

Effects and interactions of monosex culture and chelipe removal on growth performance of giant freshwater prawn *Macrobrachium rosenbergii* (De Man 1879), raised in cages

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ABSTRACT

This study was conducted to determine the effects of monosex culture and chelipe-removal in cage culture of giant freshwater prawn *Macrobrachium rosenbergii*. Juvenile prawns (5.0g) were stocked in experimental cages in a 0.09 ha pond. Six treatments with four replicates each were (1) chelipe-removed males, (2) normal males, (3) chelipe-removed females, (4) normal females, (5) chelipe-removed mixed (1:1 ratio) males and females and, (6) normal mixed (1:1 ratio) prawns. Each cage was stocked with 30 prawns m⁻². Significantly highest growth (P<0.05) was achieved by the monosex culture of chelipe-removed male prawns, with a mean size of 26.80 ± 0.56 g at harvest, followed by normal males, chelipe-removed mixed prawns, chelipe-removed females, normal females, and normal mixed prawns, with a mean weight of 25.10 ± 0.02, 22.30 ± 0.18, 20.75 ± 0.13, 20.20 ± 0.04 and 20.05 ± 0.08 g, respectively. Consequently, daily growth and specific growth rates were also significantly greater for the monosex culture of chelipe-removed male prawns. Better final survivals were demonstrated by the chelipe-removed groups and FCR was also significantly improved. There were significant interactions (P<0.05) between sex and removal of chelipes on major growth performance, feed utilization and protein efficiency ratio (PER) in both male and female prawns.

Keywords: Giant freshwater prawn; *Macrobrachium rosenbergii*; monosex culture; chelipe-removal, cage culture. Heterogeneous individual growth (HIG)

INTRODUCTION

The farming of freshwater prawn, *Macrobrachium rosenbergii*, in Thailand is limited by water supply and decrease in the number of suitable ponds. The culture of freshwater prawns has been traditionally performed in ponds (New & Singholka,

1985). Despite the reported potential use of rice fields for the culture of this species (Janssen *et al.*, 1988, Halwart & Gupta, 2004), it is still far from being widely practiced. A number of management strategies have been attempted to increase total production. Total pond production can be increased through higher stocking densities, however,

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this resulted in lower average prawn size at harvest (D'Abramo *et al.* 1989). Tidwell *et al.* (1999) examined added artificial substrate with different stocking densities and reported that in prawns stocked at relatively low densities, production and average size increased and total prawn production increased. Cage culture of this species has been attempted in Thailand since 1987 (Singholka and Virojana, 1987). In some neighboring countries, such as India, the Philippines and Singapore, alternative culture methods in cages and pen enclosures have been utilized (Pena & Prospero, 1984; Cuvin-Aralar *et al.* 2007).

Apart from the favorable characters for commercial production of prawn, the differential growth associated with male morphotype of this species is the main factor limiting the expansion of this industry (Rajeet & Madhusoodana Kurup, 2002). The complex social structure that persists in males is a condition termed "heterogeneous individual growth" (HIG). Males tend to occupy territories from which the smaller individuals are evicted. This dominant hierarchy by males defines the social structure, with territorial and aggressive behavior of blue-clawed males over orange-clawed males and smaller males. Size variation due to HIG is the major constraint to successful farming of this species (Garcia-Perez *et al.* 2000). The sex separating culture and removal of the prawn chelipes are considered to be management strategies that minimize differential growth and cannibalism. This research was designed to evaluate the effects and interactions of monosex-culture and chelipe removal on the growth performances of freshwater prawns

MATERIALS AND METHODS

Cage Preparation and Stocking

Postlarvae of *M. rosenbergii* were obtained from the hatchery of the Kalasin Fisheries Station of the Thai Department of Fisheries (DOF), and were nursed in earthen ponds for 3 months. They were fed with egg custard for the first week and eventually with commercial formulated shrimp feed. The 3-month-old juvenile (5.0 ± 0.20 g; 7.2 ± 0.17 cm) were then stocked in small experimental fixed cages ($L \times W \times H: 1 \times 1 \times 1$ m) set inside a 0.09 ha pond at the Surin Rajamankala University of Technology Fisheries Farm. The following six treatments with four replicates were used in this study: (1) chelipe-removed male prawns, (2) normal male prawn, (3) chelipe-removed females, (4) normal females, (5) chelipe-removed mixed (1:1 ratio) male and female, and (6) normal mixed at 1:1 ratio of male and female. Each cage was stocked with 30 prawns m^{-2} and provided with a feeding tray and a shelter made from used motorcycle tyre (Fig.1). The cage bottom was lined with substrate made of plastic mesh to increase available surface area (Tidwell *et al.*, 2000).

