

EXPERIMENTAL STUDIES ON HIGH DENSITY, SHORT-TERM FARMING
OF SHRIMP *PENAEUS INDICUS* IN A 'POKKALI' FIELD
IN VYPEEN ISLAND, KERALA

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ABSTRACT

High density, short-term culture experiments on the shrimp *Penaeus indicus* were carried out by setting three identical enclaves (25 m² each) using plastic netting and bamboo stakes in a paddy-cum-prawn filtration field at Narakkal during January-April, 1979. Each of the enclaves was stocked with 500 juveniles of 24-48 mm length having a modal size of 36 mm and average weight of 272 mg. Feeding with ground-nut oil cake was done once daily at the level of 5% of the body weight of shrimps. The cultures were harvested after 4, 8 and 12 weeks when the survival rates of 85.2%, 81.85% and 65.0% respectively were obtained.

In the first harvest, shrimps measured 69-96 mm with a modal size of 84 mm and weighed 3.76 g on average. Those reared after 8-weeks had a length range of 75-108 mm with mode at 93.0 mm and average weight of 5.35 g which was 1.42 times greater than that of the preceding. Size range of shrimps in the third harvest shifted between 105 and 129 mm with 117 mm at the mode and had an average weight of 11.22 g i.e. 42.25 times greater than that of the initial stock. The total yields of 1.603, 2.186 and 3.645 kg realised from these cultures became equivalent to 640.0, 874.0 and 1438.0 kg/ha.

Since it is possible to take a minimum of two short-term crops of 12 weeks duration, it is reasonable to assume that at 80% harvesting efficiency, the production of about 1750 kg/ha of marketable shrimps valued at Rs. 35,000—could be possible from fertile 'Pokkali' fields of Kerala.

During the course of experiments the temperature, salinity, pH and secchi disc reading of the field varied between 28.5 and 35.5°C, 17.2 and 26.15‰, 7.0 and 7.8 and 35 and 60 cm respectively. Diurnal oxygen level fluctuated between 1.0 ml/l and 6.8 ml/l.

Results of the present experiment indicate that *P. indicus* merits further field experiments as a species for short-term, high density farming.

INTRODUCTION

SHRIMP CULTURE practice in paddy fields (Pokkali) of Kerala locally known as 'Chemenconkotta' and 'Bhasa-badha' fishery of West Bengal contributes the largest share in India's shrimp production from sources other than the usual capture fishery. Various aspects of these traditionally existing practices in India have been described by the earlier workers (Panikkar, 1937; Menon, 1954;

Pillay, 1954; Gopinath, 1956; Kesteven and Job, 1957). Studies on the yield and economics of this fishery in Kerala (George *et al.*, 1968; George, 1974) have revealed that the successful commercial operation depends on the availability of four species of penaeid shrimps of which *Penaeus indicus* figures economically the most important though *Metapenaeus dobsoni* dominates the catches by weight. Recently, careful retrieval of the undersized

juveniles of *P. indicus* from the day to day bag net catches and growing them again in the same field to marketable size was found to improve the yield considerably (Gopalan *et al.*, 1980).

Intensive cultivation of selected species of shrimps in closed systems though successfully experimented in many parts of the world (Poster and Beard, 1974; Shiguano, 1975; Neal, 1979) does not seem to suit the rural economic conditions of India as it involves heavy capital expenditure and high technical expertise. This has prompted us to investigate on how dense a viable short-term monoculture of *P. indicus* could be sustained within the carrying capacity of paddy field ecosystem. The present communication conveys the result of an experiment carried out in this line at Narakkal in Vypeen Island, Kerala in 1979.

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MATERIALS AND METHODS

Experiments were carried out in a typical paddy-cum-shrimp culture field having an area of 4 hectares lying adjacent and connected by sluice gate with the outer bund canal at Narakkal, Vypeen Island. Three identical square enclaves (25 m²) were made at three places in the field selected at random using plastic netting (2 mm mesh) and bamboo poles in such a way that the lower side of the netting penetrated the bottom and the upper side was well above the water level. The depth of the field was nearly 1m at high tide and 60 cm

at low tide. After removing the algal patches and other obstacles the enclaves were fished using a cast net to eradicate the existing shrimps, fishes, crabs and such other organisms. The bottom of the enclave was made even except at the centre where an area of 1 m² was deepened further to get a depth of 1 m at low tide. The clogging of the netting by silt, slime and algal growth was periodically cleared by scrubbing with a brush.

