PERSPECTIVES
IN
MARICULTURE

Editors

N. G. Menon and P. P. Pillai

Central Marine Fisheries Research Institute, Cochin

The Marine Biological Association of India

Post Box No. 1604, Tatapuram P.O.,

Cochin - 682014

2001

Experimental fattening of the green mud crab Scylla oceanica (Dana)

M.K. Anil and C. Suseelan

Central Marine Fisheries Research Institute, Kochi-682 014

ABSTRACT

Results of the experimental fattening of postmoult soft crabs ('Water crabs') of Scylla oceanica *(Dana) in the size 550 g and above in a brackishwater pond of 0.05 ha area at Cochin during August 1992 - April '93 are presented. Four fattening trials were attempted under varying salinity conditions (5-29 ppt) and stocking densities (2.5-5 crabs/ 10 m²) for 45-60 days, feeding with trash fish, slaughter house waste and/or clam meat at the rate of 7% of body weight. Experiments have shown that 45 days fattening with a stocking density of 1 crab /3m² is ideal for better survival and economic returns in tide-fed conditions. Although no significant change was observed in the total weight of crab during fattening, the average protein content of the meat increased from 8.33% to 14.93% with a decrease in moisture content from 87.15% to 80.93%. Economic analysis of crab fattening trials indicated gross profit ranging from Rs. 13300 to 50400 in 5-6 crops a year.*

Introduction

For centuries, mud crabs of genus *Scylla*, also known as green crabs or mangrove crabs constituted an important secondary crop in the traditional prawn or fish culture systems of Asian countries. In India the mud crabs have come into prominence since early eighties with the commencement of live crab export to the South East Asian countries like Singapore, Malaysia and Hong Kong. This has created a renewed interest in the exploitation as well as in the production of mud crabs through aquaculture.

Technology of mud crab farming can be broadly categorised into 'grow-out culture' and 'fattening'. Grow-out culture refers to farming of undersized crabs for longer period, usually 3 to 6 months, to produce marketable sizes, whereas fattening is holding of market-size crabs for 2 to 4 weeks time to acquire certain desired biological characteristics (Chong, 1993). During grow-out culture the stocked animals moult several times before they are harvested, while during fattening, the animals are usually harvested before they moult . In the latter-case, therefore, there is hardly any change in the size of the animal at the time of harvest. The aim of fattening is either to produce female crabs with ripe gonads or to convert post-moult soft crabs to hard shelled crabs. Crabs with well developed ovary or roe filling the body cavity is considered a delicacy in many countries. Such animals fetch very high prices in restaurants and markets. Therefore female crabs with immature ovary are fattened by giving proper feed until their ovary develops and fills up the body cavity. Experienced farmers can identify the crabs with fully developed ovary by looking through the carapace, holding the crab against sun light or a bright light source.

Newly moulted crabs have soft shell and watery meat and hence are known as 'water crabs' which fetch very low price compared to hard shelled crabs. The soft shelled crabs are fattened by proper feeding for two weeks to one month, and by this time their flesh becomes firm and shell hardened. Hardness of the shell is judged by pressing the sternites of the cephalothorax.

In spite of the decline in catches due to overfishing and destruction of mangrove areas which form their natural habitat, the fishing pressure on the resource is ever on the increase all over the world because of very high price of the commodity. One of the ways of protection of natural stock is the utilisation of the under sized and post moult soft crabs by grow-out and fattening type of aquaculture. Keeping the above points in mind fattening trials were conducted and the results are presented in this paper. In order to assess the change in biochemical composition during fattening, the proximate composition of meat was analysed before and after fattening and the results presented and discussed.

Material and methods

The crab fattening experiments were carried out in a brackishwater pond of 0.05 ha (Fig. 1) situated in Vypeen island. The pond was connected to Cochin backwater by a 5m wide canal of about 200 m length. The pond had a strong bund of 3 m width at the top. A sluice gate of 1 m width connected the pond to the tidal canal. Average depth of the pond was 1.5 m.