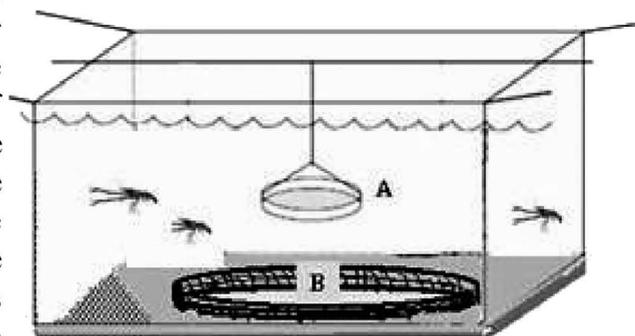


Figure1. Stationary cage set-up showing a feeding tray (A) and a used tyre shelter (B)

The chelipes of prawns in treatments 2, 4 and 6 were removed by cutting them off with sterilized scissors and then dipping

the chelipe-removed prawns in 1.0 ppm acriflavin solution for 30 minutes (Fig.2).

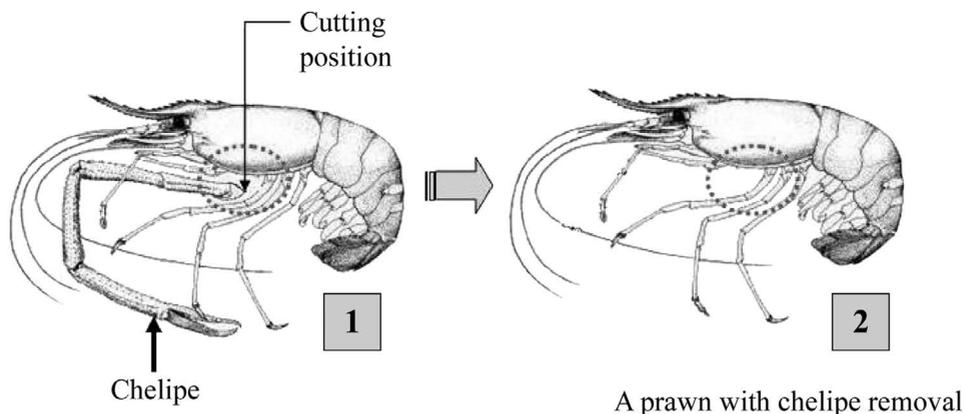


Figure 2. A giant freshwater prawn showing “chelipe” and the cutting position

Diets and Feeding

During the first two months, prawns were fed with a commercial shrimp diet (crude protein 35%) at 5% body weight (BW) three times daily (0600, 1200 and 1800 hours). Before every feeding, the feeding trays were checked to ensure that previous feed was completely eaten and then cleaned to remove any fecal matter. During the last two months the feeding rate was reduced to 3% BW. Feed was placed on a feeding tray (Fig.1), which was then submerged halfway down inside the cages to a depth of 0.5m. The feeding amount was adjusted fortnightly based on bulk weighing to provide feed slightly in excess. Fecal wastes were removed daily. FCR and PER were calculated based on the total amount of feed inputs to determine growth performance.

