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Effect of eyestalk ablation on moulting and growth in penaeid prawns :

Metapenaeus monoceros

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ABSTRACT

Penaeid prawns of two different size ranges were ablated both unilaterally and bilaterally. The unilateral eyestalk ablated (UEA) prawns consumed 8.9% (35-40mm) and 29.9% (65-70mm) more food than control prawns. Growth was estimated as length and weight changes and significant variation was observed. The moult rate and dry moult weight showed marked differences. In bilateral eyestalk ablated (BEA) prawns dry weight of moult in every succeeding moult was found to decrease. In the larger size group, values of protein efficiency ratio (PER) were almost 50% of that of the lower size group. The UEA prawns exhibited highest conversion efficiency. The production rate of UEA prawns were two to three times more than control where as BEA prawns indicated negative production.

Keywords: Moulting, growth, conversion efficiency, eyestalk ablation, Bilateral and unilateral

Introduction

Eyestalk ablation is a frequently adopted procedure for induced maturation of gonads. Crustacean eyestalk is known to have a neurohaemal function due to the presence of X-organ sinus gland system. Excision of eyestalk removes the neuroendocrine system of prawns located in the eyestalk which influences growth, reproduction and other metabolic activities. Besides, eyestalk ablation is reported to influence lipid metabolism, protein metabolism, carbohydrate metabolism, hydromineral regulation, gonad inhibition and limb growth (Cook and Sullivan, 1985).

Moulting in crustacea is only a part of the mechanism of growth. Change in form and increase in size can occur when the hard calcareous exoskeleton is shed and before the new cuticle is hardened. Removal of eyestalk leads to increased weight and decreased osmolality of haemolymph (Heit and Fingerman, 1975). Unilateral eyestalk ablation has been employed to induce both ovarian maturation and spawning with varying success in many species (Santiago, 1977; Simon John and Sivadas, 1979 ; Primnavera , 1978 ; Brown *et al* , 1980 ; Zaib Un Nisa Ahmed, 2001). Unilateral eyestalk ablation can also be used to shorten the moult interval and to stimulate gonad development in shrimps (Lin *et al.*, 2001).

Ponnuchammy *et al.* (1981) reported enhanced growth rate in unilaterally eyestalk ablated fresh water prawns, *Macrobrachium lankesteri*. Feeding experiments and food conversion efficiency have been carried out in many species of penaeid prawns. In the oriental prawn, *Penaeus aztecus*, Venkataramiah *et al.* (1973) have studied the growth rate and food conversion efficiency under different conditions. Qasim and Easterson (1974) have studied the growth and conversion efficiency of *Metapenaeus monoceros* fed on detritus. Similarly, Royan *et al.* (1977) have worked out the conversion efficiency of *M. monoceros* fed on different types of food. Effect of the unilateral ablation of eyestalk excision on the energy budget of juveniles of the Malaycian prawn, *Macrobrachium rosenbergii* was attempted by Perez and Luna, (1995).

Materials and methods

Collection of prawns

Metapenaeus monoceros was collected from Cochin Backwaters and from prawn culture fields. The prawns were collected in large plastic buckets, sorted and transferred to rearing tanks of the main recycling system (Nair *et al.* 1992).

Sea water collection

Sea water was collected from the near shore area of Fort Cochin. The water was filtered and transported in large carboys of 25 and 50 litre capacity. Salinity was adjusted to the desired level by adding aerated fresh water. Salinity and dissolved oxygen were measured by standard methods (Strickland and Parsons, 1968). E_H and pH were measured by electrodes (century, India). Salinity of sea water in the recycling system was periodically monitored and changes in salinity, compensated by adding fresh water. Water was kept fully saturated with oxygen by providing continuous aeration. pH of the water was maintained close to the value 8, by adding anhydrous calcium carbonate. The temperature of the system was recorded both in the morning and evening and the mean value was taken.

