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# 46. POSSIBILITIES OF GREEN MUSSEL CULTURE IN THE SOUTHWEST COAST OF INDIA

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## ABSTRACT

A simple and viable technology has been developed for the culture of green mussel *Perna viridis* on ropes suspended from floating rafts in the open sea at Calicut and Karwar along the west coast of India. Rafts varying in size from 5 x 5 m to 8 x 8 m were constructed using teak and bamboo poles and moored in the open sea at 8-10 m depth. Collection of seeds for the culture was done during October-December from the intertidal and submerged mussel beds. The average seed size for farming was 15-30mm and 0.5-1.0 kg seeds are required for seeding one meter length of the rope. Synthetic and coir ropes of 15-20 mm diameter were found suitable for growing mussels from the rafts. The seeds were placed around the rope and securely wrapped with knitted cotton cloth. The seeded portion of the rope varied from 5-8 m and the ropes were suspended from the rafts 0.5-1.0 m apart. Growth of mussels in the farm at Calicut ranged 11.6-12.9 mm in length and 5.9-7.3 g in weight per month. At Karwar the growth ranged 7.6-10.0 mm in length and 3.18-3.5 g in weight per month. A production rate of 12.3 kg per meter length of rope at Calicut and 10 kg per meter length at Karwar was obtained. Harvesting was done at the end of five months. The possibilities and constraints of mussel farming in the open sea conditions are discussed in the paper.

## INTRODUCTION

The green mussel *Perna viridis* though found along the west coast of India from Quilon to Ratnagiri, is densely distributed along the rocky areas of Malabar coast. Jones and Alagarswami (1973) have given a detailed account of its resources and magnitude of the fishery. The distribution and extent of mussel beds and the exploited resources of this species has been studied from 1981-84 along the Kerala coast from Calicut to Cannanore and Karnataka coast from Bhatkal to Majali by the present authors. The average annual exploited resources was around 3500 metric tonnes.

Mussel culture by various methods is widely practiced in Spain (raft culture), France (Pole culture) and the Netherlands (Bottom culture) and elsewhere (Mason 1972, 1976, Korringa 1976, Lutz 1974, 1979 and Hulburt 1974). Mussel farming in Europe and other parts of the world is limited to bays and other protected areas which are ideally suited for culture, but the configuration of the Indian coast line is such that ideal bays or protected areas are limited for farming mussels on commercial scale. Experiments on the culture of green

mussel were initiated in the open sea at Calicut for the first time in India in 1975 and continued till 1980 and later at Karwar. The possibilities of farming green mussel in the open sea condition following the raft culture technique and its production potential has been given by Kuriakose (1980), Quasim et al (1977), Silas (1980) and Pai and Kuriakose (1981). The paper deals with the observations made at Calicut and Karwar about the possibilities of mussel farming in the open sea conditions and also the adoption of the same in suitable areas along the Indian coast.

## FARM SITE AND ENVIRONMENTAL CONDITIONS

At Calicut the mussel culture farm was located in the open sea about 2.5 km away from the shore having a depth of 8-10 m. The area is a good fishing ground and is free from industrial pollution and fresh water influx from rivers. The bottom is sandy near the shore and muddy at the farm site. During the experimental period October to May, the salinity of the farm site ranged from 32.44‰ to 33.68‰ at the surface and from 31.99‰ to 33.45‰ at the bottom. The sea water temperature at the farm site for the period varied from 27.44° C to 30.66° C at the surface and from 26.70° C to 30.26° C at

the bottom. The dissolved oxygen content of the surface water was almost constant and ranged between 4.43 ml/l and 4.90 ml/l and that of the bottom was slightly lower from 3.79 ml/l to 4.32 ml/l.

At Karwar the culture farm was located off Karwar bay about 2 km away from the shore having a depth of 8-10 m. The bottom is muddy at the farm site. During the experimental period October to May of 1981-84, the salinity ranged from 34.62‰ to 35.0‰ at the bottom. The sea water temperature varied from 28.5° C to 30.5° C at the surface and from 28.2° C to 30.2° C at the bottom. The dissolved oxygen content

of the surface water varied between 3.53 ml/l and 4.93 ml/l and that of the bottom was from 4.16 ml/l to 4.9 ml/l.

