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Ingestion Rates of *Brachionus* sp. and *Artemia* sp. Nauplii by Blue Swimming Crab, *Portunus pelagicus* (Linnaeus, 1758) Larvae

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ABSTRACT

The experiment was conducted to determine the ingestion rate of *Artemia* sp. nauplii and *Brachionus* sp. by individual blue swimming crab, *Portunus pelagicus* larvae from zoea 1 until megalopa stages after 24 h. The study also to determined, if the presence of *Brachionus* sp. influences the ingestion of *Artemia* sp. nauplii by the individual *P. pelagicus* larvae. This involved three different feeding treatments, with *Artemia* sp. nauplii only (Treatment 1), *Brachionus* sp. only (Treatment 2) and with both *Artemia* sp. nauplii and *Brachionus* sp. (Treatment 3) in culture tank. Results indicates that ingestion rates of *Artemia* sp. nauplii and *Brachionus* sp. after 24 h by *P. pelagicus* larvae are 0 *Artemia* sp. nauplii and 35-36 *Brachionus* sp. for zoea 1, 1-2 *Artemia* sp. nauplii and 37-38 *Brachionus* sp. for zoea 2; 8-15 *Artemia* sp. nauplii and 38-40 *Brachionus* sp. for zoea 3; 12-18 *Artemia* sp. nauplii and 27-37 *Brachionus* sp. for zoea 4 stage; and finally 32-35 *Artemia* sp. nauplii and 16-30 *Brachionus* sp. for Megalopa stages. The individual *P. pelagicus* larvae ingested more *Artemia* sp. nauplii during the late larval stages (zoea 3, zoea 4 and megalopa stage) as compared to the initial larval stages (zoea 1 and zoea 2) but ingested more *Brachionus* sp. during the initial larval stages compared to the late larval stages. However, the presence of *Brachionus* sp. did not influence the consumption of *Artemia* sp. nauplii by the individual *P. pelagicus* larvae at each larval stage.

Key words: *Artemia* sp. nauplii, *Brachionus* sp., blue swimming crab, ingestion rate, *Portunus pelagicus* larvae

INTRODUCTION

Blue swimming crabs, *Portunus pelagicus* also known locally as 'ketam bunga' or 'ketam renjong' is an important source of income for fishermen in the Malaysia. The high price and increased demands among community contribute to over-exploitation in capture production of *P. pelagicus* (Sounndarapandian and Dey, 2008). This decline due to over-exploitation has an impact in the total productions of *P. pelagicus* in some Asian countries (Ikhwanuddin *et al.*, 2005). In Malaysia, statistics from Department of Fisheries (DOF) shows that the landings of *P. pelagicus* is 3514 tons in 2007 and increase to 4427 tons in 2008 but the landings are decreasing in 2009 with 3057 tons (Department of Fisheries, 2009). These declines of crab's production in Malaysia territorial water act as an early indication of deficiency in the future because increasing of fishing and coastal environmental damages.

P. pelagicus is distributed and available throughout coastal waters of the tropical regions of the western Indian Ocean and the eastern Pacific (Xiao and Kumar, 2004; Bhat *et al.,* 2011; Talpur *et al.,* 2011) and also considered as an invasive swimming crab (Archdale *et al.,* 2010). The culture and potential culture of the large *Portunus* species such as *P. pelagicus* and *P. sanguinolentus* (Soundarapandian and Singh, 2008; Soundarapandian and Raja, 2008), *Charybdis feriatus* and the more temperate *P. trituberculatus* are evaluated for stock enhancement potential criteria (Williams and Primavera, 2001). *P. pelagicus* is the most abundant species in Malaysia. However, *P. pelagicus* survival rate is very low and it about 10.1% until 1st day juvenile crab (Ikhwanuddin *et al.,* 2005). For further aquaculture industry development, commercial seed production technology should be reviewed to increase survival rate, durability, quality and efficiency (Talpur *et al.,* 2012). Study on water quality, phytoplankton and food organisms by Brick (1974), use of recirculation system (Heasman and Fielder, 1983), amount and different diet combinations (Baylon and Failaman, 1999; Quinitio *et al.,* 1999; Williams *et al.,* 1999; Zeng and Li, 1999; Genodepa *et al.,* 2006) and salinity tolerance (Parado-Estepa and Quinitio, 1999) have been conducted on a small-scale on portunid crabs but need further research to enhance the information in *P. pelagicus*. Many countries like Japan, Philippines, India, Indonesia, Thailand, Bangladesh, Vietnam, Australia and USA are actively involved in crab culture and research (Soundarapandian *et al.,* 2007). Based on the previous research, most of these studies focused on basic of fecundity, embryology, survival rate and growth development of crab larvae in order to increase crab seed production (Arshad *et al.,* 2006) but no information about ingestion of food especially for *P. pelagicus* larvae culture. Thus, more information on culture techniques is required to develop a suitable ingestion rate for larval rearing in *P. pelagicus*.

