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Growth of juvenile shrimp *Metapenaeus monoceros* fed with squid and mussel

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Small juveniles of both sexes and females of large juveniles of *Metapenaeus monoceros* attained faster growth with squid diet. Males of large juveniles registered better growth with mussel diet. No significant difference was observed in moult weights between diets within the size class, but weight increment per moult showed significant difference with diets in small juveniles. Faecal output in both size classes was more in those fed mussel, suggesting low conversion efficiency. Fatty acid composition showed variations between the feeds. Present results showed that an appropriate proportion of squid meat in formulated feeds would enhance growth of penaeid shrimps.

Nutrition of shrimp has gained considerable attention since aquaculture of these organisms has become a reality. A detailed review of dietary studies[1] and bibliography on shrimp and prawn nutrition[2] have been published. Although notable progress in commercial cultivation of penaeid shrimps has been made in India, there is no low-cost indegenous feed available in the market. Some attempts have been made to formulate shrimp feed in India[3,4] but their commercial viability has not been established. It has been shown that squid meat in diets stimulates the maturation processes in some Pacific and Atlantic species of shrimps[5].

Squids are relatively abundant in India and hence juvenile stages of the penaeid shrimp *Metapenaeus monoceros* were fed squid (*Loligo* sp.) meat to see whether juvenile growth is also influenced by this diet. Comparison has been made with juveniles fed on mussel tissue (*Perna viridis*) as this is generally used as a diet to maintain shrimps and other organisms in captivity. *M. monoceros* was selected as the experimental species because this is one of the abundant and larger sized *Metapenaeus* species used in traditional shrimp culture practices.

Materials and Methods

Juveniles of *M. monoceros* were collected from the Chorao Island in the Mandovi estuary of Goa and acclimated to laboratory conditions (sal. 28×10^{-3}; temp. 28°C) for 2 days before commencing the experiment. The experiment lasted for 12 weeks. Twelve smaller (♂ 5, ♀7; wet weight range, 0.97-1.57 g) and 12 larger shrimps (♂ 6, ♀6; wet weight range, 4.05-5.3 g) were picked randomly and each one was kept in separate round-bottom fibreglass tank (diameter 0.5 m, height 0.4 m) containing filtered seawater ($\approx$30 liters). The tanks were continuously aerated. Every morning water temperature, salinity, dissolved oxygen and *p*H were measured using a Hydrolab (Model 4041, Hydrolab Corporation, Texas). Seawater in experimental tanks was renewed once a week.

Six small and 6 large shrimps were fed squid meat and the rest mussel tissue. Meat was cut into small pieces and fed *ad libitum* once in the morning. No supplementary feed was given. Uneaten food was removed in the following morning without disturbing the tank bottom. Excreta were then siphoned out through a bolting silk (60 μm), rinsed with distilled water and transferred to individual petri-plates. Excreta of individual shrimp were dried (at 60°C till constant weight), pooled for a week and weighed. Wet weight (nearest mg) of animals was taken once a week after carefully blotting excess water.

Whenever moulting occurred, the moult was carefully removed and weighed after rinsing with distilled water and blot drying. Moulting frequency and moult weight were recorded for each shrimp. No mortality occurred during the experiment.

Fatty acid profiles of the experimental feeds were determined using a MIDI-Microbial Identification System (Hewlett Packard). Since the system has softwares only to identify the fatty acid composition of bacteria, most of the fatty acids > 20 carbon could not be identified. Statistical significance (*t* test) was determined[6].

Results and Discussion

Average weekly specific growth rates were similar in larger shrimps fed both diets and ranged between 0.6 and 3.3% (Fig. 1). Statistical test indicated an insignificant difference, attributable to diets ($P > .05$). But small shrimps fed squid grew significantly faster ($P < .05$) than those fed mussel. Growth ranged from 3.8 to 9.8% of wet body weight with squid and 0.5 to 6.5% with mussel diet (Fig. 1). When weekly growth rates were treated separately for sexes (Figs 2, 3), larger males fed mussel recorded faster growth (average growth rate, 1.7% wet body weight with squid and 2.5% with mussel) whereas in all other cases growth was significantly higher ($P < .05$) on squid diet.

Most shrimps moulted 4 times during the experimental period. The average moult weight to average body weight of shrimp was higher during the first moult (after commencement of experiment) in all groups regardless of diet (18.5-26%) and least during the fourth moult (9.7-16.4%) (Table 1). However, no significant difference ($P > .05$) was found in moult weight between diets within each size group. The average wet weight of moult irrespective of the moult number, were 19.7 and 20.2% of the wet body weight for the larger shrimps fed squid and mussel diets, and 14.7 and 14.1% respectively for smaller shrimps. The intermoult period (Table 1) generally increased with progressive moultings. The minimum average intermoult period was 18 d and the maximum was 27 d.