Size and weight measurements

The length of the prawn was measured by vernier calipers. Measurement was taken from the base of the rostrum to the base of the telson. Weight of the prawn was taken using electronic balance after blotting the animal on a filter paper.

Feeding

The prawns were fed, twice per day, with clam meat. For feeding, food approximately equivalent to 20% of the body weight of the animal was used. The unused food was removed after 6 to 8 hours. The individual compartments and PVC tanks were cleaned daily. The moult, excreta and unused food were blotted and weighed separately. They were dried for sufficient length of time at 55°C until a constant weight was achieved and stored in the desicators for further analysis.

Eyestalk ablation

In the present study, eyestalks were removed using sterile surgical blades by which mortality was reduced to the minimum. Prawns in the inter-moult stage were chosen for eyestalk ablation. During ablation, the eyestalk was removed after holding the prawn in precooled sea water to reduce the heart beat rate and loss of haemolymph. For bilateral eyestalk ablation, the second eyestalk was removed after a considerable lapse of time. By adopting this procedure, zero mortality was achieved. The ablated prawns were maintained in separate troughs.

Growth studies

Two sets of experiments using different size groups were conducted lasting for 15 days. The set consisted of (1) *Metapenaeus monoceros*: 35-40mm. size group and (2) *Metapenaeus monoceros* : 65-70 mm. size group. For both the experiments on growth, salinity was maintained at 16 ± 1 psu. The prawns were acclimatized at this salinity for about a week and eyestalks were ablated. The animals

were starved for 24 hours and weighed before the commencement of the experiment. In each set of experiment, 24 prawns were maintained, 8 BEA, 8 UEA and 8 intact ones as control animals. The prawns were maintained individually in separate containers. Initial and final length and weight measurements of individual prawns were recorded.

Calorific value of different samples were determined by acid digestion method. In each analysis 0.1 gm of the dried sample was used. Four samples of each material was digested and mean value taken. The calorific values were expressed as cal./g dry weight.

Production

Production P is defined as

$$P = P_2 - P_1 + M \text{ ----- (1)}$$

where P₂ is the energy content of the animal after experimental period, P₁ is the initial energy content and M is the calories expended in terms of moult formed. This value gives the actual amount of energy invested which can be considered as the real growth.

8) *Net Growth efficiency*

The net growth efficiency of ablated and control prawns were estimated by the formula,

$$\text{Net growth efficiency} = (P \times 100) / A \text{ ----- (2)}$$

where P is production in calories and A is the assimilation in calories

Results

Food consumption

Eyestalk ablation has significantly altered the food consumption rate (Fig.1). In 35-40 mm size group, the average weight of food consumed by the BEA prawns (0.109 g) was found to be 18.65% less than that of the control prawns (0.134g) while the UEA prawns (0.146g) consumed 8.96% more than the control prawns. Among 65-70 mm size group, the BEA prawns (0.249g) consumed 31.78% less food than the controls and the UEA prawns (0.479g) consumed 29.86% more food than the control prawns (0.365). About 47.468% less consumption was observed for BEA compared to UEA. The difference between the consumption rates were tested for significance (Table 1). All the differences observed were highly significant ($t_{14} > 12.45$, $P < 0.001$).

Moulting

Data on moulting frequency was subjected to Tuckey's (Federer, 1967) test of additivity for two way classification to determine the optimal value of p in the transformation

$$Y=X^p \text{-----} (3)$$

where X is the original observation and y is the transformed observation and it was found to be additive with p value very close to 1. Hence the data was not transformed and 2 way ANOVA was applied on the original data to test the significance of the difference in the moulting frequency with respect to ablation and control and with respect to days (Federer, 1967) by assuming a normal pattern for the distribution. On getting that there is significant difference with respect to ablation the moulting frequency was tested using Student's t statistic since the sample size was <30 (Sokhal and Rholf, 1981).