In order to prevent escape of crabs over the bund, a perimeter fencing of 1m height was constructed using nylon netting of 20 mm mesh size. The netting was supported by split bamboo sticks fixed on the dyke at 2 m intervals. The net was fixed in such a way that the lower portion of the same was buried in soil and secured firmly with bamboo pegs. The sticks were planted in slanting manner overhanging the pond to prevent

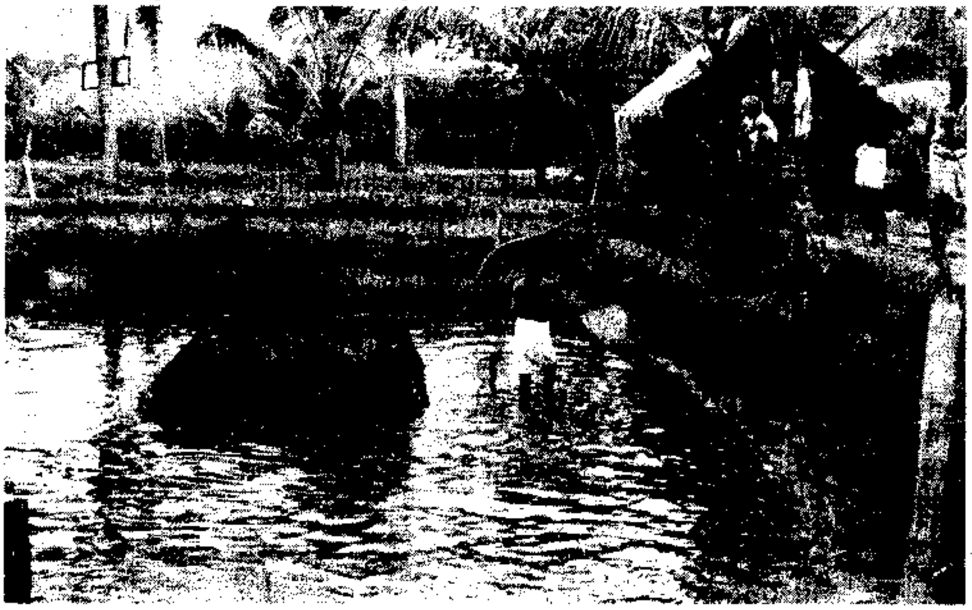

Fig. I. Final harvesting of crabs in fattening pond

crabs from climbing over the fence. Bund near the sluice gate was reinforced with bamboo matting as the crabs showed a strong tendency to burrow near the sluice gate. A watchman kept vigil to prevent poaching. Four fattening trials were conducted between August 1992 and April 1993. The fattening period varied from 45 to 60 days.

During the experiments, physico-chemical parameters like temperature, salinity, dissolved oxygen and pH were measured at an interval of 7 days. Standard methods AOAC (1965) were used for determination of moisture, ash, crude protein, total lipid, crude fibre and nitrogen free extract (NFE).

Results

The pond was first conditioned by adding lime at the rate of 600 kg/ha after reducing the water level to the minimum. Next day water was let in during high tide. The incoming water was screened using a nylon net screen to avoid entry of competitors. Soft crabs weighing above 550 g in body weight were purchased from local fishermen and active crabs with all the appendages intact were used for stocking. The carapace length of the crabs ranged from 15 to 20 cm. The crabs were fed with either trash fish, slaughter house waste or clam meat at the rate of 7 % of body weight. Boiling the slaughter house waste before feeding was found to reduce water pollution. When trash fish was available in bulk, it was salted and stored and used for feeding when trash was scarce. Water exchange was done by tidal flushing.

Four fattening trials were conducted and the experimental details are summarised in Table 1.