Growth Measurement

Body weight (g) and total length (cm) of prawns were measured fortnightly. Specific growth rate (SGR), daily growth

rate (DGR), feed conversion ratio (FCR), and protein efficiency ratio (PER) were calculated using the following equations, respectively:

$$\text{SGR} = (\ln \text{wt}_{\text{fin}} - \ln \text{wt}_{\text{ini}}) / \text{days cultured} \times 100$$

$$\text{DGR} = (\text{wt}_{\text{fin}} - \text{wt}_{\text{ini}}) / \text{days of culture}$$

Where wt_{ini} is the initial weight (g) and wt_{fin} is the final weight (g)

$$\text{FCR} = \text{Feed consumed (g)} \times \text{number of prawns} / \text{weight gained (g)}$$

$$\text{PER} = \text{Weight gain (g)} \times \text{number of prawn} / \text{protein intake}$$

The survival rate during the entire culture period was monitored. Blue clawed males (BCM), small males (SM), reproductive females (RF) and virgin females (VF) were also recorded in each of the cages at harvest. Blue-clawed males were distinguished by their long dark blue chelipeds with pronounced spines and hairy claws.

Carcass Composition Analysis

In order to determine influences of treatments on the prawns' biochemistry composition, specimens were selected randomly from each treatment and their carcass composition was analyzed for moisture, crude protein, total lipid and total ash contents according to Standard Methods (AOAC, 1985) at the end of experiment.

Water Quality Management

Water quality was daily monitored inside the cages at 0800 hours for the duration of the experiment. Dissolved oxygen (DO), pH and temperature of all cages were monitored using a YSI Model 57 oxygen meter. Levels of total ammonia and unionized ammonia in water samples collected from each cage at approximately 1300 hours were determined by spectrophotometric methods (APHA, 1975) on a weekly basis. A Secchi disc was used to determine transparency (Boyd, 1982).

Statistical Analyses

Prawn growth performance data, survival rate, specific growth rate (SGR), daily growth rate (DGR), feed conversion ratio (FCR), and protein efficiency ratio (PER) were analyzed by Analysis of Variance

(ANOVA), harvested growth data was analyzed as a 2×3 factorial and tested for significant interactions between main effects; and sex (male/female/mixed) and chelipe (removed/normal) using SPSS 11.5 statistical software. Significant differences among the treatments were compared by Duncan's Multiple Range Test (DMRT). Differences were considered significant at the level of 0.05. Percentage and ratio data were converted to arcsine values prior to analysis.

RESULTS

Water quality parameters

Table 1 shows the mean values \pm SD and range of water quality parameters throughout the experimental period. There was no significant difference ($P > 0.05$) between treatments in measured water quality variables. Overall means (\pm SD) for water quality variables were: temperature, $24.89 \pm 0.3^\circ\text{C}$; dissolved oxygen, $4.04 \pm 0.2 \text{ mg L}^{-1}$; pH, 6.6 ± 0.17 ; Secchi disc depth, $36.11 \pm 0.21 \text{ cm}$; total ammonia-nitrogen, $0.50 \pm 0.1 \text{ mg L}^{-1}$; un-ionized ammonia-nitrogen, $0.08 \pm 0.01 \text{ mg L}^{-1}$. These values represent suitable conditions for prawn culture (Boyd and Zimmerman, 2000).

Table1. Water quality parameters inside the cages

Parameter	Mean \pm SD	Range
pH	6.6 ± 0.17	6.40 - 6.90
Temperature ($^\circ\text{C}$)	24.89 ± 2.15	21.0 - 28.0
Dissolved oxygen (mg L^{-1})	4.04 ± 0.21	3.70 - 4.30
Total ammonia nitrogen (mg L^{-1})	0.50 ± 0.10	0.45 - 0.63
Unionized ammonia nitrogen (mg L^{-1})	0.08 ± 0.01	0.07 - 0.09
Secchi disc depth (cm)	36.11 ± 0.93	35.0 - 37.0
Water depth (m)	1.00	-

Growth Performance Analysis

Table 2 presents the growth performance of the freshwater prawn cultured according to different management strategies. Significantly better growth ($P<0.05$) of *M. rosenbergii* was achieved by the monosex culture of

chelipe-removed male prawns over a 2 month period (Fig. 3), with the mean size of 26.80 ± 0.56 g at harvest. This was followed by those stocked with normal male and chelipe-removed females with mean weights of 25.10 ± 0.02 and 22.30 ± 0.18 g, respectively.