Each of the enclaves was stocked with 500 healthy juveniles (2,00,000/ha) of *P. indicus* measuring 24 to 48 mm having a modal size of 36 mm and average weight of 272 mg which were carefully retrieved from filter bag nets as suggested by Gopalan *et al.* (1980). Feeding with ground-nut oil cake was done once daily at the level of about 5% of the body weight of shrimp. The cultures were completely harvested from the enclaves respectively after 4, 8 and 12 weeks of growth using cast nets and hand nets. The harvested shrimps were measured (from the tip of the rostrum to the distal end of telson) and weighed.

The normal fishery operations of the experimental field were going on in the traditional manner. Data on the catch composition, income and expenditure and other observations for the whole season were regularly recorded in a log book. The hydrographic conditions of the enclaves, open field and the feeder canal were monitored by adopting standard procedures (Strickland and Parson, 1965). The organic carbon content of the bottom sediment was analysed as suggested by El Wakeel and Riley (1957).

RESULT

The monthly averages of the hydrographic parameters monitored during the experimental period are presented in Table I. In general the lowest temperature was in February (28-30°C) and the highest was in April (33.5-35.5°C). The temperature of the enclaves

TABLE 1. Hydrographic parameters and organic carbon monitored during January-April, 1979 at Narakkall.

Month	Temp. (°C)	Salinity (‰)	O ₂ (ml/l)	pH	Secchi disc reading (cm)	Organic Carbon (%)
<i>Culture enclosure</i>						
January 1979	32.6	17.30	2.6	7.2	60.0	0.84
February ..	30.0	18.20	3.0	7.5	56.0	1.20
March ..	34.5	22.05	4.7	7.8	40.0	2.88
April ..	35.5	26.15	6.5	7.8	35.0	4.14
<i>Open Field</i>						
January 1979	32.5	17.20	2.6	7.2	60.0	0.83
February ..	28.5	18.28	2.8	7.0	60.0	1.15
March ..	33.0	21.33	5.0	7.4	55.0	1.75
April ..	34.0	25.44	6.8	7.3	43.0	2.07
<i>Outer bund canal</i>						
January 1979	31.5	16.85	2.0	7.1	75.0	1.70
February ..	29.0	18.82	3.6	7.0	70.0	1.85
March ..	33.0	21.35	3.6	7.0	67.0	2.10
April ..	31.5	25.81	2.6	7.2	58.0	2.64

TABLE 2. Income and expenditure from the traditional method of shrimp culture during 1978-79 in a 1 hectare area of paddy field.

Item	Amount (Rs.)	Item	Amount (Rs.)
INCOME		EXPENDITURE	
Sale proceeds from shrimps		Lease amount and licence fee	15,750.00
1282.8 kg of <i>M. dohrani</i> @ Rs. 3.25/kg		Sluice fabrication, installation and maintenance	1,000.00
39.75 kg of <i>M. monaceros</i> @ Rs. 8/kg	24,081.85	Preparation of field, dykes, canals, eradication of weeds and predators	300.00
782.19 kg of <i>P. indicus</i> @ Rs. 25/kg		Workshed and canoes	550.00
1.0 kg of <i>P. monodon</i> @ Rs. 40/kg		Lamos, oil, bamboo/plastic screen	780.00
Sale proceeds from fishes & other items		Nets and plastic basins	650.00
3352 kg. of <i>Tilapia</i> @ Rs. 1.10/kg		Nursery, operation (including feed)	
512 kg of <i>Betopius surateensis</i> @ Rs. 5/kg	6,422.20	Contingencies	250.00
350 kg of misc. fishes @ Rs. 12/kg		Wages of workmen	3,650.00
Total income	30,504.05	Interest on capital @ 15%	1,146.50
Income/ha.	7,626.01	Harvesting expenditure	5,823.60
Total Profit	803.95	Total expenditure	29,700.10
Profit/hectare	200.99	Expenditure per hectare	7,425.02

remained relatively higher throughout than that of the open field and outside. The salinity values showed more or less the same pattern of variation from January to April (16.83-26.15‰) in all the three areas with relatively higher values in the enclaves. As regards oxygen, higher values (2.6-6.8 ml/l) prevailed in the open field than that of the enclaves whereas lower values (1.6-3.5 ml/l) were seen in the outside canal.