#### TECHNIQUE

The raft culture or suspended culture technique suitable for west coast conditions was followed for farming mussels. Rafts varying in size from 5 x 5 m to 8 x 8 m (Tables 1&2) were constructed using teak wood and bamboo poles lashed together with coir and nylon ropes. The rafts were mounted over 5-6 metallic floats of 200 l capacity, painted with anticorrosive and antifouling paints. Three iron anchors

TABLE - 1 *Details of mussel culture work carried out at Calicut from 1975-76 to 1980-81*

Particulars	1975-76	1976-77	1978-79	1979-80	1980-81
Number of rafts used for mussel culture	1	10	24	10	3
Size of the rafts	7 x 5m	8 x 8m	8 x 8m	8 x 8m	5 x 5m 6 x 6m 7 x 7m
Depth of the farm site	5m	9m	8m	7m	8m
Period of seeding	Nov 85	Nov & Dec 78	Nov & Dec 79	Nov & Dec 79	Nov & Dec 80
Seeded length of the rope	4m	8m	7m	6m	6m
Weight of seed used for seeding 1m length rope	700g	500g	600g	750g	1kg
Average size of the seed used for seeding	26.7mm	21.7mm	20.4mm	20.4mm	24.2mm
Number of ropes suspended from one raft	3.5	5.5	100	100	65
Total number of ropes seeded during the year	35	533	2400	1000	195
Average length of the harvested mussels	80.0mm	89.22mm	84.6mm	82.00mm	72.8mm
Average weight of the harvested mussels	37.3g	41.0g	26.8g	36.4g	25.24g
Meat yield of the harvested mussels	40.1%	40.2%	40.5%	36.3%	34.72%
Production rate per meter length of rope	5.1kg	4.4kg	12.3kg	11.3kg	10.5kg
Total number of ropes harvested	35	176	145	393	100
Total number of ropes lost in the rough sea	—	375	2255	607	95
Total quantity of mussel harvested	706.4kg	6164kg	12500kg	13400kg	652kg

TABLE - 2 *Details of mussel culture work carried out at Karwar from 1980-81 to 1983-84*

Particulars	1980 81	1981-82	1982-83	1983-84
Number of rafts used for mussel culture	4	3	1	1
Size of the rafts	7 x 7m, 6 x 6m, 5 x 5mm	6 x 6m, 5 x 5m	5 x 5m	5 x 5m
Depth of farm site	8m	9m	9m	9m
Period of seeding	Jan '81	Nov & Dec '81	Dec '82	Nov & Dec '82
Seeded length of the rope	4m	5, 6 & 7m	6m	6m
Weight of seed used for seeding one meter length of the rope	1 kg	1 kg	700 g	500 g
Average size of the used for seeding	17.5mm	26mm	18.2mm	19.6mm
Number of ropes suspended from one raft	48, 41, 33 & 32	29, 38 & 26	12	32
Total number of ropes seeded during the year	154	103	12	32
Period of harvest	June '81	May '82	—	May '84
Average length of the harvested mussels	62.6mm	78mm	—	80.6mm
Average weight of the harvested mussels	14.7g	33.7g	—	36.4g
Meat yield of the harvested mussels	27.89	34.0	36.5	35.9
Production rate per meter length of rope	7.6kg	10kg	—	8kg
Total number of ropes harvested	120	42	—	8
Total number of ropes lost due to poaching	34	61	12	24
Total quantity of mussels harvested	3751kg	2520kg	—	300kg

weighing 100 kg each were used for mooring the rafts in the sea attached to iron chain links of 13 mm diameter. The rafts were anchored at depth ranging from 8-10 m in the open sea about 2-2.5 km away from the shore (Fig 1 A). The rafts could withstand wind and wave action in the sea for a period of 7 months from October to April.