The previous studies have done on feeding of crab larvae with a combination of *Brachionus* sp. and *Artemia* sp. nauplii, *Artemia* sp. nauplii or *Brachionus* sp. alone (Baylon *et al.,* 2004; Suprayudi *et al.,* 2002; Baylon, 2009). Zoea I and II was fed with live food such as *Chaetoceros* sp. and *Brachionus* sp. (Ikhwanuddin *et al.,* 2012). According to Ikhwanuddin *et al.* (2012), *Brachionus* sp. and *Artemia* sp. nauplii was given to zoea III and IV. The cladoceran, *Moina micrura* and prawn-egg custard as well as *Artemia* sp. nauplii and bivalve meat (Soundarapandian *et al.,* 2007) was provided during Megalopa stage.

In order to determine the optimum ingestion rate and feeding regimes to maximize survival rate in the larval rearing, this study had the following objectives; to find out optimum density of *Brachionus* sp. for each larval stage and to find out optimum density of *Artemia* sp. nauplii for each zoea stages and megalopa stage. The use of *Brachionus* sp. and *Artemia* sp. nauplii in the larval diet can be minimized, then substantial savings in food cost can be achieved to produce mass production of *P. pelagicus* larvae.

MATERIALS AND METHODS

Broodstocks management: Gravid broodstocks were brought from Gelang Patah, Johor, Malaysia. Then, gravid broodstocks were placed inside 100 L fiberglass tank with 1 gravid crab per tank and was filled with filtered seawater. Constant aeration was supplied during rearing of gravid broodstock until crabs hatching. Three centimeters thick of sand in tray was placed at center part of culture tank for egg hatching. Filtered seawater was exchanged 50% in every gravid crab tank at every morning and water parameters was maintained at 30 ppt salinity, 27-28°C temperature, pH 7-7.9 and more than 5 ppm Dissolved Oxygen (DO). Gravid broodstocks were monitored daily. They were fed with fresh squid. Once the eggs were hatched, water in broodstocks tank was

reduced to 50 L. Immediately broodstock was separated from new hatched larvae and placed into another tank.

Larvae management: Actively swimming larvae accumulated near the water surface were siphoned out by plastic tube into larval rearing tank (10 L tank capacity) that filled with 7.5 L of filtered seawater. Constant and slow aeration rate was supplied inside larval rearing tank. Crab larvae were stocked at a density of 50 zoea L^{-1} and placed inside larval rearing tank that covered with dark colour paint to avoid illumination. During larval rearing, every stages of crab larval must be observed under profile projector after daily fed larvae with *Brachionus* sp. as well as *Artemia* sp. nauplii.

Water quality management: Filtered seawater in 1 tons of tank was treated by using 30 ppm of Calcium hypochlorite and aerated within 24 h. After 24 h, seawater was neutralized with sodium thiosulphate at 15 ppm within 12-24 h. Then, treated seawater was siphoned into larval rearing tank for about 7.5 L for larval rearing. Water in plastic tube was monitored daily to measure pH, salinity, temperature and DO level of cultured water by using YSI Multi-parameter Probe (Model: YSI 556 MPS) and Hand Refractometer.

Experimental design: Three aquarium tanks (5 L) was set up in the experiment which the centrifuge tubes were placed where the larvae are fed with *Artemia* sp. nauplii only (Treatment 1/T1), *Brachionus* sp. only (Treatment 2/T2) and with both *Artemia* sp. nauplii and *Brachionus* sp. (Treatment 3/T3). Every aquarium tanks was equipped with 20 pieces of centrifuge tubes (ten replicates each for control and treatment). Small holes were perforated at the bottom side of aquarium tanks so that filtered seawater would enable engulfing 1/3 of bottom part of aquarium tanks. Figure 1 below shows the arrangement of the tubes and the 5 L aquarium tanks.