Table 1. Details of crab fattening experiments

Particulars	Trial-1	Trial-2	Trial-3	Trial -4
Area of pond(ha)	0.05	0.05	0.05	0.05
Duration (days)	45	45	45	60
Stocking density (No/m^2)	0.25	0.35	0.35	0.5
Number of water crabs stocked	125	175	175	250
Total weight of water crabs stocked(kg)	95.75	140.8	145.7	192
No. of hard shelled crabs harvested	98	142	154	183
Total weight of hard shelled crabs harvested (kg)	75	114	128	143

No. of soft shelled crabs at harvest	18	22	17	36
Total weight of soft shelled crabs at harvest	13	17.5	13	28
No. of dead or missing crabs	6	6	2	22
No. of damaged crabs	3	5	2	9
Survival rate (%) including Damaged crabs	95.2	96.6	98.9	91.2
Crabs used for sale* (%)	92.8	93.7	97.7	87.6

* *Both soft and hard shelled*

In the *first trial*, 125 soft crabs ('water crabs') weighing 95.75 kg were stocked and the stocking density was $0.25/m^2$. Among the stocked crabs, 30 crabs were individually tagged using numbered plastic tags. These tags were tied to the base of the last leg of the animal after noting the weight. During the first trial, salinity was low, ranging between 5.0 ppt and 7.5 ppt. The water temperature, pH and dissolved oxygen values were 25-26.7° C, 7.2-7.5 and 2.1-6.7 ml/l respectively.

Partial harvesting started from 20th day onwards using baited ring nets. All the crabs thus caught were individually tested for their shell condition by pressing the sternites of cephalothorax. Those with hardened shells were segregated and marketed. The crabs whose shells were not hardened properly were returned to the pond for further fattening. Total harvesting was done on the 45th day after completely draining the pond, by hand picking or using scoop nets locally called 'bols'. All the tagged crabs were carefully cleaned of mud and algae attached to the tags and weighed. Though a maximum individual weight increase up to 30 g/ crab was noticed, majority of the crabs showed little change in weight even after a period of 45 days of experiment. Out of the 125 crabs stocked, 98 crabs weighing 75 kg were sold as hard shelled meat crabs and 18 as water crabs. Apart from this, 3 crabs were caught severely damaged and 6 were either dead or missing. Survival rate was 95.2 % which included hard shelled, soft and damaged crabs at the time of harvesting. The percentage of crabs suitable for sale (undamaged hard or soft shelled ones) was 92.8.

During the *second trial*, stocking density was increased to 0.35/ m^2 and altogether 175 soft crabs were stocked within a week. Salinity recorded at the beginning of the experiment was 6.5 ppt which gradually increased to 24.2 ppt by the end of the trial period. The pH and temperature values ranged from 6.8 to 7.8 and 25.2 to 28.3°C respectively. Dissolved oxygen varied between 2.1 and 7.0 ml/l. Out of the 140.8 kg of soft crabs stocked, 114 kg numbering 142 were harvested in hard shell condition. The survival rate of marketable individuals was 93.7 %. Twenty two crabs remained in soft condition, 5 were caught in damaged condition. Actual survival rate was 96. 57%.

In the *third fattening trial*, stocking density was the same as that of the second trial but the feeding schedule was changed from once a day to twice a day. Only 30 % of the daily ration was given in the morning, the remaining 70% in the evening. During the experimental period the salinity varied narrowly, ranging from 24.2 to 27.5 ppt. Dissolved oxygen varied between 2.9 and 7 ml/l. Water temperature and pH were in the range of 27.3-29°C and 7.3-7.8 respectively.

During the third trial the total weight of soft crabs stocked was 145.75 kg. Out of this 128 kg numbering 154 crabs was harvested in

Fig. 2. Tying harvested crabs for sale.

hard shelled state and 17 crabs weighing 13 kg remained in soft condition. Total mortality was 2 and another 2 crabs were caught in damaged condition. Actual survival rate worked out to 98.85% of which percentage of crabs suitable for sale formed 97.7 %.

