate of zoea 1 to 1st day juvenile crab when testing the mean survival rate effect of the larvae feed with *Artemia* nauplii and without *Artemia* nauplii (Table 4). In all the larvae rearing experiments that produced 1st day juvenile crabs (larvae rearing batch No. 3a, b, c and c), the study shows that the zoea reached the megalopa stage in 11-12 days and reached the C1 in 17 days. Study also shows that the molting was not synchronous within *Artemia* nauplii treatment batches.

Treatment with and without rotifer: The study shows that there was a significant reduction in the survival of zoea 1 three day after stocking, the same results recorded as in the earlier larvae rearing batches, in all the three replicate of the larvae rearing batches feed with combination of rotifer and *Artemia* nauplii (5a, 5b and 5c) as shown in Fig. 5. At the end of zoea 2 of the 6th day, survival rate was reduced further to less than 50%. All the three run with rotifer and *Artemia* nauplii produced 1st day juvenile crabs with survival rate of 0.78, 1.09 and 0.23% for larvae rearing replicate No. 5a, b and c, respectively (Fig. 5). Similar to the earlier experiment treated with and without *Artemia* nauplii, two of the three replicates for the control (larvae rearing replicate No. 6a, b) did not survive till 1st day juvenile crab, where larvae feed without rotifer but feed with only *Artemia* nauplii (Fig. 6). The results shows that the zoea fed with *Artemia* nauplii alone was not enough to sustain survival in the earlier zoea 1 stages and all the larvae died within 3 days of the zoea 1 stage. Only one replicate for the control, larvae rearing replicate No. 6c did produced 1st day juvenile crabs with survival rate of 0.003% (Table 6). Analysis of variance also shows that there was significant difference ($p < 0.05$) in the survival rate of zoea 1 to 1st day juvenile crab when testing the mean survival rate effect of the larvae feed with rotifer and without rotifer (Table 4). In all the larvae rearing experiments that produced 1st day juvenile crabs (larvae rearing replicate No. 5a, b, c and c), the study shows that the zoea reached the megalopa stage in 12 days and reached the C1 in 17 days. Study also shows that the molting was not synchronous within rotifer treatment batches.

Physico-chemical water parameter: The physico-chemical of water parameter of the larvae rearing culture media for water temperature, pH, salinity and dissolved oxygen were recorded daily before water exchange among 08:00 to 10:00 h for every experiments batch. Throughout the study

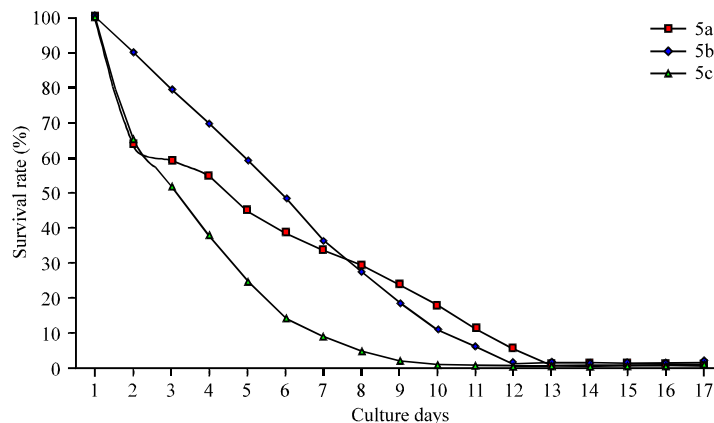


Fig. 5: Survival rate of *P. pelagicus* larvae feed with combination of rotifer and *Artemia* nauplii of larvae rearing batch No. 5 with three replicates (5a-c)

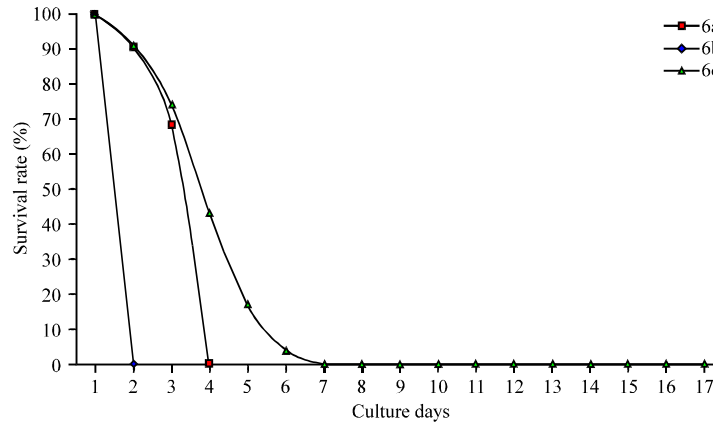


Fig. 6: Survival rate of *P. pelagicus* larvae feed without rotifer but feed only with *Artemia* nauplii of larvae rearing batch No. 6 with three replicates (6a-c)