In the experiment, 50 mL of centrifuge tubes were filled with 40 mL of filtered seawater at salinity 28-30 ppt. One individual of crab larvae was taken from master culture tank and gently pipette into three treatments tubes; T1 (*Brachionus* sp.), T2 (*Artemia* sp. nauplii only) and T3 (*Artemia* sp. nauplii and *Brachionus* sp.). Ten control tubes in every tank are without crab larvae. The experiment was conducted from zoea I until megalopa stage. Twenty tubes in T1 were inoculated with *Brachionus* sp. (50 individual/tubes). For T2, 50 individual/tubes of *Artemia* sp. nauplii were inoculated in every ten centrifuge tubes. At the same time T3, 50 individual of *Brachionus* sp. and 50 individual of *Artemia* sp. nauplii were inoculated in ten centrifuge tubes of combination *Artemia* sp. nauplii and *Brachionus* sp. A number of live feed that was inoculated in all centrifuge tubes was remained from zoea I until Megalopa stages. A vigorous aeration was

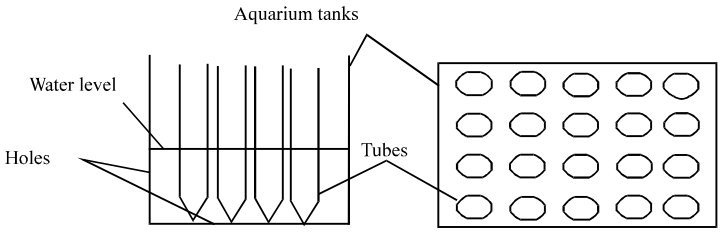

Fig. 1: Side view and upper view of the aquarium tank and the tubes

supplied in all centrifuge tubes. Water heater is used in batch culture system to control water temperature fluctuations (28-30°C). A number of preys ingested within 24 h were determined for each treatment. After 24 h, aeration in all centrifuge tubes was being stopped. All centrifuge tubes were brought to laboratory for calculation step. Seawater mixed with prey left in centrifuge tubes was filtered by using seine 40 μm (one by one). Immediately pipette filtered preys (*Brachionus* sp. or *Artemia* sp. nauplii) and all preys were placed on Sedgewick-Rafter counting chamber.

Brachionus sp. and *Artemia* sp. nauplii were first immobilized with iodine solution before being counted under the microscope. This number was labeled as final number of preys left in centrifuge tubes after 24 h. A possibility for unhatched *Artemia* sp. cysts to hatch and *Brachionus* sp. to reproduce might happen within 24 h of experimental period. Hence, the mean number of prey (*Artemia* sp. nauplii and *Brachionus* sp.) consumed by individual crab larvae was calculated by using the mean density of prey left in the control after 24 h as the initial number of prey organisms present in the experimental culture water. The formula shows as below:

$$\text{Mean No. of prey consumed by individual crab larvae after 24 h} = \text{Mean No. of prey (left without any crab larvae)} - \text{Final No. of preys (left in centrifuge tubes after 24 h)}$$

This step was followed for all aquarium tanks of T1 (*Brachionus* sp. only), T2 (*Artemia* sp. nauplii only) and T3 (combination *Artemia* sp. nauplii and *Brachionus* sp.) in every larval stage (zoea I until Megalopa stages). Different stages of crab larvae were also observed under profile projector and described based on Arshad *et al.* (2006).

Statistical analysis: In the experiment, two statistical analyses were performed by using Microsoft Excel 2007 and Independent-Samples t-test analysis using SPSS version 16.0 was used to determine the comparison mean number of *Artemia* sp. nauplii ingested by individual crab larvae with and without *Brachionus* sp. in *Artemia* sp. nauplii only-combination *Artemia* sp. nauplii and *Brachionus* sp. All results will be presented as means±SD. The difference will be displayed as statistically significant when $p<0.05$.

RESULTS

The data on *Brachionus* sp. ingested by individual crab larvae in treatment 1 (*Brachionus* sp. only) tank has been showed on Table 1. During zoea 1, there were 34.8 individuals of *Brachionus* sp. ingested by individual crab larvae. One crab larvae able to consumer at mean 37 individual of *Brachionus* sp. during zoea 2 stage, 40 individuals of *Brachionus* sp. ingested at zoea 3 stage, 37.4 individuals of *Brachionus* sp. ingested at zoea 4 stage and 29.6 individuals at Megalopa stage.

For T2 (*Artemia* sp. nauplii only), during zoea 1, there was no individual of *Artemia* sp. nauplii ingested by individual crab larvae. For zoea 2, one crab larvae was able to consume about 1.8 individual of *Artemia* sp. nauplii. Meanwhile, during stage zoea 3, 14.8 individuals of *Artemia* sp. nauplii ingested by one crab larvae, 17.8 individuals of *Artemia* sp. nauplii on stage zoea 4 and 34.7 individuals of *Artemia* sp. nauplii on stage Megalopa has been showed on Table 2.