Ablation was found to have a significant effect on moulting (Table 2). In the 35-40 mm size group the differences in the moulting frequencies among ablated and control prawns were found to be significant ($F_{(2,14)} = 5.25, P<0.05$). The average moulting rate of BEA prawns was found to be 2.875 while that of the UEA and control prawns were 2.375 and 1.875 respectively. In the 65-70 mm size group also the moulting frequencies between ablated and control prawns were found to be significantly different ($F_{(2,14)} = 24.12, P<0.05$) and the average moulting rates for BEA, UEA and control prawns were 2.5, 1.875 and 1.25 respectively.

In the size group 35-40 mm, the average intermoult days for the first moult were 7, 8.5 and 10.33 respectively for BEA, UEA and control prawns. The corresponding values for the second moult were 4.857, 6.667 for BEA and UEA while no second moult was observed for the control prawns. In the 65-70mm size group the average intermoult period for the first moult was 6.75, and 8.43 for BEA and UEA whereas for control only one group moulted a second time during a period of 14 days. In the case of second moult the average intermoult period was 5.75 for 4 sets of BEA and 7 days for one set of UEA and no second moult for the control.

Moult weight

In the 35-40mm size group, moult dry weight increase for BEA (0.0102g) was 16.95% more than the control (0.0087g) while 26.15% more than the control for UEA prawns (0.0110g) (Table 1). On comparing BEA and UEA, the second eyestalk has decreased the dry weight of the first moult. But after the second moult, it was observed that the dry weight of the moult for BEA (0.0088g) was 6% higher than the control (0.0073g) and for UEA (0.0094g) also the second moult dry weight was slightly higher than (13.4%) the first moult with respect to the control. The secondary eyestalk has

further decreased (6.5% less than the UEA during the moult 2) the dry weight. In moult 3 also the same trend followed as in the case of moult 2 showing a decrease of 128.37% for BEA (0.0080g) than the UEA (0.0098g).

In the case of higher size group, 65-70 mm a decrease (20.61%) in dry weight was observed in the case of BEA (0.037g) while a marginal increase (6.63%) in the case of UEA (0.0426g) compared to control (0.041g). In this case also for the first moult the second eyestalk has reduced the dry weight of the moult (25.55% less than that of the UEA). For moult 2 also a decrease in dry weight was observed due to second eyestalk ablation (0.0297g, 14.94% less than that of UEA (0.035g)). The observed differences in the dry weight for various moults were found to be significant ($P < 0.05$, tables 1 and 2). The significance was higher in the higher size group in all the moults.

On considering all the 3 moults together, it could be stated that BEA prawns showed an increase in moult weight of 11.5% over that of the control, while UEA prawns showed an increase in moult weight of 19.8% than that of the control. On comparing UEA and BEA it could be observed that the second eyestalk ablation decreases the moult dry weight by 10.7%. In the case of higher size group, a decrease of 20.6% for BEA and 6.6% for UEA was observed with respect to control. In this size, an average decrease of 20.3% was observed during second eyestalk ablation.

Another important aspect noticed is that in the BEA prawns dry weight of moult in every succeeding moult was found to decrease. In this species, 35-40 mm size group, the average weight of second moult was less by 12.8% than the average weight of the first moult. Similarly a decrease in weight of the third moult over that of the second was by 9.1%. In the 65-70 mm size group of this species the average weight decrease of the second moult over the first and the third moult over the second was 6.3% and 31% respectively.

Length

Data on length increase was subjected to Tuckey's (Federer, 1967) test of additivity for two way classification to determine the optimal transformation and it was found to be additive with p value very close to 1. Hence the data was not transformed and 2 way ANOVA was applied on the original data to test the significance of the difference in the length increase with respect to ablation and control and with respect to days by assuming a normal pattern for the distribution. On getting that there is significant difference with respect to ablation the length increase was tested using Student's t statistic since the sample size was < 30 (Sokhal and Rholf, 1981).

