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Efficiency of Energy Utilization in the Shrimp, *Metapenaeus monoceros* Fed Mangrove Leaves

V RAMADHAS & SUMITRA-VIJAYARAGHAVAN

National Institute of Oceanography, Dona Paula, Goa 403 004

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Energy budget of *M. monoceros* was estimated using 3 species (*Rhizophora mucronata*, *Avicennia officinalis* and *Acanthus ilicifolius*) of mangrove leaves in combination with rice bran as food. The results indicated high assimilation efficiency (86%) and low conversion efficiencies (K_1 -6.45 and K_2 -7.49) and the latter was attributed to the source of protein in the food.

Earlier works on food conversion efficiency in the shrimp, *Metapenaeus monoceros*, have been carried out using natural, processed and compounded feeds¹. Mangroves are well known to support a variety of detritivorous organisms, and the nutritive value of mangrove vegetation and the biochemical composition of different stages of mangrove leaves are reported^{2,3}. However, no attempt has so far been made to use mangrove vegetation as chief ingredient in compounded feeds. Hence, the present work is aimed at studying food conversion efficiency in *M. monoceros* using test diets with withering mangrove leaves.

Shrimps of 28-35 mm carapace length were collected from the mangrove bordered backwaters of Mandovi estuary. They were sorted into 3 experimental groups (10 animals each) and kept in glass tanks (40 × 20 × 20 cm) containing 10 l of seawater (sal. 15‰; temp., 28 ± 1°C). The shrimps were acclimatized with the following test diets (%) which were offered in dry pelleted condition and fed *ad libitum*. Group I—*Rhizophora mucronata* (60) + rice bran (40), group II—*Avicennia officinalis* (60) + rice bran (40), and group III—*Acanthus ilicifolius* (60) + rice bran (40).

Biochemical composition of the test diets is given in Table 1. Other experimental procedures and calculations of energy balance were same as reported⁴. The energy estimations of the feed, test animals and faecal matter were carried with Parr (1200) adiabatic microbomb calorimeter. The experimental duration was 30 days.

Table 2 summarises the results of feeding experiments. In all groups of shrimps, the conversion efficiencies (K_1 and K_2), relative growth rate and assimilation efficiency did not vary much. The energy loss through defaecation was little (15%) when compared to the consumed food. In general, lower conversion efficiencies with higher assimilation (86%) was observed in all groups. Similar results were reported for the same species of shrimp^{1,5} with reference to Tamil Nadu Agricultural University diet, white fish meal and Cooper Beta diets having about 40 to 60% protein.

Table 1—Biochemical Composition (%) of Test Diets

	<i>Rhizophora mucronata</i>	<i>Avicennia officinalis</i>	<i>Acanthus ilicifolius</i>
Carbohydrate	42.86	48.7	31.8
Protein	18.13	9.74	8.6
Lipid	10.25	11.65	14.95
Caloric value (cal/g dry wt)	3945	3934	3050

Table 2—Energy Balance of *M. monoceros* Fed Mangrove Leaves

[Energy values are expressed as cal/animal]

	Group I	Group II	Group III
Initial dry wt (g; W_1)	0.091	0.089	0.085
Final dry wt (g; W_2)	0.124	0.114	0.117
Weighted mean (g; \bar{W})	0.108	0.102	0.101
Initial calories (I_1)	465	468	441
Final calories (I_2)	654	613	614
Production ($P = I_2 - I_1$)	189	145	173
Consumption (C)	3212	2507	2251
Faecal out put (F)	480	381	273
Assimilation ($A = C - F$)	2732	2126	1978
Metabolism ($R = A - P$)	2543	1981	1805
Assimilation efficiency ($A/C \times 100$)	85.06	84.86	87.87
Gross growth efficiency ($P/C \times 100$ or K_1)	5.88	5.78	7.69
Net growth efficiency ($P/A \times 100$ or K_2)	6.92	6.82	8.75
Relative growth rate (g; $P/\bar{W}/\text{No. of days}$)	0.0102	0.0082	0.0106
Consumption/unit wt/d (g)	0.2579	0.2087	0.243