#### SEED COLLECTION AND SEEDING

The breeding season of the green mussel along the west coast extends for a period of five months from July to November with peak spawning activity in August and September. Juvenile mussels were found carpeting all over the intertidal and submerged rocks (Fig 1 B) reaching a density of 6225 per meter

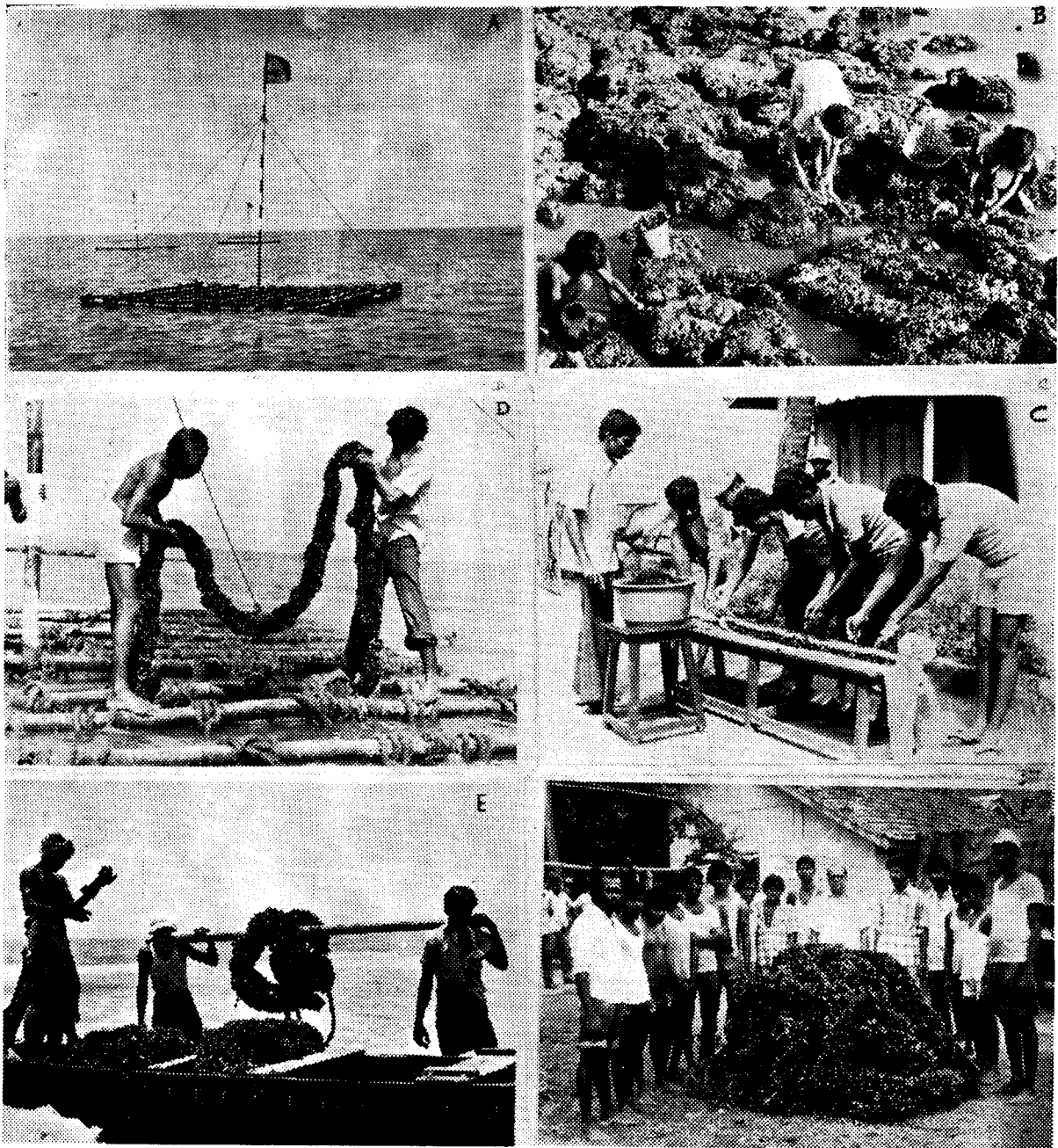


Fig. 1 Mussel culture on ropes at Calicut and Karwar. A. The rafts in the sea; B. Mussel seeds in the natural bed; C. Seeding the rope; D. Growth and Production of mussels on rope; E. Harvested mussel; F. A day's Harvest

square area in centre like Elathur. The collection of seed for the culture at Calicut was made from the intertidal and submerged natural beds at Elathur, Thikkodi and Mahe.

