STUDIES ON IMPROVED PRACTICES OF PRAWN FARMING FOR HIGHER PRODUCTION IN CENTRAL KERALA

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for the award of the degree of

DOCTOR OF PHILOSOPHY

By

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THE MARINE PRODUCTS EXPORT DEVELOPMENT AUTHORITY

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GOVERNMENT OF INDIA

CERTIFICATE

This is to certify that the thesis entitled "Studies on improved practices of prawn farming for higher production in Central Kerala" embodies the research of original work conducted by Shri K.S. Purushan under my supervision and guidance. I further certify that no part of this thesis has previously formed the basis of the award of any degree, diploma, associateship, fellowship or other similar titles or recognition.

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DECLARATION

I, K.S. Purushan (Ph.D Reg No. 732) hereby declare that the work presented in the thesis entitled "Studies on improved practices of prawn farming for higher production in Central Kerala" is based on the original work done by me under the guidance of Dr. M. Sakthivel, Director, Marine Products Export Development Authority, Cochin - 682 015.

Cochin,
5.12.1992

(K.S. PURUSHAN)
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PREFACE

Hailing from a traditional fisherman family and also being a shrimp farmer and an Associate Professor in the Kerala Agricultural University, Fisheries Station at Puduveypu, the author with his 25 years of experience is well aware of the importance of shrimp culture in the economy of central Kerala.

Hence, having realised the need for incorporating innovative technology to our traditional farming practices, in order to update it on par with other nations, the author felt it important to make a critical study of the existing culture practices in the central Kerala, a region where it has been existing since time immemorial.

Also the need was felt to work out the economics of different types and level of culture so as to provide an insight for the farming community and financial managers on investment decisions in shrimp farming.

In this context, it is worth recollecting the outcome of the "Expert consultation on planning for Aquaculture Development" held in Policoro, Italy in 1988 (ADCP Report, 1989/33). The participants proposed that appropriate action be taken starting at the inter-regional level "to prepare a catalogue listing available systems and practices of production" to assist governments of developing countries in planning and developing appropriate aquaculture methodologies.

To this end, the thesis entitled "Studies on improved practices of prawn farming for higher production in central Kerala" prepared by the author describes various practices prevailing in the study area in order to elucidate their relative merits. The study on semi-intensive farming at Mundapuram, Kannur was also carried out and included in the thesis for comparison.

Careful analysis of data accrued by the author has helped him to identify strength, weakness, opportunities and threats confronting the shrimp farming.

As a result it was possible to evolve an appropriate management technology taking into consideration the various ecological (location specific), social and economical conditions prevalent in the vast study area.

Shrimp farming being a seasonal activity and the fields having located in different areas, the author had to struggle hard spending considerable time and energy to complete the investigation over an extended period, from 1986 to 1992. Alongwith it, case, pilot and experimental studies were carried out to identify potentially useful tools, if any, for resource management.

On many occasions, author could not exercise complete control over the investigations owing to the varied nature of culture systems. Yet added attention was paid to draw as much information as possible in such situations.

Prawn versus shrimp

At a time when the terms prawns and shrimps are used vaguely it is felt necessary to clarify the usage of the word "Shrimps" in the thesis. This is an important question as the usage of these terms is becoming a matter of concern to distinguish each other. According to the recommendations of the Indo-Pacific Fisheries council in 1955, the term "prawn" should be used only in respect of the members of the family Penaeidae, Palaemonidae and Pandalidae and the term "shrimp" to species of other families. However, as early as 1967, FAO introduced a clear cut distinction that the term "prawn" will be reserved for fresh water creatures only, while their marine/brackish water relatives will all be called "Shrimps". This was further emphasised in the conference organised by FAO, INFOFISH in Bangkok, Thailand in 1988 by designating it as 'the shrimp 88'. It is in this sense that the term shrimp is used in this thesis.

The lay out of this thesis comprises mainly three parts - (1) INTRODUCTION, (2) INVESTIGATIONS & RESULTS and (3) DISCUSSION, followed by summary, recommendations, and the citation of literature referred.

The introductory part, beginning with the literature survey in general has dealt with in detail the state of Art of Aquaculture Practices - region wise, farming cycles, type and nature (level) of culture systems and harvest technology and methods. The eight important aspects of shrimp culture and six major objectives of the present study have been highlighted.

The second part on work accomplished, after describing the study area and the materials and methods used, has given elaborate descriptions of the 27 investigations carried out, along with the results also in tabular forms.

The investigations were made under five groups:

A. Six investigations covering existing practices with improvements.
B. Seven experimental case studies on higher production in growouts.
C. Eight pilot studies for higher production in mini ponds.
D. Five experimental growth studies in tanks.
E. A case study of semi-intensive farming demonstration in grow-out system.

The crucial third part has brought out the salient features and comments on ten aspects of culture management namely site selection; design; pond preparations; pond ecosystem; seed, feed and water management; harvest methods; growth studies and economics of culture.

On an appraisal of the system in detail, the prospects and constraints in the culture practices are identified. The discussion is concluded by presenting the salient features of the appropriate technology evolved after taking into consideration the various ecological, social and economical aspects prevalent in the study area.

A vivid summary has been given followed by recommendations. Literature survey has covered around 367 titles.

Besides, the author has published several scientific and informative papers and articles. 7 among them more relevant in the context of the present study have been given as an appendix.

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I wish to express my deep sense of gratitude to Dr. M. Sakthivel, Director, The Marine Products Export Development Authority (MPEDA) Kochi for his guidance, supervision and encouragement throughout the period of this study. I am grateful to the Chairman, MPEDA, Kochi for the permission and facilities provided for the work. My thanks are due to the Vice-Chancellor, Kerala Agricultural University (KAU) for the kind permission accorded to undertake the study. Also, I am thankful to Dr. E.G. Silas, former Vice-Chancellor and Dr. M.J. Sebastian, Dean, College of Fisheries, Panangad for the encouragement and keen interest evinced in the study.

On this occassion, I sincerely acknowledge the invaluable services and help rendered by the shrimp farmers, scientists of sister institutions and friends during the course of this study. Special mention should be made to:

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Finally, I have no words to acknowledge my mother, wife and children for their support during this work.

1. INTRODUCTION

1.1 LITERATURE SURVEY - GENERAL:

The contribution by way of this literature survey is an attempt to bring together information on the shrimp culture as it is practised and the research investigations carried out, in the different countries.

Noteworthy among them are: The first symposium exclusively on coastal aquaculture organised by the FAO of UN in conjunction with the 14th session of the Indo-Pacific Fisheries Councils meeting was held in 1970 in Bangkok. The world conference on Aquaculture convened by FAO (1976) high-lighted the need for developing culture technologies and their improvement through research. Second world conference by FAO held in 1986 (Bilio et al.,1986) updated aquaculture developments.

The status report on coastal Aquaculture in the 15 countries bordering Indian Ocean brought out by the Marine Biological Association of India (1980) revealed that there is an extensive traditional culture fisheries in most of the countries bordering the eastern Indian ocean whereas it is poorly developed in the countries along the western Indian ocean.

A collection of 25 review papers which appeared in the CRC Handbook of Mariculture Vol. 1 (Mc Vey,1983) also has dealt with various culture practices.

FAO (1984) participating in the "Coastal Aquaculture Demonstration and Training Project" has brought out a voluminous field document on "Malaysia Coastal Aquaculture Development" consisting of 13 areas of operations. In one area, wherein a comparative study to assess the costs and benefits of tidal versus pumped aquaculture system was made, the latter was found economically more successful (Gedrey et al.,1984). This evinced the author to include a similar study in the present investigation.

The Regional seminar on Aquaculture development in South east Asia (ADSEA) held in Philippines in 1987 (SEAFDEC, 1988) assessed the progress and success accomplished in aquaculture in the light of the then and future needs and challenges.

"Aquaculture systems and practices: A selected Review" commissioned by Aquaculture Development and co-ordination, Programme (FAO, 1989) has reviewed the aquaculture methods and practices, as well general considerations in the choice of culture systems. The review concluded that "the success of aquaculture can only be attained through proper management based on a knowledge/understanding of the culture, environment and the biological processes involved in the culture operation as well as on the existence/availability of certain vital inputs - such as seed, feed, manpower, finance and technology".

Recently, Pillay (1990) has brought out an excellent treatise on practical low level technologies resulting in cost-effective production in aquaculture in a multi disciplinary manner covering all major aspects of the subject.

Latest in the series is the FAO (UN) Fisheries Technical Paper: 318 (Meaden and Kapetsky, 1991) entitled "Geographical information systems and remote sensing in Inland Fisheries and aquaculture which has dealt with capabilities of 110 districts to support fish farming development.

In addition, a number of exclusive journals and other publications from different countries:

Philippines - Aqua Farm News, Asian Aquaculture from SEAFDEC, Naga, the ICLARM Quarterly, Brais Newsletter and Aquaculture Abstracts.

Thailand	-	SEAFDEC News letter and the IPFC News letter.
India	-	CMFRI News letter, CIFRI News letter and Aquaculture drops for farmers.
Scotland	-	Aquaculture news.
Netherlands	-	Aquaculture
U.K.	-	Fish Farming International.
U.S.A.	-	World Mariculture Society News letter, Aquaculture digest, ASFA Aquaculture abstracts, Aquaculture magazine, Aquaculture and fish farmer.
FAO	-	Aquatic Sciences and Fisheries Abstracts.
	-	Aquaculture News Letter - FAN

- are regularly bringing out articles on various aspects of shrimp farming. But a point of caution is that all these can be of some guidelines only, as shrimp culture technology is highly endemic in its true sense. The few literature available on Indian shrimp farming in vogue since about 3000 years are also of general nature. Hence only the relevant scientific ones have been cited at the appropriate places.

The results of investigations on various aspects of shrimp farming have been presented during the different "All India Symposia on Estuarine Biology" held from time to time (1969, 1972 & 1975).

The All India Co-ordinated Research Project on "Studies on Marine Prawn Biology and Resources" (CMFRI, 1975) has brought out considerable data on the prawn resources of the country within 40 metres depth zone and on the biology of the concerned species.

In December, 1978, the CMFRI organised a seminar "on the role of small-scale fisheries and coastal aquaculture in integrated rural development" at Madras which recommended for the accelerated development of the field, in view of its importance not only for augmenting fish production, but also in improving the rural economy and providing large scale employment opportunities.

In recognition of the significance of shrimp as a foreign exchange earner, the first "National Symposium on Shrimp Farming" was conducted by the MPEDA in association with CIFE, CMFRI and CIFRI in 1978 in Bombay. The symposium reviewed the status of shrimp farming work in different parts of India by various agencies till 1978 through 42 papers (MPEDA, 1980).

The review by George (1980) has elaborately dealt with the status of coastal aquaculture in India with emphasis on constraints and socio-economic aspects.

Also the symposium organised by the Marine Biological Association of India in January 1980 at Cochin has dealt with different aspects of coastal aquaculture in detail by way of over 324 papers (JMBA, 1982). Important contributions on crustacean culture, technology, production and economics were made by several workers. Most important among them are Gopalan et al. 'on high density short term farming of P. indicus; Verghese et al. 'on improved prawn production through selective stocking'; Natarajan and Jalaluddin on intesive culture of P. indicus using different stocking densities and feeds etc. Experiments on shrimp farming in different regions were presented by Nandakumar in coastal ponds at Mandapam camp; Siddharaju and Ramachandra Menon in Kovalam backwaters of Tamil Nadu; Venketesan and Bose in brackishwater ponds of Madras; Srinivasan et al. in different ponds in Tamil Nadu; Pakrasi in the low saline zone of Matlah estuary in West Bengal and Das et al. on mixed prawn farming in brackishwater ponds at Kakdwip. The economics of a traditional shrimp culture farm in the north Kanara district was given by Pai et al.

The national symposium on "Shrimp seed production and hatchery management" organised in association with CMFRI, CIFRI and CIFE in 1983 (MPEDA, 1983) has dealt with elaborately, through 35 papers, on various aspects. Important among them are: Rao on shrimp seed resources, Vedavyasa Rao on larval nutrition, Muthu on Brood stock development and management, Mohamed on hatchery production of seed and Singh on design, management and economics. Dwivedi reviewing the "Prawn seedling production - state of art" suggested setting up of a few commercial hatcheries in India by MPEDA both on east and west coast providing enough financial supports and incentives using indigenous technology.

Muthu et al. (1982) reviewed the research and technological progress, made particularly in the field of raising prawns in growout systems, seed production, induced maturation etc. till 1980, in countries along the coasts around the Indian ocean and Indo-Pacific.

Bensam (1982) and Kurian (1982) have dealt with constraints in shrimp culture in India. Important among them are inadequate water supply and consequent shortage of natural food items; havoc caused by predators, diseases etc.

MPEDA (1985) brought out the Proceedings of the National Seminar on the Status of Prawn Farming in India. In this, contributions by Silas and Muthu: "Status of Marine Prawn Hatchery Technology"; Natarajan: "Brackishwater Shrimp Farming Management"; Bhakta: "Status of Technology on Coastal Aquaculture in India"; Mukherjee and Ghosh: "Coastal Aquaculture Engineering for Developing Prawn Farming"; Choudhury: "Brackishwater Prawn and Fish culture in Kerala"; and Apurba Ghosh: "Shrimp as an important component in crop sequence in brackishwater production system - observations and seed availability" are notable among the 19 papers discussed on various aspects of shrimp farming technology and its development in the maritime states of India.

A comprehensive series entitled "Brackishwater Aquaculture

Development in India: Status and Task Ahead" designed and published by Indian Institute of Management, Ahmedabad (1987) was an outcome of a National Workshop on "Formulation of Brackishwater Fisheries Project for international bilateral funding", held in Madras during 1985. This manual containing 19 papers covered all aspects of development of Fisheries Sector. However, in the shrimp culture view point, the papers by Dwivedi: "Prawn culture: challenges and possibilities"; Chandrasekar: "Brackishwater Prawn and Fish culture in Kerala"; Silas and Rao: "Fish and Shellfish Production through Aquaculture in the Backwaters of India"; Natarajan: "Penaeid Shrimp Production Possibilities under Traditional and Intensive culture Systems in India"; Bhakta: "Brackishwater Pond/Farm Design and Economics of Operation"; Hameed Ali and Alikunhi: "Regional characteristics of culture patterns in Brackishwater Farming of Prawns"; Nair: "Large Scale Prawn Farming - A Study"; and Sakthivel: "Organizational set up required for Prawn Farming in India" are worth mentioning.

Proceedings of the seminar on estuarine management - its dynamics, chemistry, environment, management and biology - held at Trivandrum (Balakrishnan Nair, 1987), through 102 papers reviewed the state of art on the subject and formulated strategies for future development. A few among them are that of Sakthivel on "shrimp aquaculture, a fast growing dynamic industry" and Silas on "Mangroves and fisheries - management strategies".

The seminar on "Status and prospects of brackishwater aquaculture in Orissa" held in 1988 (CIBA, Spl. Publication, 1988) has brought out significant contributions in shrimp farming wherein Natarajan evaluated and analysed the traditional, semi-intensive and formulated feed based shrimp farming systems and their production possibilities in India.

The recent annotated bibliography of commercially important prawns and prawn fisheries of India (CMFRI, Spl. Publi No. 47, 1989) has dealt with 121 publications on shrimp culture.

The author through his investigations on shrimp culture in Vypeen island (Purushan, 1986, 1987, 1987 a) has indicated the vast scope to tap more shrimps from traditional paddy fields while providing more insight to the farmers to attain enhanced yield. Furthermore, the details of semi-intensive shrimp farming practice and its relevance to Kerala conditions have been adequately documented (Purushan, 1989).

The mariculture studies under taken at the CMFRI, CIFRI, CIFE and similar research organizations and departments under central and state governments, public and private sectors etc. were found regularly contributing information for the promotion of shrimp farming. The small handbook on shrimp farming issued by MPEDA (1991) is a valuable guide in this series.

In the handbook on "Satellite shrimp farming", MPEDA (1992) has made an attempt to give all information relevant to the integrated approach towards establishing nucleus facilities such as hatchery, feed mill and processing plant along with farming in the geographically varied situations of our country.

In addition, a large number of books dealing with aquaculture have appeared. Most important among them are "Aquaculture" by Bardach et al. (1972), "Fish and Fisheries of India" by Jhingran (1982) and "Aquaculture principles and practices" by Pillay (1990).

Despite the above voluminous research work, no one has made any comprehensive attempt to study the lacuna in the system covering technology, socio-economic background of the farmers and overall economics of farming in the traditional aquaculture sector.

1.2 STATE OF THE ART OF AQUACULTURE PRACTICES

1.2.1 Origin and growth - World wide and Regional

Fish culture practice is centuries old. It is believed that fish culture as an occupation originated in China in 2000 B.C. Nevertheless the first record of it appeared in the form of a book "The classic of Fish culture" by Fan Lei in 475 B.C. where in he cited the fish ponds as the source of his wealth (Ling, 1977). In India, the traditional fish culture has got a history of well over 2000 years. It appears to have been originated by a small section of the population as a means of their livelihood. 'Kautilya' had also described fish culture in 'Arthasastra' released in 300 B.C. — an epic of Indian culture of those days. Emperor Asoka had also given ample coverage for fish culture in the Sthoopas erected by him all over the empire during his time. A reference to fish culture is also presented in the book 'Manasollasum' written by King Someswara in 1127 A.D. (Menon, 1970).

All the above indicated that man has been associated with fish culture at least for a period of 4000 years. Since then, the trial and error method of fish culture has taken its own course in different countries during its long history to take the present shape. It is well established in many of the developed and developing countries.

Eventhough aquaculture has a tradition of about 4000 years, the shrimp culture practices as witnessed today is only two decades old. According to Ling (1977), one of the possibilities of aquaculture development from ancient practice is from trapping fish, with the operations steadily improving from trapping — holding to trapping — holding — growing and finally into complete husbandry practices. Philippines has been practising it for about 300-400 years (FAO, 1989). Shrimp culture development has been very recent in Australia, Newzealand and the Pacific island countries (Rabanal, 1988). Shrimp culture is practised in well over 51 countries (Bob Rosenberry, 1991).

The 'Sugpo' cultivation of Philippines, the prawn fishery in ponds of Singapore, the tambaks (embanked coastal areas) of Indonesia, the prawn culture practices of Formosa, Taiwan and main land of China, the paddy field shrimp filtration of the south west coast of India and the composite culture of fish and shrimps in the spill areas of the brackishwater rivers (Bhasa badha) of west Bengal are all traditional practices of culturing evolved based on certain knowledge of the habits of the concerned species (Mohamed, 1973).

Aquaculture in Southeast Asia - an over view

Cultivation of marine shrimps in salt water ponds has been practised in the orient for the past several centuries. These include the pond culture practices of Malaysia and Singapore involving several penaeid species (Tham, 1955, 1968; Hall, 1962), catching of shrimps from the extensive tambaks of Indonesia, and from the brackishwater ponds in Formosa (Kestevan and Job, 1957), the Sugpo culture of the Philippines (Villadolid and Villaluz 1951; Delmendo and Rabanal, 1956; Caces-Borja and Rasalan, 1968) and the large scale trapping and filtration of shrimps in the paddy fields of Kerala coast (Menon, 1954; Gopinath, 1956; George et al. 1968; George, 1974).

Thus the traditional aquaculture has been practised by shrimp farmers of S.E Asia for centuries. During the last 18 years, however, the introduction and development of modern and innovative culture technologies have transformed this age old occupation into a major industry leading to increased shrimp production. Review on shrimp production (Rothusberg et al. 1985 and Bob Rosenberry, 1991) shows that more than half of the extra demand can be met by Asian aquaculture, 70% of which from Southeast Asia alone.

Culture of 'Sugpo' in Philippines

The naturally produced fry of 'Sugpo' (*Penaeus monodon*, Fabricius) entering estuaries from the sea are collected and cultured in ponds in association with Chanos chanos from olden times. But as on today monoculture is preferred. Unlike the culture of P. japonicus in Japan, the culture of P. monodon in the Philippines is dependent on natural supply of seed or fry.

As a result of the demand, the collection of the fry has developed into a distinct and lucrative fishery. Farmers used lower stocking densities with supplemental fresh feeds (like molluscs and trash fish) and high quality P. monodon fry.

Recently with the advent of backyard hatcheries, artificially produced fry are profusely used for intensive shrimp culture.

Many discontinued the use of chemicals (disinfectants, algicides and antibiotics) in order to lower disease out break caused by Monodon baculovirus (MBV) etc.

85% of the industries' feed requirement amounting to 1 lakh tonne/year is produced by 21 shrimp feed mills. Feed accounted for 60-70% of production costs.

Philippines and Indonesia both had pollution problems due to intensive shrimp farming forcing the farmers to retreat to semi-intensive culture. Nevertheless, intensive farms increased effluent load on the rivers.

Vietnam

Shrimp production/ha in Vietnam is the lowest by international standards as most farmers relied only on the seed stock that was brought in by the incoming tide. Also poor water exchange and lack of eradication of pests contributed to the low production of 188 kg/ha.

Taiwan

Taiwan has the highest production costs in the world as the land was valued up to $ 2,00,000/acre during 1986 because of an annual production rate of 15,000 kg/ha/crop. Taiwan depended on seed stock from small hatcheries. Monodon baculovirus (M.B.V.) has become one of the causes of the mortality problem in Taiwan.

Japan

It was in 1933, when for the first time, the artificial spawning and hatching of P. japonicus in a culture tank was achieved (Hudinaga, 1935) the shrimp culture was initiated in Japan. Later on, the culture of Kuruma shrimp, (P. japonicus) was carried out under artificial conditions from spawning through hatching and rearing upto adult sizes (Fujinaga, 1969). Disused salt farms are at present converted as culture ponds. The area of ponds varied from 2000 m^2 to 100000 m^2 and the depth ranged, from 1 to 2 metres. The ponds are connected to the sea so that they are flooded and drained partly during the flood and ebb tides respectively twice a day. The best season for releasing fry in the culture pond is from May to mid June. In about 6 months time, they grow to marketable size. The number of young ones introduced into each pond is regulated taking into consideration the mortality and survival rate during the six months. Different food materials like short necked clams, shrimps and fish are supplied to the ponds for the growing shrimps. The problem of cheap food for the culture of fry to adult size is yet to be solved and that only will make shrimp culture in Japan productive and commercially feasible. At present it is very expensive and whatever commercial production possible is only because of the very high price of shrimps obtained there.

Japanese shrimp farmers producing 7,000 kg/ha on an average use two types of ponds, partial embankment and complete embankment. The partial embankment approach takes advantage of the areas of large tides. Farmers build embankments to a height half way between the high and low tides and then construct a fence on top of the embankment to enclose the shrimp. Other farmers use typical semi-intensive ponds that are completely enclosed with embankments. The warm climate in Japan permits year round production.

Korea

Based on Japanese methods, the artificial culture of the shrimp *P. orientalis* has been achieved in Korea on a commercial scale. But no detailed report about these operations is so far available.

Malaysia

The method of shrimp culture in Malaysia (Hall, 1962; Tham, 1968) differs from Philippines in that the young shrimps are not stocked in the ponds artificially by operators, but brought in naturally by tidal flow. Much of the swampy brackishwater areas are utilised as shrimp ponds. By partially clearing some of the vegetative growths and erecting mud walls with suitably sited sluice gates, the swamps are converted into shrimp ponds varying in sizes from less than 5 to 50 acres in extent. The incoming tidal waters are let into the ponds through the sluice gates twice a day and let off with the receding tides maintaining a water level of at least 60 cm inside the pond. The depth of the pond is not uniform, average mean high tide depth being about 120 cm. The sluices are about 1.2 m wide. They are lined along the sides and bottom with wooden boards. Planks of wood sliding vertically in slots are used as shutters for regulating the flow of tidal water in and out of the ponds. The shutters are operated by a wooden hand windlass. Fishing operations are conducted during low tide by placing a net attached to a wooden frame against the outflowing water at the sluice gate during nights. A wooden race way is provided on the outerside of the sluice gate so that the net does not get torn as the current rushes through it. The net is emptied at the cod end.

Indonesia

Shrimp culture started only in 1967. With its long coast line, warm temperature, good seed stock supply and consuming maximum shrimp feed from Taiwan, it finished second to China in 1991 with an annual production of 1,40,000 tonnes from 2 lakh hectares in spite of a production of 700 kg/ha (World shrimp farming 1991). Indenesia has over 100 shrimp hatcheries to supply 20 billion P. monodon fry per year. In addition, fry requirement is met by backyard hatchery which is unique to Indonesia. The 20 feed mills produce 1 lakh tonne feed per year used for 10% intensive culture ponds.

Thailand

Thailand has become the world's leading shrimp exporter by producing 85% through intensive culture in 1991 where as only 15% came from extensive culture. This was made possible by the operation of over 1000 small sized hatcheries using ocean caught brood stocks.

The good quality of post larvae ensure quite high survival rate ranging from 60 to 80% in grow out ponds from PL_{15} to marketable size.

The 10500 farms with a water depth of 1.4 to 1.6 m and a pond water area of 80000 ha are managed by the owners themselves. Water exchange at the daily rate of 30% was done using 8, two HP paddle wheels per hectare pond.

At a stocking density of 30 to 50 PL/m^2, it grows to 30 pieces/kg in 105 to 135 days with a survival rate of 60%. The production is 6 to 12 tonnes/ha/crop.

Thailand having 10 major quality shrimp feed suppliers, the farmers on an average could get an FCR of 1.5 to 1.8 at 30 pc/kg.

Establishment of 14 technical centres and mobile vans with lab for chemical and microbiological analysis offers free water quality analysis or disease diagnosis. The extension centres conduct seminars and training courses. A large number of processing plants capable of producing value added products have been set up. Most important of all is the availability of cheap and skilled work force.

Singapore

Although juveniles of 12 species are recorded in the catch of the Singapore ponds (Hall, 1962), 5 species, namely *P. indicus*, *P. merguiensis*, *Metapenaeus ensis*, *M. burkenroadi* and *M. brevicornis* contribute to major portions of the catches. The method of shrimp culture as practised is that of rearing young penaeid shrimps brought in with every incoming tide. The catch in these ponds ranges upto 800 kg/ha/year.

Bangladesh

In Bangladesh, abundant land, water and seed stock allow to produce shrimp at very low cost. They polyculture shrimp and fish in the pond after the rainy season when the creeks become brackish. In other areas of salt ponds, shrimp and fish are produced, once the rain beginsso that salinities fall.

Farmers rely on tidal flows for filling and draining their ponds. Pumps are not used. The entrance of predator and competitor fish with the inflow of water at high tide is prevented by the careful use of sluice gate screens.

Farmers construct nursery impoundments within the larger ponds. Along with the arrival of most seed stock with the incoming tide, farmers stock at low rates of 10,000 to 30,000 fry/ha. Most farmers do not provide supplemental feed. Hence, the production worked out to only 250 kg/ha.

Hatcheries are not set up due to year round non availability of sea water of suitable salinity (28-32‰) and abundant availability of wild fry.

/India

Traditionally India, mainly Kerala is well known as an exporter of dried shrimps to Srilanka, Burma, Singapore and Malaysia for the last two centuries. As per the records at the Cochin Chamber of Commerce, 6000 tonnes of dried shrimps were exported from Cochin port in 1939 indicating a production of 25,000 - 30,000 tonnes of fresh shrimp at that time. The shrimp industry showed considerable growth along west coast of India by 1950 and east coast by 1970. The total shrimp production from marine and inland capture and culture accounted for 2,36,596 tonnes in 1988 of which cultured shrimp was around 20,000 tonnes. However the figure has gone up to 35,500 tonnes during 1991 (MPEDA, 1992).

Rice field aquaculture involving the trapping of shrimp larvae in inundated fallow rice fields and growing to market size is an age old practice existing in many parts of India. According to Tamura (1961) this practice which appears to have had its beginning in Indonesia during the 19th century as an important peasant activity was introduced into south east Asia from India about 1500 years ago.

Current practices in India can be classified into three categories on the basis of the prevailing farming system (Silas and Rao, 1987).

I. Paddy cultivation during the rainy season (June to September) followed by fish and shrimp farming in the fair season (October to April) in the low lying earthern fields adjacent to estuaries and backwaters. This paddy shrimp rotation farming system is principally concentrated in central Kerala, along the northern coastal waters of Karnataka, Goa and to a certain extent in West Bengal.

II. Fish and shrimp farming in relatively larger and deeper eastern fields throughout the year as seen in certain areas of central Kerala and in the large "Bheries" of West Bengal.

III. Paddy cum fish cultured in the rainy season as practised chiefly in Goa and the West Bengal fields.

Of the 1.4 m ha of brackishwater areas of the coastal plains in India, 0.9 m ha deems to be potential areas for shrimp farming development. But only 65100 ha are currently under culture (MPEDA, 1992).

India ranked 4th during 1991 by producing 6.3% of the shrimps raised from the eastern hemisphere (Bob Rosenberry, 1991).

India producing 35,000 tonnes/annum from 2500 farms following traditional methods indicate a production of only about 538 kg/ha/year that too comprising low valued shrimps. In comparison, Mexico, Ecuador and Panama produce 2-3 tonnes/ha/year through extensive culture while that of Japan and Taiwan produce 40 & 20 tonnes/ha/year adopting intensive and semi-intensive farming respectively (World shrimp Farming 1991). Recently, farmers in Kerala, Tamil Nadu, Andhra Pradesh, Orissa and West Bengal adopting scientific methods have already achieved a production of upto 8.5 tonnes/ha/crop at selected farms (Anon, 1990 & 1992).

Since 1982, there has been rapid increase in the culture of P. monodon (Muthu et al., 1988) in brackishwater ponds in the central areas (deltaic regions) of the Godavari and Krishna rivers extending in an area of 1170 ha. In pump fed farms in East Godavari tiger prawns of 25-30 g size were produced at the rate of 650 kg/ha/crop of 7-8 months duration by stocking 50,000 seed/hectare. The shrimps reared in the ponds, fertilised with cowdung and super phosphate were fed with blood clam meat, trash fish and dried prawn head waste. The prospects of conventional pump fed ponds over that of tide fed ponds were demonstrated through the Bay of Bengal Programme (Angell, 1987).

In the west Godavari area the shrimp production depended on the salt content of the soil rather than the salinity of water which is almost fresh. As the salinity was lost due to leaching, only subsoil brackishwater could help to replenish the ponds.

In the Krishna area where paddy cultivation was impossible due to saline soil, P. indicus was cultured in waters of low salinity, 0-15‰.

There is great scope for extending the pokkali type of shrimp culture in the 'Gazani' lands of Karnataka and 'Khazan' lands of Goa and Konkan where similar low lying paddy fields subjected to tidal influence are present in coastal areas.

It is also worth mentioning that farmers of the coastal districts of Andhra Pradesh and Orissa are making rapid strides in shrimp farming taking advantage of the available technology. A recent phenomenon taking place along the coastal strip of lands in Nellore district of Andhra Pradesh is the rapid transformation of several hectares of fallow and forlorn areas into shrimp production farms. Receiving technical guidance and inputs such as shrimp seed and feed through MPEDA functioning there, the enthusiastic farmers by virtue of their inimical entrepreneurship have succeeded in blossoming these areas into quality shrimp production units enabling to earn much valuable foreign exchange. All these took place within a period of three years and the Nellore district at present is in the limelight, remaining as a centre of attraction for several farmers from different parts of the country to study the progress and learn lessons on shrimp farming (Fishing Chimes, 1991).

In West Bengal, the impounded fisheries in vogue through several decades in low lying areas of Sunderbans region and practised in Bheries or Nona Kheries is referred to Bhasa Badha fishery (Pakrasi et al., 1964). The bheries are chiefly large pereminal water bodies surrounded by earthern dykes which are constructed by borrowing earth from the trenches excavated inside the bheries near the toe line of the dykes. The bheries are deeper and larger in extent than the pokkali fields of Kerala. Usually the bheries have single sluice which serves both the purpose of taking the tidal water during spring tide and releasing water from bheri during ebb tide. The production system in bheries is largely based on trapping holding and culture of wild seeds of shrimps and fishes taken during high tide. Prawns are obtained along with the mullets and perches. The stocking is done during January-February and fishing is carried out in September-December. During the 10 months, fishes are inside the impoundments and feed on the natural food provided by the habitat which gets replenished by the animal and plant life contained in the incoming tide waters. These farms are known to yield 168-672 kg/ha of shrimp and fish and hold immense potential of development. This traditional practice is giving way to selective stocking with desirable culture species of prawns and fishes (Natarajan, 1985).

During scientific preparation of the field, care is given to provide canals of various dimensions occupying about 8% area to hold the fish in extreme situations. The height of dykes normally varied from 1.5 m to 1.8 m and the crest width is kept at 60 cm. Two tier system of sluices are also fixed suitably. From March onwards tidal water is drawn into the field which brings in the seeds of commercial species of prawns and fishes. This will be continued upto June with all earlier precautions taken not to inundate the paddy beds with saline tidal water. With the onset of monsoon, the entry of tidal water is stopped and the fishes harvested when an yield of 200-400 kg/ha/4 months is obtained.

The monsoon showers thoroughly wash the paddy beds which also raises the water level in fields. At this time required cuttings are made in the dykes to permit the free flow of water. In due course congenial ecological conditions are restored in the field when Kharif paddy is transplanted. Subsequently, fingerlings of carps and juveniles of Macrobrachium rosenbergii are introduced in 1:1 ratio. Paddy is harvested by November and fishes are retained further depending on the level of water. During December fishes are also harvested when an yield of 500-600 kg/ha/7 months is obtained. This is in addition to the yield of 2500-3000 kg/ha of paddy (Natarajan, 1985).

Kerala

According to Silas and Rao (1987) and Chandrasekhar (1987), Kerala has about 2.40 lakh ha of estuarine waters. Of these water resources available, 1.22 lakh hectares are considered suitable for brackishwater fish and shrimp culture. But commercial culture is practised in only 7000 ha of low lying fields adjacent to the back waters. A recent estimate showed that the area has been extended to 13000 ha in Kerala (MPEDA,1991). Rest of the area is used for capture fisheries by a variety of fixed as well as free gears. The culture operation is an age-old avocation practised seasonally in most fields and perennially in a few. Till 1985, the brackishwater shrimp farming in the country especially in Kerala, by and large, followed similar basic technology. It is possible to take 2 crops in the seasonal and 3 crops in the perennial fields using scientific methods giving an average yield of 1.5 tonnes/ha/yr.

The saline rice tracts known as pokkali lands are situated in the districts of Ernakulam and Alleppey in Kerala State. Similar areas ideal for shrimp culture, but not suitable for paddy cultivation on account of depth are present in Thrissur, Malappuram, Kozhikkode and Kannur districts. The more important pokkali tracts are in Edappally, Palluruthy, Vypeen and Parur of Ernakulam district where the farmers are well versed with the traditional techniques of shrimp culture. The fields comprise of low lying marshes found around the estuaries and backwaters. These tidal areas are full of mangrove and salt loving plants. The soil is stiff impervious clay, rich in organic matter as also deposits of plants and shells. Peripheral bunds are made of soil and strengthened by a row of mangrove plants or bamboo slats and splitted coconut stakes. After rice cultivation and harvest during October-November, the earheads alone are cut and after the harvest, water is let in to submerge the stubbles. This field is then used for shrimp culture.

Description of the seasonal fishery

The traditional shrimp farming practised in the pokkali fields is known as 'Chemmeen Vattu', 'Chemmeen Kettu' or 'Adappu' (Gopalan et al., 1980). The seasonal fishery is conducted in the paddy fields which are utilised for paddy cultivation during the monsoon season. All the fields have connection with the backwaters of Cochin. After harvest of paddy in September/October the fields are leased out for shrimp filtration. Bunds separating the fields are strengthened and flow of water in and out of the fields is regulated through sluice gates opening into the backwaters. The sluice gate is a rectangular wooden box-like structure with wooden shutter planks at the mouth to regulate the flow of water. The stocking of the field is accomplished by the seed brought in by the incoming tides. Water is let in during high tide and let out during low tide keeping a close bamboo screen at the mouth of the sluice to prevent the shrimp from escaping. The seed thus entered into the field is allowed to grow for a short period by feeding on the natural food available and the stock is harvested periodically. This process is continued with every high and low tide throuhgout the fishing season. The shrimps caught from the fields are mainly penaeids in addition to juvenile stages comprising mostly *Metapenaeus dobsoni*, *M. monoceros*, *M. affinis* and *Penaeus indicus* and fishes such as mullets, chanos and Etroplus and a few other species of miscellaneous groups. In the shrimp groups *Metapenaeus dobsoni* (53%), *Penaeus indicus* (42%), *M. monoceros* (4%) and *P. monodon* (1%) are usually obtained in the order of abudance (Mohamed, 1973).

A similar traditional shrimp farming prevails in the Sunderbans region, the largest mangrove belt in India. But compared to the

'Bheries' Nonakheris or 'Bhasa Badha' which are the perennial water bodies of Sunderbans comprising dead river beds, the pokkali fields of Kerala are shallower and smaller in extent. While Bheries have single sluice gates, the pokkali fields have often two or more sluice gates. Both the systems mainly depend upon trapping, holding and culture of wild seeds of shrimps taken during high tide often accompanied by fishes like mullets and perches. While stocking is done during June to February in Suderban and November-December in Kerala, the fishing is carried out during March-April in Kerala after 4 months where as it is during September-December in Sunderbans after about 10 months. The shrimp and fishes feed on the natural food available in the habitat which also gets them replenished through the incoming high tide.

By adopting techniques of 'Short-term high density farming", Gopalan et al. (1982) depending on the health of the system, could obtain two harvests in one season enhancing production upto 1750 kg/ha.

Based on experiments conducted in the paddy fields, George et al. (1968) found that long term culturing of penaeids in the paddy fields, in general, does not contribute to increased weight. On the other hand short duration culture of one month is sufficient for getting larger shrimps. According to them the paddy fields are not merely a trapping mechanism but they also provide an active and suitable biological environment for the life and growth of these shrimps. Thus a certain amount of culturing also is involved in this process.

Notwithstanding the above, this fishery is generally described as a mere process of trapping adolescent penaeids by allowing them enter into the paddy fields along with the tide, and capturing at low tide (Panikkar 1937, Menon 1954, Gopinath 1956 and Kesteven and Job, 1957).

A number of investigations have been carried out by various authors (Panikkar, 1952; Panikkar and Menon, 1956; Gopinath, 1956;

George, 1974 and Gopalan et al., 1980) regarding the mode of operation and yield obtained through the traditional system. The details of yield and economics of prawn culture from fields of Vypeen island have been worked out (George, 1974; Purushan, 1986; 1987). Studies by Purushan and Rajendran (1984) indicated that shrimp production from traditional fields is gradually dwindling year after year, the present yield being 300-400 kg/ha/year in addition to 200-300 kg of fish. But Silas and Rao (1987) estimated the average annual yield of fishes and prawns from traditional system as 1070 to 1570 kg/ha/season. While shrimps contributed only 33.3%, the rest was contributed by fishes such as mullets, pearl spot, tilapia, cat fishes and crabs Scylla serrata.

On an evaluation of the efficiency of management and productivity of traditional brackishwater farming practices of central Kerala, the author noted 5 chief defects in the systems.

The system does not involve fertilization of the field, additional stocking, supplementary feeding of the impounded stock, control over competition and predation and provision for sufficient time for growth. These defects could be rectified at little extra care on the part of the shrimp farmers (Purushan,1987). Hence, in order to transform the traditional practice to an improved system, emphasis given on the following aspects during the present series of investigations become more relevant in the Kerala situations.

a) eradication of undesirable organisms
b) preparation of the field as a habitat before stocking
c) selective stocking with fast growing species that command good price
d) supplementary feeding
e) allow the species to attain marketable size within short time.

1.2.2 Shrimp farming cycles

The cycle consists of hatchery, nursery and grow out phases. The nursery phase more closely resembling grow out than the hatchery is the one often skipped by farmers eventhough it can contribute to better survivals during grow out. While in Ecuador most farmers use nurseries, in Taiwan many skip nurseries.

Hatchery

The success of shrimp farming is mainly centred around availability of quality seed in time. This is made possible with the help of spawners which may be self-reared, captured from natural waters or purchased from the market. Farmers all over the world, who rely on wild shrimp for the production of seed stock either spawn egg-laden females (pregnant ones captured in the wild or matured in a hatchery) at a hatchery or collect wild juveniles which are transferred directly into the growout ponds or stocked in nurseries. In Ecuador, farmers consider wild post larvae the "cadillac" of seed stock.

The controlled spawning and larval rearing of shrimps was initiated by Hudinaga (1942) with wild spawners of *P. japonicus*. Commercial scale propagation has been developed for 24 *Penaeus spp* and 7 *Metapenaeus spp*. Detailed descriptions have been given by Mc Vey (1983). Different hatchery systems are available. In one system, spawning, larval rearing and fry nursery are all done in the same tank. In the second type of system more suitable to *P. monodon*, separate tanks are used for spawning and larval rearing. The third system developed by Kungvankij (1982) and reported to maximise tank utilization combines the advantage of the above two systems with separate tanks for rearing post larvae to the PL_{30} stage.

Liao (1985) referred to a "ladder system" hatchery consisting of 4 interconnected tanks built on a slopping ground, one below the other, with descending water levels. The algal culture tank at the top was followed below by rearing tank, for nauplii and zoea larvae, then another one for mysis to PL_{1-5} stages and finally a large one for post larvae.

The more favoured nursery approach necessitates rearing the nauplii through different stages by supplying appropriate feed — live or inert. The success of any hatchery operation depends mainly on the availability of the phyto plankton — the meadows of the sea, because the large scale production of molluscan, crustacean and fish larvae mainly depend on mass culture of particular species of unicellular algae as a food source in the early stages of development (Loosanoff and Davis, 1963).

In the western hemisphere and in China multimillion dollar hatcheries with high-tech facilities produce large number of seed stock in controlled environment through out the year.

In south east Asia particularly in Thailand, Taiwan, Indonesia and Philippines, small hatcheries also known as backyard hatcheries using low densities and untreated water is of common occurrence. They are often affected by bacterial and viral diseases and water quality.

Hatcheries have been marginally successful, as fast growing giant tiger prawn P. monodon reaching a maximum of 336 mm does not mature in captivity. Only the Chinese white shrimp P. chinensis is well suited for captive maturation.

It takes about 6 weeks for the larvae from spawning to stocking in grow out ponds to complete the hatchery cycle. However, hatcheries remain as the weakest link in the production cycle.

In India, success was attained to spawn and rear most of the cultivable species of shrimps in the laboratory using the Japanese technology with appropriate local alterations (Silas, 1978).

The purpose of shrimp hatchery is to create a good environment for shrimp in order to obtain highest possible yield. However, due to personnel problems, poor management and lack of skill and knowledge, the spawners fail to breed. And this is the problem with regard to farmers of Central Kerala as they are unable to procure good quality seeds in the absence of a dependable hatchery round the year.

As small scale hatcheries set up at Narakkal (CIBA), Azhikode (State Fisheries), Vallarpadom (MPEDA) Mappila Bay (MATSYAFED) were not dependable source, there arose the need to transport larvae from far off places for shrimp culture operations. Upto 30% mortality was observed in 4 to 6 hours while transport was in ordinary containers. This was set right with the help of artificial aeration, oxygen packing and feed facilities.

Using oxygenated polythene bags, long distance transportation taking over one week and without feeding was made successful (Mathew et al., 1980). The need for a standardised procedure was felt to organise regular seed transport.

Hatchery seed production is required to adjust to cultural requirements. More than one crop is possible in an year as marketable crops of shrimps can be raised in a period of 3-5 months. The culture period can be reduced provided nursery phase is prolonged until good size juveniles are ready.

Nurseries

Nurseries are an integral part of scientific aquaculture as a link between the hatchery and the production ponds. The success of nursery depends on its ability to enable maximum survival during the metamorphosis of post larvae into juveniles. In general, estuaries, backwaters, lagoons, lakes and swamps act as natural nursery grounds. Along the west coast of India, Cochin backwater ranks as the foremost natural nursery whereas on the east coast wellknown natural nurseries are Pulicat lake, Godavari, Mahanadhi estuaries, Chilka lake and Hoogly - Matlah estuary (Gopalan and Purushan, 1981).

In aquaculture concept, nurseries are well prepared small enclosures where favourable physico-chemical and biological conditions are provided for the maximum survival of shrimp fry. Usually size of nurseries varies from 50-200 m^2 and 0.5 - 0.6 m deep. The well prepared nurseries generate natural food organisms promoting growth of shrimp fry. In nurseries post larvae collected from nature or procured from hatcheries are provided with condition similar to estuaries. A matter of concern in the hatchery and nursery is the availability of proper larval feed organisms such as phytoplankton, Artemia, Rotifer (Brachionus sp) water fleas (Moina sp), copepods, marine yeast etc. Also attempts to make artificial feed for rearing larval shrimps were made (Hameed Ali and Dwivedi, 1990).

Post larvae of P. indicus (9-15 mm) and those of P. monodon (8-25 mm) attained 40-70 mm size in 30-60 days when reared in nursery ponds under densities of 2-6 lakh/ha giving a survival rate of 30-70%. The survival rate varied with the stocking densities. At Kakdweep in West Bengal, 85.5% survival rate was obtained with a higher density of 28,500/m^3. Post larvae of P. monodon and P. indicus (12.5-13.74 mm) reared in nylon cages at Kovalam (Tamil Nadu) using fresh clam meat in 15 days gave a survival rate of 60-90% under densities of 200-500/m^2 (Siddharaju et al., 1980).

The shrimp post larvae from estuaries or hatcheries when directly transferred to stagnant ponds where peculiar ecological conditions exist are likely to undergo mass mortality. It is to evade the chances of such a possibility that the post larvae are carefully reared in well set nurseries for a period of 2 to 3 weeks before they are introduced to advanced nursery system or stocked directly to the grow out pond. Earthern nursery ponds range an area from 50 to 200 m^2 with an average depth of 40-70 cm. The larvae stocked at the PL_9-PL_{10} stage at densities of 100-150 per m^2 can be reared in such ponds upto

PL_{40} or PL_{60} stages.

Some times a part of the grow out pond may be converted into nursery ponds provided with separate bunds and sluice gate. In such cases, the shrimp fry after a specified period of rearing in the nurseries are led to the growout pond for further growth either by breaking the bund of the nursery or by opening the sluice shutters. When nurseries are maintained away from the grow out ponds, the harvested shrimp juveniles are manually transported and stocked.

Grow out

Pond culture is the most popular growout system in Asia. Grow out ponds are defined as those ponds where the post larvae and juvenile shrimps after nursery rearing are stocked at a low level of 30000-50000 fry/ha to attain marketable size and harvested after 3 to 4 months. The stocking density is highly variable from 1 to 4 lakh per ha in modern practices depending upon the skill of the operator, the pond design and the amount of aeration, food and water available. The survival rate in well managed farms will be as high as 85%. Most farmers seem to be intensifying their production in response to technological improvements. Depending upon the management success, it is possible to raise 1.5 to 2.5 crops/calender year.

1.2.3 Types of culture

The different types of culture systems in vogue can be enumerated as follows:

i) culture in ponds/impoundments
ii) culture in pens or enclosures
iii) culture in cages
iv) culture in tank farms
v) sea ranching

Penaeid shrimps are generally cultured in impoundments less expensive to construct and operate, with stagnant or semi-stagnant water in comparison to running water systems.

Shrimps can also be cultured in pens ie, artificial enclosures implanted at the substratum of estuaries, bays, swamps and coastal waters. But the greatest disadvantage is that these are at the mercy of natural environment over which the aquaculturist has very little control. Hence it is not possible to employ advancedtechnologies. The widely practised pen culture organised in Japan (Felix, 1975) and is in vogue in Cambodia, Thailand and Indonesia (Devaraj, 1974) is done on an experimental basis in lagoons of southern India by enclosing suitable intertidal areas by net fencing using nylon/metal mesh and wooden poles. Shanmugham and Bensam (1982) based on their studies on pen culture of prawns in coastal lagoons at Tuticorin have suggested many improvements. Japanese pens are made of vertical concrete walls of 1 M height to hold water during low tides and covered by wooden frames with nylon netting to prevent escape of shrimp larvae (Kungvankij, 1985). These pens resembling tidal ponds often cover an area of 10000 m^2 and is capable of producing 3-4 tonnes per ha/year when stocked with a density of 20-30/m^2.

Cages originated in Kampuchia (Coche, 1979) are enclosed structures of several types (Beveridge, 1987), varying shapes, dimensions and areas usually made of bamboo, wood, nylon or metal in which shrimps can be stocked in higher densities. These are floated in suitable areas either inshore or off shore where sufficient water exchange is assured.

Siddharaju and Ramachandra Menon (1982) assumed that the nylon cages could be used for raising 2 crops of shrimps with artificial feed and could give an average annual production of 736 g/m^2 in 2 crops.

Nursery rearing experiments conducted in collapsible 36 meshes per cm nylon screen cages of 5x2x1 m size at Kovalam near Madras proved highly successful as nurseries (Siddharaju et al., 1982).

Tank farms can be built of different materials - cement concrete, fibre glass, marine plywood, metal or other hard substances, circular and rectangular in shapes and having a size even upto 0.2 ha. Having greater human control in operations, these can facilitate intensive farming.

Sea ranching is a novel technique of re-seeding the sea with desirable species of shrimps in protected areas as a measure of conservation. Sea-ranching of P. japonicus and P. monodon is practised in Japan and Taiwan respectively. In Japan, 300 million post-larvae are released every year (Uno, 1985) where as small scale stocking of rivers and dams has been attempted in Taiwan (Chao, 1974).

1.2.4 Nature of culture systems

Nature of culture systems may be classified as under.

a) Traditional/modified traditional
b) Extensive/improved
c) Semi-intensive
d) Intensive and
e) Super-intensive

The characteristics of these culture systems involve the following:

1. Species selection
2. Engineering design and lay out.
3. Pond preparation with proper fertilizers, lime and health stone.
4. Manipulation of stocking densities
5. Supplementary feeding with nutritionally balanced diet.
6. Duration of crop and cropping frequency

7. Water quality management.
8. Post-harvest technology and marketing.

Typically, depending on the density of stocking, grow out methods are categorised as "traditional" (stocking density unknown) "extensive" (low stocking density of 1-2/m² with no feeding), "semi-intensive" (medium density ie. 6-10/m² with feeding), "intensive" (higher density ie. 20-40/m² with feeding and aeration) and "super intensive" (with very high density of 200-500/m² feeding, aeration and high water exchange). With increase in density, the technology becomes sophisticated, capital costs go up and the production per unit area increases as the farms get smaller.

In general, increased production of 4600-7400 kg/ha was achieved by increasing the stocking rates to 40-45/m² and supplying high energy feeds while maintaining high oxygen values using pond aerators.

Shrimp prices are on the increase for the largest sizes (16-20 g) compared to small and medium sizes. Hence the importance of raising standard sized specimens within short duration is preferred.

a) **Traditional management** is the simplest culture to undertake with least inputs during operations. (1) Being the lowest level of intensity of culture, the production rate also is the lowest. (2) In this management, the stock is variable with many extraneous species and (3) Also there is no specific stocking rate. (4) The big ponds used are uncleared and (5) Possess only make shift dykes. (6) Due to uneven bottom, the depth of water may vary at different points (7) The crops mainly depend on the natural fertility of the fields/areas as no fertilizer is added for the growth of feed organisms. (8) Feeding is not resorted (9) Similarly neither pumps nor aerators are used (10) Also use of pesticides are not in vogue (11) In the presence of predators there can be no control over the quality or quantity. (12) The generally variable production does not require any special post harvest technology and marketing.

Such fields in Philippines may produce 100 kg/ha/year, but in Kerala it varies from 200-400 kg/ha on an average. One reason for continuation of traditional culture is lack of proper training programmes and technical assistance for shrimp farm management.

Extensive management

When the traditional method is improved (a) by construction of ponds (b) by selective stocking using seeds collected either from wild/natural sources or from hatcheries at a density of upto 1 lakh/ha. (c) with or without supplemental feeding and or (d) maintaining water quality using tidal flow, it is known as extensive. Much of the world's production still comes from these farms.

Extensive farming is common in Indonesia, Philippines, Vietnam, Bangladesh, Thailand, India, China and Ecuador in low lying impoundments along bays and tidal rivers, covering vast areas measuring hundreds of hectares. Here instead of multi species culture, monoculture ie, stocking of a selected species or polyculture with planned combination is usually practised. At times, when the local waters have large numbers of larvae, farmers open the sluice gates and impound the wild shrimp and then allow them to grow to maturity. Larvae caught by fishermen are also stocked. However, the stocking densities are found @ 25000 larvae/ha. The ponds are often well cleared, levelled and laid out for proper water management with provisions for water entrance, circulation and drainage. With moderate level of stocking pumps and aerators are eliminated. Daily water exchange provided by tides worked out to be a maximum of 10% per day. Shrimps feed on naturally occurring organisms multiplied by the added commercial organic fertilizers. Supplementary feed is rarely used. As a result of the improvements shrimp production rises to 1 to 1.5 tonnes/ha/year on an average.

The market size shrimps are caught three to six months after the juvenile shrimps are stocked in the grow out ponds. China produces one crop per year (May-October), semi-tropical countries produce two crops per year, while farms close to equator can produce three crops/year when all other conditions are favourable.

Semi-intensive management

Of the different levels of management developed by researchers for raising shrimps to suit varying pond conditions and financial capabilities, semi-intensive farming is one option that pond operators may find appropriate for their resources because it requires less capital than intensive culture.

Semi-intensive farming is practised in carefully laid out farms above the high tide line to the extent of 90% in China, 50% in Japan, 60% in Taiwan, 40% in Philippines and 25% in Thailand. Ponds for semi-intensive farming requires excavation of peripheral or diagonal canal at 10-15 m wide and 50-100 cm deep and the installation of drain and supply gates for each compartment. These are needed to protect the stock from drastic temperature changes and to provide shelter during moulting. In addition, gates are required in opposite corners one for water supply and other for water drain. Pond size varies from 2 to 25 ha. Exchange of water expected is 10-20% if possible using a pump. Water management aims at maintaining water at 70-80 cm at the pond and 120-130 cm at the canal portions.

Predation is prevented by using effective filter devices. Organic pesticides such as derris root & tobacco dust and inorganic chemicals such as ammonium sulphate and sodium hypochlorite in required doses are used to control the pests.

Fertilization to stimulate the growth of natural feed is done by applying inorganic fertilizers like ammonium phosphate and urea in the ratio 3:1 along with lime. The organic matter of the soil can be kept at 6% using organic manures as cowdung or poultry droppings.

Semi-intensive shrimp culture is a modified extensive shrimp farming that allows higher stocking densities of 1 to 2.5 lakhs/ha at less capital input. Invariably this has a nursery phase to stock wild or hatchery produced juveniles.

Supplemental feeding, greater water management and modified pond designs allow higher shrimp stocking densities than is traditionally practised. It also involves feeding with commercial feed pellets or trash fish, mussel meat etc to supplement natural food. Occasional use of water pump in addition to tidal exchange is practised.

Feeding rate normally adopted is a maximum of 15% for wet food and 10% for commercial pellets at 4-6 hourly intervals preferably during night when shrimps feed more actively. Feed can be supplied in trays to avoid wastage and fouling of water. This allows increased production of shrimp operators who have the financial capability to invest in higher operating expenses and pond development cost.

Fast growth rate (30-40 g/piece in 3 to 4 months) high survival rates (70-80%), tolerance to environmental changes and high unit value have made the giant tiger prawn Penaeus monodon ideal for semi-intensive culture with a production of 500-1500 kg/ha in Philippines. Added to that is the high export demand and promise for higher economic return. It is possible to raise 3 crops per year.

The harvest can be confined to uniform sizes. Harvest is done by draining through a net. Pre-planned post harvest procedure and marketing for a production of upto 2.5 t/ha/crop in 150 days can be arranged. 1.5 to 2.0 tonnes of feed is generally required to produce 1 tonne of the crop.

In India, three kinds of farming practices are prevalent now.

They are traditional extensive with improved practices, scientific extensive and semi-intensive farming. Results have been achieved upto 4-8.5 tonnes/ha/crop in a few places of Tamil Nadu, Andhra Pradesh and Maharashtra (Anon, 1990 & 1992). The success has been attributed to the adoption of better management techniques such as high stocking density of healthy fry, 30% daily water exchange, paddle wheel aeration and use of high energy imported feed.

Increased production can be attained through intensive culture. Where sites are abundantly available, the increase can be achieved through area expansion. Either existing farms can be converted as semi-extensive or new areas can be developed.

In any case, the development is implemented using appropriate engineering designs aimed at

a) reducing size of the farm area to small manageable sizes
b) providing facilities for effective water control and circulation and c) perhaps excavation and levelling of the ponds to attain appropriate depths required in the culture.

Ecuador is making the transition from extensive to semi-extensive farming. China also pursues semi-intensive farming. Semi-intensive farming practices are becoming popular all over the world.

Intensive farming

Intensive farming is characterised by small ponds (upto 0.5 ha), high stocking densities (more than 2 lakhs juveniles/ha), heavy feeding, waste removal, aeration and round the clock management. There is complete control over water management in quantity and essential qualities. The water exchange required is above 30% per day. Aeration using aerators and feeding with high quality feeds have to be resorted. The metabolites have to be removed periodically through central drain. Water quality has to be maintained very carefully to avoid diseases.

Yield was more than 5000 kg/crop/ha. By maintaining a stocking rate of 45 nos/m^2, a production rate of 7400 kg/ha was achieved in the case of P. vannamei in USA (Coastal Aquaculture, 1987). The production cost was calculated arounds$5-7 per kg of shrimp. Relative costs for farm development and operations under the different intensity level of management vary from area to area depending on annual operational cost and essential equipment. The economics of intensifying shrimp production have been well discussed by Hirasawa (1985). Intensive pond management methods in Taiwan have been well dealt with by Steve Hopkins (1986).

Japan (50%), Thailand (25%), Ecuador (15%) and Indonesia (10%) are some of the countries concentrating on intensive shrimp farming. High capital and operating costs coupled with diseases due to overcrowding make intensive shrimp farming risk prone.

Super-intensive farming

A few farmers in Taiwan and Japan started super-intensive farming aimed at a production rate of 20,000 to 40,000 kg/ha/year exercising greater control of the environment.

Thus, intensive and super intensive shrimp farming have achieved only marginal success, generally having problems with disease, water quality and the environment.

1.2.5 Harvest technology and methods

Pre-harvest thoughts

It is important to check a sample of shrimp for synchronous moulting to avoid tainted flavour before harvest. If a high proportion of the sample is soft shelled, harvest should be delayed for a few days; otherwise shrimp will fetch low price.

Harvest methods

Pond harvesting, apart from its construction is the most labour-intensive operation in an aquaculture farm.

Shrimps can be harvested by a variety of methods including draining, seining, trawling, cast netting, trapping and hand picking depending upon the species cultured. The most efficient method was found to be drain harvesting provided the pond is a well designed one as it can capture more than 95% of the shrimp with virtually no attached mud and less labour. As soon as more than 50% water was drained, shrimps begin to swim towards the water flow. Using a recessed impeller pump these shrimps from the drain net can be continuously lifted without damage as is practised in advanced countries.

In shrimp ponds in Asia, long bag nets are set in the sluice gates to catch the shrimps as they swim out from the pond with the out flow of water at low tide. The best time for total harvest is during the full/new moon periods as at this time the shrimps are more active. Catches are best at night and a light placed at the sluice gate will serve to lure shrimps to swim towards it. Penaeus monodon often do not swim out of the pond easily and so repeated draining is necessary in order to harvest a good percentage of the stock.

It will be worthwhile to examine the traditional fishing methods being practised in India. The indigeneous gears employed for the exploitation of fishery resources of our country are many and numerous. An outline of some of them is given by Panikkar and Menon (1956). Some of the commonly used gears in various parts of the country are the cast nets, drag nets, stake nets and wall nets. Gill nets of suitable meshes are also set for the capture of shrimps.

Traditional traps made of bamboo and fabricated in the shape of V or W with suitable openings are usually employed in front of sluice gates during the flow of water for the capture of prawns and fishes (Natarajan 1985). Traps are also made ingeniously by placing twigs in heaps to provide shelter for fishes. The fishes will hide in between the twigs within short periods which later on will be captured by encircling with suitable bamboo screens.

The Oriya fishermen use a special enclosure type trap to efficiently capture the moving shrimps during day break.

In the traditional shrimp fields of Kerala harvesting starts in December, by when the early stock will have reached marketable size. Regular harvesting by filtration helps to thin the stock, leading to a better growth rate and a higher percentage of larger shrimps. In addition to P. indicus, Metapenaeus dobsoni, M. monoceros and P. monodon incidental species include Acetes sp. finfishes (grey mullets, pearlspot, etc), miscellaneous items and crabs.

Filtration is carried out by fixing a conical sluice net at the mouth of the sluice by means of a rectangular bamboo/wooden frame. The design and size of the bag net also varies in accordance with the size of sluice gates. Filtration is done at night when the water is let out through the sluice. The shrimps collected at the cod end of the net are periodically emptied into a canoe. The fishing activity is restricted to 7-8 nights in a fortnight ie 3-4 nights on either side of the full moon and the new moon. The fishing season lasts from November to April every year. In April, the final harvesting is done by draining the water to the minimum level from the field during day time. Complete harvest of remaining population is accomplished by using cast nets, drag nets and by hand picking. A churning effect produced by the terminal fishing asphyxiates the fish and shrimp which hustles them towards the surface gasping for air.

Hand nets or scoop nets of suitable size are also used for the capture of shrimps generally towards the culmination of traditional shrimp culture operations. During hand picking the level of water is lowered to the minimum in the water body when all the shrimps escaped the other methods of operation can be well picked out.

Post harvest technology

Soon after the harvest, the post harvest technology depends on the form in which the product is to be marketed. In general the shrimps were kept in ice, protected from sunlight to prevent enzymatic blackening of the shell in lieu of treatment with sodium bi-sulphite. These were subjected to labour intensive deheading in order to reduce the unpeeled body weight by 35%, the bacterial load by 80% and the digestive enzyme by 100%.

1.3 IMPORTANCE OF AQUACULTURE

1.3.1 To tide over the enhanced operational cost of fishing owing to oil crisis

The importance of aquaculture is that it can tide over the oil crisis like that of the early seventies and recent Gulf war, which made the exploitation of aquatic resources through capture fisheries highly uneconomical. According to [illegible]sim (1979), the advantage of aquaculture as compared to traditional fishing is that it can dispense of expensive fishing craft and gear together with their cost of operation and maintenance.

1.3.2 To compensate the declining trend of capture fishery - shrimps

World production of conventional fish varieties is nearing a saturation level and may even exceed the maximum sustainable yields by 2015 A.D. The world marine landings is expected to be levelling off some where around 100 million tonnes/year (FAO, 1991). The increasing fishing pressure may force to introduce conservation measures such as fishing quota, season, gear restrictions, allocation among competing user groups and even fishery closures.

Due to the increased demand for high value items like shrimp its over exploitation may lead to its stock failure in the sea. It may force us for sea ranching or reseeding the sea by hatchery reared juveniles. Thus the emerging scenario in world shrimp production is one of significant growth in aquaculture production and the declining trend in production from capture sources. The FAO has estimated a gradual increase in the world production from the 5 million tonnes in 1973 to 13.2 million tonnes in 1987 and production of 26 million tonnes is expected by 2000 A.D. Thus it can be safely concluded that the future requirements of high value fishes/shrimps can be met only through aquaculture.

The popular belief that the ocean is an inexhaustible reservoir of fish is no more valid. The recent technology development has led to the operation of destructive gears threatening the potential resources of tuna, shark etc. The open access to coastal fishery resources in the already over exploited traditional grounds and the ever increasing fishing effort hinder the growth of capture fisheries sector further.

1.3.3 Utilization of available and untapped water resource and rational utilization of post larvae and juveniles

Aquaculture is an alternative to capture fisheries. It helps to maximise the use of idle water masses and marginal lands. The First National symposium on shrimp farming held in Bombay in 1978 (MPEDA 1980) had recommended that some studies should be undertaken for projecting the economics of cultivating the shrimp in the culture ponds, salt pans and paddy fields. The other recommendations were to undertake studies "on stocking rates and feeding in different situations for different varieties with a view to find out the commercial viability of shrimp culture" and "to find out the tidal amplitudes at the different areas in different periods in the potential areas".

Scope for development in Kerala

Kerala has extensive estuarine and backwater systems. There are 44 rivers and 30 lakes and backwaters in the state. 41 rivers flow towards the west. The lower reaches within the tidal influx of these rivers, backwaters, lakes and adjacent mangrove swamps constitute the estuarine and brackish water resources of the State, the extent of which is estimated at 2.42 lakh hectares. Of these about 1,21,000 ha distributed in Kuttanad, Vaikom, Cherthala, Kochi, North Parur, Kodungallur, Thrissur, Kozhikode and Kannur areas could be developed and utilized for shrimp culture (Rao, 1980). Out of this projected area, presently about 6000 to 8000 ha of low lying fields adjacent to the estuaries and backwaters of Alappuzha, Ernakulam, Thrissur, Kozhikode and Kannur coastal districts are being utilized for shrimp farming mostly as traditional paddy and shrimp culture systems. Also 500 ha of perennial fields are used for culture year round. These are analogous to the farms at Singapore (Hall, 1962). Thus, there is vast scope for increased shrimp production both by upgrading traditional culture in a scientific way as well as by developing new farms in the hitherto unutilized fallow areas.

Potential brackish water areas in India

The brackish water areas potentially available in India for aquaculture purposes have been realistically estimated at 1.71 million hectares (Rao 1980) lying along the 7500 km coastline in the form of bays, backwaters, estuaries, lagoons, lakes, mud flats, mangroves, swamps etc. But MPEDA (1991) has recently estimated it at 1.4 m (Table 1). It is also estimated that these water bodies have a length of 800 km in addition to 2700 km length of rivers and 1,00,000 km length of canals and channels. The tidal amplitude of these coastal waters varied between 1 and 5 metres from south to north. However, the

Table 1

STATE-WISE DETAILS OF TOTAL BRACKISHWATER AREA, AREA UNDER CULTURE AND ESTIMATED SHRIMP PRODUCTION (AS ON 31.3.1991)

State	Estimated brackishwater area (ha)	Area under culture (ha)	Estimated production (Tonnes)
West Bengal	4,05,000	33,815	12,500
Orissa	31,600	7,075	4,100
Andhra Pradesh	1,50,000	6,000	7,350
Tamil Nadu	56,000	250	450
Pondicherry	800	10	5
Kerala	2,42,000	13,000	8,925
Karnataka	8,000	2,500	1,000
Goa	18,500	525	245
Maharashtra	80,000	1,800	800
Gujarat	3,76,000	125	125
TOTAL	13,67,900	65,100	35,500

Source : MPEDA, 1991.

total area under brackish water farming in the country is estimated differently by different authors and agencies. According to Gopalan and Purushan (1981), 30500 ha areas are utilised in Kerala, Karnataka, Goa and West Bengal for aquaculture purposes. It varied from 26270 to 30000 ha (Silas and Rao, 1987). Natarajan (1985) estimated the brackishwater culture to cover an area of 45000 ha of which 75% being located in the deltaic regions of the Sunderbans in West Bengal, 7000 ha in Kerala, 4000 ha in Andhra Pradesh, 2500 ha in Karnataka and 500 ha in Goa. At present shrimp farming is practised in about 63000 ha area in India (Sakthivel, 1991). It is proposed to bring 1,20,000 ha under brackishwater shrimp/fish farming by 2000 A.D. In this connection, large magnitude of saline soils, mud flats, swamps and mangroves can be developed for brackishwater aquaculture.

According to Sakthivel (1991) thousands of hectares of fallow land along the coast line are found to be ideal sites for extensive and semi-intensive shrimp farming to add at least 2,00,000 tonnes of shrimps for export worth Rs. 2000 crores per annum. Untapped potential of coastal aquaculture is the major out let for employment of swelling human capital as this could also earn daily bread for millions of people in rural areas.

Even today, with advancement of shrimp farming, 95% of the post larval requirement is still met from natural sources. Therefore, it is important to conserve the shrimp breeding grounds and nursery areas — especially mangrove regions — from reclamation in order to ensure a steady supply of seed as hatchery seed supply is non dependable.

1.3.4 To maximise utilization of Exclusive Economic Zone

In addition, the changing laws concerning the sea and the declaration of the Exclusive Economic Zone (EEZ) by different countries have put the fishing in "alarm" the world over. The situation also might demand the development of aquaculture for those countries whose traditional fishing grounds have been severely reduced by the imposition of 360 km EEZ, primarily by the introduction of fish farming in areas well within the EEZ (Liao, 1988).

1.3.5 As foreign exchange earner

Interest in shrimp culture was triggered by the recent increased market demand and the inadequacy of the capture fishery landings to meet the demand. As the expanding markets were in economically advanced countries like Japan and the U.S.A., the prospects of an export market and opportunities for earning foreign exchange attracted the support of the government of developing countries and led to investment by private industry.

Shrimps are one of the most economically valuable marine resources in India as their export amounted to Rs.1400.00 crores during the financial year 1991-92, the export target fixed for the period being Rs.1500 crores. Now, shrimps having been identified as dollar spinners, it was found wiser (1) to make large investments (2) import modern technology and (3) introduce systems management in inputs and outputs so that high profitability is assured.

As a result, government of India having agreed to the above concept, many institutions like MPEDA, STC, NABARD, International banks, Department of Biotechnology and private concerns like Tata and Hindustan Lever have entered the field.

1.3.6 As supplier of animal protein/source of renewable energy

Though much promising is the brackishwater resource, the production attained from the same remains very low when compared to the vast fishery potential. Against a projected annual estimate of 5 lakh tonnes of fish and shrimps, the yield before a decade was only 25000 tonnes/year (CMFRI, 1978) excluding the molluscan resource. Of this almost 70% was contributed by Vembanad lake and its adjoining areas

(George and Sebastian, 1970). As estimated by George (1980), the shrimp production through culture sources was around 10000 tonnes/annum in India. The pokkali fields and other condusive brackishwater environments in Kerala yielded 6000 tonnes, Sunderban region of West Bengal 3000 tonnes and the rest from the low lying fields of Karnataka and Goa. But recently MPEDA estimated the shrimp production from brackishwater culture sources at 35,500 tonnes(MPEDA, 1991).

While the production of food grains in India has reached about 160 million tonnes/year, the annual sea food production has reached only 3.2 million tonnes, ie 3% of the world production of around 100 million tonnes. Qasim (1979) has estimated the food produced in the world by aquaculture from approximately 4,00,000 ha of wetland under cultivation as 5 million tonnes (8% of world fish production). But after a decade, the world aquaculture production is reported to reach 14.47 million tonnes in 1988 (FAO, 1990).

Supply and demand

By 2000 A.D., the projected world demand for fish is about 130 million tonnes as against the production of around 100 million tonnes. Aquaculture production expected by 2000 A.D. is around 20 million tonnes. The developing gap between fishery supply and market demand will have to be met mainly through accelerated development of aquaculture. If we can work out a production and marketing strategy to take full advantage of the expanding marketing opportunities of sea food abroad, this can turn out to be a good foreign exchange earner.

Against an anticipated global catch of 3 million tonnes of shrimps by 1995, world catch of shrimps in 1991 was 2.46 million tonnes compared to 2.34 million tonnes in 1987 (World Shrimp Farming 1991). 80% of this production was accounted by tropical shrimps both from capture and culture operations. The share of culture sector during 1991 was estimated to be around 6,90,100 tonnes (28%). China, Indonesia, Thailand, Ecuador, India, Philippines, Taiwan and Vietnam were the principal producers of cultured shrimps in the order of production. The contribution of cultured shrimp to the export basket of marine products in India was about 35500 tonnes, ie 5% of world production. In the present rate this is expected to increase to 45000 tonnes by 1993.

Aquaculture offers great potentiality as a tangible alternative to feed the world's burgeoning population. Through aquaculture, a large surplus of basic sea borne organic materials and organic debris of the estuary and the other specialized aquatic environments can be transformed into high grade edible marine protein rich food. This renewable source of energy can lead to improvements in the dietary standards of the teaming millions.

Thus in recent years, commercial aquaculture has obtained prestige and status as a potential source for augmenting food production realising its technological significance.

Aquaculture is truly a "sunrise" industry with all the vigour and growth potential. It is a "lucrative enterprise" and is the cheap source of protein to combat malnutrition. The nutritive qualities of aquaculture products are better than farm animals with high conversion efficiency.

Eventhough India achieved self-sufficiency in rice and wheat production, the country is far below in meeting its minimum animal protein especially fish production requirements. When compared to many other countries in the world, the per capita consumption of fish protein in India is very low. The per capita consumption of fish in India is 3.2 kg against 86.0 kg of Japan, 80 kg in Republic of Korea, 52.1 kg of Hongkong and 47.6 kg of Malaya (Anon, 1988). This growing demand for sea food in most of the developing countries in South Asia to meet the requirements of domestic and export market can be met only by immediately augmenting production through the shrimp farming.

Fish is highly nutritious in terms of food value on comparison with paddy or other agricultural crop. However, there is absolutely no comparison in terms of productivity per unit area. A water body can produce more animal protein than land. Hence fresh/brackish-water bodies are valuable sources for raising more protein. Against an estimated production of 100 kg animal protein or 2-3 tonnes paddy in an year from a hectare of land, it is possible to produce 2-3 tonnes of fish in extensive farming and more than 10 tonnes of fish in intensive farming from the same area of water body. Therefore, it is much important to preserve the water area. Understanding the significance of water area in proteinaceous food, many countries in the world have taken up aquaculture projects. In China, if any water body is kept idle without using it for aquaculture, suitable punishment is given to the concerned person by the government. Thus the farming of aquatic resources, especially in the unutilised water body can be seen as the best option to capture fisheries to feed the growing masses.

Since seafood is considered as important health food, the percapita consumption, is going up every year and therefore, there exists an assured market for aquaculture produce. The success depends not only on market demand, but also on production cost and availability of suitable farming sites.

Farming of shrimps is given due significance because (1) shrimp itself turns out to be an excellent animal protein diet (2) extensive culture will help to a very large extent to bring about regional self-sufficiency in the shrimp supplies of the inland areas and (3) the desirability of shrimp as a food item is partly due to the absence of bones within its flesh.

Nutrition wise, aquaculture species are more efficient in converting food into body tissue than live stock or poultry (Liao, 1988). These products are essential in improving the largely high carbonate, low protein rice diet predominant in Kerala region, where paradoxically enough, majority of rural population are engaged in labour - intensive work, but subsist on low protein diet.

Panikkar (1963) stressed the special significance of fishery resources as a means of providing a cheap source of protein for the large sections of the people whose income is low.

1.3.7 **For socio economic development — as creator of employment opportunities and for betterment of quality of life**

On account of the ever increasing market of shrimps and poor returns from paddy cultivations, certain farmers think to discard paddy cultivation and go ahead with shrimp culture year round. This practice though economically viable in terms of the cost of shrimps is not a healthy one since it may create problems of unemployment amongest the agricultural labourers. Therefore, only pragmatic measures are to be adopted to safe guard the interest and employment security of the weaker sections. The rehabilitation of brackishwater fishermen in aquaculture such as seed collection of cultivable species of shrimps and fishes, operation of seed banks, pen culture and pond culture will help much to solve the problems of protein malnutrition and rural poverty. If systematic shrimp culture is practised, ample scope for employment is possible in this field.

A comparison of the man power requirements shows that more man days are required in systematic shrimp culture than in paddy cultivation on unit area basis. In a case study in traditional field at Vypeen island, it was revealed that the per hectare man power requirement of the former was 182 mandays against 172 mandays inclusive of women labour required for the latter (Table 2). Thus the study dispensed of the apprehension of a virtual unemployment in the agrarian sector on switching over to exclusive shrimp culture in suitable paddy fields.

The uptrend in shrimp production has been due to increased

Table 2

STATEMENT OF MANPOWER REQUIREMENTS/HA FOR PADDY CULTIVATION AND SHRIMP CULTURE IN SEASONAL FIELDS AT VYPEEN ISLAND DURING 1987-88

Paddy cultivation			Shrimp culture		
Details	Manpower		Details	Manpower	
	Men	Women		Men	Women
1. Bund raising and channelling	10	-	1. Fabrication of sluice gate and its installation	5	-
2. Ploughing	35	-	2. Raising of dykes and excavation of canals	18	4
3. Seed soaking and sowing	4	4	3. Eradication of weeds and predators	4	4
4. Payal (algal macrovegetation) removal	2	25	4. Fabrication of workshed and shelter	2	-
5. Weeding	2	25	5. Fabrication of bamboo/plastic screens	2	-
6. Transplanting	2	25	6. Setting of nets, baskets and basins	2	-
7. Preparation of threshing ground and fabrication of shed	4	2	7. Nursery operation and feeding	4	-
8. Harvesting	5	5	8. Sluice gate operation, filtration etc.	79	-
9. Post harvest labour	7	15	9. Fishing operations such as cast netting, gill netting and hand picking	35	15
			10. Terminal operation	3	2
			11. Cleaning and categorization of yield	1	2
	71 +	101		155 +	27
Total	172 / Ha		Total	182 / Ha	

production in developing countries resulting in large foreign exchange earnings, greater employment opportunities and development of the rural economy.

The availability of a fairly good number of expert labour with a high sense of quality and hygiene at a comparatively low cost in the developing countries should prove as an incentive for fishery industrialists in developed countries shifting their processing units to the developing countries, either directly or through joint ventures.

The role of coastal aquaculture in integrated rural development has been recognised and development of rural communities dependant on aquaculture as main economic activity has received active consideration in the recent past.

In addition to providing employment/livelihood opportunities, aquaculture also contributes to the development of rural areas. Although traditionally fish farming was part of rural life in certain areas, the present day aquaculture has a much greater significance in socio-economic development and natural resource management. This differs considerably from the traditional shrimp culture where a fisherman without sufficient financial backing is trying to make a good living. The traditional shrimp culture can be made/developed into a cottage industry with the loans, subsidy and extension support.

Aquaculture also prompted establishment and growth of related industries like feed milling enterprises, ice making and cold storage and manufacture of equipments like paddle wheels, aerators, pump sets etc. This is a desirable industry because it employs large number of unemployed people in areas that have not been used for traditional agriculture.

The second orientation can be that aquaculture should aim at large scale culture of aquatic plants and animals such as Spirulina and Artemia (having 75 and 55% protein respectively on dry weight basis) which could be used as ingredients in formulated feeds for shrimp. This activity is also bound to generate gainful employment.

India with 1.4 million ha of brackishwater area is endowed with valuable resources of cultivable species of fin fishes and shell fishes. Three large coastal lagoons (Chilka lake, Pulicat lake and Vembanad lake) act like rich reservoir of juvenile shrimps and fishes. These juveniles provide livelihood to a lot of fishermen who depend on fishing in the brackishwater areas. Since these juveniles are caught at early stages before attaining marketable size, huge amount of money is lost every year. If these fishery resources are rationally utilized through aquaculture, it might be possible to ameliorate the sufferings of the down trodden fishermen from ignorance, illiteracy, poverty and under employment. Thus the idle man power and the untapped human energy available in the rural areas could be profitably utilized for gainful employment and overall development of the area aiming at the welfare of the people. In all the above considerations, aquaculture has the potentiality to provide with alternative livelihood opportunities to ensure the socio-economic upliftment of the weaker sections.

1.3.8 To produce specific varieties at will to meet the needs of the target group

Different segments of the world's population are used to different types of seafoods by traditional habits. Some of the seafoods like crabs and lobsters have emerged as fashionable and prestigious items in high societies. The capture fishery being unpredictable, is not able to meet these demand for selected varieties. Production of such species in aquaculture, assumes greater significance as technology is available to produce specific varieties, at will. At the same time, the dire protein necessities of a developing society have to be met by the production of fast growing and cheaper species like Tilapia (*Oreochromis* spp) using low cost technology. Again, it is becoming increasingly important to utilize valuable aquaculture feed ingredients such as trashfish for the production of quality fish and shell fish.

1.4 OBJECTIVES/AIM/PURPOSE OF STUDY

1.4.1 To prepare a catalogue listing available culture systems and practices of shrimp production to assist Governments in planning and developing appropriate aquaculture methodologies and information transfer on shrimp farming.

A detailed survey of literature and review of the state of art of shrimp farming practices have revealed, the vast lacunae in the existing culture practices world over even amidst the modern innovations available for their improvements. Eventhough considerable studies have been made abroad on pond ecology related to factors such as physico-chemical parameters of pond water, soil characteristics and productivity, such studies especially related to tide fed ponds in India are few. Also Kerala state with very high potential for shrimp production is found experiencing similar short falls in production owing to lack of technological applications, eventhough the traditional practices are centuries old. Hence the need was felt to survey, study and prepare a catalogue of available culture systems and practices of shrimp production prevalent in the study area — central Kerala — to assist governments in planning and developing suitable aquaculture methodologies.

1.4.2 To analyse economics of operation at different levels of shrimp farming

Economic evaluation of shrimp farm performance (analysis of data on costs and earnings will be of great help for shrimp farmers/ aquaculturists, economists and policy makers) is in the development of suitable aquaculture technologies and production programmes, investment appraisals and farm management.

The potential of these documented data on the operation of undivided farm or production system is that these can be used in, determining profitability and rates of return on investments (static) and sensitivity studies (analysis).

Economic considerations are more important to a shrimp culturist than biological considerations in the selection of species to be cultured. This is true even when national priorities and investment requirements are discussed. The ready availability of shrimp culture technologies supported by economic viability should guide a shrimp farmer in the selection of a species or culture system. However, reliable economic data on actual commercial production continue to be scarce.

Despite the scarcity of this type of information and the variability of economic returns of enterprises, it is of crucial importance that even information bits from actual commercial or pilot operations would be useful in validating available experimental results.

Of late, the basic importance of economic viability of sustainable aquaculture has been well recognised. Aquaculture is one commercial operation carried out till date almost entirely by individual farmers or small groups that seldom maintained the type of data required for proper economic analysis. So the paucity of adequate and appropriate data has been a major constraint (Pillay, 1990). Most of the presently available data on commercial operations are based on special surveys by investigators. Similarly, available laboratory/experimental data are also limited. Hence there arises the need for pilot production studies. Costs and earnings are undoubtedly site-specific and what is economically viable in one area may not be so in another (Smith, 1981). The above data are important for making decisions on investment in aquaculture. Absence of data also affects access to suitable financing needed for aquaculture development.

Socially oriented aquaculture can expect governmental time bound support in the form of easy loans and grants, subsidies and free technical advice and assistance intended to improve socio-economic and nutritional conditions of communities. Similarly incentives may be offerred to commercial enterprises for initial periods in the form of tax rebates and exemption, concessional loans etc. In short, whether one be a small scale farmer or an entrepreneur with large scale production, the attraction of shrimp farming depends on the economic benefits. The social benefits are always closely intermingled with economic benefits.

It was thought obligatory to inform the farmers the economics of different levels of shrimp culture by proper analysis of available data in order to enable them to choose the apt method of operation depending upon their workmanship and financial capability.

1.4.3 To develop vast areas of unutilized brackishwater resources for shrimp farming without tilting environmental balance to generate additional fish protein, employment and economic well being of the people

Kerala known for its extensive (2,42,000 ha) brackishwater resources has been able to utilise only 6000-8000 ha for aquaculture. It is also intended to provide useful guidelines for the transformation of the unused water bodies for aquaculture — especially shrimps. By converting 10% of the existing brackishwater areas for paddy cum shrimp culture without disturbing the ecology of the system and rights of other user communities, it is possible to provide a four fold increase in the employment potential in the aquaculture sector.

1.4.4 To design and develop a technology most appropriate to the socio-economic development of local fishermen engaged in traditional farming by enhanced production

A matter of urgent concern is to apply the science towards major practical problems of the shrimp farming in Kerala from two points of view, ie, (a) the industrial (Group A, B and E studies) which concerns itself with immediate solutions by the use of the existing knowledge.

and (b) the scientific (Group C and D pilot studies) which seeks entirely new knowledge with the expectation that it might provide the best solution. Transfer of this knowledge, aimed at (1) increased shrimp yield per unit area (2) maintenance of shrimp quality and (3) reduction in cost of production to the aquaculturists and planners, also is a part of the present study.

The target beneficiaries of shrimp farming development being local fishermen engaged in the field from time immemorial, the situation warrants the design and development of a technology capable of their socio-economic development. Coastal aquaculture can be an effective means for rural upliftment (Qasim, 1977). But changes in the society depends largely on the nature and aim of technologies adapted for the culture. According to Silas (1981) the benefits of application of modern technologies in fisheries have been enjoyed by people other than the rural fisher falk, the prime target. Commenting on coastal aquaculture, Prasad (1981) has pointed out the imperative need to evolve technologies that are applicable to local conditions and not to be carried away by high input and capital intensive technologies of developed nations. These points are fully reflected in the studies undertaken by the author.

Therefore, the purpose is to develop an ecologically sound and economically viable rural technology rather than designing a production oriented Hi-tech approach meant exclusively for earning valuable foreign exchange by affluent entrepreneurs.

1.4.5 Experimental growth studies in Penaeus indicus and P. monodon - species generally adapted for farming - Kerala

At the study areas, a series of field and laboratory studies have been carried out in association with shrimp farmers, in order to evolve simple management techniques aimed at better utilization of resources for enhanced production leading to economic gains. A matter of great importance for the successful culture of Penaeus indicus and P. monodon is a thorough investigation into their growth pattern and the factors that govern their growth rate in culture systems. But this information is meagre and is based mostly on length frequency studies. The extended spawning period of these species makes this type of studies more difficult and less reliable. In view of the relevance of this type of knowledge for the culture aspects of these species in the fields adjoining Cochin backwaters the present series of studies (Group C and D pilot studies) were taken up to gather more information on the growth pattern.

1.4.6 To study the feasibility of a semi-intensive technology

Since shrimp farming is emerging as one of the most profitable enterprises, development of technology by way of improvement in farm operation and management is very much imperative. Improvement in the carrying capacity of the system will ensure enhanced production of quality shrimps and income generation without any adverse environmental impacts. Therefore, the feasibility of a semi-intensive farming technology of P. monodon was studied utilizing the fertile coastal brackishwater area at Mundapuram, in Kannur (Group E).

2. AREA, MATERIAL & METHODS, INVESTIGATIONS AND RESULTS

2.1 AREA UNDER STUDY

Shrimp culture studies were carried out in fields/ponds located along the north western side of Vembanad lake extending to a distance of about 60 km. between Munambam barmouth in the north and Anthakaranazhi in the south (Fig. 1). Also this low lying coastal region was sandwiched between Cochin backwater and Arabian sea towards the eastern and western sides respectively. In general, the entire coastal belt selected for the study was situated about 1-2 m above mean sea level. Besides, all the study locations were within a distance of 2 to 5 km. from the respective beaches and were subjected to regular tidal rise and fall. Hence typical brackishwater environment prevailed for prolonged periods through interconnected canal systems, favouring shrimp culture operations except during intense monsoon season.

Of the 6 investigations (Group A) carried out in traditional pokkali fields, 5 located at Thrikkadakapilly, Ayyampilly, Kuzhupilly, Nayarambalam and Narakkal were in Vypeen island, Cochin taluk and the 6th was at Pooyapilly in Parur taluk.

7 case studies on extensive/scientific extensive shrimp farming (Group B) were carried out in grow out ponds. Of these, 3 (2 at Narakkal and 1 at Puduveypu) in Vypeen island and one at Chalippuram were part of Cochin taluk and others at Karumancheri, Cherungal and Pallithode were in Shertallai taluk.

Pilot studies (Group C) were under taken in the 6 mini ponds located within the Fisheries Station Campus, Puduveypu of Kerala Agricultural University.

Similarly experimental growth studies (Group D) were made in 6 cement tanks and 4 fibre glass tanks set up at the same place.

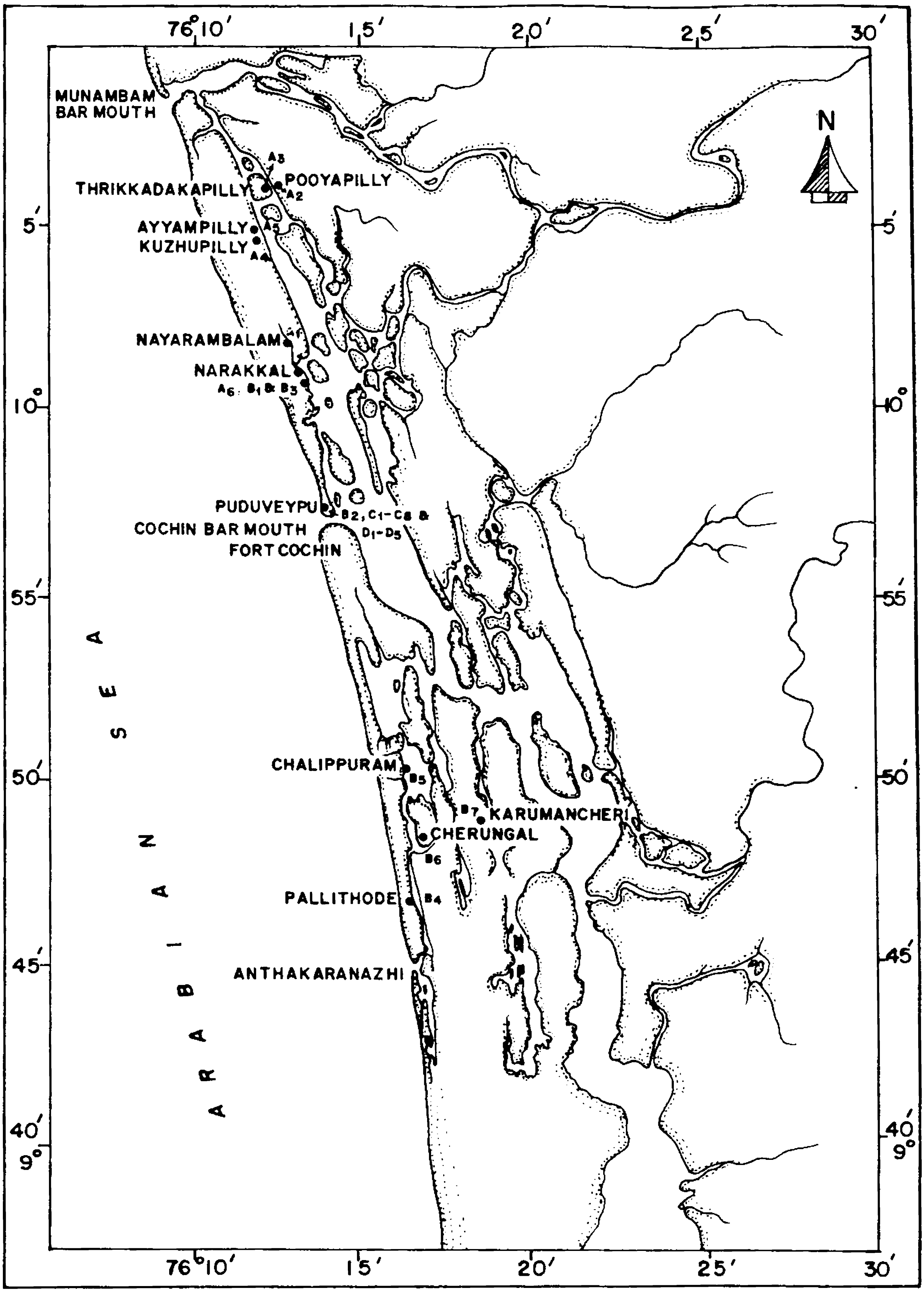


FIG. 1. LOCATION OF SHRIMP CULTURE FIELDS INVESTIGATED IN CENTRAL KERALA

Also, the fields/ponds selected (Fig. 1) for studies were of three types - seasonal (Nayarambalam (A1), Pooyapilly (A2), Kuzhupilly (A4), Ayyampilly (A5), Narakkal (A6 & B1) and Puduveypu (B2 & C1-C8) — perennial (Thrikkadakapilly (A3), Narakkal (B3), Cherungal (B6), Karumancheri (B7) — and coconut groves (Pallithode (B4) and Chalippuram (B5).

In addition, one almost rectangular shaped 1.2 ha farm (Fig.11) adjoining Mattol estuary was selected in Mundapuram at Cherukunnu, Kannur in order to study the semi-intensive farming of P. monodon (Group E).

However, in view of the significance of traditional shrimp culture, much emphasis was given to study the practices in Vypeen island.

Vypeen Island

According to available historical evidences (Menon, 1924), the Vypeen island (Lat 9°58' N to 10°12' N, Long 76°10' E to 76°12' E) (Fig. 1) located in the central Kerala was formed in 1341 AD, as a result of the huge deluge. The northern arm of Vembanad lake extending between Cochin and Kodungallur separates it from the mainland. Cochin barmouth in the South, Arabian sea on the West, Munambam harbour in the north are its other boundaries. The river Periyar emptying into the backwaters joins the Arabian sea through these barmouths. The island lying about 1-2 M above MSL has got an area of 67.90 km^2, its length being 25 km. The average width of the island is 1.5 - 3 km., the middle region being comparatively broader than the two tapering tips. Population of this place is about 1,55,000, the density of population (2279/km^2) being the greatest from amongst the rural areas of the world (Census 1981). The main profession of about 35% of the total population is fishing and fishery related avocations. The geographical position of the island provides a condusive environment for capture and culture fisheries and other allied industries. Some of the aquacultural aspects pertaining to this island have already been pointed out (George, 1974; Srivastava et al., 1985). There are 11 established fishery villages in the island which are amalgamated into 4 Fishermen Development and Welfare Co-operative societies since 1988.

