

Mortality Rate of Blue Swimming Crab (*Portunus pelagicus*) Caused by Cannibalism

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ABSTRACT

Cannibalism in blue swimming crab (*Portunus pelagicus*) raised under simulated earthen pond conditions in 1.5 x 2.5 m² concrete ponds at a density of 3 crabs/m² was studied. The experiments were conducted using a completely randomized design (CRD). Three models were used, namely crabs raised without plastic net fences and shelter (control), crabs raised individually in 0.5 x 0.6 m² plastic net fences at 12 fences/pond, and, crabs raised with 90° bent plastic plates (20 cm x 30 cm x 10 cm) as a shelter on pond bottom at 1 shelter/m², with three replications per model. Results showed that mortalities of crabs caused by cannibalism were 0.00-21.42, 0.00 and 0.00-9.39%, respectively. Mortality from other factors was 0.00-6.48% in all treatments. This study confirms that during 30 to 45 days of culture, cannibalism is the main factor causing high mortality of crabs, and that the shelter on pond bottom plays an important role in reducing cannibalism ($P<0.05$). However, after 90 days of culture, other factors outweighed cannibalism as the major cause of crab mortality.

Key words: blue swimming crab, *Portunus pelagicus*, cannibalism

INTRODUCTION

The blue swimming crab (*Portunus pelagicus* Linnaeus 1758), a commercially important species, is found throughout the tropics in the coastal waters of the western Indian and the eastern Pacific oceans (Xiao and Kumar, 2004). In Thailand, the blue swimming crabs are not only directly consumed by humans but also utilized as a raw material in the processing industry. They are caught in the Andaman Sea and

the Gulf of Thailand. Exportation of fresh, chilled or frozen crabs to the United States, Japan, Taiwan and other countries brings in multi-million dollar revenue for Thailand annually. In 2007, the production of blue swimming crabs was 24,200 tons, a decrease of 25.07% from that in 2003, and the downward trend is continuing (Department of Fisheries, 2010). Therefore, increasing the yield of blue swimming crabs is considered acceptable and would not pressure the wild stock or adversely affect the farmer's

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job stability. The current culture techniques in Thailand of breeding (Tanasomwang *et al.*, 2002; Kaoeian and Chindamaikul, 2004; Oniam *et al.*, 2009), nursing (Chutpoom and Tanasomwang, 2005; Tanasomwang *et al.*, 2006; Tanasomwang *et al.*, 2007) and raising (Kedmuean *et al.*, 2004; Thepphanich and Chumworrathayee, 2005; Thepphanich *et al.*, 2008) have encouraged farmers to raise blue swimming crab in old shrimp ponds. The method of raising blue swimming crab broodstock in earthen ponds is also well documented (Oniam *et al.* 2010). However, it still can not maintain farmer's income because of low productivity, especially in earthen ponds. Many researchers have reported that *P. pelagicus* in earthen ponds showed low productivity at 90-120 days (26.74-140.50 kg/1600 m² at harvest) due to a low survival rate (2.97-59.59%) (Kedmuean *et al.*, 2004; Thepphanich and Chumworrathayee, 2005; Thepphanich *et al.*, 2008). Therefore, the study of factors affecting the survival rate of blue swimming crab raised in earthen ponds remains necessary and is subject to study, particularly on cannibalistic behavior during the culture period.

Cannibalism is defined as the process of killing and consuming either all or part of an individual of the same species and is a behavioral trait, commonly observed in a wide variety of animals (Elgar and Crespi, 1992). Some species exhibiting this behavior include the black tiger shrimp, *Penaeus monodon* (Abdussamad and Thampany, 1994), the snow crab, *Chionoecetes opilio* (Lovrich and Sainte-Marie, 1997) and the dungeness crab, *Cancer magister* (Fernandez, 1999). The occurrence of cannibalism in aquaculture is of considerable concern and a major

problem. Maheswarudu *et al.* (2008) reported the factors contributing to low survival of crabs were Moulting Death Syndrome (MDS, death associated with moulting) and cannibalism. While MDS may have occurred in the ponds, cannibalism was the main factor affecting mortality. Therefore, control of cannibalism in the pond offers benefits in terms of reducing mortality and increasing economic returns. The objectives of this experiment were to estimate the level of cannibalism and the effect of shelters on cannibalism of blue swimming crab. The knowledge from the research will be useful for crab production, to further develop crab farming in Thailand and for a sustainable future for the crab farmers.