Table 5: Mean daily physico-chemical water parameter reading of the larvae rearing culture media from 18 experiment replicates of six larvae rearing batches with three replicates each of the study trial

Water parameter	Temperature (°C)	Salinity (ppt)	pH	Dissolved oxygen (mg L ⁻¹)
Mean	28.77	31.91	8.66	7.67
Max	30.37	33.79	9.07	8.55
Min	28.00	29.51	8.10	6.25
Sd	0.64	1.12	0.23	0.51
N	18.00	18.00	18.00	18.00

trials, all the daily water parameters of the larvae rearing culture media were maintained at 30 ppt for salinity, 30°C for temperature, 8-8.7 for pH and >6 mg L⁻¹ for dissolved oxygen. Three phase thermostat water heater was used to maintain the daily water culture medium temperature 30°C. The results show that all the mean daily water parameter reading of the larvae culture medium was more than the minimum range required (Table 5). However, it was also recorded that some of the mean daily water parameter reading excess the maximum constant water parameter variables as in Table 3. The Mean±SD (range; sample No.) of the mean daily water parameter reading through the study trial were 28.77°C±0.64 (range = 28.00-30.37°C; n = 36) for temperature, 31.91 ppt±1.12 (range = 29.51-33.79 ppt; n = 36) for salinity, 8.66±0.23 (range = 8.10-9.07; n = 36) for pH and 7.67 mg L⁻¹±0.51 (range = 6.25-8.55 mg L⁻¹; n = 36) for dissolved oxygen (Table 5). As compare to the water culture medium parameter maintained throughout the study trials as in Table 3, only mean daily water parameter reading throughout the study trials for salinity as in Table 5 excess the maximum constant water parameter variables. This may due to high water salinity reading during the dryer months of the off-monsoon season.

Growth of crab larvae: The results of the present study shows that the zoea reached the megalopa stage among 11-13 days; most zoea reached the megalopa stage at day 12 (64.29%) (Table 6). However, for the zoea to reached the C1 stages was among 16-17 days; most zoea reached the C1 stage at day 17 (92.86%) (Table 6). The above results are based on the mean daily water parameter reading through the study trial at 28.77°C for temperature, 31.91 ppt for salinity, 8.66 for pH and 7.67 mg L⁻¹ for dissolved oxygen (Table 5).

Table 6: Number of days for *P. pelagicus* crab larvae reached megalopa and C1 stages from 18 experiment replicates of six larvae rearing batches with three replicates each of the study trial

No. of days for crab larvae to reached megalopa and C1 stages	Frequency of crab larvae rearing replicates reached megalopa stage (%)	Frequency of crab larvae rearing replicates reached C1 stage (%)
11 days (megalopa)	1 (7.14)	-
12 days (megalopa)	9 (64.29)	-
13 days (megalopa)	4 (28.57)	-
16 days (C1)	-	1 (7.14)
17 days (C1)	-	13 (92.86)
Total	14 (100.00)	14 (100.00)

DISCUSSION

The study shows that zoea fed with rotifer alone had a high survival between 75.23-91.60% (larvae rearing replicate No. 4a, c) in the early zoea stage (zoea 1 stage) but this type of food was not enough to sustain survival in the next zoea stages and to promote metamorphosis up to megalopa stage. Low survival on larvae fed purely with rotifers was also analyzed on other portunid crabs. Studies by Baylon and Failaman (1997) and Zeng and Li (1999) on mud crab, *S. serrata* larvae, show that there was high survival at early zoeal stages when fed with rotifers alone but the larvae failed to develop to megalopa. The results convinced that the nutrients provided by a rotifer diet generally appear to be inadequate to meet the nutritional compulsions of larvae to sustain survival and development up to the megalopa stage. This was clearly demonstrated by Barreto and Cabalcanti (1997) where high mortalities in crustacean larval rearing is attributed to deficiency in highly unsaturated fatty acid (n-3 HUFA) such as eicosapentaenoic acid (20:5n3-EPA) and docosahexaenoic acid (22:6n3-DHA). These essential fatty acids could be obtained by the crab larvae through enrichment of prey organisms. In this present study, rotifers were not enriched and if rotifers were enriched before feeding, survival and development might be improved. Hamasaki *et al.* (1998) also recommended that the enrichment of rotifers should be a routine technique in culture of the Japanese swimming crab, *P. trituberculatus*.

