

The protein content (Fig. 1) varied between 4 and 6.18%. It increased from November and attained a maximum value in February. This rise coincided with the spawning season of this species. Since the protein content increased with the advancement in maturity stage, it could be possible that the fish is likely to resort to some kind of selective feeding during the spawning season. Correlation-coefficients between protein and moisture (-0.11) and between protein and ash (-0.54) were not significant at all levels.

The sequence for carbohydrate content was same as that for protein. Carbohydrate content fluctuated between 3% (August) and 5.04% (January) with an average value of 4.03%. The percentage of carbohydrate showed an increase in October and it continued up to March with a slight decrease in February. From April onwards, the carbohydrate content decreased and attained the minimum in August.

**Carbohydrate and protein relationship** — The relationship between carbohydrate and protein (from scatter diagram) was found to be  $Y = 1.4907 + 0.8956X$  where Y = percentage of protein and X = percentage of carbohydrate.

The estimated values of protein were worked out from this equation. The relationship between carbohydrate and protein is linear and positively correlated (+0.8; significant at 1% level).

**Ash and carbohydrate relationship** — Relationship between ash and carbohydrate of *M. cephalus* was linear and negatively correlated (-0.94; significant at 0.1% level). It was also observed that when the ash content was high, the carbohydrate content was low and vice versa. The regression equation for ash and carbohydrate was:  $Y = 17.1942 - 0.4391X$  where Y = percentage of carbohydrate and X = percentage of ash.

Marais and Erasmus<sup>15</sup> observed that the smaller mullets, irrespective of species, consumed the most nutritious substances containing highest protein and carbohydrate content and with lowest ash content than the larger ones. As could be expected from the food items and particle size involved in feeding *Liza tricuspidens*, *Mugil cephalus*, *Liza richardsoni* and *Liza dumerili* consumed the most nutritious substances (highest protein and carbohydrate and lowest ash). However, in the present investigation, slightly lower value of protein and carbohydrate and high values of ash content were observed than those found by Marais and Erasmus<sup>15</sup> in the smaller groups of mullets.

These may be because of mixed samples, irrespective of size groups, taken for the present study. Masson and Marais<sup>16</sup> noticed that fishes of smaller size groups consumed material with a higher food value which may be ascribed to more efficient selection for smaller size particles by these smaller fish. Odum<sup>17</sup> has conclusively indicated that the smaller the particle, the higher its relative food value. Hence, the variations in ash, protein and carbohydrate in the present study may be partly due to different particle sizes ingested by *M. cephalus* in different seasons. The present investigation would show that the seasonal variations in the chemical composition of the ingested food of *M. cephalus* gives

an insight into the nutritional ecology of this fish and adds to our understanding of the interrelationships between different parameters.

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#### Growth of Weaving Mussel, *Modiolus metcalfei* (Hanley), in the Mandovi River, Goa

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**Ecology and growth of 2 populations of weaving mussel, located about 5 km apart in the Mandovi estuary were studied. Growth was higher in the natural bed than on the raft. Besides the ecological differences, biological factors, such as competition for space and food, seem important for the differences in growth rate. Possibilities of culture of the weaving mussels in Goa are indicated.**

MUSSELS are successfully grown on rafts in Goa<sup>1</sup> and elsewhere<sup>2</sup>. While a good deal of information is available on green mussels<sup>2,3</sup>, the ecology of the more gregarious brown or weaving mussels is poorly known. Along the Indian coast, the weaving mussels (*Modiolus* sp.) are found in abundance in the Palk Bay and Gulf of Mannar<sup>4</sup> and can form a potential source for exploitation<sup>5</sup>. In the Goa waters, *Modiolus* sp. has been reported to be a major fouling organism<sup>6</sup>.

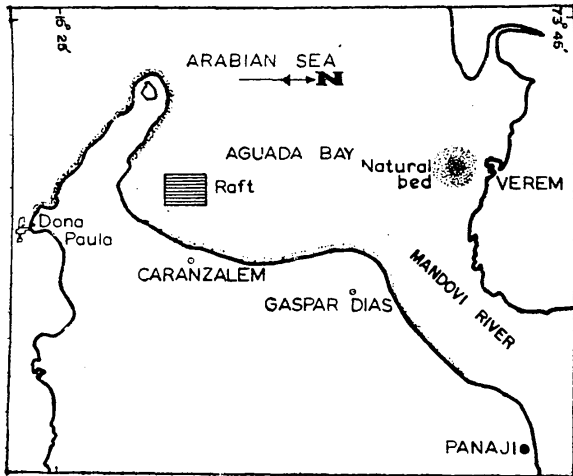


Fig. 1 — Aguada Bay-Mandovi showing position of raft and natural bed

Mussels were collected at fortnightly intervals from a natural bed and raft (Fig. 1). A Van Veen grab was used for the collection of subtidal mussels. Mussels were also observed to settle on the metallic drums of the floating rafts used for rope culture of green mussels<sup>1</sup>. From these drums, the mussels were collected by scrapping. Data on temperature, salinity, dissolved oxygen and particulate organic matter were recorded along with the biological sampling. Water analysis was done by standard methods<sup>7</sup>.