Based on Table 3 for T3 (combination *Artemia* sp. nauplii and *Brachionus* sp.), during zoea 1 stage, there were 0 individual *Artemia* sp. nauplii and 36.1 individuals of *Brachionus* sp. ingested by individual crab larvae, feeding with both *Artemia* sp. nauplii and *Brachionus* sp. For zoea 2, individual crab larvae consumes at about 0.9 individual *Artemia* sp. nauplii and 38.1 individuals of B*rachionus* sp., 8.1 individual of *Artemia* sp. nauplii and 38.3 individuals of *Brachionus* sp.

Table 1: *Brachionus* sp. ingested by individual crab larvae after 24 h from zoea 1 until Megalopa stages

	Control (without larvae crab)										*Brachionus* sp.
Larvae stage	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	MC
Zoea 1	51	44	51	54	52	54	48	48	49	48	49.9
Zoea 2	47	52	43	49	49	51	55	55	55	54	51.0
Zoea 3	53	53	51	48	50	54	54	45	51	46	50.5
Zoea 4	49	52	47	51	58	51	53	47	47	47	50.2
Megalopa	55	53	51	55	48	45	49	46	49	48	49.9

	Treatment 1 (*Brachionus* sp. only)										*Brachionus* sp. ingested/larvae	
Larvae stage	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	MT	MC-MT
Zoea 1	17	14	16	17	12	19	20	14	12	10	15.1	34.8
Zoea 2	14	15	14	15	18	16	10	10	16	12	14.0	37
Zoea 3	12	11	10	8	8	10	14	14	10	8	10.5	40
Zoea 4	15	15	11	12	15	11	17	10	10	12	12.8	37.4
Megalopa	22	20	20	24	18	22	20	19	21	17	20.3	29.6

MC: Mean No. *Brachionus* sp. left in the control without any crab larvae after 24 h, -MT: Mean No. *Brachionus* sp. left in the treatment with individual crab larvae after 24 h

Table 2: *Artemia* sp. nauplii ingested by individual crab larvae after 24 h from zoea 1 until Megalopa stages

	Control (without larvae crab)										*Artemia* sp. nauplii
Larvae stage	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	MC
Zoea 1	50	48	50	49	49	50	50	50	49	50	49.5
Zoea 2	50	50	50	50	50	50	50	49	49	50	49.8
Zoea 3	49	49	49	50	50	50	50	48	48	50	49.3
Zoea 4	49	50	47	50	50	50	50	49	49	47	49.1
Megalopa	48	48	50	50	48	49	49	50	49	50	49.1

	Treatment 2 (*Artemia* only sp. nauplii only)										*Artemia* sp. nauplii ingested/larvae	
Larvae stage	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	MT	MC-MT
Zoea 1	50	50	50	50	50	50	50	50	50	50	50.0	0.0
Zoea 2	48	49	48	47	48	48	47	49	48	48	48.0	1.8
Zoea 3	35	34	34	33	35	32	36	35	35	36	34.5	14.8
Zoea 4	34	32	31	33	34	28	28	32	31	30	313.0	17.8
Megalopa	15	14	12	14	16	16	12	15	16	14	144.0	34.7

MC: Mean No. *Artemia* sp. nauplii left in the control without any crab larvae after 24 h, -MT: Mean No. *Artemia* sp. nauplii left in the treatment with individual crab larvae after 24 h

ingested by crab larvae during zoea 3. For zoea 4, 27.1 individuals of *Artemia* sp. nauplii and 27.1 individuals of *Brachionus* sp. ingested meanwhile 32.4 individuals of *Artemia* sp. nauplii and 16.4 individuals of *Brachionus* sp. during Megalopa.

Based on Table 3, individual crab larvae mostly preferred to ingest *Brachionus* sp. during initial life of larval stage while at the last stage of larval development, *Artemia* sp. nauplii was the most selected prey. Based on Table 3, individual crab larvae mostly preferred to ingest *Brachionus* sp. during initial life of larval stage while at the last stage of larval development, *Artemia* sp. nauplii was the most selected prey. Based on the Fig. 2, there was no significant ($p>0.05$) between the

