

R. mucronata leaves with low C:N ratio were fed to shrimps, the rate of growth in the shrimp increased indicating that such a diet can give a satisfactory food value. In conclusion it can be stated that the decaying leaves of *R. mucronata* with their high caloric and protein content are a good food source for detritivorous organisms.

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Conversion Efficiency in the Shrimp, *Metapenaeus monoceros* (Fabricius), Fed Decomposed Mangrove Leaves

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Feeding experiments were carried out with *M. monoceros* using mangrove leaves at different stages of decomposition, in combination with rice bran. Maximum conversion efficiency was found in shrimps fed completely decomposed mangrove leaves. Differences in the conversion efficiency obtained in the shrimps were attributed to biochemical composition of the feeds which varied as decomposition process proceeded.

Importance of mangrove detritus as food for estuarine and marine animals is known¹⁻⁴. Withered leaves of *Rhizophora mucronata* in combination with rice bran, lead to low conversion efficiency in the shrimp, *M. monoceros*⁵. In this paper conversion efficiency in *M. monoceros* fed compounded diets prepared with partially and completely decomposed leaves of *R. mucronata* is reported.

Preparation of test diet—Withered yellow leaves (1 kg) of *R. mucronata*, collected from mangrove fringed estuaries of Goa, were cut into pieces (1 cm) and allowed to decompose in dark in 30 l aerated mangrove water (sal. 25-27‰) at room temperature (28 ± 1°C). Water was changed once in 3 days during the first 2 weeks to avoid heavy accumulation of organic matter. At the end of the 2nd week, half of the plant material which had undergone degradation due to leaching and microbial decomposition was used for compounding a test diet for the shrimps (group I). This diet, in combination with rice bran is referred as partially decomposed. The rest of the material was allowed to decompose further till the end of the 5th week. At this stage, the plant material had undergone decomposition to the level of 2-3 mm particles. This material, in combination with rice bran was used to prepare the test diet for the shrimps (group II) and is referred as completely decomposed. Decomposition beyond this stage was not attempted as it may lead to the formation of particles having primarily cellulose and lignins which would probably be of little food value².

About 60% of partially and completely decomposed material was pulverised, mixed with 40% finely powdered rice bran, made into a paste with distilled water and passed through a surgical syringe and drawn in the form of pellets, which were air dried.

Mangrove leaves were used as the chief source of protein. Since carbohydrate content (both utilizable and non-utilizable) is generally lowered during decomposition^{1,3,6}, this was supplemented with rice bran.

Experimental set-up—Juveniles of *M. monoceros* (80-90 mg) were divided into 2 groups (16 animals each) and maintained in glass aquaria (40 × 20 × 20 cm) containing 10l sea water (sal. 15‰ and temp. 28 ± 1°C). Both the groups were acclimatized to the test diet for a week. Group I was fed partially decomposed leaves and group II completely decomposed leaves. Shrimps were weighed before and at the end of the experiment. The amount of food consumed and faeces produced were recorded daily. Energy determinations of the feed, faeces and the experimental shrimps were made with Parr adiabatic calorimeter. Calculations of energy conversion were according to Crisp⁷. The experimental duration was 21 days.

Biochemical analyses—Biochemical analyses of the test diets were made following the standard methods⁸⁻¹⁰. Ash was determined by heating the dry samples in a muffle furnace at 500°C for 3-4 hr.

Biochemical composition of withered, partially decomposed and completely decomposed leaves in combination with rice bran is shown in Table 1. Table 2 summarises the energy balance of *M. monoceros* in the feeding experiments. In groups I and II, assimilation efficiency, relative growth rate and faecal output as a percentage of consumed food were almost similar. Group I shrimps consumed more food than groups II and III (data of Ramadhas and Sumitra-Vijayaraghavan⁵ were used for comparison) but higher conversion efficiency (gross and net) was recorded in group II. Group III shrimps showed lower conversion efficiency, lower assimilation efficiency and lower growth rate than others. Consumption per unit weight in groups II and III was similar.

Changes in biochemical composition of the test diets from withered to completely decomposed condition of leaves showed that energy value and protein content increased while carbohydrate content decreased though supplemented with rice bran. Ash also showed decrease while lipid content varied little (Table 1).

Present results indicate high conversion in groups I and II compared to group III, possibly due to high caloric value and protein content of the decomposed leaves. The plant protein gets altered due to the growth of microbial population which leads to the formation

Table 1—Per Cent Biochemical Composition of Test Diets (*R. mucronata* Plus Rice Bran)

	Withered leaves	Partially decomposed leaves	Completely decomposed leaves
Carbohydrate	42.86	29.93	16.98
Protein	18.13	51.93	67.35
Lipid	10.25	8.2	7.25
Ash	28.76	10.44	8.42
Caloric content (cal/g dry wt)	3945	4011	4130

Table 2—Energy Balance of *M. monoceros*

[Values are expressed as cal/animal]

	Group I	Group II	Group III*
Initial dry wt (g; W ₁)	0.0881	0.0898	0.091
Final dry wt (g; W ₂)	0.1982	0.2071	0.124
Weighed mean (g; W)	0.1432	0.1485	0.108
Initial calories (I ₁)	378	299	465
Final calories (I ₂)	1181	718	654
Production [P = (I ₂ - I ₁)]	803	419	189
Consumption (C)	8271	2817	3212
Faecal output (F)	610	216	480
Assimilation (A = C - F)	7661	2601	2732
Metabolism (R = A - P)	6858	2182	2543
Assimilation efficiency (A/C × 100)	92.62	92.33	85.06
Gross growth efficiency (P/C × 100 or K ₁)	9.71	14.87	5.88
Net growth efficiency (P/A × 100 or K ₂)	10.48	16.11	6.92
Relative growth rate (P/W̄/No. of days)	0.0366	0.0376	0.0102
Consumption/unit wt/d (g)	0.6547	0.2187	0.2579