During the *fourth trial*, the stocking density was increased to 0.5/ m^2 and 250 crabs weighing 192 kg were stocked. It took two weeks to stock the crabs. During this cycle salinity ranged 27-29 ppt, temperature 28-29.7°C and pH 7.2 to 8.1. Harvesting began from the 20th day onwards. A total of 183 crabs weighing 142 .75 kg was harvested during the fattening period of 60 days and 36 crabs weighing 28 kg remained in soft condition. Dead and damaged ones were maximum in this trial which numbered 22 and 9 respectively. Actual survival rate worked out to 91.2%. The rate of recovery of animals suitable for marketing (Fig.2) was the lowest, being 87.6% among all the four fattening trials.

Biochemical changes during fattening

In order to assess the change in biochemical composition during fattening, the proximate composition of crab meat was studied before and after fattening and the results are presented in Table 2.

Table 2. Proximate composition of meat of soft shelled and hard shelled (fattened) crabs (Standard deviation of the mean is given in parenthesis)

Constituents	Percentage of wet meat weight	
	Soft crab	Fattened crab
Moisture	87.15 (1.371)	80.925 (1.911)
Crude protein	8.328 (0.663)	14.93 (0.716)
Ash	3.559 (0.241)	3.315 (0.343)
Fat	0.293 (0.19)	0.2873 (0.021)
Crude fibre	Negligible	Negligible

The values of the different biochemical constituents in the two different conditions of crab body would reveal that considerable change occurs in the contents of moisture and crude protein during the transformation period. The protein content was 7.282-9.143% in the soft shelled condition and 13.93-16.03% in fattened condition with average values of 8.33% and 14.93% respectively. As the protein content increased, the water content showed a reduction from the average value of 87.15% in 'water crab' to 80.93% in fattened crab. The differences in protein and water content were found statistically significant. Other parameters analysed, such as, ash content, fat and NFE did not show any statistically significant difference between soft and fattened crab. The crude fibre was negligible in the meat of both the types of crabs indicating very low content of non digestible carbohydrate in their meat.

Economics of crab fattening

Based on the results obtained from the fattening experiments, the economics of crab fattening has been worked out for a 0.05 ha farm for one year separately for each type of experimental trials with varying stocking densities and feeding schedule. The comparative cost and earnings arrived at are shown in the Table 3.

Table 3. Economics of mud crab fattening in 0.05 ha farm at Vypeen Island (Values in Rs.)

Particulars	Trial-1	Trial-2	Trial-3	Trial -4
I. Initial investment				
1.Cost of land	25000	25000	25000	25000
2.Watchman's shed	5000	5000	5000	5000
3.Pond construction	4000	4000	4000	4000
4.Sluice gate	3000	3000	3000	3000
5.Fencing	750	750	750	750
Total	37750	37750	37750	37750
II. Annual fixed cost				
1.Opportunity cost of land (@10%)	2500	2500	2500	2500

2.Depreciation (20% of initial investment excluding land cost	2550	2550	2550	2550
3.Interest (20% of initial investment)	7550	7550	7550	7550
Total	12600	12600	12600	12600
III. Operating cost				
1.Pond preparation	300	300	300	300
2.Cost of soft crab(@80/kg)	7660	11280	11660	15360
3.Feed	777	1134	1182	1555
4.Labour charges	3000	3000	3000	3000
Total (per crop)	11737	15714	16142	21215
5.Annual working cost (6/5 crops/year)	70422	94284	96852	106075
IV. Annual expenditure (II+III)	83022	106884	109452	118675
V. Annual income				
1.Income from the sale of hard shelled crabs @ 200/kg	15000	22800	25600	28550
2.Income from the sale of soft shelled crabs @ 80/kg	1040	1400	1040	2240
Total	16040	24200	26640	30790
3.Annual income from 6/5 crops	96240	145200	159840	153950
VI. Gross profit (V-IV)	13218	38316	50388	35275

As the fattening period was 45 days each for the first 3 trials, the annual expenditure and income were calculated assuming that at least 6 such fattening operations could be carried out in a year. However in the case of the 4th trial, computations were made on the assumption that 5 trials could be taken in a year since the duration lasted for 60 days.