MATERIALS AND METHODS

Source of experimental crabs

Broodstock of female blue swimming crabs acquired from Klongwan Fisheries Research Station, Prachuapkhirikhan Provincied, were stocked in 200-L fiber glass tanks to allow them to release their eggs and hatch. No feed was given during this period. After hatching, crab larvae were transferred outdoors to 3,000-L concrete tanks for nursing at a density of 100 crabs/L. Newly hatched larvae were initially fed with rotifers (*Branchionus* sp.) and *Chaetoceros* sp. From the zoea II stage onwards they were fed with *Artemia* nauplii. Upon larval metamorphosis to the first crab stage they were fed with minced trash fish until the experiment commenced (Oniam *et al.*, 2010).

Experimental design and set-up

The experiments were conducted using a completely randomized design (CRD). The three treatments were as follows: raising crab without plastic net fence and shelter (control), raising crab individually in 0.5 x 0.6 m² plastic net fence at 12 fences/pond, and, raising crab with 90° of bent plastic plates (20 cm x 30 cm x 10 cm) as a shelter on pond bottom at a density of 1 shelter/m², with three replicates per treatment (Figure 1).

Crabs with a carapace width of 1.5-2.0 cm (about 45 days old) from the concrete nursing tanks were transferred to 1.5 x 2.5 m² concrete ponds, with soil substrates, at a density of 3 crabs/m². Crabs were fed with shrimp feed (Maheswarudu *et al.*, 2008; Thepphanich *et al.*, 2008). During the culture period of 1-30 days, crabs were fed with shrimp feed No. 2 at 10% of body weight per day. At 31-60 days, crabs were fed with shrimp feed No. 4, and at 61-120 days, crabs were fed with shrimp feed No. 5 at 5% of body weight per day, twice a day at 9:00 A.M. and 4:00 P.M. All crabs in each treatment were sampled to determine crab growth and survival rate every 15 days. Total mortality was calculated using the formula:

$$\text{Total mortality (TM, \%)} = 100 - \left(\frac{\text{SV}_t \times 100}{\text{ISV}_t} \right)$$

where SV_t = survival of crab culture period, ISV_t = initial survival of crab culture period, t = during 1-15, 16-30,... and 106-120 days of the culture period. Mortality composition during culture period due to cannibalism and other factors was calculated using the formula:

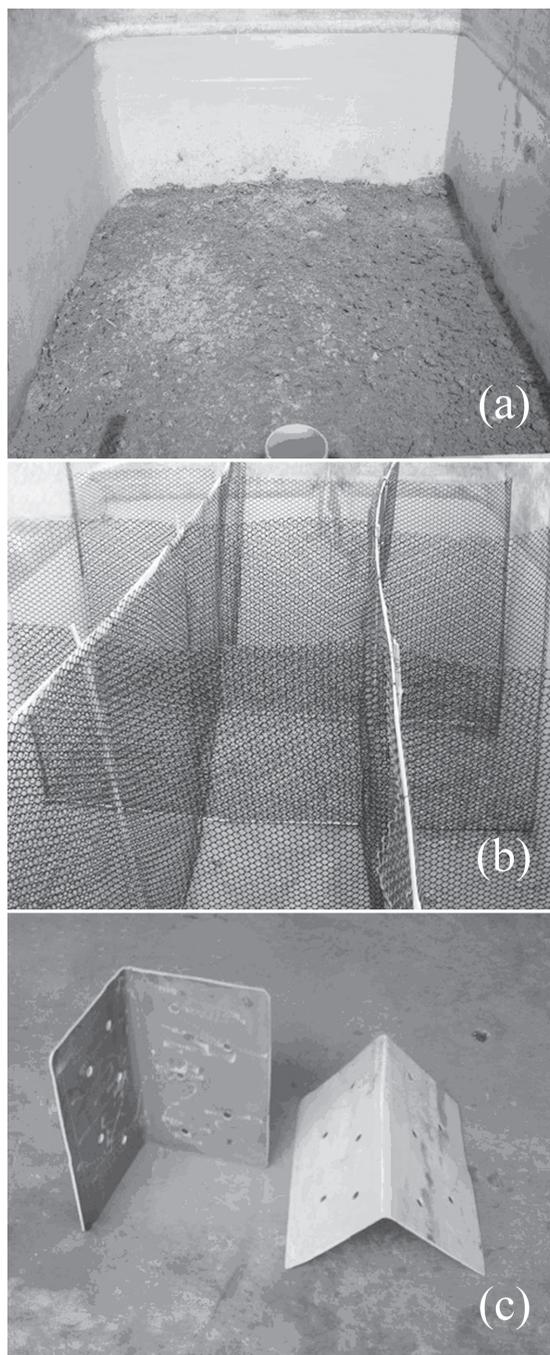


Figure 1. (a) the concrete tank with soil substrate, (b) 0.5 x 0.6 m² plastic net fence and (c) 90° bent plastic plates, as a shelter on pond bottom.

Mortality composition (%) = %C + %O

where %C = mortality of crab due to cannibalism (TM (%) of control or treatment 2 – TM(%) of treatment 1), %O = mortality of crab due to other factors.

During the culture period, 50% of the water volume was changed once a week. Water quality was analyzed twice a week. Salinity was measured by a Refractometer Prima tech, pH by pH meter Cyber Scan pH 11, temperature and dissolved oxygen concentrations (DO) by oxygen meter YSI 550A, total ammonia by Koroleff's Indophenol blue method, nitrite by Colorimetric method and alkalinity by titration method (APHA *et al.*, 1995).

Statistical analysis

At the end of the experiments, the data on crab growth, survival rate and total mortality were analyzed using Analysis of variance (ANOVA) and the difference between means was tested using Duncan's new multiple rang test (DMRT) at 95% level of confidence by the SPSS program.

RESULTS AND DISCUSSION

The study on cannibalism behavior of blue swimming crab (*P. pelagicus*) grown in earthen pond was conducted for 120 days. Optimum environmental conditions were maintained during the experimental culture period: salinity from 28 to 35 ppt, water temperature from 26.5 to 31.9°C, DO from 3.74 to 8.14 mg/l, pH from 7.4 to 7.7, total ammonia from 0.000 to 0.184 mg-N/l, nitrite from 0.000 to 0.208 mg-N/l and alkalinity

from 91 to 151 mg/l as CaCO₃. These parameters did not affect the growth and survival of *P. pelagicus*, as also reported by Lignot *et al.*, 2000, Romana and Zeng, 2006 and 2007, Maheswarudu *et al.*, 2008, and Oniam *et al.*, 2010. The average measurements of carapace width, body weight, survival rate and total mortality of the experimental crabs are shown in Table 1.

A summary of growth performance is presented in Table 1. There was no significant difference ($P>0.05$) among treatment growth performance of crab in terms of carapace width and body weight except survival rate and total mortality. In this study, growth performance of *P. pelagicus* raised under concrete pond conditions with soil substrate was similar to studies reported by Kedmuean *et al.* (2004), Thepphanich and Chumworrathayee (2005), Thepphanich *et al.* (2008) and Maheswarudu *et al.* (2008). Crabs in earthen ponds conditions had an average carapace width of 6.2-11.0 cm and an average body weight of 56.78-99.40 g for 90-120 days. This showed that the simulated earthen pond conditions in concrete ponds did not affect the growth of the crab. During 15 to 30 days culture period, the main cause of crab mortality was cannibalism. The rate of cannibalism in the control was between 2.78-8.58% while that of the systems with shelters on the pond bottom was between 3.02-5.56%. At 45 days post-stocking, average mortalities of crabs raised with plastic net and shelters on the pond bottom were not significantly different ($P>0.05$) from that of the control although they were significantly lower than the control ($P<0.05$). The mortality of normal control caused by cannibalism was 13.27% while it was 2.78% from other factors. At 60 days of culture,

Table 1. Crab growth, survival rate and total mortality of *P. pelagicus* raised under simulated earthen pond conditions (Mean±SD).