Qasim and Easterson⁶ and Royan *et al.*⁷ reported high conversion efficiencies in *M. monoceros* when fed with natural estuarine detritus (5% protein) and low protein pellet (20%). In the present study, however, although the protein content of the test diets was low (8-18%), the conversion efficiency was poor. The reason for this may be attributed to the protein source. Detritus is known to contain easily assimilable proteins of plant, animal and microbial origin. The low protein pellet was a mixture of animal and plant protein. In our studies, the feeds contained pure plant protein. Cowey *et al.*⁸ pointed out that plant protein as such or as a mixture with animal protein gave low growth rate in plaice. They attributed it to the presence of some complex carbohydrate, resistant to enzyme action as well as capable of inhibiting protein conversion, thereby resulting in lower growth rate.

It is well known that the mangroves produce large quantities of dry organic matter which form the source of food for estuarine organisms. Schuster⁹ used mangrove leaves in pond culture. In the light of the present results, it may be concluded that future experiments with decomposing mangrove vegetation would provide interesting results since associated bacterial flora of decomposing leaves would increase protein content of the plant food as well as making it into an easily assimilable form. Further, it may improve the quality of food by providing essential amino acids lacking as such in healthy (non-decomposing) leaves and by breaking down the complex carbohydrates biologically hindering with protein digestion.

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Effect of Low Oxygen Concentration on Respiratory Movements of *Balanus tintinnabulum tintinnabulum* (L.)

D G V PRASADA RAO & Y PRABHAKARA RAO

Department of Zoology, Andhra University, Waltair 530 003

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At low oxygen concentrations (3, 2.5, 2 and 1.5 ml O₂/litre), hypoventilation has been observed in the respiratory movements of *B. tintinnabulum tintinnabulum*. A critical oxygen concentration is found at 3.5 ml O₂/litre below which the respiratory movements show a decline. Extremely low oxygen concentrations (1.5 ml O₂/litre) induce anoxic arrest of the respiratory movements with the complete closure of the operculum.

Ventilatory responses of animals are affected by changes in the oxygen concentrations of the external environment. Though many invertebrates exhibit hypo- and hyper-ventilation below the ambient oxygen concentration, many crustaceans show hypoventilation. Several investigators have reviewed the work on this aspect in crustacea¹⁻³.

Except for the work of Fox and Johnson⁴ on the effect of oxygen and carbondioxide on the respiratory movements of *Balanus balanoides*, there are no other reports on this aspect in barnacles. Earlier studies on the respiration of *B. tintinnabulum tintinnabulum* are only on the oxygen consumption in relation to body size⁵, oxygen concentration⁶ and salinity variation⁷. *B. tintinnabulum tintinnabulum* occurs as a fouling organism infesting the submerged structures like jetties, piers and buoys in Visakhapatnam outer harbour. It is also found encrusted on the boulders in the littoral zone of the intertidal region where the oxygen concentration varies from 3.65 to 4.83 ml/litre, and it does not extend into the enclosed harbour channel where the oxygen concentration reaches low value (0.9 ml O₂/litre) due to industrial and sewage pollution. In the present investigation the effect of low oxygen concentration on the respiratory movements of *B. tintinnabulum tintinnabulum* has been studied with a view to comparing the results with barnacles and other crustacea.

B. tintinnabulum tintinnabulum were collected from the open intertidal region of Visakhapatnam. Collections were made from the same height to avoid any variation due to tide level⁸. Specimens of about the same size were chosen to eliminate the possible effect of age. They were acclimatized in the laboratory at 25°C in the filtered sea water for 12 hr. Whatman 42 filtered sea water was used for all the experiments to avoid the influence of diatoms and other algae. Salinity of the sea water used for different experiments ranged from 31 to 33‰ and the pH of the sea water was 8.