The initial investment of fattening operation included cost of land, cost of construction of watchman's shed, cost of construction of pond, cost of sluice gate and expenditure for perimeter fencing. Total initial investment was Rs. 37,750, which remained the same for all trials since all the trials were carried out in the same pond.

Annual fixed cost was calculated taking 10% of the cost of land as its opportunity cost, 20% as depreciation on the initial investment and interest at the rate of 20 % of initial investment. The calculated value of initial investment for all the 4 trials was Rs. 12,600.

Operating cost included cost of pond preparation, cost of stocking material (soft crabs), cost of feed and labour charges. Charges towards pond preparation included cost and transportation charges of lime, labour charges for strengthening bund etc. Feed materials such as trash fish, slaughter house waste etc. were purchased at Rs. 3-4 /kg. Cost of salt used for storage of trash fish also included under the cost of feed. Cost of stocking material was the most dominant variable among the operating cost. Consequently the operating cost/crop was lowest in the first trial (Rs. 11,737) and highest in the fourth trial (Rs. 21,215) corresponding with the lowest and highest stocking densities. The cost/crop of the third and fourth trials were Rs. 15,714 and Rs. 16,142 respectively.

Annual working cost was calculated for 6 crops in the case of first three trials and five crops in the fourth trial and the values worked out to Rs. 70,442, Rs. 94,284, Rs. 96,852 and Rs. 106,075 respectively.

Annual expenditure was calculated by adding the annual fixed cost and annual working cost. Income/crop included the revenue obtained from the sale of the hard shelled crabs or meat crabs harvested during the trial and the income from the sale of soft crabs at the time of the final harvest of each trial. The meat crabs were sold at Rs. 200/kg and soft crabs at Rs. 80/kg. Income per crop was the highest in the fourth trial (Rs. 30,790) and the lowest in the first trial (Rs. 16,040). There was no significant difference in the income/crop for the third and fourth trials (Rs. 24,200 and Rs. 26,640). Though the stocking densities were different for the last two trials, the annual income realised from these trials did not show significant variation (Rs. 159,840 and Rs. 153,950) because of the lesser number of cycles in the last trial. In the second trial the annual income was Rs. 1,45,200 which was lower than that of the third trial with an annual turnover of Rs. 1,59,840. The gross profit was calculated by subtracting the annual expenditure from the annual income. It is seen that the profit was the highest in the third trial (Rs. 50,388/annum) as against the decreasing profits realised for the 2nd (Rs. 38,316), 4th (Rs. 35,275) and 1st (Rs. 13,218) trials.

Discussion

An important problem associated with mud crab farming is the inherent tendency of crabs to escape from the farm during the period of culture. In order to prevent the escape of crabs, different management measures such as fencing the pond, reinforcing the dyke with concrete/ bricks, proper feeding schedule, adequate water exchange etc. are resorted to. Of these fencing is done invariably and for this various kinds of materials are used. In Taiwan, the fattening ponds are constructed with vertical brick walls (Chen, 1990) whereas in Indonesia the farmers use bamboo stakes for fencing the pond (Cholic & Hanafi, 1992).

During the present study the culture pond was provided with nylon netting which proved to be very effective to prevent the escape of crabs and is cheaper than other materials like wire mesh, asbestos sheet or bamboo fencing. Further, nylon net fencing was much easier to construct and cheap. As in the case of the export of processed fishery products wherein quality assurance is an essential aspect, the live crab export also demands quality assurance like healthy and disease free condition for trade. In the event of crabs attempt to escape from the pond by climbing over the dykes and fencing, injuries are bound to occur on the ventral side of the crab leading to infections. As the presence of scratches on the body or shell breakage in the crabs would disqualify their acceptability to exports, care has to be taken to prevent occurrence of scratches or shell breakage during culture operation. It is observed that the chances of such damages on the body of crabs are extremely low when the fencing is done with nylon netting.