Table 2. Mean (\pm SD) growth performances and feed utilization of juvenile *Macrobrachium rosenbergii* cultured in stationary cages in an earthen pond for 4 months (120 days) culture period

Parameters	Treatments					
	I	II	III	IV	V	VI
Initial weight (g)	5.05 \pm 0.20 ^a	5.10 \pm 0.15 ^a	5.18 \pm 0.25 ^a	5.21 \pm 0.23 ^a	5.05 \pm 0.21 ^a	5.00 \pm 0.20 ^a
Final weight (g)	26.80 \pm 0.56 ^a	25.10 \pm 0.02 ^b	22.30 \pm 0.18 ^c	20.20 \pm 0.04 ^c	20.75 \pm 0.13 ^d	20.05 \pm 0.08 ^f
Initial length (cm)	7.15 \pm 0.18 ^a	7.20 \pm 0.15 ^a	7.23 \pm 0.17 ^a	7.10 \pm 0.25 ^a	7.22 \pm 0.15 ^a	7.25 \pm 0.27 ^a
Final length (cm)	16.70 \pm 0.21 ^a	16.50 \pm 0.13 ^b	14.20 \pm 0.05 ^c	13.95 \pm 0.03 ^d	14.25 \pm 0.06 ^c	13.30 \pm 0.06 ^e
SGR	1.94 \pm 0.09 ^a	1.86 \pm 0.05 ^b	1.73 \pm 0.01 ^c	1.63 \pm 0.03 ^d	1.68 \pm 0.02 ^d	1.66 \pm 0.05 ^d
DGR	0.181 \pm 0.009 ^a	0.167 \pm 0.021 ^b	0.143 \pm 0.016 ^c	0.125 \pm 0.007 ^e	0.131 \pm 0.008 ^d	0.125 \pm 0.012 ^e
FCR	2.06 \pm 0.04 ^b	2.55 \pm 0.23 ^a	2.21 \pm 0.11 ^b	2.61 \pm 0.24 ^a	2.19 \pm 0.91 ^{ab}	2.65 \pm 0.23 ^a
PER	1.60 \pm 0.001 ^a	1.49 \pm 0.000 ^b	1.28 \pm 0.001 ^c	1.12 \pm 0.000 ^e	1.16 \pm 0.001 ^d	1.12 \pm 0.001 ^e
Survival	82.22 \pm 1.92 ^a	65.56 \pm 3.85 ^b	77.78 \pm 5.09 ^{ab}	68.89 \pm 6.94 ^b	78.89 \pm 3.85 ^a	66.67 \pm 5.77 ^b
Yield/cage (g)	659.28 \pm 13.78 ^a	496.98 \pm 3.90 ^c	521.82 \pm 4.21 ^b	418.14 \pm 8.28 ^e	485.55 \pm 3.08 ^d	403.01 \pm 1.61 ^f

Row means with different letters superscripts are significantly different at $P<0.05$

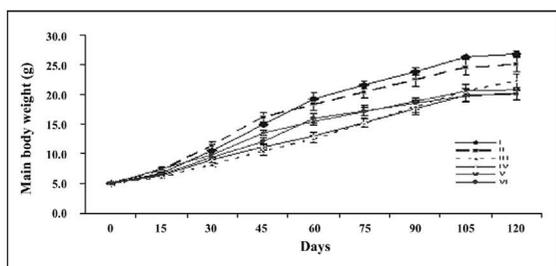


Figure 3. Growth of *Macrobrachium rosenbergii* in different treatments throughout the culture period

The SGR in treatments with normal females, chelipe-removed mixed, and normal mixed male and female prawns did not differ significantly. Consequently, the

DGR was also significantly greater in treatments with the monosex culture of chelipe-removed male prawns compared with that of the other treatments. Daily growth rate ranged from 0.181 (chelipe-removed male) to 0.125 g day⁻¹ (chelipe-removed mixed prawns). The SGR was significantly highest for the chelipe-removed males, ranging from 1.63 % (normal females) to 1.94 % (chelipe-removed males). Size variation in chelipe-removed males (Treatment I) was more than in other treatments.