The diurnal 'oxygen pulse' of the enclaves has been graphically presented (Fig. 1). The lowest values (1.9-1.6 ml/l) of oxygen in the culture enclaves were noticed during the dawn hours and highest values (5.0-6.7 ml/l) in the afternoon. Values of temperature also showed a similar trend as regards minimum and maximum.

algal material were floating in the enclaves especially after 16th week.

The organic carbon values were the same (0.34%) in the enclaves and field during the beginning of experiment which later increased to 4.15% in the enclaves and to 2.05% in the open field. The organic carbon values showed less variations (2.0-2.64%) outside the field during the experimental period.

The size frequencies of surviving shrimps at the end of 4, 8 and 12 weeks and that of the initial stock are presented in Fig. 2. Of the 500 individuals stocked in each of the three enclaves 426 (85.2%), 409 (81.8%) and 325 (65.0%) individuals respectively could be harvested by the end of 4, 8 and 12 weeks (Fig. 2). In the first harvest shrimps measured 69-96 mm,

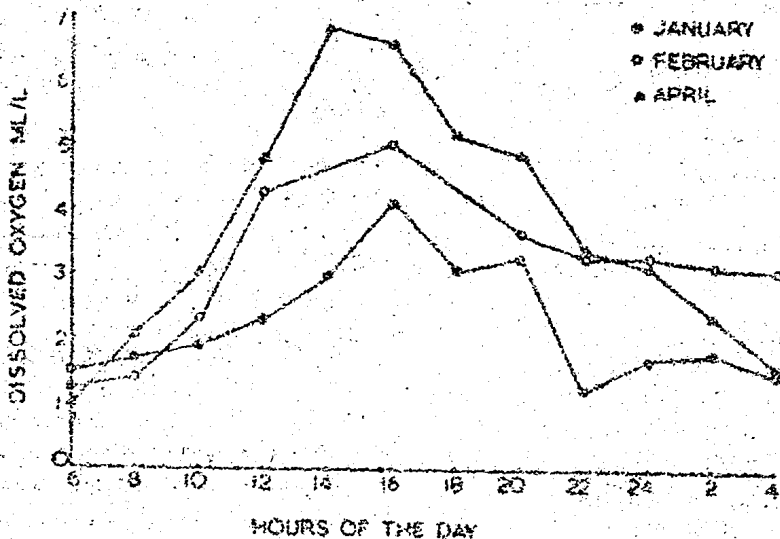


Fig. 1. Diurnal variation in dissolved oxygen in the monoculture enclaves during January-April 1979.

The pH values in all cases were 7 and above with higher values (7.5-7.8) in the enclaves during February-March. An increasing trend in turbidity of the enclaves as well as the open field, is reflected in the secchi disc reading. Scum of waste comprising dead and decaying

with the modal size 84 mm and weighed 3.76 g on an average.

Those netted after 8 weeks had a length range of 75-102 mm with mode at 93 mm and average weight of 5.35 g which was 1.42 times greater than that of the preceding.