Natural bed of *Modiolus metcalfei* (Hanley) was found near the mouth of the river Mandovi, at a depth of 3-5 m, occupying an area of about 1000 m<sup>2</sup> (Fig. 1). It was densely populated from February to May (~1500 mussels/m<sup>2</sup>) but was depleted during the monsoon months. The 2nd population was growing on wooden rafts anchored in the Aguada Bay for aquaculture studies where a population density of >2500/m<sup>2</sup> was recorded during January-April.

Size frequency distribution showed a range of 6 to 28 mm and 8 to 26 mm in natural bed and raft, respectively (Fig. 2). Population from the natural bed was dominated by 6-8 mm size group in November with a mean size of 7.76 mm. The mean size of 11.74, 12.78, 16.66, 23.17, 15.98 and 24.52 mm was recorded for the period December to May. Monthly growth progression indicated a varying rate of growth at an average of 3.35 mm. *Modiolus* sp. from the south-east coast of India was reported to attain a maximum size of 25 mm<sup>5</sup>. The specimens settled on raft showed growth at varying rates of 0.1 to 4.2 mm with an average monthly growth rate of 2.13 mm which is lower than in the natural bed. From the observations on mean length in February, it appears that the spat must have settled in November on the raft.

Natural population showed a decline in growth in April (Fig. 3). Similarly, growth in length was also slowed down in April in mussels settled on the raft. A decrease in overall growth in both the populations may be due to heavy recruitment in February and March. Mature and ripe specimens were also found in high proportion during December to March.

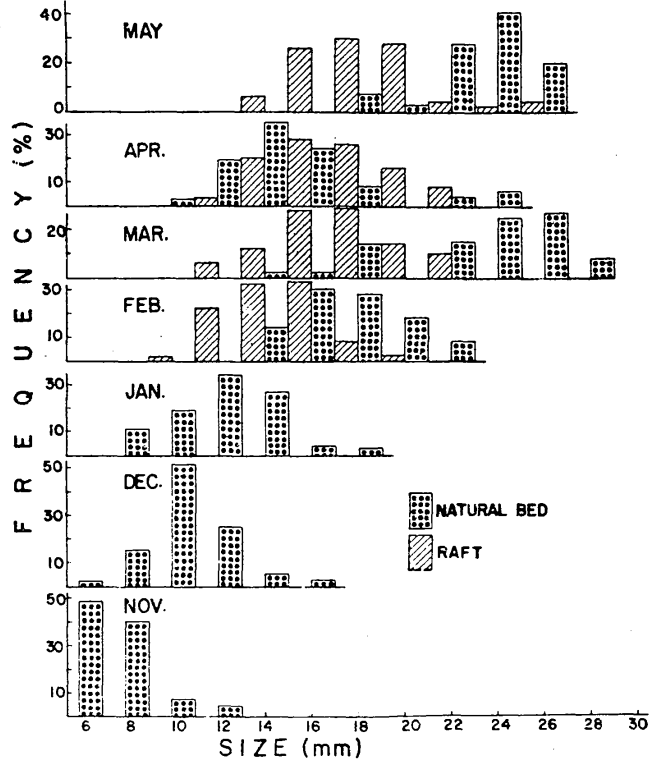


Fig. 2 — Size frequency distribution of *M. metcalfei* in the Mandovi river, Goa

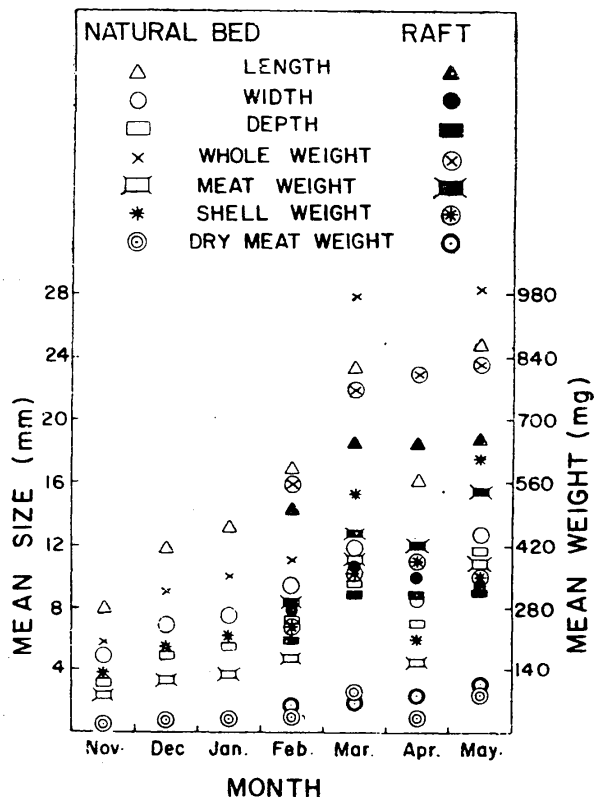


Fig. 3 — Growth progression in different body measurements of 2 populations of *M. metcalfei*