Assorted sizes of crabs falling between 550-2,000g were used in all the four trials since the preference for live crab export was within the above range and also due to non consistency in the availability of any particular size range in the backwater capture fishery which formed the source of material for the experiment.

The present study on the fattening of large size crabs was a maiden attempt to find out the ideal stocking density yielding the maximum economic returns. The stocking density was $0.25/m^2$ in the first trial, $0.35/m^2$ in the second and third and $0.5/m^2$ in the fourth trial. The duration of fattening was uniformly 45 days for the first 3 trials and 60 days for the fourth trial. The percentage survival at the time of final harvest varied significantly between different trials. In the first experiment the survival was 95.2%, which increased to 96.6% in the second trial and 98.9% in the third trial. The final survival rate in respect of 4th trial went down drastically to 91.2%. The rate of survival of crabs was good in spite of the low salinity of the pond ranging 5.0-7.5 ppt in the first trial. The most favourable salinity for mud crab farming is reported to be 15-35 ppt (Liong, 1994). Although the fattening commenced with low salinity conditions (6.5 ppt) in the second trial the salinity values increased gradually to as high as 24.2 ppt, and it remained more or less constant level of 27-29 ppt in the third trial. It is possible that the higher survival rate recorded for these two trials could have been favourably influenced by the higher salinity regime prevailing in the pond as most of the other environmental factors and pond management procedures remained more or less same. The high survival rate of 98.7% was recorded in the third trial in which the only variable factor that could be attributed to this is the difference in the feeding schedule during that trial. The feeding schedule during the third trial was changed from once a day to twice a day, about 30% of the daily ration was given in the morning and the remaining 70% in the evening.

In the 4th fattening trial though higher salinity condition (27-29 ppt) prevailed in the pond, mortality was maximum. The percentage of marketable crabs was also lower than all other experimental trials (87.6%). This poor performance coincided with deteriorating water conditions on several occasions as evident from the smell of water caused by the excess metabolic wastes released by the denser population and the lack of adequate water exchange. The temperature of the pond water was also higher than in all the previous trials because of the summer season (April), which would have adversely affected the crabs as evident from the sluggish nature of the animals and fouling of epiphytic algae on the crabs body. Taiwanese crab farmers, who stock crabs of 8-12 cm CW corresponding to about 200-250 g in weight use one crab/m^2 as optimum stocking density in summer (Sivasubramoniam and Angell, 1992). In the present study, 0.5/m^2 stocking density corresponds to about 400g/m^2 assuming that the average weight of crabs stocked was about 800g. The Taiwanese use pump sets for water replenishment as and when required whereas in the present study the water exchange was by tidal action only which would not have ensured adequate water replenishment commensurate with the crab biomass. From the above observation it can be presumed that the optimum stocking density of crab of about 800g average weight during summer period could be around 0.35 crabs/m^2 under tide fed conditions. This works out to 3500 crabs/ha water area for fattening in tide fed brackishwater condition.

The food given to the crabs consisted of fresh trash fish, salted fish and slaughter house waste. A feeding rate of 7% of body weight was adopted for trash fish and slaughter house waste while a reduced rate of 5% of body weight was used when salted fish was offered. The crab showed varying preferences for different food items when three types were offered together. The first preference was shown to trash fish, then to salted fish and finally to slaughter house waste. Chen (1990) reported a feeding rate of about 1% of body weight with trash fish and sometimes with freshwater hornshell snail during fattening of female crabs of size 220-250g size. Snail meat is added in the diet to facilitate development of gonads, as the fattening is aimed at producing crabs with well developed roe rather than converting 'water crabs' to meat crabs in Taiwan.