At Karwar, the collection was made from the submerged natural bed at Karwar, Chendia and Harwada. Immediately after the collection the seed were cleaned to remove the adher-

ing mud and epifauna. The size of the seed used for seeding ranged from 15-30 mm and 0.5-1.0 kg seeds were used for seeding one meter length of the rope. Synthetic and coir for ropes of 15-20 mm in diameter were used for growing mussels from rafts. The seed mussels were secured around the rope by enclosing and stitching in knitted cotton cloth of 25 cm width (Fig 1 C). The seeded portion of the rope

varied from 5-8 m at Calicut and 4-7 m at Karwar (Tables 1 & 2). The seeded ropes were suspended from the rafts 0.5-1.0 m apart, with the lower free end about 2 m above the bottom. The seeded mussels got attached to the ropes by means of freshly secreted byssus threads within 2 to 3 days and the cloth disintegrates in sea water within about 10 days (Fig 1 D).

### GROWTH OF MUSSELS IN THE FARM

Growth rate of mussels in the farm at Calicut from 1975-76 to 1980-81 is presented in Figs 2 & 3. Seeds having an average length

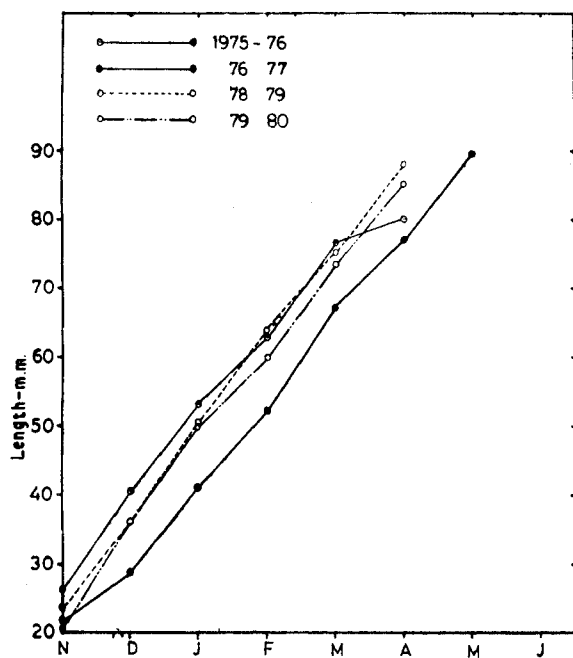


Fig 2 Growth rate of mussels in the farm at Calicut

of 20.4-26.7 mm, weighing 0.8-1.92 g transplanted in the middle of November grew to a size of 80.0-88.2 mm in length weighing 36.4-37.5 g in the second week of April, within a period of 5 months. The average monthly growth ranged from 11.6-12.9 mm in length and 5.9-7.3 g in weight. The percentage of meat yield at the time of the harvest in April ranged from 34.82 to 40.1 (Fig 4).

Growth of mussels in the farm at Karwar is presented in Figs 5 & 6. The monthly growth rate was 10.0 mm in length and 3.18 g in weight (1980-81), 7.6 mm in length and 3.5 g in weight (1981.82), 8.3 mm in length and