Average wet weight increment per moult was 0.34 g with squid diet and 0.286 g with mussel diet for large shrimps and 0.416 and 0.332 g respectively, for small shrimps. The weight increment in small shrimps showed significant difference ($P < .05$) with diets, indicating that weight increment per moult was greater with squid diet than mussel diet. However, no appreciable variations were noticed in the number of moults per week with size or diet (range 0.27-0.32 moult per shrimp per week). On the other hand, faecal

Table 1—Average wet moult weight (% wet body weight) during successive moults and average intermoult days

Moult number	Large Juveniles				Small juveniles			
	Squid		Mussel		Squid		Mussel	
	Wt	Days	Wt	Days	Wt	Days	Wt	Days
1	26.0	—	23.3	—	20.3	—	18.5	—
2	21.6	26.4	16.2	21.0	10.6	18.0	16.4	19.4
3	17.2	22.7	13.0	18.8	15.5	23.0	13.6	25.0
4	16.4	27.0	12.5	19.6	9.7	24.3	10.8	22.0

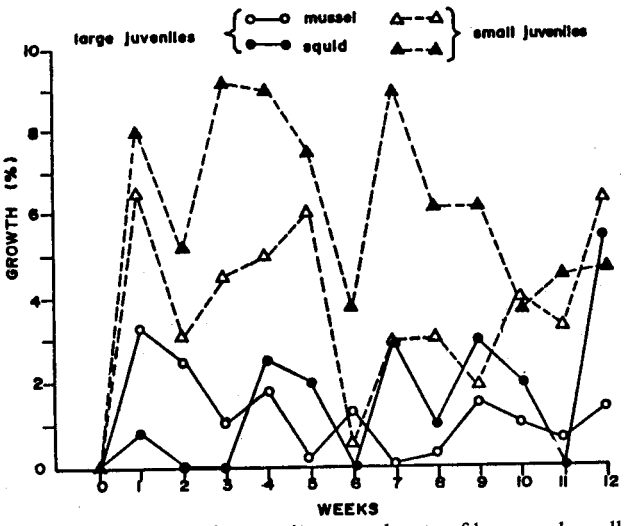

Fig. 1—Average weekly specific growth rate of large and small juveniles fed on squid and mussel meat

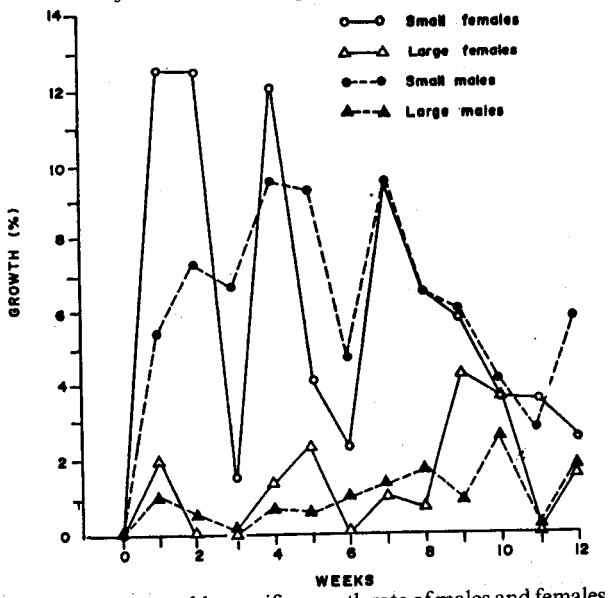

Fig. 2—Average weekly specific growth rate of males and females fed on squid meat

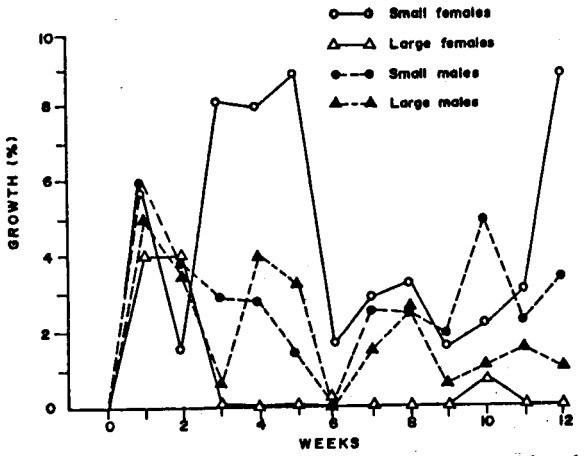

Fig. 3—Average weekly specific growth rate of males and females fed on mussel meat

production was significantly higher ($P < .05$) in both size classes fed mussel diet (Table 2).