Length measurement studies for *M. monoceros*, in 35-40 mm size group, showed that the average length increase of the BEA was 5.06 mm whereas that of UEA prawns was by 5.81 mm and

that of control prawns by 4.81 mm. The values of length increase of BEA, UEA and control were statistically significant ($F_{(2,14)} = 22.358, P < 0.01$). In the 65-70 mm size group the corresponding average length increase were 3.13 mm, 4.38 mm and 1.75 mm. In terms of percentage values, it was observed that for 35-40 mm size the BEA prawns recorded 5.19% length increase than the control whereas UEA, 20.78% increase than the control, and BEA recorded 12.90% less increase than the UEA prawns. The corresponding values for 65-70 mm length group were 78.58% more, 150% more and 28.57% less in the increase in the length. The length increase differences between the ablated and the non- ablated prawns were significantly different ($F_{(2,14)} = 128.326, P < 0.001$). Calculated $t > 2.5858 (P < 0.05)$ in all the three cases of 35-40mm and calculated $t > 11.0336 (P < 0.001)$ in all cases of 65-70 mm size group.

Wet weight

Data on wet weight increase was subjected to Tuckey’s (Federer, 1967) test of additivity for two way classification to determine the optimal transformation and it was found to be additive with p value very close to 1 for the smaller size group while p was -5.5 for 65-70mm size group. Hence the data was appropriately transformed using the optimal transformation,

$$Y = X^{-5.5} \text{----- (4)}$$

and 2 way ANOVA was applied on the transformed data to test the significance of the difference in the wet weight increase with respect to ablation and control and with respect to days by assuming a normal pattern for the distribution of wet weight increase. On getting the significant difference with respect to ablation, the wet weight increase was tested using Student’s t statistic for paired samples, since the sample size was < 30 (Sokhal and Rholf, 1981).

In the lower size group, the values of the wet weight increase of BEA UEA and control prawns were statistically significant ($F_{(2,14)} = 25.59, P < 0.01$). The BEA (0.159g) recorded almost the same wet weight increase as the control prawns (0.156g) with no significant difference ($t_{14} = 1.3677, 2.16\%$ more increase in the wet weight) while the UEA prawns (0.264) showed 69.07% more wet weight increase ($t_{14} = 43.4786, P < 0.001$) than the control prawns. The difference between BEA and UEA based on the wet weight increase was highly significant ($t_{14} = 87.3708, P < 0.001$) and BEA recorded 39.57% less wet weight increase than the UEA prawns.

The values of wet weight increase among 65-70 mm size group were not additive and hence the transformation,

$$Y = X^{-5.5} \text{----- (5)}$$

was applied. The wet weight increase among the prawns were significantly different. ($F_{(2,14)} = 11.99$, $P < 0.01$). The BEA prawns (0.221g) recorded 26.79% more increase in the wet weight than the control prawns (0.1745g) and the difference was highly significant ($t_{14} = 14.3721$, $P < 0.01$) while it showed 41% less wet weight increase than that of the UEA prawns (0.309g) with significance ($t_{14} = 38.737$, $P < 0.001$). UEA recorded 77.01% more increase than the control prawns with significant difference ($t_{14} = 14.3721$, $P < 0.01$).

Dry weight

Data on dry weight increase was subjected to Tuckey's (Federer, 1967) test of additivity for two way classification to determine the optimal transformation and it was found to be additive with p value very close to 1. Hence the data was not transformed and 2 way ANOVA was applied on the original data to test the significance of the difference in the dry weight increase with respect to ablation and control and with respect to days by assuming a normal pattern for the distribution of dry weight increase. On getting that there is significant difference with respect to ablation, the significance of the dry weight increase between ablated and non-ablated was tested using Student's t statistic, pairwise, since the sample size was < 30 (Sokhal and Rhol, 1981).