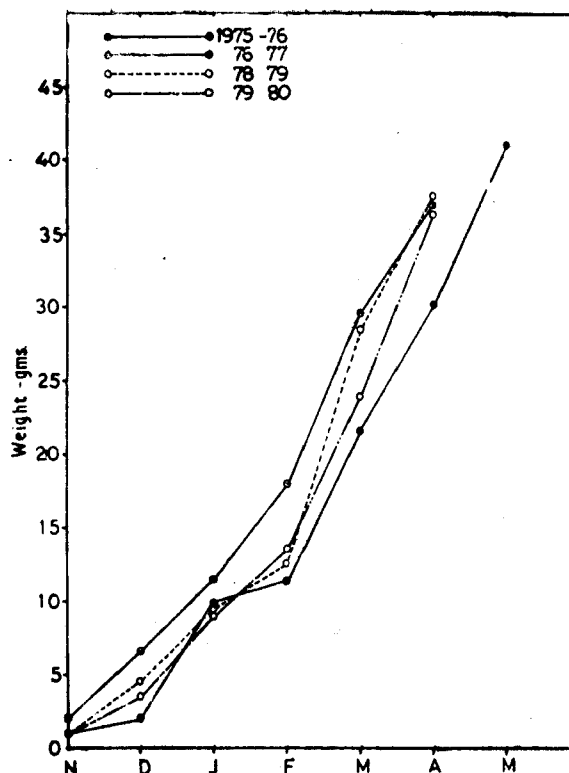


Fig 3. Monthly average weight of mussels in the farm at Calicut.

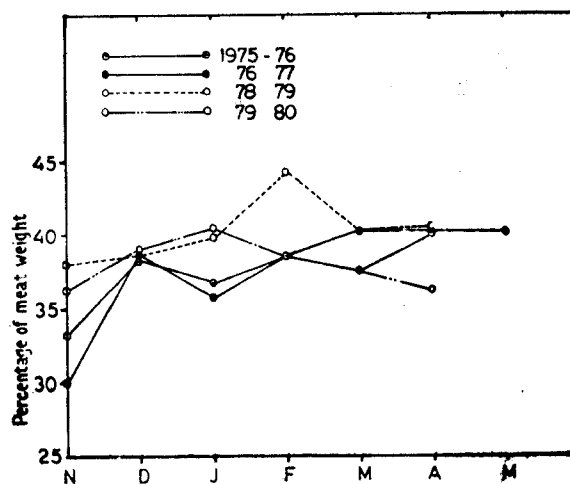


Fig 4. Monthly average meat yield of cultured mussels at Calicut.

3.8 g in weight (1983-84). The percentage of meat yield for the above periods were 27.9, 34.0, 36.5 and 35.9 respectively (Fig 7).

### PRODUCTION

Details of the harvest and the production from the mussel culture experiments at Calicut

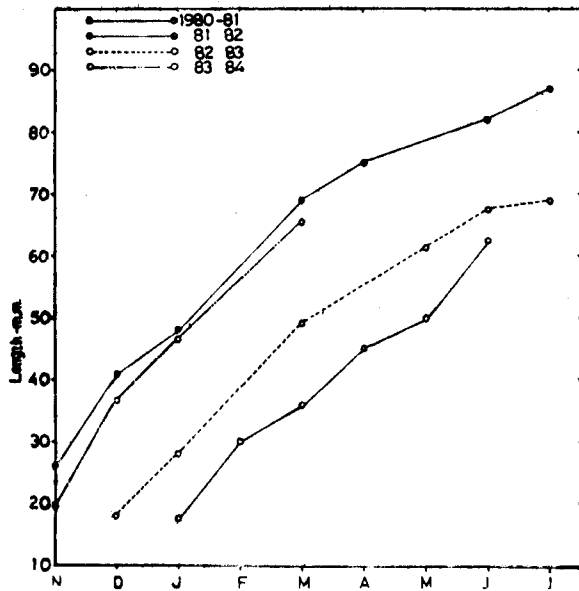


Fig 5. Growth rate of mussels in the farm at Karwar

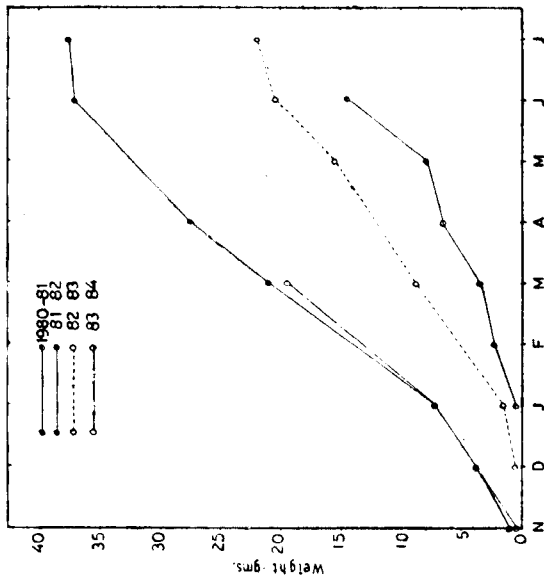


Fig 6. Monthly average weight increase of mussels in the farm at Karwar

from 1975-76 to 1980-81 are presented in Table 1. The average production per meter length of rope in 1975-76 was 5.1 kg mussels by using 0.7 kg seeds. In 1976-77, the production rate was 4.4 kg per meter length from 0.5 kg seed. The highest production of 12.3 kg per meter length of rope was obtained in 1978-79 which is 21 times the seed used for culture (Fig 1 E). The production rate in 1979-80 was 11.3 kg mussels per meter length