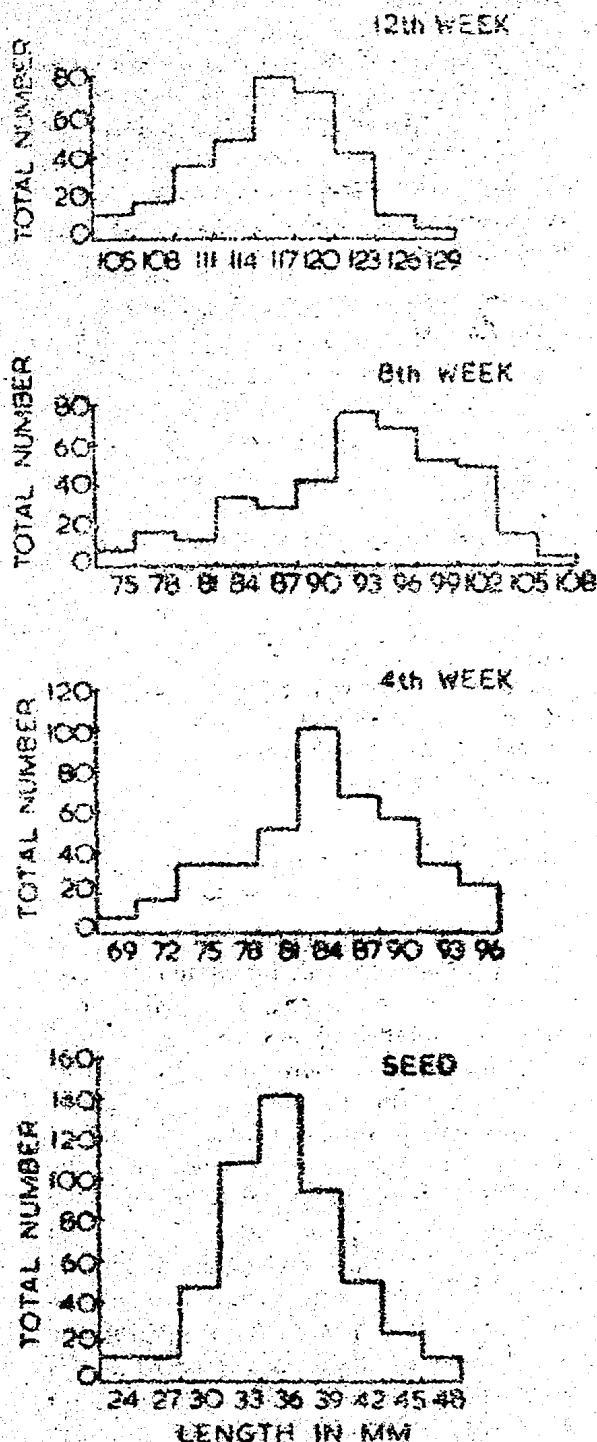


Fig. 2. The size frequencies of *Penaeus indicus* stocked and harvested after 4, 8 and 12 weeks by monoculture.

Size range of shrimps in the third harvest was 105-129 mm with mode at 117 mm and had an average weight of 11.22 g which was 42.25 times greater than that of the initial stock and 2.1 times more than the preceding.

Thus total yields of 1.601, 2.186 and 3.646 kg were harvested respectively from the three culture enclaves from an initial stock of 136.2 g in 25 m² area. This becomes equivalent to 640.4, 874.4 and 1458.4 kg/ha.

The growth rates of shrimps calculated from the first, 2nd and 3rd harvest respectively were 1.71, 1.02 and 1.13 mm per day.

The yield and economics of the experimental field which was operated in the traditional manner has been given (Table 2) for comparison with that calculated (Table 3) from the results of the monoculture of *P. indicus*. Only 30% of the production available during January-April is anticipated for the crop during October-January.

Of the 2105.74 kg of shrimps realised from the 4 ha field, *M. dobsoni* was 1282.8 kg, *P. indicus* 782.19 kg, *M. monoceros* 39.75 kg and *P. monodon* 1 kg. This works out to an average yield of 525.44 kg/ha.

The fish catch comprised mainly of 3352 kg of *Tilapia* and 512 kg of *Etroplus suratensis*. About 350 kg of miscellaneous species (crabs, Eels, *Ambassis* sp., *Etroplus maculatus*, *Bardus* sp., *Arius* sp., *Megilops* sp., *Gobius* sp.) were also caught from the same field. Thus the average yield of edible species other than shrimps was 1053.5 kg/ha, which makes a total yield of 1579.94 kg/ha.

DISCUSSION

From the results of the present experiment it can be seen that *P. indicus* stocked under a density of 2,00,000/ha attained marketable size (11.22 g) after 12 weeks of growth with a fairly reasonable rate of survival (65.0%). The yields of 640.4, 874.4 and 1458.4 kg/ha which are obtainable respectively after 4, 8 and

12 weeks of monoculture of *P. indicus* suggest the advantages of short-term, high density farming of this species in 'Pokkali' fields. This when compared to the total yield of shrimps (526.44 kg/ha) obtained during the season 1978-79 from the traditionally operated field (Table 2) is highly attractive.

50,000-2,00,000/ha (Mammen, 1978; Rao, 1980; Sebastian *et al.*, 1980) seem to be reasonable. However Siddharaju *et al.* (1980) have reported still higher stocking densities (40-70/m²) in which a production of 390 g/m² was obtained at Kovelam in cage culture of 120 days duration.