The values of dry weight in the lower size group showed highly significant differences between the ablated and control prawns ($F_{(2,14)} = 78.284$, $P < 0.001$) in the 2way ANOVA, with average dry weight decrease of 0.0031g for BEA and average increase of 0.0628g for UEA and 0.02925g for control prawns. BEA recorded a 110.68% less increase in the dry weight than the control prawns while UEA recorded 114.53% more increase in the dry weight than the control prawns. BEA prawns showed 104.98% less increase in dry weight compared to UEA prawns. The differences were all highly significant ($t_{14} > 24.22$, $P < 0.001$) in all the 3 cases of comparisons. In the 65-70 mm size group, the dry weight increase were more significantly different ($F_{(2,14)} = 132.589$, $P < 0.001$) with average dry weight decrease of 0.2288g for BEA which was 496.96% less than the increase in the control prawns (0.0576g) while it was 213.59% less than the increase in the UEA prawns (0.2014g) which resulted in a 249.46% more increase in UEA compared to control prawns. The differences in the change in the dry weight were highly significant ($t_{14} > 47.3235$, $P < 0.001$) in all the three cases of comparisons (Table 1).

Food conversion ratio (FCR)

Significant differences were observed in the FCR values of the ablated and control prawns. The UEA prawns had the lowest average FCR in both size groups indicating maximum food conversion efficiency. In 35-40 mm size group FCR of BEA (2.8838) was 22.01% less than that of the control

prawns (3.3698) while 17.05% more than the UEA prawns (2.4638) and UEA prawns showed 33.37% less than that of the control prawns. The differences in the FCR values were highly significant ($t_{14} > 8.7979$, $P < 0.05$) in the three cases of comparisons. The variations between animals was low (C.V.% < 13.79).

In the 65-70mm size group, The FCR values were nearly twice that of lower size group. The average values of FCR for BEA (5.085) was 36.97% less than that of control prawns (8.0675) while 5.72% more than that of UEA prawns (4.81) and it was 40.38% less for UEA prawns compared to control prawns. In this case also all the differences were highly significant ($t_{14} > 6.1394$, $P < 0.05$). The FCR values among the prawns was almost homogeneous in the three cases. (CV% < 12.81). Also, the weight increment in all the three groups studied showed a steady rate of growth.

Protein efficiency Ratio (PER)

It is defined as the ratio of wet weight gain to the dry weight of protein fed over the experimental period (Sedgwick, 1979). The analysis of data showed that UEA prawns had higher PER values in both cases of size group. Among 35-40mm size group the average values of PER of BEA (0.69) was 22.42% more than the control prawns (0.5636) while 20.45% less than the UEA prawns (0.8673). The PER values of UEA was 53.89% more than the control prawns. In these three cases, the differences in the PER values were all highly significant ($t_{14} > 7.1891$, $P < 0.01$). In the larger size group, the values of PER were almost 50% of that of the lower size group. The average PER of BEA (0.3785) was about 56.16% more than that of the control prawns (0.2424) while 7.739% less than that of UEA prawns (0.4105). UEA prawns showed about 69.26% more PER than the control prawns. Similar to FCR values PER values of BEA, UEA and control were more or less uniform between animals (C.V.% $< 12.44\%$). The FCR values and PER values are given in Fig.1.

Production

UEA prawns registered maximum production in terms of calories and the values of UEA prawns of the species, for 35-40 mm size group was 202 while for 65-70mm size group, it was 606. At the same time for BEA the values were negative indicating that no growth has taken place in them and the values were -33 and -772 for the smaller and larger size group. Among the intact prawns the corresponding values were 112 and 206. In 35-40mm production of BEA (-32.9125) was 129.52% more decrease than that of control prawns (111.5) and 116.28% more decrease than that of UEA prawns (202.125). Comparing UEA and control it showed an increase of 81.28% than that of control prawns. The production values were significantly different among BEA, UEA and control prawns ($t_{14} > 35.2396$, $P < 0.001$). Among the BEA prawns production values were highly varying (C.V.