The average final length of prawn differed significantly among the treatments. The longest at 16.70 cm was observed in the

chelipe-removed male prawns. This was followed by normal male prawn, normal mixed, chelipe - removed females, normal females and chelipe-removed mixed prawns, with 16.50, 14.24, 14.20, 13.95 and 13.30 cm, respectively. The average yields in terms of total weight per cage were significantly higher in the male than in female monosex-culture, both with and without removal of chelipes. The highest yield was observed in chelipe-removed male prawns (659.28 ± 13.78 g), followed by chelipe-removed female (521.82 ± 4.21 g), normal male (496.98

± 3.90 g), chelipe-removed mix prawns (485.55 ± 3.08 g), normal female (418.14 ± 8.28 g) and normal mixed prawns (403.01 ± 1.61 g), respectively.

Table 3 shows the proximate carcass composition of the prawns where no significant differences were found for crude protein, lipid, and moisture contents. The significantly highest ash content was noticed in group 2 (normal males) with the value of 20.5%, while group 3 (female with chelipe - removed) contained the lowest content (19.2% ash content).

Table 3. Proximate carcass composition (%) of prawns from different treatments at the beginning and the end of experiment

Parameters	Treatments						
	Initial	I	II	III	IV	V	VI
Crude Protein	63.1 \pm 1.2	65.2 \pm 1.9	64.3 \pm 1.2	67.1 \pm 2.5	65.6 \pm 2.9	65.1 \pm 0.5	66.1 \pm 2.3
Lipid	8.12 \pm 0.2	9.7 \pm 0.9	9.5 \pm 1.3	8.7 \pm 0.8	8.6 \pm 0.4	9.2 \pm 0.5	9.1 \pm 0.4
Ash	19.5 \pm 0.5 ^{ab}	19.5 \pm 0.4 ^{ab}	20.5 \pm 0.8 ^a	19.2 \pm 0.4 ^b	19.8 \pm 0.5 ^{ab}	19.4 \pm 0.5 ^{ab}	20.1 \pm 0.5 ^{ab}
Moisture	78.0 \pm 0.80	75.9 \pm 1.5	77.3 \pm 1.8	76.3 \pm 2.8	77.8 \pm 1.9	79.1 \pm 2.3	78.6 \pm 1.4

Results are on dry matter basis and are based on the means of three pooled samples \pm SD
Means with different superscripts in the same row are significantly different ($P < 0.05$)

The survival of *M. rosenbergii* at different treatments is shown in Fig. 4. Final survival rates of 82.22, 78.89, 77.785, 68.89, 66.67 and 65.56 % were obtained for the chelipe-removed male prawns, chelipe-removed mixed prawns, chelipe- removed females, normal mixed prawns and normal male prawns, respectively.

At the end of the 4-month culture, FCR improved significantly with chelipe-removed prawns (Fig.5). FCRs of 2.06, 2.19, 2.21, 2.55, 2.61 and 2.65 were obtained for the chelipe-removed male prawns, chelipe-removed mixed prawns, chelipe-removed females, normal male prawns and normal

mixed prawns, respectively.

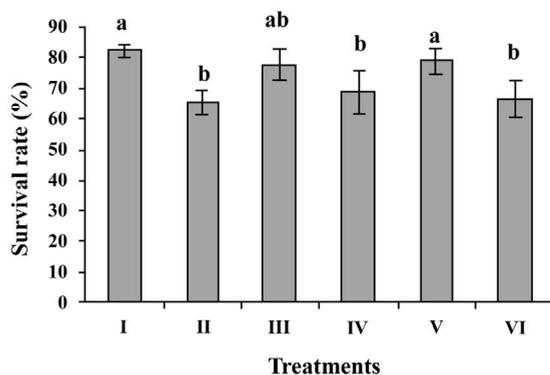


Figure 4. Survival rates of *M. rosenbergii* at different treatments in stationary cages

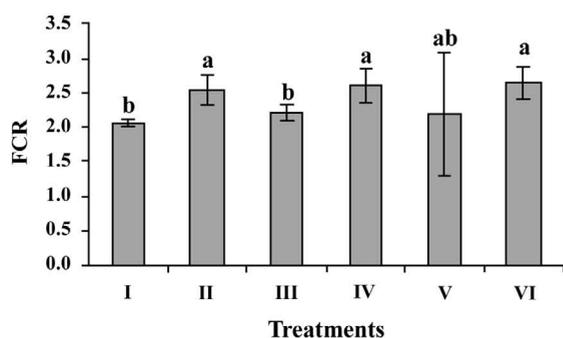


Figure 5. Feed conversion ratios (FCRs) of *M. rosenbergii* obtained at different treatments in stationary cages