Survival of zoea fed with *Artemia* nauplii alone was very low in the early zoea stage (zoea 1 stage) where mass mortality occurred within day 2 to day 3 (larvae rearing replicate No. 6a, b) and this shows that this type of food is not suitable for the very early zoea stages. Baylon *et al.* (2004) showed that on the ingestion of *Artemia* nauplii by mud crab, *S. serrata* larvae, although the zoea larvae of *S. serrata* were unable to consume the entire *Artemia* nauplius, they were able to ingest bits and pieces of the body, specifically the head and the appendages. The heavy mortalities that took place during each metamorphosis zoea larvae stages of *P. pelagicus* in the present study may show that the diet of *Artemia* nauplii alone could not provide the nutrients required for postmolt.

However, all the zoea feed with a combination of rotifer and *Artemia* nauplii only (larvae rearing replicate No. 2, 3 and 5) resulted in the production of 1st day juvenile crab (C1). Study on mangrove crab (*S. serrata*) larvae shows that combined nutritional content of these two types of food complement each other (Baylon and Failaman, 1999). This combination hence promoting survival and metamorphosis to the next zoea stage up to C1. The results of the present study concluded that a combination diet of rotifer and *Artemia* nauplii is ideal for rearing of *P. pelagicus* with rotifer is recommended for use at early zoea stage (zoea 1 to zoea 2) and *Artemia* nauplii is recommended for use at late zoea stage (zoea 3 to zoea 4) till the C1 stage. This is also clearly demonstrated by Li *et al.* (1999), Zeng and Li (1999) and Nguyen and Truong (2004) on mud crab

(*S. paramamosain*), by Baylon and Failaman (1997) on mud crab (*S. serrata*) and by Baylon (2009) on mud crab (*S. tranquebarica*) where rotifer is a suitable diet for early larval development and *Artemia* nauplii proved to be a good diet for later zoea. Rho (1976) also found that for the Z1 and Z2 stages of the Japanese blue swimming crab, *P. trituberculatus*, rotifer was efficient as food in the early zoea stages but for the 3rd to 5th zoea stages, *Artemia* nauplii was a more efficient feed. Godfred *et al.* (1997) reported that in the portunid crab, *Thalamita crenata*, Z1-Z2 larvae had highest survival when fed with rotifer alone but later stages (Z3-Z5) showed better survival and development on a *Artemia*-rotifer combination. Works by Sulkin (1975) also has the similar results where he obtained 30% metamorphosis to megalopa of the blue crab, *Callinectes sapidus* larvae raised on a diet of rotifer at Z1 and Z2, followed by *Artemia* nauplii.

Larvae rearing of *P. pelagicus* were also carried out to find out if adding mixed diatom on the culture water would improve survival of the crab larvae from zoea 1 stage up to C1, using rotifer and *Artemia* as the main food items (larvae rearing replicate No. 1). It has been reported that phytoplankton added to the culture water seemed to have a 'beneficial' affect in larval fish cultures in terms of survival by releasing oxygen into and removing certain metabolites like ammonia, from the culture medium (Baylon and Failaman, 1999). This can also be seen from mangrove crab (*S. serrata*) larvae rearing which produced maximum larval survival up to 41% by adding *Chlorella* and antibiotics to culture media (Brick, 1974). It was even suggested that phytoplankton also releases antibiotic substance into the culture medium (Baylon and Failaman, 1999). The results of the present study also shows that there are no significant different in larval survival till C1, in treatments with and without diatom (larvae rearing replicate No. 1 and 2). The results of the present study concluded that the adding of phytoplankton (i.e., diatom) to larvae rearing system where rotifer and *Artemia* nauplii is main food items did not produced high survival rate as compared to larvae rearing fed on rotifer and *Artemia* nauplii alone.

The results of the present study demonstrated that the food types not only affect survival rate but also the growth of crab larvae (i.e., moult times). These are also supported by other studies on mangrove crab species (Quinitio *et al.*, 1999; Baylon and Failaman, 1999; Nguyen and Truong, 2004). Nguyen and Truong (2004) showed that the food types affect both the survival rate and growth of mangrove crab larvae (*S. paramamosain*). Study by Quinitio *et al.* (1999) shows that the supplementation of artificial diets not only could improve the survival but also the growth of the mangrove crab larvae (*S. serrata*). Study by Baylon and Failaman (1999) on rotifer and *Artemia* nauplii as food for zoea of the mangrove crab larvae (*S. serrata*) produced high metamorphosis to megalopa (56%) and the shortest time to produce megalopa (17 days from hatching).

Food type influenced survival, development and metamorphosis to megalopa and C1 of *P. pelagicus* zoea larvae. The best survival, the most rapid development and the highest number of C1 produced were obtained from larvae fed with a combination diet of rotifers and *Artemia* nauplii from hatching till C1. The present study generally concluded that the combination diet of rotifer and *Artemia* nauplii alone is enough to produced C1 as compared by adding mixed diatom to the culture rearing system.

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