Although there were some unknown fatty acids present in small percentage in mussel tissue, all the major ones could be identified (Table 3). The dominant ones were 16:1 (16.3%) and 19:1 (15.4%). In squid, the number of unknown fatty acids were less, but one of them (>20 carbon) was the most dominant one (31.3%) followed by 16:0 (29:8%). Thus the overall fatty acid profiles were different for the two experimental diets.

Composition of various feed ingredients determines the quality of the diet and the consequent growth efficiency of concerned species. Squid meat in compounded feed has been reported to promote growth of penaeid shrimps[7] and various proportions ranging from 5 to >45% have been recommended for different species[8-11].

Present results generally support the above observations. However, the experiment was designed primarily to understand the responses in growth of juvenile penaeid shrimps to squid and mussel diets, with respect to size and sex. Squid or mussel by itself is not a complete diet for penaeid shrimps and hence the experimental animals would not have attained maximum growth rates. But the purpose of the study was to find out which of these two, if incorporated in shrimp feed would enhance growth. The results suggest that even at very early stage, regardless of sex, squid was a growth promoting supplement.

Weight increment was significantly higher after moulting in both size classes fed squid compared to mussel. This suggests that the conversion efficiency of squid meat was higher than mussel meat. The fact that moult frequency was not significantly different between the diets indicates that it was the higher growth attainment per moult and not the frequency of moulting, which was responsible for the better growth rate attained with squid diet.

The faecal output data also were generally in support of the above interpretations. Faecal production was greater in both size classes fed mussel compared to squid diet. This would also indicate that conversion efficiency of mussel tissue was relatively less.

Certain specific fatty acids, particularly polyunsaturated fatty acids (PUFA) of 20 carbon and above are known to be growth stimulants for penaeid shrimps[12-15]. Some of these fatty acids are present in high concentrations in penaeid shrimps[16-18] and their natural prey also contain them in high proportion[19]. Although the fatty acid composition of the experimental feeds could be partially identified (due to limitations of the system), the major differences could be determined. The most striking difference was the dominance (31.3%) of a >20 C fatty acid (unknown in our analysis) in the squid meat (Table 3). In the case of mussel although many fatty acids >20 C were present none formed any

Table 2—Weekly averaged faecal output (mg dry weight per g wet body weight) ± SD (in parentheses)

Week number	Large juveniles		Small juveniles	
	Squid	Mussel	Squid	Mussel
1	0.33 (0.08)	0.54 (0.29)	0.32 (0.08)	0.54 (0.29)
2	0.28 (0.09)	0.47 (0.10)	0.19 (0.07)	0.46 (0.09)
3	0.36 (0.04)	0.49 (0.34)	0.36 (0.04)	0.48 (0.32)
4	0.29 (0.03)	0.29 (0.12)	0.28 (0.04)	0.29 (0.12)
5	0.43 (0.17)	0.24 (0.11)	0.33 (0.06)	0.23 (0.10)
6	0.27 (0.05)	0.28 (0.15)	0.27 (0.05)	0.29 (0.15)
7	0.45 (0.08)	0.29 (0.14)	0.45 (0.09)	0.28 (0.14)
8	0.31 (0.13)	0.26 (0.08)	0.31 (0.12)	0.26 (0.07)
9	0.37 (0.09)	0.26 (0.17)	0.37 (0.08)	0.26 (0.16)
10	0.35 (0.09)	0.29 (0.07)	0.35 (0.09)	0.27. (0.07)
11	0.38 (0.06)	0.42 (0.19)	0.40 (0.05)	0.43 (0.02)
12	0.30 (0.10)	0.27 (0.13)	0.30 (0.10)	0.28 (0.14)

Table 3—Composition (%) of major fatty acids in squid (*Loligo sp.*) and mussel (*Perna viridis*) meat

Fatty acid	Squid	Mussel
14:0	3.8	3.0
15:0	—	1.1
16:0	29.8	16.3
16:1	1.1	2.4
17:0	1.5	1.6
Unknown	—	5.9
Unknown	—	1.4
18:0	4.2	6.2
18:1	4.2	—
19:1	1.3	15.4
20:1	1.1	—
20:4	6.6	5.2
Unknown	8.7	4.1
Unknown	31.3	3.7
Unknown	1.7	8.0
Unknown	—	3.4
Unknown	—	4.6
Unknown	—	4.6
Unknown	—	2.9
Unknown	—	5.2

substantial proportion. Therefore, this unknown fatty acids dominant in squid meat could be the growth stimulant. Clarke and Wickins[18] also suggested that diets rich in certain PUFA of 20 and 22 carbons may be essential for cultured species of marine shrimps to maintain a wild type fatty acid composition. Results of this study thus indicate that squid meat could be an essential basic component of any shrimp feed because of its growth promoting ability.

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