Culture period (days)	Control				Raised crab individually				Raised crabs with shelters on pond bottom			
	CW (cm)	BW (g)	SV (%)	TM (%)	CW (cm)	BW (g)	SV (%)	TM (%)	CW (cm)	BW (g)	SV (%)	TM (%)
Initial	1.80±0.23 ^a	0.50±0.16 ^a	100 ^a	0.00 ^a	1.80±0.23 ^a	0.50±0.16 ^a	100 ^a	0.00 ^a	1.86±0.20 ^a	0.55±0.15 ^a	100 ^a	0.00 ^a
15	3.27±0.61 ^a	7.94±1.58 ^a	97.22±4.81 ^a	2.78±4.81 ^a	3.14±0.49 ^a	7.44±0.77 ^a	100 ^a	0.00 ^a	3.50±0.30 ^a	9.48±1.18 ^a	94.44±4.81 ^a	5.56±4.81 ^a
30	4.41±0.21 ^a	20.85±1.80 ^a	88.88±4.80 ^a	8.58±0.43 ^a	4.30±0.24 ^a	19.01±2.02 ^a	100 ^b	0.00 ^b	4.32±0.14 ^a	17.58±1.44 ^a	91.66±8.33 ^{ab}	3.02±5.24 ^b
45	7.51±0.48 ^a	26.45±3.04 ^a	74.99±14.43 ^a	16.05±12.07 ^a	7.33±0.19 ^a	27.46±1.63 ^a	97.22±4.81 ^a	2.78±4.81 ^b	7.42±0.20 ^a	26.59±1.18 ^a	91.66±8.33 ^a	0.00 ^b
60	7.60±0.12 ^a	32.39±2.66 ^a	69.44±12.72 ^a	6.68±11.54 ^a	7.41±0.13 ^a	32.34±3.08 ^a	94.44±9.62 ^b	3.02±5.24 ^b	7.48±0.12 ^a	33.24±1.51 ^a	88.88±4.80 ^{ab}	2.78±4.81 ^a
75	8.19±0.27 ^a	44.12±4.05 ^a	52.77±12.72 ^a	21.42±25.75 ^{ab}	8.12±0.20 ^a	44.61±5.01 ^a	94.44±9.62 ^b	0.00 ^b	7.91±0.22 ^a	37.78±4.98 ^a	80.55±4.80 ^b	9.39±0.52 ^a
90	9.01±0.52 ^a	59.71±10.62 ^a	52.77±12.72 ^a	0.00 ^a	8.58±0.20 ^a	47.72±4.51 ^a	91.66±8.33 ^b	2.78±4.81 ^a	8.73±0.24 ^a	52.14±2.36 ^a	77.77±4.80 ^b	3.33±5.77 ^a
105	9.45±0.77 ^a	57.85±14.86 ^a	49.99±14.43 ^a	5.56±9.63 ^a	8.86±0.43 ^a	53.77±5.73 ^a	86.11±12.72 ^b	6.36±5.52 ^a	9.11±0.17 ^a	60.31±7.50 ^a	69.44±4.81 ^{ab}	10.74±0.64 ^a
120	10.33±0.43 ^a	75.68±14.92 ^a	47.21±17.34 ^a	6.66±11.54 ^a	9.20±0.41 ^a	60.62±6.06 ^a	80.55±12.72 ^a	6.48±5.78 ^a	10.02±0.23 ^a	74.13±9.56 ^a	58.33±8.33 ^a	15.73±13.70 ^a

Note : Data in the same row with different letters are significantly different (P<0.05).

CW = carapace width;

BW = body weight;

SV = survival rate;

TM = total mortality

average mortalities of each model were not significantly different ($P>0.05$). The mortality rate of crabs caused by cannibalism was between 0-3.66% while that from other factors was between 2.78-3.02%. At 75 days of culture, the average mortality in the control was not significantly different from that of the other systems ($P>0.05$). However crabs raised individually had a significantly lower mortality compared to crabs raised with shelters on pond bottom ($P<0.05$).