The Vypeen island is breadthwise traversed by 13 almost equidistant backwater canals of 8-12 m width and 1-3 m depth. All these originate from the main backwaters and reach upto the seashore ending in respective basins. The canals are interconnected by a reticulum of smaller canals. The whole system is subjected to tidal ebb and flow through the barmouths at Cochin and Munambam. As a result of the very efficient and dynamic daily mixing process, the brackishwater at this place remains as a unique ecological environment most condusive for sustained fishery resource. Thus a lucrative fishery is established in this region for several decades in which commercial shrimps predominate.

The paddy field shrimp fishery of this region is of a unique nature. The two bar mouths bring in millions of shrimp seeds to the estuary during the season which migrate into different directions. The seeds transported by regular tidal processes are made to concentrate into the traditional fields and other low lying areas which are by then be well prepared (November) after the paddy harvest (October) for shrimp culture operations. These, will remain in the fields for three to four months to attain marketable size.

Seasonal and perennial are the two types of fields categorised for the purpose of shrimp culture in Vypeen island in addition to the reticulum of other canals in which daily fishing is taking place. The extent of seasonal shrimp fields may vary from 0.25-40.0 ha with a depth range of 1 - 1½ m. Usually small holdings are grouped together as a co-operative endeavour for the purpose of shrimp filtration. 'Pokkali', the highly salt resistant variety of paddy is raised in these fields during June-October months. The agricultural labourers numbering about 20,000 play a key role in raising paddy and subsequent preparations of the fields after harvest. After paddy harvest, the fields are prepared by raising bunds and fixing sluice gates to carry out the age old practice of shrimp filtrations during summer from November 15 to April 14th. Generally these fields are given by auction for shrimp filtration during the season and contract farmers take possession of it. The auction rate now-a-days has reached within the range of Rs.20,000 - 25,000/ha for 5 months. The rate is more to those fields located nearer to the estuary and barmouth and less to those lying farther away from it (Purushan, 1987). There are about 1,200 ha of paddy fields utilised like this of which 95% are run by contract farmers and the rest by owners themselves. All the above fields are directly or indirectly connected with the main backwaters through sluice gates.

There are about 150 ha of perennial shrimp farms in the island which are comparatively deeper than seasonal fields. Generally these farms are not prepared elaborately where as it is a must in the case of seasonal shrimp fields. Included in this category are the notable 75 ha 'Kannupillakettu', 15 ha 'Cochinkettu', (Edavanakkad) 18 ha 'Pasuvekkar' (Nayarambalam) and such other holdings. In all these cases fishing right is given on lease by public auction. Paddy cultivation is not possible in these farms and therefore shrimp culture is practised year round and quality shrimps are produced. Nevertheless, since there is considerable lowering in the level of salinity during rainy season, the shrimp larval recruitment is adversely affected resulting in reduced shrimp production.

Often, the contractor/lessee is allowed only to make minor repairs in the field. The State Fisheries Department usually collects a sum of Rs. 37.5/ha as licence fee. The Lessee has to strengthen the outer bund and close all holes as a preparatory work to regulate water flow through the sluice gate. When permitted to enter the field, channels (1.5 - 2 m width 1 m depth) are made through the fields allowing a slope towards the main sluice gate around which the area is kept deep as sluice pit or sluice basin.

In the seasonal fields, shrimp harvest by filtration is practised during 'thakkoms' from November. This gradually becomes intensive yielding maximum during March-April period. The catches comprise different species and sizes viz Metapenaeus dobsoni, M. monoceros, Penaeus indicus, P. monodon, crabs and fishes. Since shrimps are frequently caught by filtration, their size at periodical harvest may not be appreciable. The growth potential of species such as P. indicus and P. monodon is not fully utilized by this practice.

At the end, in April a complete harvest is made using cast nets, drag nets and hand picking soon after draining the water to minimum level. The entire process is called "Kettukalakkal" locally.

There are several other comparatively deeper water bodies in Vypeen island from where substantial quantity of fish is tapped. All the 13 canals traversing the island are subjected to daily fishing through filtration in addition to other methods such as the cast net operation, dragging and hand picking etc. The total extent of these canals is calculated to be around 45 ha. The fishing right from these canals is issued by repsective Panchayats through public auction.

In the north western region of the island, there is a marine lagoon having an extent of 173 ha which has got direct connection with the Arabian sea on the northern end. This lagoon also communicates with the backwater system through some of the traversing canals. This water body is notable for the production of commercially important shrimps and fishes. Since this lagoon is influenced by tidal flow from the Arabian sea and the backwater simultaneously, sizeable quantity of viable fish seeds also enter which in turn move to the series of shrimp filtration fields fed by it. Again a large number of fishermen completely depend on this lagoon for their livelihood through out the year. The fishing right from this lagoon is also given on auction by the Panchayat, annually.

Puduveypu is a naturally accreted wetland at the south western tip of Vypeen island which has taken shape in recent years (Fig. 1). Being located on the north western bank of Cochin barmouth facing Arabian sea, most of the accreted area is subjected to inundation by the semi-diurnal type of tidal rhythm of Cochin barmouth. The tidal inundation also brings into the area a large number of fish and shrimp seed of commercially important species which are disseminated far and wide depending upon tidal amplitude. The fish seed recruitment details and related aspects of this tidal ecosystem have already been described (Purushan, 1989). The almost 400 ha area accreted so far is exclusively marshy with lot of mangrove vegetation of which 101 ha is under the possession of KeralaAgricultural University.

By virtue of its recent origin and the process of accretion being continued incessantly, the substratum consists of very loose mud. The extremely slushy characteristics of the deposits do not permit to have a firm bottom. So much so, the substratum and the overlying water at the place remain quite peculiar. Further, the fluid type consistency of bottom layers and the excessively silt laden water inundating the wetland accelerate the accretion process greatly. On account of the intensity of suspended particles, the overlying water remains excessively turbid with colloids. Increased values of pH and temperature generally prevail in the system.

The area available here for fish culture is the naturally formed semi-enclosed lagoon like shallow water system which remain marine in character during summer months and brackish during post monsoon season. It is believed that such systems originated by the coastal accretion, later on stabilised and transformed into the present paddy field shrimp culture system of Kerala. Therefore a study of this system in its transient state assumes great significance in the aquacultural perspective.

Under Government sector, there are 40 ha of fish farms located at Narakkal and Malipuram owned by the Department of State Fisheries, now being operated by Matsyafed. The brackishwater fishes such as

Mugil cephalus, Liza sp. Chanos chanos, Etroplus suratensis are grown in these farms under the active control of Fisheries development officer.

2.2 MATERIAL

1. Culture species

Post larvae (5-25 mm) of Penaeus indicus and P. monodon collected from wild and hatchery sources were used (Plate I A).

2. **Hapa** is a rectangular cage of velon netting with top open. The post larvae and early juvenile shrimps were initially deposited in hapa fixed in water prior to nursery rearing (Plate I B).

3. Feeds

During the investigations (2-4 A,B,C and D groups) ingredients such as ground nut oil cake (g.o.c) rice bran, tapioca flour, fish meal, shrimp meal, crushed clam meat, clotted blood, cod liver oil etc. were used in definite ratios and combinations for the pulverised feed. Dried detritus was added while preparing formulated/compounded feed pellets. In addition commercial feed pellets were also utilized. Imported feed pellets (Plate II A) of different types were preferred during the semi-intensive farming (2-4-E).

4. Manures/Fertilizers

Cowdung, buffalo dung and poultry droppings in required doses added as manures. Mahua oil cake (Plate II B) applied for predator elimination also served as manure in due course.

Mussourie phos, Super phosphate, Urea, Health stone and BN_{10} in limited doses were applied as fertilizers (2-4-B, C & E).

5. Water

Tidal water was made use of for all investigations under 2-4-A, B and C. At times required water column in 2-4-B and C was maintained after resorting to pumping. However, pumped water after filtering through a 100 μ nylon bolt was used in 2-4-C-6 and 2-4-D series of experiments and also in the 2-4-E farming system.

6. Tanks

6 circular cement tanks(Plate III A)and 4 oval shaped fibre glass tanks were used for experimental studies under 2-4-D.

7. Earthern pools and mini ponds

In addition to 8 paddy fields and 4 grow out ponds (2-4-A&B), one pump fed pond ($13m^2$), 2 earthern pools and 6 mini ponds as described in 2-4-B&C were made use of.

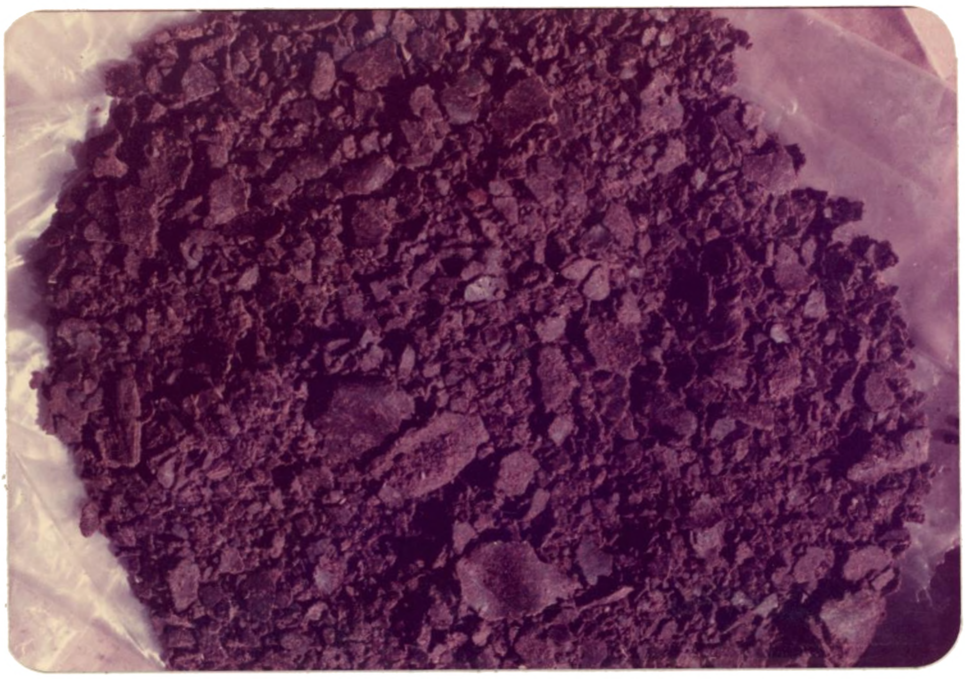
Filtration unit

a) Sluice gate (Plate III B) is a wooden box like structure with shutter planks locally known as 'Thoompu' fixed approximately in the outer bund facing the main feeder source (2-4-A, B and C). Depending on the size of the field and the tidal water entry required, the number of sluice gates may be increased (2-4-A-4). The construction cost of an ordinary sluice gate varied between Rs.5000 and Rs.15000/- (2-4-B-5) depending on the type of wood used and the purpose. At an average, a sluice gate will have 3m length, 1.75 m height and 90 cm width (KVP, Mariculture series 5, 1980). A hume pipe having 80 cm diameter installed appropriately served the purpose of a sluice gate at Mundapuram (2-4-E).

b) Adichil A closely woven screen made of nylon, bamboo slats or arecanut stripe locally known as 'Adichil' (Plate III B) is fitted

PLATE II

A - Commercial pelleted shrimp feed



B - Mahua oil cake

approximately in front of the sluice mouth. This is to prevent the exit of impounded tiny shrimps when water is let out during low tide. The designing and fabrication of 'Adichil' is a skilled job and is carefully done, as other wise a defective one could make the entire operation a complete failure (KVP, Mariculture series 5, 1980).

c) Ettavala When tidal water is drawn into the field a large meshed conical nylon net called 'Ettavala' is fixed inside the sluice gate with code end open in order to prevent escape of tiny shrimps and facilitate entry of more shrimps.

d) Conical bag net is the sluice net or thoombuvala used during, favourable filtration period called 'thakkom'. The sluice net is conical in shape with its mouth tied to a rectangular wooden frame. The net is made of strong cotton/nylon thread with fine meshed cod end. The mesh size gradually increases towards the mouth. The size of net varies according to the width of sluice gate. The normal length ranges between 15-18 feet. The cod end of the net is tied to form a bag in order to gather the shrimps. This end is lifted out of the water periodically and the catch emptied into the canoe. A float attached to the cod end facilitates the removal of the catch (KVP, Mariculture series 5, 1980).

9. Canoe

Dug out canoe was used for filtration purposes (2-4-A-1 to A-6) and also for feeding at Chalippuram (2-4-B-5) and Mundapuram (2-4-E).

10. Axial pump

An electrical/diesel operated machinery of required horse power resorted for efficient water pumping as deployed at Cherungal (2-4-B6) and Mundapuram (2-4-E).

PLATE III

A - Circular cement tanks set-ready

B - Wooden sluice gate with accessories

11. **Paddle wheel aerator**

A mechanical device electrically operated to oxygenate the water medium efficiently (2-4-E).

12.. **Other items**

Hurricane lamp (Plate III B), plastic buckets, earthern pots, baskets and velon nets etc. were used as per requirements.

2.3 METHODOLOGY

1 Pond preparation

Pond preparation in general was practised adopting standard procedure (Hickling, 1962, 1971; Natarajan, 1985) subjected to necessary modifications according to localised practices. The details are described pertaining to each investigation under 2-4-A, B, C & E.

False bottom

Dried twigs were planted where ever necessary in order to generate periphyton and to resist poaching as described under 2-4-B & C. Suitably fabricated screens were immersed within earthern tank and fibre glass tanks in order to provide additional resting place for shrimps as detailed under 2-4-C & D. Also granite stone pieces were spread at the tank bottom aimed at providing shelter.

Conditioning

The techniques adopted in the tank setting and conditioning are given in 2-4-D. (Plate XVI A&B).

Acclimatisation

The varied acclimatisation measures employed in respect of post larvae obtained from wild and hatchery sources are described under respective investigations (2-4-B-5, C-7 and E).

2 **Seed, feed and water management**

The various techniques employed in the above aspects are dealt in detail along with respective investigations under 2-4-A, B, C, D & E.

Feed preparation and feeding

The methods of feed preparation and feeding are described along with investigations under 2-4. The details of treatment of feed trays and check trays are as described in 2-4-B-5 and 2-4-E respectively.

3 **Growth measurements**

While growth measurements were taken at regular intervals with respect to experiments under 2-4-C & D, it was periodic in the case of 2-4-B & 2-4-E. But in 2-4-A investigations, measurement was made only during harvest time except in A-5 and A-6 where the size of inducted post larvae were also noted.

Length and weight measurements were taken with the help of a plastic scale graduated at 0.05 mm interval and a Keroy monopan balance of 0.1 mg accuracy respectively.

4 **Harvest methodology**

Different methods such as filtration during thakkoms using conical bag nets (2-4-A & E); cast netting, scoop netting and hand picking (2-4-A, B, C & E); and hand picking alone (2-4-D) were employed (Plate XXVI A).

Cast net

Suitably fabricated cast net of nylon make having 10' radius and 10 mm mesh size was generally made use of (Plate XXV B).

Scoop net

Scoop net of 1' radius fitted on a rim and having a mesh size of 5 mm was used.

Thakkom

Usually filtration is carried out during 7 days in each phase of the moon, ie three days preceeding, and three days succeeding the 'full' or 'new' moon day, as the case may be. It is called the 'thakkom' during which period, the ebb tide will be such that it is possible to operate the conical bag net during dusk and dawn hours when the movement and other activities of shrimps are seen to be much favourable. They show a tendency to be got collected in the conical bag nets during tidal flow. A bright light hung at the mouth of the sluice gate (Plate III B) helps in attracting shrimps. The duration of catch varies from 2 to 3 hours depending on the strength of water flow. When tide is balanced after filtration, the shutter planks are applied.

5 Post harvest technology

The details of categorisation, cleaning and disposal of shrimps are dealth with under investigations under 2-4-A, B & E.

6 Data collection methods

A. Water quality parameters

Surface water samples were regularly collected between 9 and 10 a.m.

B. Economics

Depending on the type and purpose of evaluation required, the nature of data to be collected varied. Most important among them were:

a) Assets and liabilities
b) Variable production and labour cost
c) Indirect operational costs
d) Fixed costs (interest paid, depreciation of assets etc.) and
e) operating income

The data were collected through a system of detailed book keeping at the farm gate (2-4-A, B & E). It also reflected the intricacies faced under practical farm conditions and different management strategies. Methods of estimating the economics of aquaculture as described by Smith (1981)were followed.

7 **Analytical methods**

Standard procedures were adopted for determining the water quality parameters. pH was noted using standard pH paper of wide range (pH 2 to 10.5) and universal indicator available from Glaxo (BDH) as well. Temperature was recorded using a graduated thermometer designed to measure upto 0.1°C. Winkler technique (Strickland and Parsons, 1960) was employed for the estimation of dissolved oxygen content. Salinity was estimated by Mohr's titration as given by Strickland and Parsons (1960) and at times using salinity refractometer of wide range 0-100‰ ("SDTECHS", Visakhapatnam). A standard Secchidisc was used to measure the light penetration and turbidity conditions. Sediment content in water was determined using a graduated Inhauff cone of 1 litre capacity designed for the purpose. Benthos sampled with a Van Veen grab (0.04 m^2) was categorised and identified following standard procedure.

Moisture was determined by drying the sample in a hot air oven at 105°C overnight. Total protein was determined by estimating nitrogen content by Microkjeldal method (Hawk, 1954). Crude fat was estimated following the method of AOAC (1980). Ash content was determined by igniting a known quantity of the sample in a silica crucible at 550°C for 5-7 hours using a muffle furnace. Carbohydrate was calculated by difference method.

Statistical analysis

Data collected systematically on growth parameters from different experimental ponds were subjected to detailed statistical analysis as furnished along with respective experiments. Stocking densities, treatments etc. were studied for comparison. The mean, standard deviation, coefficient of variation, standard error etc. were worked out on weight gain of shrimps. The analysis of variance technique (ANOVA) was employed for comparison between treatments as described by Snedecor and Cochran (1956). The ANOVA Table was prepared for each experiment working out the total sum of squares, mean squares, variance ratio etc and are presented. The calculated F values were compared with the respective Table values at 5% and 1% levels of significance (Statistical Tables: Fisher, R.A.& Yates, F. (1957). For testing the difference between individual mean values, Tukey's method was adopted by calculating $D=QS\bar{x}$ where D, Q, $S\bar{x}$ have the usual meanings (Snedecor & Cochran, 1956). To control the variability among the observed values, logarithmic transformation was used before subjecting the data for analysis.

2.4 INVESTIGATIONS AND RESULTS

2.4 Group A

Investigations on shrimp production in traditional fields adjoining Cochin backwaters from Thrikkadakapilly in the north to Narakkal in the south during 1986-89

Salient features

Lessee operated traditional large fields — limited structural modifications on agreed terms — seed induction by autostocking mostly — at times resorted to supplementary feeding — water management by tidal processes only — harvest during thakkoms and terminal fishing.

Investigation A1 : Studies on traditional shrimp filtration in a shallow remote field of 2.38 ha at Nayarambalam during 1988-89.

Investigation A2 : Studies on shrimp polyculture in a modified traditional shallow seasonal field of 0.8 ha at Pooyapilly during 1988-89.

Investigation A3 : Studies on shrimp polyculture in a modified deep perennial pond of 1.6 ha in Thrikkadakapilly chal at Cherai during 1987-88.

Investigation A4 : Studies on shrimp polyculture in a modified traditional and extensive deep field of 20.25 ha at Kuzhupilly during 1986-87.

Investigation A5 : Studies on improved shrimp farming practices in a traditional shallow paddy field of 3 ha at Ayyampilly during 1987-88.

Investigation A6 : Studies on improved shrimp farming practices in a traditional shallow field of 2.25 ha at Narakkal during 1988-89.

Aim

These investigations were aimed at mainly to study the traditional shrimp filtration practices in vogue along with their operational economics. In addition, assessment was made on the impact of 'remoteness of a shallow field from the main water body' (A 1), 'nearness of the field to the main feeder source along with certain minor modifications (clearing of canals and removal of macroalgal vegetation) within' (A 2), 'direct access to the open backwater body and structural modifications of the field coupled with compensatory feeding' (A 3), 'improvements in canal system and water holding capacity leading to rejuvenation of the field' (A 4), 'additional seed induction commensurate with enhanced carrying capacity of the field and supplemental feeding' (A 5) and 'influence of location specific factors if any apart from management aspects' (A 6) on shrimp production.

Investigation A1: Studies on traditional shrimp filtration in a shallow remote field of 2.38 ha at Nayarambalam during 1988-89.

1. **Aim** : i) To assess the level of shrimp yield and the operational economics.
   ii) To assess the impact of remoteness of a shallow field from the main water body.

2. **Introduction**:

Low lying fertile paddy fields are tradionally utilised for shrimp farming purposes. But seasonal variations in shrimp production have been noticed due to one or other reasons. In addition, there exists a dearth of meaningful data on the above lines. Hence the present investigation was taken up.

3. **Material and methods:**

3.1 Location, size and layout

The elongated field (Fig. 2) was lying in the eastwest direction adjoining the bunder canal — the main feeder source. The north-south running bunder canal had a width of 8-10 m with 1.5 to 2.0/m depth which communicated with the main water bodies at distant places. The length of the field was 455 m, its width varying between 50 and 55m. The width of the field was more towards the rear end almost covering half of the extent. The usual compartments of the traditional paddy field system were discernible within. Two sluice gates were fixed along the narrow western side connecting the bunder canal. The width of sluice gates were 54 and 72 cm. In general, both sluices served the purpose of entry and exit of tidal water. However, of the two, the smaller one served as the main gate for shrimp larval ingression maintaining a steady and prolonged waterflow. The depth of the field varied between 50 and 60 cm. Since the field was lying far

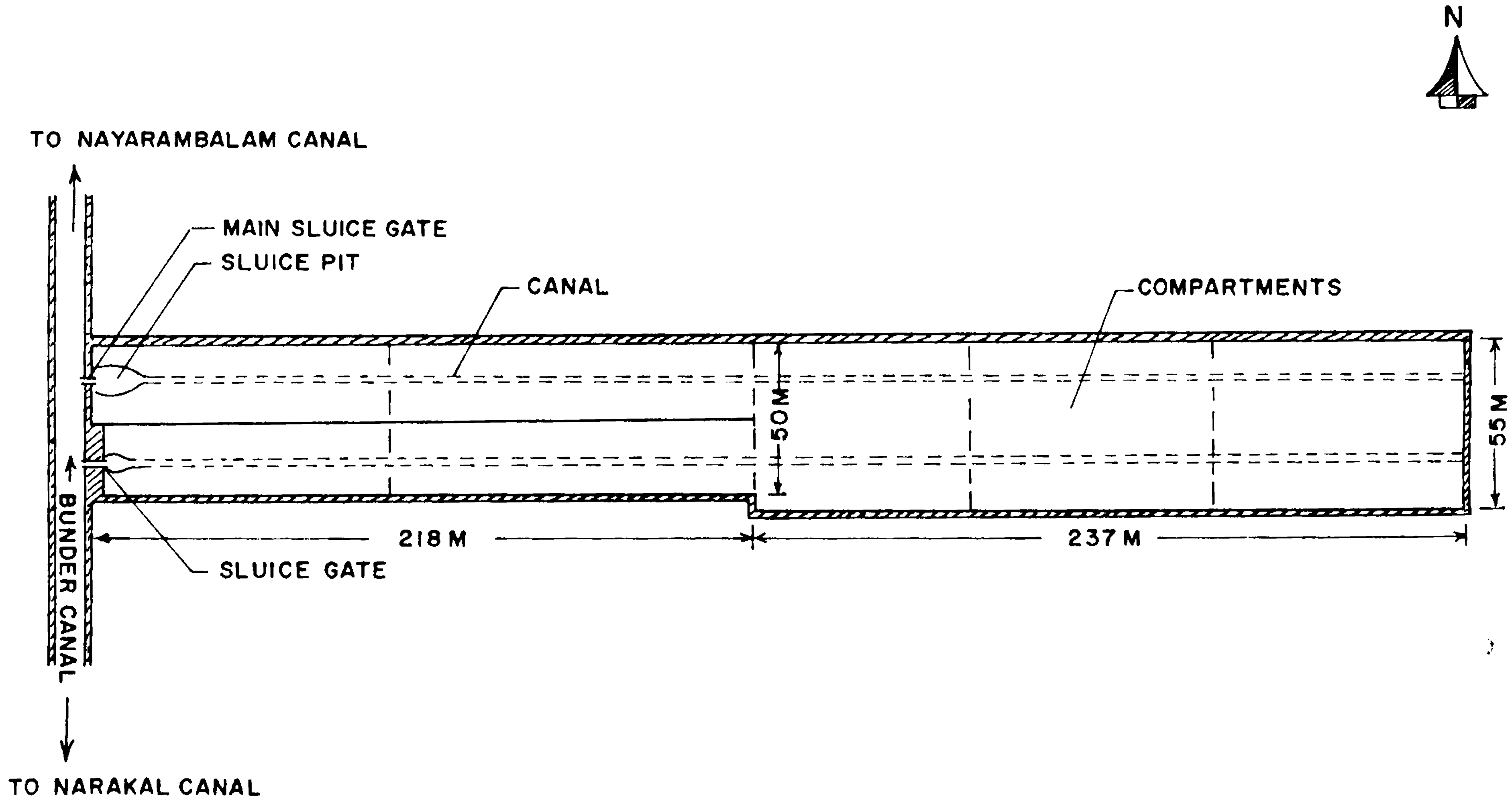


FIG. 2. LAY OUT OF THE TRADITIONAL FIELD (2·38 Ha.) AT NAYARAMBALAM

away from the main water body, the tidal gradient was low, ranging between 20 and 40 cm depending on lunar periodicity.

3.2 **Field preparation**

The field was operated in the traditional manner (Plate IV A). Sluice gates were fixed along with raising of marginal bunds. Only partial removal of paddy stumps from main canals was done.

3.3 **Substratum**

The substratum was composed of silt and clay. Debris of disintegrating paddy stalk was present. Benthic fauna comprised of very few numbers of Corophium sp. and Pandora fluxuosa during the culture period.

4. **Results**:

4.1 **Water quality parameters**

Water quality data on different parameters are presented in Table 3a. The temperature, pH, salinity and dissolved oxygen of water fluctuated between 28.0 and 31.5°C, 7.2 and 8.0, 8.5 and 26.4‰ and 3.2 and 5.0 ml/L respectively during the period of investigation. The medium was always alkaline. The salinity values gradually increased from November to reach the peak in April. The transparency level was within the range of 28 to 52 cm.

PLATE IV

A -Traditional shrimp filtration field

B-Perennial pond in full swing

Table 3a

WATER QUALITY PARAMETERS AT NAYARAMBALAM DURING NOVEMBER 1988 TO APRIL 1989

Period	Water Temp. (°C)	pH	Salinity (‰)	Dissolved Oxygen (ml/L)	Transparency (cm)
November 88	28.5	7.2	8.5	4.7	28
December 88	28.0	7.5	15.9	4.2	36
January 89	30.5	8.0	20.2	5.1	52
February 89	31.0	7.6	23.8	4.5	40
March 89	30.8	7.2	25.6	3.8	35
April 89	31.5	7.0	26.4	3.2	42

4.2 Harvest and catch data:

The operations were started during middle of November and the usual filtration began from January 1989 onwards. Depending on thakkoms, filtration was done on 54 days during the period.

The components obtained are presented in the Table 3b. The shrimp catch showed a progressively increasing trend from January to reach the peak in March (59.22%) leaving only 8.85% for April. All the four major commercial shrimp species were caught during all filtrations except that of January with no trace of *Penaeus monodon*. In all, 46.94% of the catch was *Metapenaeus dobsoni*. The quality *Penaeus indicus* consisted of 34.58% in addition to its small sized collection (15.78%). Though low quality *P. indicus* was obtained in all filtrations, its abundance was towards the fag end of operation. The average size of quality shrimp was 120.1 mm (12.58 g) and that of low quality being 98.0 mm (6.232 g) (Table 3c). *P. monodon* constituted only 0.21% of the catch whereas *M. monoceros* was 2.5%. The yield of *P.*

indicus was worked out to 260.34 kg/ha against a total shrimp yield of 516.97 kg/ha. The total production including fishes and crabs was estimated at 1291.34 kg/ha. The quantity of extraneous fishes dominated by Oreochromis mossambicus exceeded that of total shrimps.

5. **Economics of operation**:

The economics of operation is furnished in the Table 3d. The shrimps and other items collected were categorised and sold at competitive rates. The shrimp varieties realised an amount of Rs.29,688.30, out of the gross income of Rs.34,678.55.

The break up of expenditure towards operation is also presented in Table 3d. The lease amount including licence fee for the traditional field was Rs.18,125/-. An amount of Rs.14,640/- was spent during operations making the gross expenditure at Rs.32,765/-. Thus the balance of Rs.1,913.55 earned during the traditional operations in 1988-89 resulted in the profit of Rs.804.02/ha.

6. **Observations**:

Since the farm was located quite interior, the tidal gradient was not strong enough to entrap more shrimp larvae to the system. Because of the shallow nature of the field, juveniles of P. indicus were always caught during filtration.

Table 3b

SHRIMP YIELD DATA DURING 1988-89 FROM A TRADITIONAL FIELD (2.38 ha) AT NAYARAMBALAM

Category / Period	*Penaeus monodon* (kg)	*Penaeus indicus* > 10 g indiv. size (kg)	*Penaeus indicus* < 10 g indiv. size (kg)	*Metapenaeus monoceros* (kg)	*Metapenaeus dobsoni* (kg)	Total (kg)
January 1989 1st Phase 6-8th (3 days)	-	-	-	1.800	17.150	18.950
January 1989 2nd Phase 20-24th (5 days)	-	1.600	4.400	3.100	63.600	72.700
February 1989 1st Phase 4-10th (7 days)	0.100	14.100	10.650	5.300	183.600	213.750
February 1989 2nd Phase 18-24th (7 days)	0.150	14.450	2.550	2.200	68.150	87.500
March 1989 1st Phase 6-13th (8 days)	0.150	168.300	43.150	8.500	163.100	383.200
March 1989 2nd Phase 18-31st (14 days)	1.200	189.500	112.300	5.250	37.200	345.450
April, 1989 1st Phase 1-10th (10 days)	1.000	37.550	21.050	4.550	44.700	108.850
Total	2.600 (0.21%)	425.500 (34.58%)	194.100 (15.78%)	30.700 (2.50%)	577.500 (46.84%)	1230.400*

* 1782.00 kg of *Oreochromis mossambicus*, 37.5 kg trash fish and 23.5 kg of crabs were also realised during operation.

Production/ha of *Penaeus indicus* = 260.34 kg
" " of shrimps = 516.97 kg
" " including fishes = 1291.34 kg

Table 3c

PENAEUS INDICUS : SIZE RANGE OBTAINED

> 10 g		individual size	< 10 g		individual size
mm		g	mm		g
118	-	12.385	104	-	6.56
105	-	10.247	112	-	9.20
126	-	12.500	105	-	7.55
117	-	11.765	101	-	5.65
127	-	13.600	107	-	8.42
131	-	14.725	103	-	6.55
123	-	12.350	90	-	4.45
115	-	12.200	75	-	3.60
119	-	12.920	92	-	5.36
120	-	13.080	91	-	4.98
120.1	-	12.580	98.0	-	6.232

Table 3d

OPERATIONAL ECONOMICS

Sale proceeds	Rs.	Expenditure	Rs.
Cost of 2.600 kg P. monodon @ Rs.80/-/kg.	Rs. 208.00	Lease amount and licence fee	Rs. 18,125.00
Cost of 425.500 kg 1st grade P. indicus @ Rs.50/-/kg.	21,275.00	Repair of 2 sluice gates and fixation charges.	1,450.00
Cost of 194.100 kg 2nd grade P. indicus @ Rs.28/-/kg.	5,434.80	Raising peripheral bunds and canal cleaning	800.00
Cost of 30.700 kg M. monoceros @ Rs.15/-/kg	460.50	Construction of a workshed	550.00
Cost of 577.500 kg M. dobsoni @ Rs.4/-/kg.	2,310.00	Cost of net items, filter screens and accessories	1,300.00
Sub-total from shrimps	29,688.30		
Cost of 1782.00 kg of Oreochromis mossambicus @ Rs.2.50/kg.	4,455.00	Lanterns, kerosene, baskets, buckets and bamboo mats	1,075.00
		Rent for canoe	400.00
Cost of 37.50 kg of trash fish @ Rs.2/-/kg.	75.00	Wages for sluice man	4,500.00
Cost of 23.50 kg of Crabs @ Rs.1.50/kg.	35.25	Sorting charges of catch components	475.00
Sub-total	4,565.25	Wages for cast netting & fish netting	2,550.00
Total amount realised during the operation	34,253.55	Interest on capital	1,350.00
		Miscellaneous	190.00
By disposal of used items	425.00	Total expenditure	32,765.00
Total income	34,678.55	Expenditure/ha	13,766.81
		Profit (+) of operation	1,913.55
Realisation/ha	14,570.82	Nett balance per ha of operation	804.01

Investigation A2 : Studies on shrimp polyculture in a modified traditional shallow seasonal field of 0.8 ha at Pooyapilly during 1988-89.

1. **Aim**

To study the impact of modification on shrimp yield and its economics apart from nearness to main feeder source.

2. **Introduction**

Clearing of canals and removal of macroalgal vegetation were the two modifications attended in the field preparation during this investigation, compared to the traditional method. Further, nearness to barmouth and direct opening of sluice gate to main waterbody were other aspects to reckon with.

3.1 **Location, size and layout**

The 0.8 ha ideal shrimp field (Fig. 3) having 70-80 cm depth was lying at west Pooyapilly adjoining the northern end of Cochin backwater where the Parur canal joined it. The field was rectangular in shape lying in northsouth direction and was connected to the canal by a wooden sluice gate. The internal canals and compartments of the usual paddy field system were discernible. Since the sluice gate was directly opening into the main feeder canal, the tidal influence was very much predominant. On account of the comparatively better gradient experienced (70-80 cm), the chances of shrimp fry recruitment was far better. This particular situation made the field to be considered as a notable one in traditional shrimp culture practices.

3.2 **Field preparation**

The preliminaries such as raising of peripheral bunds and sluice fixation were completed by early November. Contrary to the

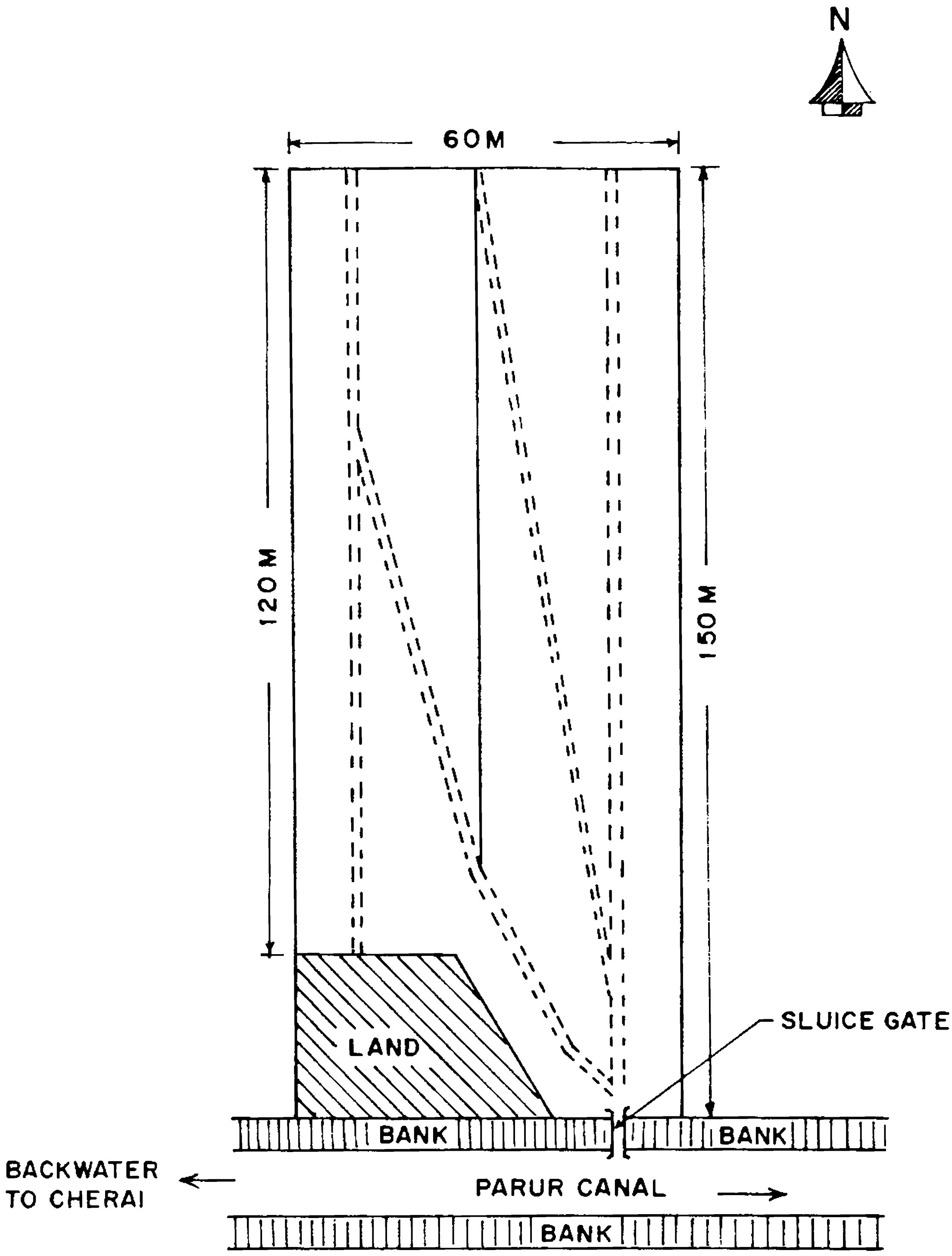


FIG.3. LAY OUT OF THE FIELD (0·8 Ha.) AT POOYAPILLY

traditional practice (Investigation 1), modifications were undertaken by (1) elimination of macro algal vegetation and (2) clearing of canals by total removal of paddy stumps enabling improved water circulation.

3.3 Substratum

Soil and clay mixed with lot of debris particles constituted the substratum. The benthic fauna was dominated by a tanaeidacean *Apseudes chilkensis* and amphipod, *Corophium sp*. during the summer months of January to March. Only very few numbers of polychaete worms were present.

3.4 Canal system

The internal canals and compartments of the usual paddy field system were quite discernible. These canals traversing properly through the compartments facilitated better water movement during tidal processes.

3.5 Fry stocking

Since the sluice gate was directly opening into the main feeder canal by virtue of its location unlike in A 1 field, the tidal influence was very much predominant. This aspect which distinguished the field from the rest indicates the importance of site selection. The advantage of each tide was made use of to the maximum - the process by which the shrimp fry concentration was accomplished. Appropriate screens and nets were deployed during respective tides for shrimp seed recruitment.

3.6 Food

No extra food was broadcast, instead, the natural food brought in by tidal water was utilised.

4. Results

4.1 Water quality parameters

The hydrographical parameters (Table 4a) such as temperature, pH, salinity and dissolved oxygen fluctuated between 28 and 31.5°C, 7.0 and 8.2, 15.4 and 27.5‰ and 4.3 and 6.4 ml/L respectively during the period of investigation. The transparency of water was within 35 - 60 cm level.

Table 4a

HYDROGRAPHICAL PARAMETERS AT POOYAPILLY BETWEEN NOVEMBER 1988 AND APRIL 1989

Parameters / Period	Water Temp. (°C)	pH	Salinity (‰)	Dissolved Oxygen (ml/L)	Transparency (cm)
November 1988	29.0	7.2	15.4	5.1	35
December 1988	28.0	7.6	18.9	5.8	43
January 1989	28.5	8.2	23.5	6.4	48
February 1989	29.3	7.8	25.8	4.5	57
March 1989	30.2	7.5	26.3	4.7	60
April 1989	31.5	7.0	27.5	4.3	52

4.2 Harvest and catch data

Periodical harvesting by sluice filtration was done during each lunar phase (thakkoms) from November 1988 to April 1989. Altogether, filtration (Plate IV A) was carried out during 72 days spread over in 11 phases of 150 days.

The catch components obtained during the harvest are presented in Table 4b. While the yield of Metapenaeus dobsoni did not show much variation during successive operations, an increasing trend was noted in the catch of Penaeus indicus, yielding maximum during the period February-March. Among P. indicus obtained, almost 28% was of commercially low quality. The average size of quality shrimp was 123.1 mm (14.0 g), whereas it was 106.4 mm (8.03 g) in the case of low quality shrimp (Table 4c). In respect of M. monoceros, the availability lasted only for the initial 3 months. The lowest yield was that of P. monodon represented in very few numbers during each month. On the whole the abundance of commercial shrimp species was in the order of Metapenaeus dobsoni (62.88%), P. indicus (27.18%), M. monoceros (9.25%) and P. monodon (0.75%) giving a total of 896.70 kg. This worked out to a shrimp production level of 1118.61 kg/ha, the respective figure for P. indicus, being 304.00 kg/ha. In addition, 493.5 kg fish and other items were obtained resulting in a total production of 1734.24 kg/ha.

5. Economics of operation

The details of operational expenditure and sale proceeds of the field are presented in Table 4d. The lease amount, cost of preparations of the field, procurement of items and other expenditures worked out at Rs.14575/- during the period. The categorised components were disposed of at competitive rates at the production site. An amount of Rs.14735.30 was obtained for shrimps and Rs.1967.00 from fishes and miscellaneous items totalling to Rs.16857.30. The operation ended with a profit of Rs.2282.30, the projected profit per ha being Rs.2847.12 during 1988-1989.

6. Observation

The precautionary measures were not adequate to prevent the entry of predatory fishes and other species. Low quality of P. indicus was a demerit of the system. Realization of 1118.61 kg/ha of shrimps was the advantage of modification and suitable site location.

Table 4b

SHRIMP YIELD DATA DURING 1988-89 FROM A TRADITIONAL FIELD (0.80 ha) AT POOYAPILLY

Category / Period	Penaeus monodon (kg)	Penaeus indicus 10 g size > (kg)	Penaeus indicus 10 g size < (kg)	Metapenaeus monoceros (kg)	Metapenaeus dobsoni (kg)	Total (kg)
8-13th (6 days)	-	3.200	1.100	13.800	52.300	70.400
November 1988						
21-26th (6 days)	0.300	4.800	2.000	12.000	48.800	67.900
7-12th (6 days)	0.300	4.950	2.150	14.500	51.400	73.300
December 1988						
21-26th (6 days)	0.500	9.100	3.100	12.000	45.500	70.200
5-10th (6 days)	0.450	13.700	4.700	13.000	59.500	91.350
January 1989						
20-24th (5 days)	0.400	12.100	3.300	10.500	54.700	81.000
4-10th (7 days)	0.300	24.250	7.250	7.100	57.400	96.300
February 1989						
18-23rd (6 days)	0.450	15.100	7.700	-	44.100	67.350
6-14th (9 days)	3.300	54.700	20.500	-	47.500	126.00
March 1989						
21-26th (6 days)	0.700	21.100	9.100	-	52.700	83.600
5-13th (9 days)	-	13.300	6.500	-	49.500	69.300
April, 1989						
Total	6.700 (0.75%)	176.300 (19.66%)	67.400 (7.52%)	82.900 (9.25%)	563.400 (62.83%)	896.700*

* 47.5 kg of *Etroplus suratensis*, 354.0 kg *Oreochromis mossambicus*, 28.0 kg crab and 64.0 kg trash fish were also realised during operation.

Production/ha of *Penaeus indicus* = 304.00 kg
Production/ha of shrimps = 1118.61 kg
Production/ha including fishes = 1734.24 kg

Table 4c

SIZE RANGE OF <u>PENAEUS INDICUS</u>

>10 mm	-	g	<10 mm	-	g
127	-	14.986	105	-	7.700
135	-	15.795	108	-	8.750
116	-	11.500	114	-	9.800
124	-	12.767	107	-	8.420
122	-	14.967	108	-	7.175
114	-	10.900	109	-	8.500
129	-	15.280	110	-	9.430
130	-	17.850	112	-	8.603
115	-	13.080	100	-	6.286
119	-	12.923	91	-	5.680
123.1	-	14.000	106.4	-	8.030

Table 4d

OPERATIONAL ECONOMICS

Sales proceeds		Expenditure	
Cost of 6.700 kg P. monodon @ Rs.80/-/kg.	Rs. 536.00	Lease amount of the field	Rs. 6,500.00
Cost of 176.300 kg 1st grade P. indicus @ Rs.50/-/kg.	8,815.00	Repair of sluice & fixation charge	900.00
Cost of 67.400 kg 2nd grade P. indicus @ Rs.28/-/kg.	1,887.20	Wages for algae removel & canal clearance	375.00
		Charges for shed making	325.00
Cost of 82.900 kg M. monoceros @ Rs.15/-/kg	1,243.50	Fabrication of filter screens	275.00
Cost of 563.400 kg M. dobsoni @ Rs.4/-/kg	2,253.60	Nets, lanterns & kerosene	625.00
Sub-total for shrimps	14,735.30	Baskets, bamboo mats & buckets	250.00
		Canoe rent	300.00
Cost of 47.5 kg Etroplus suratensis @ Rs.20/kg	950.00	Interest on capital	625.00
Cost of 354.0 kg of Oreochromis mossambicus @ Rs.2.50/kg	885.00	Unforeseen expenses	150.00
Cost of 28.00 kg of crab @ Rs.2/-/kg	36.00	Wages for sluice man	3,750.00
Cost of 64.0 kg trash fish @ Rs.1.50/kg	96.00	Allowances for the helper	500.00
Sub-total for fishes	1,967.00	Total expenditure	14,575.00
Total amount realised during operation	16,702.30	Projected expenditure/ha	18,181.94
Amount obtained by disposing used items	155.00	Profit (+) of operation	2,282.30
Total amount realised	16,857.30	Projected amount of profit/ha	2,847.12
Projected realisation/ha	21,029.06		

Investigation - A 3 : Studies on shrimp polyculture in a modified deep perennial pond (1.6 ha) in Thrikkadakapilly Chal at Cherai during 1987-88.

1. **Aim** : i) To study the impact of compensatory feeding in addition to modifications and perennial nature of pond on shrimp yield and its economics.

ii) To assess the impact of direct access to the open water body.

2. **Introduction**

The pond was one where rotation of paddy-cum-shrimp culture was regularly practiced. However recently only perennial (Plate IV B) shrimp filtration was carried out owing to its relatively higher depth and other favourable factors. During the present investigation, structural modifications to the extent of elimination of macroalgal assemblage and excavation of canals were done thereby categorizing it as modified traditional as in A 2. In addition supplementary feeding was resorted to compensate the lack of live feed resource in the system since the field was not used for paddy-cultivation. By virtue of its location and close proximity with barmouth, deep and perennial nature, direct opening of the sluice gate to the main waterbody etc. distinguished the pond as an ideal one for the shrimp culture purposes.

3.1 **Location, size and layout**

The 1.6 ha perennial pond rectangular in shape by 130m x 123m was located in Thrikkadakapilly at Cherai in Vypeen Island (Fig. 1), on the north-western side of Cochin backwater. The pond was lying in an east-west direction, its longest side adjoining the backwater. The sluice gate having 60 cm internal width was located in the middle of eastern bund opening directly into the main backwater. The pond was lying slightly inclined towards the sluice gate. The general depth varied between 50 and 60 cm during low tide. Higher depths of 2.5 m and 1.5 m were noted in the sluice pit and radiating canals respectively. The general configuration of the pond is as shown in the diagram (Fig. 4).

3.2 **Pond preparation**

The usual preparations such as sluice fixation, repair of bunds and clearing of canals were completed during the end of May 1987.

3.3 **Substratum** was composed of sand and silt mixed with very little quantity of decaying vegetation. But, remnants of molluscan shells were present. Benthic faunal composition was fairly diverse. *Apseudes* sp., *Corophium* sp., *Dendronereis estuarina* and *Notophygos* sp. showed abundance during high saline period. The gastropod *Littorina* sp. was also seen in fairly good numbers.

3.4 **Canal system**

From the sufficiently deep sluice pit, the main canal emerged towards the rear end. At equal distances from the main canal on either side, one subsidiary canal each proceeded towards the other end. The central cross canal running in a north-south direction traversed the main canals forming a network of canal systems. Thus the canals seemed ideal to serve the exchange purpose.

3.5 **Tidal flow control and larval ingression**

The tidal gradient varied between 50 and 80 cm and it was possible to take advantage of the tides in full in regulating the flow to approximately 1 m. Because of the appropriate dimensions of the sluice gate the flow could be maintained up to 3 - 3½ hours during tidal exchange. This condition and the direct opening of pond to backwater facilitated a good shrimp larval recruitment into the pond by natural tidal flow.

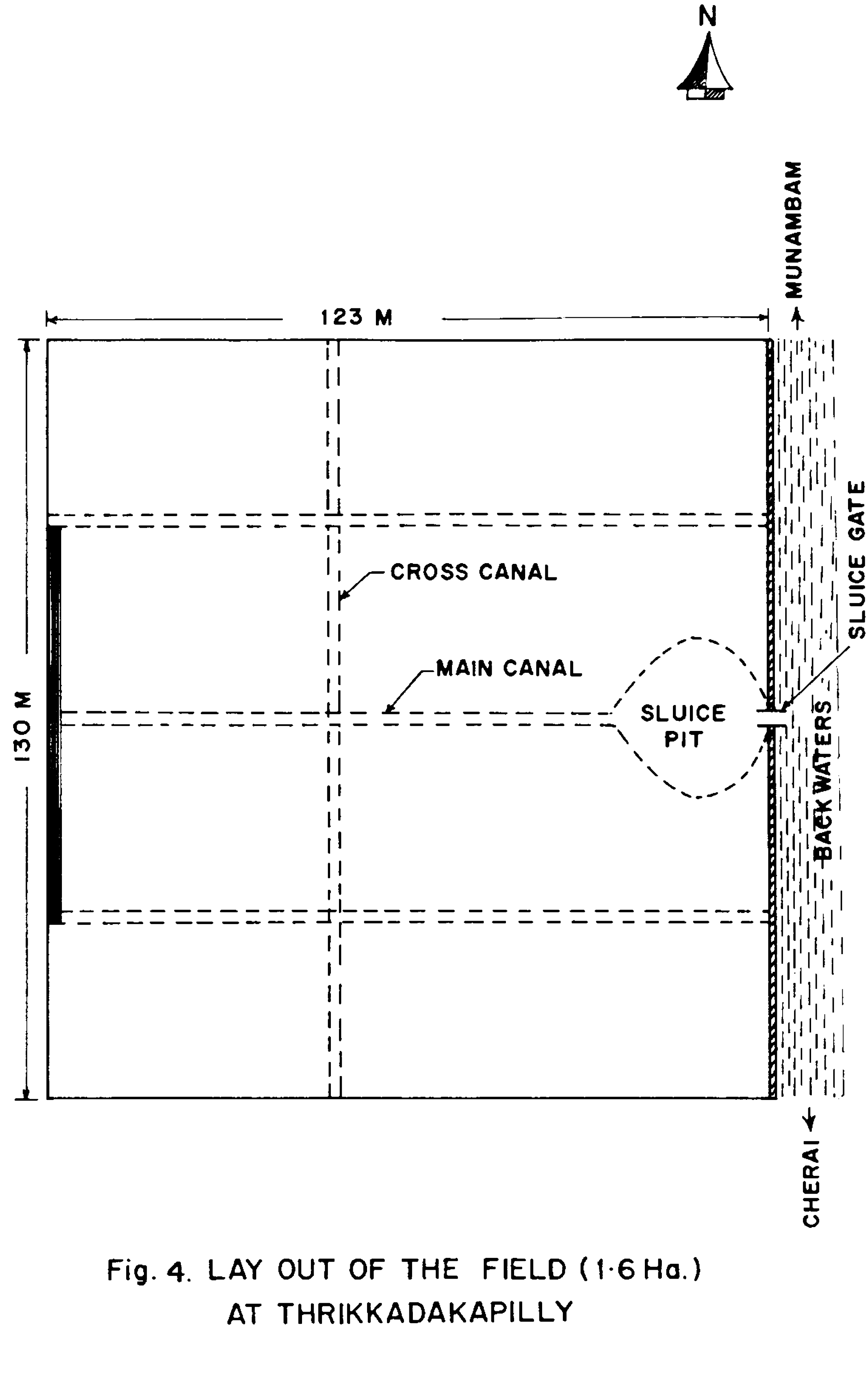


Fig. 4. LAY OUT OF THE FIELD (1·6 Ha.)
AT THRIKKADAKAPILLY

3.6 Food and feeding

In addition to feed organisms brought in through regular tidal processes, pulverised feed composed of rice bran, ground nut oil cake and fish meal in equal proportions was broadcast in the channels and remote areas of the pond during off filtration periods. The feed supply varied from 5-8 kg/dayduring August to February.

4. Results

The operations were carried out from June 1987 to April 1988.

4.1 Water quality parameters

The details of important water quality parameters are presented in Table 5a. Water temperature was fairly high and fluctuated between 28.2°C during August and 31.5°C during March. The pH of water generally remained between 7.0 and 7.6 except in January when it was shot up to 8.4. Relatively high pH values prevailed during post-monsoon months. Salinity showed clear seasonal variations from a minimum of 2.5‰ during August to 29.2‰ in April. Lower salinity values prevailed during June-August period whereas it gradually increased to reach peak values in April. Dissolved oxygen values were seen very high ranging between 4.9 ml/L in October to 6.3 ml/L in August. The transparency values ranged between 35 cm in August and 65 cm in December. Lower values prevailed during monsoon and higher values during summer months.

Table 5a

WATER QUALITY PARAMETERS AT THRIKKADAKAPILLY CHAL BETWEEN JUNE 1987 AND MAY 1988

Parameters Period		Temperature Air (°C)	Temperature Water (°C)	pH	Salinity (‰)	Diss. Oxygen (ml/L)	Transparency (cm)
June	1987	29.5	30.5	7.5	7.3	5.6	46
July	1987	29.0	28.5	7.2	3.5	6.4	38
August	1987	29.8	28.2	7.4	2.5	6.3	35
September	1987	28.5	30.5	7.5	12.6	5.2	56
October	1987	30.0	30.2	7.3	17.4	4.9	60
November	1987	29.8	30.5	7.5	18.5	5.4	54
December	1987	31.0	30.4	7.5	20.4	5.8	65
January	1988	30.3	30.0	8.4	23.8	5.2	53
February	1988	28.0	28.5	7.6	24.7	6.1	56
March	1988	30.5	31.5	7.4	28.4	5.1	59
April	1988	31.2	30.5	7.0	29.2	6.0	62
May	1988	31.8	31.0	7.1	28.0	5.3	60

4.2 Harvest and catch data

During the 320 days of operation, shrimp filtrations were carried out for 154 days spread over 21 thakkoms and the yield realised is presented in Table 5b. The important commercial shrimp species such as *P. monodon*, *P. indicus*, *M. dobsoni* and *M. monoceros* were obtained during all thakkoms. In spite of a reduced yield during August-September in the case of predominant species such as *P. indicus* and *M. dobsoni*, the catch showed an increasing trend up to February 1988 in respect of all species except *P. monodon*. The main component of the catch was M. dobsoni (64.84%) followed by P. indicus (32.80%), M. monoceros (2.01%) and P. monodon (0.35%). About 10.47% of P. indicus obtained was of low quality. The average size of the quality shrimp was 130.4 mm (15.25 g) and that of low quality being 106.3 mm (8.52 g) (Table 5c). The production/ha of P. indicus worked out to 449.94 kg against a total shrimp catch of 1371.88 kg/ha. The total production including miscellaneous groups and fishes caught during the operation was estimated to 1742.69 kg/ha.

5. Economics of operation

The operational economics is presented in Table 5d. An amount of Rs. 37040.00 was spent towards expenditure, including lease amount, wages paid for preliminaries and farm setting, cost of essential items and other unavoidable expenses.

The sale proceeds from shrimps and other items were separately accounted. The shrimps were categorised qualitywise and disposed of at competitive rates at the farm site in order to realise maximum price. By disposing 2195.0 kg of shrimps an amount of Rs.41,301.40 was obtained. An amount of Rs. 2,836.25 could be collected by selling fishes and other miscellaneous items, thereby earning a gross income of Rs.44,137.65. Thus shrimp polyculture resulted in a net profit of Rs.7,097.65 during 1987-88 giving a profit of Rs.4,436.03/ha.

6. Observations

No painstaking efforts were made to prevent the entry of predatory fishes and other items (Table 5d) in the culture system. The fairly deep nature of pond and prolonged culture duration were advantageous to obtain better quality shrimps. The application of supplementary feed aided the shrimp growth.

TABLE 5 b

SHRIMP YIELD DATA DURING 1987-88 FROM A TRADITIONAL FIELD (1.6 ha) IN THRIKKADAKAPILLY AT CHERAI

Period / Category	*Penaeus monodon* (kg)	*Penaeus indicus* >10g size (kg)	*Penaeus indicus* <10g size (kg)	*Metapenaeus monoceros* (kg)	*Metapenaeus dobsoni* (kg)	Total (kg)
June, 1987: 10-15th (6 days)	0.600	17.600	1.800	3.100	87.900	111.000
June, 1987: 23-30th (8 days)	0.400	44.600	3.500	4.300	146.000	198.800
July, 1987: 8-15th (8 days)	0.700	22.800	2.700	1.800	119.800	147.800
July, 1987: 23-29th (7 days)	0.300	22.100	4.200	2.700	75.200	104.500
August, 1987: 8-15th (8 days)	0.400	29.600	2.100	3.200	90.750	126.050
August, 1987: 22-26th (5 days)	0.250	4.600	1.100	1.200	21.300	28.450
September, 1987: 7-11th (5 days)	0.300	6.900	1.000	1.500	18.200	27.900
September, 1987: 22-29th (8 days)	0.500	26.550	2.300	2.600	75.900	107.850
October, 1987: 6-12th (7 days)	0.100	60.700	4.500	1.800	5.700	72.800
October, 1987: 20-28th (9 days)	0.200	30.200	3.700	2.200	46.100	82.400
November, 1987: 3-12th (9 days)	0.100	71.500	5.600	3.600	68.400	149.200
November, 1987: 19-26th (8 days)	0.100	40.400	2.300	2.200	21.800	66.800
December, 1987: 3-12th (10 days)	0.200	31.200	3.700	1.800	44.800	81.700
December, 1987: 19-26th (8 days)	0.100	47.500	4.100	2.700	130.300	184.700
January, 1988: 3-9th (7 days)	1.000	36.100	4.600	1.600	94.500	137.800
January, 1988: 17-23rd (7 days)	0.700	77.300	6.400	1.100	70.500	156.000
February, 1988: 1-6th (6 days)	0.400	40.950	3.900	1.650	87.100	134.000
February, 1988: 18-22nd (5 days)	0.300	22.300	6.700	0.750	19.750	49.800
March, 1988: 2-6th (5 days)	0.600	2.600	5.300	1.200	39.500	49.200
March, 1988: 16-21st (6 days)	0.150	3.300	3.400	1.500	76.300	84.650
April, 1988: 1-12th (12 days)	0.200	5.700	2.500	1.700	83.500	93.600
	7.600(0.35%)	644.500(29.36%)	75.400(3.44%)	44.200(2.01%)	1433.300(64.84%)	2195.000 *

* 14.5 kg. mullets, 53.5 kg. *Etroplus suratensis*, 287.5 kg *Oreochromis mossambicus*, 186.2 kg. Trash fish and 51.6 kg. crabs were also obtained during operation.

Production/ha of *Penaeus indicus* = 449.94 kg Production/ha of Shrimps = 1371.88 kg Production/ha including fishes = 1742.69 kg.

Table 5c

SIZE RANGE OF PENAEUS INDICUS

> 10 g			< 10 g		
mm		g	mm		g
142	-	16.673	111	-	9.565
146	-	20.932	106	-	8.940
126	-	13.980	103	-	7.617
121	-	10.910	107	-	9.320
129	-	13.850	100	-	8.528
135	-	15.280	104	-	7.584
115	-	13.080	110	-	9.664
119	-	12.923	107	-	6.875
138	-	19.150	108	-	8.750
133	-	15.740	107	-	8.420
130.4		15.250	106.3		8.520

Table 5d

OPERATIONAL ECONOMICS

Sale proceeds		Expenditure	
Cost of 7.6 kg *P. monodon* @ Rs. 80/-/kg.	608.00	Lease amount	17,500.00
Cost of 644.5 kg 1st grade *P. indicus* @ Rs. 50/-/kg.	32,225.00	Sluice repair and fixation charges	875.00
Cost of 75.4 kg 2nd grade *P. indicus* @ Rs. 28/-/kg	2,112.20	Wages for bund repair & canal excavation 53 man days @ Rs.30/- per day.	1,590.00
Cost of 44.2 kg *M. monoceros* @ Rs. 15/-/kg	663.00	Shed making cost	700.00
Cost of 1423.3 kg *M. dobsoni* @ Rs. 4/-/kg.	5,693.20	Fabrication of bamboo screens & filters	375.00
Sub-total from shrimps	41,301.40	Nets, lanterns& Kerosene	925.00
Cost of 14.5 kg of Mullets @ Rs.20/-/kg.	290.00	Bamboo mats, buckets & baskets etc.	250.00
Cost of 53.5 kg of *Etroplus suratensis* @ Rs.20/-/kg.	1,070.00	Cost of feed items	450.00
Cost of 287.5 kg of *Oreochromis mossambicus* @ Rs.2.50/kg.	718.75	Rent for canoe	750.00
Cost of 186.2 kg of trash fish @ Rs.1.50/kg.	279.30	Wages for sluice man @ Rs.750/-/month for 10½ months	7,875.00
Cost of 51.6 kg crabs @ Rs.2/-/kg.	103.20	Allowances for Helper @ Rs.250/- p.m. for 10½ months	2,625.00
Sub total from fishes	2,461.25	Interest on capital	3,275.00
Amount obtained by disposing used items	375.00	Unforeseen expenses	150.00
Total amount realised from operation	44,137.65	Total expenditure	37,040.00
Realisation/ha	27,586.03	Expenditure/ha	23,150.00
		Profit (+) of operation	7,097.65
		The nett profit/ha	4,436.03

Investigation - A 4 : Studies on shrimp polyculture in a modified traditional and extensive deep field of 20.25 ha at Kuzhuppilly during 1986-87.

1. **Aim**

To study the impact of rejuvenation of an extensive deep field by way of improvements in canal system on shrimp yield and economics.

2. **Introduction**

The collective field known as '31' owned by several people formed a Samajam for its easy operational purposes. The field was regularly used for paddy cultivation and shrimp filtration purposes for decades. The owners themselves carried out paddy cultivation in their holdings during rainy season, of course by taking advantage of the common dewatering system. But in the case of shrimp filtration, the whole field was run as a single unit. The shrimp filtration was carried out either by the Samajam or by the contract farmers who took possession of it by public auction. Though this field has got a consistent record of success stories in the past, the level of shrimp production indicated certain fluctuations during the fag end of 1950s along with the decline of paddy yield. Thereafter the paddy cultivation was not systematically carried out by certain owners leaving their holdings fallow mostly. Subsequently almost 50% of the total field became unfit for paddy cultivation as mud removal from these areas was continued for long. So much so, the field bottom became uneven in shape, the general water depth ranging between 60-180 cm. Nevertheless, the shrimp yield from traditional filtration continued to dominate even during 1970s. Subsequently there was a tremendous fall in the production leading to a slackened demand for the same field. This situation prompted the samajam to make certain alterations in the structural pattern of the field during 1986-87 aimed at better shrimp production.

3. Material and methods

3.1 Location, size and layout

This extensive, deep, rhombus shaped (Plate V A) having an extent of 20.25 ha was located at the south-western region of Kuzhupilly Panchayat (Fig. 5) adjoining a main water body on one side and a smaller waterbody on otherside flowing in the opposite direction. As a result it was possible to install 2 sluice gates on the side facing main water body and the third one (Plate V B) on the other side.

3.2 Field preparation

As usual, the outer bunds of the entire field was strengthened satisfactorily. The main and the 2 subsidiary sluice gates were installed in appropriate sites.

3.3 Substratum

In general, the substratum was more or less firm and composed of sand and clay along with calcareous deposits. But in deeper regions it was mostly clayey. Hence diverse group of benthic fauna was present. While tanaeidacean Apseudes chilkensis and amphipod Corophium sp. were least represented, dominance of amphipod Melita sp. was seen during December-February period. Polychaetes such as Dendronereis estuarina and Notophygos sp. occurred in fairly good numbers during January-April. Juveniles of bivalve Villorita cyprinoides were abundantly available during the summer period.

3.4 Canal system

The field wasdewatered by using an axial pump of 40 HP. The inner dykes of the field were raised suitably. The general inclination of the field was directed towards the centrally located main sluice gate. The centrally located main canal and subsidiary canals along

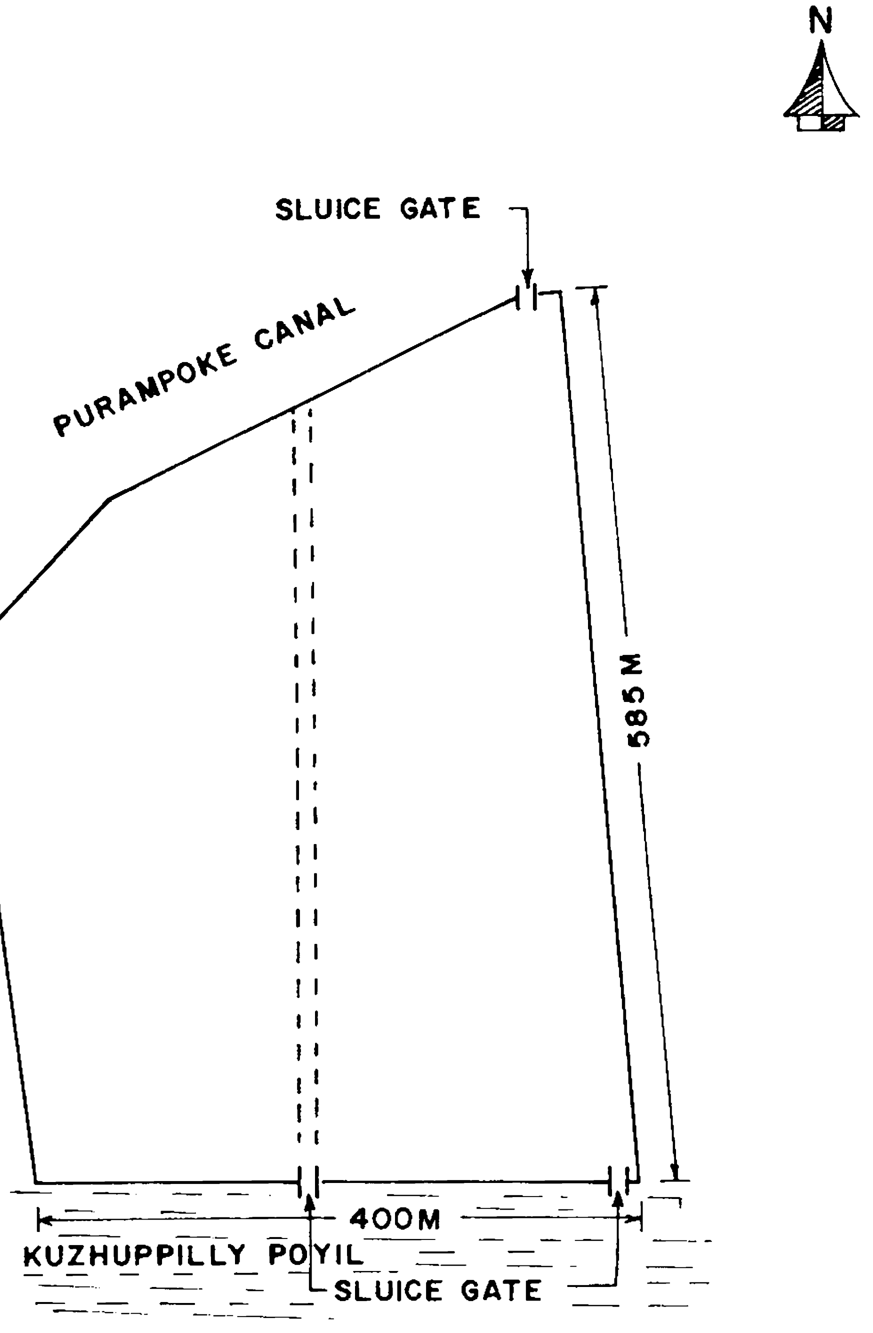


FIG. 5. LAY OUT OF THE EXTENSIVE FIELD (20·25 Ha) AT KUZHUPILLY

sides were excavated. The cross canals interconnecting these were also cleaned. All canals were excavated in such a manner as to coalese with the main sluice basin. The ramification of the main and subsidiary canals were so arranged that the flow pattern could be directed to reach even to the remotest corner of the field. The macro-vegetation and other algal assemblages were manually removed from the field towards the peripheral bunds.

3.5 Tidal flow

By second week of November 1986, all preparations were completed and the field was got ready for shrimp culture purposes. As usual for filtration, the regular ingress and eggress of water was continued through sluice gates (Plate IIIB) depending on tides. The tidal gradient oscillated between 35 and 70 cm in the area depending upon lunar phase during the study period. Ample care was taken to admit water through suitable prevention nets kept inside the main sluice gate. But during low tide, water was let out through appropriate bamboo screens (Plate V B) kept inside all the three sluice gates. This process was repeated during each tide from start to finish of operation which facilitated autostocking of shrimp larvae and fry inside the field. Depending upon availability of shrimp fry outside during lunar phase, the ingress of water to the field was also at times arranged through subsidiary sluice gates in addition to the usual practice of admitting high tidal water through the main gate. These arrangements enabled autostocking of shrimp seed to the maximum extent possible in all compartments.

3.6 Feed preparation and feeding

Considering the total absence of any remnants of paddy stalks which would have been responsible for production of natural food organisms, supplemental feed was resorted in the culture system. Accordingly compounded feed was prepared.

PLATE V

A - Paddy - cum - shrimp filtration extensive field

B - Wooden sluice installed and adichil suspended for drying

Feed preparation

The ingredients, used for feed preparation are as shown in Table 6a. Large quantity of Ambassis sp. collected from wild was steamed, sundried, powdered and stored well. The ground nut oil cake purchased from market was also sundried and powdered. Tapioca powder was also kept ready in the same manner. All ingredients were of good quality and feed was prepared hygienically. To prepare the feed, equal quantities of the three ingredients were weighed and kept in a clean surface. Then it was thoroughly mixed by hand. This mixture was then gradually introduced into a clean wide mouthed cooking vessel containing adequate quantity of boiling water and stirred well for about 10 minutes. The half cooked mash thus resulted was scattered in clean surface and sundried. Afterwards, the feed was stored in polythene covers airtight.

Table 6a

BIO-CHEMICAL COMPOSITION OF COMPOUNDED FEED SUPPLIED IN THE POND

Ingredients	Percentage composition on dry wt. basis					Energy	
& ratios	Moisture	CHO	Protein	Fat	Ash	K.Cal/g	K.Cal/kg
Fish meal* + g.o.c. @ + tapioca 1:1:1	10.516	44.0	34.0	1.25	10.235	3.233	3233

* Ambassis sp @ Ground nut oil cake

From this feed stock, quantities @ 10-15 kg/day was supplied since last week of December 1986. The feed quantity was gradually increased as the culture advanced till March 1987. Feed was generally broadcast in the field during dusk hours of each day except on days of filtration. In all 700 kg feed was supplied during the operation.

The percentage biochemical composition as furnished in Table 6a showed that carbohydrate level was highest followed by protein. While there was 10.24% ash, the fat content was the lowest (1.25%). The feed possessed an energy content of 3233 K.cal/kg on a dry weight basis.

4. Result

4.1 Water quality parameters

The details of surface water quality parameters are presented in Table 6b. The water temperature fluctuated within the range of 28.0 and 31.5°C between January and April. The medium showed pH variations between 7.0 and 8.0. The salinity values gradually increased from 17.8‰ in November to reach the peak value 28.6‰ in April. The dissolved oxygen values were also fairly high ranging between 4.25 and 5.65ml/L. The transparency values showed wide differences between 38 and 70 cm, lower values remaining during postmonsoon months.

Table 6b

WATER QUALITY PARAMETERS AT KUZHUPILLY EXTENSIVE FIELD BETWEEN NOVEMBER 1986 AND APRIL, 1987

Parameters / Period	Temperature Air (°C)	Temperature Water (°C)	pH	Salinity (‰)	Diss. Oxygen (ml/L)	Transparency cm
November 1986	29.2	29.0	7.25	17.8	4.86	38
December 1986	30.0	28.5	7.50	19.6	4.54	53
January 1987	29.2	28.0	8.00	22.3	4.38	59
February 1987	28.0	29.5	7.75	25.4	5.65	70
March 1987	31.5	30.5	7.50	26.7	4.25	56
April 1987	32.0	31.5	7.00	28.6	4.60	51

4.2 **Harvest and catch data**

Sluice filtration was regularly carried out during thakkoms by using suitable conical bag net installed at the main sluice gate. During most favourable days of March and April, filtration was also carried out in the other two sluice gates. By last week of March, 1987, cast netting was done by contract fishermen to collect shrimps and fishes, followed by hand picking by skilled women. All catches were categorised and graded for disposal as presented in Table 6c. Four major shrimp species were present. The catch of Metapenaeus dobsoni slowly increased from November to reach the peak in December and then gradually decreased to minimum quantities during April. But M. monoceros yield was reduced successfully, phase after phase. While Penaeus monodon showed gradual increase in yield during successive filtrations, that of P. indicus showed tremendous increase both attaining peak values in March (Plate VI A). Of the total 11329.9 kg shrimp realised, the highest quantity (51.4%) was that of P. indicus followed by that of M. dobsoni (45.18%). M. monoceros contributed to 2.37% whereas the least quantity was of P. monodon (1.04%). In addition, an yield of 3899.25 kg variety fishes and other miscellaneous items were also obtained from the field.

The quantity and quality wise break up of P. indicus collected during successive months is presented in Table 6d & e. The availability was very low during first two months which subsequently picked up to yield highest during March. Of the different fishing methods followed, filtration process contributed to the highest quantity (53.02%) followed by cast netting (35.76%) and the least quantity was realised through hand picking (11.22%). A great majority of P. indicus was of medium sized shrimps of size 10-15 g constituting 54.13%. While large shrimp of size above 15 g comprised 18.14%, the share of small shrimps below 10 g size was 27.72% (Table 6d).

The details presented in Table 6f revealed that from this extensive shrimp culture system, a shrimp production of 559.50 kg/ha/5 months could be obtained. The yield of P. indicus was 287.59 kg/ha against 5.84 kg/ha/5 months for P. monodon. Including fishes and miscellaneous groups the total production was @ 752.06 kg/ha/5 months.

5. **Economics of operation**

The details of operational economics given in Table 6g shows an expenditure of Rs.213093.00 for the entire operation which worked out to Rs.10523.11/ha. An amount of Rs.250881.50 was realised by sale of shrimps and Rs.17638.75 by sale of fishes and miscellaneous items on competitive rates at the form gate. Including the cost of used up items the total income realised was Rs.2,69,620.25 which worked out at Rs.13,314.58/ha. Thus, the shrimp culture endeavour from this 20.25 ha field ended in a net profit of Rs.56,527.25, the margin/ha being Rs.2,791.47/5 months.

6. **Observation**

In contrast to the surprisingly low yield of shrimps realised and consequent losses endured by the operators successively during the preceding 3 years (personal communication) from this traditional field, the operation during 1986-87 showed a remarkably positive trend in shrimp production @ 559.5 kg/ha. This improvement in shrimp yield could be an after effect of the structural changes brought about which increased life sustaining capacity and other operational aspects such as the application of supplemental feed and efficient harvesting. The arrangements made within the system were helpful to maintain a steady intake of tidal water which in turn facilitated the autostocking of more shrimp seed. Often, undersized P. indicus amounting to almost 1/3rd of total catch was caught eventhough judicious approach was followed in all the methods of harvesting. However, through the different methods of harvest more than 90% of the stock was collected.

Table 6c

SHRIMP YIELD FROM AN IMPROVED EXTENSIVE FIELD (20.25 ha) AT KUZHUPILLY DURING 1986-87

Period	Species	*Metapenaeus dobsoni* (kg)	*M. monoceros* (kg)	*Penaeus monodon* (kg)	*P. indicus* (kg)	Total (kg)
November (filtration)	2nd Phase	379.2	75.8	0.5	1.8	457.3
December (filtration)	1st Phase	567.8	60.3	0.7	4.2	633.0
	2nd Phase	753.0	50.6	1.2	9.2	814.0
January (filtration)	1st Phase	692.5	16.8	3.5	126.3	839.1
	2nd Phase	662.4	10.4	6.4	268.6	947.8
February (filtration)	1st Phase	507.4	8.5	9.8	329.8	855.5
	2nd Phase	428.6	5.2	11.3	508.7	953.8
March (filtration)	1st Phase	323.2	7.5	14.2	638.5	983.4
	2nd Phase	281.0	4.2	19.8	704.6	1009.6
March (Cast netting)		258.3	13.3	24.7	2082.7	2379.0
April (filtration)	1st Phase	197.2	9.9	12.5	495.8	715.4
April (Hand picking)		68.4	6.5	13.6	653.5	742.0
Total (%)		5119.0 (45.18)	269.0 (2.37)	118.2 (1.04)	5823.7 (51.4)	11329.9*

* In addition 1828 kg *Oreochromis mossambicus*, 422.5 kg *Etroplus suratensis*, 143 kg mullets, 1379.25 kg Miscellaneous fishes and 126.5 kg crabs were also obtained.

Table 6d

QUALITY WISE DETAILS OF PENAEUS INDICUS HARVESTED FROM DECEMBER 1986 TO APRIL 1987 FROM THE IMPROVED EXTENSIVE FIELD (20.25 ha) AT KUZHUPILLY

Period	*Penaeus indicus*			Total
	Below 10 g size* kg (%)	Between 10 to 15 g size** kg (%)	Above 15 g size *** kg (%)	kg
November 86 (filtration)	1.8	-	-	1.8
December 86 (filtration)	13.4	-	-	13.4
January 87 (filtration)	95.2 (24.11)	232.8 (58.95)	66.9 (16.94)	394.9
February 87 (filtration)	174.8 (20.85)	476.1 (56.78)	187.6 (22.37)	838.5
March 87 (filtration)	365.7 (27.23)	723.5 (53.87)	253.9 (18.90)	1343.1
March 87 (cast netting)	644.5 (30.95)	1218.6 (58.51)	219.6 (10.54)	2082.7
April 87 (filtration)	179.6 (36.22)	213.9 (43.14)	102.3 (20.63)	495.8
April 87 (hand picking)	139.2 (21.30)	287.6 (44.01)	226.7 (34.69)	653.5
Total (%)	1614.2 (27.72)	3152.5 (54.13)	1057.0 (18.14)	5823.7

* = small, ** = medium, *** = large

TABLE 6 e

SIZE RANGE AND MEAN VALUES (mm/g) OF P.INDICUS HARVESTED DURING MARCH 1987 FROM THE EXTENSIVE FIELD(20.25 ha)AT KUZHUPILLY.

Large	Medium	Small
mm - g	mm - g	mm - g
132 - 17.75	115 - 10.62	105 - 8.92
145 - 19.96	121 - 10.91	107 - 8.96
130 - 15.10	122 - 12.50	117 - 9.95
135 - 15.20	123 - 14.97	105 - 8.75
125 - 15.10	124 - 12.77	100 - 7.24
136 - 19.98	119 - 12.92	104 - 8.84
155 - 24.95	115 - 13.08	103 - 7.47
130 - 15.00	130 - 13.95	110 - 9.06
136 - 18.92	126 - 13.98	112 - 9.43
146 - 19.73	125 - 11.40	94 - 6.55
137 - 18.17	122 - 12.71	105.7- 8.52

TABLE 6 f

DETAILS OF SHRIMP CULTURE IN AN IMPROVED EXTENSIVE FIELD(20.25 ha) AT KUZHUPILLY DURING 1986-87

Area of the culture field	: 20.25 ha
Mode of operation	: Improved - extensive
Type of water management	: Tidal
Duration of culture	: 5 months
Quantity of supplemented feed and type	: 700 kg. (Mixed feed of tapioca powder ground nut oil cake and fish meal in equal ratio).
Method of harvesting	: Filtration, cast netting and hand picking.
Production of P. indicus/ha	: 287.59 kg.
Production of P. indicus and P. monodon/ha	: 293.45 kg.
Production of total shrimps/ha	: 559.50 kg.
Total production including miscellaneous groups/ha.	: 752.06 kg.

TABLE 6g

OPERATIONAL ECONOMICS OF AN EXTENSIVE SHRIMP FIELD(20.25 ha) AT KUZHUPILLY DURING 1986-87

	Expenditure	Rs. Ps.
1.	Strengthening of peripheral bunds engaging 50 labourers @Rs.40/-/head	2,000.00
2.	Installation of 3 sluice gates engaging 30 skilled labourers @ Rs.60/-/head	1,800.00
3.	Dewatering expenses by using 40 HP axial pump on contract basis	7,500.00
4.	Excavation of sluice basins, main and subsidiary canals and raising of inner bunds in required manner utilising 485 man-days @Rs.40/-/labourer.	19,400.00
5.	Removal of macro-vegetation and other algal assemblages engaging 225 women labourers @Rs.20/-/labourer.	4,500.00
6.	Repair charges of 3 sluice gates including cost of woden logs and repairs	3,250.00
7.	Cost of sundry items for sluice fixation	750.00
8.	Cost of fabrication of appropriate bamboo screens	2,500.00
9.	Cost of 4 pairs of suitable bagnets and prevention nets for sluice filtration	3,500.00
10.	Expenses towards erecting main shed and watchman shelters at required places.	1,650.00
11.	Cost of torches, whistles, lamps, keresene, basket, bamboo mats, basins etc.	1,850.00
12.	Rent for canoe for 5 months	2,500.00
13.	Cost of feed items	1,569.00
14.	Expenses towards categorisation of harvested items	1,250.00
15.	Wages towards cast netting and hand picking of shrimps @Rs.20/-/kg.	54,724.00
16.	Wages towards fish catch @ half market rate/kg. of fish	7,850.00
17.	Expenses towards special watch engaged on cast netting and hand picking of shrimps.	1,500.00
18.	Lease amount of the field and licence fee	88,500.00
19.	Interest on capital amount	6,500.00
	Total expenditure	2,13,093.00
	Expenditure/ha	10,523.11

Income		Rs. Ps.
Shrimps		
Cost of 5119 kg *M. dobsoni* @ Rs. 6/-/kg.		30,714.00
Cost of 269 kg *M. monoceros* @ Rs. 12/-/kg.		3,228.00
Cost of 1614.2 kg. small *P. indicus* @ Rs. 25/-/kg.		40,355.00
Cost of 3152.5kg medium *P.indicus* @ Rs.37/-/kg.		1,16,642.50
Cost of 1057 kg large *P.indicus* @ Rs. 50/-/kg.		52,850.00
Cost of 118.2 kg *P.monodon* @ Rs.60/-/kg		7,092.00
	Sub total	2,50,881.50
Fishes & Miscellaneous items		
Cost of 1828 kg *O.mossambicus* @ Rs.2.50/kg		4,570.00
Cost of 422.5 kg *E.suratensis* @ Rs. 20/-/kg		8,450.00
Cost of 143.0 kg mullets @ Rs. 20/-/kg		2,860.00
Cost of 126.5 kg crabs @ Rs. 3/-/kg		379.50
Cost of 1379.25 kg trash @ Rs.1/-/kg.		1,379.25
	Sub total	17,638.75
Income by disposal of used up items		1,100.00
Total income from shrimps and all other items		2,69,620.25
Income/ha		13,314.58
Total margin (+) from the endeavour		56,527.25
Therefore Profit (+)/ha of operation		2,791.47

Investigation - A5 : Studies on improved shrimp farming practices in a traditional shallow paddy field of 3.0 ha at Ayyampilly during 1987-88.

1. **Aim**

To study the impact of improved practices — deepening of canals, silt removal, removal of accumulated vegetation, predator elimination and additional seed stocking along with supplementary feeding in the production and economics of shrimp farming.

2. **Introduction**

The age old shrimp farming practice was showing unhealthy trends in production year after year. Though high cost sophisticated technologies are available elsewhere, they seem to have only limited application in our low lying rural farms. Therefore it was felt necessary to design an adaptable technology taking into account the prevailing ecological conditions and poor economic background of the shrimp farming community.

3. **Materials and methods**

3.1 **Location, size and layout**

A traditional field with strong outer bunds having 3 ha area lying amidst extensive paddy fields at Ayyampilly (Fig. 6) in Vypeen island was selected for the study during 1987-88. The rectangular field was ideally located at the confluent junction of two feeder canals running at almost right angles. A main sluice gate and a subsidiary one were fixed appropriately on either sides of the field facing feeder canals.

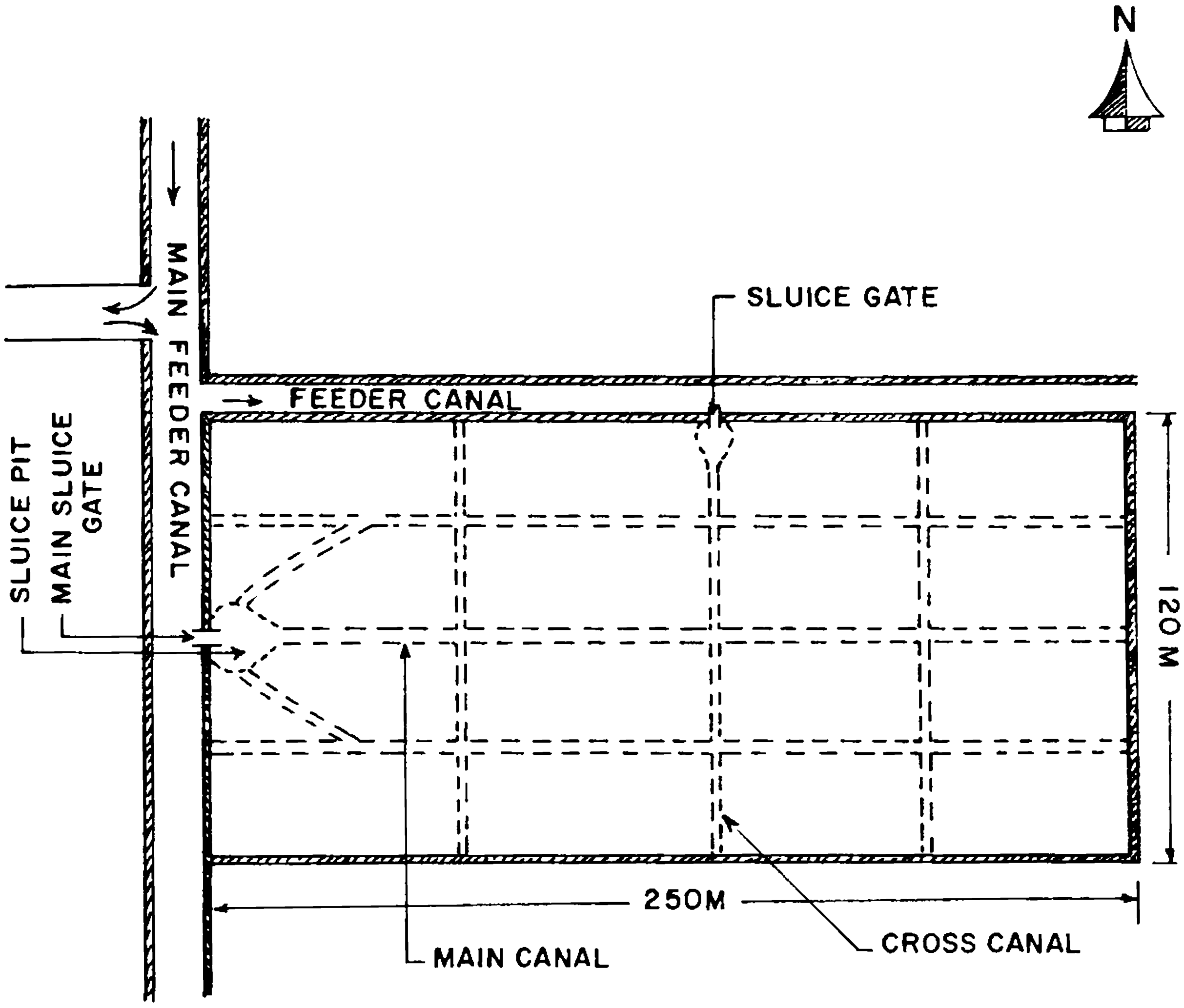


FIG. 6. LAY OUT OF THE FIELD (3·0 Ha.) AT AYYAMPILLY

3.2 Field preparation

Maintenance of peripheral bunds was properly attended to. Interconnecting dykes were also developed whereever necessary leaving gaps at the canal passage. All macrophytes and other unwanted vegetation were immediately removed by mechanical means.

3.3 Substratum

Substratum was composed of silt and clay mixed with remnants of paddy stumps. The fertile substratum showed rich faunal diversity dominated by tanaeidacean *Apseudes* sp. and amphipod *Corophium* sp. Certain unidentified groups of round worms, polychaetes and bivalves were also present in very few numbers.

3.4 Canal system

The accumulated silt was thoroughly removed from the main sluice pit and the major canal radiating from it was properly dug out to reach the periphery. The other existing canals running lengthwise and crosswise within the field were cleared in such a way to maintain connections with the main canal coalesing with the sluice basin. Ample care was also taken to maintain proper inclination of the canals towards the main sluice gate. Flow of water through canals during exchange was ascertained by maintaining proper gaps in the dykes. On the whole, the entire flow pattern within the field during exit and entry of water was so accomplished that even every nook and corner felt the pulse of each tidal exchange.

3.5 Fry stocking

Before start, a preliminary fishing was carried out in the field with cast net and gill net operations. Appropriate screens and nets were used (Plate VI B) to prevent the entry of unwanted fishes to the field thereafter. The shrimp culture operation began during the

PLATE VI

A- Harvested stock of shrimps

B - Nylon mesh screen in front of sluice gate to prevent predators

3rd week of November 1987 by autostocking of shrimp fry in the traditional manner. In addition, one lakh Penaeus indicus seed (Plate I A) of size 20-30 mm collected from wild were introduced into the nursery comprising of four compartments of the field lying far away in opposite direction of the main sluice gate during the 2nd week of December 1987. After release of the seed into the nursery compartments water exchange was permitted through appropriate bamboo screens placed at the opening end. The usual tidal exchange was regularly followed in the field. The screens placed at the mouth of the nursery were removed during last week of January 1988 to facilitate the free movements of shrimps throughout the field.

3.6 Food and feeding

From 3rd week of December 1987, supplemental feeding @ 5% of mean body weight of shrimps was resorted to in the nursery compartments. A pulverised diet made of rice bran, fish meal and ground nut oil cake in the ratio 2:1:2 was used for the purpose while in the general field, feeding was @ 2-3%. Restrictions on feeding while filtration was imposed.

4. Result

4.1 Water quality parameters

The details of surface water quality parameters are presented in Table 7a. The water temperature fluctuated between 29.0 and 31.7°C during January to April. The pH varied between 7.2 and 8.25. The salinity gradually increased from 15.35‰ in November to reach maximum value of 30.0‰ in April. The dissolved oxygen values showed variations between 3.5 and 5.10 ml/L, higher values prevailing during the middle of season. The transparency values were comparatively very low and ranged between 35 and 58 cm.

Table 7a

WATER QUALITY PARAMETERS IN THE IMPROVED FIELD AT AYYAMPILLY DURING NOVEMBER 1987 AND APRIL 1988

Months \ Parameters		Temperature Air (°C)	Temperature Water (°C)	pH	Salinity (‰)	Diss. Oxygen (ml/L)	Transparency (cm)
November	1987	31.3	30.0	7.80	15.35	3.95	35.0
December	1987	31.5	30.4	7.50	21.60	4.75	47.0
January	1988	31.8	29.0	8.25	24.80	5.10	58.0
February	1988	30.2	30.0	7.75	27.50	4.50	55.0
March	1988	32.4	31.5	8.00	29.30	4.30	50.0
April	1988	32.8	31.7	7.20	30.00	3.50	45.0

4.2 Harvest and catch details

From the end of January, periodical harvest was done, through filtration during respective thakkams. A final harvest by cast net operation and hand picking was done during the second week of April at the culmination phase.