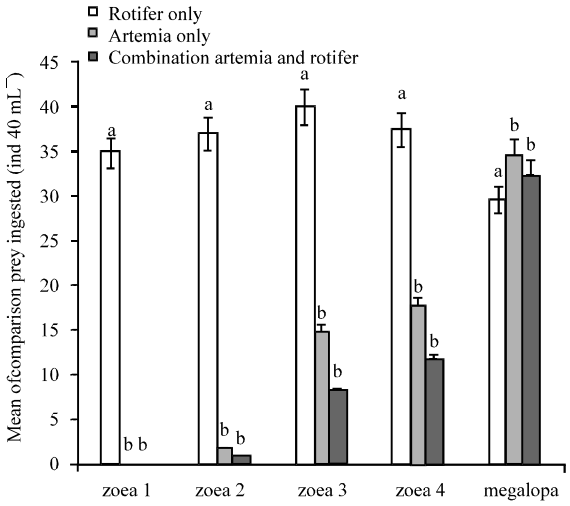

Fig. 2: Mean of comparison treatment 1 (*Brachionus* sp. only), treatment 2 (*Artemia* sp. nauplii only), treatment 3 (combination *Artemia* nauplii and *Brachionus* sp.) ingested by individual crab larvae after 24 h from zoea 1 until Megalopa stages which feeding with *Artemia* sp. nauplii and *Brachionus* sp.

Table 3: *Brachionus* sp. ingested by individual crab larvae after 24 h from zoea 1 until megalopa stages, feeding with both *Artemia* sp. nauplii and *Brachionus* sp.

	Treatment 3 (combination *Artemia* sp. nauplii and *Brachionus* sp.)										*Brachionus* sp. ingested/larvae	
Larvae stage	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	MT	MC-MT
Zoea 1	13	17	15	12	15	13	12	16	13	12	13.8	36.1
Zoea 2	16	14	13	10	13	10	15	14	13	11	12.9	38.1
Zoea 3	14	11	12	12	11	13	14	13	12	10	12.2	38.3
Zoea 4	20	22	24	25	24	22	25	20	24	25	23.1	27.1
Megalopa	35	34	32	30	34	36	34	33	35	32	33.5	16.4

MC: Mean No. *Brachionus* sp. left in the control without any crab larvae after 24 h, -MT: Mean No. *Brachionus* sp. left in the treatment with individual crab larvae after 24 h

Table 4: *Artemia* sp. nauplii ingested by individual crab larvae after 24 h from zoea 1 until megalopa stages, feeding with both *Artemia* sp. nauplii and *Brachionus* sp.

	Treatment 3 (combination *Artemia* sp. nauplii and Brachionus sp.)										*Artemia* sp. nauplii ingested/larvae	
Larvae stage	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	MT	MC-MT
Zoea 1	50	49	49	50	50	50	50	50	50	49	49.7	0
Zoea 2	49	48	50	50	48	49	49	48	48	50	48.9	0.9
Zoea 3	43	41	42	39	39	42	42	44	40	40	41.2	8.1
Zoea 4	37	38	39	39	38	35	38	36	40	35	37.5	11.6
Megalopa	19	16	16	17	14	15	15	18	18	19	16.7	32.4

MC: Mean No. *Artemia* sp. nauplii left in the control without any crab larvae after 24 h, -MT: Mean No. *Artemia* sp. nauplii left in the treatment with individual crab larvae after 24 h

mean numbers of T2 (*Artemia* sp. nauplii only) and T3 (combination *Artemia* sp. nauplii and *Brachionus* sp.) ingested by individual crab ($p = 0.0622$ for Z1; $p = 0.312$ for Z2; $p = 0.4753$ for

Table 5: Feeding regime for *Brachionus* sp and *Artemia* sp. nauplii in larvae rearing *P. pelagicus*

	Food intake			
Larvae	*Brachionus* sp.	Ind/larvae	*Artemia* nauplii sp.	Ind/larvae
Zoea 1	35-36	35.5	0	0.0
Zoea 2	37-38	37.5	1-2	01.5
Zoea 3	38-40	39	8-15	11.5
Zoea 4	27-37	32	12-18	15.0
Megalopa	16-30	23	32-35	33.5

Z3; p = 0.3463 for Z4). Meanwhile, there was no significant (p>0.05) between the mean numbers of T1 (*Brachionus* sp. only) ingested by individual crab feeding with T3 (combination *Artemia* sp. nauplii and *Brachionus* sp.) (p = 0.0561 for Z1; p = 0.6012 for Z2; p = 0.5753 for Z3; p = 0.47463 for Z4). The comparison was done for every zoea 1 until megalopa stages.

There was no significant different (p>0.05) in T3 where larval crab fed with both *Artemia* sp. nauplii and *Brachionus* sp. respectively as been showed in Table 4. The mean numbers of *Artemia* sp. nauplii ingested by individual crab larvae after 24 h are 0 individual/larvae, 0.9, 8.1, 11.6 and 32.4 individual/larvae for zoea 1, 2, 3 and megalopa stages, respectively in Table 4.