The cannibalism's decomposition rates in the control and in those raised with shelters on pond bottom were 21.42 and 9.39%, respectively. During 90, 105 and 120 days of culture, average mortalities in each treatment were not significantly different ($P>0.05$), with the cannibalism's decomposition between 0.18-9.25% and from other factors was between 2.78-6.48% (Table 1-2, Figures 2-3). The death characteristics of the crab due to cannibalism are shown in Figure 4.

Table 2. Mortality composition of the *P. pelagicus* during culture period under simulated earthen pond conditions.

Culture period (days)	Mortality composition (%)					
	Control		Raised crab individually		Raised crabs with shelters on pond bottom	
	cannibalism	other factors	cannibalism	other factors	cannibalism	other factors
15	2.78	0.00	0.00	0.00	5.56	0.00
30	8.58	0.00	0.00	0.00	3.02	0.00
45	13.27	2.78	0.00	2.78	0.00	0.00
60	3.66	3.02	0.00	3.02	0.00	2.78
75	21.42	0.00	0.00	0.00	9.39	0.00
90	0.00	0.00	0.00	2.78	0.55	2.78
105	0.00	5.56	0.00	6.36	4.38	6.36
120	0.18	6.48	0.00	6.48	9.25	6.48

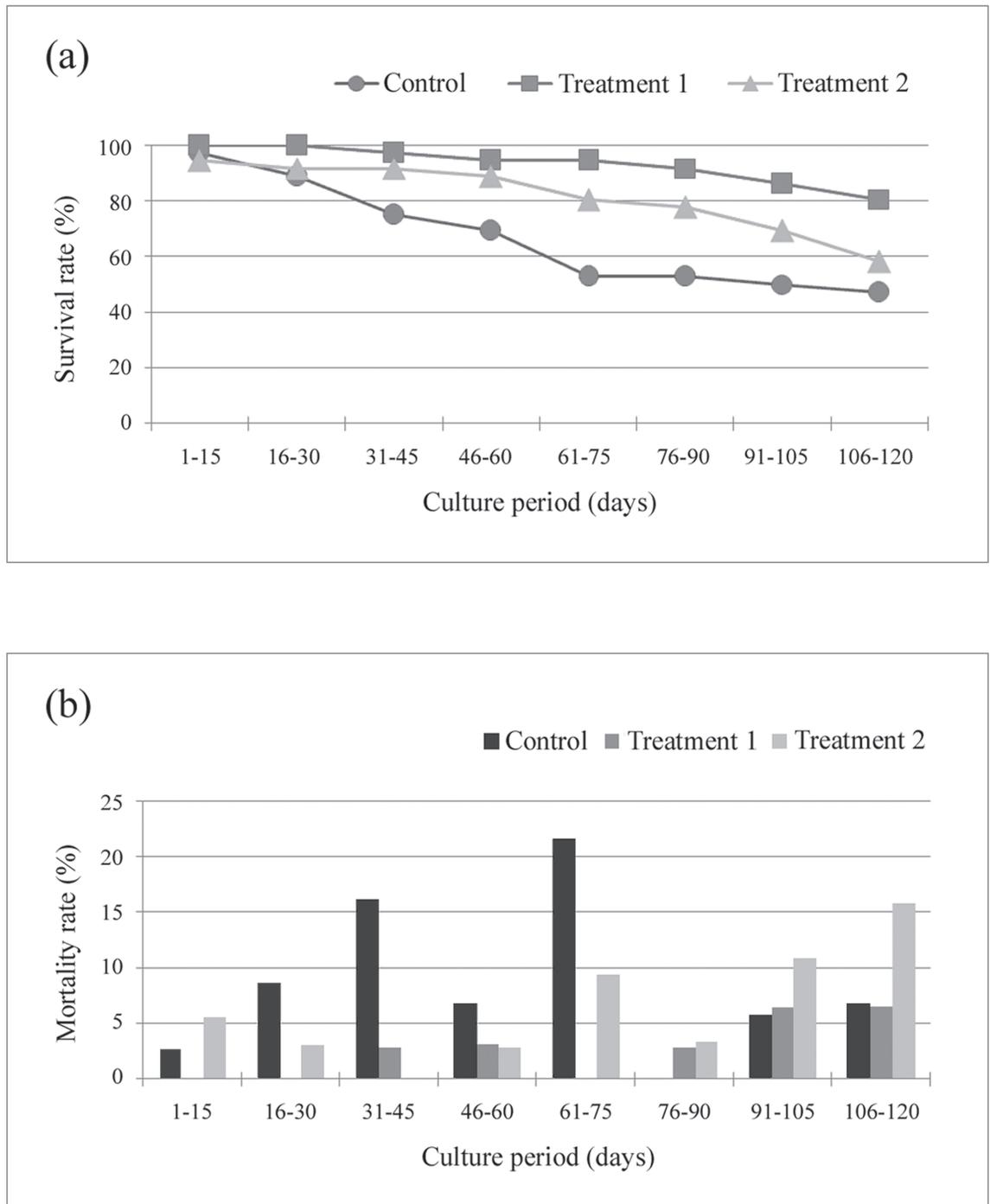
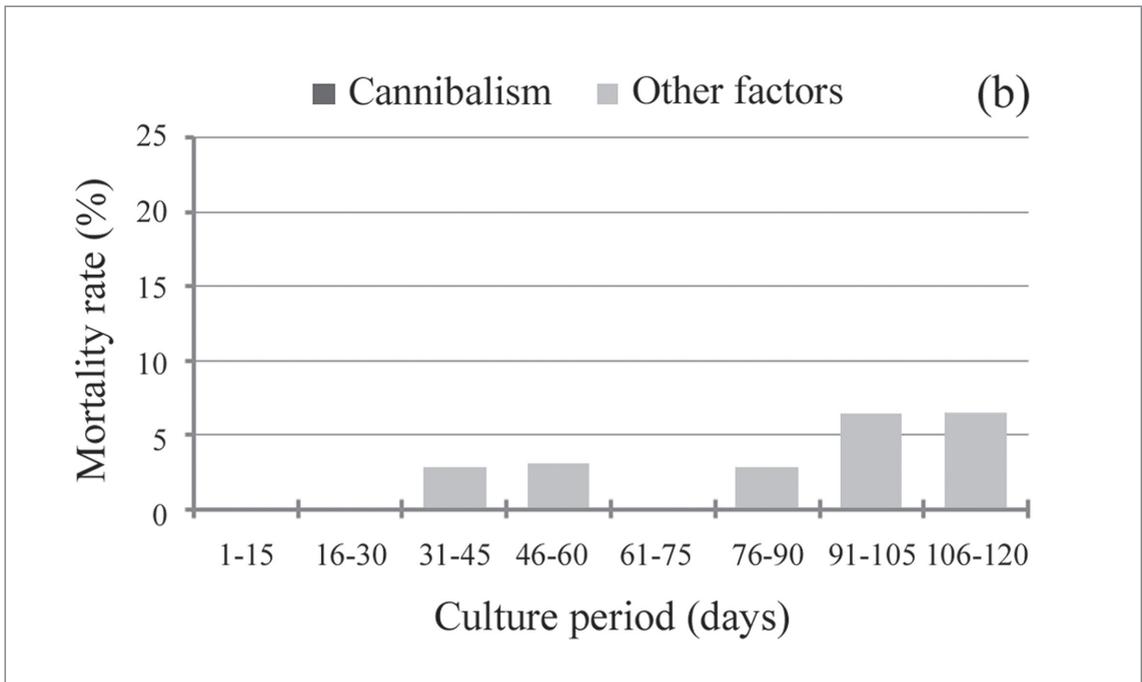
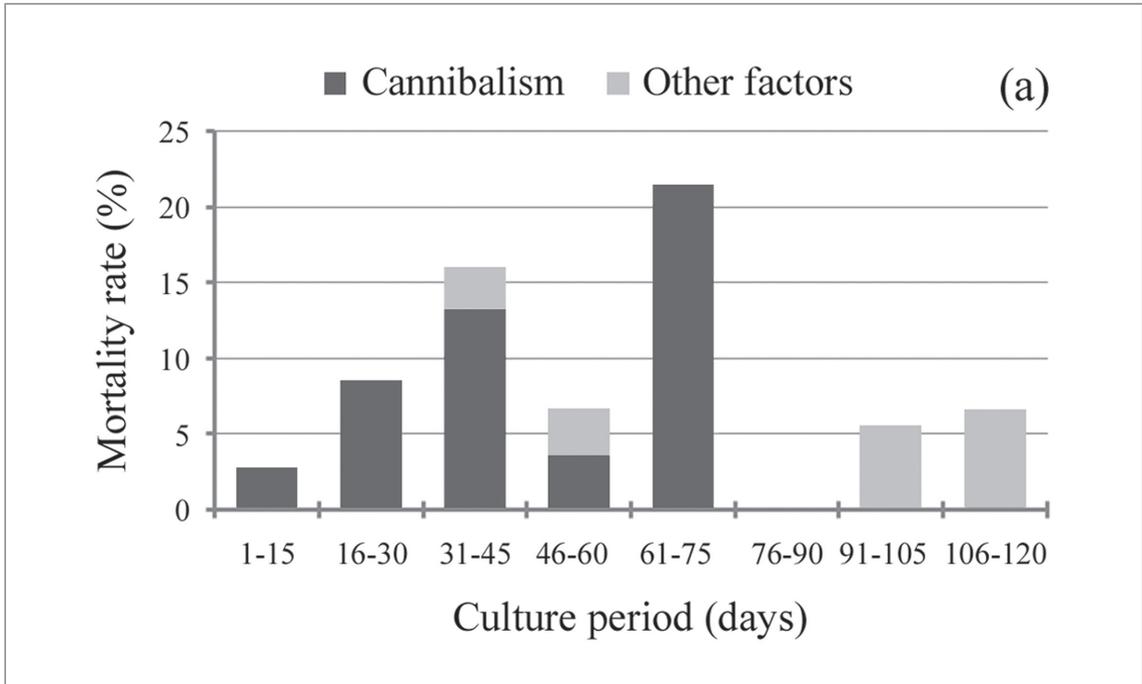