The yield of shrimps obtained from a 3 ha shrimp field by different capture methods is presented in Table 7b. A total of 2780.3 kg of shrimps could be realised through the endeavour, of which 2531.0 kg (91.03%) was Penaeus indicus. 219.0 kg (7.88%) Metapenaeus dobsoni and 30.3 kg (1.09%) M. monoceros were also obtained. A progressive improvement in the yield of Penaeus indicus through filtration was noticed from January to April. In the case of Metapenaeids sp. a negative trend was noticed and about 57% of it was caught during the January-February filtrations. Of all catches, the maximum yield (28.16%) was obtained by cast netting practised during the fag end of operation in April. About 10.6% of the total yield was caught by hand picking. 57 kg of miscellaneous fish were also realised through the last two methods of fishing. On the whole maximum catch (52.03%) was obtained during April.

The qualitative details of Penaeus indicus obtained in different months are presented in Table 7c. The shrimps were categorised into three groups based on individual weight. Almost 55% of the shrimps caught through filtration were of good quality. Cast netting provided 53.46% of quality shrimps whereas it was only 52.65% in the case of hand picking. Irrespective of the mode of operation, low quality undersized Penaeus indicus (44.6%) was caught during all months. However only 9.23% constituted size below 5 g.

5. Operational economics

Table 7d describes the statement of expenditure and income of the particular shrimp field for 5 months. The operational expenditure including wages incurred for terminal fishing and interest on capital amount worked out at Rs. 86,045/- for the season. Among this, Rs.8,750/- was spent towards improvement in operation techniques such as excavation of canals, additional stocking and supplementary feeding. An amount of Rs.1,02,608.50 realised from the gross sale proceeds, raised the proposition to a net profit of Rs.16,563.50 within 5 months ie. 5521.17/ha. But for the low unit value realised in the case of prematurely caught, sizeable quantity of Penaeus indicus, the margin would have been superb.

6. Observations

The above results indicated that the rate of shrimp production in this particular field has gone up considerably than what was obtained in contiguous fields during the same period as a result of the simple improvements as seed induction practised in the operation.

Table 7b

MONTHLY BREAK UP OF SHRIMP YIELD FROM A 3 HA IMPROVED FIELD DURING JANUARY-APRIL 1988

Period	*Penaeus indicus* Kg. (%)	*Metapenaeus dobsoni* Kg. (%)	*M. monoceros* Kg. (%)	Total Kg. (%)
January 1988 (filtration)	37.5 (39.39)	49.5 (52.0)	8.2 (8.61)	95.2 (3.42)
February 1988 (filtration) Ist Phase	145.6 (74.82)	42.6 (21.89)	6.4 (3.29)	194.6
				+ (17.37)
2nd Phase	252.7 (87.68)	31.2 (10.83)	4.3 (1.49)	288.2
March 1988 (filtration) Ist Phase	316.4 (92.22)	23.5 (6.85)	3.2 (0.93)	343.1
				+ (27.18)
2nd Phase	391.5 (94.91)	18.4 (4.46)	2.6 (0.63)	412.5
Aprill 1988 (filtration)	354.3 (95.99)	12.7 (3.44)	2.1 (0.57)	369.1 +
Cast netting	745.8 (95.26)	34.6 (4.42)	2.5 (0.32)	*782.9 (52.03) +
Hand picking	287.2 (97.46)	6.5 (2.21)	1.0 (0.34)	*294.7
Total	2531.0(91.03)	219.0(7.88)	30.3(1.09)	2780.3

* 57 kg. miscellaneous fish was also obtained.

Table 7 c

THE BREAK UP OF QUALITY AND UNDERSIZED PENAEUS INDICUS REALISED DURING SUCCESSIVE HARVESTS IN A 3 HA FIELD FROM JANUARY-APRIL 1988.

Month	Quality specimens > 10 g size kg. (%)	Undersized specimens Between 5 & 10g kg. (%)	Undersized specimens Below 5 g kg.(%)	Total kg.(%)	
January (Filtration)	18.0 (48.00)	12.4 (33.07)	7.10 (18.93)	37.5	
February 1988 (Filtration)	214.2 (53.78)	137.4(34.50)	46.7 (11.72)	398.3	
March 1988 (Filtration)	406.8 (57.47)	235.9(33.32)	65.2 (19.21)	707.9	(59.19)
April 1988 (Filtration)	213.2 (60.17)	117.6(33.19)	23.5 (6.63)	354.3	
Cast netting	398.7 (53.46)	286.5(38.42)	60.6 (8.13)	745.8	(29.47)
Hand picking	151.2 (52.65)	105.5(36.73)	30.7 (10.62)	287.2	(11.35)
Total	1402.1 (55.40)	895.3(35.37)	233.6 (9.23)	2531.0	

Table 7 d

EXPENDITURE AND INCOME OF AN IMPROVED 3 HA SHRIMP CULTURE FIELD DURING 1987-88

Operational Expenditure Details	Rs.	Income	Rs.
1. Lease amount and licence fee	44,250.00	1. Cost of 1402.1 kg. P.indicus above 10 g size @Rs.50/-/kg	70,105.00
2. Repair and fixation charges of two sluice gates.	3,975.00	2. Cost of 895.3 kg. P. indicus of size between 5 & 10 g @ Rs. 30/-/kg.	26,859.00
3. Clearing of weeds & excavation of canals	3,250.00	3. Cost of 233.6 kg. P.indicus of size below 5 g @ Rs.15/-/kg.	3,504.00
4. Fabrication charges of work shed	1,075.00	4. Cost of 219 kg.Metapenaeus dobsoni @ Rs. 4/-/kg.	876.00
5. Cost of 1 lakh P.indicus seed @ Rs. 40/-/1000 nos.	4,000.00	5. Cost of 30.3 kg. M. monoceros @ Rs. 15/kg.	454.50
6. Cost of feed	1,500.00	6. Cost of 57 kg. miscellaneous fish @ Rs. 5/- /kg.	285.0
7. Nets, lamps, screens, basins etc.	1,675.00	7. By disposal of used up items	525.00
8. Wages for sluiceman and a watchman @ Rs. 30/-/day for 5 months	9,000.00		
9. Hire charges for canoe for 5 months	914.00	Total income	1,02,608.50
10. Terminal fishing charges	12,396.00	Income/ha.	34,202.83
11. Interest @ 14% for 5 months for Capital amount	3,200.00		
12. Contingency	810.00		
Total expenditure	86,045.00		
Expenditure/ha	28,681.67	Nett profit(+) from 3 ha shrimp culture field within 5 months	16,563.50

Investigation - A6 : Studies on improved shrimp farming practices in a traditional shallow field of 2.25 ha at Narakkal during 1988-89.

1. Aim

To study the impact of location specific variations if any on the improved method followed on shrimp production and its operational economics.

2. Introduction

Age old traditional culture practices (Plate IV A) have indicated that location specific factors are responsible for variation in shrimp production. Hence the investigation illustrated in A 5 was repeated at Narakkal. However, special care was taken to restrict the entry of predators by fixing bamboo and nylon screens in front of sluice gates (Plate VI B).

3. Material and methods

3.1 Location, size and lay out

The 2.25 ha rectangular field was located in an area adjoining the Narakkal bunder canal (Fig. 7). The elongated field with a length of 250 m and width of 90 m had several compartments having interconnections. The depth ranged between 60 and 70 cm. The main and subsidiary sluices were connected to the main feeder canal which in turn opened to the Cochin backwater.

3.2 Field preparation

Soon after paddy harvest in October 1988, existing weeds were removed mechanically taking precautions to prevent their re-entry. Thereafter, the peripheral bunds were strengthened and sluice gates

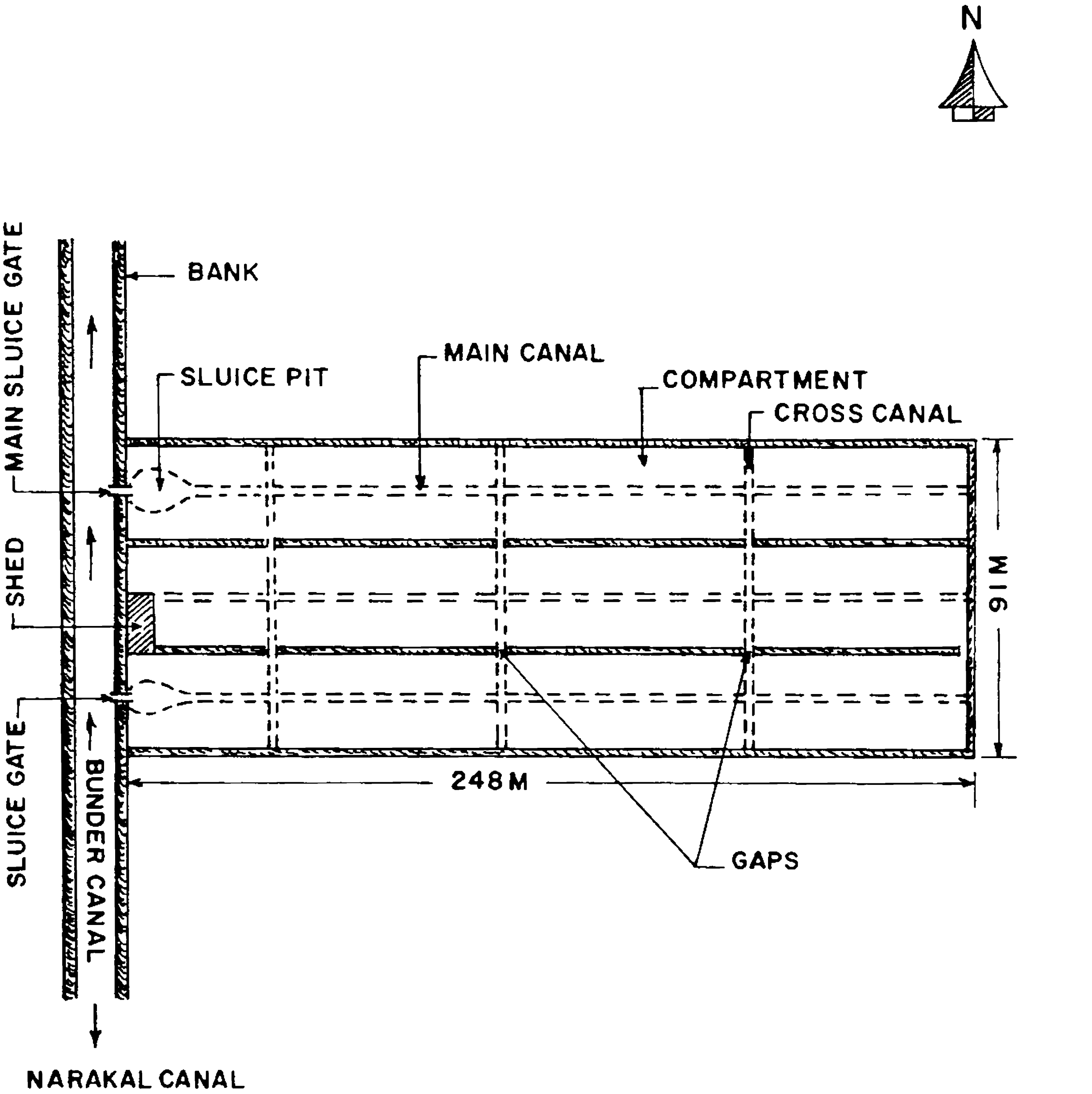


FIG. 7. LAYOUT OF THE IMPROVED FIELD (2·25 Ha.) AT NARAKKAL

with controls fixed. After draining water to the minimum level, soil sealing was done at the sluice gates. The predatory and weed fishes were removed from the field by repeated dragging and gill netting. Subsequently all existing canals were dug out. The inter-bunds and other dykes of the compartments were also properly retained. Desilting from pits and sluice basins was done to the maximum extent. Certain compartments lying adjoining the main canal were properly set up as nursery ponds. The gaps connecting nursery ponds and drain canals were fitted with specially fabricated suitable bamboo screens (Plate V B). The diagonally designed gaps of the nursery could promote efficient water exchange. Closely woven bamboo screens were also fitted to the sluice gates during water exchange. The dirt accumulated on the screens was cleared on alternate days by using suitable wire brushes. In addition, an appropriate nylon net was properly placed in front of the main sluice outside in order to restrict the entry of undesirable species to pond during tidal ingression. Bamboo poles were floated appropriately in front of the sluice gate to keep away floating vegetation and debris during tidal in take. By attending to all the works as described, the pond was got ready for improved shrimp culture practice.

3.3 Substratum

The substratum was somewhat firm composed of loam and clay mostly. A lot of disintegrating debris particles were seen associated with the bottom. Diverse benthic faunal groups such as harpacticoid copepods, bivalves and gastropods were noticed. Nevertheless, tanaidaceans and amphipods were very rare.

3.4 Canal system

From the main sluice pit of the pond, the comparatively deeper and wider primary canal radiated towards the rear end. Another longitudinal canal was seen originated from the subsidiary sluice pit. There were three cross canals within the pond lying equidistantly. In addition a series of secondary and tertiary canals ramified the entire field system each one coalesing with the respective major canal. The pond in general and the different types of canals in particular were lying inclined towards the major sluice basin and pit. This type of disposition was much helpful for better control.

3.5 Tidal flow and fry stocking

The usual ingression and egression of tidal water was carried out daily through sluice gates since November till the end of operation. Suitable screens and nets were also placed in the sluice gates during exit and entry of tidal water. Due care was taken to obtain maximum exchange during tidal processes. By this method, shrimp postlarvae were concentrated within the field as much as possible. A water column varying between 50 and 70 cm was retained in the field depending on tidal process. By middle of December, 1 lakh juveniles of wild P. indicus (Plate I A) of size 25-35 mm were introduced into the nursery compartments ensuring adequate water exchange. The screens of the nursery compartments were removed towards the end of January allowing shrimp young ones to pass into the general field system.

3.6 Food and feeding

From 3rd day of stocking of additional seed, supplemental feed made of fish meal, ground nut oil cake and rice bran in equal proportions was applied daily in the evening @ 10% of body weight. The same feed @ 5% was applied in the field except on days of filtration.

4. Result

4.1 Water quality parameters

The details of surface water quality parameters are presented in Table 8a. The water temeperature varied between 28.5 and 31.5°C. The pH values ranged between 7 and 7.75. The salinity levels gradually increased from 11.8‰ in November to reach the high value of 27.6‰ in April. The dissolved oxygen values also showed increasing trend from the minimum of 3.5 ml/L in November to reach the maximum of 6.0 ml/L during February and then decreased. So also, transparency readings fluctuated between 32 and 57 cm, low values prevailing during postmonsoon months.

Table 8a

SURFACE WATER QUALITY PARAMETERS IN THE IMPROVED SHRIMP FIELD AT NARAKKAL DURING 1988-89

Period / Parameters	Temperature Air (°C)	Temperature Water (°C)	pH	Salinity (‰)	Diss. Oxygen (ml/L)	Transparency (cm)
November 1988	30.5	28.5	7.5	11.8	3.5	32
December 1988	30.0	29.2	7.5	18.5	4.6	43
January 1989	31.5	30.5	7.75	20.3	5.4	48
February 1989	30.8	30.0	7.5	23.4	6.0	57
March 1989	33.0	31.5	7.75	24.8	5.7	54
April 1989	31.5	30.5	7.0	27.6	4.8	40

4.2 Harvest and catch data

From December 1988 onwards, the usual filtration started. However, filtration was carried out only 3-4 days during each lunar phase. But from January onwards when shrimps grew to marketable size, filtration was continued in full swing. By the end of March maximum shrimps were harvested by cast netting by many during filtration phase. Hand picking by several women was arranged during filtration phase of April 1989 when all shrimps could be collected.

The harvest details and components realised by different

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methods are presented in Table 8b. The catch details showed that a total quantity of 1846.4 kg of shrimps was realised during the entire operation of which 1286.6 kg (69.68%) was Penaeus indicus. Thus the total shrimp production worked out to 820.62 kg/ha of which P. indicus accounted for 571.82 kg/ha. Only 29.7% of the catch was contributed by Metapenaeus sp. which showed a decreasing trend as the harvest continued. The penaeids were completely absent during the filtration phase in December, 1988. However, they were obtained by filtration from January 1989 onwards showing an increasing trend during subsequent filtrations. Of the total, 76.01% (1403.5 kg) was contributed by filtration, 16.65% (307.3 kg) by cast netting and 7.34% (135.6 kg) by hand picking. In addition, 159.5 kg of quality fish, 194.5 kg of trash and 76.8 kg crabs were obtained from the field.

Table 8c presents the qualitative and quantitative details of Penaeus indicus, the main component of the catch. The shrimps were categorised into 3 groups according to size variations. Those above 10 g individual size formed better quality (*), between 5 and 10 g size as medium quality (+) and below 5 g size as low quality (@). Of the 1286.6 kg P. indicus realised 999.2 kg (77.66%) was of better quality, the medium and low quality percentages being 16.73% and 5.61% respectively. The percentage of quality shrimp caught was highest by filtration followed by hand picking. The highest percentage of low quality shrimp was collected by cast netting. The availability of medium and low quality shrimp showed an increasing trend towards the fag end of operation.

5. Economics of operation

Table 8d presents the economics of operation of the field during 1988-89. The lease amount, cost involved in the structural modification and other expenses towards additional stocking, maintenance, feeding and harvest put together worked out to Rs.52,425/-. Thus the expenditure/ha of operation was Rs.23,300/-. Ample care was taken to realise maximum unit value by spot disposing of shrimps quality wise. As seen from Table by realising a gross amount of Rs.63,346.50 a net profit of Rs.16,663.70 was obtained by operating a 2.25 ha pond for a period of 5 months; the net profit per ha of operation worked out being Rs. 7,406/-.

6. Observations

Realisation of 70% of *P. indicus* with a shrimp production @ 820.62 kg/ha was an advantage of the technology. Had the premature sacrifice of 287.4 kg of undersized and small *P. indicus* been avoided, production rate could have gone further leading to better economic return. Entry of predatory species could not be efficiently prevented owing to lacunae in the methods.

Table 8 b

CATCH DETAILS OF AN IMPROVED CULTURE FARM (2.25 HA) AT NARAKKAL, VYPEEN ISLAND DURING 1988-89

Period / Species	*Metapenaeus dobsoni* (kg.)	*Metapenaeus monoceros* (kg.)	*Penaeus indicus* (kg.)	*Penaeus monodon* (kg.)	Total (kg.)
December 1988	93.4	9.6	-	-	103.0
(Filtration)	84.1	10.5	-	-	94.6
January 1989	73.8	7.4	72.6	0.2	154.0
(Filtration)	62.3	5.8	97.8	0.6	166.5
February 1989	53.4	3.5	116.5	0.8	174.2
(Filtration)	39.5	2.3	137.8	1.3	180.9
March 1989	30.8	1.7	154.7	1.4	188.6
(Filtration)	19.6	1.2	171.8	1.6	194.2
April 1989 (Filtration)	15.2	0.9	129.7	1.7	147.5
Cast Netting	16.1	2.6	286.3	2.3	307.3
Hand picking	13.2	1.4	119.4	1.6	135.6
Total	501.4 (27.16%)	46.9 (2.54%)	1286.6 (69.68%)	11.5 (0.62%)	1846.4*

* A quality of about 159.5 kg. quality fish, 194.5 kg. trash fish and 76.8 kg. crabs were also obtained.

Production/ha of *Penaeus indicus* = 571.82 kg.
Total shrimp production/ha. = 820.62 kg.
Total production/ha = 1012.09 kg.

Table 8 c

THE RATIO OF QUALITY AND UNDERSIZED PENAEUS INDICUS HARVESTED SUCCESSIVELY FROM 2.25 HA FARM FROM JANUARY TO APRIL, 1989.

	Penaeus indicus			
	*Quality size	Under size		Total (kg)
	> 10 g (kg)(%)	+Between 5-10g (kg)(%)	@<5g (kg)(%)	
January (Filtration) Ist Phase	64.2 (88.43)	7.3 (10.06)	1.1 (1.52)	72.6
January (Filtration) 2nd Phase	86.4 (88.34)	9.6 (9.82)	1.8 (1.84)	97.8
February Ist Phase	102.8 (88.24)	11.5 (9.87)	2.2 (1.89)	116.5
February 2nd Phase	119.1 (86.43)	14.7 (10.67)	4.0 (2.90)	137.8
March Ist Phase	131.5 (85.00)	18.4 (11.89)	4.8 (3.10)	154.7
March 2nd Phase	138.4 (80.56)	25.8 (15.02)	7.6 (4.42)	171.8
April (Filtration)	92.3 (71.16)	22.4 (17.27)	15.0 (11.57)	129.7
Cast Netting	179.8 (62.80)	75.7 (26.44)	30.8 (10.76)	286.3
Hand picking	84.7 (70.94)	29.8 (24.96)	4.9 (4.10)	119.4
Total	999.2 (77.66)	215.2 (16.73)	72.2 (5.61)	1286.6

* = Better quality, + = Medium quality, @ = low quality.

Table 8d

ECONOMICS OF OPERATION OF 2.25 ha SHRIMP CULTURE FARM AT NARAKKAL DURING 1988-89

Income		Expenditure	
Cost of 501.4 kg *M. dobsoni* @ Rs.5/-/kg.	Rs. 2,507.00	Lease amount	Rs. 18,500.00
Cost of 46.9 kg *M. monoceros* @ Rs.9/-/kg.	422.10	Charges for deweeding & canal excavation (65 men labourers @ Rs.30/- and 40 women labourers @ Rs.20/- per day)	2,750.00
Cost of 72.2 kg low quality *P. indicus* @ Rs. 15/-/kg.	1,083.00	Repair and fixation charges for sluice gates (items worth Rs.1200/- and wages for 6 persons @ Rs.50/- day)	1,500.00
Cost of 215.2 kg of medium quality *P. indicus* @ Rs. 30/-/kg.	6,456.00	Expenses for shed making (items worth Rs.350/- and Rs.100/- towards wages)	450.00
Cost of 999.2 kg of better quality *P. indicus* @ Rs.52/-/kg.	51,958.40	Bamboo screen making (material & labour)	850.00
Cost of 11.5 kg *P. monodon* @ Rs.80/-/kg.	920.00	Sluice nets and cast nets	1,250.00
Total of shrimps	63,346.50	Lanterns, baskets & basins	750.00
Other items		Canoe rent	700.00
Cost of 159.5 kg quality fishes @ Rs.25/-/kg.	3,987.50	Cost of 1 lakh shrimp juveniles	7,500.00
Cost of 194.5 kg trash fishes @ Rs.5/kg.	972.50	Expenses for nursery arrangement & rearing	375.00
Cost of 76.8 kg crabs @ Rs.4/kg.	307.20	Cost of feed items	800.00
By disposal of used items	475.00	Wages for 1 watchman & 1 sluice man	7,500.00
Sub-total	5,742.20	Wages for sorting items	500.00
Total income from shrimps & other items	69,088.70	Wages for cast net operation	4,300.00
Income/ha.	30,706.09	Wages towards hand picking	1,750.00
Net profit (+)	16,663.70	Wages for fish capture	1,500.00
Nett profit (+)/ha.	7,406.09	Interest on capital amount @ 11.5% for 5 months	1,450.00
		Total expenses	52,425.00
		Expenditure/ha.	23,300.00

COMPARATIVE ANALYSIS OF CULTURE, YIELD AND ECONOMICS OF TRADITIONAL SHRIMP FIELDS FROM DIFFERENT LOCATIONS ALONG VEMBANAD LAKE

A comparative account on shrimp culture operations carried out from November 1986 to April 1989 in 6 fields located at different places in Vypeen island adjoining Vembanad lake is furnished in Table 9. The size of field varied from 0.8 ha. at Pooyapilly to 20.25 at Kuzhupilly. The shape of fields was generally rectangular in all cases except the extensive field at Kuzhupilly which was almost rhombus type. Fairly deeper fields, with sand and clay bottom characteristics were located at Thrikkadakapilly (Cherai) (1.60 ha) and Kuzhupilly (20.25 ha). While the field at Thrikkadakapilly was perennial (Plate IV B), the rest were seasonally operated. The 2.38 ha field at Nayarambalam was operated exclusively in traditional manner (Plate IV A) where as at Thrikkadakapilly, Pooyapilly and Kuzhupilly, certain desirable modifications such as clearing of canals and sluice pits to increase the water holding capacity have been made. These fields were categorised as modified traditional. But, considerable improvements in the internal structure to facilitate better water management for enhancing the life carrying capacity, have been incorporated in the fields at Ayyampilly (3 ha) and Narakkal (2.25 ha) categorising both as improved. In all the above cases, shrimp seed entry mainly depended on tidal processes. However, in the case of improved fields at Ayyampilly and Narakkal, one lakh shrimp seed each collected from natural sources have been additionally stocked apart from those regularly autostocked. Supplemental feeding with fish meal, rice bran and goc has been done in the improved and modified traditional fields. Nevertheless, no feeding has been done in the modified field at Pooyapilly and traditional field at Nayarambalam. In all cases water management was through natural tidal processes. The mean tidal gradient was the highest (70-80 cm) at Thrikkadakapilly and Pooyapilly. The lowest (30-40 cm) was at Nayarambalam where as in other three fields, the tidal amplitude was almost similar (40-60 cm). The fields at Kuzhupilly were influenced by the Munambam barmouth and that at Narakkal by Cochin barmouth both places being located equidistantly from respective barmouths.

The harvesting operations were almost similar in all cases. Filtration, cast netting and hand picking were commonly employed to completely harvest the respective systems.

Table 9 also revealed that in the improved fields at Narakkal and Ayyampilly, the production of quality shrimp P. indicus was very much higher than that of other systems studied. The respective increases were 119.6% and 224.0% more than what was yielded from the exclusively traditional field at Nayarambalam. Therefore, it stands to reason that the production of P. indicus @ 571.82 kg/ha and 843.67 kg/ha correspondingly obtained at Narakkal and Ayyampilly was related to the extent of structural modifications made in the system and the induction of seed along with supplementary feed. Again realisation of unusually high percentages viz. 69.68 and 91.03% of P. indicus from the total shrimp catch respectively at Narakkal and Ayyampilly was the result of stocking with wild seed to the tune of 1 lakh each in the improved system.

Among modified traditional fields highest percentage contribution of P. indicus (51.4%) was achieved at Kuzhupilly. At Thrikkadakapilly and Pooyapilly, the values were 27.18 and 32.8% respectively. But, the yield of metapenaeids remained fairly high as characteristic of traditional filtration systems. Eventhough the traditional field at Nayarambalam also produced a much high percentage of P. indicus (50.36%), it comprised of low quality shrimps mainly. The relatively shallow nature and associated characteristics of the purely traditional filtration system might have contributed to this low quality. At Kuzhupilly, the rate of shrimp production was found much higher with dominance of P. indicus perhaps due to the deeper and extensive nature of water body.

Again on a unit area basis, the yield of P. indicus increased @

10.5, 16.8 and 72.8% in the modified traditional fields at Kuzhupilly, Pooyapilly and Thrikkadakapilly, respectively over that obtained at the purely traditional field, at Nayarambalam. This indicated the significance of nearness of above fields to the main feeder source resulting in quality shrimp production, regardless of other inherent factors favouring growth.

So also, the performances in terms of total shrimp production per unit area at Thrikkadakapilly and Pooyapilly were 1371.88 and 1118.61 kg/ha respectively. While the modified traditional, extensive field at Kuzhupilly produced 559.5 kg/ha of shrimps, that of improved field at Ayyampilly was 926.77 kg/ha. A fairly good shrimp yield @ 820.6 kg/ha was obtained from the improved field at Narakkal compared to the least production @ 516.97 kg/ha reported from the traditional field at Nayarambalam.

The above showed that the production at Pooyapilly (seasonal field) and Thrikkadakapilly (perennial) was 2-2½ times respectively higher than that at Nayarambalam. Eventhough the fields at Thrikkadakapilly and Pooyapilly were located within a distance of 1.5 km, fairly high yield was realised from the former. While the field at Thrikkadakapilly directly opened into the main water body, the field at Pooyapilly communicated only to its tributory. The proximity of the field to main feeder canal and its nearness to barmouth were always advantageous to have efficient exchange with quality water which in turn promoted shrimp production. In this context, it could be also noted that the seed recruitment prospects of perennial field in Thrikkadakapilly at Cherai was far better than that of seasonal field at Pooyapilly and other places studied.

From the quality point of view, the highest mean sized P. indicus obtained was in the order 15.44 g (129.5 mm) from the deep extensive seasonal field at Kuzhupilly, 15.25 g (130.4 mm) from the deep perennial field at Thrikkadakapilly, 14.00 g (123.1 mm) at Pooyapilly, 13.86 g (122.8 mm) at Ayyampilly, 13.65 g (122.5 mm) at

Narakkal and 12.58 g (121.1 mm) at Nayarambalam. The same trend was maintained in the case of low quality shrimp also. From the point of total production of shrimps and fishes an increase of 34.3% and 34.95% respectively at Pooyapilly and Thrikkadakapilly was noted over that of Nayarambalam. But, a relatively higher production was attained at Nayarambalam than at Ayyampilly and Narakkal on account of the predominance of Oreochromis mossambicus in the catch. The lowest rate of production ie. @ 752.06 kg/ha at the modified traditional extensive field (Plate V A) at Kuzhupilly, attained only 58.24% of that at Nayarambalam.

In the four fields wherein supplemental feeding was resorted, the quality and quantity of P. indicus produced was higher compared to the fields at Nayarambalam and Pooyapilly where no feeding was carried out. However, at Kuzhupilly, eventhough the quantity wise increase was not much, the supplementary feeding has definitely contributed for the better quality.

In spite of supplementary feeding, the total production in the two improved fields at Ayyampilly and Narakkal and the modified traditional field at Kuzhupilly remained fairly low. This might be on account of the elimination of all the unwanted species before start of the operation.

The drastic difference in the yield of P. indicus among improved, modified and traditional fields clearly point out the advantages of induction of P. indicus fry in the fields especially when the backwater in the present day situations is found incapable of providing sufficient fry through autostocking alone.

The highest expenditure per hectare ie., more than double the rate at traditional field was incurred at the improved fields at Narakkal and Ayyampilly. However, the rate of return was commensurate with the expenditure. The lowest expenditure rate was noticed in the case of modified traditional and extensive field at Kuzhupilly.

However, the expenditure rate at Thrikkadakapilly was 25% more than at Pooyapilly. In terms of value realisation, the maximum profit/ha was obtained from the improved fields at Narakkal and Ayyampilly. Among modified traditional fields higher profit/ha was recorded at Thrikkadakapilly followed by Pooyapilly and Kuzhupilly. The lowest profit/ha was realised from the traditional field at Nayarambalam.

The net result of operation in modified fields revealed certain interesting features. While almost 5½ times more profit was achieved at Thrikkadakapilly than at Nayarambalam the level of profit at Pooyapilly and Kuzhupilly was only about 3½ times. However, considering the vast extent and the relatively low expenditure incurred, the margin per unit area attained in the modified traditional field at Kuzhupilly seemed to be very much promising. This fact also suggested that the total extent of the field also governs a lot in determining the profit level in traditional culture systems in contrast to the advantages of small units suggested for semi-intensive farming systems (Yap et al., 1979).

The considerably low rate of production and relatively low gain resulted in the purely traditional field indicated the need for certain structural modifications to be taken care of in the seasonal farming systems (Purushan, 1987). Steps adopted in this direction in the traditional shrimp culture systems located vide apart at Kuzhupilly, Pooyapilly and Thrikkadakapilly - showed its impact through increases in shrimp production and profit level.

Table ..9......

DETAILS OF CULTURE, YIELD AND ECONOMICS OF TRADITIONAL/IMPROVED FIELDS FROM DIFFERENT LOCATIONS IN VYPEEN ISLAND, KOCHI ADJOINING VEMBANAD LAKE DURING 1986-1989

Particulars / Location	Nayarambalam	Pooyapilly	Thrikkadakapilly	Kuzhupilly	Ayyampilly	Narakkal
Area of field (ha)	2.38	0.80	1.6	20.25	3.0	2.25
Type of field	Rectangular and shallow	Rectangular and shallow	Rectangular and deep	Extensive rhombus type and deep	Rectangular and shallow	Rectangular and shallow
Nature of substratum	Silt and clay	Silt and clay	Sand and clay	Sand and clay	Silt and clay	Silt and clay
Extent of change in field structure	Traditional	Modified Traditional	Modified traditional	Modified traditional	Improved	Improved
Mode of operation	Seasonal	Seasonal	Perennial	Seasonal	Seasonal	Seasonal
Source of shrimp seed	Shrimp larval entry by regular tidal processes	Shrimp larval entry by regular tidal processes	Shrimp larval entry by regular tidal processes	Shrimp larval entry by regular tidal processes	Shrimp larval entry by regular tidal processes + seed induction	Shrimp larval entry by regular tidal processes + seed induction.
Supplemental feeding/ No feeding	No feeding	No feeding	Supplemental feeding by pulverised feed	Supplemental feeding by pulverised feed	Supplementary feeding with pulverised feed	Supplementary feeding with pulverised feed
Type of water management	Tidal	Tidal	Tidal	Tidal	Tidal	Tidal
Mean tidal gradient(cm)	30-40	70-80	70-80	40-60	40-60	45-65
Year of operation	11/88 to 4/89	11/88 to 4/89	6/87 to 4/88	11/86 to 4/87	11/87 to 4/88	11/88 to 4/89
Duration of culture(Months)	5	5	11	5	5	5
Harvesting methods	Filtration, cast netting and hand picking	Filtration, cast netting and hand picking	Filtration, cast netting and hand picking	Filtration, cast, netting and hand picking	Filtration, cast netting and hand picking	Filtration, cast netting and hand picking
Mean size of quality *P. indicus*(g/mm)	12.58(121.1)	14.0(123.1)	15.25(130.4)	15.44(129.5)	13.86(122.8)	13.65(122.5)
Mean size of low quality *P. indicus*(g/mm)	6.23 (98.0)	8.03 (106.4)	8.52 (106.3)	8.52 (105.7)	6.80 (102.0)	6.65 (101.7)
Production/ha of *P. indicus* (kg)	260.34	304.0	449.94	287.59	843.67	571.82
Production/ha of all shrimps (kg)	516.97	1118.61	1371.88	559.5	926.77	820.62
Total production/ha including shrimps, fishes and miscellaneous items(kg)	1291.34	1734.24	1742.69	752.06	945.77	1012.09
Average amount realised/ha(Rs)	14570.82	21029.06	27586.03	13314.58	34202.83	30706.09
Average expenditure/ha (Rs)	13766.81	18181.94	23150.00	10523.11	28681.67	23300.00
Net profit amount/ha (Rs)	804.01	2847.12	4436.03	2791.47	5521.17	7406.09

2.4 Group : B

Case studies on improved practices of shrimp — P. indicus and P. monodon — farming in grow out systems adjoining Vembanad lake from Narakkal in the north to Pallithode in the south during 1986-91

Salient features

Owner operated with liberty for unlimited modifications - monoculture, selective stocking, supplemental feeding, water management by pumping in addition to tidal, terminal harvest etc.

Case study B1 : Experimental culture of *P. indicus* in grow out system at Narakkal during January-April, 1987.

Case study B2 : Experimental culture of *P. indicus* in 4 grow out ponds at Puduveypu during January-April, 1987.

Case study B3 : Experimental culture of *P. indicus* at Narakkal Harijan Fish Farm during February-May 1989.

Case study B4 : Experimental culture of *P. monodon* in canals between coconut groves at Pallithode, Alappuzha during March-June, 1988.

Case study B5 : Experimental culture of *P. monodon* in the canals of a coconut grove at Chalippuram, Kochi during November 90 - March 91.

Case study B6 : Experimental culture of *P. indicus* at Cherungal, Thuravoor during March-April, 1989.

Case study B7 : Experimental culture of P. monodon during monsoon (operation a) and P. indicus during season (operation b) at Karumancheri, Thuravoor during 1986-87.

Aim

These experiments were aimed at a) to test the efficacy of different feeds on growth and production of P. indicus in an existing field at Narakkal (B1).

b) to assess the techno-economic feasibility of 4 sites viz, newly accreted wet land at Puduveypu and newly excavated farm at Narakkal for P. indicus culture; canals between coconut groves at Pallithode and canals of paddy field transformed coconut grove at Chalippuram for P. monodon culture (B2-B5).

c) to assess the impact of short duration high density farming of P. indicus and its operational economics at Cherungal (B6).

d) to workout the prospects of increased production by rotation of P. monodon farming during monsoon and P. indicus farming during season in the same pond at Karumancheri (B7).

e) to test the effect of culling on growth of P. indicus at Narakkal (B3).

Case study - B1 : Experimental culture of P. indicus in a grow out system at Narakkal during January-April, 1987.

1. Aim

To test the efficiency of the different feeds on the culture of P. indicus in an existing field.

2. Introduction

Non availability of suitable commercial feed remains as one of the major constraints in the shrimp farming development, eventhough shrimpsare in high export demand. Supply of quality feeds along with other management aspects assumes significance in raising shrimp production from unit area within shortest possible time. Therefore an experimental shrimp culture was carried out at Narakkal (Fig. 1) to understand the performance of growth of P. indicus in conventional culture systems by providing locally available and cheap feeds with a view to develop low cost shrimp farming technology.

3. Material and methods

3.1 System set up

The experiment was carried out in four compartments set up ideally in a general shrimp filtration system at Narakkal. Of the 4, two compartments measured 425 m^2 each, whereas the other two had 500 m^2 area each. All the four compartments were rectangular in shape with firm muddy bottom and with water depth varying between 60 and 75 cm. Each of these compartments was connected to the central median canal of the field through respective opening in the dyke. The 8 ha shrimp filtration field opened into the common bunder canal through the main and a subsidiary sluice gate. Another sluice gate fitted at right angles also opened to the branch of the feeder canal. The tidal amplitude generally varied between 45 and 65 cm in the area.

During early January, 1987, all the bunds of the 4 compartments were strengthened properly and the gates soil sealed after letting out water to the maximum extent possible. Afterwards, mahua oil cake (Plate II B) was applied in all 4 compartments @ 200 ppm. After 12-14 days, nylon net screen was fitted in the openings of the respective compartments, to facilitate tidal exchange.

3.2 Water exchange

Since they were separated with net partition and made confluent with general filtration system, the tidal exchange within the field could be experienced in the compartments. The tidal exchange process was continued for about 2 weeks until the conditions within the systems were normalised for shrimp stocking. The compartments were named as 1, 2, 3 and 4 and each was used for separate treatments.

3.3 Substratum

The substratum was more or less firm composed of hardened loam and clay mostly. A lot of disintegrating debris particles were seen associated with the bottom. Diverse benthic faunal groups such as harpacticoid copepods, polychaetes, bivalves and gastropods were noticed. However, tanaeidaceans and amphipods were very rare.

3.4 Fry stocking

Simultaneously Penaeus indicus fry were collected from nearby waters. The healthy and more or less uniform sized fry were sorted out (Plate VII A) and kept properly in hapas (Plate I B) for stocking purposes. On ascertaining suitability of water conditions in the compartments, the fry were carefully released (Plate VII B) into the 4 compartments under definite stocking densities @ 50,000/ha and as per details shown in Table 10a. After stocking, normal exchange was continued in the compartments.

Table 10a

EXPERIMENTAL SHRIMP CULTURE IN GROW OUT SYSTEMS AT NARAKKAL DURING JANUARY-APRIL, 1987

Details	Compartment 1	Compartment 2	Compartment 3	Compartment 4
Area (m^2)	425	425	500	500
Date of stocking	23.1.1987	23.1.1987	23.1.1987	23.1.1987
No. of shrimps stocked	2125	2125	2500	2500
Stocking density	@ 50000/ha	@ 50000/ha	@ 50000/ha	@ 50000/ha
Mean size length and weight at stocking mm (g)	19.4 (0.041)	19.4 (0.041)	19.4 (0.041)	19.4 (0.041)
Date of harvest	13.4.1987	13.4.1987	13.4.1987	13.4.1987
Duration of culture (days)	80	80	80	80
No. harvested	1286	1193	1462	1689
Percentage survival	60.5	56.14	58.48	67.56
Mean size at harvest mm (g)	124.1 (13.322)	116.8 (11.052)	115.5 (11.82)	105.3 (7.925)
Yield obtained (kg)	17.10	14.95	17.23	13.45
Production/ha (kg)	402.35	351.76	344.60	269.00
Nature of treatment	Pulverised feed + clam meat	Pelleted feed	Cowdung manuring	Control
Type of water management	Tidal	Tidal	Tidal	Tidal

PLATE VII

A - Shrimp seed collection and seggregation

B - Shrimp fry release

3.5 Feed preparation and feeding

After 2 days, feeding and manuring were started in the compartments. In compartment 1, pulverised feed comprising of ground nut oil cake (g.o.c.), tapioca flour and rice bran in 2:1:1 ratio plus ground clam meat was supplied @ 8% body weight of shrimps. A commercial pellet feed was supplied @ 5% body weight of shrimps in compartment 2.

For the preparation of pulverised feed, powdered ingredients as per ratio were weighed and removed to a clean enamel tray and thoroughly mixed by hand. Adequate quantity of clean water was then added gently to the mixture to prepare it in the form of mash for immediate use.

Fresh clam meat was crushed into small pieces of 5-8 mm size by suitable means. The same procedure was followed in the preparation of feed during each time. The bio-chemical composition of feed is given in Table 10b.

Table 10b

BIO-CHEMICAL COMPOSITION OF FEED

Type	Ingredients & ratio	Percentage composition on dry weight basis						
		Mois-ture	CHO	Protein	Fat	Ash	Energy K.cal /g	Energy K.cal /kg
Pulverised	goc* + tapioca flour + rice bran 2:1:1	11.79	66.87	11.0	0.66	9.68	3.17	3170
**commercial pellets	unknown	16.15	41.74	27.37	0.16	14.58	2.78	2780

* ground nut oil cake ** procured through the MPEDA

Type	Percentage composition on wet weight basis					
	Acid insolubles	Moisture	Protein	Fat	Ash	Glycogen
Clam meat (*Villorita cyprinoides*)	0.38	78.50	10.09	2.52	0.88	6.68

In compartments 1 and 2, feed supply was in similar manner. Sufficient quantity of respective feed was spread in suitable wide mouthed earthen containers (feed trays) and immersed in several predetermined points in each compartment for feeding (Plate VIII A) usually during evening hours. The empty containers were lifted up during following morning and sundried before they were used again. The process was repeated from start to finish of operation.

In compartment 3, weekly doses of cowdung manuring using bamboo baskets was done @ 2.5 tonnes/ha/yr., whereas compartment 4 was left as such as control. Except for the treatments mentioned, all other aspects of operations were identical.

3.6 Culture operations

The experiment was carried out for a period of 80 days from 23.1.1987 to 13.4.1987 when harvesting of all compartments was done. The water was drained during ebbing to the extent possible and the rest of the water was pumped out using a 5 HP diesel pump. All the shrimps were caught by cast netting and hand picking on the same day.

4. Results

4.1 Water quality parameters

Water quality parameters were regularly observed in all compartments. The important parameters such as water temperature, pH, salinity and dissolved oxygen fluctuated within the range of 28.5 - 32.5°C, 7.0-8.5, 17.5-31.5‰ and 3.15 - 4.75 ml/L respectively in all compartments.

4.2 Growth measurements and harvest data

The mean growth values recorded periodically in compartments 1-4 are presented in Table 10c. The mean size of P. indicus at the time of stocking was 19.4 mm (0.041 g) in all the 4 compartments. Subsequently, the mean values showed variations in different compartments depending upon treatments. After one month of growth, the mean values recorded from compartments 1 to 4 were 92.0 mm (4.959 g), 77.6 mm (3.602 g), 76.2 mm (2.986 g) and 73.2 mm (2.458 g) respectively. The corresponding mean values assessed during March were 111.9 mm (9.804 g), 110.8 mm (9.431 g), 106.8 mm (7.963 g) and 95.7 mm (4.878 g) in compartments 1-4 in order. But when harvested after 80 days, the shrimps had grown to the mean sizes of 124.1 mm (13.322 g), 116.8 mm (11.052 g), 115.5 mm (11.820 g) and 105.3 mm (7.925 g) respectively in compartments 1-4 (Table 10a).

The rate of growth and growth increment values recorded periodically are presented in Table 10d. From the initial mean size of 19.4 mm (0.041 g), the growth rates reached 104.7 mm (13.281 g), 97.4 mm (11.011 g), 96.1 mm (11.779 g) and 85.9 mm (7.884 g) respectively in compartments 1-4 after 80 days. Best growth by weight was seen in compartment 1 followed by 3, 2 and 4 indicating that treatments are effective in promoting shrimp growth.

As seen in Table 10d the growth increment values were higher during the first two months in case of all treatments whereas in the third month the growth increments were very low except in the control.

Data pertaining to length and weight of individual shrimps on the harvest day (Table 10a) from all the four compartments were

Table 10 c

MEAN VALUES OF GROWTH OF PENAEUS INDICUS FED WITH DIFFERENT FEEDS UNDER NATURAL CONDITIONS AT NARAKKAL DURING JANUARY - APRIL 1987

Date of Observation	Compartment 1 Pulverised feed + clam meat.	Compartment 2 Pelleted feed	Compartment 3 Cowdung manuring	Compartment 4 Control
	mm g	mm g	mm g	mm g
23.1.1987 (initial)	19.4 - 0.041	19.4 - 0.041	19.4 - 0.041	19.4 - 0.041
19.2.1987	92.0 - 4.959	77.6 - 3.602	76.2 - 2.986	73.2 - 2.458
19.3.1987	111.9 - 9.804	110.8 - 9.431	106.8 - 7.963	95.7 - 4.878
13.4.1987	124.1 -13.322	116.8 -11.052	115.5 -11.820	105.3 - 7.925

Table 10 d

MEAN VALUES OF RATE OF GROWTH mm(g) AND GROWTH INCREMENT mm(g) OF P.INDICUS SUPPLIED WITH DIFFERENT FEEDS IN DIFFERENT TREATMENT COMPARTMENTS UNDER NATURAL CONDITIONS AT NARAKKAL DURING JANUARY-APRIL, 1987.

Date of observation	Compartment 1		Compartment 2		Compartment 3		Compartment 4	
	Rate	Growth Incr.	Rate	Growth Incr.	Rate	Growth Incr.	Rate	Growth Incr.
	mm g	mm g	mm g	mm g	mm g	mm g	mm g	mm g
23.1.1987	19.4-0.041	-	19.4-0.041	-	19.4-0.041	-	19.4-0.041	-
19.2.1987	72.6-4.918	72.6-4.918	58.2-3.561	58.2-3.561	56.8-2.945	56.8-2.945	53.8-2.417	53.8-2.417
19.3.1987	92.5-9.763	19.9-4.845	91.4-9.390	33.2-5.829	87.4-7.922	30.6-4.977	76.3-4.837	22.5-2.420
13.4.1987	104.7-13.281	12.2-3.518	97.4-11.011	6.0-1.621	96.1-11.779	8.7-3.857	85.9-7.884	9.6-3.047

statistically analysed. The results obtained are furnished in the ANOVA Table.

ANOVA TABLE

	SS	df	MS	F
Between feeds	0.3062	3	0.10207	5.68**
Error	0.647306	36	0.01798	
Total	0.9535	39		

** P (< 0.01)

The F value is found to be highly significant ($P < 0.01$). This indicates that the mean weight of shrimp obtained was highly significant between compartments. This was further tested for difference, if any between the three treatments adopted versus the control. The SS of three treatments taken together was calculated to be 0.2435. When tested against the Error mean square $F = 13.54$ which is again highly significant. This means that the growth assessment of three treatments taken together is very much different from that of control. A perusal of the mean weights obtained from treatment ponds clearly indicates the advantages of feed in compartment 1 over the other two mean weights, the values respectively being 13.32, 11.05 and 11.82 g.

5. Observations

Since the experiment was carried out in small compartments set up within the large extensive field, full control over the management aspects was not possible. Elimination of predatory species was done through application of mahua oil cake. No bottom drying was practised.

The short duration farming showed the efficacy of clam meat in promoting growth and production of *P. indicus* in natural culture systems.

Case study - B2 : Experimental culture of *P. indicus* in grow out ponds at Puduveypu during January-April, 1987

1. Aim

To assess the feasibility of a recently accreted wet land for culture of *P. indicus* fed on three different feeds.

2. Introduction

Puduveypu is a recently accreted wet land along the south-western tip of Vypeen Island (Fig. 1). The wet land ecosystem at Puduveypu is quite unique with respect to the slushy substratum and the overlying turbid brackish water characteristics. Though commercial shrimp species are available in this area, no organised shrimp farming is seen undertaken. Assessment of shrimp culture prospects in this area will help much for the profitable utilization of derelict water bodies.

3. Material and methods

3.1 Pond location and layout

Four almost identical and rectangular sized ponds (Plate VIII B) each having an area of 425 m^2 were located on the side of a feeder canal at Puduveypu. The substratum consisted of loose mud since the ponds were excavated in a recently accreted wet land. However, the bunds were made very strong, by dumping firm earth from suburban areas. Each pond was independent with a sluice gate (Plate IX A) which directly opened into the feeder canal.

3.2 Pond preparation

By middle of January, all ponds were properly drained, desilted and prepared for *P. indicus* culture adopting standard procedure

PLATE VIII

A - Feed supply in earthern pots

B - Culture system series at Puduveypu

(Natarajan, 1985). All ponds were soil sealed and kept dried for a period of 3 days in order to eliminate the unwanted weed and fishes if any remaining. The water depth varied between 75 and 80 cm. The ponds were numbered 1 to 4 from left to right.

3.3 Substratum

The substratum was composed of silt and clay mixed with calcareous deposits. Decaying vegetation, disintegrating logs and other fine debris were also seen associated at the bottom. Though benthic faunal diversity was not predominant, tanaeidaceans, amphipods, polychaetes and bivalves were represented. The soil test values and ratings are presented in Table 11a.

Table 11a

SOIL TEST VALUES AND RATINGS AT PUDUVEYPU DURING 1987

Particulars / Period	Soil type	Soil pH	TSS	Organic Carbon (%)	Average Phosphorus (kg/ha)	Average Potassium (kg/ha)
January 1987	Clayey	4.7	3.1	1.34	24.2	390
February 1987	"	5.8	8.3	1.47	28.6	390
March 1987	"	4.5	8.7	1.22	88.0	390
April 1987	"	6.9	6.6	1.10	61.6	390

3.4 Water exchange

Tidal water was allowed in all ponds through proper nylon screens kept inside the sluice gate. Since water was turbulent and silt laiden, much care was taken to admit supernatant layers of water with relatively less silt load. Exchange was continued for a period of 3-4 days to make it on par with the conditions prevailing outside.

3.5 Fry stocking

Side by side Penaeus indicus seeds were collected from natural areas. More or less uniform sized fry were sorted out and kept under hapa rearing (Plate I B) for stocking purposes. When sufficient number of seeds were got ready, stocking was done on 29.1.1987 in all ponds keeping a definite stocking density @ 53,000/ha. The particulars of stocking and other details in respect of all ponds are furnished in Table 11b.

3.6 Feeding

From the following day of stocking, treatments such as manuring, pellet feeding and mixed feeding in required doses were followed regularly in ponds 1 to 3 respectively keeping pond 4 as control. In pond 1, manuring 0.8 kg cowdung per week was done. In pond 2, commercial shrimp feed pellets were applied @ 3-5% of body weight/day. Pulverised feed comprising of rice bran, tapioca flour, ground nut oil cake in the ratio of 1:1:2 and crushed clam meat in almost 1/3rd quantity was daily applied @ 8-10% of body weight in pond 3. The mode of feeding and treatment of trays were as described in B1 (Plate VIII A). The details of composition of different feeds are as furnished in Table 10b.

3.7 Culture operations

The experiment was continued for 85 days from 29.1.87 to 24.4.87. Details of inputs supplied are given in Table 11b. Except for the difference in feed, all other procedures were identical in all cases.

TABLE 11 b

EXPERIMENTAL CULTURE OF PENAEUS INDICUS IN GROWOUT PONDS USING DIFFERENT FEEDS.

Ponds / Particulars	1	2	3	4
Area (m^2)	425	425	425	425
Date of stoking	29.1.87	29.1.87	29.1.87	29.1.87
No.of shrimps stocked	2250	2250	2250	2250
Stocking density no/m^2	5.3	5.3	5.3	5.3
Average size at stocking (mm/g)	19.4/0.041	19.4/0.041	19.4/0.041	19.4/0.041
Date of harvest	24.4.87	24.4.87	24.4.87	24.4.87
Culture duration (days)	85	85	85	85
No. harvested	1014	1219	1132	887
Percentage survival(%)	45.06	54.18	50.31	39.42
Average size at harvest (mm/g)	105.0/ 7.811	105.4/ 7.547	106.8/- 9.288	90.5/ 4.692
Mean growth increment (mm/g)	85.6/7.77	86.0/7.506	87.4/9.247	71.1/4.651
Yield obtained (kg)	7.650	9.100	10.250	4.100
Production/ha(kg)	180.0	214.12	241.18	96.47
Nature of treatment	Manuring	Pellet feeding	Mixed feeding	Control
Quantity of input applied(kg)	85.0 (Cowdung)	20.15 (Commercial pellets)	44.0 (goc,ricebran tapioca & clam meat)	Nil
Type of water management	Tidal	Tidal	Tidal	Tidal

4. Results

4.1 Water quality parameters

Regular monitoring of water quality parameters was done and the details are presented in Table 11c. The water was very turbid containing sediment load @ 0.5 - 1.0 g/L. Correspondingly very low transparency values ranging between 23 and 40 cm were noticed. The parameters such as temperature, pH, salinity and dissolved oxygen fluctuated between 30.2 - 33.5°C, 8.5 - 9.0, 21.5 - 32.5‰ and 3.25 - 5.30 ml/L respectively during the culture period.

Table 11c

WATER QUALITY PARAMETERS AT PUDUVEYPU DURING 1987

Parameters / Period	Temperature Air (°C)	Water (°C)	pH	Salinity (‰)	Diss. Oxygen (ml/L)	Transparency (cm)	Sed. (g/L)	Colour
January	30.5	32.0	8.5	21.50	5.30	40	0.5	turbid
February	27.0	30.2	9.0	27.83	4.86	35	0.7	"
March	31.5	32.0	8.5	30.35	5.15	27	1.0	"
April	31.0	33.5	9.0	32.50	3.25	23	1.0	"

4.2 Growth measurements and harvest data

Mean size attained by *P. indicus* was observed at monthly intervals from all ponds by random sampling using a suitable cast net. The mean values of length and weight were assessed from a sample of 10 numbers from each pond.

The mean values of length and weight of shrimp assessed at intervals from all ponds are presented in Table 11d. The *P. indicus*

Table 11 d

MEAN VALUES OF GROWTH OF P. INDICUS IN DIFFERENT TREATMENT PONDS AT PUDUVEYPU DURING JANUARY-APRIL, 1987.

Treatments / Date of observation	Manuring mm g	Pellet feeding mm g	Mixed feeding mm g	Control mm g
29.1.1987	19.4 - 0.041	19.4 - 0.041	19.4 - 0.041	19.4 - 0.041
19.2.1987	68.8 - 2.786	92.2 - 5.475	89.3 - 6.100	77.6 - 2.993
19.3.1987	93.0 - 4.794	103.3 - 7.200	103.1 - 7.720	85.2 - 3.490
24.4.1987	105.0 - 7.811	105.4 - 7.547	106.8 - 9.288	90.5 - 4.692

Table 11e

MEAN VALUES OF GROWTH RATE AND GROWTH INCREMENT OF P.INDICUS IN DIFFERENT TREATMENT PONDS AT PUDUVEYPU DURING JANUARY - APRIL, 1987.

Treatments	Manuring		Pellet feeding		Mixed feeding		Control	
Date of	Growth		Growth		Growth		Growth	
Observation	Rate	Increment	Rate	Increment	Rate	Increment	Rate	Increment
	mm g	mm g	mm g	mm g	mm g	mm g	mm g	mm g
29.1.1987 (0)	19.4-0.041	(initial)	19.4-0.041	(Initial)	19.4-0.041	(initial)	19.4-0.041	(initial)
19.2.1987 (3 weeks)	49.4-2.745	49.4-2.745	72.8-5.434	72.8-5.434	69.9-6.059	69.9-6.059	58.2-2.952	58.2-2.952
19.3.1987 (7 weeks)	73.6-4.753	24.2-2.008	83.9-7.159	11.1-1.735	83.7-7.679	13.8-1.620	65.8-3.449	7.6-0.049
24.4.1987 (12 weeks)	85.6-7.770	12.0-3.017	86.0-7.506	2.1-0.347	87.4-9.247	3.7-1.568	71.1-4.651	5.3-1.202

fry of uniform size 19.4 mm (0.041 g) grew to mean values of 68.8 mm (2.786 g), 92.2 mm (5.475 g), 89.3 mm (6.10 g) and 77.6 mm (2.993 g) respectively in ponds 1 to 4 after three weeks. When assessed after 7 weeks, the corresponding mean growth values were 93.0 mm (4.794 g), 103.3 mm (7.20 g), 103.1 mm (7.72 g) and 85.2 mm (3.49 g) in ponds 1 to 4 in order. When harvested after 12 weeks, the mean values observed were 105.0 mm (7.811 g), 105.4 mm (7.547 g), 106.8 mm (9.288 g) and 90.5 mm (4.692 g) respectively in ponds 1 to 4. Among all ponds, maximum growth rate was noticed in the pond in which mixed feeding with clam meat was given. This was followed by treatments such as cowdung manuring and pellet feeding, the control pond having lowest growth.

The mean values of growth rate and increment are furnished in Table 11e. The growth rate also showed the same trend as those of mean growth values recorded in respect of all ponds. Again, the maximum growth rate was recorded in the pond in which mixed feeding with clam meat was given. Lesser values were noticed in the cowdung manured and pellet fed ponds. The least growth rate was seen in the control pond.

In respect of all ponds, higher growth increment values were noticed 3 weeks after stocking, the highest being recorded in the clam meat supplied pond, followed by that in the pellet feeding pond. However, during subsequent weeks, the growth increment values were found reduced in all except those in the cowdung manured pond wherein growth continued normally without much variations between months.

The harvest details and the yield obtained from all ponds are furnished in Table 11b. The maximum survival (54.18%) was seen in Pond 2. The corresponding values of other treatment ponds 1 and 3 were 45.06 and 50.31%. The least survival (39.42%) occurred in pond 4. The shrimp yields of 7.65, 9.10, 10.25 and 4.10 kg obtained respectively from ponds 1 to 4 equated to a production of 180.0, 214.12, 241.18 and 96.47 kg/ha/3 months in order.

The data on weight of shrimps collected from all ponds on harvest day were subjected to statistical analysis. The result shows that the difference between mean weights in the ponds were highly significant ($P < 0.01$) as shown in Table below.

Table : ANOVA

Source	SS	df	MS	F
Between means	110.6923	3	36.90	6.28**
Error	211.5637	36	5.876	
Total	322.2560	39		

** $P < 0.01$

This meant that growth rate of shrimps in different ponds including control was different. This in turn also indicated that the effects of various feeds tested were significantly different. Continuing the analysis, the effect of the three different treatment vs control was tested.

$F = 15.84$ which is significant at 0.1% ($P < 0.001$).

From the mean values it was found that feed supplied in pond 3 was the most effective followed by those of ponds 2 and 1 respectively whereas the effect in control pond was the least. Also, the percentage survival was satisfactory in ponds 2 and 3 (54.18 and 50.31%) respectively. Though slightly low rate of survival was noticed in pond 3, the yield obtained was relatively high. This was on account of the better mean size of shrimps caught during harvest. The fairly high mean size seen in this case was due to the inclusion of a greater percentage of clam meat in the mixed feed applied. On the contrary, though there was not much difference in the mean sizes of shrimps between the other two treatments obtained during harvest, there was considerable difference in the percentage survival. This variation also reflected in the production level, the marginal increase in shrimp yield being occurred in the pond supplied with pellets than mere manuring. At the same time least production ie. @ 96.47 kg/ha/3 months was noted in the control pond.

5. **Observations**

The experiment proved that application of feed is effective in promoting shrimp growth. Of all the feed supplied, mixed feed incorporating clam meat proved better. The inconsistency of the slushy substratum created much problems for the shrimps for the burial and growth. The silt laden turbulent characteristics of the tidal water posed stress conditions to the shrimps leading to stunted growth. Because of silt accumulation in the ponds, much money is required to be spent year after year for its removal. Elimination of silt by appropriate means improves shrimp production.

To sum up, the newly accreted wetland was not found satisfactory for shrimp culture owing to a) low percentage survival (39.4 to 54.2%), b) low quality (size ranging from 4.7 to 9.3 g), c) low production rate (96.5 to 241.2 kg/ha) increased production cost.

Case study - B3 : Experimental culture of P. indicus at the newly excavated Harijan Farm, Narakkal during February-May, 1989.

1. **Aim**

To ascertain (1) the techno-economic feasibility of the newly excavated farm for culture of P. indicus and (2) to test the effect of culling and extended culture on growth.

2. **Introduction**

Owing to the ever-growing export value, shrimp farming is gaining much significance. Due to the dearth of conventional areas suitable for farming, chances of shrimp raising from the hitherto unutilised areas are explored. Therefore, an experimental shrimp farming was carried out in a newly excavated Harijan Fish Farm.

3. **Material and methods**

3.1 **Location and layout**

The 0.24 ha rectangular farm was located at Narakkal west, adjoining the north-south running bunder canal. The water area was lying in two unequal compartments, longer one having a depth of 90 cm was connected with the bunder canal through a sluice gate as shown in Fig. 8. Also an internal sluice gate connected this with the smaller compartment having a depth of 70 cm. The bunder canal has a width of 6-8 m and depth of 1.5 to 2 m.

3.2 **Farm preparation**

Preliminary preparations as in B2 were completed during February 1989. Except for keeping it dried for a week, no other predator eradication measure was followed. Preliminary manuring was

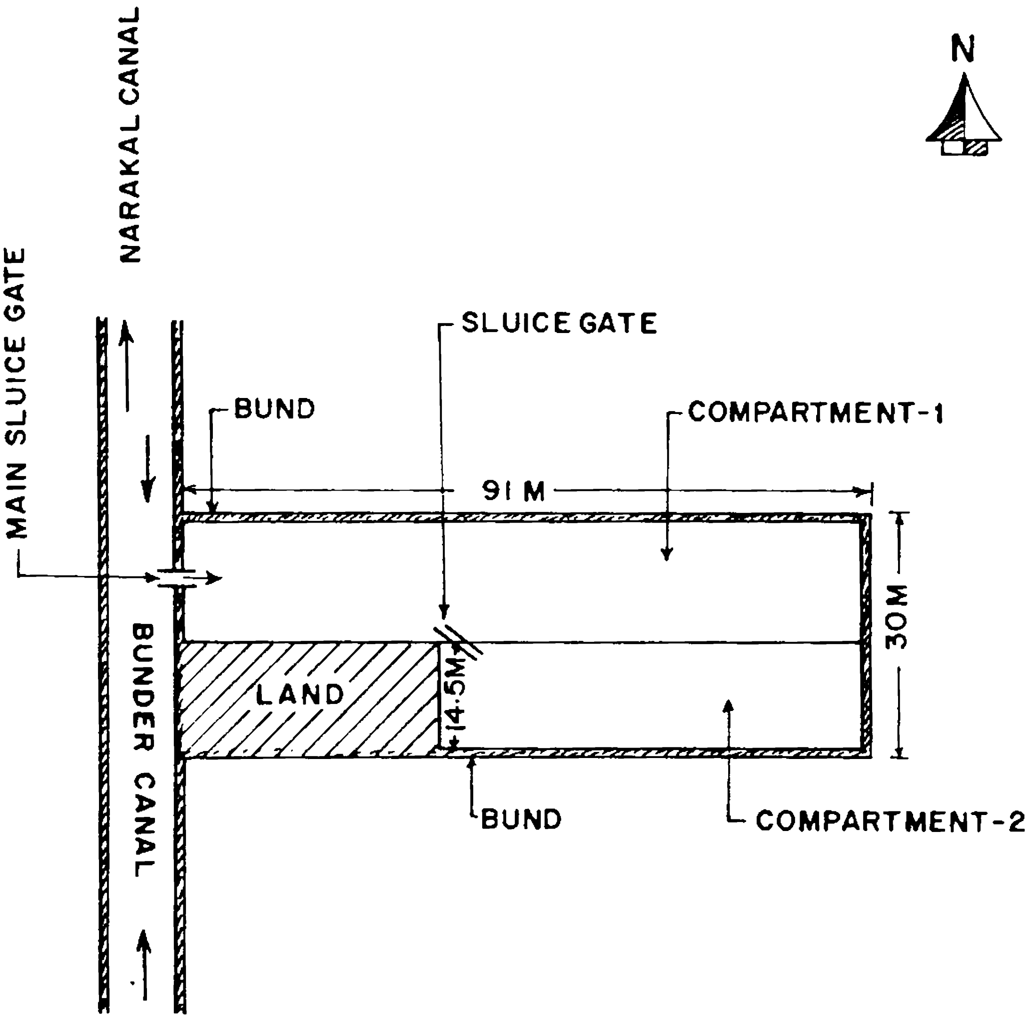

FIG. 8. LAY OUT OF THE NEWLY EXCAVATED POND (0·24 Ha) AT NARAKKAL

done with cowdung.

3.3 Substratum

The substratum was composed of silt and clay mixed with calcareous matter. Decaying organic matter was seen associated with the bottom. Because of the newly excavated nature of the farm, no benthic fauna was noticed.

3.4 Water exchange

Water was admitted through filter devices in the sluice gate, taking advantage of tidal processes. Regular exchange was continued through out the experimental period. After 1½ months of farming, one 5 HP pump set was used at times to maintain water.

3.5 Release of fry

After maintaining optimum conditions in the culture system, 28,500 wild shrimp fry with an average size of 34.5 mm (0.258 g) was introduced into the farm after acclimation, on 11.2.1989.

3.6 Feeding

Along with regular water exchange, fortnightly manuring with cow dung was continued. After 3 weeks, supplementary feeding with crushed clam meat was resorted @ 5% of body weight. During April, the feed quantity was raised to the level of 2 to 3 kg/day till harvest.

4. Results

4.1 Water quality parameters

The variations in environmental parameters are as given in the Table 12a. The medium was always alkaline, the pH values remaining between 7.5 and 8.0. The fluctuation in water temperature was within 30.0 - 31.5°C. Salinity was showing an increasing trend to reach peak values (28.2‰) during May. The dissolved oxygen values were within the range of 3.4 and 5.1 ml/L. The transparency values were relatively low and varied between 42 and 58 cm.

Table 12a

WATER QUALITY PARAMETERS AT NARAKKAL HARIJAN FARM DURING 1989

Parameters Period		Temperature Air (°C)	Water (°C)	pH	Salinity (‰)	Diss. Oxygen (ml/L)	Transparency (cm)
February	1989	30.5	30.0	7.5	22.5	4.2	58
March	1989	33.6	31.5	8.0	24.3	5.1	51
April	1989	32.0	30.8	7.5	27.5	3.9	46
May	1989	31.4	30.5	7.5	28.2	3.4	42

4.2 Growth measurements and harvest data

The details of shrimp culture operations and the results achieved are presented in Table 12b. Since shrimp seed was procured from wild and stocking effected in February, fry having fairly high average size 34.5 mm (0.258 g) could be introduced. The stocking density was @ 1,17,325 nos/ha. The average size attained was 74.3 mm (2.95 g) during March and 79.9 mm (3.57 g) in middle of April. On 30.4.89 when 75.4 kg (82.5%) of P. indicus was harvested by cast netting, the average size was 85.8 mm (4.32 g). The remaining shrimp 16.0 kg (17.5%) obtained during May showed an average size of 109.6 mm (9.77 g). Altogether 18,972 nos. were harvested on two occasions showing 66.57% survival rate. 91.4 kg P. indicus was obtained reaching a production of 376.25 kg/ha.

As shown in Table 12c the growth rate of P. indicus after 10 weeks was 51.3 mm (4.06 g) against 75.1 mm (9.51 g) after 14 weeks. The difference in average growth in weight between first and second harvests was 23.8 mm (5.45 g). This quantum of growth achieved within 4 weeks between harvests showed exceedingly higher values than that attained within initial 10 weeks growth. It indicated that the reduced growth resulted during earlier phase, due to high stocking density could be accelerated by partial harvesting, thus providing better living conditions to the remaining stock. It was made clear that the growth of P. indicus depended very much upon the stocking density and the culture duration in order to attain commercial sizes.

5. **Operational economics**

The outcome of operational economics is presented in Table 12d. Being the first endeavour it was aimed at ascertaining the suitability of the farm for shrimp production in addition to studies on culling and extended culture on shrimp growth. The total expenses for culture operations worked out at Rs.2,084.60. Though 91.4 kg P. indicus was harvested, the value realisation was very low on account of the inferior quality of yield. However, an amount of Rs.2,304.20 could be obtained by disposing the items on competitive rates. Thus the endeavour could make a profit of only Rs.219.60 (+) during 3 months effort, indicating a profit of Rs.904.00/ha.

6. **Observations**

The level of shrimp production does not seem to commensurate with the inputs supplied including the managerial skills. This may probably be on account of its newly excavated nature and lack of conditioning. Complete absence of benthic faunal generation was another factor, to reckon with. However, the production of shrimps @ 376.25 kg/ha points out the possibility of transforming this as a productive farm with aging. The higher mean growth rate noticed during second harvest may be attributed to the availability of more living space, an after effect of culling.

TABLE 12 b

THE DETAILS OF SHRIMP CULTURE OPERATIONS DURING FEBRUARY-MAY,1989 AT NARAKKAL HARIJAN FISH FARM

Area of the pond	-	0.24 ha
Date of stocking	-	11.2.1989
No. of *P. indicus* stocked	-	28,500
Stocking density	-	1,17,325 nos./ha.
Average size at stocking	-	34.5 mm (0.258 g)
Quantity of cowdung applied	-	250 kg.
Quantity of clam meat supplied	-	135 kg.
Quantity of diesel used	-	40 litres
Average size of *P.indicus* harvested on 30.4.1989	-	85.8 mm (4.32 g)
Average size of *P.indicus* harvested on 30.5.1989.	-	109.6 mm (9.77 g)
Total no. harvested	-	18,972
Percentage survival	-	66.57%
Quantity of shrimp realised	-	91.40 kg.
Production/ha of shrimps	-	376.25 kg.

TABLE 12 c

THE AVERAGE SIZE AND GROWTH INCREMENT OF P.INDICUS CULTURED AT NARAKKAL HARIJAN FISH FARM

Details	Duration	Mean size mm - g	Mean values of growth rate mm	g
February'89 (initial)	0 (initial)	34.5 - 0.258	-	-
March '89	4 weeks	74.3 - 2.950	39.8	2.692
April '89	8 weeks	79.9 - 3.57	45.4	3.312
April end '89 (Ist harvest)	10 weeks	85.8 - 4.32	51.3	4.062
May end '89 (2nd harvest)	14 weeks	109.6 - 9.77	75.1	9.512

Table 12d

OPERATIONAL ECONOMICS OF SHRIMP CULTURE AT NARAKKAL HARIJAN FISH FARM DURING FEBRUARY - APRIL 1989

Expenditure	Rs. Ps.
Charges for repair and fixation of sluice gate	275.00
Preparation charges, 4 persons @ Rs.30/- each	120.00
Cost of screen materials	115.00
Cost of 250 kg cowdung @ Rs.0.10/kg.	25.00
Cost of 135 kg clam meat @ Rs.2.00/kg.	270.00
Cost of 40 litres of diesel used @ Rs.4/-/lit.	160.00
Cost of 28,500 *P. indicus* seed @ Rs.25/1000 nos.	712.50
Harvesting charges @ Rs.1.50/kg of shrimp	137.10
Honorarium for the helper	200.00
Interest on capital @ 14% per annum	70.00
Total expenditure	2,084.60
Sale proceeds:	
Cost of 75.4 kg *P. indicus* @ Rs.22.50/kg.	1,696.50
Cost of 16.0 kg *P. indicus* @ Rs.32/-/kg.	512.00
Cost of 0.490 kg *P. monodon* @ Rs.60/-/kg.	29.40
Cost of 12.0 kg *M. dobsoni* @ Rs.5/-/kg.	60.00
Cost of 6.3 kg of Misc. @ Rs.1.00/kg.	6.30
Total amount	2,304.20
Nett balance amount (+) of operation	219.60
Nett profit per ha.	904.00

Case study - B4 : Experimental culture of *P. monodon* in canals between coconut groves at Pallithode, Alappuzha during March-June, 1988.

1. Aim

To investigate the feasibility of *P. monodon* culture in canals between coconut groves.

2. Introduction

In recognition of the importance of shrimp farming, as part of its expansion programme an attempt was made to make use of the unused coconut grove canals. One of the handicaps of these water bodies was the presence of acid sulphate soil.

3. Material and methods

3.1 Location and lay out

The 0.61 ha water body comprising 16 canals lying between coconut groves (Plate IX B) was located at Indanthuruth, Pallithode, Alappuzha. The sluice of the water body opened into a feeder canal arising from the main pozhi which was directly connected with the Anthakaranazhi at a distance of 3 km. Of the 16 canals, 13 were lying in an east-west direction and 3 in north-south direction. The average length, width and depth of the canals were 50 m, 3 m and 1.0 m respectively.

3.2 Field preparation

All canals were dewatered and desilted during 1st week of March, 1988. 30 kg lime was added to reduce the effect of acid sulphate soil. All predatory species of fishes were removed by applying mahua oil cake (Plate II B) @ 200 ppm. Sufficient number of

PLATE IX

A - Sluice gate opening in to the feeder canal

B – Canals between coconut groves at Pallithode dry twigs were planted.

3.3 Substratum

Substratum was composed of sandy loam mixed with certain calcareous particles. Acid sulphate nature of the soil was peculiar to the area. Therefore, no benthic faunal diversity could be observed. However, certain small crabs, bivalves and gastropods were represented.

3.4 Water exchange

After sluice fixation, exchange of water in canals through screens was continued for two weeks before shrimp stocking. Thereafter exchange was regular till the end of experiment. Always a water level of 70 cm was maintained using a water pump.

3.5 Nursery treatment and shrimp fry release

15,000 nos. of *P. monodon* fry (PL_{12} stage) procured from Govt. Prawn Hatchery, Azhikode were safely introduced in two out of the 16 canals set up as nurseries in view of their nearness to the main sluice gate on 22.3.1988. While maintaining required water level, regular feeding was done by using steamed clam meat along with ground nut oil cake and rice bran in equal proportions @ 8% body weight. By 2nd week of April, the nursery canals were opened into the series of canals through the interconnections, allowing free movement of shrimps.

3.6 Feeding

Periphyton was generated on the dry twigs planted well beforehand which also offered protection. In addition, feeding @ 5% body weight as in the nurseries, was continued. Weekly manuring with cowdung at a standard dose of 1 tonne/ha/yr was also resorted.

4. Results

4.1 Water quality parameters

The details of water quality parameters observed are as in Table 13a. The water temperature fluctuated between 26.5°C and 29.5°C. The medium was alkaline during March and April which developed slightly acidic conditions by May-June. Salinity values remained between 20.2 and 28.1‰. Drastic variations in dissolved oxygen values between 5.0 and 3.0 ml/L were noticed; low values consistently prevailed during the end of experimental period.

Table 13a

WATER QUALITY PARAMETERS AT INDANTHURUTH, PALLITHODE DURING MARCH-JUNE, 1988

Period	Parameters	Temperature Air (°C)	Water (°C)	pH	Salinity (‰)	Dissolved Oxygen (ml/L)
March	1988	28.5	27.5	7.5	25.7	5.00
April	1988	29.0	28.5	7.1	27.4	4.65
May	1988	29.5	29.5	7.0	28.1	3.20
June	1988	28.0	26.5	6.5	20.2	3.00

4.2 Growth measurements and harvest data

The details of culture operations, the source of *P. monodon* fry, its stocking density, manures, feeds and other inputs utilised during the culture period of 89 days are given in the Table 13b. The PL 12 stage postlarvae reached the average size of 171.4 mm (40.45 g) when harvested after 89 days of culture.

The monthly values of mean growth and the growth gained are presented in the Table 13c. The mean growth value rose to 120.2 mm (14.11 g), 153.6 mm (29.90 g) and 171.4 mm (40.45 g) after 1, 2 and 3 months respectively. The corresponding growth rates were 108.2 mm (14.098 g), 141.6 mm (29.888 g) and 159.4 mm (40.438 g).

The details of harvest are presented in Table 13d. A wide variation in the size of shrimps was seen. The shrimps were categorised into 6 according to individual weights. Shrimps weighing > 40.0 g formed higher group and < 20.0 g formed lowest group. The rest were categorised at 5 g interval.

The mean size, total number and quantity of respective categories realised are also furnished in Table 13d. 308 nos. each weighing more than 40 g and a mean size of 181.7 mm (48.93 g) accounted for 12.97 kg. 1522 nos. within the size range of 35-40.0 g having mean size 171.2 mm (37.15 g) weighed 57.60 kg. Among 30 - 35 g group with mean size 160.6 mm (31.42 g), 1198 individuals weighing 39.30 kg was obtained. The mean size of 25 - 30 g was 159.2 mm (26.63 g). The 459 individuals of this group weighed 12.27 kg. 680 nos. weighing 15.30 kg were collected in the size range of 20 - 25 g, their mean size being 151.1 mm (22.71 g). Only 393 nos. below 20 g were represented. The mean size was 138 mm (16.20 g), the quantity being 6.93 kg.

The Table also indicates that of all the six categories, the least number (6.75%) was represented by 40.0 g size group followed by the lowest category below 20.0 g size (8.62%). The 2nd and 3rd categories together constituted 59.65% and the remaining two groups formed 24.98%.

5. <u>Operational economics</u>

The operational economics presented in Table 13e shows the details of expenditure incurred towards the endeavour as Rs.3,932.50 including charges of preparation, seed, feed and other sundry expenses. As is clear from the Table the 144.37 kg shrimp obtained were categorised and sold on competitive rates at farm gate, realising an amount of Rs.12,057.50. Considering the nett balance of Rs.8,125/-, which amounts to Rs.13,319.70 per hectare, the endeavour seems to be economicably very viable. Even with a low survival rate, this level of profit within a period of 3 months seemed to be very much promising.

6. Observations

Several reasons could be attributed for the low rate of retrieval (30.4%) from this system. The inadequacies of water exchange and feeding in the nursery canals caused large scale larval mortality. On account of closure of Anthakaranazhi during the period, a general reduction in water table existed which often caused difficulties to have proper exchange. Eventhough pumping was resorted to at times, proper and enough water exchange could not be maintained. Further, the turbid water conditions retarded photosynthetic activity in general resulting in low level of dissolved oxygen. The decay of algal matter also contributed to the low O_2.

One of the reasons for the poor retrieval rate can be attributed to suspected poaching. In spite of the above constraints, in terms of the profit realised, the study pointed out the advantage of undertaking shrimp culture in the otherwise unused canals lying between coconut groves.

TABLE 13 b

DETAILS OF PENAEUS MONODON CULTURE IN CANALS LYING BETWEEN COCONUT GARDEN GROVES AT PALLITHODE,ALAPPUZHA DURING MARCH-JUNE,1988

Area of canals	:	0.61 ha
Date of stocking	:	22.3.1988
No. stocked and stocking density	:	15000 @ 24700 nos./ha
Average size at stocking and source of fry	:	PL_{12} stage obtained from Govt. Hatchery, Azhikode.
Quantity of mahua used	:	70 kg.
Quantity of lime	:	30 kg.
Quantity of cow dung	:	500 kg.
Quantity of g.o.c. and rice bran	:	6 kg. and 10 kg.
Quantity of clam meat	:	730 kg.
Quantity of diesel used	:	55.5 litres.
Date of harvest	:	19.6.1988
Duration of culture	:	89 days.
Average size of *P.monodon* harvested	:	171.4mm (40.45 g)
Total no. realised	:	4560
Percentage survival	:	30.4
Quantity of yield	:	144.37 kg.
Production of shrimps/ha	:	237.73 kg.

TABLE 13 c

MEAN GROWTH AND GROWTH RATE OF PENAEUS MONODON FROM CANALS LYING BETWEEN COCONUT GARDEN GROVES AT PALLITHODE,ALAPPUZHA DURING MARCH-JUNE, 1988.

Period of Observation	Duration of culture	Mean size mm	Mean size g	Mean growth gained mm	Mean growth gained g
March (22.3.1988)	0	PL_{12} stage.	0.012	-	-
April	1 month	120.2	14.110	108.2	14.098
May	2 month	153.6	29.900	141.6	29.888
June	3 month	171.4	40.450	159.4	40.438

Table 13d

DETAILS OF PENAEUS MONODON HARVESTED FROM CANALS (0.61 ha) LYING BETWEEN COCONUT GROVES AT PALLITHODE,ALAPPUZHA DURING JUNE, 1988

Date of stocking	Date of harvest	Culture duration	No collected	Size range (g)	Mean size mm	-	g	Quantity (kg)
			308	> 40.0	181.7	-	48.93	12.97
			1522	35 - 40.0	171.2	-	37.15	57.60
22.3.88	19.6.88	89 days	1198	30 - 35.0	160.6	-	31.42	39.30
			459	25 - 30.0	159.2	-	26.63	12.27
			680	20 - 25.0	151.1	-	22.71	15.30
			393	< 20.0	138.0	-	16.20	6.93
			4560		160.3	-	30.51	144.37

Table 13e

OPERATIONAL ECONOMICS OF PENAEUS MONODON CULTURE IN CANALS BETWEEN COCONUT GARDEN GROVES AT PALLITHODE, ALAPPUZHA DURING MARCH - JUNE 1988

Expenditure	Rs. Ps.
Charges for dewatering and preparation of canals	125.00
Sluice fixation and filter screen	160.00
Predator eradication	140.00
Cost of lime and cowdung	80.00
G.O.C. and rice bran	30.00
Clam meat	1,250.00
Diesel cost	122.00
Cost of shrimp seed	920.00
Transportation charges	120.00
Fishing charges	150.00
Watchman	750.00
Miscellaneous	85.50
Sub total	3,932.50
Income	
Cost of 70.57 kg 1st grade shrimp @ Rs.100/kg.	7,057.00
Cost of 51.70 kg 2nd grade shrimp @ Rs.75/kg.	3,877.50
Cost of 22.23 kg 3rd grade shrimp @ Rs.50/kg.	1,111.60
Cost of miscellaneous (15 Tilapia + 1 *P. indicus*)	11.40
Total	12,057.50
Profit of operation (+)	8,125.00
Profit of operation/ha.	13,319.70

Case study - B5 : Experimental culture of *Penaeus monodon* in the canals of a coconut grove at Chalippuram, Kochi during 1990-91.

1. **Aim**

To study the prospects of scientific extensive farming of *P. monodon* in the canals of newly set up coconut garden in a paddy field containing acid sulphate soil.

2. **Introduction**

Due to saline infiltration and inherent acid sulphate problems, paddy crop failure is a recurring phenomenon along the coastal southern region of Kochi Taluk. Therefore, farmers either keep such fields as vacant or transform them for coconut cultivation and other purposes. Some of these fields are at present being developed as shrimp culture farms on account of the commercial demand for shrimps. Therefore an experiment was carried out in a recently transformed farm to work out its techno-economic feasibility.

3. **Material and methods**

3.1 **Location**

The square farm (Fig. 9) having an area of 1440 m^2 and 1.5 m depth was located at Chalippuram patasekharam in the souther region of Kochi Taluk, Ernakulam District. The farm lying along the western side of main road, was indirectly connected to Anjilthara Kayal through the main culvert with the control. Because of its merging with Kallancheri and Perumpadappu Kayals, the Anjilthara Kayal was also under the tidal influence of Cochin backwater. The tidal amplitude at the Chalipuram area oscillated between 40 and 60 cm.

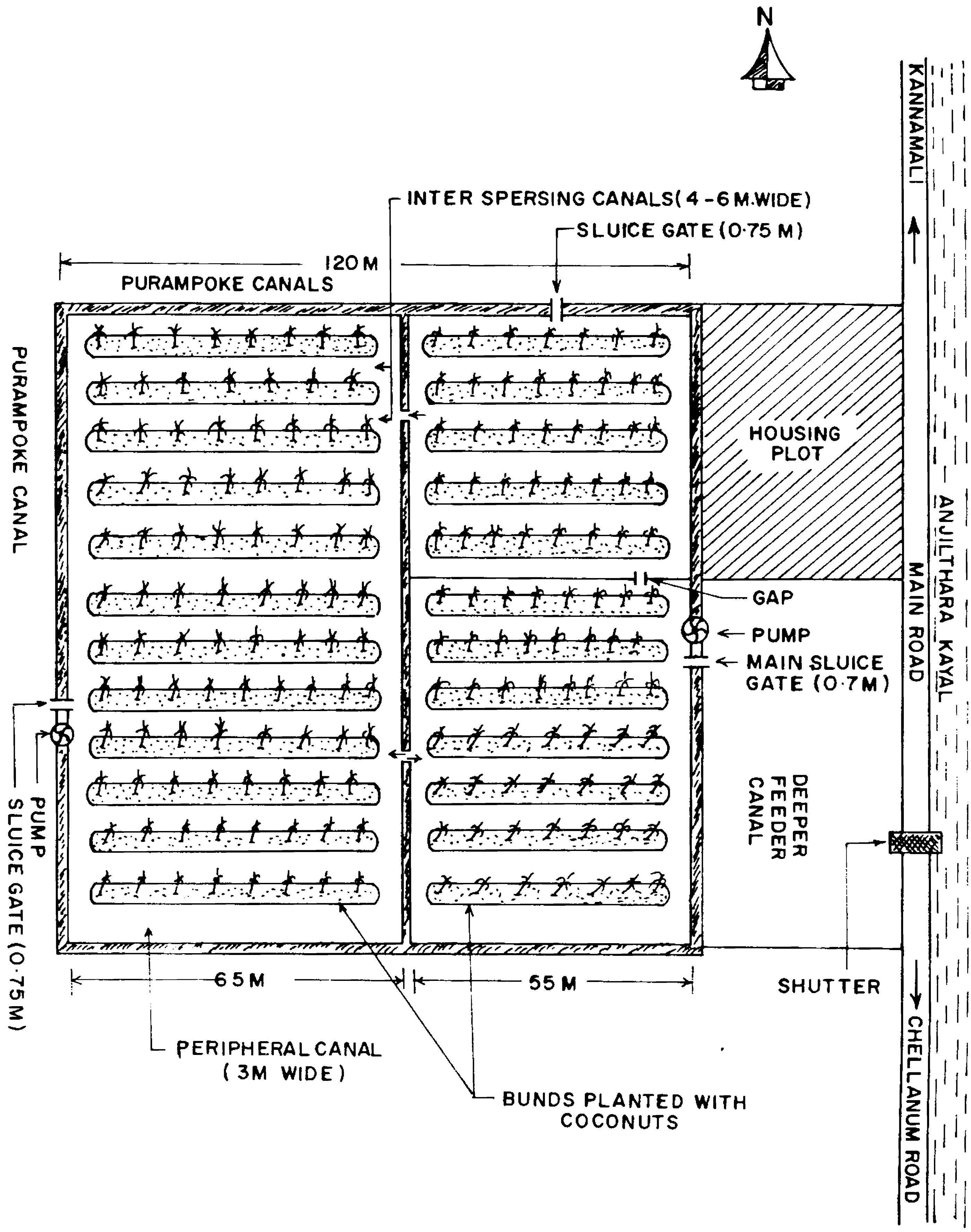

FIG. 9. LAY OUT OF THE FARM (1·1 Ha.) AT CHALIPPURAM

Field history

The selected field had a good record of paddy production up to 1970s and the peak yield of 360 standard paras was attained in 1968 (personal communication). Since then, on account of saline infiltration and consequent changes in the habitat the paddy yield was gradually dwindled to the tune of 170 standard paras, during 1986. This level of paddy production was not at all economic and the cultivator had endured heavy loss consistently. Therefore, paddy cultivation was dropped and the field was transformed into a coconut garden by making bunds and canals (Plate X A).

Layout

As shown in Fig. 9 the farm was bestowed with strong outer bunds and the two internal dyke partitions divided it into 3 dissimilar compartments. A main sluice gate of 70 cm width was erected with granite stones at the central position of the eastern bund in order to open into the adjoining deeper feeder canal. A wooden sluice gate of 75 cm width was fixed in opposite direction at the western bund which emptied into the surrounding purampoke canal.

A peripheral canal of 3 m width was running all along the sides of the farm. In addition, a series of longitudinal canals of 4-6 m width interspersed with earthern dykes of 2 m width were set up inside the farm. Coconut trees were planted along the bunds with required spacing. Altogether, there were 32 such longitudinal canals in the three compartments. Each canal at both ends coalesced with the respective periphery canal. Appropriate gaps were also left between internal compartments and earthern bunds in order to facilitate free exchange of water. Excluding bunds, the water area of the farm was about 1.1 ha.

3.2 Canal preparation

Preparations began during 1st week of November 1990. Water was drained to the minimum through both sluice gates and soil sealed. Remaining water was pumped out using 2 pumps, one of 5 HP and another of 6 HP. The bunds and dykes were properly strengthened. All canals were excavated, desilted and the bottom levelled to a maximum depth of 1.5 m. Appropriate bamboo screens and nylon mesh screens (Plate X B) were fitted to the sluice gates and at the gaps between compartments. Two canals adjoining the main sluice gate were specially prepared and gaps fitted with suitable screens to function as nurseries.

During preparation time, since sun drying of the farm was not possible due to seepage, eradication of weed fishes was done by applying ammonium sulphate and lime in the ratio of 1:5. Thus, while retaining a water column of 20-25 cm, the mixture containing 125 kg ammonium sulphate (NH_4SO_4) and 600 kg of lime (Ca(OH)2) was distributed all along the farm. The weed fishes such as Aplochilus sp., Ambassis sp., Barbus sp., Mystus sp., Gobius sp., Etroplus maculatus, and eels found dead within 2 to 4 hours and completely removed. On ascertaining the absence of predators and weed fishes, the pond was left as such undisturbed for the next 15 days.

Afterwards, 3 tonne of cowdung was applied to the farm on 15th and 16th of November, 1990. While 80% of cowdung was sprinkled as suspension in the entire water body, the rest was dumped in different corners of the canals. On the following day, 30 kg urea and 11 kg superphosphate were also applied. While adding manures and fertilizers, only 50 cm water level was maintained. Within 3 days plankton bloom was generated, followed by an increase in benthic population.

3.3 Substratum

Substratum was very firm and composed of sand, mostly mixed with clay and calcareous matter. The soil was fertile as indicated by good faunal assemblage such as tanaedaceans, amphipods and polychaetes, whose diversity and abundance varied with season. An algal mat of

PLATE X

A - Paddy field transformed coconut groves at Chalippuram

B - Sluice gate with nylon screens and filters

Enteromorpha sp. was also seen along the substratum.

3.4 Water exchange

Exchange was controlled through the sluice gates taking advantage of tidal processes. High tidal water was admitted through the main sluice gate and let out through both sluice gates. Because of the peculiar design of canals and well set gaps between compartments within the farm and also with the help of pumps, water exchange could be arranged, maintaining a water level of 1.5 m. From the 2nd month of culture onwards, additional water exchange by pumping was resorted for 3 to 4 hours especially between 2 and 6 a.m. daily in order to tide over a fall in oxygen level.

3.5 Acclimatization and stocking of fry

Before release of fry, a water level of 1 m was maintained inside the canals. Bamboo and net screens were fixed at both the opening of the nursery canals. By midnight of 25.11.91, 75000 fry of P. monodon (PL_{22}) procured from TASPARC hatchery, Visakhapatnam were brought to the farm in several well aerated polythene bags containing sea water of salinity 31.0‰. The bags were floated for 30 minutes in the canal waters and afterwards carefully emptied into 30 wide mouthed plastic tubs of 50 litre capacity each. In each tub equal number of larvae were distributed for gradual acclimatization to low salinities of 4-5‰, along with suspension feeding. Sprinkling of water along the sides of the containers was also done continuously. Well aerated and clean canal water was used for dilution and exchange. The entire process lasted for 5 hours. Afterwards the larvae from the 30 tubs, were gradually released into the nursery canals. Eventhough the larvae were fed regularly, water exchange was done only after 5 days. At the end of 15 days, the postlarvae attaining a size of 25-30 mm were let into the canal system.