The number of *Brachionus* sp. ingested by the individual *P. pelagicus* larvae in each zoea stage are 35-36 individual/40 mL for zoea 1, 37-38 individual/40 mL for zoea 2 stage, 38-40 individual/40 mL for zoea 3 stage, 27-37 individual/40 mL for zoea 4 and 16-30 individual/40 mL for Megalopa has been showed on Table 5. The mean comparison for each treatment ingested by individual crab larvae after 24 h from zoea 1 until Megalopa stages are showed in Fig. 2. The amount of *Artemia* sp. nauplii to give feed for crab larvae at different larvae stages from zoea 1 until Megalopa stages are average 0 individual/40 mL for zoea 1 stage, 1-2 individual/40 mL for zoea 2 stage, 8-15 individual(s)/40 mL for zoea 3 stage, 12-18 individuals/40 mL for Z4 stage and 32-35 individuals/40 mL for Megalopa as shown in Fig. 2. The result showed that zoea 1 and zoea 2 ingested more *Brachionus* sp. rather than *Artemia* sp. nauplii and low ingestion of *Artemia* sp. nauplii found in zoea 3, zoea 4 and Megalopa stages. The introduction of both *Brachionus* sp. and *Artemia* sp. nauplii in feeding regime showed that the present of rotifer in cultured water did not influence the consumption of *Artemia* sp. nauplii from zoea 1 until Megalopa stages.

DISCUSSION

Individual ingestion of *Artemia* nauplii by larvae *Scylla paramamosain* found that, there was an average 15, 25 and 37 of *Artemia* nauplii consumed during Z3, Z4 and Z5 stages (Nghia, 2004). Study by Baylon *et al.* (2004), *Artemia* density of 2.5 mL^{-1} was comparable with 5.0 mL^{-1} by individual Z1, Z2 and Z3 stages of *Scylla serrata*. It shows that *Artemia* nauplii is ingested more *Artemia* nauplii in late larval stage compared to initial larval stage as same as these studies as shown in Table 5. An introduction of purely *Artemia* nauplii for about 4.0 individual/mL during zoea stage (zoea 1 until zoea 4 stages) increased the survival rate of crab larvae. According to Baylon (2009), until Z4 stage, more than 70% survival rate of *S. tranquebarica* after fed with purely *Artemia* nauplii. Most of Portunid crabs were unable to maintain their survival rate after been introduced with purely *Brachionus* sp. During initial life of crab (zoea stage), crab probably can survive but mortality occurred at the Megalopa stage (at the end of the larval stages). In the previous study, larvae of *S. serrata* was able to survive during initial zoea stage but later died

before reaching Megalopa stage (Baylon and Failaman, 1999; Zeng and Li, 1999). One of the problems is probably due to inadequate of nutrition content in *Brachionus* sp. According to McConaugha (1982), lower lipid content in *Brachionus* sp. that has been fed to *Rhithropanopeus harrisii* showed a difficult of metamorphosis process of crab larvae. The small size of *Brachionus* sp. (<100 μm) was disabling to be consumed until the whole life of crab's larval. This happened because, in larvae development, they are most likely attractive to active prey such as *Artemia* nauplii compare *Brachionus* sp. during increasing larvae stage. Hence, rotifer as the sole prey failed to maintain the survival rate of crab larvae as well as other cultured species.

The presence of both important lives feed such as *Artemia* nauplii and *Brachionus* sp. would gave a beneficial effect for the mass seed production of frog crab, *Ranina ranina* (Minagawa and Murano, 1993). In term of rapid development, studied on *Callinectes sapidus* larvae found that there was 30% of metamorphosis process to Megalopa stage after the introduction of both *Artemia* nauplii and *Brachionus* sp. (Sulkin, 1975). Furthermore, study by Godfred *et al.* (1997) shows that survival rate of *Thalamita crenata* Z1 until Z2 stages is higher when fed with *Brachionus* sp. alone while Z3 until Z5 stages fed with both *Artemia* nauplii and *Brachionus* sp. There was a significant reduction in the intake of *Brachionus* sp. with increasing consumption of *Artemia* in the early zoeal stages (Z1, Z2 and Z3 stages) but at later stages (Z4 and Z5 stages) the intake of *Artemia* was no longer affected by the presence of *Brachionus* sp (Baylon *et al.,* 2004). The different size between *Artemia* nauplii and *Brachionus* sp. shows that, individual crab larvae was more prefer on *Brachionus* sp. because of small size when introduced during initial larval stage than *Artemia* nauplii. High mortality of individual crab larvae occurred on treatment feeding with Artemia only as compared to feeding with *Artemia* and *Brachionus* sp.. Different types of prey that was introduced during rearing larvae probably influence the survival rate of individual crab larvae. In T2 (*Artemia* only) tank, although crab larvae unable to fed the whole body of *Artemia* nauplii but under the microscope, there are some body parts was consumed especially the head and appendages. Furthermore, *Artemia* nauplii are the bigger size and higher swimming speed than *Brachionus* sp.