*Data from Ramadhas and Sumitra-Vijayaraghavan⁵

of a rich protozoa-bacteria-fungi-detritus complex, with much potential food value². An increase in amino acid content during decomposition of marsh plant has been reported¹¹. Low conversion efficiency and low relative growth rates in group III may probably be due to pure plant protein diet. Cowey *et al.*¹² have reported low growth rate in plaice fed diets containing pure plant protein or a mixture of plant and animal protein. In addition complex carbohydrates in withered leaves, which are resistant to enzyme action, may inhibit protein digestion resulting in low conversion efficiency as observed in *M. monoceros*¹³.

In *M. monoceros* there are wide variations in gross and net growth efficiency and assimilation efficiency^{5,14}. Thus, K₁ (gross growth efficiency) varied from 0.34-30%; K₂ (net growth efficiency) from 0.4-34.9% and assimilation efficiency from 64-93.3%. However, these values fall within the range reported for crustaceans¹⁵. Of the different feeds tried on *M. monoceros*, high conversion efficiency is obtained with estuarine detritus¹⁵ trash fish and adult *Artemia*¹⁶ and decomposed mangrove leaves. The latter occurs abundantly in nature and can be collected with ease and processed using simple procedures.

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Decapsulated Brine Shrimp Cysts—An Ideal Feed for Shrimps in Aquaculture

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Feeding experiments have been carried out with *Metapenaeus monoceros* using different stages of *Artemia salina* as feed. The importance of using decapsulated cysts to obtain greater food conversion efficiency has been indicated.

Brine shrimp, *Artemia salina*, is very widely used mostly as food of the larvae of atleast 25 organisms¹. For some species of fish and crustaceans, it is the only suitable food during certain phases of larval life. Brine shrimp as a feed is given in different forms - newly hatched nauplii, metanauplii, juveniles and adults either singly or in combination with other artificial or compounded diets. Advantages of decapsulation of dormant cysts in aquaculture hatcheries have been given². The decapsulation technique has been tried successfully on the Indian strain (Tuticorin) with a slight modification³.

To study the conversion efficiency, decapsulated cysts along with freshly-hatched nauplii, juveniles and adults of *A. salina* have been used as feed for the shrimp, *Metapenaeus monoceros* (Fabricius) and the

results obtained are presented in this communication.

Juveniles of *M. monoceros* (av. wet wt 80 mg) were collected from the backwaters of Mandovi estuary (Goa) and sorted into 4 groups. Group I to IV were fed respectively decapsulated cysts, freshly-hatched nauplii, juveniles and adults for 12-15 days. Other experimental details and methods employed in calculating dry weight balance were given elsewhere⁴. Carbohydrate, total protein and lipid for the 4 stages were estimated following the standard procedures⁵⁻⁷. Caloric content of the feeds was estimated with an adiabatic bomb calorimeter (Parr 1200).

A balance sheet of the shrimp in terms of dry weight is presented in Table 1. Group I shrimps showed a higher conversion efficiency, while low conversion efficiency was recorded in group III. Group II showed maximum assimilation (92.28%) and had a high relative growth rate as compared to the other groups. Group IV consumed most food (227.8 mg/ \bar{W} /d) but their conversion into body tissue was low as compared to group I which ate less (62 mg/ \bar{W} /d) and converted maximum into body tissue. Although group IV showed higher conversion efficiency than the group III their assimilation efficiency was lowest (77.79%). Thus, for the relative amount of food consumed, maximum growth was observed in the shrimps fed on decapsulated cysts. This could be attributed to the high caloric value of the decapsulated cysts (Table 2). Biochemical analyses revealed higher protein, lipid and carbohydrate content in the decapsulated cysts as compared with other stages of *A. salina* (Table 3).

It has been shown that of the 16 different types of feeds tried on *M. monoceros*, maximum conversion efficiency was found when the shrimps were fed adult *A. salina*⁴. The present study shows that the decapsulated

Table 1—Dry Weight Balance of *M. monoceros* Fed Different Stages of *Artemia salina* (g/animal)

Food given	Group I	Group II	Group III	Group IV
Initial wt (W_1)	0.0262	0.0261	0.0261	0.0262
Final wt (W_2)	0.1909	0.1054	0.0723	0.0717
Weighted mean (\bar{W})	0.1086	0.0658	0.0492	0.0489
Consumption (C)	0.3588	0.2138	0.1732	0.1671
Faecal output (F)	0.0425	0.0165	0.0185	0.0371
Assimilation ($A = C - F$)	0.3163	0.1973	0.1547	0.13
Metabolism ($R = A - P$)	0.1516	0.118	0.1085	0.0845
Production ($P = W_2 - W_1$)	0.1647	0.0793	0.0462	0.0455
Assimilation efficiency ($A/C \times 100$)	88.15	92.28	89.32	77.79
Gross growth efficiency ($P/C \times 100$ or K_1)	45.9	37.09	26.67	27.22
Net growth efficiency ($P/A \times 100$ or K_2)	52.07	40.19	29.86	35
Relative growth rate ($RGR = P/\bar{W}/\text{No. of d}$)	0.1269	0.0803	0.0626	0.062
Consumption/unit wt/d	0.2753	0.2166	0.2347	0.2278