Table 14a

OPERATIONAL DETAILS OF *PENAEUS MONODON* FARMING AT CHALIPPURAM (1.1 ha) DURING 1990 - 91

1.	Area of farm (ha)	:	1.1
2.	Date of stocking	:	25.11.1990
3.	Size of *Penaeus monodon*	:	PL_{22}
4.	No. stocked and stocking density	:	75000 @ 68100/ha
5.	Source of seed	:	TASPARC, Visakhapatnam
6.	Duration of culture (days)	:	107
7.	Mean size at harvest (g/mm)	:	28.0/155
8.	No. realised and percentage survival	:	56539 (75.39%)
9.	Quantity of shrimps obtained (kg)	:	1287.5
10.	Production/ha	:	1170.45
11.	Mode of harvest	:	Cast netting/Hand picking
12.	Quantity of lime applied (kg)	:	600
13.	Quantity of ammonium sulphate (kg)	:	125
14.	Quantity of urea (kg)	:	30
15.	Quantity of superphosphate (kg)	:	11
16.	Quantity of ground nut oil cake (kg)	:	135
17.	Quantity of rice bran (kg)	:	151
18.	Quantity of clam meat (Tonne)	:	4
19.	Quantity of cowdung (Tonne)	:	3
20.	Depth of water column	:	1 - 1.5 m.
21.	Type of water management	:	Tidal + pumping.

February, 1991. Since then tidal water was not available for exchange. So, it was not possible to maintain the 1 m water level even with the use of pumps. As a result plankton blooms developed beyond control. Nevertheless the culture progressed till the first week of March, 1991. Operational details are presented in Table 14a.

4. Results

4.1 Water quality parameters

The important water quality parameters such as temperature, pH and salinity were measured at intervals and the details are presented in Table 14b. The temperature was minimum (27°C) during November which reached the peak (30.0°C) in March. The high pH of 8 during November gradually became neutral during March. The O_2 values fluctuated between 3.0 and 5.5 ml/L during November-March. The very low salinity (4.0‰) prevailed during November steadily rose to attain a maximum (30.0‰) during March.

Table 14b

DETAILS OF WATER QUALITY PARAMETERS AT CHALIPPURAM FARM FROM NOVEMBER 1990 TO MARCH 1991

Date of Observation	Water Temp. (°C)	pH	O_2 (ml/L)	Salinity (‰)
09.11.1990	27.0	8.0	5.5	4.0
25.11.1990	27.5	8.0	4.8	4.0
21.12.1990	28.0	8.0	5.0	12.0
03.01.1991	28.0	8.0	4.3	15.0
27.01.1991	28.5	7.5	4.6	22.0
12.02.1991	27.5	7.5	4.5	25.0
24.02.1991	28.0	7.5	4.2	27.0
01.03.1991	29.0	7.0	3.5	28.0
05.03.1991	30.0	7.0	3.0	30.0

4.2 Growth assessment

Observations on growth were made periodically and the mean growth values assessed are presented in Table 14c. The PL_{22} after nursery rearing reached the mean size of 25 - 30 mm by 9.12.1991. By the end of December the size range shifted to 60 - 120 mm with mode at 80 mm. By January, the size range rose to 90 - 140 mm with mode at 120 mm (18 g). Subsequently P. monodon grew to 100 - 170 mm size with mode at 145 mm (25 g) during February. By first week of March 110 - 180 mm size was attained, the mode being 155 mm (28 g).

Table 14c

OBSERVATIONS ON MEAN VALUES OF GROWTH (g/mm) OF PENAEUS MONODON AT CHALIPPURAM DURING 1990-91

Date of Observations	Mean growth g		mm
29.11.1990	0.042	-	PL_{22}
26.12.1990	5.2	-	80.0
25.01.1991	18.0	-	120.0
24.02.1991	25.0	-	145.0
05.03.1991	28.0	-	155.0

4.3 Harvest data

After lowering the water level to the minimum possible, P. monodon was harvested. The details are furnished in Table 14d. Cast netting by 4 persons on four days between 5th and 12th March, 1991 could obtain 1273 kg P. monodon and 1.5 kg P. indicus. Subsequently, complete draining of farm between 13th and 28th March 1991 yielded another 14.5 kg P. monodon and 3 kg P. indicus by hand picking. Thus altogether 1287.5 kg of P. monodon was produced resulting in a production of 1170.45 kg/ha. The catch data showed four distinct size groups viz. less than 20 g. between 20 and 25 g, between 25 and 30 g and more than 30 g (Table 14e). 51% was in the size group 20 to 25 g whereas only 8% was above 30 g. Altogether 56,539 P. monodon could be realised with a survival of 75.39%. In addition about 1 kg of Metapenaeus dobsoni and M. monoceros were collected along with trash fishes (Mystus sp., Etroplus maculatus, Gobius sp.) less than 1 kg (Table 14d). All harvested items were sold at farm gate on competitive rates.

5. Economics of operation

The details of expenditure incurred and income realised during the farming operations are furnished in Table 14f. An expenditure of Rs.1,09,686/- was spent towards farming, the expenses worked out per ha being Rs.99,714.55. An amount of Rs.1,94,000/- was realised from sale proceeds, the income per ha being Rs.1,76,363.63. Thus the P. monodon culture operations resulted in a high profit of Rs.84,314.00 the return on investment worked out being 76.87%.

6. Observations

The scientific management practices adopted could promote faster growth of P. monodon within 100 days. The 30% water exchange ensured per day and the better quality of feed supplied gave a conversion ratio of 4:1 on wet weight basis. The well arranged water and feed management resulted in a better survival rate (75.39%) which was quite evident during the efficient harvest.

Eventhough farm unit was treated similarly in all aspects, there occurred variations in sizes during harvest. This might be partially due to overcrowding. Had the feeder canals not been closed during the middle of February 1991, and farming operations continued further, the P. monodon production would have been increased considerably than the present yield of 1170.45 kg/ha indicating very good prospects for P. monodon farming in the area. Thus the experiment showed that transformation of fallow suitable paddy fields into scientific extensive shrimp farms will definitely improve the yield and income of farmers contributing much to rural progress.

The presence of other shrimp species and fishes indicates the need for further improved management measures.

The lack of organised marketing facilities fetched only relatively low price when considering the superior quality of shrimps.

Table 14d

HARVEST DETAILS OF *P. MONODON* CULTURE AT CHALIPPURAM BETWEEN NOVEMBER 1990 AND MARCH 1991

Date	Mode of harvest	Harvested items				Total yield
		SHRIMPS		TRASH		
		P. monodon (kg)	*P. indicus* (kg)	Metapenaeids (kg)	Weed Fish (kg)	(kg)
5.3.91	Cast netting	863.00	0.5	-	-	863.50
6.3.91	" "	266.00	1.0	-	-	267.00
7.3.91	" "	112.00	-	-	-	112.00
12.3.91	" "	32.00	-	0.1	-	32.10
13.3.91	Hand picking	2.50	1.0	0.3	0.2	4.00
14.3.91 to 28.3.91	" "	12.00	2.0	0.6	0.7	15.30
Total		1287.50	4.5	1.0	0.9	1293.90
Production/ha		1170.45	4.09	0.91	0.82	1176.27

Table 14e

DETAILS OF SIZE GROUP, YIELD AND PERCENTAGE SURVIVAL OF *P. MONODON* AT CHALIPPURAM BETWEEN NOVEMBER, 1990 AND MARCH 1991

Size group	Mean size g/mm	No. realised	Yield Qnty. (kg)	Percentage of yield (kg)
< 20 g	17.5/133	13508	236.39	18.36
Between 20 & 25	22.5/145	29145	655.76	50.93
Between 25 & 30 g	27.4/158	10582	289.95	22.52
> 30 g	31.9/162	3304	105.40	8.19
		56539 (75.39%)	1287.50	100.00

TABLE 14 f

DETAILS OF EXPENDITURE AND INCOME DURING P.MONODON FARMING AT CHALIPPURAM BETWEEN NOVEMBER 1990 AND MARCH, 1991.

EXPENDITURE

	Item	Rs.
1.	Labout cost for bund repair @ Rs. 50/-/head for 126 men	6,300.00
2.	Charges for excavation of canals desilting and bottom levelling @ Rs. 50/-/head for 218 men.	10,900.00
3.	Cost of fabrication and fixation of wooden sluice gate.	7,000.00
4.	Erection cost of granite stone built sluice gate.	6,000.00
5.	Cost of items and labour for fencing	6,000.00
6.	Fabrication charges for 4 watchmen sheds	3,200.00
7.	Plastic netting, bamboo screens and cast nets.	3,900.00
8.	Cost for repairs, installation and depreciation for 2 pump sets.	12,083.00
9.	Electricity expense	3,250.00
10.	Diesel cost	3,100.00
11.	Inputs cost for eradication of predators and manuring (cost of lime, ammonium sulphate, urea, super phosphate and cowdung)	2,027.00
12.	Shrimp seed cost and transportation charges	13,500.00
13.	Cost of 4 tonne clam meat @ Rs. 3.5/kg.	14,000.00
14.	Cost of 135 kg. ground nut oil cake @ Rs. 5.50/kg.	743.00
15.	Cost of 151 kg rice bran @ Rs. 2.50/kg.	378.00
16.	Cost of 125 eggs @ Rs. 0.75 and Rs. 0.80/head	95.00
17.	Cod liver oil 4 x 450 ml.	160.00
18.	Charges for transportation of feed, grinding & boiling and cost of feed trays.	6,000.00
19.	Wages for 2 watchmen @ Rs. 625/- and Rs. 500/-/month respectively for 4 months.	4,500.00
20.	Harvesting charges (towards cast netting and hand picking) on contract basis.	3,000.00
21.	Charges towards canoes rent.	650.00
22.	Stationery and travel	1,550.00
23.	Miscellaneous charges	1,350.00
	TOTAL	1,09,686.00
	Expenditure/ha	99,714.55

INCOME

	Item	Rs.
1.	Cost of 1287.5 kg of *P.monodon* @ Rs. 150.50/kg	1,93,768.75
2.	Cost of 4.5 kg of *P.indicus* @ Rs. 50/-/kg.	225.00
3.	Cost of 1 kg *Metapenaeus dobsoni*	6.00
4.	Cost of trash fish items	0.25
	TOTAL	1,94,000.00
	Realisation/Ha	1,76,363.63
	Profit (+) of operations	84,314.00
	Return on investment	76.87%

PLATE XI

A – Feed supply using canoe at Chalippuram

B – The design of water flow arrangements at Cherungal

Case study - B6 : Experimental culture of *P. indicus* at Cherungal, Thuravoor during March - April 1989.

1. **Aim**

To assess the impact of short duration high density culture of *P. indicus* on its operational economics.

2. **Introduction**

Improvement in management aspects such as increased stocking density, efficient water exchange and high energy feed supply have resulted in tremendous increases in shrimp production. Evenstill, such rapid advances could not be achieved in Kerala owing to traditional practices followed mostly. However, on account of the shrimp culture promotion activities, traditional shrimp farming is slowly giving way to modern innovations. Efforts are being made to produce more shrimps from unit area during a single seasonal crop and also to take more short duration crops as well, from the same farm during an year. With this perspective, an experimental short duration culture of *P. indicus* was carried out at Cherungal.

3. **Material and methods**

3.1 **Location**

The 1.0 ha shrimp culture farm (Fig. 10) was located in an ideal place at Cherungal, near Thuravoor, Cherthala Taluk of Alappuzha District on the bank of a pozhi (marine lagoon) having connections with Vembanad lake and Andhakaranazhi. Because of its direct connection with Andhakaranazhi, fairly high salinity prevailed in the system during monsoon times also facilitating perennial shrimp culture round the year.

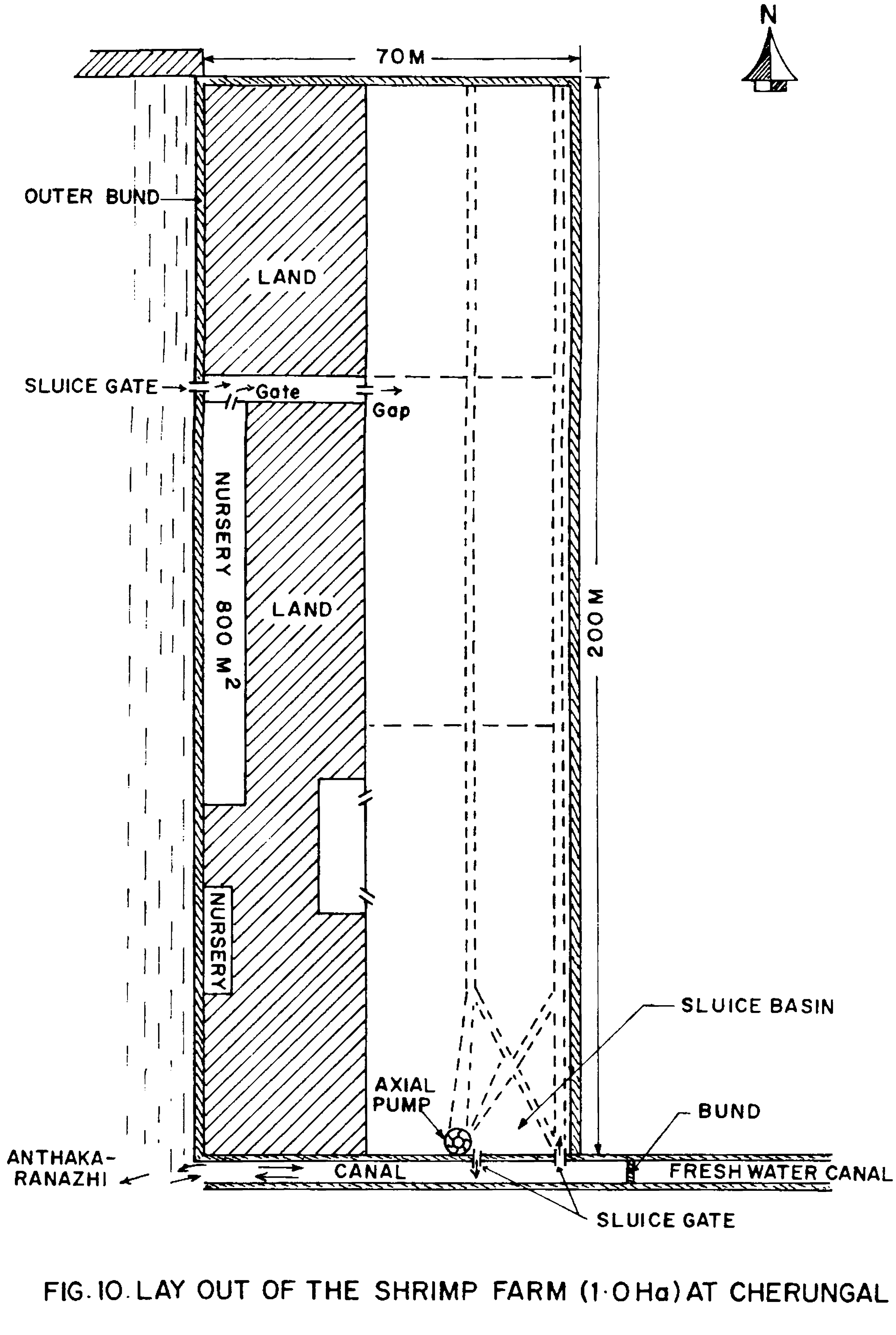

FIG. 10. LAY OUT OF THE SHRIMP FARM (1·0 Ha) AT CHERUNGAL

3.2 Farm preparation

As preparatory to shrimp culture practice, the 1.0 ha shrimp pond was drained and the two sluice gates (Fig. 10) fixed properly during February, 1989. Since one 5 HP electric pump was installed permanently at the pond site (Plate XI B) the water intake, circulation and draining could be controlled at beck and call. The channels of proper dimensions were cleared and general preparations including the strengthening of peripheral bunds completed. A well defined and clean nursery (Plate XII A) comprising an area of almost 20 cents (0.08 ha) with proper inlet and outlet was set up within the pond. The water depth in the farm varied between 80 and 100 cm. 500 kg lime ($Ca(OH)_2$) was also applied in the field at the preparation time. About 50 kg of lime was applied in the bunds before hand as a measure to check acid sulphate problem in case of unexpected rain. Therefore, no acidity problem arose during the entire operation period. Subsequently 1000 kg of cowdung was broadcast in the field. After preparations, the pond was left as such for complete drying and cracking of the bottom for one week for the escape of obnoxious gases and eradication of pests and predators.

3.3 Substratum

Clayey loam mixed with remnants of decaying organic matter constituted the substratum. Acid sulphate soil was present, which was neutralised using lime. Faunal diversity was less, represented by tube dwelling polychaetes and tanaeids.

3.4 Water exchange

After preparations, by end of February, tidal water was allowed into the pond (Plate XII B) through screens installed in the sluice gate. The exchange was continued for 3 days when suitable water quality conditions similar to that prevailing outside developed in the pond before release of shrimp larvae. Regular checking of water quality parameters was done (Table 15a).

Adequate water exchange was ensured in the nursery. In addition to occasional sprinkling of water, mild aeration using a 1.5 HP compressor was resorted.

Further, when P. indicus juveniles were released into the pond, upto 30% of water was exchanged daily irrespective of tidal influence. The pumping unit was installed in such a manner that internal circulation also could be arranged when P. indicus stock were found in distress.

3.5 Fry release

On 1.3.1989, 1.5 lakhs PL_5 fry of P. indicus procured from the Govt. Prawn Hatchery, Azhikode were released (Table 15b) after acclimatisation to the well set nursery kept ready within the culture pond. After 15 days of nursery growth, when the shrimp larvae attained a mean size of 254 mg (31.7 mm) (Table 15c) the screen separating the nursery from the main pond was removed and the juveniles were permitted to migrate into the entire pond.

3.6 Feeding

2 days after stocking, tray feeding of fry with crushed clam meat at libitum was started. Feed was applied @ 10% body weight at 18 points in the nursery using wide mouthed earthen pots. The quantity of feed was gradually raised on par with increase in size of larvae.

Juveniles were fed daily during evening hours, with crushed clam meat kept in feed trays @ 5-8% of body weight. Occasionally half cooked pulverised feed composed of ground nut oil cake, rice bran, shrimp head and blood clot from slaughter house in equal proportions was given @ 3-5% of body weight. Feeding requirements and schedules were calculated based on average weight at weekly intervals. Thus a total of 970 kg clam meat, 180 kg ground nut oil cake, 150 kg rice bran, 150 kg shrimp head meal and 150 kg clotted blood were used for feeding in the grow out pond for a period of 60 days (Table 15d).

During the 15 days of harvest, the quantity of feed supplied was reduced corresponding to the *P. indicus* caught from the pond.

4. Result

4.1 Water quality

Observations on water quality parameters during 1989 are furnished in Table 15a. The parameters such as water temperature, pH, salinity and dissolved oxygen values fluctuated between 26.5-27.0°C, 7.2-7.4, 20.4-25.5‰ and 4.30-4.50 ml/L respectively during the culture period of March and April.

The prevalence of fairly high salinity during June-August (rough season) was due to the discharge of enormous quantity of seawater into the Pozhi through leakage of sea wall all along in addition to the influence of Anthakaranazhi. On the contrary, along with the opening of the eastern bund after the middle of August, the heavy influx of river water towards the Pozhi dilutes the medium enormously which condition remains upto January.

4.2 Growth measurements and harvest data

Average growth of *P. indicus* was assessed at weekly intervals by random sampling of specimens and average size attained during 15th, 30th and 45th day of culture is presented in Table 15c. The PL_5 shrimp fry attained average size of 31.7 mm (0.254 g) after 15 days nursery care, which increased to 76.4 mm (2.833 g) and 101.6 mm (6.593 g) after 30 and 45 days respectively.

As the culture progressed for about 45 days, daily harvesting was done by cast net operation for the subsequent 15 days. By this culling method, P. indicus above 5 g were taken and the juveniles below 5 g collected during each harvest day were safely retrieved into the pond for further growth. In all 355 kg P. indicus was retrieved within 14 days. On the 60th day of culture, the water was completely drained and the remaining shrimps were picked up. Thus altogether 102576 P. indicus (68.38%) (Table 15b) could be realised. 522.80 kg were obtained by cast net operation and 154.20 kg by hand picking totalling 677 kg from the entire operation.

The produce was cleaned, categorised and sold at the farm gate on competitive rate.

5. Economics of operation

The details of operational economics are furnished in Table 15d. The total expenditure including lease amount of pond, preparation charges, cost of fry, maintenance and management charges etc. worked out at Rs.18724.00. Because of the short duration of culture, the P. indicus was of lower size category, ranging from 5.88 to 7.42 g leading to realisation of low unit values. However, Rs.25,726.00 was collected by the sale of 677 kg P. indicus and Rs.250/- by disposal of used items making the total at Rs.25,976.00. Thus Rs.7252/- was obtained as profit from an one ha pond within a period of 60 days. This indicated possibilities of carrying out short term P. indicus farming 4-5 times in an year with sufficient profit.

6. Observations

The growth potential of P. indicus could not be fully exploited. Yet irrespective of smaller size, the higher quantity realization enabled to attain huge profit within short period.

Table 15a

WATER QUALITY PARAMETERS AT CHERUNGAL DURING 1989

Parameters Month	Temperature Air (°C)	 Water (°C)	pH	Salinity (‰)	Diss. Oxygen (ml/L)
January	27.5	26.5	7.5	4.5	4.75
February	26.8	26.4	7.5	10.6	4.62
March	27.5	27.0	7.4	20.4	4.50
April	28.2	26.5	7.2	25.5	4.30
May	29.5	25.4	7.0	26.2	4.80
June	29.0	25.0	6.5	20.1	5.20
July	27.5	24.8	6.5	24.0	4.50
August	27.0	24.5	7.0	10.2	4.75
September	28.0	25.5	7.2	4.0	3.95
October	28.5	26.0	7.5	2.2	3.20
November	29.0	26.5	7.0	3.8	3.45
December	28.5	26.0	7.0	4.2	4.10

Table 15b

DETAILS OF *P. INDICUS* CULTURE OPERATIONS AT CHERUNGAL DURING 1989

Particulars		
Date of start of culture	:	1.3.1989
No. of *P. indicus* stocked	:	1.5 lakhs
Stocking density	:	15 nos./m^2
Size at stocking	:	PL_5 (Postlarva 5 days old)
Source		Govt. Prawn hatchery Azhikode
Duration of culture	:	45-60 days
No. survived	:	102576
Percentage survival	:	68.38
Size at harvest	:	5.88 - 7.42 g
Production/ha	:	677.0 kg

TABLE 15 c

SIZE RANGE AND MEAN GROWTH VALUES ATTAINED BY P.INDICUS DURING CULTURE AT CHERUNGAL DURING 1989

Stocking size 1.3.1989	Nursery rearing 15.3.1989	Rearing in grow out ponds 30.3.1984	15.4.1989
	mm g	mm g	mm g
PL_5 (Post larva 5 days old)	29.0 - 0.160	73.0 - 2.650	105.0 - 6.760
	33.0 - 0.308	82.0 - 3.645	92.0 - 5.882
	34.0 - 0.315	82.0 - 2.738	102.0 - 6.173
	30.0 - 0.230	74.0 - 2.375	93.0 - 6.452
	31.0 - 0.237	72.0 - 2.278	105.0 - 7.092
	36.0 - 0.335	74.0 - 2.748	104.0 - 6.849
	29.0 - 0.165	74.0 - 2.402	105.0 - 7.100
	28.0 - 0.150	76.0 - 2.894	101.0 - 5.920
	35.0 - 0.330	82.0 - 3.450	102.0 - 6.284
	32.0 - 0.310	75.0 - 3.150	107.0 - 7.420
Mean	31.7 - 0.254	76.4 - 2.833	101.6 - 6.593

TABLE 15 d

OPERATIONAL ECONOMICS OF A 1.0 HA SHRIMP FARM AT CHERUNGAL DURING MARCH & APRIL, 1989

EXPENDITURE	
Lease amount	Rs. 2,500.00
Preparation charges	1,200.00
Repair of sluice gate and fixation charges	500.00
Cost of 750 kg $Ca(OH)_2$	750.00
Cost of 1000 kg cow dung	100.00
Charges for watchman shed	250.00
Fabrication of cast net and other plastic items like buckets etc.	750.00
Cost of 1.5 lakh *P. indicus* seed @ Rs. 30/- per 1000 nos.	4,500.00
Transportation charges	200.00
Cost of 970 kg. Clam meat	2,910.00
Cost of 180 kg of g.o.c. & 150 kg ricebran	830.00
Cost of 150 kg butchery blood	150.00
Cost of 150 kg dry shrimp head meal	450.00
Watchman charges	1,500.00
Electricity charges	330.00
Wages for shrimp capture	1,354.00
Interest on capital	450.00
TOTAL	18,724.00
INCOME	
Sale proceeds from 677 kg of *P. indicus* @Rs.38/-/kg.	25,726.00
Income from disposal of used items	250.00
Total amount realised	25,976.00
Net profit (+)	7,252.00

Case study - B7 : Experimental culture of P. monodon & P. indicus at Karumancheri, Ezhupunna South, Alappuzha during 1986-87.

Operation - a

1. Aim

To work out the prospects of P. monodon culture and its economics during monsoon period.

2. Introduction

Alternate raising of paddy and shrimp during seasons was the customary farming practice followed in the traditional shrimp fields in Kerala. However, owing to the recurring paddy crop failures and heavy demand for shrimps, there is a tendency to raise an additional crop of shrimps instead of paddy. Therefore, an experiment was carried out to study the techno-economic feasibility towards utilizing a relatively deeper paddy field during rainy season.

3. Material and methods

3.1 Area of operation and layout

A small field of 0.4 ha area at Karumancheri, Ezhupunna South in Alappuzha District, lying adjacent to a narrow feeder canal originating from the Ezhupunna canal and indirectly connected to Cochin backwater was used for the operation (Fig. 1). The almost L-shaped field had three compartments with interconnections through openings in the dyke. The sluice gate fixed at a suitable place in the main compartment communicated with the feeder canal. The depth of water in the field varied between 60 and 70 cm and the tidal range oscillated between 30 and 40 cm.

3.2 **Field preparation and stocking**

The preliminary preparations of the field, sluice fixation and predator eradication were completed. A basal dose of superphosphate (20 kg) was applied as fertilizer during preparations. Required liming followed by cowdung manuring and fertilising with urea in the minimum recommended doses of 500 kg, 2000 kg and 100 kg/ha respectively, were also done. Dry twigs were planted with a view to generate periphyton as well as to offer protection.

3.3 **Substratum**

Substratum was constituted by clayey loom mixed with decaying vegetable matter. Presence of acid sulphate soil was indicated. But for the presence of tanaeidaceans, polychaetes and juveniles of bivalve *Villorita cyprinoides* during the study period other benthic fauna were not represented.

3.4 **Water exchange**

After preparation, regular tidal exchange was permitted till the water conditions attained similarity with that of main water body. 60 - 70 cm water level was maintained by occasional pumping.

3.5 **Release of *P. monodon* fry**

A consignment of 5000 *P. monodon* (PL_{10}) (Plate IA) procured from Govt. Prawn Hatchery, Azhikode was directly introduced after acclimatization on 24.6.1986 into the field at a stocking density of 12350 nos./ha.

3.6 **Feeding**

Except for fortnightly manuring with cowdung and regular exchange, no feeding was done during first two months. Ground, fresh clam meat was broadcast in the entire field area @ 5% of body weight of shrimps, during subsequent fortnight. Later on, crushed clam meat in the same dose was applied in trays in predetermined spots daily till harvest.

4. Results

4.1 Water quality parameters

The details of monthly variations of water quality parameters are furnished in Table 16a. Water temperature varied within 5°C from 27 to 32°C. pH was in the vicinity of 7 except in July. Salinity varied from 1.6 to 7.8‰ during June to October to 26.5‰ in May. During 86-87 the oxygen values fluctuated between 3.8 and 5.5 ml/L.

Table 16a

WATER QUALITY PARAMETERS AT KARUMANCHERI, DURING 1986-87

Period	Parameters	Temperature (°C) Air	Water	pH	Salinity (‰)	Dissolved Oxygen (ml/L)
May	1986	31.0	30.6	7.2	26.5	4.3
June	1986	26.0	27.0	7.0	4.5	5.1
July	1986	27.5	28.0	6.8	2.0	4.8
August	1986	29.0	29.5	7.0	1.6	5.3
September	1986	29.5	30.0	7.2	3.5	3.8
October	1986	28.0	28.5	7.0	7.8	4.4
November	1986	31.5	30.8	7.1	11.2	4.7
December	1986	30.5	30.0	7.2	13.6	5.4
January	1987	31.6	30.2	7.1	18.8	5.5
February	1987	30.5	31.5	7.3	20.6	5.2
March	1987	32.0	31.8	7.2	22.4	4.9
April	1987	32.5	32.0	7.4	25.3	4.6

4.2 Growth measurements and harvest data

The average growth assessed during each month is presented in Table 16b. The PL_{10} stage shrimp grew to the average size of 84.1 mm (4.073 g), 105.5 mm (8.572 g) 129.6 mm (17.01 g) and 168.2 mm (32.54 g) respectively after 1st, 2nd, 3rd and 4th months. The corresponding growth rates were 74.1 mm (4.063 g), 95.5 mm (8.562 g), 119.6 mm (17.00 g) and 158.2 mm (32.53 g).

Pond was harvested by cast netting after keeping minimum water level on 14th, 15th and 17th October, 1986. On 17th, the pond was completely dewatered by using pumps and the remaining P. monodon were also hand picked. 42.0 kg, 35.11 kg and 44.5 kg of P. monodon were obtained during 1st, 2nd and 3rd days of harvesting respectively. The corresponding average weights were 32.36 g, 32.54 g and 32.72 g. On the whole, the P. monodon acquired an overall average size of 168.2 mm (32.54 g) within a period of 115 days. As seen from Table 16c a total of 3737 nos. were harvested, the percentage survival being 74.74. 121.61 kg P. monodon was obtained resulting in a production rate of 300.38 kg/ha/115 days. The details of culture operations, inputs supplied, mean growth and yield attained are furnished in Table 16d.

5. Economics of operation

The economics of operation is also furnished in Table 16e. The expenditure, including preparation charges, cost of seed, feed, fertilizer, fishing charges, remuneration to watchman and interest on capital amount, worked out to Rs.3,823.05. By sale of 121.61 kg P. monodon at competitive rates at the farm fate an amount of Rs.11,148.62 was realised. Thus the operation ended in a profit of Rs.7,325.57 during a period of 4 months amounting to Rs.18,094.20 per hectare.

6. Observations

No nursery care was provided for the PL_{10} fry. Owing to scarcity of fry only a low stocking density @ 1.2 no./m² was possible. In spite of the above, the monsoon culture was found feasible and remunerative.

Table 16b

THE MEAN GROWTH AND GROWTH RATE OF P. MONODON AT KARUMANCHERI FROM JUNE TO OCTOBER, 1986

Period of observation	Duration of culture	Mean size mm	Mean size g	Mean growth rate mm	Mean growth rate g
June (24.6.86)	0	PL_{10} stage	0.010	-	
July	1 month	84.1	4.073	74.1	4.063
August	2 month	105.5	8.572	95.5	8.562
September	3 month	129.6	17.010	119.6	17.000
October	4 month	168.2	32.540	158.2	32.530

Table 16c

DETAILS OF P. MONODON HARVESTED AT KARUMANCHERI DURING OCTOBER 1986

Date of harvest	No. collected	Mean size (g)	Quantity (kg)
14.10.86	1298	32.36	42.00
15.10.86	1079	32.54	35.11
17.10.86	1360	32.72	44.50
Total	3737 (74.74%)	32.54	121.61

Table 16d

DETAILS OF PENAEUS MONODON CULTURE IN A 0.4 ha POND AT KARUMANCHERI DURING JUNE - OCTOBER, 1986

Area of the pond	:	0.4 ha
Date of stocking	:	24.6. 1986
No. of *P. monodon* stocked	:	5000
Stocking density	:	@ 12350/ha
Average size at stocking	:	PL_{10} stage
Quantity of mahua used	:	140 kg.
Quantity of lime	:	42 kg.
Quantity of cowdung	:	680 kg.
Quantity of fertilizers (Urea + super phosphate)	:	25 kg.
Quantity of g.o.c. & rice bran	:	7 kg & 5 kg
Quantity of clam meat	:	200 kg.
Quantity of diesel used	:	170 litres
Date of harvest	:	14 to 17.10.86
Duration of culture	:	115 days
Average size of *P. monodon* harvested	:	162.8 mm (32.54 g)
Total no. realised and percentage survival	:	3737 (74.74%)
Quantity of yield	:	121.61 kg.
Shrimp production/ha	:	300.38 kg.

Table 16e

OPERATIONAL ECONOMICS OF PENAEUS MONODON CULTURE AT KARUMANCHERI DURING JUNE - OCTOBER, 1986

Expenditure	Rs. Ps.
Charges for pond preparation	310.75
Charges for predator eradication	267.00
Repair of sluices	171.40
Bund repair and algal removal	145.00
Manures and fertilizers	252.00
Clam meat, g.o.c. and rice bran	476.30
Feed tray and shed thatching	64.50
Fencing cost and battery charges	43.50
Hire charges of engine & diesel	1,000.00
Cost of shrimp seed	259.00
Transportation charges	61.50
Fishing charges	112.10
Remuneration to watchman	500.00
Interest on capital	160.00
Sub total	3,823.05
Income	
Cost of 42.0 kg shrimp @ Rs.90/kg.	3,780.00
Cost of 35.11 kg shrimp @ Rs.92/kg.	3,230.12
Cost of 44.5 kg shrimp @ Rs.93/kg.	4,138.50
Sub total	11,148.62
Profit of operation (+)	7,325.57
Profit per hectare (+)	18,094.20

Operation - b

1. Aim

To assess the economics of *P. indicus* culture in a traditional field with acid sulphate soil at Karumancheri.

2. Introduction

The study area at Karumancheri was the one utilized for traditional shrimp culture with low yields. Hence an attempt was made to increase production with improved farming practices.

3. Materials and methods

3.1 Area, layout and preparation

Subsequent to the previous harvest, the same field was prepared for culturing *P. indicus*. The mode of preparation and other management aspects followed were the same as in operation - a. Eventhough the preparations were initiated by October end, the *P. indicus* fry was available only in January, 1987.

3.2 Water exchange

Tidal water exchange was done twice through screens in the sluice gate. At times pumping was resorted to maintain a water level of 60-70 cm.

3.3 Release of shrimp fry

32000 nos of PL_{12} stage *P. indicus* procured from Govt. Prawn Hatchery, Azhikode were stocked directly in the three compartments of the pond after acclimatization during the 2nd week of January 1987 @ 75042 nos per hectare.

3.4 Feeding

Along with water exchange, periodic manuring with cowdung @ 1 tonne/ha/yr and fertilizing with urea @ 100 kg/ha/yr were done. Pulverised feed comprising of goc and rice bran was distributed @ 5% of body weight after a week of stocking. However, fresh clam meat in crushed form @ 8-10% body weight was given after a month. P. indicus was also seen feeding on the periphytons generated on the dry twigs. The excess benthic algal assemblage formed on account of manuring and fertilizing were removed periodically.

3.5 Culture operations

The details of culture operations carried out for a period of three months are furnished in Table 17a.

4. Results

4.1 Water quality parameters

The details of water quality parameters are as furnished in Table 16a. pH ranged between 7.1 and 7.4. Temperature fluctuated between 30.2 and 32.0°C. The salinity values varied between 18.8 and 25.3‰. The dissolved oxygen values ranged between 4.6 and 5.5 ml/L.

4.2 Growth measurements and harvest data

The pond was harvested on 10th April 1987 by cast netting keeping the water level at minimum. Afterwards the pond was dewatered by pumping and the entire stock picked up. As presented in Table 17a, 18630 nos. of P. indicus with an average size of 13.53 g (130 mm) weighing 252.0 kg were obtained, the survival rate being 58.22%. The production/ha worked out was 622.44 kg.

The yield was categorised into three grades according to individual size and the details are shown in Table 17b. Specimens above 15 g with a mean size of 134.2 mm (17.602 g) constituted first category weighing 78.5 kg. Those weighing between 10 and 15 g having average size 119.9 mm (12.165 g) formed second category of 139.3 kg. Shrimps below 10 g weight with an average size of 107.2 mm (7.015 g) were included in the 3rd category, making 32.2 kg.

5. Operational economics

The operational economics of shrimp culture is presented in Table 17c. The total expenditure for the culture, including charges for preparation, seed, manure, feed and other items, worked out to Rs.4,214.45. The income realised by sale of *P. indicus* at competitive rates at the farm amounted to Rs.9,484.50. Thus, a net profit of Rs.5,270.05 equalling to Rs.13,017/- per ha. was made.

6. Observations

The delay caused by non-availability of seed in time was a matter of concern. The low survival rate may be due to lack of nursery facility and algal bloom formed. Inspite of the above, the high yield obtained was on account of improved practices adopted. It clearly speaks, therefore, that the shrimp production can be increased by adopting pragmatic methods as proved successful in the present case — increased rate of stocking, supplementary feeding, use of a pump and by alternating the culture species during the summer and the monsoon seasons disregarding any sophisticated technology.

Table 17a

DETAILS OF *PENAEUS INDICUS* CULTURE IN A 0.4 ha POND AT KARUMANCHERI DURING JANUARY - APRIL, 1987

Area of pond	:	0.4 ha
Date of stocking	:	14.1.1987
No. of shrimp seed stocked & source	:	32000 (Govt. Prawn Hatchery, Azhikode)
Stocking density	:	75042/ha
Stocking size	:	PI_{12} stage
Quality of mahua used	:	140 kg.
Quantity of lime	:	125 kg.
Quantity of cow dung	:	750 kg.
Quantity of fertilizers (Urea)	:	7 kg.
Quantity of g.o.c.	:	4 kg.
Quantity of rice bran	:	20 kg.
Quantity of clam meat	:	490 kg.
Quantity of diesel used	:	42 litres
Date of harvest	:	10.4.1987
Culture duration	:	87 days
Average size of shrimp harvested	:	130 mm (13.53 g)
Total no. caught and survival percentage	:	18630 nos. (58.22%)
Quantity of yield obtained	:	252.0 kg.
Production/ha	:	622.44 kg.

Table 17b

DETAILS OF HARVESTED PENAEUS INDICUS AT KARUMANCHERI DURING APRIL, 1987

Date of harvest	Mode of harvest	Quantity and mean size of *P. indicus* above 15 g size	Between 10-15g	Below 10 g	Total
10.4.87	Cast netting	78.50 kg	139.30 kg	32.20 kg	252.0 kg
	and				
	hand picking	17.602 g (134.20 mm)	12.165 g (119.90 mm)	7.015 g (107.20 mm)	13.53 g (130.00 mm)

Table 17c

OPERATIONAL ECONOMICS OF *PENAEUS INDICUS* CULTURE AT KARUMANCHERI DURING JANUARY - APRIL, 1987

Expenditure	Rs. Ps.
Charges for pond preparation	262.00
Charges for predator eradication	417.00
Sluice repair charges	242.00
Bund repair and algal removal	327.00
Manures and fertilizers	181.00
Clam meat + g.o.c. + rice bran	1,009.00
Shed making twig planting, fencing and feed trays, etc. charges	127.50
Hire charges of engine and diesel	254.45
Cost of seed	818.00
Transportation charges	158.00
Fishing charges	144.00
Cleaning and sorting charges	78.00
Sundry items	56.50
Interest on capital	140.00
Sub total	4,214.45
Income	
Cost of 78.5 kg 1st grade *P. indicus* @ Rs. 50/-/kg.	3,925.00
Cost of 139.3 kg 2nd grade *P. indicus* @ Rs.35/-/kg.	4,875.50
Cost of 32.2 kg 3rd grade *P. indicus* @ Rs.20/-/kg.	684.00
Total income	9,484.50
Profit of operation (+)	5,270.05
Profit per hectare	13,017.00

ECONOMICS OF SHRIMP PRODUCTION BY ALTERNATE CULTURE OF P. MONODON DURING MONSOON AND P. INDICUS DURING SEASON

The realisation of 121.61 kg *P. monodon* and 252.0 kg *P. indicus* in two successive operations within a period of 202 days equating to a production of 922.82 kg/ha from a 0.4 ha pond showed that the place was suitable for undertaking shrimp culture. However, the yield from the culture of *P. monodon* was relatively less owing to a comparatively low stocking density of 12350/ha. Much could have been realised by increasing the stocking density and also improving the survival rate.

In the case of *P. indicus* a stocking density of 75000/ha coupled with manuring resulted in the high yield. On an economic view point, an amount of Rs.20,633.72 was realised by spending an amount of Rs.8,037.50 by way of both operations. Thus a profit of Rs.12,596.22 was obtained from the endeavour. This margin though is inclusive of lease amount, substantial balance amount remained even after earmarking the normal rate of lease value. Judged from the above, it is calculated to obtain not less than Rs.25,000/- as profit through two successive shrimp culture operations from one hectare field.

COMPARATIVE ANALYSIS OF CULTURE, YIELD AND ECONOMICS OF P. INDICUS AND P. MONODON IN GROW OUT SYSTEMS ADJOINING VEMBANAD LAKE

The details are presented in Table 18a & 18b. P. indicus fry of mean size 19.4 mm (0.41 g) when grown at two separate grow outs set wide apart accrued considerable growth gain at Narakkal than at Puduvypu irrespective of the nature of supplemental feed and water management under a stocking density of $5/m^2$. This clearly indicated the importance of site selection in shrimp culture.

So also, the growth gain of P. indicus was higher in a seasoned farm when compared with that of a newly excavated one both located at Narakkal. Further, in spite of stocking advanced fry and providing better growth conditions including supplemental feeding and pumping, the growth gain of P. indicus at the newly excavated farm was much lower than that at the seasoned one emphasising the importance of conditioning of the farm.

The studies on the rotational culture of P. monodon during monsoon followed by P. indicus during regular season at Karumancheri demonstrated the possibilities of enhanced production from the same field netting higher profit. This indicated the prospects of utilising similar fallow lands.

The PL_5 P. indicus fry cultured at Cherungal could attain only a mean growth gain of 96.6 mm/6.588 g within 45 days. Irrespective of initial fry size of 41 and 10 mg of P. indicus stocked at Narakkal and Karumancheri respectively, the similar mean size of 13.3/13.5 g attained during harvest within 80-87 days indicated the variability between grow outs in promoting shrimp growth.

A differential growth performance of P. indicus was noticed depending upon the type of feed supplied, the least growth being in the control pond where there was no supplemental feeding.

Among the various supplemental feeds used in addition to manuring and fertilizing at limited doses, pulverised feed containing clam meat promoted better growth as noticed at Karumancheri.

Again, P. indicus growth was seen better in all places where clam meat was given as supplemental feed.

When compared with a stocking density of $5/m^2$ and a production rate of 402.35 kg/ha at Narakkal, a further increase in stocking density to the level of $7.5/m^2$ enhanced production of P. indicus at Karumancheri to 622.44 kg/ha. Still further increase in stocking density to $15/m^2$ at Cherungal resulted in appreciable production gain of 677 kg/ha.

However, an increase in density to $11.7/m^2$ at the newly excavated farm, Narakkal, could not make any production gain perhaps due to lack of conditioning of the site.

The importance of occasional pumping to maintain the water level coupled with the increased stocking density was demonstrated by the higher production of P. indicus at Cherungal and Karumancheri compared to Narakkal and Puduveypu where water level could not be maintained by tidal flow alone. The special pumping design adopted at Cherungal promoted to maintain a density of $15/m^2$. But for the pumping resorted to maintain a stocking density of $11.7/m^2$, the production at the newly excavated farm, Narakkal would have been poor.

From the production view point, a yield of 677 kg/ha attained at Cherungal within 45 days was a commendable success compared to 622.44 kg/ha at Karumancheri and 402.35 at Narakkal within 87 and 80 days respectively. But the size of P. indicus attained at Cherungal was relatively small when compared with the fairly large sized ones resulted in the other two places. Nonetheless, it was found more advantageous and economical to raise more number of short duration crops of P. indicus within the season.

P. monodon

Hither to enexplored areas - coconut groves at Pallithode and Chalippuram were found successful for P. monodon culture. However, groves at Pallithode produced better quality shrimps even compared with that of a regular farm at Karumancheri.

Comparative studies of stocking density of P. monodon showed the highest production at Chalippuram with a stocking density of $7.5/m^2$. It was also worth noting that the record production @ 1170.45 kg/ha leading to a realization of 76.9% return on investment at Chalippuram was possible as a result of the unified combination of the management techniques including the individual care bestowed.

Of the 5 grow outs where economics of operation was analysed, the maximum net profit of Rs.76649/- was realised at Chalippuram followed by Rs.31111/- at Karumancheri, Rs.13320/- at Pallithode, Rs.7252/- at Cherungal and the lowest profit of Rs.904/- from the newly excavated farm at Narakkal. The vast difference in the profit level/ha noted among the different systems can be attributed to several factors. Most important among them are: location of growouts, species selected, type of feed, level of water management etc. On the whole, the higher profit margin occurred in those places where P. monodon was cultured. The profit level presented being from a single crop in respect of a particular species, the chances of raising more crops within an year would lead to higher economic returns from these systems. Such gains are likely to speed up the transformation of such water bodies to the beneficial purposes in the long run.

Table 18a

CULTURE OF PENAEUS INDICUS IN GROW OUT SYSTEMS ALONG VEMBANAD LAKE DURING 87-89

Sl. No.	Place	Type of culture system	Stocking density no/ha (no/m^2)	Initial size g/mm	Growth gain g/mm	Type of feed	Type of water management	Culture duration days	Production rate kg/ha
1.	Narakkal	Paddy field compartments	50000 (5)	0.041/19.4	13.251/ 104.7	Pulverised feed mixed with clam meat	Tidal	80	402.35
		"	"	"	11.011/ 97.4	Commercial Pellets	"	"	351.76
		"	"	"	11.779/ 96.1	Cowdung manure	"	"	344.60
		"	"	"	7.884/ 85.9	Control (No feed supply)	"	"	269.00
2.	Puduveypu	Pond in accreted wet land	53000 (5.3)	0.041/19.4	9.24/87.4	Pulverised feed mixed with clam meat	Tidal	85	241.18
		"	"	"	7.566/86.0	Commercial pellet	"	"	214.12
		"	"	"	7.77/85.6	Cowdung manure	"	"	180.00
		"	"	"	4.65/71.1	Control(No feed supply)	"	"	96.47
3.	Narakkal Harijan Farm	Newly excavated pond	1,17,325 (11.7)	0.258/34.5	9.512/75.1	Cowdung manure and clam meat	Tidal occasional pumping	98	376.25
4.	Cherungal	Transformed paddy field	1,50000 (15)	0.005/5.0	6.588/96.6	Cowdung manure, clam meat and pulverised feed mixed with clotted blood	Tidal + regular pumping	45-50	677.00
5.	Karumancheri	Transformed paddy field	75042 (7.5)	0.012/12.0	13.518/ 118.0	Fertilizing, cowdung manuring, pulverised and clam meat supply	Tidal + at times pumping	87	622.44

Table 18b

CULTURE OF *PENAEUS MONODON* IN GROW OUT SYSTEMS ALONG VEMBANAD LAKE DURING 1986-'91

Sl. No.	Place	Type of culture system	Stocking density (no/ha)	Initial size g/mm	Growth gain g/mm	Type of feed	Type of water management	Culture duration days	Production rate kg/ha
1.	Karumancheri	Transformed paddy field	12350 (1.2)	0.010/10.0	32.53/152.8	Fertilizing cowdung manuring, pulverised feed and clam meat supply	Tidal + at times pumping	115	300.38
2.	Pallithode	Coconut groves	24700 (2.47)	0.012/12.0	40.438/ 159.4	Cowdung manure, pulverised feed and clam meat supply	Tidal + at times pumping	89	237.73
3.	Chalippuram	Paddy field transformed coconut groves	68100 (6.8)	0.030/22.0	27.97/133.0	Fertilizing cowdung manure, pulverised feed with goc, rb and clam meat supply	Tidal + regular pumping	107	1170.45

2.4 Group C

Pilot studies on shrimp farming for enhanced production in the newly accreted wet land at Puduveypu.

Salient features

Mini ponds - handy small earthern units - adjoining feeder canals - well prepared - selective stocking of P. indicus and P. monodon - manuring and supplemental feeding - water management by tidal processes and pumping - terminal harvest. The major drawbacks of the accreted area were loose substratum and silt laden turbid water conditions.

Study C1 : Pilot study on P. indicus culture in ponds at Puduveypu between November 86 and February 87.

Study C2 : Pilot study on P. indicus culture at Puduveypu between January and March, 1988.

Study C3 : Pilot study on P. indicus culture at Puduveypu between February and April 1987.

Study C4 : Pilot study on P. indicus culture at Puduveypu between April and June, 1988.

Study C5 : Pilot study on P. indicus culture at Puduveypu between December, 1988 and March 1989.

Study C6 : Pilot study on P. indicus culture in a pump fed pond at Puduveypu between December 1988 and March 1989.

Study C7 : Pilot study on P. monodon culture in earthern pools at Puduveypu during August 1987.

Study C8 : Pilot study on *P. monodon* culture in mini pond at Puduveypu between September 1987 and February 1988.

Aim

A series of pilot studies on shrimp farming were made in ponds at Puduveypu. These experiments were carried out in order (1) to study the effect of different stocking densities on the growth of *P. indicus* (C1 & 2), to study the effect of a) manuring (C3), b) compounded feed (C4) and formulated feed (C5) on growth of *P. indicus*, to elucidate the advantages of pump fed pond over the tidal ones using *P. indicus* (C6), to assess the comparative performance between wild and hatchery fry of *P. monodon* (C7) and to assess the impact of manure and clam meat on the growth of *P. monodon* (C8).

C 1 : Pilot study of *P. indicus* culture in mini ponds at Puduveypu between November 1986 and February 1987.

1. Aim

To study the effect of different stocking densities on the growth of *P. indicus* using commercial pellet feed.

2. Introduction

The appropriate density of stocking of shrimp fry depending on the environmental characteristics of a particular area is a much debated one. Therefore it was felt necessary to undertake this investigation in the accreted area at Puduveypu where in turbid water prevails.

3. Material and methods

3.1 Pond location, layout and preparation

Three small ponds rectangular in shape Plate XIII A were selected adjoining a feeder canal at Puduveypu during November 1986. They were numbered 1, 2 and 3 from left to right covering an area of 42, 48 and 44 m^2 respectively. Each pond was properly excavated to ensure a sufficient water depth of 70-80 cm. In each case, the sluice gate, with proper control and fitted with a suitably fabricated nylon screen opened directly into the canal. After soil sealing each pond was thoroughly cleaned, properly levelled and prepared adopting standard procedure (Hickling, 1962). The slushy bottom of the pond was made more firm by dumping sand from suburban areas. An initial dose of mussouriephos (P_2O_5 - 22.24%) @ 5 kg/pond was applied in the bottom during final stages of preparations. Dried twigs were planted (Plate XIII B) to offer adequate protection to the stocks as well as to generate periphyton.

3.2 **Water exchange**

On completion of the pond preparation, soil sealing of the sluice gate was removed and water exchange through filter screens was permitted in each pond. This was continued for 3-4 days by which process the water quality was made similar to that prevailing outside. Thereafter regular water exchange was carried out taking advantage of available tides. However, on certain occasions, when minimum water level could not be retained by tidal flow, pumping was resorted to keep the desired water level of 70-80 cm in all ponds. 25-30% water exchange was provided daily.

3.3 **Substratum**

Substratum was composed of loose mud, sand particles and molluscan shell remnants. Decaying vegetation and disintegrating small logs were also associated. Benthic fauna was very scarce represented by very few numbers of tanaeidaceans, amphipods and polychaetes.

3.4 **Fry stocking**

Simultaneously wild *P. indicus* fry were collected from backwaters. More or less uniform sized and healthy fry were sorted out (Plate VII A) and retained in suitable hapas (Plate I B) for stocking purposes. On 27.11.1986 fry numbering 420, 720 and 1100 were released in ponds 1, 2 and 3 to maintain a stocking density @ 1, 1.5 and 2.5 lakh/ha respectively as furnished in Table 19a.

3.5 **Feed and feeding**

Regular water exchange was continued from the subsequent day of stocking but regular supplemental feeding, was started after one week only. In all ponds commercial pellet feed (Table 10b) was applied @ 8-10% of body weight daily. Initially, 5, 7.5 and 12.5 g feed was applied in ponds 1, 2 and 3 respectively. Gradually this was increased

Table 19a

PARTICULARS OF CULTURE OF *PENAEUS INDICUS* AT DIFFERENT STOCKING DENSITIES

Details	Pond 1	Pond 2	Pond 3
Area (m^2)	42	48	44
Date of stocking	25.11.1986	25.11.1986	25.11.1986
No. stocked	420	720	1100
Stocking density	@ 100000 nos/ha	@ 1,50,000/ha	@ 2,50,000/ha
Size of stocking (mm/g)	16.2 (0.029)	16.2 (0.029)	16.2 (0.029)
Date of harvest	27.2.1987	27.2.1987	27.2.1987
Culture duration (days)	93	93	93
Average size at harvest (mm/g)	100.1 (6.523)	92.8 (4.814)	93.8 (4.855)
No. realised and survival %	278 (66.19%)	543 (75.42%)	479 (43.55%)
Yield obtained (kg)	1.81	2.60	2.25
Production/ha (kg)	430.95	541.67	511.36
Nature of feed	Commercial pellets	Commercial pellets	Commercial pellets
Type of water management	Tidal + Pumping	Tidal + Pumping	Tidal + Pumping

to 80, 120 and 200 g. In all cases, feed was supplied during evening in suitable wide mouthed earthern containers (Plate VIII A) kept at 4-5 predetermined places in each pond.

4. Results

4.1 Water quality

The details of water quality parameters are presented in Table 19b. The water temperature, pH, salinity and dissolved oxygen fluctuated between 29.0 and 31.5°C, 8.5 and 9.25, 11.05 and 28.2‰ and 3.50 and 5.2 ml/L respectively during the period of culture.

Table 19b

WATER QUALITY PARAMETERS AT PUDUVEYPU BETWEEN NOVEMBER 1986 AND FEBRUARY 1987

Parameters Period	Temperature (°C) Air	Water	pH	Salinity (‰)	Dissolved oxygen (ml/L)
November 1986	31.0	31.5	9.25	11.05	5.20
December 1986	29.0	30.0	9.00	18.45	4.75
January 1987	31.0	30.4	9.00	24.30	4.87
February 1987	27.0	29.0	8.50	28.20	3.50

4.2 Growth measurements and harvest data

In all cases, mean values of growth were ascertained from a random sample of 10 specimens each.

The mean values of growth assessed at intervals from the three treatment ponds are presented in Table 19c. The initial mean size at stocking was 16.2 mm (0.029 g) in all ponds. However, the mean values showed tremendous variations subsequently in respect of each pond. The mean values of growth attained after 2 months were 72.3 mm (2.442 g), 74.5 mm (2.807 g) and 81.6 mm (3.560 g) respectively in Ponds 1, 2 and 3. During harvest after 93 days on 27.2.87 the corresponding values recorded from the three ponds were 100.1 mm (6.523 g), 92.8 mm (4.814 g) and 93.8 mm (4.855 g).

The rate of growth and growth increment achieved in different ponds are furnished in Table 19d. During initial periods, increased rate of growth and growth increment were noticed in ponds with high stocking density. However, during the 3rd month, rate of growth and growth increment considerably advanced in the pond with comparatively low stocking density. The growth rates recorded during harvest in the three ponds were 83.9 mm (6.494 g), 76.6 mm (4.785 g) and 77.6 mm (4.826 g) respectively. While higher growth increment values of 20.5 mm (1.792 g) and 22.6 mm (2.350 g) after 2 months were respectively recorded from ponds 2 and 3, the corresponding value from pond 1 was only 20.3 mm (1.523 g). However, the increment values attained after ten weeks were 18.9 mm (2.390 g) and 12.3 mm (1.176 g) respectively in ponds 1 and 2 while it was fairly low in pond 3. On the whole, relatively appreciable growth was recorded in pond 1 employing a stocking density of 1.0 lakh/ha.

The data on weight measurements (log values) from all the three ponds on the harvest day (Table 19a) were subjected to statistical analysis. The result showed that the difference between mean weights of P. indicus in three ponds were highly significant ($P < 0.01$). The relevant analysis of variance table is furnished below:

Source	s.s	df	Ms	F
Between means	0.0783	2	0.03915	8.77*
Error	0.12058	27	0.004466	
Total	0.19888	29		

** ($P < 0.01$)

Again for comparing the means individually, Tukey's test was applied and value of D = QS$\bar{x}$ = 0.061. The difference of mean weights between ponds 1, 2 and 3 indicate that the mean values of 2 and 3 are not different whereas that of 1 is different from both 2 and 3. The average mean weight in pond 1 was 6.523 g whereas those of 2 and 3 were 4.814 g and 4.855 g respectively. The better growth performance seen in pond 1 could be due to the maintenance of more or less moderate stocking density ie. @ 1 lakh/ha.

The percentage survival noted in ponds 1, 2 and 3 were found to be 66.19, 75.42 and 43.55 respectively (Table 19a). The quantities of P. indicus realised were in the order of 1.81, 2.6 and 2.25 kg arriving at a production level of 430.95, 541.67 and 511.36 kg/ha/3 months respectively.

Though variations in stocking densities between ponds 2 and 3 were high, increased rate of production occurred in pond 2. In addition, the survival rate in pond 2 was also considerably high ie. 75.42% in contrast to the lowest survival rate ie. 43.55% recorded in pond 3. Hydrobiological conditions being similar in both ponds, the increased stocking density opted in pond 3 did not reflect in the final yield. This indicated that the stocking density of 1.0 lakh/ha was appropriate in the area.

5. Observations

The mean size attained by P. indicus in different treatment ponds within 3 months was not comparable to that of other condusive environments. This might be attributed to the stressful effect of turbid water conditions inherent in the place.

Table 19c

MEAN GROWTH VALUES OF *PENAEUS INDICUS* AT VARYING DENSITIES OF 1, 1.5 AND 2 LAKH/ha

Date of observation	Pond 1 mm - g	Pond 2 mm - g	Pond 3 mm - g
25.11.1986	16.2 - 0.029	16.2 - 0.029	16.2 - 0.029
24.12.1986	52.0 - 0.919	54.0 - 1.015	59.0 - 1.210
24.1.1987	72.3 - 2.442	74.5 - 2.807	81.6 - 3.560
23.2. 1987	91.2 - 4.832	86.8 - 3.983	82.8 - 3.987
27.2.1987	100.1 - 6.523	92.8 - 4.814	93.8 - 4.855

Table 19d

MEAN VALUES OF RATE OF GROWTH AND GROWTH INCREMENT OF *P. INDICUS* DURING HIGH DENSITY CULTURE

Date of observation	Pond 1 Growth rate mm - g	Pond 1 Growth increment mm - g	Pond 2 Growth rate mm - g	Pond 2 Growth increment mm - g	Pond 3 Growth rate mm - g	Pond 3 Growth increment mm - g
25.11.1986	16.2 - 0.029	(initial)	16.2 - 0.029	(initial)	16.2 - 0.929	(initial)
24.12.1986	35.8 - 0.890	35.8 - 0.890	37.8 - 0.986	37.8 - 0.986	42.8 - 1.181	42.8 - 1.181
24.1.1987	56.1 - 2.413	20.3 - 1.523	58.3 - 2.778	20.5 - 1.792	65.4 - 3.531	22.6 - 2.350
13.2.1987	75.0 - 4.803	18.9 - 2.390	70.6 - 3.954	12.3 - 1.176	66.6 - 3.958	1.2 - 0.427
27.2.1987	83.9 - 6.494	8.9 - 1.691	76.6 - 4.785	6.0 - 0.831	77.6 - 4.826	11.0 - 0.868

C 2 : Pilot study on P. indicus culture at Puduveypu between January and March, 1988.

1. **Aim**

To study the effect of different stocking densities on growth of P. indicus using formulated feed.

2. **Introduction**

In the turbid water environment at Puduveypu, no information is available on the effect of stocking densities on shrimp growth. In this experiment a formulated feed was used.

3. **Material and methods**

3.1 **Location and layout**

Three rectangular mini ponds (1, 2 & 3) of equal water spread area (50 m^2) and lying side by side were selected adjoining a feeder canal at Puduveypu (Plate XIII A) for experimental study. Each independent pond with suitable sluice gate and control (Plate IX A) and fitted with a nylon screen separately opened into the adjoining feeder canal.

3.2 **Pond preparation**

All the ponds were thoroughly cleaned and kept dried for a period of 3-5 days. As part of preparations, sea sand was dumped into the pond bottom to make the slushy substratum more firm. The sluice gates were soil sealed. 25 kg dry cowdung was applied in each pond as basal manuring dose. A fair water depth of 75 cm was maintained in all ponds.

After preparations, the soil sealing was removed and fresh tidal water was admitted through the sluice gate of respective ponds during the 2nd week of January, 1988. This process was repeated for 3 days to have more or less similar water conditions prevailing in the main water body.

3.3 **Substratum**

The structure of the substratum was similar to the one described as in C-1.

3.4 **Water exchange**

The regular exchange through filters of sluice gates depending on tidal processes was continued thereafter. On account of peculiar characteristics, the tidal water always remained turbid and silt laden. Hence care was taken to admit water during balanced condition of tidal level when most of the particles were settled down. All ponds were treated identically in respect of water management, manuring and feeding. Almost 25-30% water was exchanged daily. At times of low tidal level, one 5 HP diesel pump was used to maintain level of water, at 75 cm.

3.5 **Stocking and release of fry**

While preparing the pond, P. indicus wild fry was collected and kept in hapa (Plate I B). Of these uniform sized 2250 fry were carefully released into ponds 1, 2 and 3 in the ratio of 2:3:4. The respective stocking densities were 100,000, 150,000 and 200,000 nos./ha respectively (Table 20a).

3.6 **Feeding**

During every week, 5 kg dry cowdung was regularly immersed in baskets in each pond. After 2 weeks of stocking formulated feed was applied, daily evening using suitable feed trays at 2 points in each

Table 20a

EXPERIMENTAL PARTICULARS OF P. INDICUS

	Particulars	Pond 1	Pond 2	Pond 3
1.	Size of the pond	Rectangular	Rectangular	Rectangular
2.	Are of the pond (m^2)	50	50	50
3.	Average water depth (cm)	75	75	75
4.	Date of stocking	16.1.88	16.1.88	16.1.88
5.	Date of harvest	26.3.88	26.3.88	26.3.88
6.	No. of culture days	70	70	70
7.	Size at stocking (mm/g)	52.8/0.848	52.8/0.848	52.8/0.848
8.	Size at harvest (mm/g)	108.5/8.584	85.5/4.272	74.7/2.922
9.	Growth increment (mm/g)	55.7/7.736	32.7/3.424	21.9/2.072
10.	No. of seeds stocked	500	750	1000
11.	Stocking density (no./ha)	1,00,000	1,50,000	2,00,000
12.	No. of shrimps harvested	346	493	587
13.	Percentage survival (%)	69.2	65.73	58.70
14.	Total production (kg.)	2.58	2.16	1.87
15.	Production (kg/ha)	516.0	432.0	373.0
16.	Total manure (Cowdung) applied (kg)	75	75	75
17.	Others (Nature of water management)	Occasionally pump fed in addition to tidal	Occasionally pump fed in addition to tidal	Occasionally pump fed in addition to tidal

pond. Trays were sundried daily. During initial periods, the feed schedule was @ 10%/day. Subsequently it was brought down to 5%/day on the 58th day of culture. The culture was continued from 16.1.1988 to 26.3.1988 for a period of 70 days (Table 20a).

Feed composition

The feed was prepared by compounding dry and powdered fish meal, detritus, tapioca flour and ground nut oil cake in the ratio of 4:3:2:1. Standard method was adopted to make the feed. The pelleted feed prepared in hygienic manner was stored under dry conditions for daily use till the end of experiment. The bio-chemical composition of the feed is shown in Table 20b below:

Table 20b

BIO-CHEMICAL COMPOSITION OF FORMULATED FEED USED FOR *P. INDICUS* CULTURE

Ingredients & ratio	% Biochemical composition on dry wt.basis					Energy	
	Moisture	Protein	Fat	Ash	CHO	K.Cal/g	K.Cal/kg
Fish meal* + Detritus** + Tapioca flour + g.o.c.*** 4:3:2:1	14.59	26.25	2.06	12.5	44.6	3.02	3020

* *Oreochromis mossambicus*, ** *Avicennia sp.*, *** Groundnut oil cake

4. Results

4.1 **Water quality parameters** were observed at weekly intervals and monthly mean values are presented in Table 20c. The values of water temperature, pH, salinity, dissolved oxygen, alkalinity and sediment load ranged between 29.0 - 30.6°C, 8.5 - 9.25, 28.93 - 30.9‰, 2.52 - 4.54 ml/L, 190.0 - 304 mg/L and 0.25 - 1.50 g/L respectively during the period.

Table 20c

WATER QUALITY PARAMETERS DURING EXPERIMENTAL CULTURE OF P. INDICUS BETWEEN JANUARY AND MARCH, 1988

Parameters / Period	Temperature (°C) Air	Water	pH	Salinity (‰)	Diss. oxygen (ml/L)	Alkalinity (mg/L)	Sediment (g/L)
January	27.5	30.0	9.25	28.93	4.54	190	0.25
February	27.0	29.0	8.50	29.09	3.82	304	0.35
March	31.5	30.6	8.50	30.90	2.52	292	1.50

4.2 **Growth measurements and harvest data**

Periodic measurements of *P. indicus* (length in mm/weight in g) were made by taking random samples employing suitable cast nets. The progress of growth was assessed on 24th, 34th, 58th and 70th day based on mean size in each pond. The results are presented in Table 20d.

Harvesting in all ponds was done on 26.3.1988 on the 70th day of culture.

The maximum gain in weight of *P. indicus* was observed in Pond 1. The fry attained a mean size of 108.5 mm/8.58 g in 70 days; whereas it was 85.5 mm/4.27 g in pond 2 and 74.7 mm/2.92 g in pond 3.

The rates of growth and growth increments presented in Table 20e show that the maximum rate of growth was seen in Pond 1, the growth values after 70 days being 55.7 mm (7.74 g). The corresponding values in Ponds 2 and 3 were 37.2 mm (3.42 g) and 21.9 mm (2.072 g). A decreasing trend in the rate of growth with increase in stocking

TABLE 20 d

TREND OF GROWTH-P.INDICUS

No. of Culture days.	Pond 1 Mean ± SE mm/g	Pond 2 Mean ± SE mm/g	Pond 3 Mean ± SE mm/g
0	52.80 ± 2.82	52.80 ± 2.82	52.80 ± 2.82
	0.8482 ± 0.085	0.8482 ± 0.085	0.8482 ± 0.085
24	55.20 ± 3.38	60.40 ± 4.50	61.60 ± 5.78
	0.9800 ± 0.240	1.34 ± 0.34	1.56 ± 0.33
34	71.40 ± 3.88	65.60 ± 1.99	67.80 ± 1.07
	2.26 ± 0.39	1.60 ± 0.15	1.836 ± 0.044
58	96.80 ± 7.05	79.60 ± 7.45	74.20 ± 6.01
	5.92 ± 1.42	3.08 ± 1.17	2.01 ± 0.72
70	108.50 ± 1.86	85.50 ± 3.71	74.70 ± 0.72
	8.584± 0.360	4.272 ± 0.464	2.92 ± 0.05

Table 20e

RATE OF GROWTH (mm/g) AND GROWTH INCREMENT (mm/g) OF *P. indicus* IN DIFFERENT PONDS

No. of culture days	Pond 1 Growth rate mm	Pond 1 Growth rate g	Pond 1 Growth increment mm	Pond 1 Growth increment g	Pond 2 Growth rate mm	Pond 2 Growth rate g	Pond 2 Growth increment mm	Pond 2 Growth increment g	Pond 3 Growth rate mm	Pond 3 Growth rate g	Pond 3 Growth increment mm	Pond 3 Growth increment g
0	52.8	0.848	-	-	52.8	0.848	-	-	52.8	0.848	-	-
24	2.4	0.132	2.4	0.132	7.6	0.492	7.6	0.492	8.8	0.712	8.8	0.712
34	18.6	1.412	16.2	1.280	12.8	0.752	5.2	0.260	15.0	0.988	6.2	0.276
58	44.0	5.072	25.4	3.660	26.8	2.232	14.0	1.480	21.4	1.162	6.4	0.174
70	55.7	7.736	11.7	2.664	37.2	3.424	5.9	1.192	21.9	2.072	0.5	0.910

density was quite evident. In general, the growth increment in terms of weight showed faster rates after 5 weeks in the case of all treatments. However, the quantum of growth increment varied very much in different ponds, the highest increment values being presented by the low density culture pond. A decreasing trend in growth increment in relation to increased stocking density was also clearly discernible.

Table 20a also presents the outcome of experimental operations. Pond 1 showed highest percentage survival (69.2%) followed by pond 2 (65.73%) and pond 3 (58.70%). The quantities of shrimps realised from Ponds 1, 2 and 3 were in the order of 2.58, 2.16, and 1.87 kg. The above indicated that survival rate and resultant yield are depended on stocking density to a certain extent.

The length and weight measurements of P. indicus were subjected to statistical analysis for comparison of means. The data on weight of shrimps collected at harvest from 3 ponds were subjected to logarithmic transformations and the application of Analysis of Variance technique (Table ANOVA) proved that the difference between mean values was highly significant ($P < 0.001$). This indicates that there was high variation of growth rate among the stocking in the 3 ponds.

Table ANOVA

Source of variation	SS	df	MS	F
Total	1.31304	29		
Between ponds	1.1303	2	0.56515	83.4**
Error	0.1827	27	0.00677	

** $P < 0.001$

Further for testing the differences between individual mean values, the Tukey's method was adopted. The value of D was calculated to be D = $QS\bar{x}$ = 0.091 which was observed to be higher than all the individual mean differences. Hence all the individual mean values differ from each other.

The maximum gain in weight was observed in Pond 1, followed by Ponds 2 and 3 in order. This indicated that the growth rate was restricted with increase in stocking density. Of the three stocking densities studied the stocking rate as adopted in Pond 1 was found best.

5. Observation

On account of sediment load and turbid water conditions, very poor dissolved oxygen values prevailed which resulted in poor feeding and stunted growth of *P. indicus*.

C 3 : Pilot study on *P. indicus* culture at Puduveypu between February and April, 1987.

1. **Aim**

To study the effect of three organic manures on growth of *P. indicus*

2. **Introduction**

Eventhough the role of organic manures in improving the fertility of aquatic environment is fairly well known, much data is not available on their effect in enhancing growth of shrimps. Therefore, an experiment was carried out to gather more information along this line by growing *P. indicus*.

3. **Material and methods**

3.1 **Pond selection, layout and preparation**

Four identical rectangular ponds each having an area of 42.5 m^2 and a sluice gate with control which opened independently into the feeder canal were selected. All ponds were thoroughly prepared for shrimp culture purposes adopting standard methods (Natarajan, 1985). Because of the loose consistency of the substratum, adequate quantity of sand was spread on the pond bottom to make it more firm. The depth of each pond ranged between 75 and 80 cm. A suitably fabricated nylon screen was fixed in the sluice gate of each pond in order to permit entry of only filtered tidal water to the culture systems during exchange.

The ponds were numbered 1, 2, 3 and 4 (Plate XIII A). The pond 1 was used as control and others for separate manures. To start with organic manures such as poultry droppings,cowdung and buffalo dung @ 10 kg each were respectively applied in Ponds 2, 3 and 4 as basal dose keeping an initial water level of 10 cm in each pond. After 3 days, the water level was raised by intake of fresh tidal water through filter screens (Plate VI B) and the process of exchange was continued for 4 days in order to condition the water within the ponds. All ponds were got ready for stocking purposes by the end of February 1987.

3.2 **Water exchange**

No exchange was permitted during the following three days of stocking to facilitate the acclimatisation of shrimp fry to experimental conditions. Thereafter regular water exchange @ 25 - 30% was continued through filter screens in all ponds daily.

3.3 **Substratum**

The substratum was similar to what has already been described as in C-1.

3.4 **Fry stocking**

Subsequently shrimp fry were collected from the nearby brackish waters. 425 nos of hand picked uniform size fry of P. indicus (Plate VII A) measuring about 28 mm were carefully released into each pond keeping a definite stocking density of 1 lakh/ha. The details of stocking and other particulars are presented in Table 21a.

3.5 **Manuring**

During each week, a regular dose of manures @ 2 kg poultry dropping, @ 5 kg cowdung and @ 5 kg buffalo dung was respectively applied in Ponds 2, 3 and 4 till the last week of experimental operations. The droppings and dungs were collected from the farms where in the animals were fed on standard feeds. On application of manures, there was no water exchange for two days. Except for the difference in the application of manures, all ponds were identically treated during the entire period of experimental operations.

3.6 Culture operation

The experiment was continued for 2 months from 28.2.87 to 27.4.87 (Table 21a).

4. Results

4.1 Water quality parameters were measured at fortnightly intervals in the ponds. The mean values of temperature, pH, salinity and dissolved oxygen, fluctuated between 29 and 31°C, 7 and 8.5, 28.2 to 31.8‰ and 2.5 to 3.8 ml/L respectively during the operation period.

4.2 Growth measurements and harvest data

The mean values of length and weight of P. indicus at stocking and those assessed at fortnightly intervals from different ponds are presented in Table 21b. The mean values at the stocking time in all the ponds were uniformly the same ie. 28.0 mm (0.155 g). Since then, variations in mean values of growth were noticed in all the ponds. Thus, during harvest after two months, the mean values recorded in length and weight of shrimps in ponds 1 to 4 were 75.2 mm (2.414 g), 80.3 mm (3.442 g), 78.8 mm (3.30 g) and 70.3 mm (2.334 g) respectively.

The results presented in Table 21a indicated a growth rate of 47.2 mm (2.259 g), 52.3 mm (3.287 g), 50.8 mm (3.145 g) and 42.3 mm (2.179 g) respectively for P. indicus in ponds 1, 2, 3 and 4. This also indicated that maximum growth was in the pond manured with poultry droppings followed by that of cowdung and buffalo dung in order. However, the rate of growth attained in the buffalo dung manured pond was lower than that of the control. This can be on account of the poor nutrient status of buffalo dung among farm yard manures showing its negative impact on aquatic productivity. On harvest 345, 383, 349 and 338 numbers of shrimps were realised from ponds 1 to 4 respectively

Table 21 a

EXPERIMENTAL CULTURE OF P. INDICUS FROM FEBRUARY TO APRIL, 1987.

Details	Pond 1	Pond 2	Pond 3	Pond 4
Area of pond (m^2)	42.5	42.5	42.5	42.5
Treatments (Manuring)	Control	Manuring with poultry droppings	Manuring with cowdung	Manuring with buffalo dung.
Date of shrimp stocking	28.2.87	28.2.87	28.2.87	28.2.87
No. of shrimps stocked	425	425	425	425
Stocking density (no./ha)	1 lakh	1 lakh	1 lakh	1 lakh
Mean size at stocking mm/g	28.0/0.155	28.0/0.155	28.0/0.155	28.0/0.155
Date of harvest	27.4.87	27.4.87	27.4.87	27.4.87
Duration of culture	2 months	2 months	2 months	2 months
Mean size at harvest (mm/g)	75.2/2.414	80.3/3.442	78.8/3.30	70.3/2.334
Growth rate/2 months (mm/g)	47.2/2.259	52.3/3.287	50.8/3.145	42.3/2.179
No. of shrimps harvested	345	383	349	338
Percentage survical	81.18	90.1	82.1	79.53

Table 21 b

MEAN VALUES OF GROWTH OF PENAEUS INDICUS DURING EXPERIMENTAL CULTURE USING DIFFERENT MANURES FROM FEBRUARY TO APRIL 1987.

Days of observation	Pond 1	Pond 2	Pond 3	Pond 4
	mm/g	mm/g	mm/g	mm/g
28.2.1987	28.0/0.155	28.0/0.155	28.0/0.155	28.0/0.155
14.3.1987	58.6±/1.23±	56.6±/1.090±	62.2±/1.581±	64.8±/1.65±
	2.16.0.05	2.09 0.114	2.61 0.182	1.69 0.125
28.3.1987	60.4±/1.29±	74.4±/2.56	68.4±/1.94±	65.6±/1.74±
	1.20 0.054	1.86 0.18	1.17 0.124	2.48 0.17
11.4.1987	69.6±/1.93±	74.6±/2.60±	75.6±/2.76±	69.40±/2.014±
	0.93 0.026	1.30 0.101	2.227 0.20	2.40 0.201
27.4.1987	75.2±/2.414±	80.3±/3.442±	78.8±/3.30±	70.3±/2.334±
	1.16 0.109	0.473 0.119	1.73 0.14	2.75 0.231

with a percentage survival of 81.18, 90.1, 82.1 and 79.53 (Table 21a). Thus the results clearly revealed that best growth and percentage survival occurred in the pond manured with poultry droppings whereas the poorest performance was in the buffalo dung manured pond both in respect of growth and percentage survival. The relatively high percentage of organic carbon and nitrogen contained in the poultry dropping than other farm yard manures is quite evident (K.A.U., 1986).

The weight measurements of individual shrimps obtained on harvest day were subjected to statistical evaluations. The weight measurements were converted to logarithmic values and the results of analysis are furnished in Table 21c.

Table 21c

COMPARISON BETWEEN CONTROL AND TREATMENTS

ANOVA

Source of variation	SS	df	MS	F
Between ponds	0.2670	3	0.089	11.63
Error	0.2753	36	0.00765	$P < 0.001$
Total	0.5423	39		

The F value reveals that the difference in the mean weights of shrimps on harvest day was highly significant ($P < 0.001$).

On comparisons: (i) between 3 treatments and (ii) between mean of the control and mean of three treatments, the corresponding sum of squares were calculated to be 0.210105 and 0.05686 and F values being 13.74 and 7.43 respectively. These values being highly significant ($P < 0.001$) it could be concluded that the mean weights between treatments are significantly different and that the mean of control is significantly different from mean of the three treatments. This implied that the treatments in general are highly effective. A perusal of the data indicated that the rate of growth of *P. indicus* in ponds 2 and 3 were very high compared to control or pond 1. The shrimps attained the size of 3.3 to 3.44 g in ponds 3 and 2 whereas the mean growth recorded was only 2.4 g in control or pond 1. Hence it could be concluded that treatments in ponds 2 and 3 ie. manuring respectively with poultry droppings and cowdung were highly effective compared with the buffalo dung.

5. Observations

Prevalence of sediment loaded turbid water, inconsistent bottom characteristics and relatively low level of dissolved oxygen leading to stressful conditions were the likely causes for the stunted growth of *P. indicus*.

C 4 : Pilot study on *P. indicus* culture at Puduveypu between April and June, 1988.

1. **Aim**

To study the effect of 3 compounded feeds on growth of *P. indicus*.

2. **Introduction**

The characteristic turbid nature of the wetland area at Puduveypu is not at all congenial to promote shrimp growth. Therefore, an attempt was made to test the efficacy of 4 different feeds to accelerate the growth of *P. indicus* aimed at better production.

3. **Material and methods**

3.1 **Pond selection, layout and preparation**

Five identical rectangular mini ponds each having an area of 50 m^2 and situated along the bank of a feeder canal (Plate XIII A) at Puduveypu were dewatered, desilted and got ready for shrimp culture purposes. Since the pond texture was slushy, care was taken to spread sand in the pond bottom to make it more firm during preparations. In each pond a suitable wooden sluice gate with shutters was fitted (Plate IX A) in order to facilitate exchange of water from the feeder canal. In general, each pond was lying inclined towards respective sluice gate.

3.2 **Water exchange**

After complete preparation of the pond, initial exchange of tidal water was permitted, through appropriate filter screens kept inside the sluice gate (Plate VI B), with a view to develop suitable conditions for fry stocking. Tidal exchange was regularly done in all ponds to maintain an average level of 75 cm. At times pumping was also resorted in order to maintain required water level during the experimental culture period of 6 weeks from 25.4.88 to 9.6.88.

3.3 **Substratum**

The details are as mentioned in C 1.

3.4 **Fry stocking**

After conditioning the ponds to acceptable range of water qualities for shrimp growth, stocking was effected in each pond. On acclimatization, @ 1 lakh uniform sized fry per hectare were stocked in each one of the 5 ponds on 25.4.88.

3.5 **Feed preparation and feeding**

The details of different feeds and their compositions are as given in Table 22a. The ingredients used for making feeds were of good quality and in powdered form. To prepare the feed, the ingredients in definite ratios were weighed on a dry weight basis into a clean enamel tray and thoroughly mixed by hand. Required quantity of boiled water was added to the mixture gently and half cooked for 5 minutes in each case. The mash thus resulted was pelleted by using a small pelletiser and sun dried on clean surfaces. Later the feed pellets were properly stored in airtight plastic containers for subsequent use. Strict hygiene was observed in all stages of feed preparation.

The bio-chemical composition of dry feed was analysed by following standard methods. The percentage composition of each feed and the energy content arrived at based on standard formula are also presented in the table.

Table 22a

DETAILS OF DIFFERENT FEEDS AND THEIR BIO-CHEMICAL COMPOSITION

Code No.	Ingredients & ratio	Percentage composition on dry weight basis					Energy	
		Moi-sture	Pro-tien	Fat	Ash	CHO	K.Cal/g	K.Cal/kg
Feed 1	Shrimp head meal + Detritus* + Tapioca flour 2:1:1	7.385	17.0	1.0	24.59	50.03	2.771	2771
Feed 2	Tilapia meat + * Detritus + Tapioca flour + g.o.c. 4:3:2:1	14.59	26.25	2.06	12.50	44.6	3.02	3020
Feed 3	Tilapia meat + * Detritus + Tapioca flour + g.o.c. 3:4:2:1	18.60	26.79	0.91	10.85	44.85	2.87	2870
Feed 4	Shrimp head meal + * Detritus + g.o.c. + rice bran 2:5:2:1	12.05	23.25	1.98	11.60	51.12	3.14	3140

* Dry powder of *Avicennia* sp.

From second day onwards after stocking, daily feeding @ 8-10% of body weight of shrimps was followed in ponds 1, 2 and 3 by using prepared compounded feed 1, 2 and 3 respectively. The feed was supplied in suitable trays made of clay (Plate VIII A) kept at two points in each pond daily. In Pond 4, only manuring with cow dung was done at weekly intervals ie. @ 2 tonns/ha/year. Usually manure was suitably immersed in the pond in bamboo baskests to facilitate its easy leaching. No feeding or manuring was done in pond 5 which served as a control.

4. Results

4.1 Water quality parameters

Monitoring of important water quality parameters was done at weekly intervals in each pond. The mean values of temperature, pH, salinity, dissolved oxygen and alkalinity fluctuated between 30 and 32.5°C, 8.5-9.0, 28-32.8‰, 2.75-4.78 ml/L and 216 - 340 mg/L respectively.

4.2 Growth measurements and harvest data

Observations on growth of P. indicus were taken at fortnightly intervals by random sampling using suitable cast nets. Standard procedure was followed to measure the length and weight of P. indicus from each pond. The mean size at stocking and those attained at fortnightly intervals in respective treatment ponds and control are furnished in Table 22b. The initial mean size of 39.8 mm (0.388 g) was uniform in all cases. The mean values showed notable variations during subsequent fortnights in relation to different feeds. In general, the lowest mean values were noted among P. indicus in the control pond.

The mean values of rate of growth in all the ponds at fortnightly intervals are presented in Table 22c. The values were found higher in Pond 1-4. The best growth rate was produced by feed 2 followed by the manure. Thus the growth rate in the pond with manure was better than that of feed 3 and 1. Lowest growth rate was noted in the control pond.

The values of growth increment attained by P. indicus in different ponds are given in Table 22d. In general the best growth increment was between 4th and 6th weeks in respect of all feeding ponds. While an almost uniform trend of growth was seen in the control pond through out the experimental period, the pond with manure showed better growth increment during 2nd week than other periods.

The details of experimental culture of P. indicus are given in Table 22e. Except for the type of feed used in different ponds, all other operational aspects were maintained identical. Yet the survival was low and vaired from 23.2 to 35.4% with the exception of 76% in pond 4 to which manure was added.

5. **Observation**

The low survival percentage (23.2 - 35.4) noticed except for one pond (76.0) is indicative of suspected poaching. As in the previous series, stunted growth of P. indicus might be due to the turbid nature of water etc.

Table 22 b

MEAN VALUES OF GROWTH OF P.INDICUS FED WITH DIFFERENT FEEDS

Details	Feed 1	Feed 2	Feed 3	Manuring	Control
	mm g	mm g	mm g	mm g	mm g
25.4.1988	39.8 - 0.388	39.8 - 0.388	39.8 - 0.388	39.8 - 0.388	39.8 - 0.388
10.5.1988	59.2 - 1.406	73.2 - 2.340	59.2 - 1.313	79.4 - 2.892	55.6 - 1.182
24.5.1988	66.0 - 1.992	82.2 - 3.354	77.2 - 2.758	80.4 - 3.077	69.4 - 2.110
09.6.1988	83.8 - 4.019	97.8 - 5.533	89.2 - 4.614	90.6 - 4.210	76.4 - 2.831

Table 22 c

MEAN VALUES OF GROWTH RATE OF P.INDICUS FED WITH DIFFERENT FEEDS.

Details	Feed 1	Feed 2	Feed 3	Manuring	Control
	mm g	mm g	mm g	mm g	mm g
Initial(0 day)	39.8 - 0.388	39.8 - 0.388	39.8 - 0.388	39.8 - 0.388	39.8 - 0.388
2 weeks	19.4 - 1.018	33.4 - 1.952	19.4 - 0.925	39.6 - 2.504	15.8 - 0.794
4 weeks	26.2 - 1.604	42.4 - 2.966	37.4 - 2.370	40.6 - 2.689	29.6 - 1.722
6 weeks	44.0 - 3.631	58.0 - 5.145	49.4 - 4.226	50.8 - 3.822	33.6 - 2.443

Table 22 d

GROWTH INCREMENT OF P. INDICUS FED WITH DIFFERENT FEEDS

Details	Feed 1	Feed 2	Feed 3	Manuring	Control
	mm g	mm g	mm g	mm g	mm g
Initial (0 day)	39.8 - 0.388	39.8 - 0.388	39.8 - 0.388	39.8 - 0.388	39.8 - 0.388
2 weeks	19.4 - 1.018	33.4 - 1.952	19.4 - 0.925	39.6 - 2.504	15.8 - 0.794
4 weeks	6.8 - 0.586	9.0 - 1.014	18.0 - 1.445	1.0 - 0.185	13.8 - 0.928
6 weeks	17.8 - 2.027	15.6 - 2.179	12.0 - 1.856	10.2 - 1.133	4.0 - 0.721

Table 22e

DETAILS OF EXPERIMENTAL CULTURE OF *P. INDICUS* FROM APRIL TO JUNE 1988

Details	Compounded feed			Manuring with Cowdung	Control
	Feed 1	Feed 2	Feed 3		
Area of Pond (m^2)	50	50	50	50	50
Date of stocking	25.4.88	25.4.88	25.4.88	25.4.88	25.4.88
No. of shrimps stocked	500	500	500	500	500
Stocking density (no./ha)	100000	100000	100000	100000	100000
Mean size at stocking mm (g)	39.8 (0.388)	39.8 (0.388)	39.8 (0.388)	39.8 (0.388)	38.8 (0.388)
Nature of treatment	Daily feeding @ 5-8% body wt.	Daily feeding @ 5-8% body wt.	Daily feeding @ 5-8% body wt.	Weekly manuring @ 2000 kg/ha/yr	No feeding
Nature of water management	Tidal	Tidal	Tidal	Tidal	Tidal
Date of harvest	9.6.88	9.6.88	9.6.88	9.6.88	9.6.88
Duration of culture (weeks)	6	6	6	6	6
No. realised	116	171	177	380	158
% survival	23.2	34.2	35.4	76.0	31.6
Mean size at harvest mm (g)	83.8 (4.019)	97.8 (5.533)	89.2 (4.614)	90.6 (4.210)	76.4 (2.831)

C 5 : Pilot study on P. indicus culture at Puduveypu between December 1988 and March 1989.

1. **Aim**

To study the effect of 5 formulated feeds on growth of P. indicus.

2. **Introduction**

Along with other inherent problems of the habitat, lack of a proper feed also hampers the progress of shrimp farming at Puduveypu, eventhough quality seed is profusely available during season (Purushan, 1989). Therefore, an experiment was carried out to test the efficacy of 5 formulated feeds utilising cheap and locally available ingredients in order to promote growth of P. indicus.

3. **Material and methods**

3.1 **Location and layout**

Six rectangular mini ponds each having approximately 50 m^2 area were set up adjoining a feeder canal at Puduveypu. All ponds were situated side by side in a linear row along the bank of the canal and were marked 1 to 6 (Plate XIII A). Each pond was independent with a sluice gate and control which directly opened into the feeder canal (Plate IX A). Suitable wooden shutters and nylon screens were also fitted inside the sluice gate. The depth of each pond ranged between 75 and 80 cm. The substratum was generally of loose mud which was made more firm by spreading sand from the nearby area during the time of excavation.

3.2 **Pond preparation**

By 3rd week of December 1988, all ponds were dewatered,

PLATE XIII

A – Series of mini ponds along feeder canal at Puduveypu

B – Dried twigs planted to generate periphyton

PLATE XIV

A– Pump fed earthern tank at Puduveypu

B – Screens made of dry twigs immersed in the earthern tank desilted and prepared for P. indicus culture purposes adopting standard methods (Hickling, 1962). Enough number of dry twigs were planted inside all ponds with a view to generate periphyton and to offer protection (Plate XIII B).

3.3 Substratum

The characteristics of the substratum was similar to the one described in C-1.

3.4 Water exchange

Afterwards, tidal water was allowed into the pond through sluice gates. After exchange of water for 3-4 days, the water conditions were ascertained to be similar to that of feeder canal. No exchange was permitted in ponds for 2 days following stocking in order to facilitate shrimp fry to settle. Thereafter, 30% exchange of tidal water was allowed daily to maintain a water level of 75 cm, often supplemented by the use of a pump.

3.5 Fry stocking

On retaining water level at 75 cm, 500 uniform sized and healthy P. indicus fry collected/sorted out from contiguous natural environments and acclimatized were safely introduced separately into each pond @ 10 nos/m^2. All 6 ponds were stocked on 26.12.88, the mean size at stocking being 17.7mm/0.030 g. The details of stocking and other particulars are furnished in Table 23a.

3.6 Feeding

Feeding was started from the same day in five ponds using different feeds keeping pond 6 as control. Feeds 1-4 were formulated using shrimp head meal, mangrove detritus, groundnut oil cake and rice bran, but in various proportions (Table 23b). Feed 5 comprised of

Table 23a

EXPERIMENTAL CULTURE DETAILS OF *P. INDICUS* FED WITH DIFFERENT FEEDS FROM DECEMBER 1988 TO MARCH, 1989

Culture details	Pond 1 (Feed 1)	Pond 2 (Feed 2)	Pond 3 (Feed 3)	Pond 4 (Feed 4)	Pond 5 (Feed 5)	Pond 6 (Control)
Area of Pond (m^2)	50	50	50	50	50	50
Date of stocking	26.12.88	26.12.88	26.12.88	26.12.88	26.12.88	26.12.88
No. of *P. indicus* stocked	500	500	500	500	500	500
Stocking density (no./m^2)	10	10	10	10	10	10
Average size at stocking (mm/g)	17.7/ 0.030	17.7/ 0.030	17.7/ 0.030	17.7/ 0.030	17.7/ 0.030	17.7/ 0.030
Date of harvest	21.3.89	21.3.89	21.3.89	21.3.89	21.3.89	21.3.89
Duration of culture (days)	85	85	85	85	85	85
Quantity of feed supplied (kg)	2.10	2.10	2.10	2.10	2.10	nil
No. of *P. indicus* harvested	142	167	122	124	119	162
Average size at harvest (mm/g)	122.2/ 12.701	112.6/ 9.176	117.3/ 11.751	117.7/ 12.104	105.0/ 7.294	82.7/ 3.707
% survival	28.4	33.4	24.4	24.8	23.8	32.4
Quantity of *P. indicus* realised (kg)	1.80	1.53	1.42	1.49	0.87	0.60
Yield/ha/85 days (kg)	360	306	284	298	174	120

ground nut oil cake, rice bran and tapioca flour in 2:1:1 ratio. The feeds 1 to 5 were applied @ 5% of body weight in ponds 1 to 5 respectively while pond 6 was maintained without any feed application. The regular feed supply in treatment ponds was gradually raised from 10 g to 20, 25, 30 and 40 g/day as the growth advanced. Usually the feed was daily supplied during evening hours in suitable earthern trays (Plate VIII A) at several points in respective treatment ponds. Nevertheless, all other operational aspects were common to all ponds. The experiment was continued for 85 days up to 21.3.1989 (Table 23a).

Table 23b

DETAILS OF FEED AND PERCENTAGE COMPOSITION

Code No.	Feed ingredients & ratio	Percentage composition					Energy	
		Moisture	Protein	Fat	Ash	CHO	K. Cal/g	K.Cal/kg
Feed 1	Shrimp meal + * Detritus + g.o.c. + rice bran (5:2:2:1)	9.63	21.25	2.46	16.66	50.00	3.07	3070
Feed 2	Shrimp meal + * Detritus + g.o.c. + rice bran (4:3:2:1)	9.90	25.00	2.36	16.87	45.87	3.05	3050
Feed 3	Shrimp meal + * Detritus + g.o.c. + rice bran (3:4:2:1)	10.47	23.50	2.10	13.09	50.84	3.16	3160
Feed 4	Shrimp meal + * Detritus + g.o.c. + rice bran (2:5:2:1)	12.05	23.25	1.98	11.60	51.12	3.14	3140
Feed 5	G.O.C. + rice bran + tapioca flour (2:1:1)	11.79	11.00	0.66	9.68	66.87	3.17	3170

* Detritus used in all cases was the dried and powdered matter of *Avicennia sp.* without getting rid of tannin content by any process.