Figure 2. (a) average survival rate and (b) mortality rate of crabs raised without plastic net fences and shelter (control), crab raised individually (treatment 1) and crabs raised with shelters on pond bottom (treatment 2).



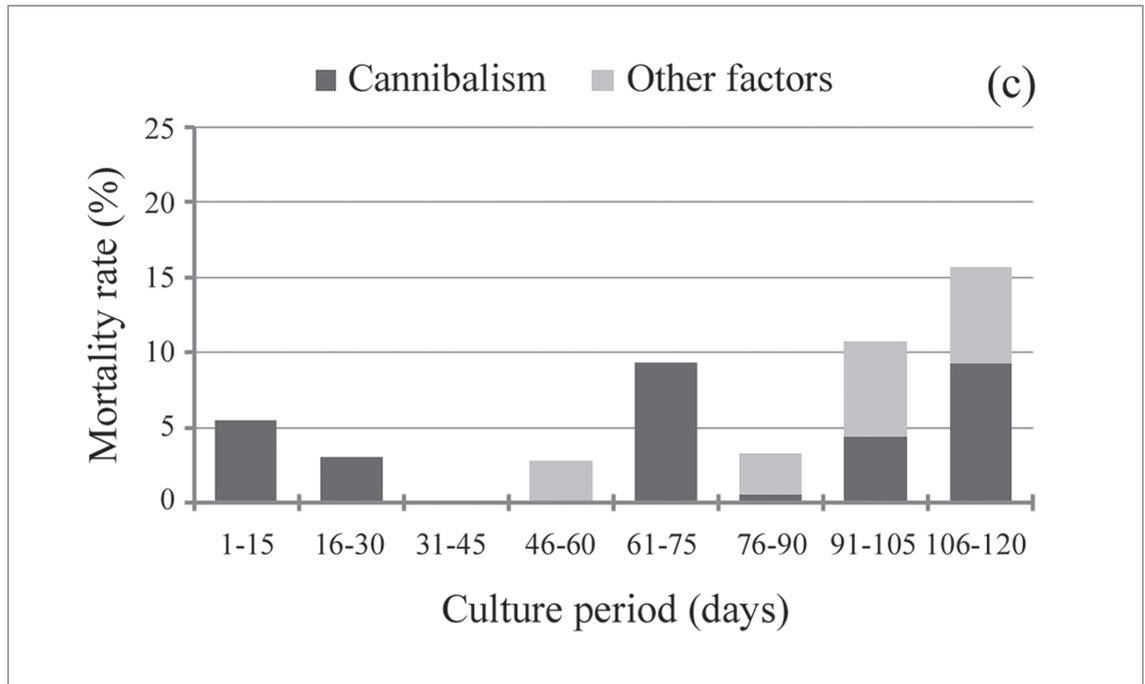


Figure 3. Mortality of cultured *P. pelagicus* due to cannibalism and other factors: (a) control, (b) raised individually and (c) raised with shelters on pond bottom.



Figure 4. Appearance of cultured *P. pelagicus* after cannibalism.

Cannibalism is a serious problem in decapod crustaceans, (Abdussamad and Thampy, 1994; Lovrich and Sainte-Marie, 1997; Fernandez, 1999). The occurrence of cannibalism is usually associated with limited food availability, high population density and limited space (Soundarapandian *et al.*, 2007). This study showed that the factor that contributed most to high mortalities in crab culture was cannibalism, especially during the 30 and 45 days of culture period. This was because crabs were small during the first 45 days (<7.5 cm carapace width) and smaller crabs had a high moulting frequency, compared to larger crabs raised for 60 days and onwards. After the crab moults (crabs with soft-shells), it enters the postmoult stage, and continues to harden over the next 24 h after which it will enter the intermoult stage (Marshall *et al.*, 2005). Cannibalism was recorded in the postmoult stage of the crab. This was due to the crab having thin integuments, which cannot provide serious protection during attacks against each other (Marshall *et al.*, 2005). Marshall *et al.* (2005) also reported that body size and moulting of crabs were the factors correlated with the likelihood of cannibalism. The smaller crabs (<60 mm carapace width) were cannibalised early and the rate of cannibalism increased with all moult stages: intermoult, premoult and postmoult. Hence, the mortality rate of crab culture due to cannibalism decreases as the crab's age increases. Meanwhile after 90 days of culture, other factors contributed more to the mortality of crabs. Mortality from other factors in this study could have been caused by moult death syndrome (Maheswarudu *et al.*, 2008), nutritional quality of feed (Soundarapandian *et al.*, 2007) or pond bottom soil quality (Boyd *et al.*, 1994).

In this study, crabs raised with plastic plates as shelters on the pond bottom, at a density of 1 shelter/m², resulted in a lower mortality rate due to cannibalism, especially during 30 and 45 days of culture. This study proves that plastic plates as shelters on pond bottoms are important in reducing mortality due to cannibalism resulting in higher survival rates. A study by Tidwell *et al.* (1998) reported that it was possible to increase productivity of fresh water prawns, *Macrobrachium rosenbergii*, in ponds by adding shelters. Marshall *et al.* (2005) reported that cannibalism in juvenile crab, *P. pelagicus*, might partially be controlled by refuge availability and increased refuge density. These methods increased survival of juveniles proportionally. However, a study on shelter quality is necessary, with other factors to be considered for further studies such as number, size and type of shelter.

CONCLUSION

In this study, it was observed that cannibalism contributed most for the high mortality of cultured blue swimming crab, *P. pelagicus*, during 30 and 45 days of culture. After 90 days other factors caused mortality of the crab more so than cannibalism. Adding plastic plates as shelters on the pond bottom, at a density of 1 shelter/m², decreased mortality rate due to cannibalism. However, more extensive research has to be done to determine the effects of other factors, such as soil quality, nutritional quality of feed and diseases that affect the survival of crabs raised in earthen ponds.

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