According to Rattanchote and Dangwatankul (1992) a higher rate of feeding is practiced in Thailand where trash fish and horse mussel are given at the rate of 7-10% of body weight once or twice in a day. De Silva (1992) used offal, clam meat and fish for feeding mud crabs and found that first preference was for clam meat and then for offal. Cholic and Hanafi (1992) reported the use of dried trash fish at higher feeding rates of 10-15% of body weight. The feeding rate of 5-7% of body weight followed during the present experiment appears to be reasonable considering the prevailing environmental conditions of the brackishwater farms of Kerala coast which are tide fed. The slaughter house waste when offered in fresh condition was found to pollute the water as evident from the colour change and foul odour. Though this problem could be partly overcome by half cooking of meat before use, regular use of slaughter house waste in crab fattening pond is considered undesirable from the view point of environmental safety.

Fattening in cages or pens is considered more advantageous as the stocking rates in such systems could be considerably high (Natarajan and Thankaraj, 1983; Bensam, 1986; Marichamy *et al.*, 1986). In Philippines as many as 18 crabs are stocked in a cage of 140x70x25 cm size with 18 compartments, keeping one crab in each compartment (Larda, 1992). In Indonesia crabs are stocked in individual compartments at the rate of $40/m^2$ in which condition the mortality rate is less than 5% (Cholic and Hanafi, 1992). This is in contrast to a stocking rate of $2/m^2$ for crabs of 150-200 g size in pond systems. Observation on crab fattening in wooden cages (2.5x2.5x2 m) which was commenced in small scale in Cochin backwaters in recent years have shown that as many as 25-30 'water crabs' of size 550g and above are successfully raised at a time without mortality. This high stocking density is possible since the cages facilitate constant water replenishment in the open backwater providing very ideal condition for the crab. From this it would appear that the optimum stocking density of 0.35 crabs/m^2 worked out for fattening ponds could be further increased by resorting to frequent water exchange and aeration coupled with appropriate feeding as practiced for shrimps in the semi-intensive systems. Further under such improved environmental conditions a denser population can be raised safely since no moulting takes place during fattening period which would make the animals vulnerable for cannibalism and consequent mortality.

A clear change was noticed in the biochemical composition of meat during fattening. The average moisture content decreased from 87.15 % to 80.93% whereas the crude protein content increased from 8.33 to 14.93 % during the transformation. This would indicate that the water profusely absorbed during moulting gets replaced with protein during fattening apparently with little change in body weight.

Economic analysis of mud crab farming practiced in most of the East Asian countries (Anon, 1992; Kathirvel, 1983; Viswakumar, 1993) have established that the culture is highly profitable when compared with other forms of aquaculture due to the increasing price live mud crabs command in the international markets.

In the crab fattening experiments the initial investment and fixed cost were the same for all the four trials as they were conducted in the same pond. Among the operating costs, cost of soft crabs was the most important variable since the stocking size was big. The operating cost per crop was lowest in the first trial corresponding to the lowest stocking density and highest in the fourth trial corresponding to the highest stocking density tested. The operating cost of the second and third trial did not differ much because of the uniformity of stocking density and the meagre variation in the weight of animals. Feed, which was given according to the biomass of the stocked animals also showed a similar pattern with respect to its cost.

The lowest income per crop was obtained in the first trial and the highest in the fourth trial corresponding to the lowest and highest stocking densities used in these trials, but the annual income was higher in the third (Rs. 1,59,840) and second (Rs. 1,45,200) trials. Even though the income per crop was the highest in the fourth trial, the annual income worked out for this trial was lower than that of the third trial because of the lesser number of trials in the former case. The gross profit from the fourth trial amounted to Rs. 35,275 which was less than the gross profit from the third (Rs. 50,388) and second (Rs. 38,316) trials as the operating cost was the highest in the fourth trial. This would probably indicate that stocking density of $0.5/m^2$ or above cannot be recommended under the present level of management. The lowest profit obtained at the stocking density of $0.25/m^2$ shows the under-utilization of the pond. The higher gross profit obtained in the third trial as compared to the second trial shows that even at the same stocking density profit can be increased significantly by adopting better management techniques.

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