4. Results

4.1 **Water quality parameters** were observed at weekly intervals. The mean values of surface water temperature, pH, salinity, dissolved oxygen and sediment load fluctuated between 29.5 and 33.0°C, 7.0 and 8.25, 18.75 and 32.25‰, 3.05 and 4.25 ml/L and 0.2 and 1.5 g/L respectively during the period in the ponds.

4.2 Growth measurements

Mean values of length and weight of P. indicus were noted while stocking and at periodic intervals by random sampling. Mean values assessed as in C 1 are furnished in Table 23c. The mean values at stocking were 17.7 mm (0.030 g). Considerable variations in mean values of growth were noticed during subsequent observations. When harvested after 85 days the mean values were 122.2 mm (12.701 g), 112.6 mm (9.176 g), 117.3 mm (11.751 g), 117.7 mm (12.104 g), 105.0 mm (7.294 g) and 82.7 mm (3.707 g) respectively from ponds 1-6.

In general, as furnished in Table 23a, the percentage survival was comparatively very low ranging between 23.8 and 33.4% in the culture ponds. Though with poor survival rate, quantities of 1.8, 1.53, 1.42, 1.49, 0.87 and 0.60 kg of P. indicus were obtained from ponds 1-6 respectively. Again these yields gave production rates in the order of 360, 306, 284, 298, 174 and 120.0 kg/ha/85 days, from different ponds. The comparatively better production from ponds 1-4 indicated that ingredients of formulated feed such as shrimp head meal and Avicennia detritus could promote better shrimp growth than that of pulverised feed with low conversion rate. Among formulated feeds, feed 1 proved to be more efficient owing to its better conversion rate.

The changes in the ratio of ingredients of formulated feed influencing the mean growth of P. indicus clearly denote the significance of feed composition. Therefore, the higher mean growth and production obtained from ponds 1, 3 and 4 can be definitely due to

TABLE 23 c

MEAN VALUES OF GROWTH OF P.INDICUS FED WITH DIFFERENT FEEDS FROM DECEMBER 1988 TO MARCH 1989

Date of observation	Pond 1 mm - g	Pond 2 mm - g	Pond 3 mm - g	Pond 4 mm - g	Pond 5 mm - g	Pond 6 mm - g
26.12.1988	17.7 - 0.030	17.7 - 0.030	17.7 - 0.030	17.7 - 0.030	17.7 - 0.030	17.7 - 0.030
19.01.1989	48.8 - 0.922	72.5 - 2.642	49.3 - 0.762	59.8 - 1.782	59.4 - 1.423	53.4 - 0.940
18.02.1989	72.4 - 2.570	89.0 - 4.472	73.6 - 2.324	86.8 - 3.560	64.4 - 1.765	57.2 - 1.256
03.03.1989	99.7 - 7.132	103.7 - 7.580	99.2 - 6.687	94.4 - 5.645	98.4 - 3.033	60.4 - 1.340
21.03.1989	122.2 -12.701	112.6 - 9.176	117.3 -11.751	117.7 -12.104	105.0 - 7.294	82.7 - 3.707

TABLE 23 d

MEAN VALUES OF GROWTH RATE (mm/g) AND GROWTH INCREMENT (mm/g) OF P.INDICUS FED WITH DIFFERENT FEEDS FROM DECEMBER 1988 TO MARCH 1989

Date of observation	Pond 1 Growth rate	Pond 1 Growth incr.	Pond 2 Growth rate	Pond 2 Growth incr.	Pond 3 Growth rate	Pond 3 Growth incr.	Pond 4 Growth rate	Pond 4 Growth incr.	Pond 5 Growth rate	Pond 5 Growth incr.	Pond 6 Growth rate	Pond 6 Growth incr
	mm/g	mm/g	mm/g	mm/g	mm/g	mm/g	mm/g	mm/g	mm/g	mm/g	mm/g	mm/g
26.12.1988	17.7/ 0.030	(init)	17.7/ 0.030	(init)	17.7/ 0.030	(init)	17.7/ 0.030	(init)	17.7/ 0.030	(init)	17.7/ 0.030	(init)
19.01.1989	31.1/ 0.892	31.1/ 0.892	54.8 2.612	54.8/ 2.612	31.6/ 0.732	31.6/ 0.732	42.1/ 1.752	42.1/ 1.752	41.7/ 1.393	41.7/ 1.393	35.7/ 0.910	35.7/ 0.910
18.02.1989	54.7/ 2.540	23.6/ 1.648	71.3/ 4.442	16.5/ 1.830	55.9/ 2.294	24.3/ 1.562	69.1/ 3.530	27.0/ 1.778	46.7/ 1.735	5.0/ 0.342	39.5/ 1.226	3.8/ 0.316
03.03.1989	82.0/ 7.102	27.3/ 4.562	86.0/ 7.550	14.7/ 3.108	81.5/ 6.657	25.6/ 4.363	76.7/ 5.615	7.6/ 2.085	80.7/ 3.003	34.0/ 1.268	42.7/ 1.310	3.2/ 0.325
21.03.1989	104.5/ 12.671	22.5/ 5.569	94.9/ 9.146	8.9/ 1.155	99.6/ 11.721	18.1/ 5.064	100.0/ 12.074	23.30/ 5.459	87.3/ 7.264	6.6/ 4.261	65.0/ 3.677	22.3/ 2.367

the right combinations of feed ingredients such as shrimp head meal, Avicennia detritus, ground nut oil cake and rice bran enhancing its energy content (Table 23b). Though with low mean growth values, the appreciable production achieved in pond 2 could be on account of better survival rate.

As presented in Table 23d, the growth increments showed considerable fluctuations from January to March. The quantum of mean weight increase, though was comparatively low during January, it ranged between 2 - 4.5 g during February. But during March, the mean growth increment ranged between 5.0 and 6.5 g in all the treatment ponds except the one with feed 5. Nevertheless, the increments in control pond showed only negligible increase during January-February period. But it also showed an increased mean value of 2.4 g during March. In general, highest growth increments were noticed in all ponds except Pond 2 during March than other months.

The weight measurements taken on harvest were subjected to statistical analysis after making logarithmic transformation. The analysis showed that (Table 23e) the difference between mean weights were highly significant ($P < 0.01$).

Table 23e

Source of variation	SS	df	MS	F
Between ponds	2.0896	4	0.5224	33.80**
Error	0.5411	35	0.0155	
Total	2.6307	39		

** $P < 0.01$

The stocking density, culture period, size of juveniles at stocking etc. being uniform, the difference in growth is indicative of the efficiency of different feeds supplied.

Proceeding further, two comparisons have been made (i) Treatments vs. control and (ii) among 5 treatments. The sum of squares of treatments vs control and between treatments were compared against error M.S. The corresponding F values are observed to be 108.13 and 10.26 which are highly significant. This meant that the control was highly significantly different from the treatments and that the treatments were different among themselves. The mean values observed in Ponds 1, 3, 4 were evidently higher than those of ponds 2 & 5 as shown in Table 23f.

Table 23f

Treatments	Mean $\bar{X}$	$\bar{X}$ - 0.851	$\bar{X}$ - 0.953	$\bar{X}$ - 1.068
1	1.091	0.24	0.14	0.02
3	1.068	0.22	0.12	
4	1.068	0.22	0.12	
2	0.953	0.10		
5	0.851			

The experimental details presented in Table 23a showed that formulated feeds 1, followed by 4, 3 and 2 induced better growth of *P. indicus*. Since same yardstick was followed in the feed application, the feed quantity supplied was about 2.10 kg in different ponds. In all cases, the growth performance of *P. indicus* was double or trible than that of control pond which indicated the importance of adequate feed supply in shrimp culture systems.

5. Observations

The 5 feeds tested were able to enhance the production of *P. indicus* to a certain extent. Still, *P. indicus* failed to attain the quality size on par with those realised from other condusive areas. This might be due to the silt laden turbid water characteristics which often reflected in the surfacing of *P. indicus*.

C 6 : Pilot study on P. indicus culture in a Pump-fed pond at Puduveypu between December 1988 and March 1989.

1. **Aim**

To evaluate the advantage of pump-fed ponds in the culture of P. indicus.

2. **Introduction**

The turbid nature of tidal water and slushy substratum were creating unfavourable conditions for the shrimp growth. This situation prompted to make an investigation whether pump-fed ponds would help to promote growth of P. indicus.

3. **Material and methods**

3.1 **Pond location, layout, preparation and conditioning**

A rectangular pond of 4.5 m x 3.0 m area and 1.0 m depth was constructed in an elevated place (Plate XIV A) adjoining the feeder canal at Puduveypu. The bottom and sides of the pond were made leak proof by plastering with thick mud and clay. Productive sand was spread at the bottom at 10 cm thickness. Two outlets with 3" hose and control were fixed at the bottom diagonally to facilitate draining of water. Suitable filters were also attached at the mouth of the outlets.

3.2 **Water exchange**

The functioning of the pond was checked by permitting exchange of water by pumping and draining. One 5 HP diesel engine with connected hose was used to fill the pond with brackish water of turbid nature from the adjoining feeder canal. Utmost care was taken to draw supernatent water always in order to reduce sediment load. Draining of water @ almost 70% and subsequent filling the level up to 75 cm by pumping were done twice daily during morning and evening. The water column oscillated between 20 and 75 cm during exchange. Two triangular shaped screens of about 0.5 m^2 area each made of closely packed dry bamboo slats were immersed and floated in the pond (Plate XIV B) to generate periphyton and also to offer a false resting place for shrimps. The conditioning of the pond and screens was accomplished by change of the water as above for a week. Thus the system was perfected for stocking of shrimps by the end of December, 1988.

3.3 Substratum

Substratum was composed of loose mud and clay, but was made firm by spreading productive sand from suburban areas. The bottom thus prepared afresh and kept dried as required did not possess any benthic fauna.

3.4 Fry stocking

400 nos. of Penaeus indicus PL_6 stage (6 mm) procured from Govt. Prawn Hatchery, Azhikode were released (Plate VII B) at 4.00 PM on 27.12.1988 after acclimatization, to have a stocking density of 4,00,000/ha. Considering the small size of postlarvae, no water exchange was done for 3 days to enable them to settle properly in the system.

3.5 Feeding

Thereafter, water exchange was continued on 4th day onwards once daily. After a week, daily feeding was done by using crushed clam meat in suitable earthern pots (Plate VIII A) kept at two points during evening. Feed was supplied @ 10% of body weight. The empty pots were sundried before they were used again. Draining and pumping were done twice daily and a water level of 75 cm was maintained in the system.

4. Results

4.1 **Water quality parameters** were regularly observed. The surface water temperature, pH, salinity, dissolved oxygen and sediment load fluctuated between 29.0 and 32.2°C, 7.25 and 8.5, 22.6 and 32.3‰, 4.25 and 5.4 ml/L and 0.2 and 1.0 g/L respectively.

4.2 Growth measurements and harvest data

Growth measurements were made from random samples collected at each time.

The mean values of growth observed during stocking and at intervals are furnished in Table 24a. The initial mean weight of 0.006 g changed to 0.326 g, 1.293 g and 2.717 g during 1st, 2nd and 3rd months respectively. Nevertheless, the mean weight during harvest after 90 days on 27.3.1989 was 3.47 g. The corresponding mean values of length were 6.0, 40.2, 58.9, 77.8 and 82.1 mm. The growth rate was slow during initial periods which was seen increasing with age. The growth increment was higher during 2nd and 3rd months.

From the projected yield of 800 kg/ha/3 months (Table 24b), it is quite clear that the rate of shrimp production is almost double in this particular pump-fed culture system than the usual yield obtained from other natural culture systems. The high rate of production can definitely be due to the synergestic effect of management aspects such as efficient water exchange, increased stocking density and supplemental feed adopted during operation. A comparison of the inputs supplied (2.65 kg of clam meat) and yield attained (0.8 kg) indicated that the feed conversion was to the tune of 30% which is a clear evidence of the efficacy of the feed. The low % survival and the undersize of *P. indicus* produced could be on account of turbid nature of prevailing water as well as the infinitely small size of the fry stocked.

5. Observations

As a result of high density stocking, clam meat feeding and water exchange twice daily @ 70% with the help of a pump, the yield @ 800 kg/ha/90 days of P. indicus attained is quite attractive over those recorded in the tidal ponds B2 and C1. However, the low quality of P. indicus might be due to the poor water quality conditions prevalent in the area. The 58% survival is a matter to reckon with.

Table 24a

MEAN VALUES OF GROWTH OF P. INDICUS IN THE PUMP FED POND AT PUDUVEYPU BETWEEN DECEMBER 1988 AND MARCH 1989

Date of observation	Length (mm)	Weight (g)	Growth rate (g)	Growth increment (g)
27.12.1988	6.0	0.006	-	-
20.01.1989	40.2	0.326	0.320	-
18.02.1989	58.9	1.293	1.287	0.967
18.03.1989	77.8	2.717	2.711	0.489
27.03.1989	82.1	3.470	3.464	0.753

Table 24b

EXPERIMENTAL CULTURE OF *P. INDICUS* IN PUMP FED PONDS AT PUDUVEYPU BETWEEN DECEMBER, 1988 AND MARCH, 1989

Details		
Area of pond (m^2)	:	13.5
Depth of water column	:	0.75 m
Water holding capacity of pond	:	10 m^3
Nature of substratum	:	Clayey and sandy
Date of shrimp stocking	:	27.12.1988
No. stocked	:	400
Stocking density	:	@ 4,00,000/ha
Mean size at stocking	:	PL_6 (6 mm - 0.006 g)
Culture duration	:	3 months
Date of harvest	:	27.3.1989
No. survived	:	232
Percentage survival (%)	:	58.0
Mean size at harvest (mm/g)	:	82.1/3.47
Quantity of inputs supplied (Supplementary feed - clam meat) (kg)	:	2.65
Quantity of yield obtained (kg)	:	0.80
Production/ha (kg)	:	800.00
Nature of water management	:	Pump-fed
Water quality	:	Turbid

C 7 : Pilot study on *P. monodon* culture in earthern pools at Puduveypu during August 1987.

1. **Aim**

To evaluate the performance of wild and hatchery fry of *P. monodon* by growth measurements.

2. **Introduction**

With the progress of shrimp farming, farmers depend on fry both from natural and hatchery sources. However, opinions differ regarding their growth in culture systems. Therefore, an investigation was carried out to evaluate their comparative performances.

3. **Material and methods**

3.1 **Pool location, layout and preparation**

Two rectangular earthern pools X and Y of 10 m^2 area each (Plate XV A) were selected adjacent to a feeder canal at Puduveypu. They were dewatered, desilted and prepared ready for *P. monodon* stocking purposes by the end of July, 1987.

3.2 **Water filling**

Water was automatically accumulated in the pool owing to seepage of the area. Water table of the place being fairly high, the water level in the pools oscillated according to the rise and fall of tides between 30 and 50 cm daily.

3.3 **Substratum**

Substratum was sandy with lots of disintegrating molluscan shell matter. A large number of spats of the gastropod *Melania* tuberculata was seen associated with the bottom.

3.4 Fry release

After ascertaining water quality parameters, 250 nos. of uniform sized fry of P. monodon collected from wild using midnapore nets were introduced in pool X whereas P. monodon fry (Plate I A) produced from Vallarpadom hatchery were released into pool Y on 1.8.1987. But for the differences in the source of fry, all other aspects of rearing in both pools were identical.

3.5 Feeding

The fry of both ponds were fed with crushed clam meat @ 8-10% of body weight daily. The water level of the pools was noted everyday and at no time it was found below 30 cm level as indicated through a permanently fixed graduated scale.

3.6 Sampling

Sampling was done at weekly intervals at both pools by using suitable hapa net and average size was assessed as in C1. The rearing was continued up to 29.8.1987 for a period of 4 weeks and the total number survived in each pool was counted, measured and weighed.

4. Results

4.1 **Water quality parameters** were regularly observed. The surface water temperature, pH, salinity, dissolved oxygen and alkalinity varied between 28.5 and 29.5°C, 9.0 and 9.5, 1.86 and 2.80‰, 3.20 and 5.42 ml/L and 84 and 120 mg/L respectively.

4.2 Growth assessment

Table 25a shows the particulars regarding experimental rearing of wild and hatchery fry of P. monodon carried out in separate earthern pools at Puduveypu during 1987. From an initial mean size of 10 mm (0.010 g), the wild fry of P. monodon attained the size of 69.4 mm (2.458 g) after a period of 4 weeks. But hatchery fry of mean size 10 mm (0.010 g) attained only 59.2 mm (1.508 g) within the same period. The weekly observations on mean growth presented in Table 25b also showed considerable variations in size and weight between wild and hatchery fry, with higher values always for the wild. As seen in Table 25c the mean growth rate values progressively increased in both cases, the quantum of growth of wild fry being much faster than that of hatchery fry in all weekly observations. The same trend was also discernible in the case of growth increment values as presented in the same Table.

5. Observations

On harvest the gain in weight of wild fry was almost double than that of hatchery fry. The unusually low survival rate 27.6% even for the wild fry denoted the unhealthy nature of the area.

TABLE 25 a

PARTICULARS OF EXPERIMENTAL REARING OF WILD AND HATCHERY FRY OF P.MONODON IN EARTHERN POOLS DURING AUGUST 1987

Details	Pool X	Pool Y
Type of system	Stagnant water pool	Stagnant water pool
Area in m^2	10	10
Date of stocking	1.8.1987	1.8.1987
Source of fry	From natural environs	Hatchery from Vallarpadom
No. of fry stocked	250	250
Initial mean size (mm/g)	10.0 (0.010)	10.0 (0.010)
Date of harvest	29.8.1987	29.8.1987
Duration of rearing	4 weeks	4 weeks
Final mean size (mm/g)	69.4 (2.458)	59.2 (1.508)
No. survived	69	42
Percentage survival (%)	27.6	16.8
Quantity of biomass obtained(g)	169.6	63.34
Nature of feed	Ground clam meat @ 8-10% body wt.	Ground clam meat @ 8-10% body wt.
Type of water management	Tidal oscillations	Tidal oscillations.
Nature of water	Turbid	Turbid

TABLE 25 b

MEAN VALUES OF GROWTH OF WILD AND HATCHERY FRY OF P.MONODON IN EARTHERN POOLS DURING AUGUST 1987.

Period	Pool X Wild fry mm g	Pool Y Hatchery fry mm g
01.8.1987 (initial)	10.0 - 0.010	10.0 - 0.010
08.8.1987 (1 week)	36.0 - 0.342	30.2 - 0.230
15.8.1987 (2 weeks)	47.4 - 0.880	38.6 - 0.478
22.8.1987 (3 weeks)	56.6 - 1.316	48.8 - 0.856
29.8.1987 (4 weeks)	69.4 - 2.458	59.2 - 1.508

Table 25c

COMPARISON OF RATE OF GROWTH AND GROWTH INCREMENT BETWEEN WILD AND HATCHERY FRY OF *P. MONODON*

Deatils	Wild fry				Hatchery fry			
	Rate of growth		Grwoth increment		Rate of grwoth		Grwoth increment	
	mm	(g)	mm	(g)	mm	(g)	mm	(g)
Initial	10.0	0.010	10.0	0.010	10.0	0.010	10.0	0.010
8th day	26.0	0.332	26.0	0.332	20.2	0.220	20.2	0.220
15th day	37.4	0.870	11.4	0.538	28.6	0.468	8.4	0.248
22nd day	46.6	1.306	9.2	0.436	38.8	0.846	10.2	0.378
29th day	59.4	2.448	12.8	1.142	49.2	1.498	10.4	0.652

C 8 : Pilot study on *P. monodon* culture in mini pond at Puduveypu between September 1987 and February 1988.

1. Aim

To assess the impact of cowdung manuring and clam meat supplemental feed on the growth of *P. monodon* juveniles.

2. Introduction

Owing to turbid water nature and slushy habitat, shrimp culture is not picking up at Puduveypu although vast wetland areas are available. Lack of suitable technologies may be one of the reasons for not utilising such water bodies for productive purposes. Therefore, an experiment was carried out to assess the growth of *P. monodon*.

3. Material and methods

3.1 Pond location, layout and preparation

A small rectangular pond of size 5 x 8.5 m^2 with a suitable sluice gate located beside a feeder canal at Puduveypu (Plate XV B) was selected. The sluice gate was soil sealed and the pond was kept sundried for complete eradication of weeds and predators. In the meantime, a basal dose of 15 kg dry cowdung was applied as manure in the pond. Subsequently soil sealing was removed for entry of tidal water into the pond up to 10 cm level and sluice gate was soil sealed again. Dry twigs of *Casuarina* sp. were also fixed in the pond to generate periphyton (Plate XIII B).

3.2 Water management

After three days, tidal water was admitted into the pond to a maximum level of 1 metre. After stocking of *P. monodon*, water exchange was regularly done by tidal processes. At times of requirement pumping was also done to keep up the level above 80 cm. Water quality parameters were regularly monitored. About 30% water was exchanged daily.

3.3 Substratum

The substratum was similar to the one described in C1. Benthic fauna such as gammarids and tanaeids were present in very few numbers whereas gastropod Melania tuberculata occurred in large numbers.

3.4 Juvenile release

Juveniles of P. monodon were obtained by suitably rearing wild postlarvae collected during July 1987 through midnapore shooting net operations from the adjoining canals. 115 nos of similar size (68.4 mm/2.211 g) were released into the pond (Plate VII B) on 14.9.1987.

3.5 Feed supply

Manuring with cowdung was done @ 5 kg/week. Supplemental feeding with crushed clam meat was also begun after a week of stocking. The feed was supplied in sundried earthern pots (Plate VIII A) at two points @ 3-5% of body weight. The quantity of feed varied from 25 to 200 g/day from the start to finish of culture operations.

4. Results

4.1 Water quality parameters

The monthly mean values of various parameters are presented in Table 26a. The surface water temperature, pH, salinity, dissolved oxygen alkalinity and sediments ranged between 26.5°C and 29.0°C, 7.0 and 7.5, 6.65 and 32.48‰, 3.20 and 4.53 ml/L, 110 and 360 mg/L and 0.5 and 1.2 ml/L respectively.

Table 26a

MONTHLY MEAN VALUES OF WATER QUALITY PARAMETERS BETWEEN SEPTEMBER 1987 AND FEBRUARY 1988

Months	Parameters	Temperature (°C) Air	Water	pH	Salinity (‰)	Diss. oxygen (ml/L)	Alkalinity (mg/L)	Sediment load (ml/L)
Sept.	1987	27.5	28.5	7.0	9.50	3.73	190	1.2
Oct.	1987	27.5	29.0	7.5	6.65	3.65	210	1.0
Nov.	1987	28.0	28.5	7.0	18.48	4.18	110	0.8
Dec.	1987	27.0	26.5	7.5	23.92	4.53	280	0.5
Jan.	1988	27.5	26.5	7.5	30.20	3.78	320	0.6
Feb.	1988	27.5	27.5	7.5	32.48	3.20	360	0.8

4.2 Growth measurements and harvest data

The particulars of *P. monodon* rearing operation carried out at Puduveypu from September 1987 to February 1988 are presented in the Table 26b. The advanced juveniles of mean size 68.4 mm (2.211 g) stocked @ 27000 nos./ha reached the mean size of 172.0 mm (44.135 g) after 150 days rearing. On termination, only 58 specimens survived, the survival rate being 50.43%. 2.55 kg of quality *P. monodon* amounting to a production of 600 kg/ha was realised on harvest.

The mean values presented in Table 26c showed that the growth rate increased regularly achieving a maximum growth rate of 103.6 mm (41.924 g) within 150 days. As is clear from Table the monthly mean values of growth increment indicated relatively slow growth during the 1st month followed by a steep increase in 2nd month with gradual fall during the succeeding months.

Table 26b

PARTICULARS OF *P. MONODON* CULTURE FROM SEPTEMBER 1987 TO FEBRUARY 1988

Details		
Nature of culture system	:	Mini pond
Area (m^2)	:	42.5
Type of substratum	:	Sand, clay and silt laden with lot of molluscan shell pieces
Colour of water	:	Turbid
Depth of water (m)	:	0.8 - 1.0
Date of stocking	:	14.9.1987
No. of shrimps stocked	:	115
Stocking density (no./ha)	:	@ 27000
Mean size at stocking (mm/g)	:	68.4 (2.211)
Date of harvest	:	11.2.1988
Culture duration	:	150 days
No. of shrimps harvested	:	58
Percentage survival (%)	:	50.43
Mean size harvested (mm/g)	:	172.0 (44.135)
Quantity realised (kg)	:	2.55
Production/ha/(kg)	:	600.00
Quantity of cowdung applied (kg)	:	110
Quantity of crushed clam meat supplied (kg)	:	10.5
Type of water management	:	Tidal + pumping.

Table 26c

MEAN VALUES OF GROWTH, GROWTH RATE AND GROWTH INCREMENT OF *P. MONODON* DURING CULTURE FROM SEPTEMBER 1987 TO FEBRUARY 1988

Date of observations	Growth mm	Growth g	Growth rate mm	Growth rate g	Growth increment mm	Growth increment g
13.9.1987 (initial)	68.4 -	2.211	-	-	-	-
10.10.1987	103.1 -	7.583	34.7 -	5.372	34.7 -	5.372
10.11.1987	135.8 -	19.955	67.4 -	17.744	32.7 -	12.372
11.12.1987	150.7 -	29.200	82.3 -	26.989	14.9 -	9.245
10.1.1988	162.9 -	38.070	94.5 -	35.859	12.2 -	8.870
11.2.1988	172.0 -	44.135	103.6 -	41.924	9.1 -	6.065

5. <u>Observations</u>

In spite of stocking juveniles, 50.43% survival denoted the unhealthy nature of the place for farming purposes. However, the *P. monodon* yield @ 600 kg/ha is indicative of efficient production using better management techniques such as regular manuring, feeding and water management.

2.4 **Group D**

Experimental studies of P. indicus in tanks using natural turbid water at Puduveypu.

Salient features

Circular cement tanks and oval fibre galss tanks - natural turbid water conditions - daily 70% water replenished after filtration using pumps - limited stocking - supplementary feeding - terminal harvest.

Expt. D1 : Impact of two different feeds on the growth of *P. indicus* in circular cement tanks between April and June 1987.

Expt. D2 : Impact of feeding commercial pellets @ 5 and 10% body weight on the growth of *P. indicus* in circular cement tanks during February - March 1989.

Expt. D3 : Impact of four stocking densities on the growth of *P. indicus* fed with pellets in fibre glass tanks between December 88 and February 89.

Expt. D4 : Growth studies on *P. indicus* juveniles fed with clam meat in circular cement tanks between November 86 and January 87.

Expt. D5 : Growth studies on *P. indicus* fry fed with clam meat in circular cement tanks between November 86 and January 87.

Aim

5 series of high density culture experiments were carried out in tanks (4 cement and one fibre glass) kept along a feeder canal at Puduveypu. Through out the experiment, eventhough, the water used was filtered through a 100 μ nylon sieve, the medium was highly turbid

(0.1-0.3 ml/L) leading to low quality. Yet the water quality parameters such as pH, temperature, salinity and dissolved oxygen fluctuated within permissible limits. The aim of the above series of experiments was to test the effect of feed both commercial and clam meat (D1), the adequacy of the feed supplied @ 5% and 10% body weight (D2), to arrive at an appropriate high stocking density (D3) and to study the growth rate of juveniles and fry (D4 & D5).

D 1 Impact of two different feeds on the growth of *P. indicus* in circular cement tanks between April and June 1987.

1. Aim

To test the effect of feeds on growth of *P. indicus* at high density culture in turbid waters.

2. Introduction

It is well known that shrimp growth in general is very much depended upon the quality and quantity of feed supplied. However, the relevance of locally available feeds on growth of shrimps is yet to be ascertained especially in turbid water conditions. Therefore, an experimental culture of *P. indicus* was undertaken to gather more information along this line.

3. Material and methods

3.1 Setting up of tanks

Three circular cement tanks of identical dimensions with 71 cm height and each having a water holding capacity of 0.59 m^3, were set ready (Plate III A) for experimental purpose at Puduveypu. A suitable draining outlet with control was also provided at the bottom of each tank. 6.0 - 8.0 cm column of productive sand was also laid at the bottom of the tank. Subsequently tanks were carefully filled with filtered water through pumping using a half HP motor from the nearby canal. The tanks were conditioned (Plate XVI A) for stocking of fry by frequently filling and draining the water for a period of one week.

3.2 Water exchange

From the third day of stocking onwards exchange of water @ 70% was done once daily maintaining a water column of 60 cm in each tank.

Water was pumped through a 100 micron nylon net.

3.3 Fry stocking

On perfecting the system, uniform sized wild fry (Plate I A) of P. indicus were safely introduced in to each tank in equal numbers (30 each at the rate of 50 nos./m^3), the details of which are given in the Table 27a.

3.4 Feed and Feeding

Daily feeding with clam meat and commercial pellets (procured through MPEDA, Cochin) was done @ 10% body weight in the tanks 1 and 2 respectively, while the third tank was kept as control with out feed. The method of feed supply (Plate VIII A) and treatment of trays was as described in B1. The biochemical composition of feed is as given in Table 10b. But for the differences in the feed, all other operational aspects were similar in all tanks.

4. Results

4.1 Water quality parameters

The parameters such as temperature, pH, salinity, dissolved oxygen and sediment load ranged between 29.5 and 31.5°C, 7.5 and 8.25, 17.6 and 32.3‰. 3.25 and 4.40 ml/L, 0.1 and 0.3 ml/L respectively during the culture period.

4.2 Growth measurements

The specimens in each tank were counted at fortnightly intervals and the mean size was measured by random sampling.

The results of high density culture of P. indicus (50 nos./m^3) carried out in circular cement tanks are furnished in Table 27a-d. The survival rate varied from 40 - 56.67% in tanks 1 to 3 respectively (Table 27a) with maximum in the control tank. Compared to the initial mean size of 27.4 mm (0.112 g), the mean values of subsequent observations showed variations in different culture tanks. The treatment tanks showed increased rate of mean growth than that of control in all observations. After a period of 8 weeks, the mean values recorded were 83.0 mm (3.478 g), 80.6 mm (3.315 g) and 75.6 mm (2.678 g) in tanks 1, 2 and 3 respectively (Table 27b). In general, stunted growth was observed in all cases.

The growth rate (Table 27c) also indicated enhanced values in treatment tanks than control. Between treatments, the growth rate was slightly higher in tank 1 fed with clam meat.

So also, the mean growth increment, values by length showed better performance in treatment tanks than control as presented in Table 27d. In all cases growth increment rate was slackened after the first four weeks. However, growth increment by weight showed an increasing tendency in general.

During the culture, symptoms of rostral rot, at times specimens without rostrum were noticed along with some kind of pigmentations indicating microbial infestations. Also soft shell syndrome was observed.

5. **Observations**

The prevailing low quality water characterised by the high sediment load and turbidity might have contributed for the high mortality and stunted growth. Added to that the microbial infestations arising out of high stocking density of $50/m^3$ and exchange of only 70% of the medium once daily might have been responsible. The soft shell syndrome frequently observed indicated the unhealthy nature of the system. Nevertheless in *P. indicus*, growth was better when fed with clam meat.

TABLE 27 a

PARTICULARS OF HIGH DENSITY CULTURE OF PENAEUS INDICUS IN CIRCULAR CEMENT TANKS OF PUDUVEYPU BETWEEN APRIL & JUNE 1987

Details	Tank 1 (treatment)	Tank 2 (treatment)	Tank 3 (Control)
Tank capacity (m^3)	0.59	0.59	0.59
Stocking date	23.4.1987	23.4.1987	23.4.1987
No.of Shrimp fry stocked	30	30	30
Stocking density (no . m^{-3})	50	50	50
Mean size at stocking (mm/g)	27.4(0.112)	27.4(0.112)	27.4(0.112)
Culture duration(days)	60	60	60
No. survived	12	14	17
Percentage survival(%)	40.0	46.67	56.67
Mean size at harvest (mm/g)	83.0(3.478)	80.6(3.315)	75.6(2.678)
Nature of feed	Crushed clam meat @ 10%	Pellet feed @ 10%	No feed
Type of water management	Pump fed	Pump fed	Pump fed
Colour of water	Turbid	Turbid	Turbid

TABLE 27 b

MEAN GROWTH VALUES OF PENAEUS INDICUS DURING HIGH DENSITY CULTURE AT PUDUVEYPU

Details	Tank 1 Clam meat fed @ 10% body wt.	Tank 2 Pellets fed @ 10% body wt.	Tank 3 Control No feed
	mm g	mm g	mm g
23.4.87(initial)	27.4 - 0.112	27.4 - 0.112	27.4 - 0.112
08.5.87(2 weeks)	48.2 - 0.680	44.8 - 0.516	43.0 - 0.479
23.5.87(4 weeks)	69.6 - 1.780	62.2 - 1.423	58.2 - 1.135
08.6.87(6 weeks)	72.0 - 2.649	69.4 - 2.301	68.8 - 1.913
22.6.87(8 weeks)	83.0 - 3.478	80.6 - 3.315	75.6 - 2.678

TABLE 27 c

MEAN GROWTH RATE OF PENAEUS INDICUS DURING HIGH DENSITY CULTURE AT PUDUVEYPU

Details	Tank 1 Clam meat fed @ 10% body wt.		Tank 2 Pellets fed @ 10% body wt.		Tank 3 Control No feed	
	mm	g	mm	g	mm	g
23.4.87(initial)	27.4	0.112	27.4	0.112	27.4	0.112
08.5.87(2 weeks)	20.8	0.562	17.4	0.404	15.6	0.367
23.5.87(4 weeks)	42.2	1.668	34.8	1.311	30.8	1.023
08.6.87(6 weeks)	44.6	2.537	42.0	2.189	41.4	1.801
22.6.87(8 weeks)	55.6	3.336	53.2	3.203	48.2	2.566

TABLE 27 d

MEAN VALUES OF GROWTH INCREMENT OF PENAEUS INDICUS DURING HIGH DENSITY CULTURE AT PUDUVEYPU

Details	Tank 1 Clam meat fed @ 10% body wt.		Tank 2 Pellets fed @ 10% body wt.		Tank 3 Control No feed	
	mm	g	mm	g	mm	g
23.4.87(initial)	27.4	0.112	27.4	0.112	27.4	0.112
08.5.87(2 weeks)	20.8	0.562	17.4	0.404	15.6	0.367
23.5.87(4 weeks)	21.4	1.110	17.4	0.907	15.2	0.656
08.6.87(6 weeks)	2.4	0.869	7.2	0.878	10.6	0.778
22.6.87(8 weeks)	11.0	0.829	11.2	1.014	6.8	0.765

D 2 : Impact of feeding commercial pellets @ 5 and 10% body weight on the growth of P. indicus in circular cement tanks during February - March, 1989.

1. Aim

To test the adequacy of the commercial feed supplied @ 5 and 10% of body weight.

2. Introduction

Commercial shrimp feeds available in the market seldom give details of dosage to be supplied in shrimp culture systems with regard to stocking density. Often, inadequate or surplus quantities of feeds are supplied to the systems without producing desired results. Nevertheless, it is common to supply feed @ 3 to 10% of body weight in culture systems. Therefore, an experimental culture of P. indicus was carried out by supplying a commercial feed @ 5% and 10% body weight.

3. Material and methods

The experiment was conducted in three identical circular cement tanks (1, 2 and 3) each having 56 cm internal radius and 70 cm height (Plate III A). After conditioning the tanks by keeping ambient water for sufficient time, the tanks were set ready for stocking purposes. The tanks were filled by pumping in water using 0.5 HP motor from adjoining feeder canal. A 100 micron nylon net was used to filter water being pumped in. The tanks were conditioned (Plate XVI A) by frequent filling and draining for a period of 3 days before stocking.

3.2 Water exchange

In each tank 70% of the water was daily exchanged during every morning by proper draining and adequate pumping to ensure 60 cm water level. Ample care was bestowed to supply fresh tidal water during exchange, after filtering through 100 micron nylon mesh.

3.3 Fry stocking

Uniform sized 50 numbers of *P. indicus* wild fry (Plate I A) were carefully introduced into each tank on 15.2.1989, the stocking density being 85 nos./m^3.

3.4.a Feed analysis

The feed was the same as used in D-1.

3.4.b Feeding

Since stocking, daily feeding @ 5% and 10% of body weight, was done in tanks 1 and 2 respectively keeping 3rd tank as control. The feed quantity was assessed on a weekly basis. The feed was supplied during evening hours, in trays sundried daily.

4. Results

4.1 Water quality parameters

The quality of the water pumped in was regularly monitored. The parameters such as temperature, pH, salinity, dissolved oxygen, alkalinity and sediment load ranged between 28 and 30.0°C, 6.5 and 8.5, 25 and 30‰, 2.5 and 5.25 ml/L, 159 and 350 mg/L and 0.1 and 0.2 ml/L respectively during the course of the experiment.

4.2 Growth rates

The mean size of *P. indicus* at the time of stocking and thereafter at intervals of 2, 4 and 6 weeks are presented in Table 28a. The mean size was assessed at weekly intervals using random samples. From an initial size of 32.2 mm (0.196 g) in all tanks, the mean sizes of 64.1 mm (1.698 g), 69.1 mm (2.132 g) and 55.7 mm (1.139 g) in tanks 1, 2 and 3 respectively were obtained after a period of 6 weeks. However, P. indicus exhibited stunted growth. The rates of growth achieved after 6 weeks in tanks 1, 2 and 3 were in the order of 31.9 mm (1.502 g) 36.9 mm (1.936 g), and 23.5 mm (0.943 g) (Table 28b). The growth rate was comparatively higher in tank 2 (feeding @ 10% body weight/day) followed by tank 1 (feeding @ 5% body weight/day) and tank 3 (control).

The rate of growth increment (Table 28c) was more between 4th and 6th weeks in all cases. At the sametime consistently high values of growth increment were recorded in tank 2 (@ 10% daily feeding) than those of tank 1 (@ 5% daily feeding) and 3 (control). Again there was not much difference in the quantum of growth noted in tanks 1 and 3 up to a period of 4 weeks. However, there was a well defined difference in growth rate between the two subsequently.

The survival rate decreased with the increase in number of experimental days irrespective of treatments and control (Table 28d). Comparatively lower rate of mortality and higher percentage survival prevailed in tank with 10% feed supply. However, 76% mortality was noticed in the control tank.

5. Observations

The significance of adequate quantity of feed in the survival of P. indicus was quite evident from the level of mortality (Table 28d). The use of filtered water devoid of feed material might have been responsible for 76% mortality in the control tank. The supply of feed @ 10% body weight was seen to have beneficial effect on P. indicus growth. The overcrowding of shrimps in turbid water might have caused stress conditions leading to stunted growth.

TABLE 28 a

MEAN SIZE OF P.INDICUS IN THE DIFFERENT TANKS IN AN EXPERIMENTAL CULTURE

Date of Observation	Tank 1 Dry feed @ 5% body wt.		Tank 2 Dry feed @10% body wt.		Tank 3 Control (No feed)	
	mm	g	mm	g	mm	g
15.2.1989	32.2	0.196	32.2	0.196	32.2	0.196
02.3.1989	34.0	0.370	39.2	0.410	33.4	0.260
16.3.1989	48.6	0.795	51.9	0.928	48.6	0.729
31.3.1989	64.1	1.698	69.1	2.132	55.7	1.139

TABLE 28 b

RATE OF GROWTH OF P.INDICUS IN AN EXPERIMENTAL CULTURE DURING FEBRUARY-MARCH, 1989.

Details	Tank 1 (5% feed)		Tank 2 (10% feed)		Tank 3 (Control)	
	mm	g	mm	g	mm	g
Initial(0 day)	32.2	0.196	32.2	0.196	32.2	0.196
2 weeks	1.8	0.174	7.0	0.214	1.2	0.064
4 weeks	16.4	0.599	19.7	0.732	16.4	0.533
6 weeks	31.9	1.502	36.9	1.936	23.5	0.943

TABLE 28 c

INCREMENT OF GROWTH OF P.INDICUS IN AN EXPERIMENTAL CULTURE DURING FEBRUARY-MARCH, 1989

Details	Tank 1 (5% feed)		Tank 2 (10% feed)		Tank 3 (Control)	
	mm	g	mm	g	mm	g
Initial (0 day)	32.2	0.196	32.2	0.196	32.2	0.196
2 weeks	1.8	0.174	7.0	0.214	1.2	0.064
4 weeks	14.6	0.425	12.7	0.518	15.2	0.469
6 weeks	15.5	0.903	17.2	1.204	7.1	0.410

TABLE 28 d

DETAILS OF SURVIVAL AND MORTALITY OF P.INDICUS IN AN EXPERIMENTAL CULTURE

Date of observation	Tank 1(5% feed)		Tank 2(10% feed)		Tank 3(Control)	
	No.surv.	% Mort	No.Surv.	% Mort	No.Surv.	% Mort
15.2.1989	50	0.0	50	0.0	50	0.0
02.3.1989	37	26.0	44	12.0	26	48.0
16.3.1989	33	34.0	39	22.0	17	66.0
31.3.1989	31	38.0	33	34.0	12	76.0

D 3 : Impact of four stocking densities on the growth of P. indicus fed with pellets in fibre glass tanks between December 1988 and February 1989.

1. Aim

To test the effect of varying stocking densities on growth of P. indicus fed on cheap locally made compounded feed.

2. Introduction

In areas with lowered water quality, it is thought appropriate to reduce the stocking density correspondingly, aimed at reasonable production level. Hence P. indicus was cultured @ 20, 40, 60 and 80/m^3 using turbid water at Puduveypu to arrive at a suitable density.

3. Material and methods

3.1 Tank set up

Four oval-shaped fibre glass tanks of 1 tonne capacity each, were arranged in series (Plate XVI B) near the feeder canal at Puduveypu. Each tank was filled 3/4 by pumping water from the feeder canal with the help of a 0.5 HP pump. Always water was filled in the tanks after proper filtration through 100 micron nylon cloth. The tanks were conditioned by pumping in and out water, daily once for a week. A suitably fabricated oval screen of dry twigs of Casuarina sp. was also kept immersed in each tank in order to provide a false bottom for the fry to rest.

3.2 Water exchange

50% of water was daily exchanged in each tank by proper siphoning and pumping. 3/4th level of water was maintained in each tank throughout the experimental period of 6 weeks from 22.12.1988 to

6.2.1989.

3.3 Fry stocking

Uniform sized (17.7 mm/0.030 g) Penaeus indicus wild fry (Plate I A) were stocked in the order of 20, 40, 60 and 80 specimens per m^3 in tanks 1, 2, 3 and 4 respectively after acclimatization.

3.4.a Feed preparation

The feed 4 as described in Table 22a was used.

3.4.b Feeding

From the 2nd day of stocking onwards, the feed was daily supplied in equal doses in all tanks. The feed was daily applied usually during afternoon in sundried clay containers (Plate VIII A). The quantity of the feed to be applied was assessed based on 5-10% of the mean weight at weekly intervals. Daily observations of the remnants of feed showed more or less the same trend of consumption from start to finish of experiment. Nevertheless, the intensity of feed intake was more towards the fag end of experiment in respect of all tanks as revealed by the reduced quantities of left over.

4. Results

4.1 **Water quality parameters** were regularly monitored. The temperature, pH, salinity, dissolved oxygen, alkalinity and sediment load fluctuated between 27.5 and 31.5°C, 7.5 and 9.0, 27.36 and 30.20‰, 3.5 and 5.8 ml/L, 180 and 320 mg/L and 0.1 and 0.2 ml/L respectively.

4.2 Growth measurements

The mean size showed much variations in different tanks when measurements were made at fortnightly intervals. The mean size noticed after 6 weeks growth was 84.6 mm (3.767 g), 75.3 mm (2.410 g), 64.2 mm (1.755 g) and 59.6 mm (1.267 g) in tanks 1, 2, 3 and 4 respectively (Table 29a).

The rates of growth (Table 29b) showed a decreasing trend from tanks 1 to 4, the respective values being 66.9 mm (3.737 g), 57.6 mm (2.380 g), 46.5 mm (1.725 g) and 41.9 mm (1.237 g) after 6 week clearly indicating an inverse relationship between growth rate and stocking density.

The growth increment values at times with negligible differences also showed similar trend (Table 29c). The survival rate was found decreasing as the number of experimental days advanced in all cases (Table 29d) with a maximum percentage in tank 1 (55%) and the minimum in tank 4 (21.25%). Realization of biomass of 41.11, 30.94, 27.6 and 21.03 g of *P. indicus* in spite of stunted growth obtained from tank 1, 2, 3 and 4 respectively also confirmed the inverse relationship between production and stocking density.

5. Comments

A positive correlation between increased growth rate and survival rate was quite evident in low density culture tanks (Table 29b & d). Of the 4 stocking densities tried, the lowest @ 20/m^3 was found appropriate. The problems of low quality water along with overcrowding might have caused stress conditions resulting in poor growth and survival.

TABLE 29 a

MEAN SIZE OF P. INDICUS IN DIFFERENT TANKS

Details	Tank 1	Tank 2	Tank 3	Tank 4
	mm g	mm g	mm g	mm g
22.12.88 (initial)	17.7-0.030	17.7-0.030	17.7-0.030	17.7-0.030
06.01.89	35.2-0.288	35.0-0.231	33.0-0.174	30.8-0.145
21.01.89	65.1-1.680	63.1-1.482	54.3-0.998	50.4-0.762
06.02.89	84.6-3.767	75.3-2.410	64.2-1.755	59.6-1.267

TABLE 29 b

RATE OF GROWTH OF P. INDICUS IN DIFFERENT TANKS

Details	Tank I	Tank 2	Tank 3	Tank 4
	mm g	mm g	mm g	mm g
Initial (0 day)	17.7-0.030	17.7-0.030	17.7-0.030	17.7-0.030
2 weeks	17.5-0.258	17.3-0.202	15.3-0.144	13.1-0.155
4 weeks	47.4-1.650	45.4-1.452	36.6-0.968	32.7-0.732
6 weeks	66.9-3.737	57.6-2.380	46.5-1.725	41.9-1.237

TABLE 29 c

GROWTH INCREMENTS OF P.INDICUS IN DIFFERENT TANKS

Details	Tank 1	Tank 2	Tank 3	Tank 4
	mm g	mm g	mm g	mm g
Initial (0day)	17.7-0.030	17.7-0.030	17.7-0.030	17.7-0.030
2 weeks	17.5-0.258	17.3-0.201	15.3-0.144	13.1-0.155
4 weeks	29.9-1.392	28.1-1.251	21.3-0.824	19.6-0.617
6 weeks	19.5-2.087	12.2-0.928	9.9-0.767	9.2-0.505

TABLE 29 d

DETAILS OF SURVIVAL AND MORTALITY OF P. INDICUS IN DIFFERENT TANKS

Date of Observation	Tank 1 No. Surv.	Tank 1 % of Mort.	Tank 2 No. Surv.	Tank 2 % of Mort.	Tank 3 No. Surv.	Tank 3 % of Mort.	Tank 4 No. Surv.	Tank 4 % of Mort.
22.12.1988 (Initial)	20	0	40	0	60	0	80	0
06.01.1989	18	10.0	34	15.0	49	18.33	56	30.00
21.01.1989	14	30.0	24	40.0	29	51.67	38	52.50
05.02.1989	11	45.0	13	67.5	16	73.33	17	78.75

D 4 : Growth studies on *P. indicus* juveniles fed with clam meat in circular cement tanks between November 1986 and January 1987.

1. Aim

To study the growth rate of *P. indicus* juveniles in turbid water at a higher density of 100/m^3.

2. Introduction

Faster rate of growth is the main concern in shrimp farming endeavour. Realising the importance of stocking size and density on the above, an experimental high density culture of *P. indicus* was carried out.

3. Material and methods

3.1 Tank set up

One circular cement tank having a water holding capacity of 0.59 m^3 and 71 cm height was set ready (Plate III A) for experimental stocking of *P. indicus*. A suitable drainage tap with control was also fitted at the bottom of the tank. 7 to 8 cm column of productive sand was laid at the bottom. Tank was filled by pumping in water filtered through a 100 micron nylon mesh from the nearby feeder canal by using a 0.5 HP motor. The tank was conditioned (Plate XVI A) for juvenile stocking purpose by regular filling and draining for a week.

3.2 Water exchange

After first day of stocking, 70% water from the tank was replenished daily by pumping. Utmost care was taken to maintain a water column of 60 cm always in the tank.

3.3 Stocking

59 wild juveniles of uniform size (0.789 g/49.2 mm) after acclimatization were introduced into the tank, maintaining a density of $100/m^3$ (Table 30a).

3.4 Feeding

From third day of stocking onwards, juveniles were fed daily evening with crushed clam meat @ 8-10% body weight, using sundried earthern tray (Plate VIII A).

4. Results

4.1 Water quality parameters

The water quality parameters such as water temperature, pH, salinity, dissolved oxygen, alkalinity and sediment load, varied between 27.5 and 31.5°C, 7.8 and 8.5, 12.5 and 29.3‰, 2.84 and 5.05 ml/L, 256 and 324 mg/L and 0.1 and 0.3 ml/L respectively during the period of experiment.

4.2 Growth measurements

Fortnightly measurements on growth of juveniles were made from a random sample of 10 specimens after counting the total juveniles (Table 30b). After 8 weeks, the juveniles attained a mean size of 82.0 mm/3.256 g, the growth rate being 2.467 g (32.8 mm). In spite of a heavy mortality rate of 81.36% and stunted growth, 35.8 g of P. indicus was harvested (Table 30a).

5. Observations

The very low survival rate of 18.6% might have been the after effect of high density stocking coupled with low water quality and associated stress factors leading to mortality of juveniles. However, the quantum of growth achieved during 8 weeks is not at all appreciable even with regular feeding with clam meat at this high stocking density.

Table 30a

PARTICULARS OF EXPERIMENTAL CULTURE OF PENAEUS INDICUS IN CIRCULAR CEMENT TANK

Details	Cement tank
Capacity (m^3)	0.59
Date of stocking	12.11.86
No. of shrimps stocked	59
Stocking density (no./m^3)	100
Mean stocking size (g/mm)	0.789/49.2
Date of harvest	8.1.87
Culture duration (days)	56
No. harvested	11
Survival rate (%)	18.64
Mean size at harvest (g/mm)	3.256/82.0
Total biomass collected (g)	35.8
Type of water management	70% water replaced daily by pumping

Table 30b

MEAN VALUES OF GROWTH, RATE OF GROWTH AND GROWTH INCREMENT OF PENAEUS INDICUS

Period	Growth	Growth rate	Growth increment
	g mm	g mm	g mm
12.11.86 (initial)	0.789-49.2	0.789-49.2	0.789-49.2
26.11.86 (2 weeks)	1.523-61.6	0.734-12.4	0.734-12.4
10.12.86 (4 weeks)	2.271-72.8	1.482-23.6	0.748-11.2
24.12.87 (6 weeks)	2.621-75.0	1.832-25.8	0.350- 2.2
08.01.87 (8 weeks)	3.256-82.0	2.467-32.8	0.635- 7.0

D 5 : Growth studies on *P. indicus* fry fed with clam meat in circular cement tanks between November 1986 and January 1987.

1. **Aim**

To study the growth rate of *P. indicus* fry in turbid waters at a very high stocking density of 800/m³.

2. **Introduction**

High density stocking of fry and their better survival are factors important in successful shrimp culture. However, its prospect is yet to be elucidated in wetland ecosystems with turbid water characteristics. Therefore, the feasibility of a high density culture of *P. indicus* fry was tried at Puduveypu.

3. **Material and methods**

3.1 **Tank set up**

Tank dimensions, set up and its conditioning were similar to that described in the previous experiment, D 4.

3.2 **Water exchange**

Quite similar as in previous experiment, D 4

3.3 **Fry stocking**

472 uniform sized wild *P. indicus* fry (0.128 g/24.2 mm) were introduced into the tank after acclimatisation maintaining a stocking density of 800/m³ (Table 31a).

3.4 Feeding

After two days of stocking crushed clam meat @ 8-10% of body weight was supplied daily evening in a wide mouthed earthern tray (Plate VIII A) sundried before use throughout the experiment.

4. Results

4.1 Water quality parameters

The water quality parameters such as temperature, pH, salinity, dissolved oxygen, alkalinity and sediment load ranged between 27.5 and 31.5°C, 7.8 and 8.5, 12.5 and 29.3‰, 3.4 and 5.05 ml/L, 256 and 324 mg/L and 0.1 and 0.2 ml/L respectively during the period of experiment.

4.2 Growth measurements

The details are presented in Table 31b. The shrimp fry with an initial size of 0.128 g (24.2 mm) attained the mean size of 0.851 g (50.8 mm) after 8 weeks. In spite of stunted growth and a mortality rate of 73.52%, the total yield amounted to 106.1 g (Table 31a).

5. Observations

High mortality rate and stunted nature of growth were noticed irrespective of stocking of juvenile or fry in turbid waters especially in increased density. The inability of the fry to attain juvenile size even after 8 weeks growth could be the after effect of excessively high rate of stocking. Nevertheless, the higher biomass yielded might be on account of high density.

Table 31a

PARTICULARS OF EXPERIMENTAL CULTURE OF PENAEUS INDICUS IN CIRCULAR CEMENT TANK

Details	
Capacity (m^3)	0.59
Date of stocking	12.11.86
No. of shrimps stocked	472
Stocking density (no./m^3)	800
Mean stocking size (g/mm)	0.128/24.2
Date of harvest	8.1.87
Culture duration (days)	56
Nos. harvested	125
Survival rate (%)	26.48
Mean size at harvest (g/mm)	0.851/50.8
Total biomass collected (g)	106.1
Type of water management	70% water replaced daily by pumping.

Table 31b

MEAN VALUES OF GROWTH, RATE OF GROWTH AND GROWTH INCREMENT OF PENAEUS INDICUS DURING EXPERIMENTAL CULTURE

Period	Growth	Mean value of Growth rate	Growth increment
	g mm	g mm	g mm
12.11.86 (initial)	0.128-24.2	0.128-24.2	0.128 - 24.2
26.11.86 (2 weeks)	0.228-30.4	0.100- 6.2	0.100 - 6.2
10.12.86 (4 weeks)	0.537-37.2	0.409-13.0	0.309 - 6.7
24.02.86 (6 weeks)	0.680-45.6	0.552-21.4	0.143 - 8.4
08.01.87 (8 weeks)	0.851-50.8	0.723-26.5	0.171 - 5.2

2.4 Group E

Case studies on semi-intensive farming of P. monodon during February - June, 1992 at Cherukunnu, Kannur.

Salient features

Rectangular earthern pond - elevated area - adjoining feeder canal - predators eliminated - well prepared - selective, direct stocking of P. monodon hatchery bred post larvae in high density - manuring - imported high quality supplemental feed - water management by pumping — 6 - 25% water exchange daily - paddle wheel aeration - terminal harvest. The inadequately acclimatised fry, insufficient water depth, indiscrimate use of feed and forced harvest due to medium dilution were the major drawbacks.

Studies on semi-intensive farming of P. monodon during February - June 1992 in Mundapuram at Cherukunnu, Kannur.

1. Aim

To study the role of water quality parameters and other management aspects during high density farming for the enhanced production of tiger shrimp.

2. Introduction

Realizing the limitation of production (up to 1.2 tonnes/ha/season) from the traditional, improved and extensive farming practices, it was thought worth to explore means of enhanced shrimp production (2-4 tonnes/ha/season) by applying modern scientific methods in Kerala where vast areas remain untapped. This study was made in association with MPEDA, Kochi and M/s. Choice Canning Co., Kochi in a demonstration programme.

3. Material and methods

3.1 Location

The private farm covering an area of 1.2 ha leased by M/s. Choice Canning Co., Kochi was located adjoining Mattol estuary connected to Azhikode barmouth, in Mundapuram at Cherukunnu, Kannur (Fig. 11).

3.2 Layout

The almost rectangular farm was bestowed with strong outer bunds, but without any internal dyke partitions. On the western and southern sides facing tidal water source, a fringe of mangrove vegetation (Plate XVII A) was growing offering strength to the bunds. A hume pipe having 80 cm diameter installed at the south eastern side

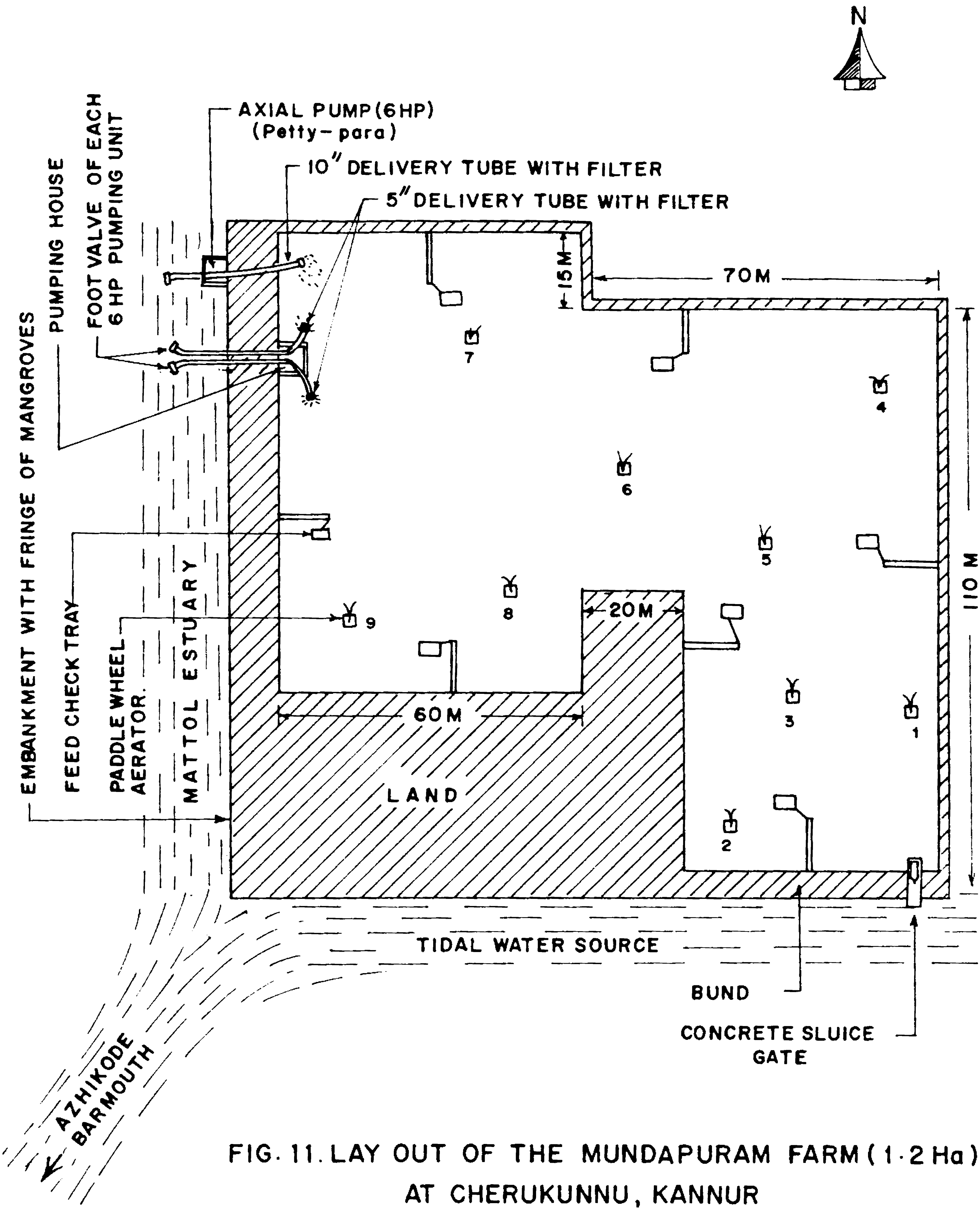

FIG. 11. LAY OUT OF THE MUNDAPURAM FARM (1·2 Ha) AT CHERUKUNNU, KANNUR

diagonally opposite to the delivery point served as an exit for draining water to the adjoining canal, accomplishing the purpose of a sluice gate. The farm elevated above mean low tide level was found slanting 30° towards drain gate. Except for the presence of a 3 M x 1 M x 0.5 M pit seen in front of the drain gate, the bottom of the farm was even. Surprisingly, the characteristic canal system of traditional/improved fields was not present.

3.3 Substratum

The firm, fertile substratum was composed of mud and clay in 3:2 ratio. The soil pH varied between 6.5 and 6.8. Benthic fauna comprised of nereids, tanaeids and gastropods.

3.4 Farm preparation

Preparations, initiated on 24th January, 92, included draining, raking, levelling and drying. Weeds and predators were eradicated on 5th February by the application of 490 kg Mahua oil cake (Plate II B) retaining 15 cm water column. About 80 kg of cat fishes, Tilapia (Oreochromis mossambicus), Etroplus maculatus, Ambassis sp and eels were removed dead within 3-5 hours after mahua application. On the following day, 375 kg Health stone (volcanic ash) was added for raising the pH. Thereafter, water level was raised upto 25 cm screening through 1/60 nylon mesh. On 11th February, a semi-liquid mixture containing 10 kg each of urea and dried, powdered cowdung was sprinkled all over the pond followed by 10 kg superphosphate dissolved in 5 litres water, with the help of a canoe (Plate XI A). 3 days later, 30 kg each of tea seed cake and lime were added, raising the water column to 30 cm, simultaneously. A mixture of 5 kg each of dry cowdung, urea and super phosphate was added on the next day. On 16th February, 125 kg Health stone was applied at 5.00 A.M. to adjust pH to 8.5. Around 10.00 A.M., when water was warm, 3 kg BN-10 dissolved in 4.5 litres of tap water and frequently stirred for 2 hours was added in order to reduce the bacterial load. Thereafter continuous aeration (Plate XVII

B) followed for 24 hours.

All preparations including arrangements for illuminating the farm area during night were completed on 18th February when water level was raised to 75 cm by pumping. During the course of culture, 825 kg Health stone was also added at intervals.

Besides, square shaped (2' x 2' size) wooden frames fitted with 1/60 nylon mesh at the bottom and having legs were suspended from platforms one each at seven points, to serve as feed check tray (Plate XVIII A).

3.5 Water management and aeration

To start with, 2 high discharge diesel water pumps of 6 HP each with 5" delivery hose were installed. Water exchange was effected once daily during the balanced phase of high tide. From the 42nd day of culture onwards, one axial pump (petty - para) of 6 HP, with 10" delivery pipe, replaced the above pumps (Fig. 11). Close meshed nylon (1/60) was fitted at the delivery and exit points.

Water exchange rate increased from 6 to 25.8% as the culture advanced from February to June maintaining a water column between 70 and 75 cm (Table 32a). During 3rd week of June, owing to heavy rainfall estuarine salinity was dropped to 13‰ leading to lowering of farm salinity to 23‰. Hence, exchange was forced to be reduced to 20%. On an average, water exchange was @ 15% per day.

3.6 Acclimatization and release of fry

3 lakh PL_{20} *P. monodon*, procured from TASPARC Visakhapatnam and brought to the farm site by late midnight in 150 oxygen filled polythene bags in 22‰ saline media containing 2000 nos each, sufferred 10% mortality during transit. The remaining fry were gradually acclimatized to the farm salinity of 36‰ in 4 hours time.

Thereafter, fry were released to the farm between 6 and 11.00 AM on 19.2.92 maintaining a stocking density of 2,25000/ha. Though, in general, aeration is not advisable for 45 days after fry stocking, it was not fully observed in the present case.

3.7 Feeding

The fry were fed with a small quantity of PL_2 (Hanaqua - 48% protein) feed during acclimatization. Subsequently, subject to availability, 8 different feeds as detailed in Table 32b were used indiscriminately.

The different supplementary feeds were given in dry pellet (Plate II A) form except in the case of clam meat. The feed ration was gradually reduced from the initial dose of 20% to 5% as the culture advanced giving due regard to body weight and consumption. In general, a quantity ranging between 0.5 and 1.4% was supplied through the check tray (Plate XVIII A) depending on requirement during each time. The quantity of feed was decided upon the left over in the check trays.

The feed schedule was increased from once daily at 7.00 pm initially (3 days) to twice daily at 6.00 a.m. and 6.00 p.m. (24 days), thrice daily at 6.00 a.m., 2.00 p.m. and 10.00 p.m. (22 days), four times daily (6 days) and upto 5 times a day (7.00 a.m., 11.00 a.m., 4.00 p.m., 8.00 p.m. and 12 night) for the remaining period. During the fag end of operation, the daily feed supply rose to about 218 kg. In all 3.6 tonnes dry pellets and 2 tonnes of clam meat were supplied, in addition to 50 kg of compounded feeds containing clam meat, soybean, fish meal and oil in specified ratio. The mixture comprising 1.2 kg prawn stronger and 52 eggs applied on 100th day of culture served as appetizer. The FCR worked out was 1.4:1. The highly nutritious feed pellets of Hanaqua, Grobest and Goldcoin were imported ones.

3.8 Harvest

After an initial harvest on 114th day using cast nets and filtration net, regular harvesting was done on 5 days between the 121st and 130th day's of culture (18.6.92 to 27.6.92). In addition, hand picking was also resorted to.

4. Results

4.1 Water quality parameters

The important parameters such as temperature, pH, salinity, dissolved oxygen and turbidity were monitored regularly during morning (8.00 a.m.) and evening (5.00 p.m.). The monthly mean values are presented in Table 32a.

Surface temperature was found always higher by 2 to 3°C during evening hours. In general, the temperature during the entire culture period varied from 26 to 32°C during morning and from 28 to 35°C during evening.

Except during the last week of culture when pH recorded was 7.1, the medium remained alkaline (8.2 - 8.5) through out, on account of the periodic application of lime and Health stone.

The highest salinity of 36‰ recorded during February was reduced to 32‰ during 1st half of June and then abruptly lowered to 23‰ during the third week on account of heavy rain fall.

High values of dissolved oxygen (between 6 and 8 ppm) were recorded during evening and low values (between 4 and 5.8 ppm) were recorded during morning. At no time, the dissolved oxygen values (less than 4 ppm) were noticed owing to the use of 2 HP paddle wheel aerators (Plate XVII B) during culture operation (Fig. 11).

The transparency of the medium fluctuated between 30 and 42 cm during morning and between 27 and 38 cm during evening. The transparency was uniformly higher during morning by 1 to 4 cm than of evening (Table 32a).

4.2 Growth assessment

But for the surfacing of shrimps and vigorous activity noticed on the 30th day of farming, no disturbance was seen in the farm. The condition of the stock was regularly assessed by observing specimens collected in the feed check trays. The mean value was assessed from a sample of 10 specimens collected through cast nets. Details of mean growth (28 g/150 mm) attained by P. monodon during the 120 days of farming are shown in Fig. 12.

4.3 Harvest data

In all 2868.45 kg P. monodon (97.33%), 23.7 kg P. indicus (0.8%), 24.5 kg M. monoceros (0.83%) and 30.5 kg M. dobsoni (1.04%) totalling 2947.15 kg shrimps were obtained. The production of P. monodon was worked out @ 2390.4 kg/ha/4 months with a survival rate of about 45%. About 1.2 kg miscellaneous items such as catfish, Oreochromis mossambicus and Ambassis sp were also collected. While 94.77% was obtained through filtration, only 2.49 and 2.73% were collected by hand picking and cast netting respectively.

5. Economics of operation

The details presented in Table 32b indicate that an expenditure of Rs. 371301.65 was incurred towards operation realizing an income of Rs. 434077/- from the 1.2 ha farm. A net profit of Rs. 62775.35 (+) was made with a return of 16.91% on capital investment during a single crop of 120 days.

TABLE 32 a

WATER QUALITY PARAMETERS IN MUNDAPURAM FARM (1.2 ha) AT CHERUKUNNU, KANNUR BETWEEN FEBRUARY AND JUNE, 1992

Month of observation	Water level (cm)	Rate of water exchange (%)	Temperature (°C)		pH		Salinity (‰)		Dissolved Oxygen (ppm)		Transparancy (cm)	
			M	E	M	E	M	E	M	E	M	E
2/92	70	6.0	31	33	8.5	-	36	-	4.7	-	36	33
3/92	74	7.0	31	34	8.2	-	30	-	4.0	8.0	38	35
4/92	73	9.0	32	35	8.4	-	30	-	4.0	6.0	30	27
5/92	71	14.5	31	33	8.5	8.7	34	36	5.8	6.1	42	38
6/92 Ist fortnight	73	25.8	30	32	8.5	9.2	32	-	5.0	6.5	33	30
6/92 2nd fortnight	72	20.0	26	28	7.1	-	23*	-	5.0	-	35	34

M = 8 a.m., E = 5 p.m., * Estuarine salinity dropped to 13‰.

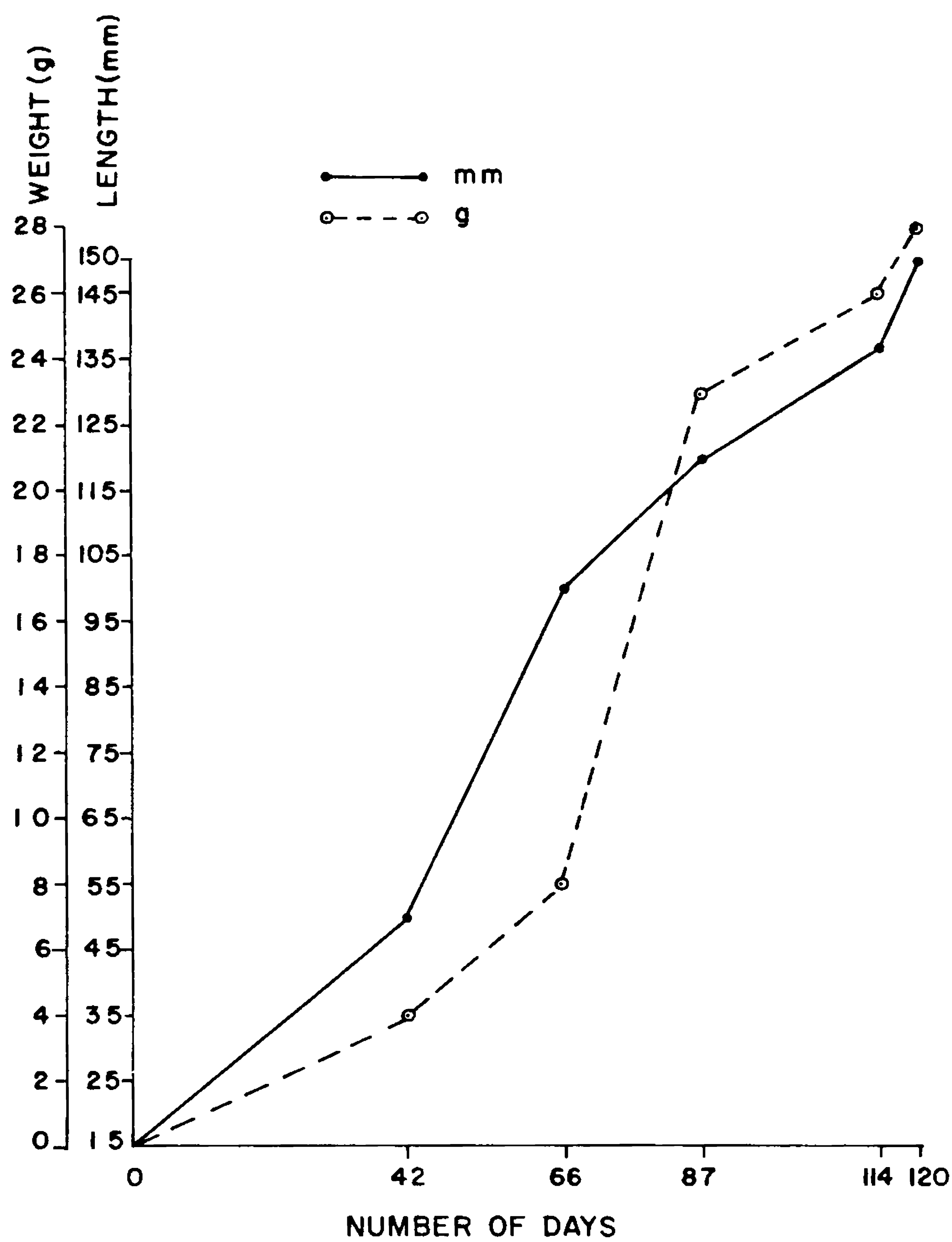

FIG. 12. GROWTH OF *Penaeus monodon* IN MUNDAPURAM CHERUKUNNU

TABLE 32 b

DETAILS OF EXPENDITURE AND INCOME DURING SEMI-INTENSIVE FARMING OF P.MONODON IN MUNDAPURAM(1.2 ha) DURING FEBRUARY-JUNE, 1992.

EXPENDITURE		Qty.(kg)	Rate/kg	Rs.
1.	Lease amount of the farm(1.2 ha) for 4 months			25,000.00
2.	Charges for maintenance during operation			5,000.00
3.	Cost of input items used during preparation	Qty.(kg)	Rate/kg	
	1. Mahua oil cake	490	5.0	2,450.00
	2. Dried cowdung	70	0.5	35.00
	3. Urea	25	2.2	55.00
	4. Super phosphate	25	1.7	42.50
	5. Health stone	1325	25.0	33,125.00
	6. BN-10	43	50.00	2,150.00
	7. Tea seed cake	110	35.0	3,850.00
	8. Lime	800	1.25	1,000.00
4.	Feed			
	1. Hanaqua PL_2	200	45.00	9,000.00
	2. " S1	1000	45.00	45,000.00
	3. Grobest F3	1000	30.00	30,000.00
	4. " A6	400	30.00	12,000.00
	5. Goldcoin G	1000	50.00	50,000.00
	6. Jaypee(Compounded) feed	50	12.00	600.00
	7. Clam meat	2000	6.00	12,000.00
	8. Prawn stronger	1.2	850.00	1,020.00
	9. Chicken egg	52 Nos	1/one	52.00
5.	Seed			
	3 lakh *P. monodon* (PL_{20}) @ Rs. 150/1000 Nos.			45,000.00
6.	Fuel			
	1. Diesel 3909 ltrs @ 6.35/ltr			24,822.15
	2. Engine oil 30 " @ 40.0/ltr			1,200.00
7.	Labour +			
	Salary and wages for 2 management executives 1 electrician/mechanic and 4 watchmen			50,000.00
8.	Sundry			
	Repair of machinery, electrical fittings and miscellaneous items			5,000.00
9.	Harvesting expenses			750.00
10.	Depreciation @ 1/3rd on 10% ofthe *Capital investment			7,150.00
		Total		3,71,301.65
		Expenditure/ha		3,09,418.84

INCOME		Rs.
1.	Cost of 2868.45 kg *P.monodon* @ Rs. 150/kg	4,30,267.5
2.	Cost of 23.7 kg *P.indicus* @ Rs. 125/kg	2,965.5
3.	Cost of 24.5 kg *M.monoceros* @ Rs. 22/kg	539.0
4.	Cost of 30.5 kg *M.dobsoni* @ Rs. 10/kg	305.0
	Total	4,34,077.0
	Profit margin (+)	62,775.35
	Income/ha	3,61,730.83
	Profit margin/ha (+)	52,312.79
	Return on investment (ROI)	16.91%

+	Production Executive(Senior)	1 Rs. 3500/month	Rs.	14,000.00
	Production Executive	1 Rs. 3000/month	Rs.	12,000.00
	Electrician /Mechanic	1 Rs. 2000/month	Rs.	8,000.00
	Farm hands/watchman	4 Rs. 1000/month	Rs.	16,000.00
				50,000.00

* Capital investment
Generator shed, water pumps, aerators, electrical fittings and installations, Nets and Wages of watchman worked out at Rs. 2,14,500/-

6. <u>Observation</u>

The low survival rate ($<$ 45%) and the reduced mean growth rate (28 g) after 120 days of farming against the anticipated mean weight of 30 g, might have been the result of the following 4 factors.

a) The time taken for acclimatization of transported fry from a low saline medium (23‰) to the high saline stocking medium (36‰) was only four hours.

b) The continued aeration with the help of paddle wheels soon after stocking might have caused mechanical damage to the fry.

c) The water column was restricted to 70-75 cm against the normal requirement of 100-150 cm leading to over crowding.

d) Delay in the procurement of feed and their indiscriminate application regardless of starter, grower and finisher type during specified stages, as required.

In spite of above short comings, the attainment of a production @ 2390.4 kg/ha/120 days is the highest record in Kerala in *P. monodon* farming. Realization of additional crops soon after monsoon as the salinity rises and depending on fry availability, the production figure on an annual basis will be much more attractive. From an economic view point, the net profit margin of Rs.52313/ha per crop realized within 4 months will be worth rewarding for the entrepreneurs.

However, in view of the high investment requirement of Rs.309419/ha, this will remain beyond the reach of traditional farmers in their present socio-economic background. Above semi-intensive farming can be practised only by financially sound entrepreneurs with the technical assistance of MPEDA who can afford imported feed and other sophisticated equipments.

In a national perspective, semi-intensive farming, making use of untapped, water sources can fetch the much sought after foreign exchange owing to enhanced production. Thus, transformation of waste lands into shrimp production units can boost up rural development.

3. DISCUSSION

3.1 IN SEARCH OF AN APPROPRIATE TECHNOLOGY

3.1.1 Site selection with reference to species, technology, eco-characteristics such as Tidal Range, Soil, Topography, Water, Environmental aspects and infrastructure

To a certain extent shrimp farming is site specific due to its peculiar requirements. It is an accepted well known fact that the right selection of site is probably the most important factor that determines the feasibility of viable operations. Poor selection of sites leads to enormous loss of money. In addition, most problems associated with shrimp farming are location specific. There is considerable area to area variation in the physico-chemical parameters, such as those related to the soil and water characteristics, climate and other infrastructural facilities. Also, the success of production depends upon the cumulative effect of all the inputs made available in adequate quantity at appropriate time. Hence the production problems in different areas of the country are dissimilar and non-comparable. So the practical problems faced by Kerala farmers are entirely different from those in Gujarat/Andhra Pradesh/Goa/Karnataka/Orissa/West Bengal etc.

In general ideal sites with 100% favourable natural conditions may not be available due to various interacting environmental factors. Unfortunately a lot of coastal area is reclaimed for unproductive agricultural crops and the return is low. The best land use policy to get maximum output has not yet been evolved. Since coastal aquaculture has emerged as a new science/profession with high return, it requires a major change in the policy of government.

Given an opportunity to select an ideal site, it shall depend upon the species to be cultured, nature of environment and the technology to be employed and marketing opportunities. Limitation in any of the three factors namely, site characteristics, species selection and appropriate technology obviously restrict choice of the others. The species to be selected for culture and the technology to be adopted depend on the characteristics of site selected as noticed in the study area.

Some of the factors which have to be taken into consideration before the site selection is done are agroclimatic conditions and support facilities like communication, protection from natural disasters, public utilities, security, skilled and unskilled labour, access to markets and extension sources which can seriously affect profitability.

The criteria for the selection of a brackishwater farm site for shrimp culture have been discussed by Hora and Pillay (1962), Jhingran, et al. (1970), Sengupta (1976), Muthu (1980) and Purushan (1986).

The assessment of suitability necessitates critical examination of meteorological and environmental information especially the existing and future sources of pollution and the type of pollutants. Satyadas et al. (1989) analysing the cost and return structure of shrimp filtration have noted wide variation in net returns among the fields in three areas namely Rs. 2080 in Vypeen, Rs. 830 in Parur and a loss of Rs. 1400 in Varapuzha on account of the effect of pollution emanating from the nearby Eloor industrial belt resulting in the low productivity and absence of P. indicus.

However, in the present study, the average net return from three different traditional fields between Nayarambalam and Thrikkadakapilly in Vypeen island varied from Rs. 804 to 4436/ha where as at Pooyapilly (Parur) it was Rs. 2847/ha (Table 9).

It is worth noting that the figures given are not comparable with that of Sathidas et al. (1989) because of the time gap and the method of selection of observational units.

Mangrove vegetation is often considered as a positive indicator of soil types, elevation and salinity for field development (Plate XVIII B) as it is very much influenced by the soil particle size, topography, tidal range, flooding and the extent of fresh and marine water mixing. Sandy soil and acidic soil which has a reddish hue should be avoided. It is also wiser to avoid excessively low areas and conversely areas with high elevation.

Thus the soil characteristics, the quantity and quality of water and the draining facility by gravity are important. Unrestricted availability of good quality water and tube wells, springs etc. will be an added advantage as the level of intensification goes up.

In the study area, the coastal ponds and paddy field farms (Group A and Group B) are situated in protected tidal areas near river estuaries. So the most economical method of water management in this area is through tidal flow. Hence it is necessary to know the tidal amplitude and its fluctuations in the site.

The relationship between tidal levels and ground elevation at the pond site is decisive. A tidal fluctuation of around 3 m is considered ideal for coastal ponds against the range of 0.3 - 0.75 m being experienced in the fields investigated (Group A). The southern fields at Nayarambalam and Narakkal were influenced by the tidal processes of Cochin barmouth where as the northern fields from Kuzhupilly to Thrikkadakapilly and Pooyapilly were under the influence of Munambam barmouth. The distance from the barmouth was 10-12 Km in the former case where as it was within 5-8 Km in the latter. Therefore, the tidal amplitude was more towards the northern fields ranging from 50-75 cm against the fairly low range of 30-40 cm experienced at the southern fields. Even though physico-chemical properties of tidal water of both barmouths were more or less similar, relatively high values of transparency and salinity were characteristics of tidal water of Munambam barmouth on account of the lack of harbour development activities and its nearness to the sites.

On the contrary, the site selected for the semi-intensive farming of P. monodon at Mundapuram (Group E) was elevated above mean sea level. Nevertheless, it was also under the tidal influence of Mattol estuary fed from Azhikode barmouth.

Gopinathan et al. (1982) studying the environmental characteristics of the shrimp culture fields in the estuarine systems of Cochin from Azhikode to Kumarakom during 1977-78, noted significant variation in the composition of epifauna and benthos, chemical composition of the mud and primary production. Accordingly areas of high (> 1500), moderate (500 - 1500) and low productivity (< 500 mg $c/m^2/day$) were delineated as observed during the present studies.

High productivity fields are located in the dynamic environments such as Cochin barmouth areas and Azhikode barmouth areas where there is constant incursion of sea water and influx of river water resulting always in new water due to high replenishments. The presence of two barmouths for sea water entry within a short distance along with freshwater discharge from Periyar river contribute to definite ecological advantages. The moderate fields are present in between Cherai and Vallarpadom. This substantiates the earlier observations (George et al. 1968; George, 1974 and Gopinathan, et al., 1982).

Because of the influence of soil on productivity and its suitability for dyke construction, its quality is decisive in paddy field/ponds/farms. The characteristics of the soil also greatly determines its ability to retain the overlying water in required level. The nature of soil stratification may also necessitate adoption of appropriate measures to prevent seepage. Preference is given to dominant clayey silt mixture (45-60%) type with good water retention capacity with soil pH of 7.0 - 8.5 and good nutrient contents. Several new methods developed to arrest seepage are expensive (Bhakta, 1987).

Simple visual and tactile inspection to detailed subsurface exploration and laboratory tests are necessary to study the soil suitability. Two important physical properties of the soil are its porosity and texture. The soil texture which can be determined roughly by touch and feel, depends on the relative proposition of particles of sand, silt and clay. Clay and organic fractions will facilitate aggregation of sand particles and encourage crumb structure formation, the most desirable structural form. This will improve water and nutrient holding capacity, reduce excessive drainage and losses of nutrients through leaching, regulate soil aeration and temperature and prevent erosion (Kumaraswami, 1991). The nature of bottom soil is of great importance in brackish water aquaculture (Hickling, 1971). It has been observed that in Taiwan highly productive fish ponds were distributed in regions having silty loam soils.

In general, estuarine sediment composition expressed as percentage on a dry weight basis indicated sand as a major constituent followed by clay and silt. The type of sediment appeared sandy clay loam or sandy clay. Organic carbon expressed as mg c/g varied from 1.5 to 7%.

Subramanian (1981) noted significant correlations between the abundance of shrimp seed populations and mud organic carbon and salinity values. The soft organically rich sedimentary substratum (texture) of the inshore region preferred by penaeid shrimps is brought about by the filtering effect of the estuary (Nair and Hashimi, 1986). The shrimp population in relation to substratum was discussed by Williams (1958), Grady (1971) and Ruello (1973). Williams (1958) through laboratory experiments showed that while the pink shrimp selected most often the comparatively hard substrate of mixed shell and sand, the brown and white shrimps occurred most frequently on softer bottom composed of loose peat, sandy mud or muddy sand. The primary attractant appeared to be protective cover rather than food content.

One may assume that a gross exchange in substrate composition arising due to increased silt load or a reversal in circulation pattern with attendant changes in scouring action and rate of sediment deposition, could alter estuarine carrying capacity.

Sandy clay to clayey loam soils are found suitable for pond construction. The fine textured soil, because of their cohesive properties are more suitable for fish ponds than light textured soils which can cause high seepage and percolation. The average loss of water due to evaporation and seepage can be as much as 2.5 cm. per day in tropics compared to 0.4 to 0.8 cm. per day in Europe.

Eswara Prasad and Pillai (1984) studied on soils of some shrimp culture fields around Cochin. The results showed Pokkali fields ranking first in the fertility status of the soil in respect of all the soil parameters monitored except soil texture. This can be attributed to the predominance of clay and silt in the soil composition.

The fields and ponds selected (Group A, B & C) for the study were low lying and the soil was composed of silt and clay. But the farm was elevated at Mundapuram (E) where the ratio of mud was more than the clay. Vypeen soils in general are fine textured, black silty clayey loam soils occurring along the long land portions in the coastal belt. Being developed in areas with relatively high ground water table, these soils showed aquatic properties. In some areas of pokkali fields, undecomposed organic matter is observed in lower layers causing problems of acidity (Anon, 1989). The pond bottom was more firm in the deeper fields, but southern fields were seen usually more muddy. All fields were seasonably operated for shrimp culture alternating with paddy except for the one at Thrikkadakapilly (Cherai) which was perennial since five years.

Silas (1987) estimated that there are some 3,90,000 ha. of acid sulphate soil in India which are on the increase with poor management. Analysis revealed that development of acid sulphate soils is one of the major factors involved in the failure of old style aquaculture farms in Indonesia and Philippines. The pokkali fields along the mangrove backwaters of Cochin are another example of low productivity caused by excessive soil acidity, the condition leads to the occurrence of "soft shrimps" in affected ponds and frequently results in the loss of the entire stock. This is a matter of alarm for the shrimp farmers in this area. Rao (1987) also observed "soft prawn" syndrome generally in summer months both from the seasonal and traditional fields in Kerala. Rajamani (1982) based on biochemical studies on soft prawns concluded that the soft condition caused by the higher non protein nitrogen fraction (NPN) compared to that of healthy ones with high protein content (PN) is the after effect of protein starvation in the adverse ecological conditions. Acid sulphate soil may be acting as an adverse factor.

Nevertheless, the potentiality of this system to generate food is quite well known. Alternating paddy and shrimp culture in the pokkali fields of Ernakulam district is the most traditional, advantageous and economic method of crop raising. Hari Eswaran (1991) commented this age old practice as the proper, stable and correct method of farming having significance even in the present era of novel farming practices. It is advantageous in the sense that it enables exploitation of fertile organic resource less expensively in the form of rice and fish depending upon season.

In the case of owner operated grow-out ponds (B1-B7) the tidal exchange was accomplished through canals linked to Vembanad lake and Anthakaranazhi. The tidal amplitude varied between 30 and 60 cm. The tidal water was more turbid at Puduveypu due to its proximity to the Cochin harbour with increased dredging activities than that at Narakkal. However, the tidal water available in the ponds at Cherthala taluk was relatively silt free, since they were located far away from the Cochin barmouth. Probably the silt load in the tidal water will gradually get deposited enroute to long distances.

The substratum was more firm at Narakkal with soil composed of fine silt and clay where as at Puduveypu it was muddy with loose consistency. A firm substratum consisting of sand and clay containing acid sulphate soil was noticed at Chalippuram. In ponds at Karumancheri and Cherungal the substratum was composed of saline hydromorphic soils. Undecomposed organic matter was also observed in the lower layers at Pallithode causing problems of acidity at times. The soils in general were brownish, deep and imperfectly drained. The firm substratum containing mud and clay at Mundapuram (E) was only slightly acidic (pH 6.5 - 6.8) without doing any harm to the associated fauna.

The prevalence of acid sulphate soils/cat-clays is a major constraint in site selection for coastal paddy field/pond farms in the brackish water areas of the tropics.

This state can be defined as one in which toxic quantities of iron and aluminium are released, rendering phosphorus not available for algal growth leading to sudden fish kill during rain soon after dry spell. Acid sulphate soil results from the formation of pyrite especially in the mangrove swamps.

While sodium chloride is the dominant salt of the soil in most of the maritime states, the largely sandy loam - loam to sandy loam - clay loam soil in Kerala makes out an exception where sodium sulphate is the dominant salt which is reflected in low soil pH (3.5 - 5.5) (Natarajan, 1988). The acid soil types, high monsoon precipitation, low tidal amplitude are some of the major environmental constraints that restrict culture period of shrimp in Kerala.

Though it is possible to minimise the harmful effects of acid soils, it is expensive and time consuming. However in the tropics, especially in the study area, there may be only little choice to have sites with good soil. The only alternative is to choose sites that can be reclaimed readily by removing the source of acidity by oxidising the pyrite from the pond bottom and flushing it out of the 10-15 cm. deep surface soil and preventing further diffusion of acids, aluminium and iron salts from the subsoil. This way, the farm can be made suitable for aquaculture within 5 years.

The construction of ponds in areas reached only by the high spring tides would require excavation leading to higher construction costs. The drainage may be affected by excavation. Further, the removal of fertile top soil which is important to induce the growth and maintenance of benthic organisms in coastal ponds, will result in the loss of much time in reconditioning the pond bottom to stimulate such growth. Gedrey et al. (1984) estimated that the construction and operation of a farm with a pump water supply system can be more economical than that of a tidal water farm. Bhakta (1987) while commenting on the economic aspects on investment and operation of tide fed, pumpfed and tide cum pump fed farms categorised the last type as more expensive. As is the case in the study area, tidal movements related to its elevation and ranges are depended on, for filling and draining the ponds and also for leaching out toxic elements. However, by virtue of elevated nature only pumping was resorted for filling in water in the semi-intensive farm at Mundapuram (E). But, draining was accomplished during low tide through the exit gate.

If pumping is to be substituted for tidal flow, the cost of construction of dykes and sluice gates would be minimised and the ponds could be constructed and operated without disturbing the acid soils, allowing a non acidic layer of sediment to deposit on the bottom. On a long run this can be economical especially in paddy fields when paddy crop rotates with that of shrimp crop.

Depending on season, shrimp culture was practised during summer months as a single crop in all cases except at Karumancheri where two crops were raised within a year. Because of prevalence of higher salinity in all months except during intense monsoon, chances of raising more crops at Mundapuram (E) also seem very bright.

Temperature and salinity of water also are important in site selection as they are species specific, P. monodon preferring an optimal salinity of 10 to 25‰ and P. indicus at the range of 15 to 40‰. However in the present study, the level of salinity while stocking P. monodon was less than 5‰ at Chalippuram. Therefore, the post larvae were acclimatised to the prevailing salinity levels by a gradual and prolonged process to avoid the ill effects of mortality. But in the case of P. indicus culture, the level of salinity in all farms remained within the range required. The higher temperature (26-35°C) and salinity (32-36‰) prevailing at Mundapuram (E) was favourable for the culture of P. monodon. But when the salinity dropped to 23‰ during June, the culture was terminated.

Due to decreased light penetration into high turbidity water column caused by suspended solids (about 4% or more), the productivity will be reduced considerably, naturally affecting shrimp production. Often increased turbidity was found responsible for oxygen deficiency in water. The turbid water situations at Puduveype due to high sediment load also contributed to low organic productivity and low levels of oxygen having its effect on the shrimp growth and production. The exclusively traditional field operated at Nayarambalam was also affected by these characteristics having its impact on shrimp growth and yield.

In the study area it has become necessary to select sites with highly turbid water with all its characteristics especially at Puduveypu - the recently emerged wetland ecosystem. Owing to higher operational costs, it was not possible to adopt methods of reducing turbidity such as repeated applications of gypsum, settling tanks and filters. However, maximum care was taken to reduce sediment load by settling before tidal water was drawn to ponds at Puduveypu. The filtration devices followed before filling experimental tanks by pumped water was also not efficient to prevent the ill effects of colloids and other microparticles present in the medium. Even by using filter beds during filtration only particle above 50 micron were retained; those particles less than 50 micron size being misible with the medium, their intensity was capable of causing stress to the shrimps grown in the tanks. The continued prevalence of such stressful factors and also lack of proper aeration of the medium did not provide suitable living conditions to the stock resulting in stunted growth and survival of shrimps during pilot studies in the miniponds and experimental culture in tanks. Since filtered pumped water was used at Mundapuram, turbidity range at no time affected the growth of P. monodon.