SHORT COMMUNICATIONS

TABLE 1 — MEAN GROWTH IN DIFFERENT BODY MEASUREMENTS IN *M. metcalfei* IN MANDOVI ESTUARY

No.	Size, mm			Weight, mg			
	Length	Width	Thick-ness	Whole	Shell	Meat	Dry meat
			NATURAL				
927	3.35	1.54	1.6	155	90	65	14.6
			RAFT				
230	2.14	1.47	1.52	160	57	103	17.5

Increase in other dimensions also varied greatly in the 2 populations (Fig. 3). As seen from Table 1, growth rate was higher in the natural bed. However, the increase in the meat content was greater in the raft settled animals. The ratio of meat weight to total weight was 1:2 and 1:1 in natural and raft populations, respectively. It indicates that the rate of conversion of energy in terms of soft tissue is greater in mussels growing on the raft than in the natural population. Similarly, the ratio of dry weight to total weight was higher in the raft settled mussels.

Further, in order to test the magnitude of differences in growth in the two populations, relationship between total weight (W1), shell weight (W2) and dry meat weight (W3) on length (L) were studied by the least square technique. The regression equation used was:  $Y = a + bx$ .

Where Y is weight (W1, W2, W3, etc.), x is length and a and b are constants to be determined empirically. The results are:

(a) Raft

$W1 = 0.066 L - 0.394; r = 0.98$

$W2 = 0.031 L - 0.195; r = 0.98$

$W3 = 0.006 L - 0.048; r = 0.98$

(b) Natural bed

$W1 = 0.068 L - 0.626; r = 0.98$

$W2 = 0.037 L - 0.325; r = 0.98$

$W3 = 0.009 L - 0.088; r = 0.94$

As can be seen from the above equations, the increase in dry meat weight (W3) in relation to growth in length (L) was more significant in raft (0.98) than in the natural populations (0.94). The t test was applied to the relevant data and the differences were significant at 95% confidence level. The differences found in the 2 populations can be attributed to differences in habitat and environmental conditions. Though both the populations were in the mouth region of the river Mandovi, the natural population was subtidal while the raft grown population was in the surface waters. Accordingly, the range in temperature (4.4°C) and salinity (4.04‰) was greater in the natural bed whereas the dissolved oxygen (2.8 ml/litre) was greater at the site of the raft (Table 2).

Bohle<sup>8</sup> observed that the suspended organic matter is an important ecological factor and variations in its quantity affects the suspension feeders like mussels, clams and oysters. The particulate matter (mean value) was greater in the natural bed (313 mg/litre)

TABLE 2 — ENVIRONMENTAL VARIATION DURING NOVEMBER-MAY IN NATURAL BED AND RAFT

Month	Loca-tion	Tempe-rature (°C)	Salinity (‰)	Dis-solved oxygen (ml/litre)	Parti-culate matter (mg/litre)
Nov.	1	25.6	33.81	3.87	106
	2	29.7	33.34	3.92	156
Dec.	1	26.7	32.3	3.74	345
	2	28.1	34.99	1.71	70
Jan.	1	25.4	31.62	5.82	301
	2	27.5	32.58	3.58	139
Feb.	1	26.5	33.23	4.85	469
	2	28.2	33.81	4.59	509
March	1	29.1	33.93	5.1	327
	2	29.5	33.86	3.91	147
April	1	29.4	34.98	4.25	349
	2	30.3	32.53	4.53	241
May	1	30	35.66	4.9	298
	2	28.7	34.73	4.22	259

1 = natural bed; 2 = raft.

than at the raft (217 mg/litre) and accordingly the rate of growth was higher in the natural population than in the raft animals. Monthwise correlation between particulate organic matter and growth rate was attempted, but no definite relationship could be established. Another probable reason for lower growth rate of raft settled animals could be overcrowding as the population density on the raft was >2500/m<sup>2</sup> as against 1500/m<sup>2</sup> in the natural bed. The mussels on the raft had to face severe competition for food with the green mussels which were being cultured on ropes suspended from rafts and therefore their growth rate was lower than in the natural bed.

The growth of mussels, on the other hand, is greatly enhanced in the raft culture<sup>1-3</sup>. Though the growth was lower on the raft it can be improved, if monoculture is practised. As seen from the results of the present investigation, even the ground culture method<sup>2</sup> will give good yield. Although brown mussels are not much in demand at present as food for human consumption, if their culture could be undertaken commercially, these can be used for the production of fish meal or poultry feed, in addition to their direct use in human dietary.

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