When introduced at the first zoea stage, crab larvae may unable to catch *Artemia* nauplii and facing difficult in holding the prey against the mouthparts because the abdomen part was not well developed especially at the beginning of zoea stage. The function of the abdomen was important in prey capture, holding the prey against the mouthparts and prey graze (eat slowly) also applied to other carnivorous zoea. The abdomen part helped in catching prey and presses them against the mouthpart by the zoea of *Scylla serrata* (Ong, 1964).

CONCLUSION

The study concluded that the initial larval stages ingested low *Artemia* sp. nauplii rather than *Brachionus* sp. and high ingestion of *Artemia* sp. nauplii found in the late larval stages.

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REFERENCES

Archdale, M.V., C.P. Anasco and A. Nakagawa, 2010. Liftnets compare favorably with pots as harvesting fishing gear for invasive swimming crabs. J. Fish. Aquat. Sci., 5: 510-516.

Arshad, A., M.S.K. Efrizal and C.R. Saad, 2006. Study on fecundity, embryology and larval development of blue swimming crab *Portunus pelagicus* (Linnaeus, 1758) under laboratory conditions. Res. J. Fish. Hydrobiol., 1: 35-44.

Baylon, J.C. and A.N. Failaman, 1999. Larval rearing of the mud crab *Scylla serrta* in the Philippines. Proceedings of the International Scientific Forum on Mud Crab Aquaculture and Biology, April 21-24, 1997, Canberra, pp: 141-146.

Baylon, J.C., 2009. Appropriate food type, feeding schedule and Artemia density for the zoea larvae of the mud crab, *Scylla tranquebarica* (Crustacea:Decapoda:Portunidae). Aquaculture, 288: 190-195.

Baylon, J.C., M.E.A. Bravo and N.C. Maningo, 2004. Ingestion of *Brachionus plicatilis* and *Artemia salina* nauplii by mud crab *Scylla serrata* larvae. Aquacult. Res., 35: 62-70.

Bhat, B.A., S. Ravichandran and S.A. Allayie, 2011. Influence of the eyestalk hormones on the metabolism and ionic regulation of the Crab *Portunus pelagicus* (Lineaus, 1857). J. Biol. Sci., 11: 203-209.

Brick, R.W., 1974. Effects of water quality, antibiotics, phytoplankton and food on survival and development of larvae of *Scylla serrata*. Aquaculture, 3: 231-234.

Department of Fisheries, 2009. Fisheries Statistics of Malaysia in 2009. Fisheries Statistics of Malaysia, Fishery Economic Division, Malaysia, pp: 1-329.

Genodepa, J., P.C. Southgate and C. Zeng, 2006. Determining ingestion of microbound diet particles by mud crab, *Scylla serrata*, larvae. J. Fish. Aquatic Sci., 1: 244-252.

Godfred, J., A. Ravi and T. Kannupandi, 1997. Larval feed preference of the estuarine edible portunid crab *Thalamita crenata* (Laterille). Indian J. Fish., 44: 69-74.

Heasman, M.P. and D.R. Fielder, 1983. Laboratory spawning and mass rearing of the mangrove crab, *Scylla serrata* (Forskal), from first zoea to first crab stage. Aquaculture, 34: 303-316.

Ikhwanuddin, M., M.L. Shabidin and B. Khairulhayadi, 2005. The development of seed production technology of blue swimming crab, *Portunus pelagicus* in Sarawak. Proceeding of the Tropical Fish Aquaculture Conference, May 2-3, 2005, Kuala Terengganu, Malaysia, pp: 1-21.

Ikhwanuddin, M., M.N. Azra, Y.S. Yeong, A.B. Abol-Munafi and M.L. Shabdin, 2012. Live foods for juveniles production of blue swimming crab, *Portunus pelagicus* (Linnaeus, 1766). J. Fish. Aquat. Sci. (In Press).

McConaugha, J.R., 1982. Regulation of Crustacean morphogenesis in larvae of the mud crab, *Rhithropanopeus harrisii*. J. Exp. Zool., 223: 155-163.

Minagawa, M. and M. Murano, 1993. Effects of prey density on survival, feeding rate and development of zoeas of the red frog crab *Ranina ranina* (Crustacea: Decapoda: Ranindae). Aquaculture, 113: 91-100.