A pH of 6.7 to 8.0 measured before day break is considered as the most suitable medium for shrimp culture as values below and above this leads to reduced growth and production. While the above range was commonly seen in all fields and ponds at Vypeen island, there were fluctuations in the range at southern ponds of Cherthala taluk selected for the study. Therefore it has become necessary to maintain the correct pH adding lime to nutralise the acidity during the study period. In the semi-intensive farm at Mundapuram, the pH was maintained more alkaline (8.2 - 8.5) by the periodic application of lime and health stone in order to promote growth of P. monodon.

The likelihood of discharges from facilities used for intensive culture polluting public water bodies and spreading communicable diseases from farm stocks to wild stocks should be considered, as this can lead to social conflicts. Hence there arises the need to select sites avoiding conflicts. Conflicts may also arise when paddy fields are totally converted as shrimp farms. Also indiscriminate conversion and reclamation of mangroves impairing the ecosystem may be avoided during site selection.

Fortunately, none of the above problems affected the shrimp culture fields and ponds selected for the study. However, reduction in the general water column and concomitant impairment of quality were noticed during the fag end of operation, i.e., beyond the end of March in the study area. The situation created troubles especially to the seasonal shrimp farms with shallow depth. Also at Chalippuram, the restricted tidal water entry since the middle of February as the rule of land was strict, accelerated water quality deterioration endangering the P. monodon culture. Again, the P. monodon culture carried out at Pallithode during the fag end of summer (April - May) had to tide over the adverse environmental situations. Thus the inability of farmers to take full advantage of the growth potential of the shrimp species, on account of the drastic and undesirable changes in the water medium, continues to remain as a hurdle for enhanced shrimp yields from culture systems in terms of quality and quantity. However, even with relatively low water column of 75 cm and lack of proper living space for shrimps due to high stocking density, highest yield of quality P. monodon @ 2390.4 kg/ha/4 months was attained at Mundapuram on account of the management aspects attended to, maintaining the system healthy.

3.1.2 Design, layout and construction; and size and shape of fields/grow outs/farms/ponds

The design and construction of a farm in ensuring both technical and economic success of shrimp culture are equally important as that of site selection. Kotoh (1982) has suggested the general standards for the design and construction planning of aquaculture ponds for maintenance of water quality inside. Also Miyamaru and Kotoh (1986) have described the fundamentals of planning and designing of aquaculture ponds, particularly on essential points of the planning of penaeid shrimp ponds and giving emphasis on the effective and defective factors. Sengupta (1980) and Reddy (1980) have dealt with the salient features of construction and maintenance of shrimp farms for commercial production in 'bheris' of West Bengal and Kakkinada respectively. Often farm design and construction are controlled by financial constraints. However, in the traditional fields of the study area (Group A) this has no relevance as shrimp culture rotates with paddy culture and the ownership rests with the agriculturists. Any change in the structural design was strongly objected by the owners of the field.

However, in the owner operated extensive farms (Group B) where only shrimp farming was practised, design could be accomplished in the most desired manner.

In the traditional field at Nayarambalam, the bed was left almost undisturbed. But, maximum silt was removed from the extensive field at Kuzhupilly along with clearing of canals. In the other four cases, the bottom was levelled and canals of different dimensions were excavated to the extent agreed upon by the owners to traverse the entire area for increasing the water holding and life carrying capacities of the fields.

The design and lay out of the six traditional fields (Group A) had slight deviations in their disposition. All fields were compact units with rectangular shape except the large and extensive one at Kuzhuppilly with rhombus shape. All fields were lying below the low tide level with bottom elevation towards the main sluice gate. Even bottom prevailed in all, but for the extensive one at Kuzhupilly.

The main and subsidiary canals of all fields drained towards the main sluice pit. The perimeter dyke was wider and stronger where as the partition dykes were narrower and shorter depending upon the size and shape of respective fields. Compared to others, the fields at Thrikkadakapilly and Kuzhupilly were fairly deep. The main sluice gate of the fields opened directly towards the main water body at Thrikkadakapilly, Pooyapilly and Kuzhupilly where as at Ayyampilly, Nayarambalam and Narakkal it opened into feeder canals. The water supply and drain gates were separate in all places except at Thrikkadakapilly and Pooyapilly. At Kuzhupilly extensive field, the water entry and exit gates were located in opposite directions where as both the gates were fixed on the same side at Nayarambalam and Narakkal fields. However, at Ayyampilly improved field, they were fixed at right angles to open at different points to the feeder canal. Nurseries were set up in the improved fields at Ayyampilly and Narakkal. Mukherjee (1977, 1980), Hickling (1971), Pillay (1948, 1954), Hora and Nair (1944) and Hora & Pillay (1962) have described various aspects of sluices.

Screens made of bamboo slats and nylon meshes were used at respective sluice gates to prevent the entry of predators and the escape of stocked shrimps. Neither any pumps nor any aeration pipes were used except at Kuzhupilly extensive field where draining of water was possible only with the help of an electrical axial pump.

The owner operated extensive 7 farms (Group B) located from Narakkal in the north to Pallithode in the south, were rectangular shaped and compact. Similarities were seen in the nature of elevation with slope towards the main sluice gate and in the installation of sluice gates. Differences were noticed in their disposition, size and physical facilities available.

Four, rectangular shaped small compartments within an 8 ha shrimp field with three sluice gates formed the unit at Narakkal. Each of the four compartments was connected to the central median canal of the field through respective openings in the dyke fitted with screens made of bamboo slats and nylon mesh. 4 rectangular, small and independent ponds with separate sluice gates made up the unit at Puduveypu.

A 0.24 ha rectangular pond comprising of two longitudinal and unequal compartments connected each other and opening with the bunder canal with a single sluice gate formed the culture system at Narakkal Harijan farm. Though generally with even bottom, the depth varied between 70 and 90 cm. in the small and large compartments respectively.

The one ha rectangular farm at Cherungal was well designed with a central drain inclined towards the main sluice gate. Also other subsidiary canals traversing the farm were merging with the main canal coalesed with the sluice pit where pumping system was erected. The well defined nursery comprising an area of 0.08 ha with suitable inlet and outlet set within the farm accomplished the purpose in the most efficient manner.

At Chalippuram, the 1.1 ha paddy field transformed coconut grove was divided into three dissimilar compartments containing 32 interconnected lognitudinal canals of 4-6 m width and 1.5 m depth each inclined towards the main gate. Coconut trees were planted on the wider and strongest bunds.

The L shaped pond with three rectangular, dissimilar compartments connected one another and inclined towards the sluice gate constituted the 0.4 ha culture field at Karumancheri. The shallow pond having even bottom maintained a water level between 60 and 70 cm.

At Pallithode 13 longitudinal and 3 horrizontal canals each of 50 x 3 x 1m size constituted the 0.61 ha water body. All these were interconnected and set inclined towards the sluice gate.

While one sluice gate each served at the Narakkal Harijan farm, Puduveypu, Karumancheri and Pallithode, two gates each installed at right angles functioned at Chalippuram and Cherungal and three gates at the Narakkal 8 ha field. A suitably designed, electrical 5 HP axial pumping system was permanently installed at Cherungal. At Chalippuram 2 diesel engines of 5 and 6 HP and in other places one 5 HP diesel engine each were at times made use of. Nurseries within the farm with appropriate screens fitted, facilitating efficient water exchange were set up at Chalippuram, Cherungal and Pallithode. The above improvements were incorporated for better water management leading to high production.

In contrast to the above, the semi-intensive farm at Mundapuram (Group E) was slopping towards the cylindrical drain gate set at the opposite corner. Though with even bottom, canals of any kind were peculiarly absent within the farm. Further, there was no entry gate for admitting tidal water. Since the farm was elevated, the water filling upto 75 cm level was always accomplished using a suitable 5 HP axial pump with accessories (Fig. 11).

Eventhough separate feeder and drainage canals as well as inlets and outlets located on opposite sides of ponds are advisable for operational efficiency and safety, in the study area, the same canals were used both for drainage and feeding in order to economise on space and construction costs. This continues to be a serious draw back in the study area. In the case of tide fed ponds, water supply is controlled by the size of feeder canals and the size and number of water gates. Also the duration of low tides and their amplitude determined the quantity of water that could be drained.

From the angle of feed distribution and waste removal, elongated or rectangular ponds with central drains are preferable for a round one. According to Malca (1983) ponds should have a rectangular shape in order to aid water flow during exchange. At the same time the pond bottom should possess an inclination of 0.3 to 0.5% towards the drain structures so as to facilitate harvest and correct exchange of bottom water in order to maintain optimum oxygen levels. Failure to drain the ponds completely makes, harvest and competitor and predator control difficult.

In the existing conditions of the study area, the above modifications remained out of reach.

The commonly used water control device in Asian coastal farms is the wooden type open sluice, although its economical life will be less than that of concrete structures. In this connection the ferrocement gates and dykes developed at SEAFDEC Aquaculture department was found to reduce the cost minimising routine maintenance work and providing safety to the stock. The circular movement of water created by paddle wheels were able to concentrate waste products towards the central drain from where the waste could be flushed out as the need arises (Anon, 1987). Incorporation of above was beyond the reach of the present attempt.

For proper water management in tide fed ponds, it is necessary to determine the ground elevation which actually approximate the tidal levels of mean lower high water or of mean high water at neaptides. Otherwise, resorting to pumping for water management will be uneconomical.

The size of a farm has to be determined on the basis of various factors such as level of technology, production and income anticipated to make it viable economically, extent of available land and water. The size of an ideal pond was found to be 0.05 - 2.0 ha for nursery and 0.25 to 10 ha for grow outs. For greater control, intensive ponds should be small ranging from 1 to 5 ha. where as extensive can be upto 10 ha (Yap et al., 1979). Square shaped ponds are considered preferable from the point of view of cost of construction. The shape of the traditional fields in the study area largely followed the land contours, many of them having irregular shapes.

The disadvantage of a small pond is that it has a high dyke area to surface area ratio. Concrete dykes can solve this problem of higher run off of water. It is recommended that small ponds be located if topography permits with their long axis parellel to the prevailing winds in order to provide maximum aeration (Plate XVIII B). Some times larger ponds may have the long axis at right angles to the prevailing winds as the winds blowing over a long stretch of water may create higher waves and greater erosion of the dykes. But all the fields and ponds selected in the present case were in agreement to the general rule in this regard.

Depending on the culture practices and on climatic conditions, the depth of water to be maintained in a pond varies between 0.8 and 3.0 m for grow outs. In this respect also, all culture systems of the study region were within the range mentioned recording the maximum depth of 1.5 m at Chalippuram.

The traditional culture pond should be large, otherwise it is not ecnomical and wastes much man power, facilities and money. On the other hand management will be very difficult if the ponds are too large. The optimum area will vary from place to place. Most of the traditional shrimp filtration fields in central Kerala come under this category including the ones studied at Kuzhupilly and Narakkal.

Since all the owner operated farms (Group B) selected for the study were compact and small (area varying between 0.24 and 1.1 ha) their management was effective through out the operation. So also, the small size and shape of mini ponds (Group C) and experimental tanks (Group D) facilitated adequate control of system management. Similarly, it was on account of the handy shape and small size (1.2 ha) that the efficient management of the pumpfed farm at Mundapuram (E) was feasible.

Nevertheless, small ponds have a preference with the high level of intensity of culture. Regarding the question, what can be the maximum size of a pond for optimal production determined by its shape, water circulation and feed distribution efficiency, the answer is that no differences in production rates were correlated with pond size either in the study area nor in other areas/part of the world. However in India - Orissa and West Bengal - size has a bearing on economic viability as ponds upto 0.5 ha are given singlely or in clusters to marginal farmers and landless labourers.

Central Institute of Coastal Engineering for Fishery, Bangalore categorised brackish water shrimp farms into three types (a) tide fed (b) tide cum pump fed and (c) pump fed (Bhakta, 1987). Invariably the tide fed farm required a main sluice gate on the periphery dyke to prevent the farm from flooding during astronomical tides or floods and every pond required an individual sluice for exchanging filling and draining the pond, as and when required through the supply cum drainage channels. All fields in Group A belonged to this category.

In tidal cum pump fed farms where spring tide range is smaller and exchange of water will not be possible at times, supplementary water supply using diesel pumps was required as was the case with Group B & C ponds.

Pump fed farms are seen in places where the mean spring tide range is too small (less than 0.8 m) or too big (more than 2.0 m). A pump fed farm would not require the main big sluice or expensive individual sluices for the ponds. There would be plenty of savings in the formation of periphery bunds internal bunds and sluices, though partly this would be offset against the installation of pump and pump house. The earthern tank (C6) and all other cement & fibre glass tanks of Group D and the semi-intensive farm at Mundapuram (Group E) belonged to this category.

While tide fed farms proved expensive on investment, but economical in operation, pump fed farms proved economical on investment but expensive on operation. In a comparative study to assess the costs and benefits of tidal versus pumped aquaculture systems in Malaysia, the latter was found economically more successful (Gedrey et al., 1984).

To sum up, in the traditional shrimp fields, use of pumps was seldom required where as in the extensive culture ponds, proper water management was accomplished using pumps in addition to tidal effect in all cases studied. The successful culture of P. monodon was made possible at Chalippuram and Pallithode because of the added advantage of pumping alone. So also the added advantage of pumping in water management contributed much to the enhanced production of P. indicus at Karumancheri and Cherungal. Of all the series studied, the highest rate of production in respect of P. monodon was resulted at Mundapuram (E), where pumping was resorted exclusively for water management, although other aspects were also equally important for the success. However, the cost benefit return was too low (16.9%) when compared with that of Chalippuram (76.87%) where relatively low production rate was achieved.

3.1.3 Pond preparation

In pond preparation, the requirements are drying of pond beds (Plate XIX A) to eliminate pests and predators, release toxic gases, disinfect harmful wastes and mineralise part of the organic matter making nutrients available (Hickling, 1962).

Pond conditioning can be done by tilling, enabling light penetration through loosening of soil. Lime is added to nutralise acidic nature, sterilize soil and control disease. Depending on the initial pH, hydrated lime can be added at a rate of 1-2 tonnes per ha to raise the pH to 7.0. Also the application of hydrated lime (calcium hydroxide) at the rate of 20 to 40 Kg. per surface acre (0.84 ppm lime for every 1 ppm of CO_2) was found good as a remedy for low dissolved oxygen for years. CO_2 in the presence of $Ca(OH)_2$ is converted to calcium bicarbonate enabling the shrimps to utilise the available oxygen better. Expensive sodium carbonate may be used in lieu of lime to avoid the rise of pH above 11 and the accompanying ammonia problems.

According to Norfolk et al. (1981) ammonium sulphate (21-0-0) can be added to lime at a rate of 1:5 in the watered portion of the ponds to eradicate pests and predators during pond preparation. The use of organic pesticides such as derris root, tea seed cake and tobacco dust has been encouraged by Seafdec AQD (Apud et al., 1983).

In short the main objectives of pond preparation are (1) to maintain stability of pond conditions at a level condusive to growth and survival of the shrimp crop by preventing or minimising fluctuations, (2) to eliminate or atleast minimise competition between the shrimp stock and other organisms and (3) to install shrimps as the top consumers by eliminating any organisms that may prey on them.

The nature of pond preparation varied according to the type of operation in all the six traditional fields (Group A) selected for the study. Raising of peripheral dykes and inner dykes and partial removal of paddy stumps from main canals (Plate V A) were commonly practised in all cases along with sluice fixation. Nothing more was done at Nayarambalam, where as at Pooyapilly and Thrikkadakapilly fields, mechanical removal of macroalgal vegetation and use of proper bamboo screens and nylon nets at the sluice gate during tidal water entry and exit were also attended to. In addition at Thrikkadakapilly, all the three main canals and cross canals were properly dug out to reach the extremities apart from clearing the sluice basin. Drawing of water using a 40 HP axial pump, removal of accumulated silt from sluice pits and basins, excavation of canals to proper dimensions, bottom levelling, slopping of canals towards main sluice gate, dyke repair and predator elimination by drying were the aspects given emphasis during preparation in the extensive field (Plate V A) at Kuzhupilly with a view to increase the water holding capacity. So also in the improved fields at Ayyampilly and Narakkal, adequate attention was bestowed to enhance the life carrying capacity of the fields by way of desilting the sluice basins and canal systems and also by ramifying the canals to reach every nook and corner. Since minimum water level was maintained while preparation, the repeated dragging and cast netting practised in these fields could eliminate all the predatory species.

No application of lime, manures or fish poisons was applied in any of the cases during preparation.

On account of small size of holdings, the extensive shrimp farms (Group B) selected could be dewatered completely. Hence bottom levelling and silt removal from the basins and canals could be carried out satisfactorily. Peripheral bunds and inner dykes leaving appropriate gaps for traversing canals were strengthened. A suitable nursery each was set up adjoining the supply channel within the farms at Chalippuram, Cherungal (Plate XII A) and Pallithode.

Since hour long sundrying of ponds (Plate XIX A) was not possible in the compartments at Narakkal farm and canals at Pallithode, on account of seepage problem, mahua oil cake (Plate II B) @ 200 ppm was applied to eradicate predators. In both these cases water exchange was permitted through screens only after a fortnight. Except for drying the pond bottom till cracking, no other, predator eradication measure was followed in Harijan farm at Narakkal and at Puduveypu. Since there was no problem with acidity at Vypeen island, no application of lime was required in farms at Narakkal and Puduveypu.

However, basal dose of lime as a precaution to resist acid sulphate problem and cow dung as a manure were applied (Plate XIX B) in farms at Chalippuram, Karumancheri, Cherungal and Pallithode. In addition, fertilising with required quantities of superphosphate and urea was done at Karumancheri. In all these farms, dried twigs were planted (Plate XIII B) to generate periphyton and to offer protection to the stock as well. Further, they helped to provide the natural habitat for shrimps. The sluice gates and gaps of nursery of all farms were fitted with appropriate screens made of bamboo slats and nylon mesh (Plate X B) to control the predators and pests during water supply and draining.

The same procedure as adopted in Group B2 was repeated in the preparation of Group C mini ponds except in C6 wherein earthern tank (Plate XIV A) above tidal marks was excavated afresh. Thick plastering with mud and clay was given to the bottom of earthern tank in order to remove its broken nature owing to sun drying. Since the substratum of group C ponds was loose, a layer of sand was used at the bottom to facilitate the shrimps to bury as practised in Japan.

No preparations were required for the cement and fibre glass tanks (Plate XVI A&B) of Group D experiments, but for the conditioning of tanks. However, a sand bed of 8-10 cm. thickness was provided in the circular cement tanks (Group D) to facilitate burying of shrimps. The oval screen made of dry twigs kept immersed (Plate XIV B) in the fibre glass tanks functioned as a false bottom and provided resting place for shrimps.

Compared with others, the method of preparation was peculiar in the semi-intensive farm (E). Timely application of required quantities of inputs and precautionary measures adopted thereafter were effective in the predator elimination and in improving the organic productivity of the farm. The unique supply of health stone and BN_{10} helped to maintain alkaline conditions and reduce bacterial load, respectively. Elevated nature and use of a pump (Fig. 11) accelerated the preparatory process in time.

3.1.4 Pond ecosystem: Physico-chemical and biological factors governing the natural and enhanced production

Role of environmental parameters on benthic and pelagic populations is well known. Environmental parameters such as temperature and salinity of water determine the distribution, spread and abundance of estuarine organisms (Kinne, 1967). Thorson (1966) stated that factors such as salinity, dissolved oxygen, temperature, turbidity, availability of food etc. exert their influences individually or collectively on the distribution pattern of pelagic and benthic organisms. The tidal influence on the physico-chemical conditions in the backwaters, connected canals and adjacent paddy fields along Cochin estuary had been pointed out (Sankaranarayanan et al., 1986).

The estuaries and backwaters feeding the shrimp farms are specialised ecosystems as they are in a state of perpetual flux due to the conglomerate influence of marine, terrestrial and fresh water elements. However, estuaries are not self contained ecological systems. The salinity of the estuaries is regulated by the differential exchange of waters from the open sea on one side and from the extensive freshwater sheds on the otherside (Pritchard, 1967). Same way, the fertility is controlled by allochthonus nutrients from the sea and from the land.

The rainfall of peninsular India, depends on 2 monsoons, viz south west and the north east. The profound effect of the monsoon is reflected on the physico-chemical parameters of the shallow estuarine environment, variations depending to a large extent on the time of the year and the place of observation (Qasim, 1980). The summer maximum of salinity values were recorded by Ganapati and Murthy (1955) in Visakhapatnam, Jayaraman (1951) in Madras, Krishnamurthy (1966) and Subramanian (1981) in Portonovo waters. Salinity showed positive correlations with temperature, registering the peak values in summer season in Vellar estuary (Subramanian, 1981).

The semi-catadromous, cyclic life of most of the penaeids involving the sea and low saline coastal ecosystems has been well established and salinity has been considered as one of the important abiotic factors influencing their survival, growth (food intake and FCR) and production of tropical penaeids. The inter-relations between tidal cycle and shrimp distributions have been recorded by Subramanyam (1965), Hughes (1969), Young (1975) and Clark and Caillouet (1975). The distribution of shrimps based on salinity and temperature was well documented by Gunter (1950), Williams (1958), Gunter et al. (1964), Aldrich et al. (1968), Pullen and Trent (1969) and Rao (1973). The importance of temperature and salinity on the survival and growth of shrimp post larvae and juveniles was discussed by Williams (1960), Zein-Eldin (1963), Zein-Eldin and Griffith (1969) and Venkataramiah et al. (1972).

Nair and Krishnankutty (1975) experimenting on the influence of salinity on the growth of juveniles of the shrimp (Penaeus indicus) at different periods of their stay in backwaters noticed significantly high growth rate in low salinity for the post larval specimens; where as the larger juveniles showed a significantly high growth rate in high saline waters.

Paul Raj and Sanjeeva Raj (1982) elucidating the effect of different salinity levels on the growth and survival of P. indicus and P. monodon noted their preference for low salinity levels (15-25‰) for better growth. Paul Raj (1976) noted higher population density in low saline areas. Nair and Krishnan Kutty (1975) reported high growth for postlarval stages in 10‰ and for juveniles in 30‰ salinity. Venkataramaiah et al. (1974) stated that although the young shrimp can survive a wide salinity range, the best growth and survival rates were obtained in optimum salinities of 8.5 and 17‰. Kinne (1970) stated that "in most of the euryhaline invertebrates, growth is restricted to a narrow range than survival is".

Shrimps, at one life history stage or another have been observed in waters ranging in salinity from less than 1‰ (Gunter 1956, 1961) to more than 60‰ (Gunter et al., 1964). The interaction between shrimp population and algal vegetation was reported by Strawn (1954), Allen and Inglis (1958), Hughes (1966), Rajyalakshmi (1973), Young (1975), Kannan and Krishnamurthy (1978) and Subramanian et al. (1980).

In recognition of the importance of benthos in sustaining the productivity of the culture ponds, Srinivasan and Rao (1984) studied on benthos in prawn culture fields of Vypeen island, in relation to environmental parameters. The results showed the main factors which limited the abundance and distribution of macrofauna as salinity followed by organic carbon, redox potential and nitrite - nitrogen in the perennial fields, nitrite followed by organic carbon, salinity and redox potential in the pokkali fields and redox potential in one coconut grove.

Studies on the physical and biological aspects of Cochin backwaters mainly centred around the Cochin harbour have been made by Sankaranarayanan and Qasim, (1969), Ramaraju et al. (1979) and Qasim et al. (1969). Sankaranarayanan et al. (1986) found that during SW monsoon season, due to influx of freshwater, longitudinal salinity gradient could be noticed only upto short distance. During post monsoon (shrimp culture season) the partially mixed estuary with the saline intrusion extended further upstream upto 17 km where as in the pre-monsoon season the extension was beyond 21 km.

Depending upon seasonal changes from monsoon to post monsoon and pre monsoon the longitudinal salinity gradient of Cochin estuary gradually extended upto 21 km upstream, thus providing estuarine water suitable for shrimp culture.

Laxmanan et al. (1982) observed seasonal variation in temperature (25.2 - 33.8 °C)and salinity (0-30‰)in Cochin estuary.

Ramaraju et al. (1979) noted at the Cochin barmouth highly stratified saline conditions existing during the monsoon season, gradually changing to partially mixed and homogeneous conditions of the post and pre monsoon periods apparently due to decreasing river flows and increasing tidal influence.

Shynamma and Balakrishnan (1973) and Balakrishnan and Shynamma (1976) have reported seasonal dial variations in hydrographic conditions in Cochin backwater.

The hydrobiological conditions of Cochin backwater have been studied by Haridas et al. (1973). Pollution of the Cochin backwaters by the effluents of FACT and the coconut husk retting in some places was noted by Shetty (1963).

Vijayan et al. (1976) reported that organic pollution has significant effects on dissolved oxygen, BOD_5 and sulphate content of waters in Cochin estuary, while the temperature and salinity are not significantly affected. The effects of pollution on benthos have been studied by Remani (1979) and Saraladevi (1986).

Estuarine temperature showed diurnal/tidal variations with increased temperature during ebb and reduced temperature during flood especially in monsoon months. But during warmer weather, solar radiation overshadowed these changes. In the Cochin backwaters, the temperature varied from 23 to 34°C; with maximum value during premonsoon months. From May onwards temperature falls. Intrusion of cold upwelled water from the sea was usually noticed during May. Cochin backwater as is the case with Vellar estuary is always confluent with sea waters, there being no complete closure of the mouth and thus may be said to be a true estuary.

Salinity of estuarine waters also showed diurnal and seasonal variations varying from place to place depending on the fresh water intrusion. While isohaline features were common during premonsoon, vertical salinity gradients were predominant during the monsoon months. One of its most variable yet easily measured attributes, salinity more so than any other property, characterised the estuary (Pritchard, 1967).

Norfolk et al. (1981) found at pH above 9 ammonia becoming toxic to animals. Same time, the water pH reaching below 6.5, usually influenced by potentially high acidic soil, reduced the production considerably.

The pokkali fields along the mangrove backwaters of Cochin are another example of low productivity caused by excessive soil acidity. The condition leads to the occurrence of "soft prawns" in affected ponds and frequently results in the loss of the entire stock (Silas, 1987). The water quality can be high with proper pH.

Turbidity as measured by the vertical distribution of luminous energy in any water body depends upon the quality, density and aerial extent of the suspended organic and inorganic matter it contains. According to Flint (1956), Darnell (1958) and Hall (1962), such detrital material may serve in the dual capacity of nutritive food in suspension and protective for the transient shrimp from predation. A gradual reduction of light at all levels of the water column, due to a steadily increasing silt load could be expected to suppress algal productivity in open bay waters(Ragotzkie, 1959) and thereby indirectly inhibit the development of shrimp.

Gilbert and Pillai (1987) collected soil samples from different seasonal and perennial shrimp culture fields around Cochin backwaters during the premonsoon and monsoon season for estimating their lime requirement ie, the amount of liming material needed to nutralise the acidity of bottom muds and increase the total hardness and alkalinity to atleast 20 mg./litre. The statistical analysis of their data showed no relationship between pH and the liming rate indicating the high potential acidity in soil samples even with normal pH necessitating higher liming rate.

In Cochin backwaters, siltation is the major factor contributing to the progressive shallowing by 35% during the past 50 years. The siltation occurs as a result of river discharge and tidal inflow. This has been accelerated by man made alterations (Gopalan et al., 1983). The magnitude of siltation is reflected in the removal of 2.5 million cubic yards of silt by dreging every year in order to maintain the Cochin harbour shipping channel. The rate of silting is 180 cm/year (Kurup, 1971). The resultant reduction in volume together with effluent discharge has considerably reduced the carrying capacity of system affecting fisheries. The carrying capacity of a natural ecosystem is the maximum production of fish species which can be maintained by naturally available food resources (Rosenthal et al., 1988).

Rangarajan (1958) observed the lowest oxygen values in Vellar estuary during dawn hours and noted their increase as the day profused. Often, the low oxygen levels in estuaries could be linked to the presence of higher silt composition too in the area.

Subramanian (1981) showed significant negative correlation for the dissolved oxygen values with salinity. In general, the rate of oxygen consumption increased with decrease in salinity of the medium indicating that P. indicus spends least energy as the salinity goes up and the maximum in low salinity.

Tidal flow and diesel pumps are the means adopted to circulate water in shrimp culture ponds. The exchange brings freshly oxygenated water and flushes wastes out of the pond. Water exchange by flushing with water of lower oxygen demand (less bacteria, algae, NO_2, NH_3 and H_2S) is a relatively expensive means of simply increasing oxygen levels. Instead aeration can reduce pumping costs. But as the intensity of production increases, aeration alone becomes inadequate to avoid accumulation of metabolic wastes such as NO_2, NH_3 and H_2S. Consequently increasing levels of water exchanges are required. Normally, the tidal water exchange is @ of about 5-10% per day in extensive farms while it is @ 10-20% and 20-30% per day in the semi-intensive and intensive farms respectively. But in the intensive ponds of U.S.A., the daily rate is increased from 1% to 15% in step, with increasing biomass of shrimps in the pond (30 nos/m^2) in 90 days. Also for effective removal of wastes during water exchange, the use of a central drain has been highly successful (Anon, 1987).

Often the 2 functions of water exchange namely gas exchange and circulation are performed by the use of paddle wheels or a combination of air lifts (a blower connected to submerged diffuser strips to increase oxygen concentration at nights by gas exchange) and submerged low speed propeller (to prevent day time stratification and maintain anaerobic pond bottom). Shrimps flourish in the currents created by aeration.

The most important requirement in aquaculture is unpolluted water. Biochemically the shrimp body consists of 80% water ie 72% oxygen. Water is the "life blood' of aquaculture industry since it forms the medium of transport of oxygen and food to the culture organisms. Also oxygen is the primary factor limiting productivity

(Sakthivel, 1988). The water control system has to achieve and sustain complete reliability under all extremes of weather. It has been pointed out that in seasonal paddy cum shrimp fields low oxygen values usually prevail due to decomposition of organic matter present at the bottom and the increased microbial activity during summer period between December and April (Nair et al., 1988). Accumulation of waste products on the bottom of the pond appears to be a limiting factor especially in intensive culture systems. This waste consuming oxygen creates an anaerobic zone on the bottom where the shrimps live. Therefore it is very important to maintain clean bottoms free from waste products (Sakthivel, 1988).

Water quality problem is found mainly around centres of population, due to lack of adequate sewage treatment systems and lack of any treatment after use by coastal industries including petro-chemicals and run off containing pesticides from agricultural lands. In addition to the above problems, the concentration of shrimp ponds also leads to very high organic loadings in the water nearby, a result of the large water exchanges taking place daily from the ponds especially towards the fag end of the seasonal operation in central Kerala. High BOD (5) values (6.21 to 280.40 mg/L), low dissolved oxygen values (0.05 to 3.081 mg/L) and high sulphide content in the bottom water have been reported from some localities in the Cochin backwater (Unnithan et al., 1975).

As a result of increased rate of inflow of industrial (260 million litres/day) and domestic effluents (80 million litres/day) in the Cochin region (Anon, 1982) its adverse effect has been reflected in the incidence of mass fish kills and the increased bacterial activity (Unnithan et al., 1975, 1977; Venugopal et al., 1980).

Gesamp (1991) has brought out a document on the need for reducing environmental impacts of coastal aquaculture. Coastal wet lands are amongest the most productive ecoystems and are important in sustaining the ecological integrity and productivity of adjacent coastal waters. Mangrove areas for example, are important nursery grounds for many commercial fish and shrimp species (Linden, 1990). Therefore, mangrove swamps form excellent areas for extensive shrimp farming with minimal negative ecological impacts utilising tidal energy, for water exchange and shrimp larval supply (Purushan, 1991). They also prevent erosion and reduce turbidity by trapping sediments and binding nutrients.

The craze for intensive shrimp farming at the expense of mangrove areas and such other natural environs have disrupted the equilibrium of ecosystems in Ecuador and many other southeast Asian countries. This in turn has considerably affected the livelihood of poor traditional rural communities who depend on it and produced other negative social consequences in tapping the organic food source (Bailey, 1988). Therefore, it is apparent that mangrove areas should be protected and no further development of shrimp farms allowed in these areas.

More often, the imbalances taking place in the ecosystem can be attributed to the averacious human activities. The pumping of enormous quantity of ground water for intensive shrimp and eel farming in Taiwan has promoted land subsidence and salt water intrusion creating impediments to agriculture activities and fresh water supply apart from causing many other damages (Huang, 1990).

Most of the shrimp farming countries in Southeast Asia face environmental problems and farmers attain low profit or no profit from the endeavour. Therefore, it is important to mitigate or minimise the environmental degradation, emanating from intensive farming methods. The effluents from semi-intensive and intensive ponds located adjoining small estuaries contain waste products, nutrients from disintegrating feeds and fertilizers which along with sewage and remnants of industries cause unhealthy conditions to the aquatic ecosystem. The results are disastrous - stunted growth and mortality to the stock. In the deteriorated water quality conditions with stress, usually burgeoning population of Vibrio bacteria, virus, protozoa, fungi and other microbes thrive well resulting in out break of diseases damaging farmed fish/shrimp species. Because of the failure to maintain clean water in the systems, the shrimp farming industries collapsed in China, Thailand, Indonesia and Taiwan at one time or another during 1988-89 owing to disease problems (Anon, 1990). Consequently, farmers have to endure heavy loss and they learnt to space their farms and balance their demand for water. It is also reported that public health consequences resulted in red tide out breaks in areas where shell fish are grown (Maclean, 1989).

The processes that occur beneath the waters of a pond/field could indicate the difference between profit or loss to a shrimp farmer. To enable the pond operator to manage the pond/field in a manner that will ensure maintenance of conditions condusive to better growth and survival of shrimps stock and therefore better production, it is important to understand well the factors contributing to pond ecosystem processes. Functional role of the environment aims at the evaluation of cause - effect relationships and the probable results of short and long term changes.

There is constant interaction among soil, water, air, sunlight, weather conditions and the living organisms in the field/pond.

Some of the physical and chemical factors to be reckoned with during shrimp farming are as enumerated below.

1. Water as a universal solvent can dissolve / contain both beneficial as well as harmful substances.
2. The oxygen used by organisms for breathing to sustain life is the one in the gaseous state dissolved in water and in so doing oxygen content in the pond is lowered to the point of depletion.
3. Decomposing organic matter produce harmful products such as NH_3 and H_2S.

4. Amount of O_2 can be increased by letting new water, bubbling air or agitating.
5. Salinity and temperature affect dissolved oxygen content; saltier and warmer waters holding less oxygen.
6. As the temperature increases, the density is lowered, allowing warm water to float over cold water.
7. The denser and heavier sea waters allow fresh water to float over it.
8. The free or dissolved hydrogen and hydroxyl ions present in water measured as pH in a scale from 1-14 are decisive factors for maintenance of life. The water pH is determined by soil pH and the amount of CO_2 in the water.
9. The transparency of the water is decreased by the increased presence of particles.

In the light of the above, it is appropriate to examine the various ecobiological factors prevalent during the present study.

In the contractor operated traditional fields (Group A), shrimp culture operations were carried out during the favourable season - November to April except the one at Thrikkadakapilly (Cherai) where perennial culture was practised from June 87 to April 88.

Pooyapilly, Nayarambalam and Narakkal fields were operated during the same season, ie between November 88 and April 89. In the other three fields, culture operations were carried out separately during three consecutive seasons between November 86 and April 88.

In the owner operated extensive shrimp culture ponds (Group B) shrimp farming was done during the summer season between November and June except at Karumancheri (Ezhupunna) where an additional crop of P. monodon was raised during rainy season between June and October.

The pilot studies on P. indicus in mini ponds (Group C) were also carried out during the summer period between November and June in different seasons without being affected by the influence of monsoon. However, the P. monodon culture being extended between February and September could tide over the hazards of extreme summer and intense monsoon.

In the case of experimental tank culture of P. indicus (Group D) carried out between November and June under controlled water conditions, the ill effects of ecobiological variations were minimal.

The ecobiological variation in the semi-intensive farming at Mundapuram (E) was also negligible, since the farming was conducted during summer months of 1992. However, the monsoonal influx and consequent dilution during June, partially affected the culture during the fag end.

The water quality parameters, in respect of Group A fields, fluctuated within tolerable limits. The pH of water remained alkaline (7.0 - 8.4). So also, the water temperature ranged between 28.0 and 31.5°C. The salinity varied between 14 and 30.2‰. Owing to the relatively higher depth maintained at Thrikkadakapilly wherein saline waters always prevailed, shrimp culture started in June could tide over the ill effects of monsoonal influx.

The dissolved oxygen values fluctuated between 2.6 and 7.3 ml/L, the lowest values being noticed during the fag end of operation ie, during the end of March to April. The diurnal variations in O_2 values were noticed in all fields at one time or other. During certain occasions values between 1 and 2 ml/L prevailed during 3-6 AM especially when there were difficulties for intake of water due to tidal effect during such time. However, in no case, any mortality level was encountered.

On account of suspended particles in the medium, the transparency was generally low ranging between 28 and 58 cm. However, at Thrikkadakapilly and Kuzhupilly, transparency was higher ranging between 35 and 70 cm probably because of the absence of disintegrating paddy stumps and partly due to their increased depth. The meio and macrofaunal diversity were illustrative of condusive biological factors prevalent in these fields. The present data also enunciated the observations of earlier workers (Nair et al., 1988) that environmental conditions highly suited for prawn culture prevail in seasonal fields of Vypeen island during summer months.

In group B ponds, the water quality parameters such as pH, temperature, salinity and dissolved oxygen fluctuated between 6.5-9.0, 28.5-34.5°C, 4.0-32.0‰ and 2.75-5.30 ml/L respectively. The lowest salinity (4.0‰) was at Chalippuram during November 90 which gradually picked up to 30‰ during the terminal period of operation in March. Of all, the two ponds selected at Narakkal and one at Puduveypu in Vypeen island were within the tidal influence of Cochin barmouth where as the other four ponds had the additional effect of Anthakaranazhi. However, at Karumancheri (Ezhupunna) eventhough the level of salinity was less than 8‰ during June-October period, it was possible to raise an additional crop using P. monodon. So also at Chalippuram, a successful crop of P. monodon was raised taking advantage of the wide range of salinity 4-30‰ prevailed during the culture period. At Cherungal, as the salinity was less than 5‰ upto January on account of the influx of fresh water from the eastern source, P. indicus culture was possible only after February. The increase in the level of salinity continued even during rainy season upto August (Table 15a) on account of the tidal influence of nearby pozhi connected with Anthakaranazhi and also due to the unique saline water intrusion through the holes of sea wall all along the beaches from Maruvakkad to Chellanum. Since a large volume of sea water was thus emptied into the pozhi along with the abundance of penaeid shrimp post larvae, P. indicus culture could be made possible in the surrounding farms during the rainy season.

The coconut groves at Pallithode often encountered general water reduction, increased water temperature, impairment in water quality and algal blooming during the culture period. Hence water management was done with extreme caution and pumping was resorted to maintain stability of the medium.

The usual benthic faunal groups similar to that of traditional fields occurred in both ponds at Narakkal. At Puduveypu, Apseudes chilkeusis, Corophium sp and certain polychaete worms were represented. While at Chalippuram, the benthic fauna comprised of tanaeids (amphipods was more abundant and diverse), it was very scarce at Karumancheri and Cherungal. At Pallithode, lamellibranchs and gastropods were noticed occasionally. It is to be pointed out at this juncture that except for the compartmental farm at Narakkal, all other farms were kept sundried (Plate XIX A) for 3-7 days during the preparation time without giving any considerations for benthic faunal generation.

In the semi-intensive farm at Mundapuram (E), the firm bottom characteristics and alkaline conditions of the medium remained favourable for shrimp growth. The diurnal fluctuations of water quality parameters were within tolerable limits. The regular pumping resorted to retain 70-75 cm water column and use of paddle wheel aerators (Fig. 11 and Plate XVII B) ensuring adequate water circulation in addition to increasing dissolved oxygen content were advantageous to maintain suitable water quality. The summer salinity maximum (36‰) occurred at the beginning of farming operations, gradually lowered, remaining at congenial levels (30-32‰) during the period of farming. The successful crop was harvested without any damage at the time when the salinity was dropped considerably ($<$ 23‰) with the advancement of monsoon showers. Eventhough the substratum was fertile, no much regard was given to the benthic fauna, since the shrimps were grown on nutritious supplementary feed.

Thus the analyses of data from the various regions of the study clearly indicated that the physico-chemical and biological factors of culture systems are decisive for the success of shrimp farming. Of course, the dynamic processes taking place in the estuarine environment and the capacity of the ecosystem to maintain a condusive environment contribute very much for the sustenance of shrimp culture.

The significance of the above informations is best appreciated when one speculates on the fate of estuary depended shrimps, in the event they are deprived of estuarine habitat. But the basic question being advocated by those engaged in development of estuaries, at the expense of the living resources is that 'can't shrimp adjust to the new conditions wrought by human activity? and if not, why'?

It stands to reason, from the material available, that any unusual disturbance of the physical and chemical constitution of an estuarine system, would almost certainly be manifested in subtle changes. Accordingly in each species, the capacity to achieve a biomass (equivalent to that attained under environmental conditions characterising the ecological niche into which the species has evolved) will be subjected to the alterations in the habitat. Abrupt modifications of their respective niches would, superficially speaking, affect every species to a different degree.

With the imminent changes of estuarine biotope whether the shrimp species can adapt or gradually disappear is a logical one.

The fertile estuary, from the ontogenic point of view, constitutes an irreplaceable factor in the survival strategy of major shrimp resources. The perpetuation of such resources at commercial levels of productivity, (apart from their continued existence per se) will be contingent of our ability to minimize disturbance of the shrimp's estuarine habitat.

Environmental conditions may become increasingly severe for shrimp growth. The use of fertilizer supports the growth of other organisms, one of which is a protozoa which infects the gills of the shrimps. This alters shrimp's normal negative phototropism and causes individuals to surface more frequently than normal, making them more vulnerable to seagull predation. Further oil spills are causing problems for both farmers and hatchery operators. Losses of wild larvae and other ecological damage were substantially larger.

Shrimp farmers in some areas also complained of losses resulting from the over burdening of the ecosystem with organic material, sewage and agricultural run off. The reducing conditions of the bottom substrate associated with water stagnation at times caused unhealthy situations in the experimental tanks. Surfacing of shrimps during early hours of the day was not uncommon.

Based on above factors among a number of uncertain others, one is forced to accept their interactive roles in controlling the distribution, survival and growth of juveniles during their estuarine occupancy. Still much remains to be done to know the extent to which above environmental factors control the productivity of shrimp resources. The ecological observations made in all the areas renowned as shrimp farms during this study could give only general feature of the habitat environment.

Experimental studies by Panikkar (1951), Williams (1960), Mc Farland and Lee (1963), Dobkin and Manning (1964), Rao (1958), Zein-Eldin (1963) etc. have provided the needed direction for meaningful pursuit of ecological (cause-effect) relationships, by which we can defend the maintenance of our estuaries as a necessary environment for biological resources as shrimps.

Still more, the shallow estuaries and the biological populations are prone to the consequences of unpredictable natural adversities like droughts, floods, freezes, tropical storms etc. leading to abrupt changes in the environmental properties.

Hildebrand and Gunter (1953), Gunter and Hildebrand (1954), Parker (1955), Viosca (1958) and Thomson (1956) have related the annual production of shrimps to extended drought and floods. Effect of tropical storms has been studied by Kutkuhn (1962).

Java, the major shrimp producing area in Indonesia was hardest hit from the drought in 1991 damaging the grow out ponds and reducing hatchery production.

The unusually long cold spell during November 91 to January 92 in Thailand resulted in farm failures of over 70%, also delaying production out-put by one month.

The grow outs in South America (Ecuador and Peru) were heavily flooded due to rainfall attributed to the 'El Nino current' (Anon, 1991).

To conclude, most of man's activities in coastal lands - change in basin configuration, protective works, change in volume and seasonal distribution of fresh water inflow, domestic, industrial and agricultural pollution and development of mineral resources - generally affect the shrimp habitat, restricting economic levels of productiveness.

It is against the unabated distribution of estuarine habitat by a rapidly advancing civilization that the culture of shrimps on a commercial scale has received wide attention. The process aims at greatly improving the carrying capacity of a comparatively smaller area of estuarine habitat through manipulation of the numbers of juvenile shrimps involved and by the control of biological and environmental factors. The farming according to Allsopp (1960), Hall (1962) and Fujinaga (1963) depends primarily on local tides of sufficient height to permit alternate flooding and draining of diked off areas of swamp, bay and estuary. Hudinaga (1942), Delmendo and Rabanal (1956), Kesteven and Job (1957) and Allen (1963) have reviewed shrimp culture practices of the world. Lack of adequate tide differential, difficulty in leasing or acquiring title to submerged lands and problems to growth in semi-natural conditions are some of the problems encountered

(Johnson and Fielding 1956; Lunz, 1956; 1958; Manning 1963; 1964).

What ails shrimp farming in Kerala?

A matter of concern is the question of continued productivity and perpetuation of shrimp stocks in the face of man's steady incursion of estuaries. This situation has evolved specifically as a result of the rapid urban and industrial development along our estuary rich Kerala coast. The most serious anthropogenic environmental alteration taken place in the estuaries of Kerala is its alarming rate of reduction in extent. The largest Vembanad kayal which had an area of 36500 ha in the last century is predicted to have only 17% left as open brackish water by the dawn of 21st century for aquaculture purposes (Gopalan et al., 1983). Hence it is necessary to analyse the functional relationships between the estuarine environment and commercial shrimp sources and suggest measures to be adopted to offset the untoward effect of civilization.

It is almost centuries, since we recognised the multifaceted uses of our estuaries. The wetlands were reclaimed for farming, urbanizing and industrialization by the expanding society. Our manifold wastes were dumped in these readymade pools. Waters were deepened in some areas for waterborne transportation. Underlining sand mud and shell deposits were extracted. Natural areas were used for recreational purposes. The fresh water flow was directed for municipal, agricultural and industrial uses.

The above activities in turn have posed an ever increasing threat to those species of high economic value as food for man, harboured by the estuaries. The shrimp is a single constituent of the distinctive ecosystem of each estuary composed of communities of biological elements exhibiting different gradients of tolerance to each other as well as to an infinity of combinations of the physical and chemical factors that characterize it.

Most of the penaeid shrimps of commerce have a distinctive life history characterised by a period of more or less predictable length which it passes in an estuary or comparable brackish water environment (Mohamed & Rao, 1971). In each of the species so evolved, the parent population breeding in the sea at various distances from the mainland, produces seasonally large numbers of microscopic semi buoyant eggs which almost immediately hatch into small, planktonic nauplii. Development proceeds rapidly through the protozoeal and mysis stages, the larval shrimp all the while moving or being transported land ward in a still not fully explained manner towards the mouth of the river or to passages into broad and shallow estuaries. The amount of time lapsing between hatching off shore and entry of the small shrimp into brackish waters inshore may vary from a few days to several weeks, again depending on the species as well as on the prevailing oceanic conditions.

Mangroves as food godowns

It is worth utilising the otherwise unused wetlands - mangrove swamps - as the most valuable coastal resources. The importance of mangrove can be viewed as a buffer zone against wave and wind erosion; as a silt trap; as a spawning and nursing ground for aquatic organisms; as an organic food factory which exceeds 10 tonnes/ha of dry matter/year. Hence it is very much important to conserve such resources without its conversion as low productive culture ponds. The significance of mangrove ecosystems has been well documented (Snedaker and Snedaker, 1984).

The natural, valuable habitats such as shore areas and mangrove waters of several commercial shrimps such as P. monodon and P. indicus are under destruction in many areas. Therefore it is important to propagate their fry and adult artificially (Motoh, 1984).

The paradox of mangrove clearance is that the natural shrimp population uses mangrove backwaters to spawning; the removal of such areas is in itself important for the farming industry as they rely on wild seed to provide larvae for production.

Many of the perceived environmental problems of the shrimp industry of India including the study area are those associated with loss of mangrove areas in the estuaries of rivers in order to use for multivariable activities (Purushan, 1991).

Ecuador endowed with great diversity of potential environments for aquaculture ranging from sea weed culture to bull dog farming could produce 70000 MT tonnes of shrimp biomass from an area covering 90000 ha covering 80% of potential area during 1990. However, in Kerala 90% of the potential area is yet to be utilised for shrimp farming. Hence it is all the more important to conserve the estuarine environment without any further deterioration by way of reclamation effluent dumping, lime shell extraction and mangrove clearance for the sustenance of estuarine dependent fisheries, especially shrimps.

3.1.5 Seed management - Species, larval habitat and abundance, autostocking and supplemental (wild and hatchery)

Seed management is centred mainly around availability of quality seed in time. One of the pre-requisites of this is the development of hatchery technique which is slowly taking up in Kerala. From the production and economic point of view, the question to be considered is the type of species to be cultured, whether in mono or polyculture.

The science of shrimp farming as distinct from traditional shrimp culture is relatively new. The traditional shrimp culture remained as a polyculture system because of the inability to control the composition of the seed. The long traditional experience and scientific research, so far, is yet to succeed in domesticating shrimp culture in the sense of animal husbandry practices for large scale commercial aquaculture. Species have to be selected according to the objectives of culture, for example increased protein supplies to poor, export to earn foreign exchange etc.

Biological characteristics of aquaculture shrimp species include a) a faster growth rate to attain marketable size in a short time before it attains first maturity b) breeding easily with high fecundity and spawning frequently under captive conditions in hatcheries to ensure seed availability c) species with larval preference for artificial diet than live ones d) species low in food chain and also preferring artificial diet e) species that can tolerate/resist unfavourable conditions and f) behaviour pattern in confinement for intensive purposes.

But, to an aquaculturist/shrimp culturist economical considerations are more important than biological factors in the selection of a species for culture. They are a) availability of proven technologies of culture backed by economic viability b) consumer acceptance and c) availability of markets for the species.

The above considerations even demand introduction of exotic species for which established culture technologies exist and the economics of production and marketability have been demonstrated.

Jhingran and Gopalakrishnan (1974) have catalogued 465 species belonging to 28 floral families and 107 faunal families. Of the 32 shrimp species that have been investigated and cultured through out the world, seven species including P. monodon (Plate XX A) and P. indicus (Plate XX B) are most commonly cultured in south east Asia (Liao, 1987). Tropical waters of India, both sea and inland are abound in a variety of shrimps, contributed by 55 species. Of these 8 penaeids and 6 non penaeids are of considerable significance. Of the 7 cultivable species P. indicus, P. monodon and M. monoceros are widely distributed and the other 4 are of local importance only (Rajyalakshmi, 1980; George, 1967).

The largest (336 mm) and fastest growing P. monodon contributes to 43% of world production of farm raised shrimps (Plate XXI A) in the south east Asia where as P. chinensis from China growing upto 183 mm accounts for 18%. The preferred species in western Asia and Ecuador is the tough P. vannamei (17%) growing to a maximum of 230 mm. Rest of the culture shrimp species (22%) include a number of species (World shrimp Farming, 1991), P. indicus being the preferred one in the extensive farms through out south east Asia, especially India.

In our country depending on export demand and value realization, Penaeus sp which grow to large size is preferred. Eventhough P. monodon is the most preferred owing to its outstanding growth rates, omnivorous feeding habit (leading to a relatively low dietary protein requirement), its euryhaline nature (which results in normal growth from 5 to 25‰ salinity) and its high tolerance against handling stresses, P. indicus has also better farming prospects, in view of its faster growth rate, shorter duration of culture in grow out ponds and easy availability of seed. Recently, the record production of P. monodon (Plate XXI A) in hyper saline conditions (45 to 47‰) reported from a farm at Radhanallur, Tamil Nadu has over-ruled the earlier belief that it can be farmed only within the salinity range of 15 to 25‰ (MPEDA, 1991). Efforts should also be made to augment their production by culture as well as by improving the existing traditional farming practices by adopting scientific methods (Mohamed, 1969., Gopalakrishnan, 1973). Furthermore, the significant drawbacks associated with P. monodon culture are high price of its seed and insufficient availability of fry due to shortage of mother shrimp. The growth rate of P. indicus is similar up to a body length of 12-13 cm in 89-90 days rearing. Cheap cost and a large supply of seed will easily compensate for the small size. In the commercial view point it is very significant to note that P. indicus will continue to grow in prolonged confinements and attain bigger size in the brackish water conditions (Subramanian and Rao, 1968, Mohanty, 1974 and George, 1974). It is therefore important to expand P. indicus culture in Kerala due to its relatively low production cost compared to P. monodon.

A considerable body of information is available on the shrimp larval recruitment as well as on the distribution of their adult counterparts and their fishery from geographically different regions in India (Menon, 1952 and George 1962 in the west coast and Evangeline and Sudhakar, 1973 in the east coast of India).

Also studies have been made on the occurrence of juvenile shrimps in the inland waters and their prospects in a culture undertaking (George et al., 1968; George and Sebastian, 1970 and Selvakumar et al., 1972) from the west coast of India, and Gopalakrishnan (1952, 1968), Chacko et al. (1954), Pillay (1954), Evangeline (1969), Jhingran and Natarajan (1969), Ghosh et al. (1973), Sampson Manickam and Srinivasagam (1973), Evangeline et al. (1975), Victor Chandra Bose et al. (1980) and Subramanian et al. (1980) on the east coast of India.

A comparative study on penaeid shrimp juvenile abundance in Indian brackish water bodies has been carried out by Gopalakrishnan (1973), Muthu (1973) and Rajyalakshmi (1973), Rao (1980) and Rao (1983). Relative occurrences in quantitative term and size distribution with regard to estuarine shrimps were done by Subramanian (1981) and George and Suseelan (1982).

Such a detailed survey on the availability of penaeid shrimp juvenile resources of an area is a sine qua non to practise their culture (Mhaswade, 1980; Alikunhi, 1980). The surveys conducted on availability and abundance of seed of cultivable species in different brackishwater bodies stand as a milestone in this direction (Rao, 1983; Ghosh, 1985).

India with a brackish water hinter land of coastal localities has an area of 2.2 million ha available for coastal aquaculture. The vast inland and brackish water localities hold promise to solve the problem of quantitative procurement of required species for undertaking shrimp culture (Silas, 1980). Nevertheless, proper conservation and maintenance of brackish water shrimp seed resources is very essential for a sound management and promotion of aquaculture ventures.

The availability of epibenthic shrimp juveniles in dynamic brackish water ecosystems could show fluctuations (George, 1973; Pillai, 1978; Alikunhi, 1980). From the information on pattern of distribution of penaeid shrimp juveniles in Vellar estuary, it has become evident that most of the species are perennial, while some showed seasonal and a few others sporadic distribution. Also considerable year to year variation in their abundance (P. monodon and P. indicus) was noticed as their life span would last more than a year. Also biological (predator - prey relations) and ecological stresses would exert their influences for fluctuations (Walker, 1975; Palaniappan et al., 1978; Krishna Murthy et al., 1978).

George (1962) has observed that the larvae of P. indicus would enter into backwaters of south west coast of India (Kerala) during November - December. P. indicus post larvae were abundantly recruited to the Cochin backwaters along with tidal current during September and January and May to July (Rao, 1973). The size of recruits was less than 10 mm total length (Panikkar and Menon, 1956). In Cochin estuary, eventhough a lot of shrimp/fish seed are available from the Puduveypu locality (Plate XXI B) during season, a great majority undergo stress due to the turbulent water conditions (Purushan, 1989). This in turn affects the survival of shrimps and fishes in culture systems of that region apart from creating problems of efficient pond management.

The presence of vegetation would provide shelter for the moulting shrimps (Plate XXI B) and it also provides rich organic debris as a fresh food source (Rajyalakshmi, 1973; Young, 1975). Total organic carbon forms the base of the detrital food system. Hoese (1960) related the abundance of juveniles in Gulf of Mexico to the sea grass beds. Allen and Inglis (1958) reported on the habitations of the post larval and juvenile penaeid shrimps among salt grass. Similar reports have been made on turtle grass (Strawn, 1954) and upon Cymodocea isoetifoliums (Kannan and Krishna Murthy, 1978 and Subramanian et al., 1980). Young (1975) reported the marked occurrence of juvenile shrimps on sea grasses than on bare exposed substrate. The sea grass containing Philippine meadows are considered as preferred substrata for the large scale recruitment of P. monodon post larvae. The conspicuous absence of such a habitat along Vembanad lake especially in the study area might be the reason for the low level of recruitment of P. monodon post larvae.

Young shrimps, irrespective of species prefer phytoplankton, mainly diatoms as their staple food. These diatoms were found to occur upon periphyta, on the stalk of the submerged vegetation and were voraceously preyed upon by the juvenile shrimps (Ghosh et al., 1973). Mohanty (1975) and Evangeline (1973) observed the presence of Enteromorpha sp and Chaetomorpha sp in the stomachs of post larval and early juvenile shrimps. In places like Portonovo, presence of low lying areas like mud flats along side was found to help trap and retain the nutrients of the nutritive estuarine waters for eventual growth of sea grass and algal vegetation. These were also found to harbour characteristic fauna. Hence, the shrimps in such areas were found to prefer algal vegetation for their food and shelter.

In the Cochin back water, in the case of commercial shrimp larval recruitment, it is believed that usually 4 to 6 weeks might have elapsed by the time, the young begins to arrive as 5-10 mm post larvae, which no longer be classified as true plankters. Once in the estuarine waters, the post larvae quickly transform into juveniles. Over the subsequent 90-150 days, they grow rapidly and reach commercially acceptable size shortly before their return to the sea where the life cycle is completed.

Appreciable variations occur among the commercial penaeidae of the world, both in the degree to which each species utilizes an estuarine type environment during its life history and in the distribution of its parent population along the brackish-marine gradient of the littoral zone at the sea's edge.

Thus a species completes its life cycle wholly within the confines of an estuary (Morris and Bennet, 1951), while another undergoes entire development in the ocean at depths approaching 900 metres (Maurin, 1965). In between may be noted all shades of difference in the ontogenetic - estuarine relationship.

In the light of the above back ground it will be interesting to analyse the seed management methods adopted in the farming systems selected for the study.

In all the contractor operated traditional fields (Group A) shrimp larvae were autostocked by regular tidal processes. All efforts were made to concentrate maximum larvae by skilful techniques. The intake of tidal water and its draining through appropriate screens taking full advantage of all high and low tidal processes especially during dusk and dawn hours was followed. Therefore no conditioning or acclimation of any sort, of larvae was necessitated as the environmental conditions were quite similar both inside and outside. The confluent nature of the general field system also enabled the fry to enjoy the entire niche from the very moment of their entry. So also, there was no known method to assess the shrimp larval density within, by the process of autostocking. Nevertheless, experienced shrimp farmers derived satisfaction when they observed juvenile shrimps getting buried profusely in the bottom with eyes projected. These countless objects discernible during day and dusk hours on close observations of the shrimp fields were indicative of the satisfactory level of shrimp juveniles recruitment.

In the aforesaid aspect, the ideal site location and the extent of tidal amplitude played significant role in the shrimp production capacity of traditional fields. Eventhough all fields selected from Thrikkadakapilly (Cherai) to Narakkal were situated advantageously in this regard, fields at Thrikkadakapilly and Pooyapilly were situated in strategic positions having all the advantages for close proximity with main water body and maximum tidal gradient. In contrast, the field at Nayarambalam was located quite interior from the main feeder source and with minimum tidal amplitude. The autostocking of shrimp larvae in fields at Ayyampilly, Kuzhupilly and Narakkal was also satisfactory, since they were able to draw high tidal water with fair gradient being influenced by Munambam and Cochin barmouths respectively.

Apart from autostocking, supplemental seed induction was done in improved fields at Ayyampilly and Narakkal where adequate arrangements to increase the carrying capacity were made during preparations. One lakh each of P. indicus healthy juveniles (Plate I A) procured from natural sources with a mean size of 25-30 mm were additionally released into the appropriate compartments within the field earmarked as nurseries upto 2 months. Since these young ones were collected from the nearby back waters and kept under hapa rearing (Plate I B) in the same environment, no further acclimation was required while introducing them into the fields. However, injured, unhealthy and undersized ones were avoided while transferring. The inducted shrimp larval densities were 3.3 nos/m² and 4.4 nos/m² at Ayyampilly and Narakkal respectively.

The method of seed management varied very much in the owner operated extensive farms (Group B). Both P. monodon (Plate XX A) and P. indicus (Plate XX B) were farmed in respective growouts depending upon season and seed availability. Of the eight operations carried out in 7 farms, sequential farming of P. monodon and P. indicus was carried out only in the farm at Karumancheri. P. monodon farming was done at Chalippuram and Pallithode. In other four farms - Narakkal (two) Puduveypu and Cherungal - P. indicus was cultured.

There were much differences in the procurement, size, stocking density and other management aspects of seed of both P. monodon and P. indicus. Only hatchery (Plate XXII A) fry were made use of in the case of P. monodon, the fry size being PL_{10}, PL_{12} and PL_{22} at Karumancheri, Pallithode and Chalippuram respectively. Also, the stocking densities in order were @ 12350, 24700 and 68100/ha. While the fry after acclimatization (Plate XXII B) were directly released at Karumancheri, there was two to three weeks nursery rearing in the other two systems.

In the case of P. indicus, both hatchery (Plate XXII A) fry and wild (Plate XXI B) seed were made use of. Tiny PL_5 and PL_{12} hatchery fry were released at Cherungal (Plate XII A) and Karumancheri respectively at stocking densities of 1.5 lakhs and 75000/ha. While uniform sized (0.041 g/19.4 mm) wild seed were stocked @ 50,000/ha both in the compartments at Narakkal and ponds at Puduveypu, fairly advanced juveniles (0.258 g/34.5 mm) @ 1,17325/ha were released in the Harijan farm at Narakkal. No nursery rearing was done in the case of P. indicus except at Cherungal.

Even by using fry from different sources and treatments, no incidence of disease was noticed at any time, despite the stocking densities ranged between 12350 and 1.5 lakh/ha comprising both species.

Of the 8 experimental series under group C, 6 were carried out using P. indicus and the other 2 with P. monodon. In the 5 series of experiments in the miniponds with P. indicus, uniform sized wild fry kept under hapa rearing (Plate XXII B) were made use of. The size of fry and stocking density varied from one experiment to another. Though with uniform stocking size, the stocking density of fry also varied from 1 to 2.5 lakh/ha in different treatments of the same series. The mean size (length/weight) at stocking was 16.2 mm/0.029 g; 53 mm/ 0.848 g; 28.0 mm/0.155 g; 39.8 mm/0.388 g and 17.7 mm/0.030 g respectively in the series of experiments 1 to 5. All fry were introduced into the miniponds after proper conditioning.

In the C6 experiment PL_6 fry of P. indicus obtained from Govt. Prawn hatchery (Plate XXIIA) Azhikode were conditioned and released @ 4 lakh/ha into the pump fed earthern tank (Plate XIV A).

Uniform sized P. monodon wild fry (PL_{10})and similar sized ones procured from MPEDA hatchery at Vallarpadom were separately stocked @ 2.5 lakh/ha after conditioning (C7) in the respective earthern pools

(Plate XV A). In C8 nursery reared and mean sized (2.211 g/68.4 mm) P. monodon juveniles after conditioning were stocked @ 27000/ha in the minipond.

In all cases, fry remained in stagnant water conditions mostly except during the time of water exchange.

Under group D, P. indicus fry were stocked in 4 series of circular cement tanks (Plate XVI A) and one series of fibre glass tanks (Plate XVI B). The mean size of wild fry stocked was 27.4 mm (0.112 g); 32 mm (0.196 g); 49.2 mm (0.789 g) and 24.2 mm (0.128 g) respectively in the series of experiments 1 to 4. The corresponding fry stocking densities were 50,85,100 and 800/m^3.

In the fibre glass tanks, the mean size of wild fry was 17.7 mm (0.030 g). The stocking densities varied in each tank @ 20,40,60 and 80/m^3 respectively. All fry were conditioned before stocking in both set of tanks.

3 lakh, PL_{20} P. monodon fry were brought from TASPARC, Visak in 22‰ saline medium. During the transport around 10% mortality was noticed. The fry were transferred in batches after 4 hours of acclimatisation to the semi-intensive farm at Mundapuram (group E) having a salinity of 36‰, at a stocking density of 2.25 lakh/ha. The entire operation lasted for 10 hours. Subsequent mortalities observed in the vicinity of the transfer points might be indicative of the stress conditions experienced by the fry owing to the short duration acclimatisation. Various researchers (Rao, 1973; Subramanian, 1981 and Pillai, 1991) have indicated the importance of optimal salinity for greater survival and growth of prawn larvae.

The limiting factor in the large scale adaption of shrimp farming is the non availability of seed from natural sources.

So the success of brackish water culture depends upon one basic

Trivedi et al. (1982) in Shetrunji estuary both in Gujarat; Achuthankutty and Sreekumaran Nair (1982) in Goa; Sambandam et al. (1982) in Vellar estuarine system and Bose and Venketesan (1982) in Marakanam estuary, both in Tamil Nadu. Mathew et al. (1982) deviced a quantitative seed sampler for sampling in the estuaries and backwaters during the field surveys.

As noted above the natural shrimp seed supply is periodical, unreliable and most important of all, limited. Also seed collection is rather destructive method as usually not more than 10% of the collected seed is belonging to the preferred species (the rest is destroyed) and similarly a low percentage of the selected seed reach the grow out ponds and have a chance of survival.

Most highly priced and expensive is the wild caught seed, reputed to produce much more hardy shrimp with better growth characteristics as observed in Ecuadorian shrimp industry (Liam Kelly, 1991). However, supply is erratic dependent on the current of the coastal waters and the natural abundance of the spawning shrimps.

While P. indicus seed are available through out Indian coasts, P. monodon seed are confined to certain localities only. Compared to Tamil Nadu, Orissa and West Bengal, the seasonal abundance of P. indicus is low in the Cochin backwaters and Vembanad lake areas of Kerala.

Auto stocking of post larvae and juveniles by natural ingression along with rising tide, being subjected to unpredictable fluctuations, is not a dependable procedure. Also it has the disadvantage of bringing in predators too. Further, the back waters in Kerala show a predominance of slow growing shrimp species. Metapenaeus dobsoni is plentyful through out the year with peak in October - January where as M. monoceros occurs during October - December.

The alternative to tide over the above is to make use of the

PLATE XV

A – Earthern pools

B – Minipond under *P. monodon* rearing at Puduveypu

PLATE XVI

A - Conditioned circular cement tanks

B - Conditioned fibre-glass tanks

PLATE XVII

A — Fringe of mangrove vegetation at Mundapuram farm

B - Paddle wheel aerated semi-intensive farming at Mundapuram

PLATE XVIII

A - Test feed trays suspended from platform

B - Pond excavated amongst mangroves and exposed to wind aeration

PLATE XIX

A- Pond preparation - drying

B - Manuring

PLATE XX

A – *Penaeus monodon*

B – *Penaeus indicus*

seed of the growth potential species selected from the natural environment or the establishment of enough hatcheries.

Gopalan and Rao (1981) following Rao (1980) estimated an annual requirement of 11368.5 million seed of P. indicus for culture in 75757 ha of brackishwaters.

But, Dwivedi (1985) estimated the seed requirement to be 256 billions (10^9) with a stocking density of 1,50,000/ha in a potential area covering 1.711 million ha (10^6). This can be made possible by raising the stocking material by profusely breeding shrimp under controlled conditions as in Japan (Furukuwa, 1972), Taiwan (Chen,1972) and Philippines (Villaluz, 1974).

As early as 1942, Hudinaga successfully spawned wild spawns of P. japonicus. Since then, P. indicus and P. monodon are among the 24 penaeid species for which commercial scale propagation methods are available. P. monodon was spawned using unilateral eye-stalk ablation.

Japan and Taiwan virtually produced all the required seed in hatcheries. The requirement for setting up hatcheries are 1) brood shrimps from sea 2) spawning and rearing of eggs to post larval stages, 3) availability of suitable feed depending on larval stages and 4) setting up and management of the controlled systems.

However in recent years, with the functioning of about 18 viable shrimp hatcheries of different capacities both in public and private sector through out the country (MPEDA, 1992), almost 200 million shrimp seed PL_4 to PL_{25} are annually supplied against the present requirement of about 5000 million.

Throughout the experiment it was noticed that the over pampered fry obtained from hatcheries are not able to adapt easily to the more harsh field environment leading to high mortalities and low growth rates in grow out phase as observed at Puduveypu and Pallithode.

Percentage survival of shrimps and their yields are often interlinked by a linear relationship, provided the seeds are of good quality. Also better survival rates could be ensured by controlling cannibalism, using uniform sized hatchery bred seed which moult synchronously. However, by virtue of their sturdiness and lower prices, the natural/wild seeds are preferred for extensive management.

Kurata and Shigueno (1976) observed higher survival rate in P. japonicus if large fry of 1.10 to 6.08 g weight were stocked in the culture ponds. Mohanty (1974) recorded higher rate of survival in the experiment when advanced juveniles of P. indicus were stocked and lower rates of survival when early juveniles were stocked in the ponds. Above observations enlighten the importance of stocking of advanced fry.

Alikunhi et al. (1980) noted the percentage survival as 96, 75, 78 and 55 when P. merguiensis advanced post larvae were stocked at a rate of 1000, 2000, 3000 and 4000/m^2 respectively without aeration, but with artificial feeding and water exchange.

One of the most important problemsencountered in shrimp culture is the large scale and unaccounted mortality of the stocked shrimps in the grow outs/ponds. According to Rajyalakshmi (1982), 70 to 80% mortality of P. monodon in the culture ponds is caused by cannibalism, inadequate feed and its relationship with salinity, temperature and oxygen content of the medium controlled by exchange of water. Nandakumar (1982) found higher survival rate for P. indicus when fed with supplementary feed.

3.1.6 Feed and feed management

Aquaculture is one of the fields where opportunities to increase food production in a relatively short time and at a reasonable cost, seems very promising. Also world-demand for shrimp is on the increase, since last decade. It is estimated that currently around 0.7

million tonne of shrimps are produced annually by world aquaculture and is projected to double by 2000 A.D. (World Shrimp Farming, 1991). One way to achieve this target is by optimal feeding coupled with improved water quality after selective stocking. This is possible only by developing one of the pressing strategies namely feed, which is one of the essential inputs in shrimp farming.

A point to remember is that as the shrimps grow to marketable/ harvestable size of 20-30 g, their nutritional (dietary) requirements vary. Also, as they grow, undergoing several moults, a change in the size of feed particles is warranted in relation to the different growth phases. Therefore, the search for a suitable, high quality water stable food for the post larval stages, juveniles and adults of P. indicus (Plate XX B) and P. monodon (Plate XX A) is one of the important areas of study in the production. The feed for shrimp growout are broadly classified as (1) post larval (2) starter (3) grower and (4) finisher feed.

As the feed cost constitutes over 60% of the overall cost of production, it has an important decisive role in the economics of farming. Feed quality, quantity and the manner in which feed is given would influence the shrimp yield. Hence the need arises for selection/ production of a cost effective feed with high feed conversion ratio (FCR 1.2:1) among the various raw materials available locally or at least within the country.

The Feed conversion ratio (FCR) - the value which measures the efficiency of feed utilization for growth can be defined as "the dry weight of feed offered to shrimp during a certain period of time divided by the wet weight gain of shrimp during the same period of time". A primary use of the FCR is to evaluate nutritional quality of feeds, more nutritious feeds yielding lower FCR values. A ratio between the quantities of feed applied and shrimp produced will be very close in the case of good quality feed where as a distant ratio between the two will denote a poor quality feed (Purushan, 1991).

Poor FCR means considerable loss of feed to pond bottom in the form of undigested wastes polluting the water thereby incurring reduced products and profits.

According to Asian Shrimp News, 1st quarter 1992, FCR performance is related to shrimp size, with the smaller sized shrimp having the lower FCR and the larger sized shrimp, the higher FCR (1.15 for 20 g size raised to 1.65 for 50 g size in the case of P. monodon). Furthermore, the Thailand farmers were successful to achieve an FCR of even 1:1 due to the increased reliance on natural feed availability in the environment along with optimum supplemental feeding in a semi-intensive culture system with a stocking density of 10-20/m² (Asian Shrimp News, Issue No. 8, 1991).

As on today, the 5000 farmers engaged in the shrimp farming in about 50,000 ha in our country, following traditional culture with a production ranging from 200-500 kg/ha, do not apply feed.

In brackishwater shrimp culture, the natural productivity of the estuarine water which is rich in nutrient elements and food organisms, is being utilised to the extent possible by exchanging water under impoundments with the tide water (Hickling, 1971).

The basic organic productivity of the seasonal paddy fields is seen to be of a higher order which in turn reflects in the shrimp production (George, 1974). The disintegrating paddy stalk releases required nutrients for generating optimum plankton growth which promotes the favourable growth of shrimps resulting in higher production. The debris and detritus accumulated in the paddy field shrimp culture system are also consumed by shrimps which enhances the production to a great extent. In a densely populated shrimp ground large food masses may be insufficient to support a healthy population and this deficiency is likely to be made up by feeding on the epifauna and epiflora of the mud surface (Dall, 1968).

Studies by Sugunan and Parameswaran Pillai (1984) on vertical distribution of the meiofauna of the sediment in selected culture fields around Cochin showed 85% of the population occupying the upper 2 cm layer indicating the role of salinity, dissolved oxygen, available phosphorus and temperature as controlling factors.

The composition of the epifauna comprised of rotifers 50%, copepodites, copepods like Oithona spp, Acartia spp, Pseudodiaptomas spp, Acartiella spp, Diaptomus spp, nauplii of crustaceans, bivalve larvae, nematodes, polychaetes, fish eggs, Cladocerans, tintinnids and harpacticoid copepods. The dominant benthic fauna included bivalves, molluscs, polychaetes, amphipods, isopods and cumaceans.

Shrimps graze on the soft parts of the plants associated with small animals and particularly on the decaying remains of the plants in the pond bottom (Primavera and Gacutan, 1985). In general, shrimps move around the perimeter of the pond in the late afternoon and evening and eventhough they feed at anytime during the day, they prefer to bottom feed when there is light (Apud et al., 1980). Strangely benthic algal control was necessitated to avoid trapping of post larvae.

George (1972) analysed the food contents of shrimps of the backwaters of Cochin and found that in juveniles, small crustaceans formed the major food item, and only a small portion consisted of unidentified objects and debris. There is an indication of varying food differences to some extent.

Kuttyamma (1974) has made a study of the feeding habits of M. dobsoni, M. affinis, M. monoceros, P. monodon and P. indicus in the Cochin area. The food in general consisted of varying amounts of organic matter mixed with sand and mud. Gut content analysis of P. indicus from various fields showed crustaceans as the major constituent in the stomach (21.11%) followed by detritus (19.64%), vegetable matter (18.41%) and polychaetes (16.49%). There was no significant variation in the gut contents between ponds. Hence it may be concluded that the seasonal availability of food organisms in the environment determines their selectivity.

Benthic (fauna) food items of shrimps identified in the mud samples of the study area consisted of polychaetes - Prionospio sp and Heteromastides sp, nereidae, tanaidaecids such as Apseudes chilkensis and A. gymnophobium. Amphipods like Corophium sp, Gammarus sp and Melita sp, mysids of decapods, bivalve Pandora flexuosa and gastropod Littorina sp were represented apart from unidentified objects and debris. Quantitative and qualitative differences were also observed in different months.

Plankton management

According to Chen (1987), the production potential of farms is related to the pond water colour depending on the type and extent of plankton bloom. Rubright et al. (1981) observed the influence of adequate pond fertilization on shrimp growth and production possibly (via) plankton - detritus food chain. Kongkeo (1990) has high-lighted the important role of plankton production and its regulated supply to grow out ponds practised in Thailand. Eventhough the technology of preferential blooming of the proper phyto-plankton and its regulated supply to grow outs is yet to be tried in India, the author has successfully bloomed phytoplankton in the study farms by proper broadcasting of fertilizers and manures.

The role of natural productivity in earthern ponds in the study area is highly significant. The growth of natural food in ponds is enhanced by fertilization, which is a standard practice in pond preparation for extensive and semi-intensive farming. This is done by normally applying organic manure @ 1 - 2 tonnes/ha. Also inorganic fertilizers such as ammonium phosphate (16-20-0) and urea (46-0-0) at 75-150 and 25-50 kg/ha respectively are in use. Generally fertilization is not done in intensive ponds. Subosa (1986) demonstrated the feasibility of producing shrimp stocked at 7500 per ha

(*P. monodon*) reaching marketable size in 120 days through the use of 1 tonne chicken manure/ha.

In general feeds control production in ponds, as inadequate feeds reduces production. As the stocking density is increased to progressively more intensive levels, the contribution of food chain organisms to the diet, diminishes. This necessitates increase in quantity and quality of feed to maintain good nutrition and growth.

Studies have indicated that supplemental feed is required in densities higher than 15000/ha for *P. monodon* and 30000/ha for *P. indicus*.

The shrimp being cultured are receiving part of their nutrient required from natural sources and part from the artificial feed being added to the pond. Supplementary feeds are cheaper than complete feeds. Moist feeds are normally proportionately cheaper than the equivalent dry feeds, if made at the farm site.

The Chinese shrimp farmers rely on live feeds (primarily crushed clams and mussels) supplemented with pelleted feeds consisting of agricultural byproducts (soy bean meal, pea nut meal and corn). Japanese shrimp culture depends mainly on feeding with short necked clam and the mussel (*Mytilus edulis*). Formulated moist and dry feeds are also used very widely.

Supplemental feeds generally used consisted of chicken entrails, frog meat, mussel meat, trash fish, worms, snails, clams, slaughter house waste etc. But to get an enhanced production of 1 tonne/ha, the problems encountered were their mass production, storage, free availability and quality. Hence the need arose for the development of commercial feed/dry pellets.

Supplementary feed is basic to intensification and the highest recurring cost in intensified practices is attributed to the feed cost.

Usually high protein formulated diets are used in intensive culture.

Despite higher cost, most intensive farms used balanced diet formulations with 35-40% protein, an effective binder for underwater stability and a complete mix of vitamins and minerals. However in the laboratory experimental series, formulated compounded feed were used and good results obtained.

Commercial feeds are available in the form of water stable pellets of different shapes and sizes (worm like or crumbles) prepared using finely ground ingredients and different kinds of binders, by cooking - extrusion or dry or wet pelletizing.

The manual on "Feed and Feeding of Fish and Shrimp" (FAO, ADCP/REP/87/26) is an easy to read guide to the choice, manufacture, storage and use of feed in small scale aquaculture.

Feeding has a most significant potential role to play in increasing the revenue and profitability of any aquaculture unit (New, 1987). According to Shang (1981) the cost of feed in aquaculture often exceeds 50% of total production cost, rising to as high as 75%. But, the higher feed costs might be a disadvantage.

The status of shrimp nutrition and feed development in SE Asia has been extensively reviewed by Pascual (1989). Accordingly formulated feed constitutes around 50-60% of the operational costs in shrimp culture and hence there is a need to develop, low cost effective feeds. However, owing to limited information on feeding habits and nutritional requirements, development of feeds of P. monodon has been dependent on data derived from other penaeid species.

Shrimp culture can be promoted by producing feed in pellet form economically by utilizing locally available inexpensive raw materials like rice bran, ground nut oil cake and cotton seed oil cake. This vegetarian diet has to be fortified with animal protein to accelerate the shrimp growth. In the absence of a standard reliable shrimp feed, formulated feeds prepared from locally available and cheap materials were made use of in different culture systems (Purushan, 1991).

Rarely few fed shrimps with imported feed to get a production of 2 to 4 tonnes/ha. Supplemental feeding is done in about 15000 ha (Andhra Pradesh 6000, Maharashtra 1800, Tamil Nadu 250 and Orissa 7100 ha) where extensive farming methods are followed. Farmers in Andhra Pradesh generally used farm made feed and as the name indicates, the quality and composition of feed varied considerably. Goc, brocken rice, soybean cake, rice bran and dried fish formed the ingredients in the feed meant for extensive farms. Sametime, the farmers opting for improved extensive farms used fish meal, shrimp head meal, squilla, soyacake, goc, rice bran, wheat flour, meat, bone, vitamin and mineral mixes. According to Ponnuchamy et al. (1990), few chose lecithin too. Only less than 200 ha located in Tamil Nadu and Andhra Pradesh are under semi-intensive system. Intensive system was able to produce upto 8 tonnes/ha/yr at Nellore in Andhra Pradesh and Paradeep in Orissa.

But, for the success of production, one major limiting factor is the nonavailability of appropriate quality feed in time. This necessitates development of local substitute feeds economising import costs.

Based on above facts, it is estimated that in the coming 5 years, the annual requirement of feed may go up to 30000 tonnes from the present 5000 tonnes. The annual feed requirement by 2000 AD may touch 2,50,000 tonnes (MPEDA, 1992). In this context, the functional feed mills like the one being set up at Cochin have to play predominant roles for the development of shrimp farming. The six functional feed mills set up in Andhra Pradesh possessed capacity to produce 20,000 m.t./annum.

According to Chiu (1989), the composition of diets and feeding management should provide for maximum growth. Both feeding rate and feeding efficiency contribute to differences in growth response and feed efficiency.

Proper feeding management is important for the attainment of maximum growth and feed efficiency. Both parameters vary with many factors including the species and size of shrimp, water temperature and dietary energy level and the physiological status of the shrimp. Growth and feed frequency are positively related. Shrimps at the higher feeding regime naturally grow faster.

However, there is a maximum limit to extensive feeding at which the increase is negligible when considering the amount of food given (Chua and Teng, 1978) and this is defined as the optimal feeding frequency which varies among different species. Semi-intensive culture requires regular supplementary feeding in addition to natural food. In contrast, intensive farming necessitate supply of formulated feed 3-6 times per day.

It has been reported that the changes in temperature, salinity, dissolved oxygen etc. have a profound influence over the appetite of shrimps. So feeding rates can be adjusted 5 to 10% up or down on a daily basis. The feed rations generally found varying from farm to farm, decreased from 25% in the early juvenile stage to 2-4% before harvest.

Improvements in feed efficiencies can be done in three ways. One way is to maximise production of free food chain organisms as practised in the present experimental investigations. According to Moriarty (1986), most of the feed supplied to shrimp ponds is actually being utilised first by bacteria. In the extensive paddy field traditional system, the left over paddy stumps are devoured by shrimps in the same manner. The meiofauna eaten by shrimps feed on these bacteria. A limiting factor in this process is availability of dissolved oxygen for growth of the aerobic bacteria. According to Moriarty, aeration can be an effective tool to accelerate the conversion of wastes into nutritious food organisms. Also aeration is found capable of increasing plankton growth which serves as forage for shrimps with a conversion ratio of 1.5. Usual biweekly fertilization with urea, superphosphate, calcium silicate etc. increased diatom population considerably.

A second method of improving feed efficiency is to feed several times per day rather than just once, because shrimp forage for small quantities of food continuously. Also multiple frequent feedings reduce the deterioration and waste that occurs when pellets are not eaten immediately. This careful feed management could lead to a conversion efficiency of 1.7. Also frequency can be increased towards the end of growing season. This kind of feeding could be adopted in the experimental culture tanks where as only one time supplemental feed could be provided in the extensive grow outs. In the improved extensive farms at Andhra Pradesh, farmers divide the daily feed into two portions and broadcasting is done during the dawn and dusk hours.

The third method is to avoid over feeding or under feeding keeping pace with weekly growth rates and survival rate. This can be done by looking at the residual feed left on the feeding trays which can be an active indicator of feeding also. This necessitates close monitoring of feed off-take. This practice was followed in all experimental tanks and mini ponds. Very similar method of feed supply also proved successful in the extensive grow outs at Chalippuram (B5) and Cherungal (B6) and in the semi-intensive farm at Mandapuram (E).

In the extensive farm in Andhra Pradesh, feed is supplied from the 31st day of stocking @ 10% of the daily estimated biomass. But the feed ration is reduced to 4% after 90 days. Often better survival rates and yields are contributed by the pelletised feed compared to the wet dough balls.

The papers presented during the Third Asian Fish Nutrition, Network meeting held at Philippines (De Silva, 1989) have dealt with, in detail various aspects of basic nutritional requirements of fish and shrimps.

What is lacking still is information on the nutritional requirements of the shrimps and the conversion ratio of the existing conventional feeds. Artificial dry feed pellets containing essential components for growth were used in experimental shrimp culture at Puduveypu. Application of nutritious and cheap feed of relevant quality helped very much to increase production. However, shrimp being slow eaters, the feed stuffs used in ponds should not leach easily to avoid water quality deterioration in the culture system. Therefore feed application in suitable containers will help to maintain water quality conditions apart from minimising feed wastage. The ability to correctly judge and positively respond to the requirements of the culture medium does promote production success (Purushan, 1991). All precautions taken in this regard while supplying feed in all the owner operated farms, especially at Chalippuram produced commendable results.

On comparison with other systems, where indigenous feeds were only used, the strategy adopted at Mundapuram (E) was different. Recognising the importance of nutrient rich high quality feeds in the semi-intensive farming, 7 brands of imported feeds (Plate II A) were made use of. However, owing to the delay caused during import, the sequence of feed supply in the order - starter, grower and finisher - could not be adhered to, leading to topsyturvy nature of distribution. The scarcity of feed was compensated with clam meat. In addition, corresponding to the increase in mean size, feeding frequency was raised giving emphasis to feed adjustments as judged from test trays and distribution techniques. The supply of prawn stronger as appetizer was an exception in this case. However, the culture resulted in an enhanced production of P. monodon (@ 2.4 tonnes/ha/4 months) with the highest record in Kerala, eventhough the FCR was 1.4:1. This rate did not commensurate the highly nutrient rich quality of imported feed owing to the reasons mentioned.

In 1986, SEAFDEC (Vol 8 (27) demonstrated that with supplemental feeding of commercial pellet (Plate II A) and trash fish added to the natural food in the pond, a record production of 843.35 kg/ha was feasible at a nominal (+10%) stocking rate of 25,000 fry of P. monodon/ha. During the 124 days of operation, the fry grew from 0.57 g to 31.42 g with an estimated survival rate of 97.6%.

But, in the present series, still amazing was the results achieved at Chalippuram. The PL_{22} fry of P. monodon cultured @ 68100/ ha grew to an average size of 28 g (155 mm) and attained a production @ 1170.5 kg/ha after 107 days with a survival rate of 75.39%. This stands as the most shining example to indicate the significance of feed and water management among the whole set of investigations made in a variety of culture systems.

In addition to the live feed generation, the feeding technique employed at Chalippuram was quite peculiar both in nutritive contents and method of supply. The P. monodon post larvae were fed ad libitum by a suspension containing ground clam meat, boiled egg and cod liver oil from the very moment of its acclimatisation and conditioning which practice was not followed in any other case. Further, the same feed @ 10% of body weight was supplied once daily during the 2 week nursery rearing. Subsequently, the shrimp juveniles were fed with specially cooked and vitaminised nutritious feed containing clam meat, g.o.c. and rice bran in 6:1:1 ratio.

The use of 250 numbers of wide mouthed earthern trays (Plate VIII A) suspended at fixed points and 3 suitable canoes (Plate XI A) facilitated proper feed distribution in the entire system without disturbing the bottom. The daily feed ration @ 10% body weight and the manner of its application helped to promote efficient utilization without leading to any wastage and associated water quality problems. Because of the systematic approach adopted, no difficulties were encountered or any stress noticed at any time, even when the feed ration was around 100 kg/day towards the fag end of operation. The freshly prepared palatable feed with better conversion rate induced faster shrimp growth thereby tremendously enhancing quality and quantity of yield within the short culture duration. The quality of feed ingredients, the care and attention bestowed in its preparation, the frugal quantity distribution etc. were the important aspects of management stood unique in the system at Chalippuram when compared with other places.

Artificial feeds/diets can be developed based on nutritional/dietary requirements obtained from food intake studies in the natural habitat/in the wild and in ponds. In the present series, such studies have been pursued in the traditional shrimp culture fields, grow out ponds, miniponds and experimental tanks.

Feed strategies adopted in the contractor operated fields (Group A), showed much similarities than differences among one another. Except for the large amount of organic detritus resulted from the decay of paddy stumps and the usual forage available in the paddy fields, no other feed source was available to the shrimps in the traditional and modified fields at Nayarambalam and Pooyapilly. But, in addition to natural forage, pulversied feed composed of rice bran, ground nut oil cake and shrimp head meal (Plate XXIII A) in equal ratios was supplied in the modified traditional and perennial field at Thrikkadakapilly during the interphase period of filtration. The feed supply ranged from 5 to 8 kg/day during the prolonged culture period of 7 months from August to February.

So also in the improved fields at Ayyampilly and Narakkal, similar type of pulverised feed was supplied daily @ 5-10% of body weight in the additional shrimp seed stocked compartments while distributing only lower doses of feed in other areas. Only after ascertaining considerable advancement in the mean size of shrimps by virtue of the frugal feeding followed in these compartments that the juveniles were permitted to move out to graze in the general system. Both being paddy cultivated fields for decades, there was no shortage

PLATE XXIII

A – Feed ingredients – shrimp head meal

B – Fish meal

of decaying paddy stumps during the ensuring shrimp culture season. Therefore a surplus quantity of natural forage was always available.

On the contrary, no decaying paddy stumps were present in the large and extensive field (Plate V A) at Kuzhupilly where in, the paddy cultivation had been stopped for many years. Nevertheless, other natural forage was available in the vast and perennial water body. Further, considering the magnitude of the extent and the chances of recruitment of enough shrimp seed in the system, supplemental feeding with a pulverised diet made of powdered tapioca, ground nut oil cake and fish meal (Ambassis sp) (Plate XXIII B) in equal ratios was done. Eventhough the stocking density was not known, a feed ration @ 5-8 kg/day was broadcast during dusk hours altogether providing a quantity of about 700 kg feed during 4 months between December and March.

In the owner operated extensive farms (Group B), though considerable variations in feed and water management occurred between farms, much emphasis was given to generate live feed within. Ever since the time of preparation, this aspect has been well cared. Dry twigs were planted (Plate XIII B) before hand in the farms with a view to generate periphyton for shrimps. Subsequent to shrimp seed stocking, calculated quantity of cowdung as weekly doses @ 2.5 tonne/ha/yr was regularly applied in all farms except at Cherungal and Pallithode. Besides, at Karumancheri, fertilizing with urea was also done at regular weekly intervals in addition to cowdung manuring. These applications were helpful to evolve live feed organisms in the farming systems.

Since known and higher stocking densities of shrimps were employed, supplementary feeding was done in all farms although the type of feed and feed ingredients varied greatly depending on the place and season of farming. More or less similar type of feed in the form of different treatments was supplied in the farms at Narakkal and Puduveypu. The effect of cowdung manuring @ 2.5 tonnes/ha/yr as fortnightly doses, application of commercial feed pellets (Plate II A) @ 3-5% of mean body weight/day and supply of pulverised feed comprising of rice bran + goc + clam meat @ 5-8% of body weight/day on growth of shrimps was demonstrated at Narakkal and Puduveypu.

During the initial rearing of shrimps in nurseries and ponds, pulverised feed comprising of rice bran and goc in required doses was broadcast at Karumancheri and Pallithode. But in the nurseries at Cherungal (Plate XII A), ground clam meat as ad libitum doses was supplied during the earlier stages. Crushed clam meat @ 5-10% of body weight was supplied during daily evening in farms at Karumancheri, Cherungal and Pallithode and also in the excavated farm at Narakkal. However, in the latter case, the application of feed was not regular on account of short supply of clam meat. But, the daily application of crushed clam meat @ 8-10% of body weight in farm at Karumancheri and steamedclam meat @ 5% of body weight in Pallithode was quite regular through out the period of farming. However, at Cherungal, apart from supplying clam meat @ 5-8% of body weight regularly, another feed in the form of a half cooked mash comprising goc, rice bran and shrimp head meal incorporated with clotted blood from butcher house was given alternately @ 3-5% of body weight. Thus the type of feed supply and management at Cherungal was more or less similar to that at Chalippuram but, considerably different from that of other farms.

Since suitable containers (Plate XVIII A) and earthern pots (Plate VIII A) were used while applying manures and feeds, necessary control could be effected depending on the response of shrimps in the farming units. As the feed was supplied as ration/day and frugal measures adopted in its application, no water quality problem arose at any time during the farming period. Except for the frequent removal of algal mat developed in the farm at Karumancheri on account of periodic manuring and fertilization, no other side effects were noticed in any other farming systems.

In an experimental series under group C it was observed that use of organic manures such as poultry droppings and cowdung in calculated quantity was highly effective to promote the growth of P. indicus than buffalo dung. Positively the increased energy contents of the former might have contributed to enhanced fertility resulting in better growth increments of shrimps.