The percentage contribution of individual morphotypes of final harvested prawns is shown in Table 4. Heterogeneous

individual growth (HIG) in males was observed in two treatments with normal males (Groups 2 and 6) by the fourth month, as shown by the proportion (%) of the various morphotypes. The percentages of blue clawed males (BCM) were 10% in normal male group and 5.5% for normal mixed at 1:1 sex ratio groups. The percentage of reproductive females (RF) or berried females was significantly higher (16%) in the normal female or non-berried female group than in the normal mixed prawns (2.5%). Small males (SM) were evident (90%) in all treatments with normal males. Similarly the virgin female (VF) morphotypes were dominant (>80%) in treatments with normal female prawns.

Table 4. The proportion (%) of the various morphotypes of prawns at harvest from treatments stocked with all normal prawns

Morphotype	Treatments		
	Treatment II (Normal Male)	Treatment IV (Normal Female)	Treatment VI (Normal Mixed 1:1 sex ratio)
Female			
Reproductive females (RF)	-	16.0	2.5
Virgin females (VF)	-	84.0	47.5
Total	-	100.0	50.0
Male			
Blue-clawed males (BCM)	10.0	-	5.5
Small males (SM)	90.0	-	44.5
Total	100.0	-	50.0

Note: RF = Reproductive female (Berried female), VF = Virgin Female (Non-berried female), BCM = Blue-clawed Male, SM = Small Male

Interactions of main effects

Analysis indicated that there were significant interactions ($P < 0.05$) between sex and removal of chelipes on major growth performance variables (Table 5.). Chelipe removal increased final weights,

and improved growth performance, feed utilization and protein efficiency in both male and female prawns. Higher survival rates were obtained in treatments where there were chelipe-removed prawns. The chelipe-removed prawns in male monoculture

demonstrated a significantly higher final weight, SGR, DGR, PER and survival rate than those of normal male prawns. Similarly, better performances were also observed in chelipe-removed female prawns and chelipe-removed mixed prawns, compared with those in normal female prawns and normal mixed prawns, respectively.

Table 5. Main effect means for prawns in cages with normal and chelipe-removed prawns and separated by sex. Means with different superscripts in the same column are significantly different ($P < 0.05$)

Main effect	Final weight (g)	SGR	DGR	FCR	PER	Survival (%)
Sex:						
Normal males	25.10±0.02 ^b	1.86±0.05 ^b	0.167±0.021 ^b	2.55±0.23 ^a	1.49±0.000 ^b	65.56±3.85 ^b
Normal females	20.20±0.04 ^d	1.63±0.03 ^d	0.125±0.007 ^d	2.61±0.24 ^a	1.12±0.000 ^d	68.89±6.94 ^b
Normal mixed prawns	13.30±0.06 ^e	1.66±0.05 ^e	0.125±0.012 ^c	2.19±0.91 ^{ab}	1.12±0.001 ^c	66.67±5.77 ^b
Chelipes:						
Chelipe-removal males	26.80±0.56 ^a	1.94±0.09 ^a	0.181±0.009 ^a	2.06±0.04 ^b	1.60±0.001 ^a	82.22±1.92 ^a
Chelipe-removal females	22.30±0.18 ^c	1.73±0.01 ^c	0.143±0.016 ^c	2.21±0.11 ^b	1.28±0.001 ^c	77.78±5.09 ^{ab}
Chelipe-removal mixed prawns	14.25±0.06 ^c	1.68±0.02 ^d	0.131±0.008 ^d	2.65±0.23 ^a	1.16±0.001 ^d	78.89±3.85 ^a

The harvested final weight data were analyzed as a 2×3 factorial and tested for significant interactions between main effects; sex (male/female/mixed) and chelipe (removed/normal) in Table 6. Analysis indicated significantly interactions ($P < 0.05$) between sex and presence or absence of chelipe on final weight variables.