Nghia, T.T., 2004. Optimization of mud crab *Scylla paramamosain* larviculture in Vietnam. Ph.D. Thesis, Faculty of Agricultural and Applied Biological Sciences, Ghent University, Belgium.

Ong, K.S., 1964. The early developmental stages of *Scylla serrata* (Forskall) (Crustacea, Portunidae), reared in the laboratory. Proc. Indo-Pacific Fish. Counc., 11: 135-146.

Parado-Estepa, F.D. and E.T. Quinitio, 1999. Larval survival and megalops production of *Scylla* sp. at different salinities. Proceedings of Mud Crab Aquaculture and Biology Workshop, April 21-23, 1997, Darwin Northern Territory, Australia, pp: 174-177.

Quinitio, E.T., F. Parado-Estepa and V. Alava, 1999. Development of Hatchery Techniques for the Mud Crab *Scylla serrata* (Forskal): Comparison of Feeding Schemes. In: Mud Crab Aquaculture and Biology, Keenan, C.P. and A. Blackshaw (Eds.). ACIAR, Canberra, Australia, pp: 125-130.

Soundarapandian, P. and R.K. Singh, 2008. Biochemical composition of the eggs of commercially important crab *Portunus pelagicus* (Linnaeus). Int. J. Zool. Res., 4: 53-58.

Soundarapandian, P. and S.D.A. Raja, 2008. Fattening of the blue swimming crab *Portunus pelagicus* (Linnaeus). J. Fish. Aquatic Sci., 3: 97-101.

Soundarapandian, P., E. Thamizhazhagan and N.J. Samuel, 2007. Seed production of commercially important blue swimming crab *Portunus pelagicus* (Linnaeus). J. Fish. Aquatic Sci., 2: 302-309.

Sounndarapandian, P. and S.S. Dey, 2008. Proximate composition of the eggs of commercially important crab *Portunus sanguinolentus* (Herbst). J. Fish. Aquat. Sci., 3: 60-65.

Sulkin, S.D., 1975. The significance of diet in the growth and development of larvae of the blue crab, *Callinectes sapidus* Rathbun, under laboratory conditions. J. Exp. Mar. Biol. Ecol., 20: 119-135.

Suprayudi, M.A., T. Takeuchi, K. Hamasaki and J. Hirokawa, 2002. The effect of n-3HUFA content in rotifers on the development and survival of mud crab, *Scylla serrata*, larvae. Suisanzoshoku, 50: 205-212.

Talpur, A.D., A.J. Memon, M.I. Khan, M. Ikhwanuddin, M.M. Danish Daniel, A.B. Abol-Munafi 2011. A novel of Gut Pathogenic bacteria of blue swimming crab *Portunus pelagicus* (Linneaus, 1758) and pathogenicity of *Vibrio harveyi* a transmission agent in larval culture under hatchery conditions. Res. J. Applied Sci., 6: 116-127.

Talpur, A.D., A.J. Memon, M.I. Khan, M. Ikhwanuddin, M.M.D. Daniel and A.B. Abol-Munafi, 2012. Isolation and screening of lactic acid bacteria from the gut of blue swimming crab, *P. pelagicus*, an *in vitro* inhibition assay and small scale *in vivo* model for validation of isolates as probiotics. J. Fish. Aqua. Sci., 7: 1-28.

Williams, G.R., J. Wood and B. Dalliston, 1999. Mud Crab (*Scylla serrata*) Megalopa Larvae Exhibit high Survival Rates on Artemia-Based Diets. In: Mud Crab Aquaculture and Biology, Keenan, C.P. and A. Blackshaw (Eds.). Watson Ferguson and Co., Brisbane, Australia, pp: 131-137.

Williams, M. and J. Primavera, 2001. Choosing tropical portunid species for culture, domestication and stock enhancement in the Indo-Pacific. Asian Fish. Sci., 14: 121-142.

Xiao, Y. and M. Kumar, 2004. Sex ratio and probability of sexual maturity of females at size, of the blue swimmer crab *Portunus pelagicus* of southern Australia. Fish. Res., 68: 271-282.

Zeng, C. and S. Li, 1999. Effects of Density and Different Combinations of Diets on Survival, Development, Dry Weight and Chemical Composition of Larvae of the Mud Crab *Scylla paramamosain*. In: Mud Crab Aquaculture and Biology, Keenan, C.P. and A. Blackshaw (Eds.). Watson Ferguson and Co., Brisbane, Australia, pp: 159-166.