Formulated and compounded feeds prepared from locally available and cheap materials in definite ratios and combinations when applied in specified doses had their clear influence on the growth of P. indicus and P. monodon as demonstrated in similar series of experiments. In general, shrimp growth was seen highly promoted with the application of ground and fresh clam meat exclusively or other diets containing clam meat or shrimp meal (Plate XXIII A) or fish meal (Plate XXIII B) as one of the major ingredients. The quality P. indicus realised in comparatively large numbers from C5 indicated that ingredients of formulated feed such as shrimp meal and mangrove detritus (Plate XXIV A&B) contained required composition to promote shrimp growth with better conversion rate than other feeds with low conversion rate.

In group D experiments, in tanks using natural turbid water, application of increased doses of quality commercial pellet feed (Plate II A) was not effective to obtain satisfactory growth and production of P. indicus. However, better growth was resulted when ground clam meat was fed as observed in the earlier series.

Rapid growth of cultured organism is possible only through a balanced diet. This shows the importance of proper feed and feeding techniques. This can be done in the form of supplemental feed or complete diet. Therefore, it is important to have an insight into the development of feed techniques based on basic nutritional concepts in order to increase production.

The following factors are to be taken into consideration in the formulation of a feed.

PLATE XXIV

A – Detritus – *Avicennia* spp.

B – *Rhizophora* spp.

a) for good agrowth adequate nutrition is essential
b) the dynamic equilibrium of the nutrients in the body must be maintained without over/under supply of one
c) nutrient needs are controlled by age, physical activity, body size, state of health, growth, reproduction and pathological disorder.
d) the feed must have nutrients similar to those found in natural feed
e) nutrient requirement of each species must be identified separately
f) a variety of feed stuffs may be preferred to one source.

Feed composition

To ensure proper growth, a standard shrimp feed require about 40 dietary ingredients and nutrients grouped under protein and energy concentrates, roughages, (crude fibre > 18%), minerals, vitamins and additives (New, 1990).

Owing to the slow feeding rate of shrimps, the feed has to be in the water for 4 to 6 hours. To avoid leaching of nutrients into water, one of the 8 available binders is often used in preparing feed. In addition, pigment improvers, chemo-attractants and preservatives are added. In general 11 formulae are widely accepted.

Pandian (1989) reviewing protein requirements of fish and prawns cultured in Asia, observed prawns as poor converters than fish in general. He noted the dietary protein requirement of Penaeus spp as nearly two times higher than the maximum required among fish. According to him prawns lose over 20% of the converted body substance at moulting. So prawns receiving low protein diet (< 25%) almost exhaust the converted energy on exuvia production. According to Castell and Budson (1974) protein acts both as structural component and as an energy source in decapods.

Studies on protein requirement for growth (Alava and Lim, 1983; Millamena et al., 1986; Bautista, 1986; Nezaki, 1986) revealed a protein content of 50% as optimal.

There exists considerable differences in dietary requirements of protein between species. Much of the information on nutritional requirements is not readily available as they are proprietary in nature. According to New (1987), a higher protein level (48-60%) is required for P. japonicus compared to a low level (35-39%) of P. monodon. However, Pandian (1989) has reported a still wider ranges of protein level requirement viz 60-76%, 25-60% and 21-53% for P. japonicus, P. monodon and P. indicus respectively. Studies on amino acid pattern in the diet by Deshimaru and Kuraki (1974) showed the need for 10 amino acids varying with species pattern. Highest percentage weight gain and feed efficiency was found when fed with a diet having closest similarity of amino acid with the particular species; closer the amino acid pattern of the diet, the more effective is the growth.

Alawa and Lim (1983) and Pascual (1989) used squid meal, fish meal, shrimp meal, casein, soybean meal and earth worm meal as protein source in diet with protein content varying from 25 to 60% and found best growth rate with 40% protein diet.

According to Hameed Ali et al. (1982) crustacean wet tissue suspension is reported to be used as larval feed successfully in small scale hatchery operations in India. Thus Mysis and Acetes blended into a fine particulate suspension and graded by fine meshed sieves have been used as the only feed during the entire larval phase and an average larval survival of 44% has been reported.

Both quality and quantity of protein is known to have a significant effect on the growth of shrimp. The weight gain of the shrimps fed with meat may be attributed to the quality of the protein. Alava (1979) found that 40-45% protein is optimal for the growth of P. monodon juveniles where as Bages and Sloane (1981) reported 55% protein level requirement for the early larval stages.

During the present studies, the growth responses of P. monodon and P. indicus fed with various diets (treatments) were found significantly different. Often weight gain had no relevance with survival rate. Among all feeds clam meat promoted higher growth gains in shrimps irrespective of its supply either alone or in combination with other items. Hence it also served as a substitute for high energy imported feed during semi-intensive farming at Mundapuram (E).

There were considerable variations in the biochemical composition of the different formulated feeds used. In all cases, the percentage carbohydrate level was considerably higher than that of proteins. But, the fat content was very low in all, except in the case of a pulverised feed. The energy content of the feeds ranged between 2771 and 3233 K.cal/kg. The relatively high energy content of formulated feeds prepared from locally available and cheap materials speak well for their large scale use in production systems, although their performance depends upon several other water quality factors.

P. monodon post larvae (P/ml) fed to excess with a diet of finely ground cooked mussel meat (Mytilus) had significantly lower weight gain ($P < 0.05$) than those fed with live preadult Artemia (Yashiro, 1987). But survival rate was highest (47%) for P/ml fed with mussel meat than Artemia.

Aside from the nutritional value of feed, other factors could have caused the difference in survival rate. Low survival rate can be attributed to over feeding causing severe fouling and stress as noted by Gopalakrishnan (1976) for P. merginatus larvae.

Another cause of mortality was the "jumping" behaviour of the shrimps which resulted in escape or being trapped on the side of the tanks.

Physico-chemical conditions of the water are also important factors affecting the survival of shrimps.

The importance of carbohydrates in the diet was found to be their binding properties in addition to their energy value and protein sparing function.

Lipids and fatty acids were required for the energy value and vitamin value. Millamena and Quinitio (1985) have demonstrated the importance of poly unsaturated fatty acids (PUFA) for larvae for growth and metamorphosis. Mendoza (1982) and Bautista (1986) showed a 10 to 12% lipid content in the diet as optimal and effective in getting good growth and survival.

3.1.7 Water management

The very concept of water quality management is based on the fact that "all other things being equal, a pond with 'good' water quality will produce more and healthier shrimp than one with 'poor' water quality". But one of the major constraints in shrimp farming is inadequate water replenishment leading to reduced stocking density. Supply of vital requirements like oxygen, optimal temperature and salinity, calcium content etc. are closely linked with water management. According to Shigueno (1975), for increasing production, it is imperative to ensure effective water management in ponds. In this connection, it is worth noting that the shrimp body, consists of about 80% water. The importance of water management is (1) it provides living space (b) helps to maintain optimal physico-chemical qualities required for the growth and survival (c) acts as carrier of required feed items (d) helps to eliminate metabolic wastes and (e) promotes fry distribution. In the traditional shrimp culture practices, autostocking of fry is exclusively depended upon tidal processes. It also appears to be the cheapest way of water renewal and hence its significance in the prevailing ecological conditions of the study area. The most inexpensive method of water replenishment for culture ponds is to make use of the tidal amplitude prevailing in the area. In India, second half of the year usually experiences higher amplitudes. While the amplitude is more than 1 to 1.5 m towards north of 14° Latitude, it is less towards south. Effective water exchange depends upon topography of the site selected. Also deep ponds can hold more water. However, often pumping was necessitated in extensive farming systems to supplement water exchange maintaining optimal water level. But water management exclusively depended on pumping was required in the case of semi-intensive farming at Mundapuram (E).

An alternative to above is to make use of ground water supply involving sophisticated techniques at huge expenditure. Prabhakara Rao and Raghavulu (1982) attempted culture of P. monodon in saline ground waters used for salt manufacture at Kakinada in Andhra Pradesh, after allowing it to flow through shallow evaporation channels. Though the shrimps attained an average size of 123.4 mm (16.7 g) in 135 days, the outcome was not satisfactory.

Basavakumar et al. (1992) based on their studies on the culture of P. monodon in sea water (33 to 40‰) at Ankola, Karnataka, brought out the importance of daily water exchange by pumping in addition to tidal intake as an enhancer of profitability in shrimp farming. However, in the study area, on account of socio-economic problems including land lease policy and inability to take advantage of engineering innovations, it was not found feasible. Yet, area to area modifications to a certain extent were made possible in the series of studies as enumerated below in order to maintain optimal conditions so that they were within a desirable range for increased shrimp production from unit area. Often, the water supply to the farms was maintained through a feeder canal. The intake and outflow of water was controlled through one or more sluice gates.

In all shrimp fields (Group A) water management was one exclusively depended on the tidal processes. Except for the exclusively traditional field at Nayarambalam, the life carrying capacity in all other fields was very much increased by the modifications made in the field structure. The disposition of sluice gates in appropriate and strategic locations was a note worthy feature in all cases to accomplish the purpose of seed and live feed intake through exchange. But, the number of sluice gates varied according to the size of extent, the larger fields always having more than one sluice gate.

By virtue of the general inclination of the fields towards the main sluice gate and the planned orientation of the dug out canals coalescing with the main sluice pit, it was possible to exchange 15-20% of water daily in all fields taking full advantage of tidal processes. Further increase in water exchange could be achieved at Thrikkadakapilly and Pooyapilly on account of the higher gradient, ranging between 50 - 80 cm. present in the area. Fairly high gradient ranging between 40 and 60 cm. prevailed in all other areas except at Nayarambalam. The traditional field at Nayarambalam was located quite interior and far away from the main feeder source. Hence relatively low tidal amplitude (30-40 cm) occurred in the area with the result that the extent of water exchange was less than 15% per day.

Among group B series, the farms at Narakkal and Puduveypu were suitably located along feeder canals emerging from main water body under the influence of Cochin barmouth. Therefore, the tidal gradient was fairly high and fluctuated between 40 and 60 cm. depending on lunar periodicity. But the tidal rise and fall was relatively low (25-35 cm) at Karumancheri as the farm was situated far interior being connected through a feeder canal with the backwater fed from Cochin barmouth. The farm at Cherungal and the canals at Pallithode were located adjoining a brackishwater lagoon (pozhi) connected to Anthakaranazhi where the tidal oscillation remained between 30 and 50 cm.

The normal water level within the farms varied between 50 and 80 cm. The water entry and exit was through the single sluice gates in the Harijan farm at Narakkal and other farms at Puduveypu, Karumancheri and Pallithode. But in the 4 compartments set inside large (8 ha) farm at Narakkal, there were 3 suitably installed sluice gates functioning separately towards the entry and exit of tidal water. So also in the farm at Cherungal, ingress and egress of water was accomplished through separate sluice gates fixed in almost opposite directions. In addition, the permanently fixed 5 HP axial pumping unit (Plate XI B) was a unique facility in this farm for efficient water management. The daily water exchange to the tune of 15-30% could be achieved through tidal processes in all farms depending on the phase of the moon. At times when difficulties were encountered to growing shrimps due to scarcity of water, pumping of water was arranged in all farms. Since diesel engine pump sets were frequently functioning at Narakkal Harijan farm and canals at Pallithode, quality water could be supplied at remote ends maintaining the farming units healthy. But at Cherungal, owing to the unique facility of permanent pumping arrangements, water management in the farm could be accomplished to any level irrespective of the tidal rise and fall. Therefore, taking advantage of this facility, it was quite easy to make water always in motion getting rid of problems of stagnation and enhancing the rate of growth of shrimps. Further, it was also quite easy to raise short duration crops of shrimps in the farm.

The farm at Chalippuram (Fig. 9) being located at a distance of about 12 km. away from Cochin barmouth and the feeder source connected the main backwater body only indirectly, the tidal amplitude was not up to the mark in the area, the gradient oscillated between 40 and 60 cm. Yet, the peculiar design of canals and favourable position of sluice gates helped to maintain a satisfactory tidal flow during exchange. However, frequent pumping was necessary to retain sufficient water level in the fairly deep (1-1.5 m) farm. Eventhough pumping could only build up 7-8 cm. more increase in water level owing to the higher depths, it facilitated circulation of more oxygenated water especially during critical period between 2.00 A.M. and 6.00 A.M. -- the most important single aspect in shrimp pond management. Furthermore, daily replenishment @ 30% water by tidal and pumping processes was quite efficient in removing metabolites considerably, getting rid of stress factors associated with it. Thus the synergistic effect of all the above aspects resulted in the enhanced shrimp production @ 1170 kg/ha/ crop which was a record in the present series of investigations.

However, at Mundapuram (E), the water intake and exit functioned at diametrically opposite points (Fig. 11). Further, the continual use of the 9 paddle wheels for aeration (Plate XVII B) which was never used in other cases also enhanced the water in motion. With these perfections, the most successful crop of P. monodon @ 2.4 tonne/ha was achieved during high density farming eventhough water column was maintained only at 70-75 cm with a daily exchange rate of $< 25\%$.

Nandakumar (1982) noted, 25% of water level in coastal ponds, going down per day due to seepage and evaporation and hence pumping of sea water was necessary to maintain the pond water level around 0.75 m.

One way to prevent seepage is by excavation of ponds in such a manner that the pond bottom is at a level lower than the substratum of the source from where water is drawn. Alternately polythene film lined ponds can be used (Lalmohan and Nandakumaran, 1982).

Optimal level of oxygen can be maintained in the pond water by the development of indigenous contrivances for aeration.

Atmospheric oxygen can be diffused into the water in windy areas by planning the lay out in such a way that the pond water is exposed to maximum wind action (Plate XVIII B).

One of the pre-requities, for efficient water management at minimal expense, is regular monitoring of various parameters.

Proper water management warrants maintenance of optimal level for dissolved oxygen in the medium, taking into consideration all aspects leading to oxygen depletion. P. indicus has been found to tolerate as low as 1.49 ml oxygen per litre.

In the extensive grow outs where small quantities of feed are used due to low stocking rate, management of water qualities is made easy by regular water exchange. Daily feeding rates of 40 or 50 kg/ha would result in unacceptably low dissolved oxygen in pond water (Boyd, 1989). This may even lead to mortality, diseases, poor growth rates and low FCR. This can be overcome by the use of artificial aeration devices.

Aeration

Shrimp farmers use tidal flow and diesel pump (Fig. 9&10) to circulate freshly oxygenated water and to flush out wastes from their extensive and semi-intensive ponds respectively. In addition, all the intensive farmers and semi-intensive farmers use paddle wheel (Fig. 11) (low cost) and aspirating aerators (high cost) and electromechanical devices that add oxygen to the water. Also, simple, non mechanical systems that can be maintained with unskilled labour and which can break up temperature stratification are in use. These blower type aeration deliver air to the bottom of the pond through a net work of pipes and tubes.

Ghosh et al. (1987) have confirmed the advantage of installing simple indigenously developed aeration devices in farms for maintaining optimal dissolved oxygen level aimed at increased yields.

As the level of culture intensifies, water management becomes critical with waste accumulation. To a certain extent, an efficient plankton and feed management can reduce the level of waste production. Yet measures for reducing the balance waste and resuspension of sediments are required. Aerators or circulators can help in the resuspension of sediments for removal through water exchange.

3.1.8 Harvest and post harvest technologies

Successful shrimp culture is planned in such a manner that harvest period tunes with high market prevalence for the product. Usually, a sample of shrimp is checked before harvest for synchronous moulting to avoid tainted flavour. If a high proportion of the sample is soft shelled, harvest should be delayed for a day or two to avoid this fragile stage when the product is easily damaged.

In general, shrimps are selectively harvested in our country using a large mesh seine (Plate XXV A) by which method most of the large shrimps are caught. Similar selective harvesting is practised by Japanese also when more than one age group is stocked into the same pond. However, Japanese stocked the pond with additional small shrimps. But, at the traditional filtration fields, this was not usually done resulting in availability of more natural food for the remaining stock. According to Hirasawa (1985), selective harvest of large shrimps allows additional room for smaller shrimps. Probably, this can be the reason for the success of shrimp filtration fields in Kerala.

Multiple harvesting was the method adopted in all the traditional shrimp fields. In the seasonal shrimp filtration fields eventhough operations started during November, initial filtration began at different periods between November and January depending on the location of the field and nature of management. In all cases, sluice gate filtration using suitable bagnets (Plate IV A) was the main harvesting method employed during thakkoms. In general, filtration was usually restricted to only one or two favourable days adjoining the full moon or new moon days as the case may be especially during earlier thakkoms.

In the perennial field at Thrikkadakapilly filtration was carried out during all the 21 thakkoms comprising 154 days within 10 months culture period, where as filtration was restricted to 10

PLATE XXV

A - Harvest - use of seine

B - Cast netting for sampling

thakkoms in the modified traditional fields at Pooyapilly and Kuzhupilly. Since the traditional field at Nayarambalam was far away from the mainstream leading to poor seed recruitment, the filtration was practised during the last 7 thakkoms occurring between January and April months.

In the case of improved fields, owing to the delayed induction of seed, filtration was carried out only on minimum number of days limited to 6 thakkoms between January and April at Ayyampilly and 9 thakkoms between December 88 and April 89 at Narakkal.

Filtration was the only method of harvest practised at Thrikkadakapilly, Pooyapilly and Nayarambalam where as other methods such as cast netting (Plate XXV B) and hand picking (Plate XXVI A) were also employed in the extensive field at Kuzhupilly and improved fields at Ayyampilly and Narakkal. Filtration process could catch the entire shrimp yield at the former three places. However, only part of shrimp yield accounting to 53.02, 58.83 and 76.01% was obtained in the latter three fields respectively. In general, shallow fields of the former series showed better performance in the filtration process. With increasing depth, a dwindling trend in shrimp catch by filtration was quite evident with the notable exception at Thrikkadakapilly. Positively, this field being fairly deep and perennial, all shrimps could be collected by way of filtration, only because of the prolonged nature of operation lasting for 10 months. Moreover, the tidal gradient prevailing in the area being very high, it was possible to entrap all shrimps in the filter bag nets at one time or another during the almost year round operation.

Besides, in the latter three fields, the share of shrimps obtained by cast netting (Plate XXVI B) was 35.76, 31.36 and 16.65% respectively against the corresponding figures of 11.22, 9.81 and 7.34% attained during hand picking.

The quality of shrimps obtained through filtration was superior to those of other methods. Lesser quality shrimps were collected by cast netting where as medium quality shrimps were available through hand picking in all cases.

Perennial and extensive fields at Thrikkadakapilly and Kuzhupilly produced a sizeable quantity of shrimps of large size (> 15g). This can be due to the relative increase in the depth of fields and also the prolonged culture duration promoting the shrimps to acquire better sizes. Above factors are given due significance while leasing out the fields for commercial shrimp farming.

In the traditional and modified fields, metapenaeids and small ones dominated over that of P. indicus (Plate XXVII A). On the contrary, the selective seed induction adopted could enhance the share of P. indicus production to the level of 92.7% at Ayyampilly and 70.7% at Narakkal leaving only negligible percentages for low prized shrimps. A matter of concern is the premature sacrifice of a large number of undersized ones owing to the strictly restricted farming season in the traditional fields.

In Kerala, due to relatively low tidal gradient, no impairment of quality was noticed after filtration while in Malaysia a large number of shrimps are damaged or killed by high water pressure.

In the group B, experimental culture ponds, harvesting was done both by cast netting and hand picking (Plate XXVI A). Filtration was not practised.

Complete harvest was accomplished in different manners such as - 'on a single day', 'continuously for three days', 'on two days at an interval of 4 weeks' and 'daily harvesting continued during the last two weeks'. Cast netting (Plate XXVI B) was done after retaining minimum water level by ebbing. Water was completely drained by pumping for hand picking.

PLATE XXVI

A - Harvest - Hand picking

B - Harvest - Cast netting

Harvesting was done in a day in all compartments at Narakkal on 80th day, in the ponds at Puduveypu on 85th day and canals at Pallithode on the 89th day.

At Narakkal Harijan farm harvesting was done on two occasions by cast netting at an interval of 4 weeks. First harvest after 10 weeks realised 82.5% and 2nd harvest after 14 weeks collected 17.5%.

Cast netting by 4 persons at Chalippuram catching 1273 kg (98.87%) of *P. monodon* (Plate XXVII B) in 4 days was the most efficient technique, leaving only 14.5 kg (1.13%) for hand picking. Complete draining accomplished within a fortnight also enabled to pick up the negligible percentage of intruder shrimps such as *P. indicus* and metapenaeids from the farm.

Selective harvesting by cast netting of *P. indicus* > 5g was practised daily at Cherungal from 45th to 60th day taking care to return the younger ones into the farm. During the first week, while the quantity of shrimps collected was @ 15-20 kg/day, it was gradually raised to 25-35 kg/day during 2nd week thereby collecting 52.44%. Rest was harvested on the 60th day by cast netting followed by hand picking. In all, 77.22% of the yield was collected by cast netting and 22.78% by hand picking.

At Karumancheri, two crops were raised in the same farm in two different seasons in an year. During the first crop, *P. monodon* raised within 115 days was harvested by cast netting for three days followed by hand picking after complete draining of water. The second crop of *P. indicus* (Plate XXVII A) was harvested in a single day after 87 days. Cast netting followed by hand picking was employed as above.

Planned and nonselective harvest was accomplished within 5 days at Mundapuram (Group E) after 120 days of farming. Since water management was at will in this semi-intensive farm, 95% of the *P. monodon* (Plate XXVII B) was bagnetted through drain gate during

PLATE I

A - Shrimp post-larvae

B - Post-larvae under hapa rearing

favourable ebbing time. The rest was collected by cast netting (Plate XXVI B) and hand picking (Plate XXVI A) along with complete draining.

The continuous harvesting Indian method as opposed to the batch method of foreign countries mainly warranted additional harvesting labour adding to variable cost. However, the method of selective harvesting is very much important in temporate countries where they have to keep post larvae in small ponds until favourable temperature conditions set in.

On account of the differences in handling after harvest, there occurs a price advantage of farm raised shrimps over ocean caught ones. Further, disposal of shrimps after harvest was not a problem at any time owing to the evergrowing export demand.

Since many bidders came forward in search of shrimps during harvest time, the need for post harvest technology is limited at the farm gate. In all cases, the harvested shrimps were cleaned, categorised and graded according to prevailing market trend. At times, shrimps obtained through filtration during odd horus at night were properly iced and kept ready for disposal. All categories of shrimps were sold at competitive rates on per kg. basis at farm gate itself realising maximum unit price. Nevertheless, the rate of shrimps varied much, depending on the season of operation and also location of the farm. Since shrimps of better quality and facilities for post-harvest processing were easily available, relatively high rates for shrimps were realised at farms in Vypeen island than at other places.

3.1.9 <u>Growth studies</u>

The ultimate aim of studies carried out by way of a series of experiments (Group A to E) is enhanced production of shrimps from unit area. This in essence means increased growth rate by length and weight on a per day basis with least mortality which is the cumulative effect of a number of biotic and abiotic factors. Any shortfall in the interaction of above factors is likely to be detrimental to the desired out put as happened in the 'E' series of the present investigations. Hence the growth measurements are of significance in any sort of studies pertaining to culture systems.

A critical review of the literature indicates paucity of comparable data due to their diversified nature, eventhough many deal with growth aspects. Also majority has not made any attempt to relate growth increment with that of production. Hence in the present series of growth studies, the growth increment data are correlated with respect to the culture systems, as well with that of other studies.

Shrimp culture studies in the traditional fields (Group A1-A6) indicated occurrence of quality P. indicus with higher mean growths (15.44 g/129.5 mm) and (15.25 g/130.5 mm) in the deep and extensive fields at Kuzhupilly and Thrikkadakapilly where as the lowest mean growth (12.58 g/121.1 mm) was noticed at the exclusive traditional field at Nayarambalam. Rest three fields designated as modified traditional and improved exhibited a mean growth of 13.65 g/122.5 mm to 14.08 g/123.1 mm (Table 9). The present data based on the 'unique' filtration technique practised in the study area are not comparable with data from other areas owing to the autostocking process adopted in seed recruitment. Also, studies on P. indicus indicated that growth rate varied considerably in the estuarine waters from place to place and in different environments, probably depending on the food availability and prevalence of favourable environmental factors.

George (1974) recorded a model size of 126-130 mm for P. indicus from seasonal fields and 136-140 mm from the perennial fields of the study area. George (1975) recorded a monthly mean growth of 15 mm for P. indicus in a paddy field where as Paulinose et al. (1981) obtained 19.0 to 30.4 mm during January - February period in cage culture at Cochin. In the traditional pokkali fields of Vypeen, Gopalan et al. (1982) recorded a growth rate of 1.71, 1.02 and 1.13 mm/day when harvested at the end of 4, 8 and 12 weeks attaining a model length of 84 mm (3.76 g) 93 mm (5.35 g) and 117 mm (11.22 g) respectively from an initial mean size of 36 mm (0.272 g).

The experimental growth studies of P. indicus (Table 18) carried out in 5 grow outs (Group B) revealed that the highest growth rate in terms of length and weight was associated with the pokkali fields at Narakkal (0.166 g/1.31 mm) and Karumancheri (0.155 g/1.356 mm) where as the lowest (0.088 g/0.7 mm) was at the newly excavated farm, Narakkal. But even following the same stocking density, feed and other management aspects, the growth rate of 0.108 g/0.8 mm attained at Puduveypu was very much inferior when compared with the pokkali fields at Narakkal. However, at Cherungal, the higher growth rate (0.11 g/1.61 mm) per day noticed was on account of the shorter culture duration limited to 60 days.

Nandakumar (1982) carried out three experiments in the culture ponds at Mandapam during 1978-79. P. indicus at a stocking rate of 5 nos/m^2, with supplementary feed (clam meat and minced fresh trash fish @ 10% of body weight) showed a growth rate of 0.62 mm/day for 158 days where as those fed with natural food elements produced by application of inorganic fertilizers (urea and superphosphate in the ratio of 4:1 @ 100 kg/ha) grew 0.64 mm/day for 78 days. At the end of 158 days, the mean was 0.30 mm. These rates are higher than those observed by Hall (1962), Subrahmanyam (1968) and George (1975) for P. indicus and compare well with the growth rate of P. monodon in the culture ponds at Philippines (Delmendo and Rabanal, 1956) and of P. indicus in cage culture (Rajendran and Sampath, 1975) and at Narakkal (CMFRI, 1978). Sampath and Menon (1975) noted a growth rate of 0.99mm/day in P. indicus during the 95 days of cage culture with artificial feed. George (1961) recorded a faster daily growth rate of 1.39 mm in the brown shrimp P. azetecus from the estuaries of Louisiana (USA). Nandakumar (1982) recorded a growth rate of 0.482 mm/day for P. semisulcatus on par with P. indicus as observed by George (1975).

Kunju (1978) observed a direct relationship between growth of shrimps and the amount and quality of feed required. Slower growth rate due to non availability of proper food after 60 days was reported for P. indicus (Sampath and Menon, 1975). Rajendran and Sampath (1975) noticed better survival and growth rates and Sampath and Menon (1975) found faster growth in P. indicus which were given artificial feed in cage culture in Kovalam. Nandakumar (1982) noted reduced growth rate after 78 days for P. indicus without supplementary feed. Siddharaju and Ramachandra Menon (1982) estimated average growth of P. indicus during cage culture at Kovalam, to be 18.5 mm/month and 29.8 mm/month in 120 and 90 days rearing respectively, where as in the natural environment of Kovalam backwaters, monthly growth ranged from 15 mm to 28 mm (CMFRI, 1975). P. indicus recorded a highest growth rate of 24 mm/month in the backwaters of Madras.

P. indicus post larvae with an average length of 42 mm when stocked @ 100/m^2 in Adyar estuary, grew to an average length of 81.4 mm on the 110th day resulting in a yield of 400 g/m^2 (Natarajan and Jalaluddin, 1982).

Jose et al. (1987) observed that P. indicus post larvae of initial size 15 mm when stocked in Vytilla pokkali fields at a density of 3/m^2 grew to a mean size of 93 mm (4.5 g) in 36 days with 74% retrieval. Similarly, when post larvae of 14 mm (11 mg) size, stocked @ 6/m^2 in the pokkali fields at Narakkal and Edavanakkad in Vypeen island attained mean size of 130 mm (14.2 g) and 126 mm (13.5 g) in 83 and 90 days respectively.

Comparative studies on the growth of P. indicus (Table 33a) in 6 sets (Group C) carried out at Puduveypu exhibited differential growth gains with respect to treatments. The salient observations are presented below.

Two different sets of experiments (C1&C2) with varying stocking densities showed that stocking @ 1 lakh/ha was satisfactory for the production of quality P. indicus (6.494 g/83.9 mm and 7.74 g/55.5 mm).

Table 33 a

COMPARATIVE DETAILS OF EXPERIMENTAL CULTURE OF PENAEUS INDICUS IN MINI PONDS AT PUDUVEYPU

Sl. No.	Type of culture system	Stocking density no/ha/(no/m^2)	Initial size g/mm	Growth gain g/mm	Type of deed	Type of water managment	Culture duration days	Production rate kg/ha
C1.	Mini pond	1,00,000 (10)	0.029/16.2	6.494/83.9	Commercial pellet	Tidal + pumping (25-30% exchange)	93	430.95
	"	1,50,000 (15)	"	4.785/76.6	"	"	"	541.67
	"	2,50,000 (25)	"	4.826/77.6	"	"	"	511.36
C2	Mini pond	1,00,000 (10)	0.848/53.0	7.74/55.5	Cowdung manure and pulverised feed containing fish meal detritus,goc and tapioca flour in 4:3:2:1 ratio	Tidal + pumping (25-30% exchange)	70	516.00
	"	1,50,000 (15)	"	3.424/32.5			"	432.00
	"	2,00,000 (20)	"	2.074/21.7		"	"	373.00
C3	Mini pond	1,00,000 (10)	0.155/28.0	2.179/42.3	Baffalo dung	Tidal + pumping (25-30% exchange)	60	-
	"	"	"	3.145/50.8	Cowdung	"	"	-
	"	"	"	3.287/52.3	Poultry droppings	"	"	-
	"	"	"	2.259/47.2	Control	"	"	-
C4	Mini pond	1,00,000 (10)	0.386/39.8	3.631/44.0	Feed 1	Tidal + pumping (25-30% exchange)	42	-
		"	"	5.145/58.0	Feed 2	"	"	-
		"	"	4.226/49.4	Feed 3	"	"	-
		"	"	3.822/50.8	Cowdung manure	"	"	-
		"	"	2.443/33.6	Control	"	"	-
C5	Mini pond	1,00,000 (10)	0.030/17.7	12.671/104.5	Feed 1	Tidal + pumping (30% exchange)	85	360.00
		"	"	9.146/94.9	Feed 2	"	"	306.00
		"	"	11.721/99.6	Feed 3	"	"	284.00
		"	"	12.074/100.0	Feed 4	"	"	298.00
		"	"	7.264/88.0	Feed 5	"	"	174.00
		"	"	3.677/65.7	Control	"	"	120.00
C6	Pumpfed pond	4,00,000 (40)	0.006/6.0 (hatchery)	3.464/81.5	Crushed clam meat	Pump fed (70% exchange)	90	800.00

Table 33 b

COMPARATIVE DETAILS OF EXPERIMENTAL CULTURE OF PENAEUS MONODON IN MINI PONDS AT PUDUVEYPU

C7	Earthern pool	2,50,000 (25)	0.010/10.0 (hatchery)	1.498/49.2	Crushed clam meat	Seepage water oscillating between 30-50 cm level	28	-
		"	0.010/10.0 (wild)	2.448/59.4	"	"	"	-
C8	Mini pond	27,000 (2.7)	2.211/68.4	41.924/103.6	Cowdung manure + crushed clam meat	Tidal + pumping (30% exchange)	150	600.00

Of the two types of feed used in the culture of P. indicus, formulated feed (C2) was found superior to the commercial feed (C1) at a stocking density of 10 per m^2.

Of the three manures used (C3), poultry dropping and cow dung were seen highly effective to promote P. indicus growth (3.287 g/ 52.3 mm and 3.145 g/50.8 mm) compared to buffalo dung (2.179 g/42.3 mm).

Among the different feeds with varying energy contents (C4&C5), the feeds consisting of fish meal or shrimp meal along with other ingredients having high energy contents (Feed 1&4 in C5) were found best to promote the growth of P. indicus.

Experimental studies at Puduveypu demonstrated a higher yield of P. indicus (800 kg/ha) in the pump fed pond (C6) over that of tidal ponds (241.0 kg/ha).

Similarly, the following inferences were drawn from the results of pilot studies on P. monodon (Table 33b) undertaken in mini ponds under natural turbid water conditions at Puduveypu.

Experimental studies on P. monodon at Puduveypu (C7) indicated superiority of wild fry over that of hatchery fry.

Clam meat when fed to P. monodon juvenile (C8), the growth size achieved was remarkable.

Further, as presented in Table 34, the comparative analysis of the experimental studies on P. indicus in tanks (D1-D5) brought out the following conclusions.

In the experimental studies in cement tanks (D1), clam meat fed P. indicus showed better growth.

TABLE 34

COMPARATIVE DETAILS OF EXPERIMENTAL CULTURE OF PENAEUS INDICUS IN TANKS AT PUDUVEYPU

Sl. No.	Type of culture system	Stocking density no/ha(no/m^3)	Initial size g/mm	Growth gain g/mm	Type of feed	Type of water Management	Culture duration days
D1	Circular cement tanks	5,00,000 (50)	0.112/27.4	3.366/55.6	Crushed clam meat	Pumpfed water filtered through 100 µ sieve (70% exchange)	60
	"	"	"	3.203/53.2	Pellets	"	
	"	"	"	2.566/48.2	Control	"	
D2	Circular cement tanks	8,50,000 (85)	0.196/32.2	1.502/31.9	Pellets @5% of body wt.	Pumpfed water filtered through 100 µ sieve (70% exchange)	42
	"	"	"	1.936/36.9	Pellets @10% of body wt.	"	"
	"	"	"	0.943/23.5	Control	"	"
D3	Oval shaped fibre glass tanks	2,00,000 (20)	0.030/17.7	3.737/66.9	Locally made compounded feed @ 5-10% of body weight	Pumpfed water filtered through 100 µ sieve (50% exchange)	42
	"	4,00,000 (40)	"	2.380/57.6	"	"	"
	"	6,00,000 (60)	"	1.725/46.5	"	"	"
	"	8,00,000 (80)	"	1.237/41.9	"	"	"
D4	Circular cement tank	10,00,000(100)	0.789/49.2 (juvenile)	2.467/32.8	Crushed clam meat @ 8-10% of body wt.	Pumpfed water filtered through 100 µ sieve (70% exchange)	56
D5	Circular cement tank	80,00,000(800)	0.128/24.2 (fry)	0.723/26.5	Crushed clam meat @8-10% of body wt.	Pumpfed water filtered through 100 µ sieve (70% exchange)	56

P. indicus when fed with pellets @ 10% of body weight grew better than @ 5% (D2).

The growth rate of P. indicus cultured in the fibre glass tanks (D3) was inversely proportional to the stocking density.

Experimental stocking of 100 juveniles/m^3 and 800 fry/m^3 of P. indicus (D4&D5) was not proved successful since the mortality in either case was exceeding 70%.

It is generally believed that using high density stocking (100/m^2), the lower survival rate can be balanced. But during the present study series (Group C & D), after scrutiny of the data, it is found that lower density helps for higher yields. Similar study in Thailand showed maximum profitability in intensive shrimp culture at a stocking rate of 20-30/m^2 with an average daily gain of 0.27 g (Asian Shrimp News, 1st Quarter, 1992).

The P. monodon shrimps grown in brackish water ponds at Madras (Venketesan and Bose, 1982) attained an average size of 154.5 mm and a weight of 25.7 g in 90 days at a stocking density of 25000/ha and 129.5 mm and 14.4 g in 90 days at a density of 40,000/ha. The results indicate high growth rate at low stocking densities. Sundararajan et al. (1979) suggested an optimal density of 20,000 P. monodon as optimum when they obtained an average weight of 32.26 g in 80 days. Chen (1976) reported a growth rate of 40 g in 90 days rearing at lower stocking densities of 5000 to 8000/ha in Taiwan when shrimp and chanos were cultivated.

P. monodon showed a rapid growth rate of 25 mm/month in the younger stage, but the growth rate slowed down considerably as the animal attained adulthood (CMFRI, 1975).

But, 15 mm (20 mg) post larvae of P. monodon stocked @ 22.5/m^2 in the semi-intensive culture farm at Mundapuram (Group E) attained a mean size of 150 mm (28.0 g) within 120 days registering a mean growth rate of 34 mm (7.0 g) per month. Also P. monodon post larvae (22 mm/ 0.030 g) when stocked @ 6.8/m^2 at Chalippuram attained a mean size of 155 mm (28.0 g) in 107 days, the monthly mean growth being 37.3 mm (7.842 g). Thus Chalippuram growout presented the best growth rate among the studies carried out.

3.1.10 Economics of shrimp farming as revealed through case studies

One of the serious constraints in the studies regarding economics of shrimp farming is that comparisons and conclusions are made difficult due to the wide variations in culture practices, shrimp species selected and the regional variations in climate. Quite often, the rate of production in an area is given as metric tonne/ha/yr without specifying whether it is a seasonal farm where only one crop is possible or a perennial/scientific farm where more than one crop/year is feasible. Also reliable economic data on actual commercial production are scarce.

Hirasawa (1985) analysed in detail the economics of shrimp culture in Asia, based on the type of production systems, investment costs and the present and expected future markets. He suggested the need to reduce the cost of cultured shrimps because of severe competition in the market. According to him, the intensive pond system will face extinction, since it is difficult to cut production cost, in case the cost of shrimp falls down. Hence, he has advocated the extensive and semi-intensive farming methods by which shrimps can be produced at low cost.

Shang (1983) made a general survey of shrimp farming in Asian countries, Ecuador and USA to show the variation in costs and returns. According to him, the average gross revenue per unit area of monoculture farms growing tiger shrimps is about double that of polyculture farms growing the same shrimps together with milksfish and crab. He further reported that the average return on operating costs ranges from 11 to 118% indicating that all farms were profitable. The lowest returns were from places where labour costs, capital investments and management costs were high. This was confirmed by Griffin et al. (1985) who found the internal rate of return from a 200 ha farm in Ecuador to be 2.8 times that of similar one in the USA with high variable costs.

Jhingran (1977) working out the cost of production and projected unit economics by experimental culture operations observed that a net return of Rs.30000/- was feasible through shrimp culture in brackishwater ponds in West Bengal.

Shrimp culture and its economics were dealth with through 16 papers presented during the first National symposium on shrimp farming (MPEDA, 1980). The results were found sufficiently realistic and indicative, but not perfect owing to variations in capital investment from place to place. Based on their studies at Ratnagiri, Raje and Ranade (1980) indicated that the lowest rate of profit @ 30 to 35% was quite attractive.

Reddi (1980) demonstrated the economic viability of fish and prawn culture in the salt pans in Kakkinada area. The economics of a 0.78 ha farm with a single wooden sluice gate, located in the vast "gazani" areas of N. Kanara district (Karnataka) following the traditional practice of trapping and holding, in stocking the farm was worked by Pai et al. (1982). The entrepreneur, with proprietory rights over the farm, even assuming that rent, 15% interest on capital investment and recoupment of capital were allowed, got a net profit of 80% return on the capital. George (1980) observed in the Pokkali fields of Vypeen, Kerala that it is possible to have 2 harvests in the seasonal fields and 3 in the perennial fields thus making it more remunerative.

The author in an earlier case study (Gopalan et al., 1980) on the economics of an improved method of paddy field shrimp culture in

Vypeen island found that the amount of profit was directly proportional to the quality of shrimps like P. indicus and inversely proportional to the quantity of other species realised. Further the results showed that the improved method of operation incurring more initial expenditure was economically more advantages than the traditional one.

Jose et al. (1987) working out the feasibility and economic viability of selective culture of P. indicus in pokkali fields, recorded a production of 552 kg/ha/83 days and 382 kg/ha/90 days at Narakkal and Edavanakkad, yielding a net profit of Rs. 3958 and Rs.8250 respectively.

The author in a recent study (Purushan, 1987) concluded that by structural modifications of the traditional farms and inductions of healthy fry at large, quality shrimp can be produced, thereby raising economic returns.

Economics studies on semi-intensive shrimp farming at Nellure, TASPARC farm and certain other farms in Andhra Pradesh (Surendran et al., 1991; Haran et al., 1992 and Viswakumar, 1992) are the latest in this series.

All the above studies have confirmed the wide variability of investment and production costs in different areas.

In all the 6 case studies carried out by the author in the traditional fields (Group A) there were variations in the average lease value per unit area. The lowest lease value @ Rs.4,370.37/ha was at the modified traditional field at Kuzhuppilly and the highest rate of Rs.14,450/ha at the improved field at Ayyampilly. The lease amount was the major cost component in all cases ranging from 35.29% at Narakkal to 55.32% at Nayarambalam (Table 35a). The next cost component was that of labour which was highest (41.42%) in the modified traditional field at Kuzhuppilly and lowest (23.96%) in the traditional field at Nayarambalam. The expenditure components of seed induction in respect of improved fields at Ayyampilly and Narakkal were 4.65 and 14.31% respectively, where as other four fields were devoid of additional expenses on seed component, since they were run by autostocking processes alone. The expenditure component towards operation was the lowest (4.97%) at the improved field at Ayyampilly against higher figures above 10% incurred in modified traditional fields at Thrikkadakapilly and Kuzhupilly and in the traditional field at Nayarambalam. The cost component towards sluice gates constituted between 3 and 8% with the low and high figures seen at Kuzhupilly and Pooyapilly. The expenditure of net items also varied similarly within the range of 2.8 and 6.4%. The feed and sundry items were the lowest cost component in all the 6 cases.

The cost of shrimp production/kg. was the lowest (Rs.16.25) in the modified field at Pooyapilly (A2) and the highest (Rs.30.95) in the improved field at Ayyampilly (A5), the respective values in other places remaining in between. In general, along with increase in quality shrimp yields, the cost of shrimp production was higher at improved fields than at modified traditional fields with low production costs. In this context, it is worth pointing out that being poly culture systems, the substantial amount realised through disposal of fishes and other components has helped to reduce the production cost of shrimps. But on account of high demand of the field and concomittant increase in lease amount, the cost of shrimp production at the traditional field (A1) was also higher with out much difference from that of improved fields. However, a moderate cost of production prevailed at the large extensive field at Kuzhupilly in spite of spending huge amount towards labour. It is evident from the study that relatively low lease rate and large size were factors favouring low cost in production of shrimps.

The level of profit was seen related to the extent of modification adopted in the farming practice. In the present studies, only marginal profit of 5.84% was realised at the exclusively traditional field (A1) against a fairly good margin of 31.79% and

19.25% attained in the improved farming practices at Narakkal (A6) and Ayyampilly (A5) respectively. Absence of quality shrimps and the low productivity rate generally lead to low profit in traditional field (A1). The margin of 26.53% obtained from the modified field at Kuzhupilly (A4) was indicative of the worthness of the larger size of field in the extensive practices, eventhough there was slight increase in the cost of shrimp production. However, the generally improved quality of the produce could surpass the increase in cost of production on comparison with fields at Thrikkadakapilly (A3) and Pooyapilly (A2). On the whole, it is quite clear that modifications in the structure of traditional fields and induction of seed together play an effective role in improving the quality and quantity of yield having its positive impact on economic gains in shrimp farming. Purushan (1987) in an earlier communication has pointed out the prospects of enhanced shrimp production from traditional fields.

In the case of group B series (B3 to B7), the expenditure towards seed, feed, labour and other operational aspects - the major cost components - varied very much according to the level of management technology adopted (Table 18). But in contrast to group A fields, the lease value was not accounted except for the one at Cherungal (B6). Further, the grow outs being scientifically managed, substantial cost was met towards seed and feed which was rarely required in group A. Labour constituted the highest component (25-35%). While the cost of feed varied between 13-35% that of seed ranged between 8.4 and 30.0% depending upon the species and type of feed. Among other operational aspects, the regular pumping resorted for better water management and circulation incurred added expenditure as exemplified at Chalippuram (B5) and Cherungal (B6).

The economic analysis revealed that return on investment (ROI) was related to the species and type of management technology adopted. The profit level was infinitely low in those farms where P. indicus was farmed where as huge profit margins were realized with P. monodon (Table 18). However, an exceptional performance during the farming of

P. indicus with 125.04% (R01) was seen at Karumancheri (B7b) against the very poor margin of 13.53% (R01) at Narakkal Harijan Farm (B3). Eventhough the relatively high profit of 38.73% (R01) realized at Cherungal was not matching with that of Karumancheri (B7b) it has indicated chances of realising more short duration crops within favourable season.

In respect of P. monodon farming, the highest profit of 236.61% (R01) was achieved at Pallithode (B4) followed by 191.61% at Karumancheri (B7a) and 76.87% at Chalippuram (B5). Even though, the former two cases were seen very much remunerative apparently, the quantum profit realization was low due to their smaller extent. On the contrary, the huge profit margin @ Rs.76649/ha realised at Chalippuram (B5) made it all the more attractive on comparison with others. This success can probably be on account of the innovative technology and the manageable size of the unit, as well.

In the semi-intensive farm at Mundappuram (Group E), highest expenditure was incurred on feed (43%) followed by wages. The seed cost constituted 12.11% against 11.5% for farm preparations. Almost 12.92% was spent on other expenses including lease value, farm maintenance and depreciation on capital expenses, where as, only 7% was incurred for fuel. However, the farming resulted in a profit of Rs.52312.79/ha which worked out to 16.9% return on investment (Table 32b).

Data collection for aquaculture economic studies

A reliable estimation of parameters warrants collection of data from a sufficient number of farms in order to explain the output variations through a production function.

Data on inputs, output, prices and costs can be obtained from:

1) many aquaculture farms for a single production cycle

2) one farm for numerous production cycles or

3) many farms over time - the most desirable but rarely available one.

These data types are respectively cross-sectional data, time series data and time series of cross section (Garrod and Aslam, 1977). But, what is done is analysis of cross sectional data collected in record keeping farms from randomly chosen production areas.

Economic justification

The change in trend towards more intensive management of shrimp farms is important from an economic point of view. The duration of growing season is relatively short in Kerala restricting to summer months between November and April. Cost of land or lease charges and pond construction costs are on the increase year after year (Table 35a). So to be competitive internationally, culture facilities available must be highly productive and efficient during the short growing season. In economic terms, the proportion of fixed costs relative to variable costs (ie. seed, feed and energy) must be reduced by increasing production rate. But the annoying part is that variable costs are always on the increase, making it impossible to produce beyond a certain level.

The bestway to reduce the high fixed cost is to convert the farms as intensive/semi-intensive as practised in countries like Taiwan and Ecuador. But, it has got considerable limitations in our farming situations. Usually the paddy cum shrimp filtration fields in Kerala are leased out at rates depending upon fluctuating market trend which varied from Rs.4370.37 to Rs.14,450/ha. compared to the land costs of over $2500/ha. in Ecuador and $2.5 to 5 lakh/ha in Taiwan (Anon, 1987). As a result of variations in the lease amount, it is not easy to determine standard cost for each farm in India. Eventhough on a per ha basis, expenditure is relatively low in Kerala owing to the leasing practice, the production cost is fairly high on a per kg. basis because of the reduced yield. In fact, the unhealthy competition prevailing to take over the field on lease contribute much to the total cost of production in Kerala regardless of the factors associated in its operation. Lack of proper management aspects and general nature of impoverished back water conditions do not help to attain higher yields in traditional systems. More often the dwindling yield (Purushan and Rajendran, 1984) fluctuates from field to field and in the same field from season to season. However, owing to the high unit price, shrimp culture is found 3 to 5 times more profitable than paddy culture.

The sad part regarding intensive farming is that the variable costs are on the increase. The naturally available feed, aeration through tidal processes and good quality water made use of in extensive systems must be supplemented at higher levels of intensification of the technology. The quality and quantity of natural food organisms available in the fields/ponds is reduced with increasing density necessitating to supplementary feed of high cost. The cost of shrimp production mounted up very high at the semi-intensive farm at Mundapuram (group E) compared to the most successful extensive farm at Chalippuram (B5).

As costs of variables rise, the intensive management is less profitable per kg. but the sheer increase in number of kgs. can improve profitability on a per ha basis as seen successful in countries like Taiwan. But such hitech practices are not yet developed or found feasible in the agranian set up of our country. But recently, a joint effort of Kingfisheries, Kollam and MPEDA, Kochi has been reported to achieve production @ 2 tonne/ha./100 days of quality P. indicus from traditional fields at Ezhupunna by way of semi-intensive farming (Anon, 1992). Still encouraging was the record production @ 2.4 tonne/ha/120 days attained in a semi-intensive farming at Kannur during 1992, the details of which are presented under 2-4-E of the study.

In the case of Taiwan/Ecuador/Kerala example, it is more profitable to make $0.50/kg on 12000 kg/ha ($ 6000/ha) than $ 2/kg. on 500 kg/ha (Anon, 1987). The production from Indian farms remaining at an average level of 538 kg./ha through our extensive farming practices, the per ha gain can be on par with that of Ecuador, but far below from what Taiwanese have attained.

In this context, it is worth noting the significance of extensive farming of P. indicus, realising still higher production @ 677 kg/ha and 622.44 kg/ha at Cherungal (B6) and Karumancheri (B7b) respectively, within short duration. Still more fascinating was the record production @ 1170.45 kg/ha attained at Chalippuram (B5) in the case of P. monodon with high economic return.

A comparison between the most successful farms at Chalippuram (B5) and Mundapuram (E) showed that the highest profit margin was achieved at Chalippuram where indigenous farming technology using local feed dominated by clam meat and additional water cirulcation by pumping was practised (B5). A disadvantage of the semi-intensive farm (E) was that the exceedingly higher cost of imported feed, the avoidable managerial cost, the superfluous use of aerator devices etc. added the production cost considerably (Table 32b). Hence, even with the highest production, ie @ 2.4 tonne/ha, the semi-intensive farming technique did not cope with the highest economic returns of the indigenous technology practised at Chalippuram (B5).

The data presented in Table 35b shows that shrimp production costs went up with the level of technology followed. While Rs.126/- was spent to produce one kg P. monodon in semi-intensive manner (group E), it was between Rs. 27.24 and 85.19 during the extensive farming (group B4, 5 & 7a). In the case of P. indicus it varied between Rs.15.72 and 27.66 per kg (B3, 6 & 7b). More or less similar was the cost of production of P. indicus in traditional fields (group A) as already discussed (Table 35). The data clearly denoted that while the expenses due to additional feed supply and water management added up the production cost in the extensive grow outs, it was the spiralling lease value which determined the same in traditional fields.

In a comparative study at 5 farms adopting three different practices in Andhra Pradesh, Viswakumar (1992) estimated 14 fold increase in cost of production between extensive farming with supplementary feeding and semi-intensive farming. Also the operational profit indicated a 10 fold increase while the net profit per kg of shrimps produced decreased from Rs. 50 to 24.87 correspondingly.

Experiments on intensive culture of P. japonicus (123/m^2) conducted by Shigueno (1975) in Japan revealed the possibility of harvesting a crop at a rate of 2.26 kg/m^2 in 180 days. According to Mock (1973), an intensive culture at a stocking density of 156/m^2 yielded a production of 0.7 kg/m^2 in closed race-ways in 63 days. Even in the case of "Shigueno Style" super intensive system in Japan which produced about 20,000 kg/ha/crop it had financial crisis as a result of increased energy costs. It is worth remembering that supply of shrimps are on the increase as aquaculture continues.

The aforesaid being the trend in shrimp production, it is quite likely that there may occur a price reduction of shrimps in international market proving detrimental to the hitech shrimp farming countries at high costs (Hirasawa, 1985). Even in such situations, there lies immense scope for the well managed extensive shrimp farming practices in Asia followed by India, the endeavour always keeping a positive cost-benefit margin. Cost forcast for cultured shrimps seems to indicate that extensive and semi-intensive method will become dominant in the Asian region. The present low productivity of the systems can be greatly improved by proper management techniques.

In this background, the most sensible approach for shrimp farmers of central Kerala appears to be moderate improvement from extensive production levels of 500 kg./ha/crop by way of quality seed induction, supplementary feed application and a more judicious water management in culture systems.

TABLE 35 a

THE COMPARATIVE DETAILS OF OPERATIONAL ECONOMICS OF SHRIMP FARMING IN DIFFERENT LOCATIONS ALONG VYPEEN, ISLAND, KOCHI.

Location/ Details	Nayarambalam	Pooyapilly	Thrikkadakapilly	Kuzhupilly	Ayyampilly	Narakkal
	1	2	3	4	5	6
Extent of field (ha)	2.38	0.8	1.6	20.25	3.0	2.25
Period of operation	11/88-4/89	11/88-4/89	6/87-4/88	11/86-4/87	11/87/4-88	11/88-4/89
Lease rate/ ha (Rs.)	7615.55	8125.0	10937.5	4370.37	14,450	8222.22
Expenditure(Rs)						
Lease value(%)	18,125(55.32)	6500(44.70)	17,500(47.25)	88,500(41.53)	44,250(51.43)	18500(35.29)
Labour including fishing charges.	7,850(23.96)	4625(31.73)	12,090(32.64)	88,274(41.42)	24,646(28.64)	16550(31.57)
Sluice gate	1,450(4.43)	1175(8.06)	1,250(3.37)	6,500(3.05)	3,975(4.62)	2350(4.48)
Seed	Nil	Nil	Nil	Nil	4,000(4.65)	7500(14.31)
Feed	Nil	Nil	450(1.22)	1,569(0.74)	1,500(1.74)	800(1.53)
Canoe, net etc	1,700(5.19)	925(6.35)	1,675(4.52)	6,000(2.82)	2,589(3.00)	1950(3.72)
Operational	3,450(10.53)	1200(8.23)	3,925(10.60)	21,500(10.09)	4,275(4.97)	4275(8.15)
Sundry items	190(0.58)	150(1.03)	150(0.40)	750(0.35)	810(0.94)	500(0.95)
Production cost of shrimps/ kg (Rs.)	26.63	16.25	16.87	18.81	30.95	28.39
Income(Rs)						
Shrimps(%)	29688.3(85.60)	14735.30(87.41)	41301.40(93.57)	250881.50(93.05)	101798.5(99.21)	63346.5 (91.69)
Fishes (%)	4565.25(13.16)	1967.00(11.67)	2461.25(5.58)	17638.25(6.54)	285.0(0.28)	5267.2(7.62)
Miscellaneous(%)	425.00(1.23)	155.00(0.92)	375.00(0.85)	1100.00(0.41)	525.0(0.51)	475.0(0.69)
Profit (+)						
Return on Investment(%)	105.84	115.66	119.16	126.53	119.25	131.79

TABLE 35 b

THE PRODUCTION COST AND VALUE REALIZATION OF P.INDICUS AND P.MONODON IN DIFFERENT FARMING SYSTEMS UNDER GROUP B AND E

	Penaeus indicus			Penaeus monodon			
Farm Location	Narakkal B-3	Cherungal B-6 *	Karumancheri B-7(b)	Pallithode B-4	Chalippuram B-5	Karumancheri B-7(a)	Mundapuram E **
Production cost (Rs./kg)	22.81	27.66	15.72	27.24	85.19	31.43	125.99
Value realization(Rs./ kg)	25.21	33.37	37.64	83.52	149.93	91.68	147.29
Profit(Rs./kg)	2.40	5.71	21.92	56.28	64.74	60.25	21.30

* Pumping   ** Pumping and aeration

Thus, adaption of an extensive type indigenous farming technology as found successful in the case of P. indicus at Cherungal (B6) and Karumancheri (B7b) and for P. monodon at Chalippuram (B5) for enhanced production and better economic return assumes greater significance.

With reference to an individual acquaculturist, instead of optimum input levels based on an estimated production function, he needs location specific advice. A technology package may make sense in one area where the input/output prices reveal marginal returns greater than marginal costs. In another area, it may be the reverse because of location specific differences.

Researchers have attributed the success of viable shrimp culture system to the optimum utilization of various inputs. The identification of input levels which are significant in explaining variation in the output from various culture centres are reported by Smith (1981). The significant inputs in a shrimp culture system (£ or the explanatory variables) are the stocking density, supplementary inputs (feed, fertilizer, pesticides etc), labour (hired and family), managerial expertise, environment factors (soil, pH, water salinity etc) and the technology used. The input-output relationship referred to as production function is of paramount importance for the cost benefit analysis of any system.

The due attention bestowed in all these aspects in the series of investigations under group A, B and E have contributed much to the production increase and better economic return. Although the production cost remained at reasonable levels in the traditional (A) and extensive (B) farming practices, it soared up high in the semi-intensive (E) farming. While in groups A and B, maximum profits were obtained at low levels of input use and output, it did not hold true in 'E' even maximising production owing to its increased reliance on costly imported feed, surplus use of aerator devices and managerial expenses.

Often low profits are the result of poor FCR due to the indiscriminate feed supply. Viswakumar (1992) analysing the impact of varying FCRs on net income per kg production in different farming practices (extensive, improved extensive and semi-intensive) showed that variation in FCR has the least influence on profits in the case of extensive farm where as it is the maximum in the case of semi-intensive farm.

For the cost - benefit analysis of culture system, the estimation of production function identifies the inputs that influence the product yield and shows the efficiency of inputs applied.

Many production economists have expressed that these production estimation methodologies are primarily of interest to policy makers only and that it would be unwise to use production function to advise farmers on input levels. Also it is very difficult to make any sensible comparison. In this context location specific studies are more relevant as there exists wide ecological as well as input/output price differences between culture areas.

Shrimp farm management

Of late it was realised that the key to successful aquaculture is not just availability of adequate technical knowledge, but it depends on efficient farm management even in a small scale farm. Huguenin and Colt (1986) have defined the managerial process as the ability to organize and implement an aquaculture technology which is a complete combination of technical, economic, marketing, social and political elements towards some specific goals. In this context, the technology most appropriate to local conditions evolved, taking into consideration, various social economical and ecological aspects, stands most relevant towards fulfilling the objective. Furthermore, adoption of such an intermediate technology will enable the producer community to step into more sophisticated technology in due course.

Webber and Riodan (1979) pointed out that "new problem areas are engendered and many of the old problems become more critically significant" as small scale fish farms owned and operated by single family units primarily for subsistence or at least for a small cash crop, evolved into large scale agri-business enterprise incorporated and conducted for economic profit. Management consists of the application of scientific laws and principles to the conduct of farm activities.

Most of the present day aquaculture farms in India are too small to afford a manager. However, situations are taking new dimensions in our country with the entry of big companies in the field of aquaculture. A well beginning has been indicated in Kerala too, under the joint auspices of MPEDA and other firms (Anon, 1992). Hence, the semi-intensive farming technology worked out as part of the present investigations at Mundapuram (E) attaining a production of 2390 kg/ha/4 months for P. monodon with 16.91% return on investment will be a forerunner in this direction.

3.2 SYSTEM APPRAISAL

3.2.1 Strength, prospects and opportunities

Index of successful farming and economic impact depend upon its profitability and in terms of jobs, animal protein and foreign exchange created. The significance of shrimp farming is that it can easily become the most valuable renewable protein resource (Wisely, 1975).

India is estimated to have nearly 1.4 million ha of brackishwater area all along the coast in the form of lagoons, creeks, tidal mud flats, estuaries, mangrove swamps etc. The natural ingress of tidal waters upto 1 m in these areas is really a boon to coastal aquaculture.

In general, during the last 40 years India has made some progress in the field of brackishwater shrimp culture such as

a) breeding and propagation of commercial species.
b) study of abundance of naturally occuring seed and establishment of seed banks.
c) nursery management
d) appropriate crop sequence
e) feed formulation for intensive farming
f) survey and selection of suitable sites for farms
g) development of designs for sluices and dykes in relation to topography, tidal amplitude, tidal flow and soil types.
h) development of basic designs and lay out for farms, necessitating further refinements and improvements.
i) development of silt traps to check siltation of ponds.

In addition, the strength of the industry is contributed by the following factors.

a) availability of infrastructure facilities specific to each area
b) existence of localised talents in farming
c) profusely available and exclusively skilled low cost labour
d) scope for increased production through intensification of modern technology
e) preference of cultured shrimp over captured ones owing to improved quality
f) much export demand with high profitability
g) dynamic interest of private entrepreneurs leading to import of technology and adoption to local conditions through modification
h) keen interest shown by central and state governments for shrimp culture even by arranging financial support from foreign agencies.
i) leadership of the Indian shrimp industry backed by nodular agencies like MPEDA, BWFFDA etc.

Thus well suited climatic condition, relatively unpolluted water sources and availability of fast growing tropical species attract the involvement of different talents, since aquaculture still is "an art by itself" rather than a technology".

The first positive aspect is that because of the high price of shrimps it can become profitable at a relatively lower level of technology than for other aquatic species as fish.

Another positive aspect is that most shrimp farms can be built using marginal land for traditional aquaculture. This means that shrimp farming provides additional economic return to the country without reducing production of agricultural crops. In addition to the coastal land, the marginal land includes any land having ground water of adequate salinities (Recent developments in Nellure,Andhra Pradesh).

Kerala is blessed with 2,42,000 ha of brackishwater area suitable for shrimp culture in contrast to limitation of space in terms of water and land for the establishment/expansion of aquaculture in other countries.

The special features that render Kerala backwaters well suited for brackishwater culture are:

a) availability of extensive areas of rectangular shaped paddy cum shrimp filtration fields with firm perimeter bunds, having adequate slopes varying from 2:1 to 4:1, to aid water flow through sluice gates during tidal water exchange.

b) the large extent of coconut groves and unfertile paddy fields available can be suitably converted to farming at low cost.

c) low tidal amplitude making it possible to use relatively simple dykes and bunds.

d) low prevailing temperature and high humidity that reduce evaporation loss maintaining favourable salinity during season.

e) location outside the cyclonic belt obviating possible risk of damage to the farm dykes and bunds.

f) a tradition of filtration which has proved the commercial prospects of shrimp culture.

g) existence of established trade channels for selling the products to external markets.

h) availability of technically competent work force.

3.2.2 Weakness, threats and constraints of shrimp farming

By making an ardent survey of literature, it was possible to understand the weaknesses, threats and constraints hampering the progress of shrimp farming.

The current production constraints may be classified as technical and non technical, each category encompassing several factors.

Technical constraints

a) **Limited introduction of engineering innovation in pond design and management**

Though shrimp culture is seen gradually extending in the study area, it was peculiar to note that the farmers do not give much attention to this aspect. The water management - maintenance of proper exchanges - requires innovative technologies similar to those developed at IIT, Kharagpur involving huge capital investment.

Similarly absence of proper drainage especially central drains for waste removal during water exchanges adds to the above.

b) **Lack of technicians**

Insufficient strength of skilled staff who are able to design pens, culture cages, embankment protection devices, sluice boxes, inlet and outlet water arrangement of shrimp culture systems and feeding equipments etc. hamper the development.

c) **Seed availability**

Guaranteed availability in time and in required quantity of quality seed of potential species collected from wild or produced through hatcheries by bio-technological processes contributed to the success of shrimp culture in many S.E. Asian Countries, where as, insufficiency of seed continues to prevail in our country on account of the following reasons. Against the requirement of 3 billion (300 crores) shrimp seed in India for converting atleast 1 lakh ha of potential brackishwater areas as culture ponds practising culture at extensive, semi-intensive and intensive levels in 75, 20 and 5% areas respectively, only 0.5 billion (50 crores) seeds are available.

Over fishing in coastal waters resulting in depletion of spawners leading to reduced recruitment of wild fry is a factor to reckon with. Post larval and early juvenile stages of shrimps have traditionally enhanced the catches for subsistence of fishermen, but the growing trade in seed shrimp will have an adverse effect upon these catches and will also reduce recruitment of adults to the inshore fishing grounds. Further, the methods currently used for collecting seed, leave much to be desired. For every kg of P. monodon seed collected, as much as 10 kg of fish fry and shrimp seed of other species is discarded with a heavy mortality rate. This wanton destruction of juveniles is bound to be reflected in smaller inshore adult spawners and a reduced fishery yield.

Research carried out for improvement of culture species through genetic studies and breeding are at the infant stage.

Lack of proper breeding in captivity of potential species and non-existence of viable hatcheries coupled with high mortalities of fry remain as a critical factor.

Absolute lack of a gene pool and knowledge of artificial insemination for continuous supply of fry.

Lack of research in genetic engineering for production of disease resistant fast growing shrimps with high survival rates for better market value.

The constraints in the traditional practice of trapping cum holding are the severe limitation of low production, poor quality and growth, uneconomic varieties and above all the menace of predators.

d) **Non availability of quality feed**

Successful shrimp farming very much depends upon the application of efficient, complete and inexpensive feeds suitable for each stage in its life cycle. But in India non availability of such formulated feed, bestowed with required biological and physical qualities continues. Compared to a maximum production rate of 33 to 40 tonnes/ha/year achieved in many south east Asian countries, even to double the Indian average production from the present 538 kg/ha/yar, we are forced to import high energy quality feed. The point here is that the cost of good quality feed (Plate II A) often accounts more than 50% of total production cost.

Even when some supplemental feeding is resorted, same type of feed is given through out, against the normal requirement of starter, grower and finisher feeds for different phases of growth of shrimps as practised in other places.

Of late, a factory with technical assistance from Japan has been set up to produce annually 12000 tonnes of quality feed at

Kuthiathode in Kerala. Of the 20 ingredients, required for feed making five are imported (Mathrubhumi, 7.2.92).

e) **Lack or inadequacy of required inputs other than feed**

The lacunae noticed in the management operations due to inadequacy of inputs are the following.

Lack of studies on optimal culture conditions, Pesticides to control pests and predators, Fertilizers - organic and inorganic, Essential facilities such as water pumps, blowers and aerators, Non availability of equipments required for monitoring water quality, Non availability of infrastructure facilities for adequate water exchange and aeration leads to oxygen depletion due to metabolic waste accumulation.

The shrimp body being composed of 80% water, the role of aeration as a donar of oxygen for growth is of paramount importance.

It is reported that on an average 25% increase in crop value can be expected by the use of paddle wheels for aeration as demonstrated at Ezhupunna during February, 1992 and at Cherukunnu between February and June, 1992. Lack of aeration reduces rate of food conversion. However, this could not be practised in the study area except at Mundapuram (Group E) because of low water column, the loose nature of substratum and non availability of electricity.

f) **Environmental stress**

Estuaries are major coastal resources subjected to a great deal of environmental stress. Man's intervention in the environment by way of (1) construction of harbours (2) dredging for navigational purposes (3) regulating fresh water flow through construction of dams for irrigation purposes and (4) discharging waste products from industries and cities situated in their vicinity affect the coastal estuarine system to varying degrees. As the need for the above increases, the ecosystem dynamics is adversely affected necessitating greater importance to water quality management to protect the biological resources including shrimps.

The natural ingression of high tidal water is really a boon to coastal aquaculture. Since paddy cultivation is given more importance during previous years, strong bunds and barricades have been constructed to prevent the saline water entry into the interior areas during high tide from the sea. In Kerala, the Govt. constructed the spillway at Thottapilly in 1955 and a barrier at Thanneermukkom in 1974 in Vembanad lake for checking the intrusion of saline water in order to raise 2 to 3 crops of paddy in an year. Such actions have really damaged the entire ecosystem destroying the fishery resources of the coastal area. The unscrupulous developmental activities taken place, in Cochin backwater have considerably reduced its size in area and volume having detrimental effect on survival of shrimps (Gopalan et al., 1983).

g) Impairment of water quality due to aquatic pollution

The degradation of water quality due to pollution threats consequent to discharge of domestic, agricultural and industrial wastes to backwaters used for aquaculture is on the increase as reported in the Vembanad lake during 1991 owing to lack of awareness and limitation of protection measures.

Mass mortality is caused due to lowering of habitat conditions such as low pH, oxygen deficiency, excessive turbidity, eutrophication etc. beyond the tolerance limits of cultured organisms.

As intensification leads to accumulation of micro-organisms in crowded aquaculture environment, mortalities can occur due to bacterial or viral infection. Similar conditions also occurred in the inland ecosystems of Kerala during 1991 leading to large scale fish kill.

h) **Lack or poor understanding of the suitable technology**

There arises the need for applied or practical training in aquaculture practice, due to

i) inadequacy or lack of properly trained managers, technicians and skilled labourers.

ii) lack of a multipronged strategy of education, extension and financing required to transfer the research achievements to the farmers, eventhough breeding and culture techniques are being transferred to the farmers hither and thither.

iii) lack of awareness of farmers even to adapt to the indigenous technology available and

iv) lower level of understanding of management and proper execution of shrimp culture projects.

The current aquaculture practices are primarily an "art". The artisanal nature makes transfer of technology difficult, underlining the need for a base, provided by practical experience in this field. The success of development plans in Aquaculture in Asia depends upon the methodology of delivery of information properly disseminated. The expertise can be developed only through excellent co-operation between researchers and commercial producers.

i) **Unpredictable yield levels**

The geographical remoteness affecting availability of quality water and seed reflects on production very much.

One of the set backs confronted with the farmers in Kerala is that irrespective of the type of farming, production varies from crop to crop or pond to pond and even from one individual site and or facility to another similar to experiences pointed out by Smith (1981) and Apud (1988). This is because of the alternating/reversing monsoonal influence. As such, it is difficult to design a standard shrimp farming method for Kerala.

j) **Energy crisis**

Energy crisis owing to non availability of electricity for the operation of water pumps and other installations create impediment in shrimp culture development.

The problem farmers encounter, is lack of a sufficiently strong organisational base which could undertake developmental work on long term basis. Creation of a task force to achieve this will be a welcome step.

k) **Constraints in harvest**

In the absence of aqua engineering information on harvest technology and post harvest handling and storage facilities, the bulk of aquaculture produce is forcibly marketed at the production centres at a very low rate sustaining loss to the farmers.

l) **Financial crisis**

Lack of finance to instal sophisticated equipments in different levels of operation does not favour farming community. Non availability of the high overhead expenses to be incurred by farmers on easy terms and low interest credit for development and operation.

m) **Foreign technology**

Over and above all, import of culture technology poses a great threat when indigenous technology is in the offing.

Non technical constraints

Extension of aquaculture activities into low lying areas inundated by tidal waters is likely to harm the paddy crop sustaining loss to agriculturists. The continued failure of crops also will throw agricultural labourers out of employment affecting their livelihood eventhough the endeavour is much more remunerative to other sections. Naturally conflicts between agriculturists, agricultural labourers and aquaculturists arise and continue to exist assuming different dimensions depending upon the regional situation.

Land used for aquaculture should be fertile, clayish and with good source of water on par with paddy cultivation requirements leading to conflict of interests.

Conflict in the utility of land and water resources needed in aquaculture hampersyear round shrimp culture in potential paddy fields.

Legal and institutional constraints such as obtaining licences for shrimp farming.

Lack of adequate extension services by institutional agencies is a matter of concern. Although there are few specifically designated agencies as MPEDA, KVK and BWFFDA to cater to the needs of shrimp farmers, there are no statutes or laws enacted in this regard.

Socio-economic and political constraints resulting from impounding of open back water bodies depriving opportunities for fisher folk in meeting their livelihood.

Usually aquaculture areas are occupied by socially backward communities. These backward people won't be in a position to raise the needed capital for aquaculture ventures. The poor security conditions and law and order in these areas can hamper development. These require modification by government as has been successfully resolved along the Chilka lake in Orissa. The modern concept of satellite shrimp farming is a welcome step in this regard.

There are also conflicts regarding use of coastal and inland waters used for fishing with that for aquaculture.

Dead lock due to non allotment of land to fishermen eventhough their life is intimately entwined with fishery activities adds to above.

3.3 THE TECHNOLOGY

(Ecological, Social and Economical considerations for indigenous technology, implications of intensive farming and the technology in detail)

3.3.1 Major Ecological considerations

Shrimp farming results of the present study showed general increase in production rates depending on management intensity, so do cost. It was found that the choice of the appropriate management system for a given farm is dependent on many site specific factors, particularly the higher lease value of the land, cost of pond preparation and other inputs. As such, extensive pond management is appropriate in Kerala owing to the vast existing impoundments where new investment is minimal. Also availability of vast areas of brackish water sites favours extensive culture in Kerala compared to Srilanka where farming sites are highly limited forcing farmers to go for intensification. A more productive management system can be thought of only when new ponds are constructed along coastal areas at high costs involving modern technology. However, it is doubtful, how far such system can economically function against deteriorating environmental conditions of the backwater system, energy crisis etc.

In Kerala on par with Ecuador, Brazil and Thailand, one is fortunate enough to locate enough coastal property/previously constructed impoundments, ie. the low yielding (300 kg/ha/crop), natural extensive systems as most appropriate compared to United States with relatively high costs of suitable land, also demanding highly productive management systems. It is possible to push up the yield in India by maximising production at little extra care.

Recent studies showed that the low tidal amplitude prevailing along the study area has got its limitations to support high density farming. Also, the silt laden turbid water conditions associated with clayey substratum act as decisive factors. An alternative to the above is to switch over to intensification taking advantage of the ground water resource. However, in the wake of acute scarcity of drinking water consequent to lowering of ground water level, this should be done with caution.

It is often found that intensification can be a failure as observed during 1988 in the case of better and more sophisticated technology developed by Taiwanese (Anon, 1989). Taiwanese shrimp production was reported to have gone down dramatically due to a variety of climatological and technical reasons like over crowding resulting in environmental stress which in turn weakened the shrimps making them more susceptible to diseases. The dominant virus (MBV) at times become virulent causing the hazards. What is certain is that such widespread occurrence of diseases can be avoided by resorting to low stocking rates.

A similar mortality problem hit the high-tech shrimp farm in Srilanka by a virus leading to its closure within 2 years of its operation. Similar instances were reported from Philippines also. In 1990, shrimp farming industries in Ecuador, Thailand, Indonesia and

China contributed to environmental problems (World Shrimp Farming, 1990). Same time, it is worth noting that no such instances have been recorded in the past in the study area. Hence it is advisable to opt for extensive farming with less environmental impact.

Commensurate with intensification, there arises the need for the timely supply of enormous quantity of quality shrimp fry. In the present situations, it may not be possible for the hatcheries functioning at suboptimal levels to meet the requirements.

Intensive farming demands high energy quality feed which is not locally available, but has to be imported at high cost. This situation compels the shrimp farmers to opt for an indigenous technology where supplemental feed prepared from cheap and locally available materials can serve the purpose.

3.3.2 Social considerations

The likely socio-economic benefits of biotechnology in the Third world are positive in terms of increasing productivity of tropical commodities. Despite several remarkable achievements, in India the improved methods are slow to reach the producers, primarily due to weakness in extension. Development of more intensive methods is also hampered by a contradictory land use/land lease policy. In Kerala, subject to the prevailing land rules, shrimp culture can be undertaken only after the paddy harvest, during the post monsson period from November to April. The major constraint is regarding ownership of the field being vested with the paddy farmers mostly and the shrimp farming being practised by a different set of contract farmers who take possession of the farm by public auction on a seasonal basis. Eventhough there are chances of converting certain ideally located filtration fields exclusively for shrimp farming for the whole year, the existing land utilization policy of the government restricting the conversion of paddy fields to raise other crops, it would appear that round the year shrimp culture under the existing frame work may not be a practical proposal in the study area. Thus the traditional shrimp culture practices in Kerala evolved through generations having their inherent unproductive tendencies can be altered only to a limited scale in the present situations.

Also with the advent of modern innovations, it can be noticed that the traditional aquaculture fishermen who are poor and illiterate are found displaced by a set of new people (entrepreneurs). Until job guarantee is ensured by law, the modernisation can be practised with caution alone. Government of Tamil Nadu has formulated a land leasing policy to allot coastal saline lands for shrimp farming for a period of 10 years, soon after layouts and environmental clearance are obtained.

Under this policy 60% of the area available estimated at 800 ha will be allotted to target groups, 20% will be allotted to medium and small scale entrepreneurs and the remaining 20% land will be allotted to large scale entrepreneurs. The lease rent per year will be Rs. 25/ha for target groups, Rs. 100/ha for small and marginal farmers, and Rs. 250/ha for medium and large scale entrepreneurs.

A similar policy if adopted in Kerala will give opportunities to continue the extensive new technology evolved in the study by the traditional farmers where as the few large scale entrepreneurs can switch over to sophisticated technologies depending on their capabilities as demonstrated at Mundapuram (Group E) during the present study.

Large scale destruction of potential mangrove areas for pond construction resulting in impoverished coastal waters, reduced production of domestic food fish by culture, saline intrusion making agricultural lands fallow, dependence on hatchery fry for stocking against the labour intensive natural fry collection, lesser number of man power for management, monopoly of capitalists and deprival of chances of employment to farmers and fisher folk are the disadvantages associated with intensification of high-tech shrimp farming. To engulf such negative aspects for the mere increase in the production of export earning shrimps at a lesser cost-effective ratio cannot be afforded by India in fulfilling the national goal of offering food and avocation to the teeming millions. In this situation it is doubtless to say that extensive farming with better management is the only alternative to augment shrimp production taking maximum advantage of labour and vast potential areas available in our country. In this context, the easily adaptable rural technology evolved seems to have more relevance in the socio-ecological situations prevailing in Kerala. This will also contribute much to promote social equity and environmental conservation as pointed out by Primavera (1989).

3.3.3 Economic consideration

According to Chandrasekhar (1987), the traditional culture in Kerala is advantageous from the view point of farmers, as it involves only limited investment. In the traditional system of shrimp production, the production cost is minimal when operated by the owner of the field as revealed through the case studies under group B series. However, often the field are leased from owners for shrimp growing and the value of the lease is relatively high (group A). This influences the net return from shrimps to a major extent.

From the point of view of owner himself operating the field, the income from shrimp production will be doubled as otherwise, the field will remain fallow only (group B5). In the rotational culture, this adds to the income of the farmer and is a more efficient use of land and farm resources (case study group B7).

A review by Csavas (1988), forecasted production of 8 lakh tonnes of cultured shrimp in Asia much earlier than 2000 AD if the present trend continued. The growth curve for India is expected to reach 50000 tonnes provided, the 4 basic phases of the curve - development, growth,maturity and decline follow the general rule.

In the above context, it is worth preferring a culture practice by reasoning, giving due regard to all factors. According to Hirasawa (1985), most of those who are using semi-intensive methods, can easily survive a 20% price decrease whi e the same decrease would drive into the red all of the intensive ventures which are operating with a high profit per unit of culture area, but, with a narrow profit margin per volume. Owing to a narrow profit margin per area often depended upon fluctuating export market prices of high density farms, in the final analysis it is preferable to accept lower production levels with lower production costs and higher quality of the product - extensive culture.

So it is worth advisable to select a particular intensity of culture whose production can be adjusted to the demand during the declining phase of industries development. The less intensive shrimp farming methods are also supported by economic considerations in addition to ecological and social causes.

After making a cost benefit analysis of various shrimp farming systems, Hirasawa (1985) has proved the advantage of extensive farming over sophisticated methods anticipating its capacity to tide over the crisis in case an economic regression takes place for shrimps in export market.

Silas et al. (1988) pointed out the importance of shrimp farming for the economic rehabilitation of the rural poor as successfully demonstrated at Chilka lake. This was possible by the political decision during 1982-83 to apportion small units of peripheral land in the Chilka lake bed for shrimp culture to the poor under the main schemes, viz. The Economic Rehabilitation of Rural Poor Programme (ERRP) and an Area Development Approach Programme (ADAP) under the overall aegis of Brackish water Fisheries Development Agency. In the absence of such promotional programmes in Kerala, farmers have to content with the extensive farming practices only.

3.3.4 The technology most appropriate to the study area - the Central Kerala - in the prevailing conditions, based on the studies undertaken.

Importance of indigenous technology

The importance of modified traditional/improved/scientific extensive shrimp farming is because of the social, ecological and economic trade-offs. Also this is necessitated by the national mandates of social equity and environmental conservation.

It is necessary to establish a ratio of food crop-to-cash crop area based on biological, socio-economic and ecological criteria. Shrimp production should not be at the sacrifice of paddy crops. Economic success should not take precedence over nutritional success.

As early as 1983, the Seafdec Aquaculture Department has called for a diversification of culture species and markets in anticipation of a global slump in prices (Primavera, 1983). This also substantiated the need to control the mad rush to intensify farming resorting to foreign technology when our country is facing economic crisis. According to Hirasawa (1985), many farmers are after the total profit per hectare rather than the profit per kilogram. In other words, many shrimp farmers have joined a mad race for the greatest profit in the short time, mindless of the social, environmental and economic costs.

Any genuine development must show, over and beyond economic profitability, a responsiveness to society's needs and a soundness that will not threaten environmental resources. In short, in our farming situations only the technology advocated by the author can satisfy all the three criteria of ecological, economical and social concern to fulfil the promise of sustainable development for present and future generations.

A search on the types of rural technologies available in India revealed that whatever technologies in vogue are extremely location specific and hence most difficult to be transplanted. Regarding the question on what type of technology India can ask for from the International agencies, it can be safely concluded that owing to difficulties in land leasing systems and lack of finance, no foreign technology is worth acceptable to the traditional farmers of India.

With the development of the new technology appropriate to local situations, it is possible to raise 3-4 short term crops in the growout ponds in the prevailing enviornmental conditions making use of the more or less disease resistant 30-50 mm size fast growing juveniles of P. indicus and P. monodon and inexpensive feed resulting in higher survival rate. Furthermore, one of the advantages of this technology is that adequate care was taken to keep the construction cost of shrimp farms as low as possible in order to make it within the reach of rural farmers.

The technology explained

Location

Site selection is the foremost ecological factor. Ideal location of the farm with respect to its proximity with open brackishwater body (direct access) or nearness to barmouth is considered well suited for shrimp farming purposes. Availability of good quality tidal water and the prevalence of a realtively sufficient tidal amplitude ranging between 50 and 80 cm will help adequate shrimp larval entry and efficient water exchange. The important physico-chemical properties of water such as pH, temperature, salinity, dissolved oxygen and alkalinity should be within the range of 6.5-8.5, 26-32.0°C, 15-28.0‰, 3.0-6.0 ml/l and 30-300 mg/l respectively. Such desirable characteristics of water occur in places where the tidal water supply is direct. Soft clay - soil, rich in organic matter provided ideal substratum for the growing shrimps and forage organisms in traditional shrimp farms. Also a firm bottom composed of sand and clay with overlying silt free and nutrient rich tidal water having a transparency level varying between 20 and 35 cm, measured with a secchi disc, will be very fertile. This can generate live feed organisms such as zoophytomatrix and benthic organisms promoting better shrimp growth and production.'

Preparation of the field as a habitat and not a trap

The structural modifications carried out within the farm, without disturbing the bottom characteristics much, by way of removal of excessive silt, paddy stumps and algal assemblages and excavation of canals of various dimensions depending on farm extent, could generally increase the water holding capacity.

About 6 to 10% of the total extent can be converted as sluice/catch basin with a depth of 2 to 4 metres, depending on the size and location of the field.

Major canals radiating from sluice basin should be 2 to 3 metres deep with a net work of minor canals ranging from 0.5 to 1.5 metre deep. This also helps uniform distribution of post larvae entering to every nook and corner of the field. These canals can act as shelter from sun's heat and ensure better feeding ground.

The disposition of required compartments and other arrangements set within, could maintain steady well oxygenated water flow facilitating internal water circulation at required levels.

The increased flow rate and efficient movement of water made possible within the system during entry and exit of tidal water preferably with the help of separate sluice gates could enhance the life sustaining capacity very much. The dykes and sluice gates have to be designed, constructed and fixed depending on the area of the field, tidal range and current pattern of the vicinity. Care has also to be taken to fix the main sluice gate and subsidiary ones facing the incoming tides. Thus, the pond system could be maintained always healthy by removing the metabolites then and there, without getting accumulated thereby avoiding chances of water quality deterioration leading to pollution.

Decaying paddy stumps can produce local anoxic condition which is often detrimental to young shrimps. Also noxious weeds like Salvinia sp, Eichornia sp and excessive growth of floating filamentous algae lead to reduced light penetration. Hence their removal to a certain extent will be desirable for improved production.

Predator eradication

Several methods are employed for the elimination of undesirable species of fishes and predators. Complete draining of the pond and keeping it sundrying for a week will be much beneficial. This will promote the mineralization process by which the complex molecules of organic and inorganic compounds lying at the bottom will become simpler adding to the nutrient enrichment (Hickling, 1971).

Predators, weed fish and pests can be simultaneously eradicated by the application of non selective agents. Toxins from natural products, organochlorides and organophosphates are quite effective. Application of an aqueous solution of 216 kg tea seed cake or saponin with 144 kg quicklime to the pond bottom is effective to get rid of weed and predatory fish as well as snails. Unwanted fishes can also be eliminated by using tobacco dust or nicotine @ 2 ppm. So also Rotenone or derris powder @ 1.5 ppm level will control undesirable fish in shrimp ponds, while @ 20 ppm will be quite effective to kill unwanted fish, the toxicity remaining for 8-12 days (Pillay, 1990).

By applying Mahua oil cake (Bassia latifolia) (Plate II B), @ 2500 kg/ha/1m, unwanted fishes and other vertebrates can be got rid of, within 3-4 hours. However, the poisonous effect of Mahua will be gradually lost contributing to the fertility of the pond. Within a fortnight, the system will become receptive again.

Application of a mixture (1:5) containing 125 kg Ammonium sulphate and 600 kg lime will be sufficient for a hectare, retaining 20-25 cm water column to eliminate predatory fishes within 2-4 hours. The system will be left undisturbed for a fortnight when it will regain stability.

Stocking

Owing to better living conditions prevailing in such culture fields/ponds, it is possible to maintain increased stocking densities of shrimps. Eventhough in traditional systems, shrimp larvae are stocked exclusively through tidal water entry, such processes may not be efficient to entrap enough number of shrimp post larvae in the improved systems where the shrimp holding capacity is greatly increased. Furthermore, precautionary measures adopted to prevent the entry of unwanted species using appropriate screens inside the water entry gate (Plate VI B), will also restrict the autostocking of shrimps very much. Nevertheless, it is possible that some post larvae will definitely get autostocked through the nylon webbing or bamboo screens kept inside the sluice gate while allowing tidal water exchange (Purushan, 1989). A bright light preferably with a red filter fixed at the sluice gate can attract larvae better. Maximum seed can be collected at dawn and dusk hours during high tides with satisfactory gradient. But, aiming a better crop during the season, additional stocking of shrimp larvae/juveniles should be done giving due regard to the management aspects attended to and also the capacity of the farms. These larvae (Plate I A) can either be procured from hatcheries (Plate XXII A) or collected from wild environments (Plate XXI B). It is preferable to introduce uniform sized larvae as obtained from nurseries. In the case of wild post larvae suitable ones may be selected after sorting (Plate VII A), which practice is widely adopted.

Considering the nature of management, additional stocking @ $5/m^2$ (50000/ha) in the case of P. monodon and @ $10/m^2$ (100000/ha) in the case of P. indicus can be easily done. Post larvae are usually released to nursery compartments arranged inside or to nurseries set up within (Plate XII A). After special care and nursing assured in the nurseries, the larvae assume juvenile size quickly when they are let out to the general system.

Retrieval and conservation

Conservation and exploitation of the growth potential of the undersized juveniles can be an important step in the indigenous technology. It is a matter of fact that large number of undersized juveniles are killed during the traditional paddy field filtration process. It is possible to retrieve these undersized juveniles by frequently emptying the contents of the cod end into suitable nursery ponds for further growth. For the above, a nursery pond may be made in one corner of the field by raising temporary earthern units. This deviation from the traditional practice can be an added success.

Often, the short seasonal culture becomes a failure as the natural tidal incursion of seed into the fields is delayed or poor. This can be overcome by timely conservation of destructive juvenile shrimp fishery into a profitable seed resource for shrimp farmers thereby also averting a socio-economic problem(Gopalan et al., 1983).

Supplementary feeding

The farm being kept sundried for a week during preparation time before start of operations, speeded up the mineralization process addding the fertility status of the soil (Hickling, 1962). The basal dose of fertilizers and manures supplied and subsequent manuring practised at periodic intervals corrected the deficiency of nutrients if any in the system maintaining better organic productivity. Also, it has been reported that a very high FCR of even 1:1 can be achieved by the increased reliance on natural feed (Asian Shrimp News, 1st Quarter 1992). Thus successful shrimp culture could be achieved by way of proper plankton management leading to reduced requirement of high cost quality feed.

However, to overcome the shortage of feed in the system on account of additional shrimp stocking, nutrient rich feed made by combining different ingredients or procured from market can be supplied daily @ 3-10% of average body weight of shrimps. Pulverised raw feed composed of vegetable matters or ground clam meat/shrimp head meal can also be supplied in required doses apart from natural forage (Purushan, 1991). In Kerala alone it is estimated that about 25,000 tonnes of supplementary feed would be required in the existing farms, the preparation of which can provide employment for about 5000 people, if it is produced at the cottage level departing from factory based production.

Better water management

Owing to the increased rate of shrimp stocking and consequent use of supplemental feeds, frequent exchange of water is required in addition to maintaining a sufficient water level of 70-100 cm within the culture pond. In many of our farms, desired water exchange or maintenance of sufficient water level may not be possible exclusively depending on tidal processes. This will have repercussions on the shrimp stocked ponds especially when the biomass increases considerably. Such situations will lead to stress conditions due to metabolite release, dissolved oxygen depletion, variations in pH, temperature and such other factors. If not checked properly, the variations in the physico-chemical factors beyond the limit may endanger the shrimp stock within the system. In order to avoid such casualities, it is desirable to instal and use pumping units facilitating adequate water exchange (20-30%) and also to compensate the fall in the minimum water level. Therefore, farms of compact and smaller size are considered better for efficient control and water management.

Growth related to thakkoms

Depending on the type of farming, the growth of shrimps will vary much in the shrimp fields. Since shrimp seed stocking and filtration during thakkoms is a continuous phenomenon in traditional fields, no specific time is allowed for shrimps to grow before harvest. Therefore, size variations in the harvested shrimps can not be ruled out. But, in the semi-intensive farms, shrimps are harvested only after attaining better commercial size within specified period. In an efficiently managed farm, it is possible to grow P. monodon to 30-40 g size within 3-4 months where as shorter period of 2-3 months only is required for P. indicus to attain 12-20 g size.

Harvest Technology

The success of shrimp farming always depends on the efficiency of harvest. The efficient harvesting is to collect the entire stock without damage at minimum cost. Different methods such as sluice gate filtration, cast netting (Plate XXVI B) and hand picking (Plate XXVI A) are employed at different stages in the farming. Usually, in semi-intensive farming most shrimps are cast netted after keeping minimum water level in the ponds with a view to avoid damage to the produce. The remaining shrimps are easily hand picked after draining the pond completely.

But in the case of traditional fields multiple harvesting technique dominated by filtration is the regular practice followed. Since, this culling process provides more living space and food to the remaining stock, it is usual to obtain grown up shrimps by this practice during each thakkom. Nevertheless, cast netting and hand picking are also employed at different stages during the prolonged operation period in order to harvest the stock completely. Because of the protracted harvesting practice and varied techniques employed, marketable sized shrimps are always obtained during the prolonged operation.

Since shrimps produced by the above scrupulous methods of harvest are of better quality, higher unit price is realised for the product at the farm gate. Moreover, the harvest is always tuned at a time when the demand for the commodity is at its peak. These measures of maximising production and return are very much important in the economic view point also, in order to make the shrimp culture a maximum profit realising enterprise in the cost-benefit ratio level.

4. SUMMARY AND RECOMMENDATIONS

4.1 SUMMARY

1. The literature survey in general is an attempt to bring together information till 1992 on the shrimp culture practices carried out in different countries. The review calls for a scientific study on the state of art of traditional practices along with the economics of operation in Kerala.

2. State of art of aquaculture practices is presented under five heads with particular reference to South East Asian countries followed by that of India in detail. The technology adapted within India varied from area to area.

3. The shrimp farming cycles consisting of hatchery, nursery and grow out phases are described.

4. The different types of culture systems in vogue viz. impoundments, pens, cages, tank farms and sea ranching are properly enumerated.

5. The levels of culture in the grow out systems classified as a) Traditional/modified traditional b) extensive/improved c) semi-intensive d) intensive and e) super-intensive are dealt in detail.

6. The levels of culture are related to the following criteria 1) Species used and stocking densities 2) Engineering design and lay out 3) Fertilizers used 4) Food and feeding regime 6) Rearing duration and cropping frequency 7) Quantity and quality of production and 8) Harvest, post harvest technology and marketing.

7. Harvest technology, the most labour intensive operation in a farm included draining, trapping, seining, cast netting and hand picking depending upon the species cultured.

8. Scope of aquaculture is aptly described under eight sub heads.

9. The objectives of the study are clearly spelt out as under 1) to undertake a scientific study on existing practices of shrimp farming in central Kerala 2) to analyse economics of operation at different levels 3) to introduce shrimp culture in the untapped backwater areas 4) to come out with an appropriate technology 5) to carry out experimental growth studies and 6) to study the feasibility of a semi-intensive technology.