>55.22%). In 65-70 mm size group average production for BEA (-772.0) decreased by 475.67% of that of the control prawns (205.5) while it decreased by 228.35% of that of UEA prawns (601.5) whereas the production in UEA prawns increased by 192.71% of that of control prawns. In this higher size group also the differences in production were highly significant ($(t_{14} > 35.1789, P < 0.001)$).

Growth efficiency

Significant differences in growth efficiency among the ablation groups in the 35-40 mm size group were observed ($F_{(2,14)} = 316.25, P < 0.001$). BEA prawns recorded net growth efficiency of -2.0288, which was about 136.12% less than that of UEA prawns (9.1837) (Fig. 1). The UEA prawns recorded 68.05% more net growth efficiency than the control prawns. In the case of 65-70 mm size group the net growth efficiency values of BEA (-20.371) decreased by 537.15% that of control prawns (4.66) while decreased by 331.23% compared to UEA prawns (8.81). UEA showed an average increase of 89.06% compared to control prawns. In this size group also high significance for the difference ($(t_{14} > 109.49)$) was observed among the ablated and non-ablated prawns ($P < 0.001$).

Discussion

In crayfish, adult *Procambarus clarkii*, unilateral eyestalk ablation effect on the physiological components that integrate the energetic balance was evaluated and it resulted in a significant increase in the food consumption rate for ablated, compared to non-ablated. Also the energetic expense towards the respiratory routine metabolism and ammonia production was lower in ablated compared to non-ablated (Sierra *et al.* 1997). Stella *et al.* (2000) have drawn the inference that bilateral ablation is a very strong inducer of moulting for both sexes during any season of the year. It has been observed by Jiraporn (2000) that intermoult periods of *Penaeus monodon fabricius* increased with the increase in the size of the experimental shrimps, decreasing water salinity in the range 10-30 PSU has no significant effects on moulting cycle of *Penaeus monodon*.

Chakravarthy (1992) noticed in his study on males of *M. rosenbergii* shortening of the intermoult period and increase of growth was more in bilaterally eyestalk ablated prawns than in unilaterally ablated ones or the controls. High mortality following eyestalk ablation has been reported in many crustaceans. Chakravarthy (1992) had noticed that mortality was high in eyestalkless animals. It was more in bilaterally ablated prawns than the unilaterally ablated ones. High mortality in bilaterally eyestalk ablated animals and high survival in unilaterally ablated animals was observed in *M. lankesterii*. It was found that several operated animals died at the time of moulting particularly in bilaterally eyestalk ablated prawns. It may be due to the fact that there is a rapid increase in the body

size of the eyestalkless animals followed by impairing preparations for moult and this leads to failure at moult ultimately leading to death.

Both moulting and growth in eyestalk ablated prawns recorded higher values than that of their unablated counterparts. The conversion efficiency also followed a similar trend. High survival rate and generally higher growth rate of unilaterally ablated lobsters compared with unablated lobsters was reported in small juveniles of *Panulirus ornatus* (Juinio Menez and Ruinata, 1996). Sanjeevraj *et al.* (1996) showed that the smaller size groups responded quickly than the bigger size group of *Macrobrachium rosenbergii*. In the study of growth of *metapenaeus dobsoni* (Venkitraman *et al.* 2004), it was observed that the food consumption rate of BEA prawns was found to be much lower than that of control prawns and the condition was considered as a certain degree of starvation.

Conclusion

The results obtained on the two size groups of *M. monoceros* on feeding, growth rates, moulting, conversion efficiency and production clearly indicate that unilateral eyestalk ablation leads to enhanced growth and conversion efficiencies. Bilaterally eyestalk ablated prawns did not survive for more than 15 days. Even though they exhibited enhanced moult rate, significant differences in their growth in terms of weight increase was not noticed. Mortality may be possibly due to physiological imbalances.