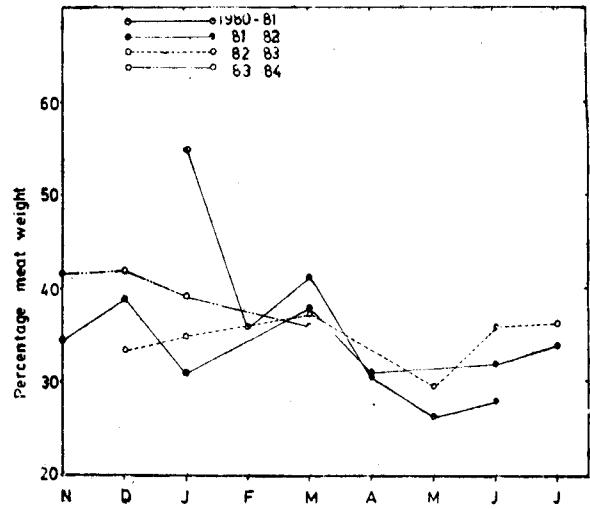


Fig 7. Monthly average meat yield of farm mussels at Karwar

registering an increase of 15 times of the seed weight. During 1980-81 the production rate was 10.5kg per meter length of rope.

The results of harvest and production from the mussel culture experiments at Karwar from 1980-81 to 1983-84 is presented in Table 2. The production rate of mussel per meter length of rope during 1980-81 and 1981-82 was 7.6 kg and 10.0 kg from an initial weight of 1.0 kg seeds (Fig 1 F). In 1983-84, the production from an initial seed weight of 0.5 kg was 8.0 kg mussels registering an increase of of the seed used.

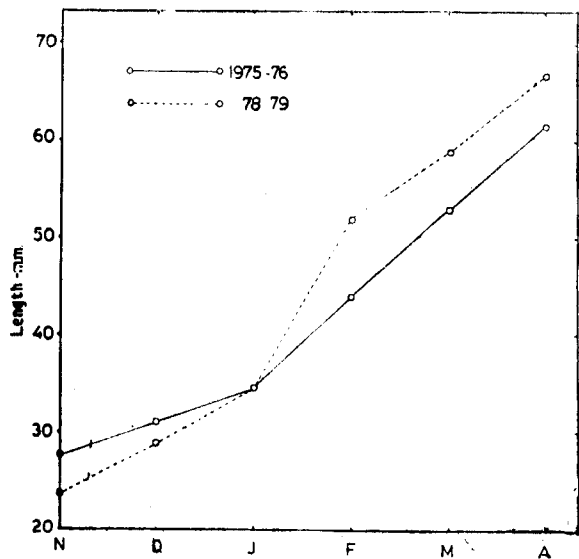


Fig 8. Growth rate of mussels in the natural bed at Calicut

## DISCUSSION

The results of the experiments conducted in the open sea conditions along the west coast showed that the growth of mussels in the farm is very fast, 10.6–12.9 mm in length and 5.8–7.3 g in weight per month at Calicut. Growth of mussels of the same brood in the natural bed was only at the rate of 6.9 mm in length and 3.6 g in weight in 1975-76 and 6.8 mm in length and 3.8 g in weight in 1978-79. (Figs 8&9). The farm mussels gave a better meat