10. The study areas extending between Munambam barmouth and Anthakaranazhi and comprising the contractor operated six traditional fields, owner operated seven grow out ponds, six mini ponds, six cement tanks and four fibre glass tanks and the demonstration site at Mundapuram are well described.

11. Particulars of culture species, feeds supplied, manures applied, nets and other accessories used are presented under materials.

12. Methods of pond preparation, seed, feed and water management; harvest, data collection and processing and analytical procedures are aptly described.

13. 27 experimental studies are dealt with in detail. Traditional shrimp filtration in a shallow field at Nayarambalam demonstrated poor economic return owing to its remoteness from the main water body leading to low tidal gradient and consequent poor autostocking (A-1). The shallowness of the field led to enhanced entrapping of juveniles during filtration.

14. Shrimp polyculture in a traditional shallow seasonal field at Pooyapilly demonstrated that modifications like clearing of canals and removal of macro-vegetation along with nearness to feeder canal can raise shrimp yield considerably (1119 kg/ha). The better tidal gradient and concomittant higher autostocking were positive factors in this regard (A-2).

15. Increased shrimp yield (1372 kg/ha) was made possible by compensatory feeding apart from structural modification, perennial nature of the field and proximity to feeder source as demonstrated on shrimp polyculture study in Thrikkadakapilly chal (A-3). Higher depth and prolonged culture improved the quality of shrimps.

16. Shrimp polycutlure in a traditional extensive deep field at Kuzhupilly showed that by way of improvements in canal system, capacity of a field can be rejuvenated leading to increased shrimp yield (500 kg/ha) (A-4).

17. By way of improved practices - deepening of canals, silt removal, clearing of vegetation predator elimination and additional seed induction along with supplemental feeding - it was possible to enhance quality shrimp yield (927 kg/ha) in a traditional shallow field at Ayyampilly (A-5).

18. Similar study when repeated at Narakkal showed a relatively low rate of shrimp production from unit area (821 kg/ha) indicating the impact of location specific factors (A-6).

19. From an economic view point, the additional stocking of wild seed led to high percentages of P. indicus @ 70 and 91 at Narakkal and Ayyampilly, resulting in high profit of Rs.7406/- and Rs.5521/ha respectively. The lowest profit of Rs.804/ha was at Nayarambalam owing to the exclusively traditional practice adopted.

20. The size of extent determined the level of profit in traditional fields. Thus Kuzhupilly with an extent of 20.25 ha, realised a net profit of Rs.56527/- during season, compared to Pooyapilly with an extent of 0.8 ha realising only Rs.2282/-.

21. Experiments using 3 feeds -- pulverised, commercial pellets and natural food through cowdung manuring, conducted in well set compartments of a large shrimp culture grow out system at Narakkal

indicated that pulverised feed containing clam meat promoted better growth and production of P. indicus (402 kg/ha) compared to other feeds (B1).

Similar experiments conducted at Puduveypu in uniform sized independent ponds using above feeds also showed same trend (B2).

22. The yield/ha obtained at Puduveypu was fairly low than at Narakkal eventhough similarities were there in the stocking density, nature of feed, mode of feeding and other management aspects. This indicated that factors other than above, perhaps the accreted environment at Puduveypu is not much condusive for shrimp culture compared to Narakkal (B2).

23. In spite of cowdung manuring and feeding with clam meat, the adverse factors such as low quality water, insufficient water exchange and absence of diverse benthic faunal generation owing to lack of conditioning affected the production of P. indicus (376 kg/ha) at the newly excavated Harijan farm at Narakkal (B3).

24. The differential growth of P. indicus between two growouts at Narakkal (B1&B3) indicated the importance of site selection and conditioning for culture purposes.

25. The suitability of canals in the coconut groves for the successful culture of P. monodon (238 kg/ha with mean size of 40.45 g) in spite of a number of constraints high-lighted the importance of undertaking shrimp culture in such otherwise unused water bodies in the coconut groves (B4).

26. The highest rate of P. monodon production @ 1170.45 kg/ha within 107 days at Chalippuram is a record in Kerala. Also, the realization of a return of 76.87% as profit on investment from the canals of the newly set up coconut garden in the paddy field indicated the worthness of the endeavour (B5). This type of efficiency of the

saline paddy fields for raising substantial quantity of quality shrimps is an eye opener to the farmers possessing similar sites. The transformation of such areas into shrimp farms might open up employment avenues thereby improving rural economy.

27. The growth measurements of P. indicus made during the study at Narakkal Harijan fish farm revealed higher quantum of growth between 10th and 14th weeks (mean size 4.32 and 9.77 g) compared to earlier phase. This could be accounted to the reduced density after 10 weeks as a result of culling (B3).

28. The high density short duration culture (45-60 days) of P. indicus at Cherungal, Thuravoor resulted in the increased production (677 kg/ha) realizing high profit (Rs. 7252/kg) in spite of their under size (5.88-7.42 g). Hence, the significance of short duration culture, facilitating more crops on an annual basis has been highlighted (B6).

29. At Karumancheri, the attempt to culture P. monodon during monsoon was successful yielding 300.38 kg/ha within 115 days. The P. indicus culture in sequence during regular season also resulted in a production of 622.44 kg/ha. This pointed out the possibility of improved yield @ 922.82 kg/ha by rotational culture of P. monodon during monsoon period followed by P. indicus during usual season (B7).

30. Comparative analysis of economics of culture in 5 growouts indicated differential profits ranging between Rs.904 (newly excavated farm at Narakkal) and Rs.76649/ha (Chalippuram) owing to several factors such as site selection, species, type of feed etc.

31. Of the three different stocking densities of 1, 1.5 and 2.5 lakh/ha fed with commercial pellet feed, 1 lakh/ha was found satisfactory in the production of quality P. indicus in mini ponds at Puduveypu (C1).

32. Similar studies using formulated feed and stocking densities of 1, 1.5 and 2.0 lakh/ha also indicated reduced growth rate with increase in stocking density. Again stocking @ 1 lakh/ha was found satisfactory for the production of quality P. indicus (C2).

33. In the series of experiments using different manures such as poultrydroppings, cowdung and buffalo dung, better quality (mean 3.442 g) P. indicus was resulted in the pond manured with poultrydroppings and the least (mean 2.334 g) in the pond manured with buffalo dung (C3).

34. In another set of experiments using compounded feeds 1, 2 and 3 and cowdung manuring, all the feeds showed better growth compared to control. However feed 2 with high energy content demonstrated maximum mean weight (5.538 g) of P. indicus during harvest after 6 weeks (C4).

35. In the experimental series using 5 formulated feeds, the efficiency of feeds was in the order 1, 4, 3, 2 and 5 with respect to the quality of P. indicus. In terms of quantity also, feed 1 (shrimp meal + detritus + goc + rice bran in the ratio 5:2:2:1) proved to be the best (C5).

36. Culture of P. indicus in the pump fed earthern tank system could produce a higher yield of 800 kg/ha/3 months over that of 241.18 kg/ha realised from tidal ponds thereby indicating its advantage (C6).

37. Growth studies on P. monodon fry in earthern pools showed better survival percentage (27.6) and higher growth rate (2.448 g) in respect of wild fry compared to hatchery fry (16.8% & 1.498 g) (C7).

38. P. monodon juveniles attained a mean size of 44.135 g after 150 days when fed with clam meat in a cow dung manured pond (C8).

39. High mortality (43.3 - 60%), stunted growth and microbial infection were noticed among P. indicus reared in cement tanks at

Puduveypu using turbid silt laden natural waters. However, relatively better growth (3.478 g) was noticed when fed with clam meat (D-1).

40. Experimental culture of _P. indicus_ conducted in cement tanks attained only a mean growth of 2.132 g even when fed with commercial pellet @ 10% of body weight (D-2).

41. _P. indicus_ in varying densities when reared in fibre glass tanks recorded retarded growth showing inverse relation with increase in stocking density (D-3).

42. High density culture of _P. indicus_ juveniles (100/m^3) and fry (800/m^3) in cement tanks at Puduveypu experienced heavy mortality (81.36 & 73.52%) in spite of feeding with clam meat (D-4 & D-5).

43. _P. monodon_ farming was successfully carried out in semi-intensive manner at Mundapuram (Group E). However, the farm shape could not conform to the general pattern with many of the essential points typical of a semi-intensive farm due to its original irregular design.

44. Studies on semi-intensive farming of _P. monodon_ (22.5 fry/m^2, imported high energy feed, pumpfed system with 6-25.8% daily exchange and paddle wheel aeration) resulted in a record production of 2.4 tonnes/ha/4 months with a mean weight of 28 g, in spite of the low survival rate of 45%.

45. Analysis of economics of operation indicated realization of Rs.52313/ha with 16.9% return on investment (ROI). However, the high investment requirement of over Rs.3 lakhs/ha involving foreign exchange for feed import will be an impediment in the present socio-economic background of shrimp farmers.

46. Successful shrimp farming being location specific, the right selection of site with reference to species, technology, eco-

characteristics (tidal range, soil texture, topography, water quality, turbidity etc.) and support facilities determined the feasibility of viable operations.

47. The tidal fluctuations of 0.3 to 0.75 m experienced in the study area is too feeble against an ideal fluctuation of around 3 m.

48. The acid sulphate problems were not encountered in fields at Vypeen island where as in other areas - Chalippuram, Karumancheri, Cherungal, Pallithode and Mundapuram its effect was nullified by lime application.

49. The highly turbid silt laden natural tidal water characterised by reduced oxygen level, retarded the growth of shrimps at Puduveypu.

50. The role of environmental parameters in site selection is discussed.

51. *P. indicus* and *P. monodon* were found the most appropriate species for culture in the study area.

52. Importance of design, layout and construction along with size and shape of fields/ponds is discussed.

53. The modern concept of layout, design and construction of culture farm has very little relevance in the study area, as shrimp culture rotates with paddy and the ownership mainly rests with agriculturists.

54. The destined nature of the canals to serve the dual purposes of drainage and feeding in the case of tide fed farms is a serious draw back in the study area.

55. Importance of pond preparation and the measures adopted to maintain stability of pond conditions at a level condusive to shrimp

growth and survival are described. The predominant role of lime in this regard is adequately stressed. The need for predator elimination is emphasised.

56. Live feed generation to a limited extent is made feasible by the addition of manures and fertilizers along with planting of dry twigs for periphyton.

57. Role of water quality parameters such as pH, temperature, salinity, dissolved oxygen, turbidity and siltation in the natural and enhanced shrimp production was analysed in detail. Also, the impact of pollution and other environmental factors like mangrove distribution etc. are discussed.

58. Functional role of environment aimed at evaluation of the cause - effect relationship is analysed in detail in order to identify the factors to be reckoned with, during shrimp farming.

59. On account of profound seasonal variations in environmental conditions, shrimp culture was found feasible only between post monsoon and premonsoon months in Kerala.

60. Seed management studies highlighted the importance of selective supplemental seed induction of wild larvae compared to hatchery ones, in addition to autostocking. Factors favouring an optimal stocking density and larval size are discussed. The need for viable shrimp hatcheries is emphasized.

61. The prevailing ecological conditions, profuse availability of seed and the low production cost favour farming of P. indicus in Kerala. However, restricted farming season led to destruction of a large number of juveniles of P. indicus in traditional practices.

62. Problems encountered in the seed recruitment are discussed.

63. Discussion on feed management is centred around increased production through optimal feeding after selective stocking coupled with improved water quality. The need for preparing cheaper nutritive (high FCR) feed using locally available waste material in preference to expensive formulated feed is stressed. The role of sufficient water exchange to bring in required quantity of natural feed and also the role of natural productivity are analysed in detail. Supplemental feeding helped to pave the way for higher stocking densities.

64. Water management was accomplished taking full advantage of tidal effect only in the traditional fields where as pumping was also resorted in other pond systems.

65. The percentage exchange of water always depended upon the duration and amplitude of tidal processes (30-80 cm).

66. Any improvement in shrimp farming in Kerala over the traditional practice necessitates use of a pump owing to the low tidal amplitude.

67. A daily water exchange of over 15% was made possible by way of structural modifications of the field.

68. The various structural modifications, use of pumps and paddle wheels were found efficient for improved water management.

69. The importance of water management in enhancing living space, maintaining optimal water quality, disseminating seed and feed and eliminating waste products is brought out.

70. The success of shrimp filtration in Kerala is due to the selective harvest practised during thakkoms coupled with the high market and export demand. Multiple harvesting is adopted in all the traditional fields.

71. Compared to autostocking in traditional practices wherein metapenaeids dominated, selective seed induction contributed to higher levels of production of P. indicus considerably.

72. Reliable economic data on actual location specific commercial production are made available. The profit depended on capital investment, type of technology, management and lease amount which varied from place to place. The steps to be taken for raising economic returns in the context of increasing variable costs are discussed.

73. Farmers were not able to take full advantage of the growth potential of the shrimps on account of the termination of the contract period during middle of April coupled with the characteristics of lowered water levels.

74. Low tidal amplitude, non existence of viable hatcheries, lack of quality feed etc. warrant only an indigenous technology.

75. By way of system appraisal, the strength prospects and opportunities for shrimp culture have been enumerated. Also several factors classified under technical and non technical constraints, threats and weaknesses have been identified. Non availability of seeds in time, lack of nutritive feed and deteriorating water quality are prominent among them.

76. Inspite of the key role for the farm management in a successful aquaculture system, most of the farms in Kerala are operated employing engaged watch personnel alone.

77. The land use and lease policies along with ownership of lands being vested with the agriculturists, the backwardness of the illiterate traditional fishermen, impact of mangrove destruction etc. are some of the social considerations for an indigenous technology.

78. Economic considerations speak for preferring a culture practice

by reasoning, ie. to select one which can be adjusted to the demand and which can help in the economic rehabilitation of the rural poor.

79. Extensive pond management is found most appropriate in the central Kerala owing to the vast existing impoundments where new investment is minimal.

80. The technology most appropriate for sustainable development of the study area, taking into consideration various ecological, social and economical factors is explained. The salient features of the technology are enumerated.

The greatness of the technology is that it shows, over and beyond economic profitability, a soundness that will not threaten environmental resources.

The sought after technology being a location specific one, no other technology can be successful in the prevailing ecological condition of the place of study.

4.2 RECOMMENDATIONS

The following recommendations can be made in order to attain success in shrimp farming in the central Kerala.

i) Land reform policy

Under the existing policy, the coastal shallow areas where paddy cum shrimp culture is carried out are generally classified in revenue records of state governments as agricultural lands. There is no classification of special nature permitting fish and shrimp culture in low lying areas alone or as an alternative crop in paddy cultivation. Eventhough thousands of hectares of such areas are available in maritime states of India, all are classified as agricultural lands. Conversion of these lands exclusively for much more remunerative avocations like fish/shrimp production is not permitted by law. Enactment of special laws for conversion is the need of the hour to tide over the oft repeated social conflict in the farming areas. This necessitates a labour intensive appropriate technology adapted for aquaculture in traditional farms.

ii) Leasing policy

In Kerala, the paddy cum shrimp farm is leased out for filtration only for 5 months from November 15 to April 14th, beyond which it is unlawful to carry out shrimp culture. Therefore the contract farmers who take the farm on lease for 5 months are not able to invest more money for scientific methods of farming. The multilevel ownership of most private farms also creates troubles for long term planning.

It is also not possible to take water to all holdings independently in an area where there are many small land owners. Eventhough co-operative farming is ideal in such areas, it is not easy to ameliorate different interests in the existing conditions.

Hence the situation warrants to follow a liberal policy of leasing lands on a long term basis amongest farmers.

Investigations revealed that sociological factors were limiting the yields from Kerala farms using more pond areas compared to the shrimps produced. First is the lack of crop security for shrimp farmers. The present day yield from traditional shrimp farms is around 200-300 kg/ha/yr. To go above this yield, the farmer must pay hard cash for feed to be added to the pond. Also the nonavailability of a dependable quality feed adds to the misery. The farmer can not afford this if a local gang can come and rob him with impunity just prior to harvest as the rule of law is weak. This is a recurring phenomenon in the seasonal shrimp filtration fields during the fag end of operation, ie, between the end of March and middle of April.

The 2nd is that the non capitalist principles apply in the rural areas. It is simply impossible to fence off hundreds of hectares of land and grow shrimps in disregard to social conditions outside the fence. The unwritten law dictates that the crop must be shared with the not too fortunate. The fact that one invested money, effort and risk into the project is irrelevant. These practical aspects of aquaculture are not discussed even in conferences.

iii) Conservation of water bodies

Often unscrupulous measures adopted in the name of developmental programmes seem to hamper shrimp culture in a large way. It should be borne in mind that it is against law of nature to create impediments in the backwater systems affecting the flow patterns in the name of saline ingression and crop protection. The Thannermukkom barrage erected in Vembanad lake during 1974 is a glaring instance in this regard which has practically destroyed the lucrative fishery of Macrobrachium rosenbergii in the Vembanad lake. Adequate laws have to be enacted to protect the natural water bodies which are capable of yielding shrimps and fishes spontaneously.

iv) Considering the significance of mangroves to improve the life supporting capacity of aquatic ecosystems - especially as the natural breeding, nursery and feeding grounds of a variety of faunal assemblages including edible shrimp and fish species - it is highly necessary to re-establish the mangrove vegetation along suitable habitats in Kerala.

v) The need of the hour is setting up of a Kerala State shrimp Development Corporation on the model of KSCD Corporation set up in 1969. At present, the shrimp export industry is exclusively controlled by the private sector which is exploiting helpless fishermen, farmers and workers to make fortunes in the international market. Once the workers become organized they can demand better wages/deals like imposition of minimum wages. This corporation can be made the monopoly procurer of raw shrimps. This can give ample working days to farmers/ workers.

Also a Kerala State shrimp Farm workers Apex Industrial Co-operative Society can be registered for taking over factories and organizing them into co-operatives. This can be appointed as the sole agent for procuring raw shrimps.

vi) The present extension service meant for training necessitates strengthening and modernisation so that it can undertake speedier delivery of innovations from laboratory to the farmers in the field.

vii) Extensive macro and micro level survey has to be done to identify primafacia areas suitable for shrimp farming.

viii) A properly planned approach ensuring adequate discharge of the 41 west flowing large and medium rivers of the state with a catchment area of 20,000 km^2 is necessary as the monsoons greatly influence the hydrological regime of estuaries and backwaters.

ix) Monitoring of environmental parameters is required to assess economic feasibility of the area commensurate with the cost of development. A series of units under recognised agencies should be set up for this purpose.

x) The effect of man made engineering works and other human interferences on the productivity and quantity of water need critical evaluation, as it prevents shrimps from entering into spawning grounds.

xi) Preparation of shrimp culture project reports mainly centred around engineering works has to be accelerated and made available easily to the farmers.

xii) Extension of feeder canals to interior potential areas to ensure natural seed and quality water availability for better production.

xiii) Establishment of shrimp parks and sanctuaries or reserve areas as done in the case of Mahseer in Ganga basin for enhanced breeding and production along with setting up of viable hatcheries and seed banks to ensure supply of quality seed in time and in required quantity.

xiv) It is imperative to encourage co-operative ventures for economically feasible indigenous feed manufacture.

xv) Storage facilities are to be set up at selected production centres for the benefit of farmers.

xvi) In the light of ecological economic and social considerations, the author recommends an improved extensive indigenous technology which can raise the present production of 300 kg/ha to the level of 1500-2000 kg/ha as the most appropriate rather than hunting after foreign technology.

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* Not referred in original

ABBREVIATIONS

BRAIS	Brackishwater Aquaculture Information System, Iloilo, Philippines.
BWFFDA	Brackishwater Fish Farmers Development Agency.
CIBA	Central Institute of Brackishwater Aquaculture, Madras.
CIFE	Central Institute of Fisheries Education, Versova, Bombay.
CIFRI	Central Inland Fisheries Research Institute, Barrackpore, West Bengal.
CMFRI	Central Marine Fisheries Research Institute, Kochi.
FAN	FAO Aquaculture News Letter
FAO	Food and Agriculture Organisation, Rome, Italy.
ICLARM	International Centre for Living Aquatic Resources Management, Metro Manila, Philippines.
KVK	Krishi Vigyan Kendra
KSCDC	Kerala State Cashew Development Corporation.
MATSYAFED	Kerala State Co-operative Federation for Fisheries Development, Thiruvananthapuram.
NABARD	National Bank for Agricultural and Rural Development.
SEAFDEC	Southeast Asian Fisheries Development Center, Iloilo, Philippines.
STC	State Trading Corporation
TASPARC	The Andhra Pradesh Shrimp Seed Production and Research Centre, Visakhapatnam.

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GLOSSARY

Acclimatisation	adjusting to a new environment or climate
Compound feed	a feed composed of several ingredients
Detritus	aggregate of fragments of a structure as of detached or broken down tissues
Ecosystem	a natural complex of plant and animals and the environmental conditions in which they live
Fish meal	a valuable aquaculture formulated feed ingredient made from whole non-oily fish and fish residues which are oven dried and ground.
Growouts	ponds where shrimps after the nursery stage, are reared upto marketable size.
Lecithin	a phospholipid extracted from Soybean/egg yolk, found useful to promote the survival and growth of shrimps.
Mangrove	salt tolerant plants growing in muddy swamps covered at high tide or on tropical coasts and estuary shores.
Shrimp meal	a dried meal similar to fish meal made from waste heads, shells of large prawns or shirmps or from whole small shrimps or crustacea of no human food value.
Tide	the periodic rise and fall of ocean level in response to the gravitational interaction of earth, moon and sun.
Turbidity	cloudy condition of water or reduced water clarity resulting from the presence of suspended matter.

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APPENDIX

1. Case studies on the economics of an improved method of paddy field shrimp culture in Vypeen island, Kerala.

2. Experimental studies on high density, short-term farming of shrimp *Penaeus indicus* in a 'pokkali' field in Vypeen island, Kerala.

3. Prawn production in Kerala : Budding or withering ?

4. Economics on traditional prawn farming in Kerala.

5. Case studies on the prawn production potentials of traditional paddy fields at Vypeen island, Kerala.

6. Semi-intensive shrimp farming and its relevance in Kerala.

7. Puduveypu : A potential brackishwater fish seed resource.

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CASE STUDIES ON THE ECONOMICS OF AN IMPROVED METHOD OF PADDY FIELD SHRIMP CULTURE IN VYPEEN ISLAND, KERALA

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INTRODUCTION

Raising of shrimps in the paddy fields (Pokkali) of Kerala locally known as "Chemmeen Kettu", "Chemmeen Vattu" or "Adappu" is a practice more akin to capture fishery than to culture. The essential aspects of this operation in vogue include the trapping of shrimps in the field with the incoming high tides after the annual paddy harvest and filtering them through the sluice gates during favourable low tides. The prevalent state of this fishery and the possibilities for improving the production in the light of eco-biological know how have been appraised by the earlier investigators (Panikkar, 1937, 1952; Menon, 1954; Gopinath, 1956; Kesteven and Job, 1957). Experimental studies on the growth of shrimps contributing to the paddy field fishery have been made by George, Mohamed and Pillai (1968). A comparative study of the species-wise yield and economics of the traditionally operated seasonal and pereannial fields of Vypeen Island has been carried out by George (1974). These authors have directly or indirectly pointed out the need for introducing more culture techniques to enhance the yield of shrimps from paddy fields. The same had been realised by the farmers at Narakkal where half a century ago, actual culture by rearing young shrimps for two to three months was practised (Menon, 1954). However, this was not viable at that time mainly due to economic reasons.

The present communication deals with an attempt to improve the traditional paddy field shrimp fishery by incorporating culture techniques such as nursery pond, supplementary feeding, and more conducive physical environment. Of the yield and economics of four case studies reported here, three were operated using improved method and one in the tradtional manner.

Materials and Method

Investigations were carried out with the close co-operation of some of the lease holders who have accepted our guidance from time to time. Data on the catch composition, day to day income expenditure and other observations were systematically maintained in a log book.

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During 1975-76 season a 6.25 ha field at Cherai (Field A) and in 1976-77 a 7.57 ha field at Narrakal (Field B) were operated using improved method. To understand the relative efficiency of improved operation, in 1977-78 a 4.93 ha field at Narakkal (Field C) was operated with improved techniques and another field adjacent to that was operated in the traditional manner. Period of operation lasted for five months, from the middle of November to the middle of April.

All the fields were naturally well connected with the backwater system and had regular tidal flow. Field A had the additional advantage of access to' Poyil, a marine lagoon.

Preparation of the field (Inproved method)

After the raising of dykes, the sluice gates were installed in a position slightly inclined towards the incoming tide. The catch basin/sluice basin was sounded to confirm the depth 3-4 m) and evenness of bottom configuration. Irregularities detected were rectified.

The primary irrigation canals radiating from the sluice basin to the periphery of the field which were silted and eroded during the paddy harvest activities were excavated to get a width of 2-3m and a depth of 1-1.5 m at the lowest low tide. Similarly secondary-tertiary canals having 1.5-1 m width and 0.75-0.5 m depth were elaborated to form a net work, so that almost every 10 m^2 of the field was traversed by a canal. Excessive accumulation of paddy stumps and noxious weeds like Salvinia, Eichornia and filamentous algae were removed. An initial fishing was carried out using cast nets and dragnets to eliminate predatory and uneconomic species including Tilapia.

Trapping operation

Almost all the high tides during day and night particularly at dusk with satisfactory gradient were used for trapping the shrimps. A petromax lamp with a red filter was used at the sluice gate while trapping at night.

Nursery pond

In the peripheral part of the field an area of approximately 0.4 ha was maintained as a nursery pond by raising mud bunds. Bamboo screens were fixed at some places where the canals traversed the pond. During filtration the contents from the codend of the filter bag net were frequently emptied into a plastic basin half filled with water. The undersized juveniles were quickly sorted out using small hand nets and transferred to the nursery pond. When the container was immersed into the nursery 95-98% of the young shrimps actively swimmed out. Among the undersized juveniles re-introduced were *P. indicus* and *P. monodon* of length range 25-75 mm and *M. dobsoni* and *M. monoceros* measuring 15-45 mm. Considering the importance of the fast growing *P. indicus* and *P. monodon* in the economy, more attention was paid in the handling and re-introduction of these species

Crushed ground nut cake at the rate of 25 kg/0.4 ha per week was used for supplementary feeding in the nursery pond for three months (Dec--Feb.). About 3 5% of the undersized juveniles, died during the operation has also contributed to the food resource in the nursery. At the time of filtration one of the bamboo screens of the nursery pond was removed to permit passage of shrimps into the canal. Towards the close of the leasement period, in addition to the usual filtration the terminal fishing was carried out in 3-4 days, using "Pachil", cast nets, gill nets and hand fishing. Traditionally terminal fishing in paddy fields is done by "Churning" and asphyxiating all organisms, in a destructive manner.

Yield from improved operation

The total yield of shrimps; fishes and miscellaneous species obtained during various phases [lunar] of filtration and terminal fishing operations from three fields [A, B&C] has been given in tables I-III. Maximum yield of shrimps 965.04 kg/ha was at Cherai [Field A] in 1975-76 and the minimum was 784.92 kg/ha from Narakkal (Field C) in 1977-78. The average yield of shrimps comes to 864. 80 kg/ha.

As has been observed by earlier investigators the shrimp fishery was mainly contributed by four species: *Penaeus indicus, Penaeus monodon, Metapenaeus dobsoni* and *Metapenaeus monoceros*. Among these, the highest yield was that of *P. indicus* which gave 681.29, 427.83 and 403.37 kg ha from fields A, B and C with an average yield of 504.16 kg/ha. Though this species formed the main bulk of the shrimp yield, it did not figure much in the early phases of fishing. The catch rate of this species increased with the advancement of the season.

M. dobsoni forms quantitatively the next important species, the maximum yield of which (363.5 kg/ha) was obtained from field B and the minimum was 266.03 kg/ha from field A with an average of 321.41 kg/ha. This species was available in sizable quantities from the beginning of filtration. *M. monoceros* gave an average yield of 30.2 kg/ha with a maximum of 47.95 kg/ha from field B. Among the commercial species available the lowest yield was that of *P. monodon* which formed 9.3 kg/ha on an average with the highest 17.32 kg/ha from field A.

It is interesting to note that in general the high values of percentage composition of *M. dobsoni* and *M. monoceros* apparently decreases towards the close of the season. *P. indicus* dominates the percentage composition of shrimp catch during March-April. The same is true in the case of *P. monodon*.

On an average, the net yield of edible organisms from the improved operation comes to 1273.45 kg/ha. As regards the yield of fishes, the major contribution comes from Tilapia, Etroplus and Mullets. A drastic variation could be noticed in the total yield of fishes from 76 kg/ha-588 kg/ha during 1976-78. Of these Tilapia accounted for 75% of the catch in field B and C whereas in field A it was below 10%.

Miscellaneous catch was comprised of a host of species of Crustaceans and fishes. *Ambassis* sp, *Barbus* sp, *Arius*

TABLE - I

Yield of shirmp and fish (in Kg) from a 6.25 ha. paddy field (A) at Cherai operated under Improved method during 1975-76

Sl. No.	Period of fishing	Catchcomposition of shrimps: *P. indicus*	*P. monodon*	*M. dobsoni*	*M. monoceros*	Total catch of shripms	Yield of shrimps per hectare	Yield of fishes	Miscellaneous catch	Total yield	Total yield /ha
1.	5.12.75-9.12.75	-		162.00 (100%)	-	162.00	25.92	-	-	162.0	25.92
2.	15.12.75-19.12.75	-	-	183.00 (100%)		183.00	29.28	5.5	5.0	193.5	30.96
3.	29.12.75-2.1.76	10.95 (32.4%)	0.500 (1.48%)	19.90 (58.87%)	2.45 (7.25%)	33.8	5.41	12.0	8.0	53.8	8.61
4.	14.1.76-23.1.76	283.75 (58.12%)	-	204.50 (41.88%)	-	488.25	78.12	16.5	10.0	514.75	82.36
5.	28.1.76-6.2.76	355.50 (58.76%)	7.000 (1.15%)	242.50 (40.08%)	-	605.00	96.8	27.5	25.0	657.5	105.2
6.	12.2.76-20.2.76	533.00 (64.22%)	31.000 (3.73%)	266.00 (32.05%)	-	830.00	132.8	32.5	15.0	877.5	140.4
7.	26.2.76-7.3.76	465.50 (69.84%)	26.000 (3.9%)	175.00 (26.26%)	-	666.5	106.64	65.0	2.0	733.5	117.36
8.	12.3.76-21.3.76	807.80 (86.59%	27.150 (2.91%)	98.00 (10.5%)	-	932.95	149.27	85.0	8.0	1025.95	164.15
9.	28.3.76-6.4.76	888.16 (95.54%)	4.400 (0.47%)	37.00 (3.98%)	-	929.56	148.73	75.0	7.0	1011.56	161.85
10.	Terminal fishing 8.4.76	913.5 (76.13%)	11.700 (0.97%)	274.80 (22.9%)	-	1200.0	192.00	156.0	125.0	1481.00	236.96
11.	Total catch	4258.1 (70.60%)	108.25 (1.79%)	1662.70 (27.57%)	2.45 (0.04%)	6031.5	965.04	475.0	205.0	6711.5	1073.84
12.	Catch/hectare	681.29	17.32	266.03	0.39	965.04	-	76.0	32.8	1073.84	

TABLE - II

Yield of shrimp and fish (in kg) from a 7.57 ha paddy field (B) at Narakkal operated under improved method during 1976-77

Sl. No.	Period of fishing	Catch composition of shrimp: *P. indicus*	*P. monodon*	*M. dobsoni*	*M. monoceros*	Total catch of shrimp	Yield of shrimps per hectare	Yield of fishes	Miscellaneous catch	Total yield	Total yield/ha
1.	3.12.76-8.12.76	-	-	126.00 (85.19%)	21.9 (14.81%)	147.9	19.54	-	-	147.9	19.54
2.	18.12.76 23.12.76	0.500 (0.16%)	-	264.60 (85.82%)	43.22 (14.02%)	308.32	40.73	-	-	308.32	40.73
3.	2.1.77-8.1.77	3.800 (0.78%)	-	382.80 (78.70%)	99.82 (20.52%)	486.442	64.26	-	-	486.42	64.26
4.	16.1.77-23.1.77	195.19 (24.37%)	0.500 (0.06%)	524.60 (65.48%)	80.80 (10.09%)	801.09	105.82	14.00	19.0	834.09	110.18
5.	1.2.77-8.2.77	310.10 (37.88%)	3.600 (0.44%)	437.20 (53.40%)	67.76 (8.28%)	818.66	108.14	30.0	27.0	875.66	115.68
6.	15.2.77-22.2.77	346.70 (47.75%)	5.400 (0.74%)	350.5 (48.27%)	23.52 (3.24%)	726.12	95.92	69.0	31.0	826.12	109.13
7.	2.3.77-9.3.77	423.80 (57.83%)	8.100 (1.11%)	286.2 (39.06%)	14.62 (2.00%)	732.72	96.79	118.0	48.0	898.72	118.72
8.	16.3.77-23.3.77	496.80 (74.59%)	11.300 (1.70%)	148.98 (22.37%)	9.00 (1.35%)	666.08	87.99	565.0	67.0	1298.08	171.48
9.	1.4.77-9.4.77	527.5 (89.68%)	4.200 (0.71%)	56.50 (9.61%)	-	588.2	77.70	1136.0	94.0	1818.2	240.19
10.	Terminal fishing	934.3 (83.64%)	6.100 (0.55%)	174.30 (15.60%)	2.30 (0.21%)	1117.0	147.56	1298.0	107.0	2522.0	333.16
11.	Total	3238.69 (50.66%)	39.200 0.61%)	2751.68 (43.05%)	362.94 (5.68%)	6392.51	844.45	3230	393.0	10015.51	1323.05
12.	Catch/hectare	427.83	5.18	363.50	47.95	844.45	-	426.68	51.92	1323.05	-

TABLE - III

Yield of shrimp and fish from a 3.93 ha paddy field (C) at Narakkal, operated under improved method during 1977-78

Sl. No.	Period of fishing	Catch composition of shrimp: P. indicus	P. monodon	M. dobsoni	M. monoceros	Total catch of shrimps	Yield of shrimps per ha	Yield of fishes	Miscellaneous catch	Total Yield	Total Yield/ hectare
1.	8.12.77 - 10.12.77	-	-	90.00 (100%)	-	90.00	18.96	-	-	90.00	18.96
2.	22.12.77-25.12.77	-	-	148.00 (100%)	-	148.00	30.02	-	-	148.00	30.02
3.	6.1.78-10.1.78	2.00 (0.57%)	-	269.50 (77.33%)	77.00 (22.09%)	348.5	70.69	-	-	348.5	70.69
4.	20.1.78-27.1.78	131.50 (25.56%)	-	332.50 (64.63%)	50.50 (9.82%)	514.5	104.36	-	-	514.5	104.36
5.	4.2.78-11.2.78	204.50 (38.66%)	0.500 (0.09%)	280.00 (52.93%)	44.00 (8.32%)	529.0	107.3	50.5	-	579.5	117.55
6.	19.2.78-26.2.78	185.70 (48.63%)	1.200 (0.31%)	187.00 (48.97%)	8.00 (2.09%)	381.9	77.46	270.0	-	651.9	132.23
7.	6.3.78-13.3.78	277.00 (65.64%)	2.990 (0.71%)	135.00 (31.99%)	7.00 (1.66%)	421.99	85.60	459.0	23.50	895.49	181.64
8.	21.3.78-29.3.78	330.25 (81.42%)	4.600 (1.13%)	66.00 (16.27%)	4.75 1.17%	405.60	82.27	512.0	37.00	954.6	193.63
9.	4.4.78-11.4.78	288.30 (90.59%)	7.700 2.42%	16.50 (5.18%)	5.75 (1.81%)	318.25	64.55	768.0	60.50	1146.75	232.61
10.	Terminal fishing	569.40 (79.97%)	5.70 (0.80%)	125.56 (17.64%)	11.34 (1.59%)	710.0	144.42	849.0	127.00	1688.00	342.39
11.	Total catch	1988.65 (51.39%)	22.6 (0.58%)	1650.06 (42.65%)	208.34 (5.38%)	3369.65	784.92	2900.0	248.00	7017.65	1423.46
12.	Catch/hectare	403.37	4.58	334.69	42.26	784.92	-	588.24	50.30	1423.46	-

sp., *Cyprinoides* sp., *Platycephalus* sp., *Gobius* sp., *Anchoviella* sp., *Therapon* sp., *Hemiramphus* sp., *Sillago* sp., *Ophiocephalus* sp., *Muraenosox* sp., etc. were occurred in small quantities. Decapods like *Scylla serrata, Neptunus pelagicus Acetes* sp. and a few species of uneconomic varieties of shrimps were also caught.

Yield from traditional field

Shrimp yield from the traditionally operated field comes to 637.46 kg/ha which is the lowest among four fields. As regards the species, the highest yield was that of *M. dobsoni* (293.55 kg/ha). Among all the four fields *M. monoceros* gave the highest yield 72.28 kg/ha in the traditional farm (See Table IV). In the magnitude of yield *P. indicus* ranks second with a total of 268.02 kg/ha and *P. mondon* is represented with 3.61 kg/ha.

The yield of 662.71 kg/ha obtained from this field was the highest among the fish yield from all the four. However, 90% of the fish catch was comprised of *Tilapia* which was rather uneconomic. A total yield of 1372.39 kg/ha was available from the traditional field.

Economics

A statement showing the expendeture and income of improved and traditional operation (Table V) reveals that the highest net profit, Rs 2,365.44/ha was realised from field A at Cherai in 1975-76 and the lowest profit was from field C at Narakkal Rs 718.38/ha. The amount of profit appears directly proportional to the availability of the quality shrimps like *P. indicus* and also it seems to be inversely proportional to the quantity of species other than shrimps.

Expenditure on paddy field fishery, is mainly influenced by the lease amount which is increasing year after year. It can be seen from the table that the lease amount fixed for a 6.25 ha field (A) in 1975 remains almost unchanged for a 4.93 ha field (C) in 1977. As regards expenditure the main difference between the improved and traditional method lies on items like preparation of the field and nursery operation. However, this difference did not figure much in the operational expenditure of field D (Rs 8,074.06) as the lease amount was rather high. This, together with low yield of shrimps from traditional operation resulted in a loss of Rs 1,408.75/ha. The expenditure on wages did not vary considerably during these years. As could be seen in the yield of shrimps, the level of profit in improved operation also shows a downward trend from 1975-76 to 1977-78.

Discussion

Results of the case studies show that the improved method of operation is economically more advantageous than the traditional one even though the former incurs more initial expenditure. Prawn production in paddy fields of Kerala has been estimated by several investigators in the past. Menon (1954) has arrived at an average annual rate of 1079 kg/ha and Gopinath (1956) has observed 1184 Kg/ha. Production figure of 514 kg/ha has been reported by George, Mohamed and Pillai (1968).

TABLE IV

Yield of shrimp and fish from a 3.03 ha paddy field (D) at Narakkal operated in traditional manner during 1977-78

Sl. No.	Period of Fishing	Catch composition of shrimp: *P. indicus*	*P. monodon*	*M. dobsoni*	*M. monoceros*	Total catch of shrimps	Yield of shrimps per ha	Yield of fishes	Miscellaneous catch	Total yield	Total yield per ha
1.	8.12.77-10.12.77	-	-	24.40 (100%)	-	24.40	8.05	-	-	24.40	8.05
2.	22.12.77-25.12.77	-	-	57.81 (100%)	-	57.81	19.08	-	-	57.81	19.08
3.	6.1.78-10.1.78	-	-	150.08 (70.52%)	63.00 (29.48%)	213.68	70.52	11.0	-	224.68	74.15
4.	20.1.78-27.1.78	8.60 (3.21%)	-	202.12 (75.38%)	57.40 (21.41%)	268.12	88.49	60.0	-	328.12	108.29
5.	4.2.78-11.2.78	92.60 (29.16%)	0.25 (0.08%)	180.50 (56.84%)	44.20 (13.92%)	317.55	104.80	134.0	-	451.55	149.02
6.	19.2.78-26.2.78	221.40 (64.65%)	0.75% (0.22%)	96.10 (28.06%)	24.20 (7.07%)	342.45	113.02	187.0	9.8	539.25	177.97
7.	6.3.78-13.3.78	134.30 (60.97%)	2.20 (0.99%)	69.98 (31.77%)	13.80 (6.26%)	220.28	72.70	276.0	16.6	512.88	169.27
8.	21.3.78-29.3.78	178.25 (72.16%)	3.70 (1.50%)	54.82 (22.19%)	10.30 (4.17%)	247.03	81.54	314.0	31.4	592.43	195.52
9.	4.4.78-9.4.78	83.00 (80.95%)	1.60 (1.56%)	15.43 (15.05%)	2.50 (2.44%)	102.53	33.84	486.0	43.0	631.53	208.43
10.	Terminal fishing	93.94 (54.42%)	2.45 (1.42%)	72.62 (42.07%)	3.61 (2.09%)	172.62	56.97	540.00	118.0	830.62	274.13
11.	Total catch	812.09 (42.04%)	10.95 (0.57%)	889.48 (46.05%)	219.01 (11.34%)	1931.53	637.46	2008.0	218.8	4158.33	1372.39
12.	Catch/hectare	268.02	3.61	293.55	72.28	637.46	-	662.71	72.21	1372.39	-

TABLE V

Statement showing the expenditure and income from the improved/traditional method of shrimp culture in paddy field

Sl No.	Item	Operated under improved method Field A (6.25 ha) 1975-76	Field B (7.57 ha) 1976-77	Field C (4.93 ha) 1977-78	Traditional Field D (3.03 ha) 1977-78
	EXPENDITURE				
1.	Lease amount and licence fee	19,250.00	37,250.00	19,400.00	16,150.00
2.	Sluice fabrication, installation and maintenance	1,930.00	1,750.00	1,450.00	1,000.00
3.	Preparation of field, dykes, canals, eradication of weeds and predators	1,850.00	2,275.00	1,479.00	300.00
4.	Workshed and Canoes	1,150.00	1,300.00	1,050.00	550.00
5.	Lamps, Oil, Bamboo/Plastic screen	1,420.00	1,550.00	1,320.00	780.00
6.	Nets and Plastic basins	1,100.00	1,250.00	1,025.00	650.00
7.	Nursery, operation (including feed)	750.00	810.00	900.00	-
8.	Contingencies	1,035.00	950.00	875.00	258.00
9.	Wages of workmen	10,567.00	11,250.00	7,776.00	3,650.00
10.	Interest on capital @ 14%	1,557.50	2,646.88	1,500.56	1,134.41
11.	Total expenditure	40,609.50	61,031.88	36,775.56	24,464.41
12.	Expenditure per hectare	6,497.52	8,062.34	7,459.55	8'074.06
	INCOME				
1.	Sale proceeds from shrimp	54,001.00	62,499.37	36,217.33	16,257.90
2.	-do-from fishes and other items	1,392.50	11,698.00	4,100.00	3,938.00
3.	Total income	55,393.50	74,197.37	40,317.33	20,195.90
4.	Income per hectare	8,862.96	9,801.50	8,177.93	6,665.31
5.	Total profit (+)/loss(—)	14,784.00	13,165.49	3,541.77	4,268.51(—)
6.	-do-per hectare	2,365.44(+)	1,739.16(+)	718.38(+)	1,408.75(—)

George (1974) worked out an average yield of 903.3 kg/ha with the range from 1059.6 kg/ha in 1969-70 to 754.6 kg/ha in 1971-72. In general these reports points at a regressive trend in the yield of shrimps from the traditionally operated paddy field fishery during past three decades. In the present study, an yield of 637 kg/ha obtained from the traditionally operated field in 1977-78 confirms this trend. But in the same year an yield of 784 kg/ha has been obtained from the adjacent field which is ecologically identical to the former (data unpublished). Moreover higher yields of shrimps were available from the improved operation in 1976-77 (844.45 kg/ha) and in 1975-76 (965.05 kg/ha).

It has to be admitted that the 1977-78 season was in general a failure as regards paddy field shrimp. fishery and most of the lease holders had to sustain heavy losses. Probably the lingering of rain towards the post monsoon months, till December and the consequent efflux of fresh water from the estuary might have hindered the ingression of shrimp from the inshore waters to the backwater. In paddy fields, a salinity less than 10‰ was observed till the end of December in 1977 whereas in the normal course it would be 20-25‰ in December.

Further, a recession in the market value of shrimps together with an unusually high lease amounts in 1977-78 rendered the operation unprofitable to traditional operators. Against this background, a profit of Rs 718.38/ha realised from field C in 1977-78 season seems to be mainly due to the improvement in operation, particularly fattening in the nursery. Constant retrieval of undersized juveniles from the filter bag net and growing them in the nursery pond with supplementary feed have resulted in improving the rate of yield.

In the traditional operation *M.dobsoni* used to dominate the catch composition of shrimps, (George 1974) whereas in the improved operation, *P indicus* was found to dominate (Table I-IV) This may be due to the facility provided for exploiting the potentiality for fast growth of this species by nursery technique. Thus the improved operation could enhance the production of more economically important species and at the same time facilitate the efficient utilization of the juvenile shrimp resource naturally recruited into the paddy fields.

The average net production of edible species (Crustaceans and fishes) from the improved fields comes to 1272.45 kg/ha. Compared to this, the traditional field yielded a better crop of 1372.34 kg/ha. This shows that the improved method has not basically influenced the total yield which is interlinked with the primary productivity of backwater environment (Qasim et al, 1969).

During the warmer months (March-April) heavy mortalities of juvenile shrimps could be noticed in the shallower regions of some of the traditional field especially when they happen to get trapped in ditches during day time. Also excessive accumulation of organic matter (paddy stumps and weeds) rapidly decompose to create local anoxic condition harmful to animals and aerobic bacteria (Ardiwinata, 1958). The deeper and elaborate net work of canals in the improved fields were designed to provide shelter from higher temperature and access to a more oxygenated medium.

As mentioned earlier *Tilapia* formed the main component of the fish catch in recent years. It has emerged as a major consumer population competing with all other species for the food and environment. It has been observed that they turn to be facultative predators on shrimp juveniles at times. Elimination of all fishes in the beginning of operation helped to reduce the density of their population in improved fields.

Investment in the present day paddy field shrimp fishery of Kerala involves an element of risk as the economic success depends largly on the coincidence of environmental factors conducive to the ingression of juveniles and post larval shrimps into the field. However, the improved operation incorporating culture techniques like nursery, supplementary feeding, retrieval of undersized juveniles, improved canal system, weeding and elimination of predators and uneconomic species can certainly reduce the risk by enhancing the production of desirable species like *P. indicus* and *P. monodon*. Further improvement in the economy of the system could be achieved if dependable source of juvenile shrimps could be opened by developing hatchery and rearing techniques. The basic incentive for the expansion in this field warrants a stable and reasonable market value for shrimps. However, the problem of regressive trend observed in the past three decades in this fishery remains unanswered. Probably the study of intensity of exploitation of natural stock and the environmental deterioration might answer this meaningfully.

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The authors wish to express their gratitude to Dr. S. Z. Qasim, Director, National Institute of Oceanography, Goa, for his keen interest during the course of this investigation. Thanks are also due to our colleagues in the costal aquaculture project for their valuable help and to Dr. M. Krishan Kutty for his encouragement. Besides, we are indebted to the lease holders of Vypeen Island who have accepted our guidance and extended their utmost co-operation in this study.

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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 m^2 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 netted 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 1.601, 2.186 and 3.646 kg realised from these cultures became equivalent to 640.0, 874.0 and 1458.0 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 'Chemmeenkettu' 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; Kestevan 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 (Foster and Beard, 1974; Shigueno, 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.

The authors wish to express their gratitude to Dr. S. Z. Qasim, Director and Dr. T. S. S. Rao, Head, Biological Oceanography Division, National Institute of Oceanography, Goa, for their keen interest and encouragement during this investigation. Thanks are also due to Dr. M. Krishnankutty, Scientist-in-Charge and other colleagues in the Regional Centre of NIO, Cochin for their help. We are indebted to the leaseholders, Mr. C. N. Gopi and partners for their utmost co-operation in this study.

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 m^2) 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 were an area of 1 m^2 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 1. 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 Narakkal.*

Month	Temp. (°C)	Salinity (‰)	O_2 (ml/l)	pH	Secchi disc reading (cm)	Organic Carbon (%)
Culture enclave						
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	2.20
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
Open Field						
January 1979	32.5	17.20	2.6	7.2	60.0	0.85
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
Outer bund canal						
January 1979	31.5	16.83	2.0	7.4	75.0	1.70
February ,,	29.0	18.82	1.6	7.0	70.0	1.85
March ,,	33.0	21.33	3.6	7.0	67.0	2.10
April ,,	33.5	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 4 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 *M. dobsoni* @ Rs. 3.25/kg		Sluice fabrication, installation and maintenance ..	1,000.00
39.75 kg of *M. monoceros* @ Rs. 8/kg	.. 24,081.85		
782.19 kg of *P. indicus* @ Rs. 25/kg		Preparation of field, dykes, canals, eradication of weeds and predators ..	300.00
1.0 kg of *P. monodon* @ Rs. 40/kg			
Sale proceeds from fishes & other items		Workshed and canoes	550.00
3352 kg. of *Tilapia* @ Rs. 1.10/kg		Lamos, oil, bamboo/plastic screen	780.00
512 kg of *Etroplus suratensis* @ Rs. 5/kg	.. 6,422.20	Nets and plastic basins	650.00
350 kg of misc. fishes @ Rs. 12/kg		Nursery, operation (including feed)	—
Total income	.. 30,504.05	Contingencies ..	250.00
Income/ha.	.. 7,626.01	Wages of workmen ..	3,650.00
Total Profit	.. 803.95	Interest on capital @ 15% ..	1,146.50
Profit/hectare	.. 200.99	Harvesting expenditure ..	5,623.60
		Total expenditure ..	29,700.10
		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 tne open field than that of the enclaves whereas lower values (1.6-3.6 ml/l) were seen in the outside canal.

The diurnal ' oxygen pulse ' of the enclaves has been graphically presented (Fig. 1). The lowest values (1.0-1.6 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 10th week.

The organic carbon values were the same (0.84%) 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,

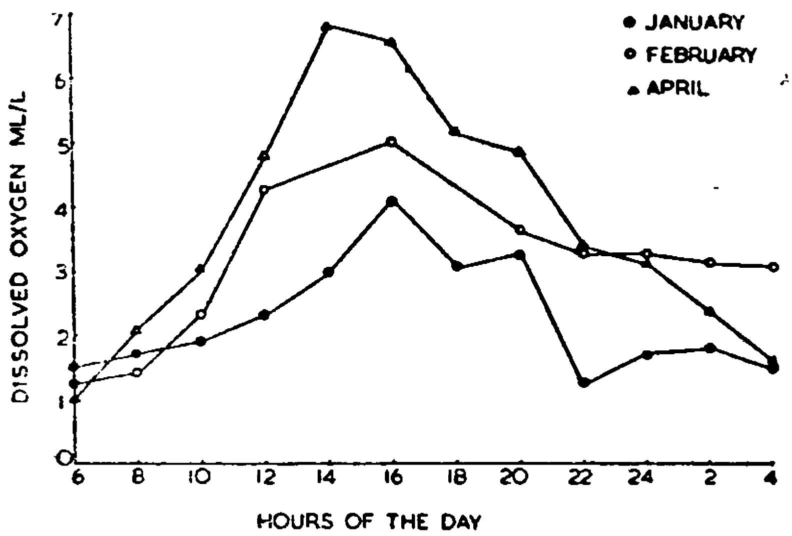

Fig. 1. Diurnal variation in dissolved oxygen in the monoculture enclaves during January-April 1979.

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 75-108 mm with mode at 93 mm and average weight of 5.35 g which was 1.42 times greater than that of the preceding.

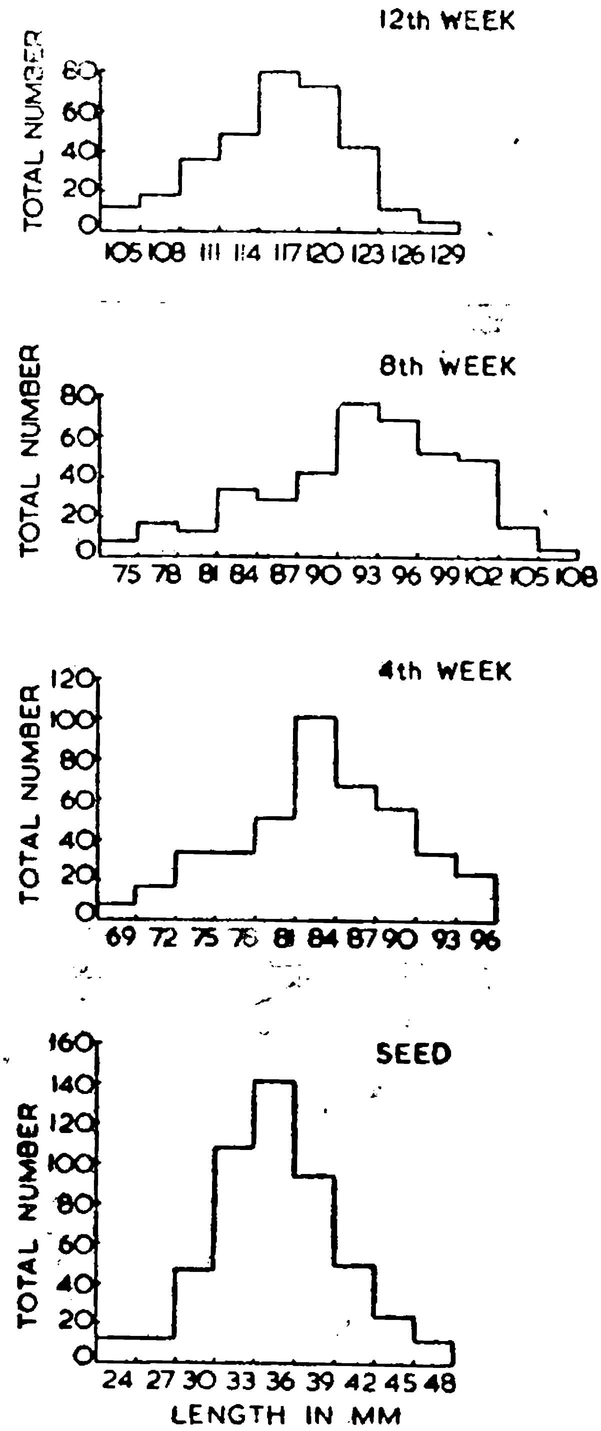

Fig. 2. The size frequencies of *Penaeus indicus* stocked and harvested after 4, 8 and 12 weeks by monoculture.

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 m^2 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 50% 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, *Ambasis* sp., *Etroplus maculatus*, *Barbus* sp., *Arius* sp., *Meglops* 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.

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
		Auxiliary feeding ..	1,000.00
		Wages for workmen ..	3,600.00
Total income ..	35,001.60	Interest on capital investment @ 15% ..	562.50
		Harvesting expenditure @ Rs. 3/kg ..	5,253.00
		Handling and marketing charges ..	1,000.00
		Contingent expenditure ..	500.00
Profit ..	12,086.10	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 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/m^2) in which a production of 390 g/m^2 was obtained at Kovalam in cage culture of 120 days duration.

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 (Sundararajan *et al.*, 1980)		Brackish water Exp. Fish Farm, Kakdwip		Brackish water Farm, Kakinada	Present data		
Stocking density (No./ha) of *P. indicus* ..	70,000	37,000	50,000	25,000	70,000	2,00,000	2,00,000	2,00,000
Size at stocking (mm)	42.2	48.5	24.0	20.0	45.00	36.00	36.00	36.00
Size at harvest (mm)	130.7	147.5	97.3	100.00	120.0	83.34	91.93	115.94
Culture days	130	70	90	70	180	28	56	84
Rate of survival (%)	32.2	91.5	57.2	55	—	85.2	81.8	65.0
Average growth/day (mm) ..	0.68	1.41	0.81	1.14	—	1.72	1.01	0.96
Estimated total production kg/ha. ..	301.8	704.4	475.0	310.0	243.14	640.0	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 Shigueno (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 downward 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 culture.

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 m^2) which facilitated the harvesting of all the surviving shrimps. In larger systems percentage recovery may not exceed 80% 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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Prawn Production in Kerala: Budding or Withering?

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PRAWN culture is centuries old in Kerala, especially on the banks of Vembanadu lake. Vypeen Island, located on the northwestern region of Ernakulam District is notable in this respect from ancient times. The enthusiastic farmers of this place were very keen to increase their prawn yield from culture fields even before this commodity assumed significance in the internal and export markets. Prawns being a highly esteemed item in commerce, its exploitation from nature has exceeded the limits. Consequently, there is now the apprehension of an overfishing which has practically hit the resource all over the country. This being the background, it is hoped that an analysis of the present status of prawn culture will help to shape future research.

Owing to the market importance of prawns, there is an all round effort from the level of administrator to the common man to pay more attention to fisheries extension programmes by way of research and education. The recent researches have no doubt helped to increase the prawn yield from experimental fields. At the same time the application of the same techniques in the field could not meet with the desired success. This necessitates further intensive research in order to clear the hurdles prevailing in this field.

The traditional prawn culture fields are usually taken on lease for the period from November 15 to April 14 every year. Because of the increasing cost of prawns, the lease amount of fields are also increasing year after year. This endeavour being a lucrative one, now-a-days, entrepreneurs are ready to offer even upto Rs. 7500/- per hectare as lease amount. Nevertheless, there is no certainty for their success in the operation, as, this more often depends on the blessing of nature. In most cases, the success of prawn culture lies on the cumulative effect of so many desirable factors promoting the growth of prawns.

In a favourable season, quality prawn seeds usually enter the paddy fileds well before November. In the seasonal paddy field operation it is always desirable to have the seeds stocked before December. But in certain years, if stocking could be done beyond December, the potential time available for the growth of prawns would be very much reduced, as the fields are to be vacated before the middle of April. The natural shortage of prawn seeds on account of lingering of monsoon and resultant flooding affect the entry of prawn seeds into the backwaters, causing much difficulties to the farmers. On such occasions, the damage caused to the farmers will be considerable, taking into account the present-day spiralling of expenditure. The nondependability of other sources as regards the availability of prawn seeds makes the scene all the more disappointing.

The trials conducted in the instructional farms have clearly demonstrated the advantage of intensive prawn culture over traditional practices. So much so, the idea of scientific prawn culture is in vogue among the farmers, for the last one decade. Accordingly many a farmer has earnestly resorted to the culture of prawns on scientific lines. It stands to reason that for successful farming adequate number of suitable species of prawns should be available in time, the most important species being *Penaeus monodon* and *Penaeus indicus.* But in Kerala, the dominant species with culture potential is *Penaeus indicus.*

For a proper stocking of quality prawns in the field, farmers resort to all means to collect the prawn seeds not only from nature but also from all the available sources. Now-a-days it appears that even during the favourable season the good quality prawn seeds are scanty in nature. This is the awful situation in which the traditional prawn culture operation has reached today. The prawn seed nurseries functioning in certain places of our country are also not in a position to cater to the requirements of the farmers in time. All these things pose a threat to prawn culture, both traditional and scientific.

In certain years, even during a favourable prawn catch season, there are instances of unaccountable mortalities of prawns in fields. The most common disease encountered is on account of the softening of shells which more often leads to moribund stage initially and finally to death. Although, in most cases this can partially be compensated by the application of some nutritional diets, there are occasions of total disappearance of the stocked animals leaving the farmer in extreme difficulties. During such periods the loss incurred by the farmer by way of investment and untiring effort will be considerable.

As far as Kerala is concerned, prawn production from culture field is, more during the seasonal operation period, that is from November to April. The yield obtained during the other periods is comparatively low, even in scientifically operated fields. Surprisingly, in certain selected perennial fields there occur abnormal catches of quality prawns during the usual off season. This can be due to the prevailing higher salinity in the medium on account of their greater depths.

Again, the growth obtained in different fields also vary very much. Even in two contiguous fields, one may be astonished to find the difference in the size of prawns being caught after full growth. Quantity-wise also, there occur remarkable differences between two fields which are normally fed from the same water body. In other words it is a reflection of the plankton and benthic productivity characteristic to each region. The nature of the bottom mud also plays an important role in generating the basic food on which the prawns survive.

The backwaters and adjoining water systems are said to be the natural nursery grounds of commercial prawns. But these habitats are being affected by acute human interference. As a result of this, not only is the area getting diminished but also environmental degradation is going on at a rapaid speed. The transformations taking place in the regions contiguous to Cochin harbour mouth can itself be illustrated as a striking example in this direction. The available fishery data from this place clearly show that there is much change in the composition of the fish populations during the last five years showing a negative trend both in quantity and quality. The marine reclamation programmes and the advent of super tanker berth bund are adversely affecting the fishery of this area. Forgetting about the future havoc this might throw upon the entire fishery of this region, the present barricade created by the huge bund on the mouth of the estuary has definitely played a predominant role in diverting the proper recruitment of the prawn seeds in the Cochin estuary. With the functioning of the super tanker berth in full swing we can imagine the environmental deterioration which is likely to take shape in the years to come.

Even now there are much hue and cry regarding the problem of aquatic pollution. Due to industrialisation many factories are coming up especially on the banks of rivers which empty their effluents directly into them. Naturally this will lead to the reduction of water quality parameters in the medium which in turn becomes deterimental to the existence of animal life. Any negative change taking place in the aquatic medium will most easily be affecting the gill breathing animals. Likewise the much affected organisms will be the invertebrate fauna to which the commercial prawns belong. Many of the diseases afecting prawns are attributed to the deterioration of the aquatic environment. Only a healthy environment can offer healthy survival and existence of organisms.

Besides, aquatic pollution has got an unlimited rôle in negating the proper prawn seed recruitment in the estuary. The washings from the shipping cargo and other motor boats make the surface layers of the backwater with oil emulsion, which is a visible scenery, especially in the mouth of Cochin estuary. The subsequent degradation of these hydrocarbons will definitely interfere with the marine food chain activities causing harm to the aquatic life. Again, the illicit prawn filtration during high tides by using minute meshes is also going to affect this fishery in due course, if unchecked. The present shortage and depletion are clear indications in this direction. The inferences drawn from the results of recent investigations are also not much different.

The production figures show that about 8000 tonnes of quality prawns are available in Kerala from culture source, among which 6000 tonnes are caught from Vembanadu lake and its tributaries. About 4000 tonnes of prawns are produced from the fields adjoining Vypeen island which is the well-known place where prawn fishery existed from time immemorial. Nevertheless, the hit generally encountered in the production of prawns are very well discernible in this place also. The previous records of prawn culture in Vypeen island indicate that the prawn production from traditional fields two decades ago was in the range of 1000-1500 kg/ha. On tne contrary, the present yield of 300–400 kg/ha. has astonishingly no parallel with its glorious peak. Not only that, it is also experienced by the farmers that the prawn production in paddy fields is diminishing year after year. The fall in the trend of production from traditional fields donotes a less optimistic picture for the prawn fishery in general. Against this background the entire hope lies on the prediction of scientists to raise the yield of prawns almost to about 2000/ kg/ha. on modern lines. The proper releasing of the technical tips to the farmers by way of training and extension is only a pragmatic approaeh towards this goal.

The analysis of the catch statistics reveals that the depletion noticed in the case of prawns is not at all apparent. Owing to the reduction in the natural nursery grounds and associated unhealthy environments resulting from the interfering human activities, majority of the fragile aquatic organisms are not in a position even to propagate freely as before. Intensive exploitation with no scruples even on the size of the species caught has resulted in causing irreparable damage to the stocks. Thus the resource is confronted with a threatened phase at present because of the impoverishment of the coastal waters. If this is permitted to continue for long the havoc will be beyond repair.

From the situation we have reached to-day as regards prawn fishery it is worthwhile to think of some positive measures so as to conserve the existing prawn resource. As a first step in this direction, the keeping away of the trawlers off the coastal regions and imposing some kind of a mesh regulation in certain periods to avoid the destruction of quality prawn seeds from all the water bodies with special reference to the nursery grounds can be effected immediately. In order to compensate the natural breeding of prawns it is also suggested to artificially breed the impor-tant species of prawns under controlled conditions and after a stage release them in the sea as a measure to improve the natural stock as is being practised in the case of *Penaus japonicus* in Japan.

In India seafood industry is mainly oriented on prawns. With the shortage and scarcity of prawns from capture fishery, the industry itself is undergoing a crisis now. The only hope for sustaining the industry is by depending more on the culture fishery. That is why, it is envisaged to introduce prawn culture in all the available fields giving due regard to artificial seed production through hatcheries. Since even the aquatic habitats are also not spared by environmental deterioration, the present level of prawn production from traditional paddy fields/ha. has enormously come down to about 25% of their peak. If this is the outcome of the endeavour, who will have the confidence to undertake such a profession? Likewise if the culture attempts also collapse, what will be the future of seafood industry in India? Therefore, it is imperative to resort to all methods so as to organise prawn culture in a big way. Even a multidisciplinary approach may be adopted in order to achieve this goal. This will also be capable of providing a stable basis for the shrunken industry. Any delay in putting this idea into practice will definitely pave the way clear to the detriment of a fishery which during this decade has attracted global attention.

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Economics on Traditional Prawn Farming in Kerala

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The traditional paddy field prawn culture in Kerala originated decades ago. It has been practised in an organised manner in the tide affected fields adjoining open backwater systems in central Kerala. The process essentially involves trapping seeds of commercial species of prawns and fishes in the field during each high tide and holding them there for sufficient periods to grow to marketable size. The fields will be prepared suitably by fixing sluice gates etc. after the paddy harvest to receive the juveniles of commercial prawns and fry of fishes. Usually a hurricane lamp is suspended in front of the sluice gate to attract the prawns during favourable high tide. A closely packed bamboo screen is placed at the mouth of the sluice gate while letting out water during low tide in order to prevent the escape of the entered seeds. This culture practice is a seasonal operation conducted during summer between November and April The paddy cultivation is done in these fields from Jun- to October.

A lot of investigations have been carried out by various authors (Menon 1954, Gopinath 1956. Mohamed 1972, George 1974 and Gopalan et al 1980) regarding the mode of operation and yield obtained through the traditional prawn culture systems However, studies on yield and economics of this system are recent and very few (George 1974 and Gopalan et al 1980). On the whole, all these could reveal some of the secrets of a rural enterprise. Nevertheless we lack information on the actual clues guiding to the well performance of paddy field ecosystems.

In general it has been agreed that the paddy field prawn culture systems are well productive. Its capacity to generate proteinaceous food items in addition to usual paddy is rather commendable. The production level of a prawn field depends upon factors such as its geographical position, nearness to open backwater systems, inherent productivity, the nature of traversing canals and the possibility for adequate prawn fry recruitment etc. More often a unified combination of these factors determines the quality and quantity of prawn production. In such condusive environments prawn yield will be considerable. Such properties are exhibited by majority of paddy fields lying along the Vembanad lake in central Kerala.

Prawn being an important item of commerce, its better yield from a field quite naturally will raise the economic status of the field. This is the most important criterion preferred while giving it on lease for prawn filtration. Accordingly positive co-relation exists between productivity of an ideal field and its lease amount. Often the previous year's performance of the field in terms of yield as reflected through the seasonal operation practice is given due regard in this respect. On the contrary when the paddy fields are located far interior to the main backwater systems with hindrances for exchange of water and such other retarding factors the level of prawn production will be low and hence the lease amount. These have been proved by traditional farmers through decades of experience. Thus prawn fields are categorised in terms of attainable yields. Again, because of the commercial significance of prawns the demand of a prawn field will also depend upon the fluctuating market of the prawns. Therefore to speak on the economics of traditional prawn farming system one should give consideration to all such factors governing the peroformance of the system.

Since the farmers adopt paddy cultivation and prawn culture in the same field alternately, it is interesting to have a general idea on the economic returns resulting from such propositions. The rotation of crops followed in this system is said to have an unlimited role on the production aspects of these fields. Therefore, I propose to present the yield data (Table I and II) of an 8 ha productive paddy field ideally located at Narakkal having suitable connections with Cochin backwater operated in traditional manner The observation was carried out in the same field during 1983-84

The economic details presented in table I & II of the traditional paddy field reveal that the proposition of paddy cultivation and prawn culture is still encouraging if properly operated. On comparing the two it is seen that almost double profit is realised by way of traditional prawn culture than that of paddy cultivation. Table II also reveals that more or less equal quantity of prawns and fishes are resulted through the traditional operation, the increased yield of fishes being mainly contributed by *Sarotherodon mossambicus*. The main components of the catch are contributed by penaeid prawns and fishes such as mullets, milk fish, pearl spot and *S. mossambicus*. Among prawns *Metapenaeus dobsoni* (52.63%), *Penaeus indicus* (37.59%), *Metapenaeus monoceros* (9.02%) and *P. monodon* (0.75%) are obtained in the order of preference. Most of the prawns are caught by way of filtration through sluice gates during favourable tides of the full moon and new moon phase Several other harvesting methods such as cast netting gill netting, dragging, scooping and hand picking are also employed during the terminal fishing time.

Analysis of the data from the production view point shows that the system is still capable of retaining its potentiality yielding 665 kg of prawns and 750 kgs of fishes from unit area. Nevertheless, if we exclude the cost of fishes, the sale proceeds from prawdn viz. 255 kg of penaeids and 410 kg of metapenaeids from unit area could not balance the expenditure leading the endeavour in a lean position. This seems to be obviously due to the spiralling rates of lease amount prevailling in the system especially during recent years. Again the preponderance of low priced prawn groups over the quality prawns can also be attributed to be another factor. This situation calls for urgent pragmatic measures at least to maintain the statusquo of the system.

The retarding trend of quality shrimp production from paddy fields (Purushan et al 1984) is very much evident in this study also. This does not indicate a good omen for a prospering enterprise. The threads acting against it will have to be traced out. This aspect is to be given more emphasis while shaping future research. Thus it becomes imperative to undertake need based research pertaining to this field to find out a viable alternative. Therefore the concerned should pay more attention to evolve adaptable technologies suitable to the prevailing farming conditions.

Any workable technology capable of improving prawn yield from unit area can enthral the rural farmers. It is in this circumstance that we are to suggest the farmers to take a deviation from the traditional pattern. If the traditional prawn farms are transformed in the light of modern eco-biological knowhow, it is possible to convert the total biological productivity of the fields suitable to the growth of selected commercial species of prawns. If such induction is adopted at large, the quality prawn production from fields can be raised to atleast 1 tonne/ha which will definitely boost the economic returns manifold. Viewed in this light there lies immense scope to tap more prawns from our traditional fields, the economics of which will have a marked influence on the rural development of the state.

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Table — 1

EXPENDITURE AND INCOME/HA FOR PADDY (POKKALI) CULTIVATION IN A SUCCESSFUL TRADITIONAL FIELD DURING 1983

DETAILS	LABOURERS		EXPENDITURE
	Men @ Rs. 25/- per day	Women @ Rs. 15/- per day	Rs. Ps.
1. Bund raising and channelling	10	—	250.00
2. Ploughing	35	—	875.00
3. Cost of seeds	—	—	180.00
4. Soaking seeds and sowing	4	4	160.00
5. Removal of algal macrovegetation	2	25	425.00
6. Weeding	2	25	425.00
7. Transplanting	2	25	425.00
8. Preparation of crushing and shed construction	4	2	130.00

PER HECTAR INCOME/5 MONTHS FROM THE SAME PRAWN FIELD BASED ON AN AVERAGE PRODUCTION

SALE PROCEEDS FROM SHRIMPS

1.	Cost of 250 kg. of *Penaeus indicus* @ Rs. 35/- / kg.	8750.00
2.	Cost of 5.00 kg. of P. monodon @ Rs. 55/- / kg	275.00
3.	Cost of 60 kg. of *Metapenaeus monoceros* @ Rs 15/- / kg	900.00
4.	Cost of 350 kg. of *M. dobsoni* @ Rs 7 / kg.	2450.00
	Total income from prawns	12375.00

SALE PROCEEDS PROM FISHES

5.	Cost of 150 kg. of quality fishes @ Rs. 18/- / kg.	2700.00
6.	Cost of 500 kg of *Sarotherodon mossambicus* @ Rs. 4/- / kg	2000.00
7.	Cost of 100 kg. of miscellaneous groups @ Rs 3/- / kg.	300.00
	Total for fishes	5000.00
8	Income from disposing the dismantled shed and other used items	300 00
	Total income / ha	17675 00
	Net profit (+) / loss (—) / ha from traditional paddy field prawn culture Rs 17675—16520 =	Rs. 1155 (+)

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9.	Cost of materials for shed	—	—	250.00
10.	Harvesting	5	5	200.00
11.	Post harvest labour	7	15	400.00
12.	Miscellaneous charges	—	—	100.00
	Total expenditure			3815.00

INCOME

Obtainable paddy / ha	2000kg	
Obtainable hay / ha	1600kg	
Cost of paddy @ Rs. 2/kg.		4000.00
Cost of hay @ Rs. 0.25/ha		400.00
Return from the disposal of dismantled shed		100.00
		4500.00

Net profit from paddy cultivation = 4500 — 3815 = 685 / ha

TABLE II

EXPENDITURE AND INCOME / HA FOR PRAWN CULTURE IN A SUCCESSFUL SEASONAL FIELD.

OPERATIONAL EXPENDITURE OF A TRADITIONAL 8 HA PRAWN FIELD DURING 1983

	DETAILS	EXPENDITURE
1.	Lease amount and licence fee	Rs. 87500 00
2.	Charges for fabrication of 3 sluice gates	4500.00
3.	Cooli charges for sluice fixation, preparation of field dykes and canals	3800.00
4.	Workshed and canoe	2500.00
5.	Lamps/kerosene & bamboo/plastic screens	1860.00
6.	Nets and baskets	1500.00
7.	Wages for sluice man and 3 other workers engaged in watch and ward duty @ Rs. 500/- month for 5 months.	10000 00
8	Workers share for terminal fishing	13500.00
9.	Contingencies	1000.00
10.	Interest on capital @ 14%	6000 00
	Total expenditure	132160 00

Expenditure / ha $\frac{132160}{8}$ = 16520.00

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CASE STUDIES ON THE PRAWN PRODUCTION POTENTIALS OF TRADITIONAL PADDY FIELDS AT VYPEEN ISLAND, KERALA

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An investigation on prawn culture was carried out at Kuzhupilly in Vypeen island between November '85 and April '86 in a 3 ha traditional paddy field with strong outer bunds lying amidst extensive fields. It was ideally located in the confluent junction of two main feeder canals running at almost right angles. The field was connected to each feeder canal by a suitable sluice gate with control. Canals of proper dimensions were dug inside the field to maintain sufficient water movement even at remote corners during the entry and exit of tidal flow. All precautions were taken to eliminate weeds and predators before start. Careful prawn seed ingression was ascertained through tidal flow from November. Additional stocking with 1 lakh seeds of *Penaeus indicus* of 25-30 mm size was done by early December when daily feeding at required doses with ground nut oil cake and trash fish meal was followed. The prawn stock was periodically removed through filtration during February-April. Complete harvesting was done in April when a total yield of 2691.9 kg of *P. indicus* could be obtained, of which 2069.4 kg were of good quality. Thus the total and quality prawn yields equivalent to 897.3 kg and 689.8 kg respectively from an hectare in 5 months seem to be substantial.

The case study indicates that re-orientation of the traditional paddy fields in the scientific manner can increase its life carrying capacity with definite positive impact on prawn yield. But the combined ownership of the field and the complicated terms of the presently followed lessor-lessee system offer much resistance for any modification. It is suggested to switch over to easily manageable and independent farm units of standard size with direct accession to common feeder canal and provision for quality prawn seeds and feeds aiming at better production in two to three crops. If rational transformation is accepted at large, in the existing 1200 ha of prawn fields of Vypeen island, it is possible to get an additional yield of 800-1000 tonnes of quality prawns annually. From the economic view point, the revenue realizable from this resource will be considerable. It is also emphasised that the avocation of prawn culture can surpass all other enterprises in rural development by generating employment and income to a large section of population.

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Semi-Intensive Shrimp Farming and its Relevance in Kerala

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Scientific shrimp farming has made revolutionary changes in production in many Southeast Asian countries such as Taiwan, Thailand, Malaysia and Philippines (Anon, 1988). Japan and China have also established their eminence in shrimp culture. Ecuador in south America is also emerging as a high shrimp producing country. All these countries depend on semi-intensive, intensive and super-intensive shrimp farming technologies developed by them in order to obtain maximum quantity of quality shrimp from unit area. Sophisticated equipments and high energy feeds are also tremendously applied by them in shrimp culture.

In India traditional prawn culture has been carried out for ages without remarkable changes in operational aspects. Since it became uneconomic in the long run, the tempo of research was accelerated during 1970s to develop techiques of increasing prawn production. Consequently some improved methods of operation could obtain prawn production @ 1 tonne/ha from traditional paddy fields (Gopalan et al., 1980). Further advancement in the technology assured still higher production of prawn from unit area (Gopalan et al., 1982). Recently a very simple semi-scientific prawn culture technique capable of yielding enhanced prawn production from traditional paddy fields has been described (Purushan 1987 a). Since it gives more emphasis on the ecobiological condition of the habitat, it can be successfully practised in the low lying fields of Kerala and such other places without much expenditure or depending on any costly equipment. Presently, increased shrimp production @ 4.6-9.0 tonnes / ha / year by scientific means has also been achieved in India by M/s. Hindustan Lever (Anon, 1988 a). With all these developments, Shrimp culture is in a state of transition in India. However, the development is rather slow to make a total shift from traditional to modern techniques, especially on account of the prevailing farming situations.

Against a high-tech approach in prawn production by advanced countries, the rural technology advocates conscientious utilization of natural habitat for maximum advantage. In short, it is an induction of certain scientific principles on traditional methods and hence semi-intensive. Such an innovative pursuit clearly demonstrated significant increase in prawn production from fields in Kerala (Purushan 1987 a). Its operational efficiency could very much benefit the farmer. Therefore it may be interesting to analyse the 'modus operandi' of such a simple technology and its relevance to the prevailing conditions of Kerala.

Of the several factors contributing to the success of prawn production, site selection in ideal locaton is considered to be the formost. The geographical position, the quality of bottom soil, the physico - chemical properties of tidal water, the tidal amplitude and extent of exchange are factors to be considered beforehand while going for profitable prawn culture (Purushan 1987). The strengthening of farm bunds and the fixation of sluice gates in appropriate places are other aspects to be given equal importance. Complete draining of the pond and keeping it sundrying for a week will be much beneficial. This will promote the mineralisation process by which the complex molecules of organic and inorganic compounds lying idle at the bottom will become simpler adding to the nutrient enrichment (Hickling, 1962).

Adequate canals of suitable dimensions both crosswise and length-wise are to be provided inside the pond to facilitate better water circulation. Basic manuring can also be done at this stage. Manuring in limited doses only is required since fertility status in most of our brackishwater culturable ecosystems is reported to be of a better order (Easwara Prasad, 1982; Gopinathan et al., 1982). However, it is advisable to apply @ 50-100kg Mussourie phos and 1-2 tonne cowdung/ha as basic manure. This type of manuring will help to generate zoophytomatrix and benthos production required for the growth of prawn. It may also help to correct the deficiency of some of the essetial elements likely to occur in the medium during the growth of prawns.

The area and the design of the farm determine the dimension, size and number of internal canals required. In addition to permitting the entry and exit of water, the well designed canals perform the tidal exchange properly within the farm. This efficiency of exchange is vital in the oxygenation process as well as in the removal of the metabolites as and when released maintaining the system perfectly healthy. It will also serve the purpose of live feed distribution in the entire farm-an important aspect of pond management. The imaginatively planned and meticulously followed processes effect very much to the success of scientific prawn culture. In this context it is to be remembered that farms of smaller size (3-5 ha) are considered to be better for efficient control (Yap et al., 1979).

In a suitably designed and well prepared semi-intensive prawn farm, the water holding and life carrying capacities will be at a much higher maginitude. Naturally such fields can maintain higher stocking densities. In Kerala, normally the paddy fields are kept ready for trapping prawn seed during season (November-April.) Depending upon the type of operation, differences occur in the nature of preparation and procedures to be followed in prawn fields. However, tidal water intake will be more or less similar in most cases. The scientifically operated prawn farms will also use pumps to maintain adequate water level. Suitable filters/nylon screens are usually kept in front of sluice gates of semi-intensive prawn fields during tidal water ingression. Nevertheless, they may not be perfect to prevent the entry of minute prawn larvae especially in fields adjoining Vembanad lake. So much so, a few seed invariably enter and autostocked in the prepared field along with natural tidal ingression during season. Desregarding the above, it is also possible to stock @ 60000 *Penaeus indicus* or 25000 *P. monodon* seed/ha in the improved prawn farms. The seed can either be collected from the wild or obtained from hatcheries. The hatchery fry may require a short period of nursery rearing before stocking.

After prawn seed stocking, the regular water exchange is continued as much as possible. It is desirable to have optimum quality to the water admitted (pH 6.5-8.5, temperature 27.30°C, salinity 15-28%, dissolved oxygen 3-6ml/litre and alkalinity 30-300 mg/litre). It is also significant to note that the dual functions of adequate oxygenation and metabolite elimination to and from the system exclusively depend upon the efficiency of water exchange. Therefore, considering the higher stocking density, maximum care should be paid to allow water to pass through the system 2 to 3 times per day. The more efficient the quality water exchange, the better will be the rate of prawn production. Any break in its functioning can lead to metabolite accumulation in the system leading to unbearable situations to the growing stock ending in total loss. Since the tidal amplitude of Kerala seldom exceeds the range of 60-80 cm level, it is highly necessary to use pumps to maintain required water level in prawn farms in addition to what is being achieved through sluice operations.

In the optimal stocking ponds, it is equally important to apply supplementary feeds as well, Supplimentary feed can be given either as dry pellets or in fresh pulverised form. Usually dry feed is given @ 3-5% of body weight of prawns whereas it is 10% in the case of raw feed. A little increased rate of feeding is also recommended during the fry and early juvenile stages of growth. In the absence of a factory made standard prawn feed, pulverised feeds having high energy content are usually applied in prawn farms. In this context application of mussel meat/crustacean meat is found more beneficial than feeds of vegetable origin. Recommended daily rations made of fresh or boiled clam meat, meat of small crustaceans & crabs and fish meal are at present widely applied in scientific prawn culture. Aiming better feeding and conversion efficiency by prawns it is desirable to apply feed in bits of 5-8 mm size in culture ponds. Cheap and suitable feed trays are also being extensively used to practise economy in feeding. In addition, it will also minimise the load of organic pollution in the system.

In the semi-intensive prawn farming, the aforesaid procedure is cautiously followed from start to finish of culture operation. In a well maintained system, the combined effect of water quality, the quality and quantity of prawn seed stocked at optimum and conversion efficiency of nutritious feed reflect very much upon the growth. If everything goes normal, optimum growth of prawns will be attained within 3 months in the case of *Penaeus indicus* and $4\frac{1}{2}$-5 months in the case of *Penaeus monodon*. The *P. indicus* may grow to 15-20 gm size *P. monodon* to 30-50 gms by this time quite easily. It is also expected to reap 75-80% of the stock during final harvest when the prawn production can be within the range of 600-900kg/ha/crop. Since two such prawn crops can be made possible in the extended prawn farming season (October-May period) in many of the prawn farms in Kerala, attainment of 1-1 5 tonnes of prawns/ha is quite possible. This rate seems to be very substantial over the deteriorating trend of prawn production reported from traditional fields (Purushan et al., 1984).

Therefore, it seems worth while to go for semi-intensive prawn farming in Kerala especially when we take into account the chances of higher prawn yield on adopting improved technology. The spiralling cost of prawns in world markets and the dwindling tendency of prawn capture fishery from our coastal waters may also favour the move very well. Judged from the above it is high time to reorient our prawn farms on technological manner to produce more. Such radical changes in the approach of farming community and large scale adoption of appropriate prawn farming technology in selected areas in Kerala can definitely bring about substantial increase in prawn production. It will also play significant role in promoting employment avenues and overall rural development.

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Puduveypu: A Potential Brackishwater Fish Seed Resource

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Timely availability of quality fish seed in adequate quantity is the most important requirement in fish culture. Even today brackishwater fish farming depends very much on natural fish seed supply. In the South-west coast of India, the Cochin backwater and its adjoining low lying areas serve as natural nursery grounds for brackishwater prawn and fish. The spawn of important fishes and prawns in different stages of growth reach the estuarine areas by tidal ingression where they accomplish their early growth. The conducive ecological environment (optimum conditions of pH, water temperature, salinity, dissolved oxygen, and organic productivity) prevailing in the estuarine areas promote their survival and growth.

A vital role in this regard is played by the low-lying tide-inundated areas of Vypeen island in which Puduveypu, a naturally accreted area at the southern most tip of Vypeen island is located, assumes significance in having an extent of 300 ha. The entire area is marshy with lot of mangrove vegetation. It also forms an important place for the seasonal occurrence of commercially important seeds of fishes such as **Mugil cephalus** and other mullets, **Chanos chanos, Lates calcarifer, Eleutheronema tetradactylum** and prawns such as **Penaeus indicus** and **P.monodon.** This article examines how far the seed resources potential of this area could be depended upon for planning viable aquaculture programmes.

Being located on the northwestern bank of Cochin bar-mouth facing Arabian sea, most of the accreted area at Puduveypu is daily inundated by the semidiurnal tidal rhythm of Cochin barmouth. This tidal inundation brings in lot of fish seed of commercially important species which are disseminated far and wide depending upon the tidal amplitude.

During ebbing, the entered seed find shelter in the natural basins, sand pits, crevices and canals characteristic of the naturally accreted area. The seed thus trapped will concentrate at these points which will be discernible in accordance with their intensity and schooling behaviour. At this time they can be easily removed by skilled persons employing suitable gears. The surf and hapa nets are found to be the most efficient gears to collect the early fry.

The collected fry are removed to plastic/aluminium buckets containing water of the same habitat and immediately transported for release into the specially prepared nearby earthen nurseries for subsequent rearing. If the fry is too small, they will be kept in the hapa for 3-5 days before direct release into the nurseries. Close meshed cast nets are also employed to collect advanced fry/fingerlings which can directly be stocked in the grow-out ponds.

RECRUITMENT

The quality, quantity and variety of fish seed vary with season, apart from the intensity of tidal effect. Since the breeding of all the commercially important brackishwater fish and prawn takes place in the sea and is mostly linked with monsoon period, a well pronounced seasonal influence is seen in the seed recruitment in respect of each species. The seed availability at Puduveypu also conforms to this general rule and is discussed below.

MILK FISH

The fry of **Chanos chanos** begin to appear during early February and their availability gradually increases to reach peak in May-June. The spindle shaped body, oblique mouth, silvery white colouration, fast swimming nature and

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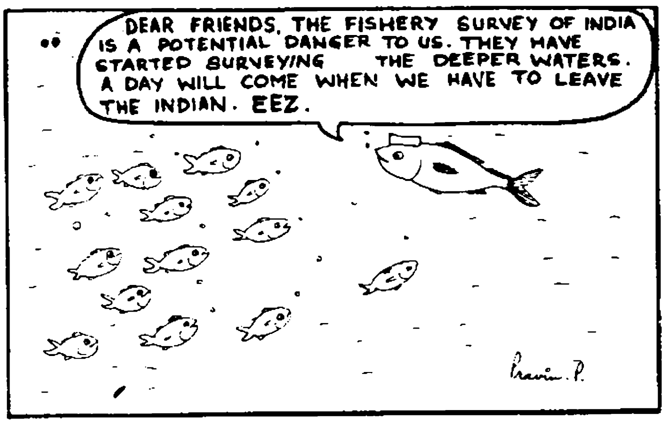
shoaling behaviour make them easily identifiable in their habitat. In a peak day during May it is possible to collect 1500-2500 fry by two persons working with hapa net for a period of 8 hours. The success lies in the combined effect of technical skill, gear efficiency, favourable tide and other ecological factors. If all the factors remain positive, fry recruitment also goes up proportionately during the season.

The fragile fry of **Chanos chanos** of the size range of 10-15 mm obtained from the wild are reared in the specially prepared earthen nurseries for two to three weeks. The standard procedure is followed in manuring to generate plankton and microbenthic algal assemblage to serve the early feeding requirement of the milk fish fry. In case, hapa rearing is required for the fry within the earthen nursery, microbenthic 'lab lab' is introduced into the hapa feed. On attaining a size of 25-30 mm the fry are distributed to the farmers in oxygen filled polythene bags containing clean and filtered water having ambient temperature for long distance transport.



MULLET

The **Mugil cephalus** fry recruitment at Puduveypu also occurs during the monsoon months. The fry collection starts during middle of June and lasts till the end of August, the peak period being July. As mentioned in the other case, the fry concentrate at certain pockets during the season. The shoaling behaviour, broad head with dark dorsal plate, peculiar linear rows of scales, purplish notch on the base of pectoral fin and the bluish white shining colouration are the identifiable criteria for the fry. During peak days 2 persons can collect a maximum of 750-1500 fry within a period of 8-10 hours. They are removed in the similar manner to the earthen nurseries for subsequent rearing as described for chanos fry. The fry measuring 10-15 mm will reach 25-30 mm within 2 to 3 weeks, then they will be distributed to the needy farmers in oxygen filled containers.

The fry of other mullets are available in fairly good quantity almost year round at Puduveypu except for one or two months during the period of post-monsoon interface. It is possible to collect 2000-3000 mullet fry during a favourable day by two skilled persons by hapa/surf net operation. During summer months profuse occurrence of seed shoaling in extensive areas is not uncommon. These white and shining fry of 10-15 mm size are also removed to nurseries and after careful rearing are distributed to the farmers for culture purposes. Of all the seed resources, 90% is contributed by other mullets at this place. A great majority is left untapped owing to lesser demand.

SEABASS

Fish seed of **Lates calcarifer** are also obtained at Puduveypu area during the South-west monsoon period, but in very less quantity. They are trapped from the crevices and such other hiding places in the area while making efforts to collect other available seed. The coloured seed with dark and brown bands in the size range of 10-20 mm are caught by scoop net or hapa net. The success of fry collection depends on the success of monsoon. It is experienced that a feable monsoon will affect their recruitment. However, it is possible to trap 20-60 **Lates calcarifer** seed in a favourable day during the monsoon period by two skilled persons. The fry are reared in suitable earthen nurseries containing live plankton. As their size changes beyond 30 mm, live weed fish and chopped trash fish are fed till they are removed to grow out ponds.

INDIAN SALMON

Very few fingerlings (140-160 mm) of **Eleutheronema tetradactylum** are collected at this place during August-September period. It is virtually very difficult to collect any sizeable quantity of this species for culture purposes. Nevertheless, it is also seen that a seasonal fishery of the adult specimens is seen in the contiguous regions from September to January when a gill net operating country craft is able to catch about 40-80 kg fish/night in a good fishing night.

TILAPIA

Tilapia **(Sarotherodon mossambicus)** seems to be well →

established in this brackishwater habitat. Prolific breeding of the species is taking place incessantly by which offsprings of any number can be raised within short period. Therefore enough seed could be at hand for commercial culture purposes. In the brackishwater mixed culture systems these fry can attain a size of 200-300 gm within a period of 6-8 months.

Seeds of **Penaeus indicus** and **Metapenaeus dobsoni** are profusely available during November-May. During favourable low tide from November to January two persons can collect 2000-3000 seed by napa net within 6 hours. Because of this potential, a prawn seed trade is seen practised at this place by trained youth during the season. The quality seed are disposed off to the farmers @ Rs.50/1000 nos. at the collection centre. The post larvae of **P. mondon** begin to appear in this area during April-June period. However, their quantitative performance is not much appreciable now-a-days seldom exceeding 100-300 post-larvae per midnapore net per tide even during its expected peak season of May-June.

SCOPE FOR UTILISATION

Thus there is an abundance of fish seed resources at Puduveypu. Needless to say that immense scope lies for taking up farming of **Chanos chanos** and mullets in large areas exclusively depending upon their natural seed availability. The large scale abundance of **Penaeus indicus** seed also speaks in favour of its culture in vast areas during the season. So much so, seed availability in respect of **Mugil cephalus** and **Lates calcarifer** from wild also holds good for undertaking their culture in a modest way. So is the case of tiger prawn. The nighly unpredictable and sporadic occurrence of seed of **Eleutheronema tetradactylum** does not permit any culture venture at this place. It is necessary to resort to adoption of induced breeding techniques to produce the fish seed of these species. On the contrary, tilapia seems to have great potential because of its better conversion ratio quickly reaching appreciable size within a short period at this brackishwater habitat.

Despite availability of the seed resource potential, brackishwater fish farming still has not attained the required momentum in the area. However, farmers transport the seed during season to long distances for culture purposes elsewhere and obtain higher yields. Probably, the slushy habitat and the associated ecological conditions may be the factors hampering the progress of fish culture at this place. Naturally, the fish seed resource is also dwindling season by season during recent years because of the stressful environment. The high sediment load of the ambient water mostly generated by the harbour development activities also creates problems for the fragile fry leading to mortality. Therefore, much caution is required not to tilt the balance of ecosystem in order to save the natural food resource from further shock.

PLATE XXVII

A-Harvested lot of *P. indicus*

B - Harvested lot of *P. monodon*