Table 6. Summary of ANOVA test for significant interactions ($P > 0.05$) between main effects; sex (male/female/mixed) and chelipe (removal/normal) on final weight prawns

Source	Sum-of-Squares	DF	Mean-Square	F-Ratio	P
Sex	158.503	2	79.252	1899.001	0.000
Chelipes	8.93	1	8.93	213.987	0.000
Sex* Chelipe	11.345	2	5.672	135.919	0.000
Error	0.751	18	0.042		

DISCUSSION

In the present study, the yield and final mean weight of prawns were significantly higher in males than females in monoculture systems, both with and without removal of chelipes. The results showed that cage farming of giant freshwater

prawn *M. rosenbergii* with their chelipes removed generally obtained better yield than normal prawns, and is considered as a possible alternative to pond culture.

Relatively higher survival rates were observed in chelipe-removed prawns, whereas adding substrates provided a shelter for the prawns thereby reducing possible

cannibalism. These results are in agreement with those reported by Tidwell *et al.* (1999) for ponds with added substrates. The stocking density used in this study (30 prawns m^{-2}) were much higher than those traditionally used for pond culture.

The overall mean weights of the prawns after 4 months of culture in cages are slightly higher than those obtained by Cuvin-Aralar *et al.* (2007) in cages in lakes, which was a mean weight at harvest of 20.07 g. The culture period in their case was 5 months with a stocking density of 30 prawns m^{-2} . Prolonging the culture period in cages will also result in greater weight gain. Although the removal of chelipes showed no influence on major proximate carcass compositions of prawns, the highest level of ash contents in carcass composition was found in the normal male prawns. This result may be due to the fact that each chelipe of the male prawn has a certain mineral content contributing to the high level of ash content when compared with the other treatments.

The interaction of monosex culture and chelipe removal resulted in reduced FCR and improved PER. FCRs obtained in this study were comparable to typical ratios (2:1- 3:1) often reported for pond-based culture of prawns (FAO, 2002). The higher survival rates (82.22 and 77.78 %) in treatments with chelipe-removed prawns in both male and female groups may be explained by the reduction of cannibalism among the prawn population. Although the chelipe removed prawns required a few days for acclimatization at the starting period, no regeneration of chelipes were observed. The prawns were then accustomed to the new

situation and environment. Further research is recommended on the use of lower stocking densities and their reliance solely on natural production in the water, particularly algal mats growing abundantly on the sides and bottom of the cages. Cuvin-Aralar *et al.* (2007) suggested that this may be more cost-effective by way of reducing input costs.

Heterogeneous individual growth (HIG) in the present study was only observed in normal male treatments (Group 2 and 6), while the female morphotype was observed in normal females (Group 4 and 6). The percentages of blue clawed males (BCM) were 10% in normal male group, equivalent to 5.5% in normal mix 1:1 sex ratio groups, whereas the percentage of reproductive females (RF) was 16% in the normal female group, and 2.5% in the normal mix prawns. The undersize small males (SM) were mainly about 90% were evident in all treatments stocking normal males. Similarly the virgin female (VF) morphotypes were dominant groups (>80%) in treatments with normal female prawns. These proportions (%) of various morphotypes were similar to those demonstrated in previous studies (Cohen *et al.* 1981; Kuris *et al.* 1987).

CONCLUSION

In conclusion, monosex-culture and removal of chelipes of freshwater prawns increased total production and improved feed utilization efficiency. There was a statistically significant interaction of these two strategies, with the highest yield obtained in the treatment combination of male monosex-culture with chelipe-removed prawns.

Experimental findings demonstrated the degree of which chelipe removal in giant freshwater prawn (*Macrobrachium rosenbergii* De Man) is an effective management strategy. Positive interaction between mono-sex culture and chelipe removal of prawns was reflected by the prawn yields and prawn's growth performance in particular treatments. However, as the sizes of the experimental cages were quite small compared with what is traditionally used in commercial-scale production, verification studies still need to be conducted to evaluate fully the potential for commercialization of these management strategies. Cost return analysis should also be performed during these verification studies to determine the economical viability of this farming system.

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A



B



C



D



E



F

Plates: A - Cages (1x1x1m3), B - A used tyre-shelter, C - Cutting of male chelipes, D - Cutting of female chelipes, E - Prawn samples and F - the removed chelipes