TABLE 3. Statement showing the income and expenditure estimated from the results of the experimental monoculture of *P. indicus* (Rs./ha)

Item	Amount (Rs.)	Item	Amount (Rs.)
INCOME		EXPENDITURE	
Sale proceeds of shrimp		Lease amount and licence fee	5,000.00
At 80% harvesting efficiency and @ Rs. 20/kg		Sluice gate	1,000.00
(Value of the 1166.72 kg of prawns available during Jan.-April)	23,334.40	Preparation of field	1,000.00
Value of the 50% of the above expected from the crop during Oct.-Jan.	11,667.20	Cost of stocking material and transportation (2,00,000/ha)	4,000.00
Total income	35,001.60	Auxiliary feeding	1,000.00
		Wages for workmen	3,600.00
		Interest on capital investment @ 15%	562.50
		Harvesting expenditure @ Rs. 1/kg	5,253.00
		Handling and marketing charges	1,000.00
		Contingent expenditure	500.00
Profit	12,086.19	Total expenditure	22,915.00

In India very little information is available on the monoculture of *P. indicus*, as attempts in this line began only in recent years. Some estimates on the stocking density and yield of this species reported from various brackish water systems in India are presented for comparison (Table 4). As can be read from the table relatively higher yield of *P. indicus* (704.4 kg/ha) was obtained in 70 days of culture under a stocking density of 37,000/ha (Sundararajan *et al.*, 1980). About twice this quantity obtained in the present case can mainly be attributed to the high stocking density applied. In this perspective the recent estimates of seed requirement for the intensive cultivation of *P. indicus* in Kerala waters ranging from

The rates of growth and survival of *P. indicus* vary considerably not only in relation to stocking density but to the environmental characteristics prevailing in different water systems. In the monoculture enclaves as well as in the open field at Narakkal a gradual increase in environmental parameters (Table 1) could be seen from January to April, a common feature of the backwaters during the season. The gradual degradation of the paddy stumps might be enriching the field with organic matter and at the same time leaching of nutrients into the overlying water enhances the photosynthetic activity which is reflected in the diurnal variation in the oxygen level. These factors seem to accelerate the growth of shrimps in paddy

TABLE 4. Comparative statement of stocking and harvesting in the monoculture of *P. indicus* in various brackish water regions in India

	Place/Reference			
	Santhome Fish Farm, Madras (Sundararatn et al., 1980)	Brackish water Exp. Fish Farm, Kakkavip	Brackish water Farm, Kakinada	Present data
Stocking density (No./ha) of <i>P. indicus</i>	70,000	50,000	70,000	2,00,000
Size at stocking (mm)	42.2	24.0	45.00	36.00
Size at harvest (mm)	120.7	97.5	120.0	83.34
Culture days	130	90	180	56
Rate of survival (%)	32.2	37.2	—	85.2
Average growth/day (mg)	0.68	0.81	—	1.72
Estimated total production kg/ha.	301.8	475.0	243.14	680.0
				874.0
				1458.0

fields during this period. The accumulation of photosynthetic material, unconsumed food, dead animals and metabolic wastes might have resulted in the higher value of organic carbon (4.14%) within the enclave at the end of the experiment. The formation of the floating patches of scum is the outcome of these decomposing organic material. This has produced a state of pollution which can be understood from the drastic fall of oxygen level (1 ml/l) particularly at night. The relatively low survival noticed among the larger individuals as shown in the histogram clearly indicates the adverse effect of the deteriorating medium though the oxygen minimum was well above the suffocation level for penaeid shrimps as proved by Shigeno (1975). However surfacing of larger shrimps during the early hours of the day observed in the enclave especially after the 10th week suggests their intolerance to the decreased oxygen content as observed by Subramaniam (1962) in the same species. This indicates the inability of the medium to support dense cultures like this for longer period.

It could be seen from the data (Table 2) that the shrimp yield from the traditionally operated field (526.44 kg/ha) continued to show a down-

ward trend in recent years as has been pointed out by Gopalan *et al.* (1980). At the same time total production including fishes (1492.44 kg/ha) showed a marginal increase which is mainly due to the dominance of *Tilapia* which has been treated as a pest in brackish waters of Indonesia, Ceylon and Thailand (Pillai, 1972). The yields of 640.0, 874.0 and 1458.0 kg/ha obtained respectively after 4, 8 and 12 weeks of monoculture of *P. indicus* suggest the lines for future planning and development of paddy field shrimp cultures.

On the whole the results of the present experiment reveal potentiality of paddy field ecosystem of Kerala to sustain a many fold increase in the production of quality shrimps. If carefully managed, two short-term, high density crops of *P. indicus* are possible during the non-paddy season. Nevertheless the present data has its limitations as it is projected from the operation of relatively smaller area (25 m²) which facilitated the harvesting of all the surviving shrimps. In larger systems percentage recovery may not exceed 50% of the surviving shrimps. With this allowance it can be estimated that a total of 1750.08 kg/ha of shrimps valued at Rs. 35,001.60 could be harvested in two crops.

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