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Table 1. Mean(\pm Standard deviation (SD)) values for characteristics measured in *M. monoceros* prawns in two size groups subjected to different levels of eyestalk ablation and Students *t* statistic for comparing the ablation groups

	35-40 mm size group			65-70 mm size group		
	Mean (\pm SD)	Students <i>t</i> statistic		Students <i>t</i> statistic	Students <i>t</i> statistic	
		UEA prawns	Control prawns		UEA prawns	control prawns
Food consumption						
BEA prawns	0.109 \pm 0.010	40.015 ^{***}	25.158 ^{***}	0.249 \pm 0.019	150.075 ^{***}	64.542 ^{***}
UEA prawns	0.146 \pm 0.009		12.450 ^{***}	0.474 \pm 0.011		75.373 ^{***}
Control prawns	0.134 \pm 0.011			0.365 \pm 0.018		
Dry weight(moult 1)						
BEA prawns	0.01018 \pm 0.00125	3.483 ^{**}	7.706 ^{**}	0.03173 \pm 0.00050	33.786 ^{***}	29.653 ^{***}
UEA prawns	0.01098 \pm 0.00119		12.329 ^{***}	0.04261 \pm 0.00233		6.389 ^{**}
Control prawns	0.00870 \pm 0.00071			0.03996 \pm 0.00202		
Dry weight (moult 2) BEA prawns	0.00819 \pm 0.00272	2.687 [*]	3.239 ^{**}	0.02974 \pm 0.00074	2.947 ^{**}	-----
UEA prawns	0.00941 \pm 0.00063		5.190 ^{**}	0.03496 \pm 0.01325		-----
Control prawns	0.00834 \pm 0.00293			No moult		
Dry weight (moult 3) BEA prawns	0.00800 \pm 0.00231	3.335 ^{**}	-----	-----	-----	-----
UEA prawns	0.00980 \pm 0.00449		-----	-----		-----
Control prawns	No moult			-----		

*--- Calculated *t* is significant at 5 % level of significance, (P<0.05) ** ----- Calculated *t* is significant at 1 % level of significance, (P<0.01)

*** -----Calculated *t* is significant at 0.1% level of significance, (P<0.001).

Table 2. Moulting frequency and intermoult periods of ablated and control *Metapenaeus monoceros*

no	<i>Metapenaeus monoceros</i> 35-40 mm size group									<i>Metapenaeus monoceros</i> 65-70 mm size group								
	Moulting frequency			Inter moult period 1			Inter moult period 2			Moulting frequency			Inter moult period 1			Inter moult period 2		
	BEA	UEA	Control	BEA	UEA	Control	BEA	UEA	Control	BEA	UEA	Control	BEA	UEA	Contro 1	BEA	UEA	Control
1	3	2	2	7	8	10	5	*	*	3	2	2	6	9	*	6	7	*
2	3	3	2	7	9	9	5	6	*	2	2	1	7	7	*	*	*	*
3	3	2	2	8	10	11	4	*	*	3	2	1	7	8	*	6	*	*
4	3	2	1	7	8	*	6	7	*	2	2	1	7	8	*	*	*	*
5	2	3	2	8	8	11	*	7	*	2	2	1	6	8	*	*	*	*
6	3	3	2	6	8	*	5	*	*	3	2	2	6	9	*	6	*	*
7	3	2	2	7	8	10	5	*	*	3	2	1	8	10	14	5	*	*
8	3	2	2	6	9	11	4	*	*	2	1	1	7	*	*	*	*	*

LEGEND TO FIGURE

Fig.1. shows the daily food consumption of control, UEA and BEA prawns during the experimental period, food conversion ratio, protein efficiency ratio, production and net growth efficiency in the case of control prawns , UEA and BEA prawns in the two size ranges, 35-40mm and 65-70mm of the penaeid prawn *Metapenaeus monoceros* .