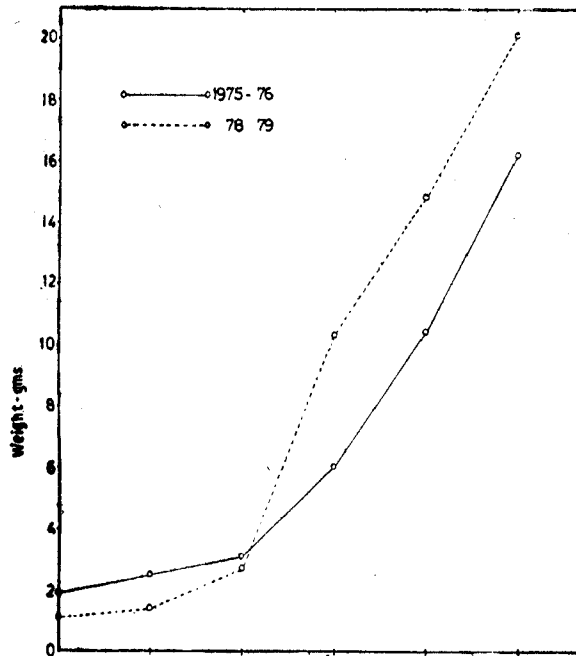


Fig 9. Monthly average weight increase of mussels in the natural bed at Calicut.

yield than the mussels in the natural beds (Fig 4 & 7). The average wet meat yield ranged from 34.82–40.5 percent of the total weight at Calicut and 27.89 to 36.5 percent at Karwar. Whereas, in the natural mussels at Calicut the meat yield was only 27.2–32.9 percent (Fig 10).

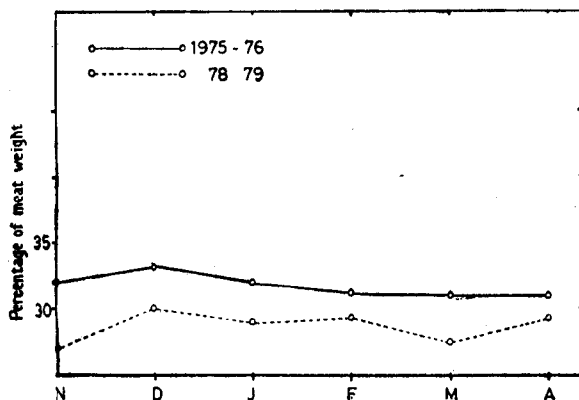


Fig 10. Monthly average meat yield of mussels in the natural bed at Calicut

The seed mussels transplanted from the natural bed to the culture rafts in the open sea at Calicut in November, showed signs of gonad development in December within a period of 30 days and 100 percent of the mussels in the farm was in the developing stages. In January 100 percent was in the matured condition (Table 3). Spawning of mussels in the farm started in February, within 90 days. In the culture farm 65–100 percent were in the maturing, matured and spawning stages (Table 3). This is quite encouraging because mussel seed can be easily collected from the farm on suitable spat collectors. In the natural beds at Calicut, gonad development commenced only in April and only 47 percent was in the early developing stages in 1975-76 (Table 4). In 1976–77 gonad development did not commence till April and 100 percent was in the indeterminate stage. During 1978-79, gonad development started in March when 6 percent was in the developing stages. In April, 6 percent was in the developed condition and 10 percent in the developing stages.

At Karwar, in the seeds transplanted from the natural beds to the farm in November, gonad maturity started in December and 100 percent of mussels were in the developing stages (Table 5). Spawning started within 90 days and 40 percent spawned in January. In March 100 percent completed the spawning and were in the indeterminate stage. Re-development of the gonad commenced in farm in April with 5 percent in the developing stages, 41 percent in the fully developed condition and 54 percent in the spawning stage (Table 5).

The green mussel attained harvestable size of 80–88 mm in length within 5–6 months, as against 15–18 months in Spain and 24–36 months in the Netherlands and France (Korringa 1979, Mason 1976). A production rate of 12.3 kg mussels per meter length of rope was achieved within 5 months and this is much more than the production rate in the Galician bays of Spain, the leading mussel producing country in the world.

Availability of seeds in the wild is restricted to a few rocky patches along the coast, that too only for a short period from October–December every year. To overcome this possible



TABLE - 3 *Percentage of indeterminate, maturing, matured and spawning stages of mussels in the farm at Calicut*

Months	No. of mussels in sample	Indeterminate	Male			Female		
			% maturing	% matured	% Spawning	% maturing	% matured	% Spawning
1975-76								
Nov	100	100	—	—	—	—	—	—
Dec	100	17	47	—	—	36	—	—
Jan	100	—	—	47	—	—	53	—
Feb	100	—	—	32	15	—	36	17
Mar	100	30	—	9	22	—	11	28
Apr	100	15	—	14	20	—	18	33
1976-77								
Nov	100	100	—	—	—	—	—	—
Dec	200	32	37	—	—	31	—	—
Jan	200	3	16	30	—	15	36	—
Feb	200	—	—	45	—	1	54	—
Mar	200	9	—	36	9	—	37	9
Apr	200	—	—	24	18	—	29	29
1978-79								
Nov	200	100	—	—	—	—	—	—
Dec	150	—	42	—	—	58	—	—
Jan	150	—	16	25	—	14	45	—
Feb	150	3	—	32	11	—	31	23
Mar	100	19	—	5	34	—	5	37
Apr	100	28	—	24	5	—	35	8
1979-80								
Nov	100	100	—	—	—	—	—	—
Dec	100	—	38	13	—	28	21	—
Jan	100	—	—	46	—	—	54	—
Feb	100	—	—	18	28	—	21	33
Mar	100	—	—	13	32	—	22	33
Apr	100	35	5	13	12	1	16	18

shortage of seed it appears desirable to develop methods to collect seed from the farm by using suitable spat collectors. Non-availability of required quantity of seed may pose problems

for future farming operations. At present we have very little information as to the extent of mussel spat availability along the west coast of our country. A detailed survey to identify

TABLE 4. *Percentage of indeterminate, maturing, matured and spawning stages of mussels in the natural bed at Calicut*

Months	No of mussels in sample	Indeter- minate	Male			Female		
			% maturing	% Matured	% Spawning	% maturing	% matured	% Spawning
1975—76								
Nov	100	100	—	—	—	—	—	—
Dec	100	100	—	—	—	—	—	—
Jan	100	100	—	—	—	—	—	—
Feb	100	100	—	—	—	—	—	—
Mar	100	100	—	—	—	—	—	—
Apr	100	53	30	—	—	17	—	—
May	100	47	25	1	—	27	—	—
Jun	100	19	39	4	—	37	1	—
1976—77								
Nov	100	100	—	—	—	—	—	—
Dec	100	100	—	—	—	—	—	—
Jan	100	100	—	—	—	—	—	—
Feb	100	100	—	—	—	—	—	—
Mar	100	100	—	—	—	—	—	—
Apr	100	100	—	—	—	—	—	—
1978—79								
Nov	200	100	—	—	—	—	—	—
Dec	100	100	—	—	—	—	—	—
Jan	100	100	—	—	—	—	—	—
Feb	100	100	—	—	—	—	—	—
Mar	100	94	1	1	—	1	3	—
Apr	100	84	4	2	—	6	4	—

TABLE - 5 *Percentage of indeterminate, maturing, mature and spawning stages of mussels in the farm at Karwar*

Months	No of mussels	Indeterminate	Male			Female		
			% of maturing	% of matured	% of Spawning	% of maturing	% of matured	% of Spawning
1981-82								
Nov	100	100	—	—	—	—	—	—
Dec	100	—	43	—	—	57	—	—
Jan	100	2	—	30	20	—	28	20
Feb	100	2	—	10	40	—	6	42
Mar	100	100	—	—	—	—	—	—
Apr	100	—	3	28	25	2	13	29
May	100	—	—	40	—	2	58	—
Jun	100	—	—	32	19	2	33	30

these areas and knowledge about the season of availability is very necessary.

Mussel farming is done only from November to April and the rafts are beached in the unfavourable season. Modifications of the rafts is needed for the year round culture in the open sea. Long line culture has to be tried to overcome the limitations of raft culture. The coastal areas of the west coast are good fishing grounds. Floating rafts in the active fishing zones comes in conflict with the interest of the traditional coastal fisheries. Demarcation of farm site using suitable light fittings can overcome this constraint to a certain extent. At present mussel meat is relished only along the narrow coastal belt. Popularisation of mussel meat in cities and interior places will act as an incentive to production by mussel farming.

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