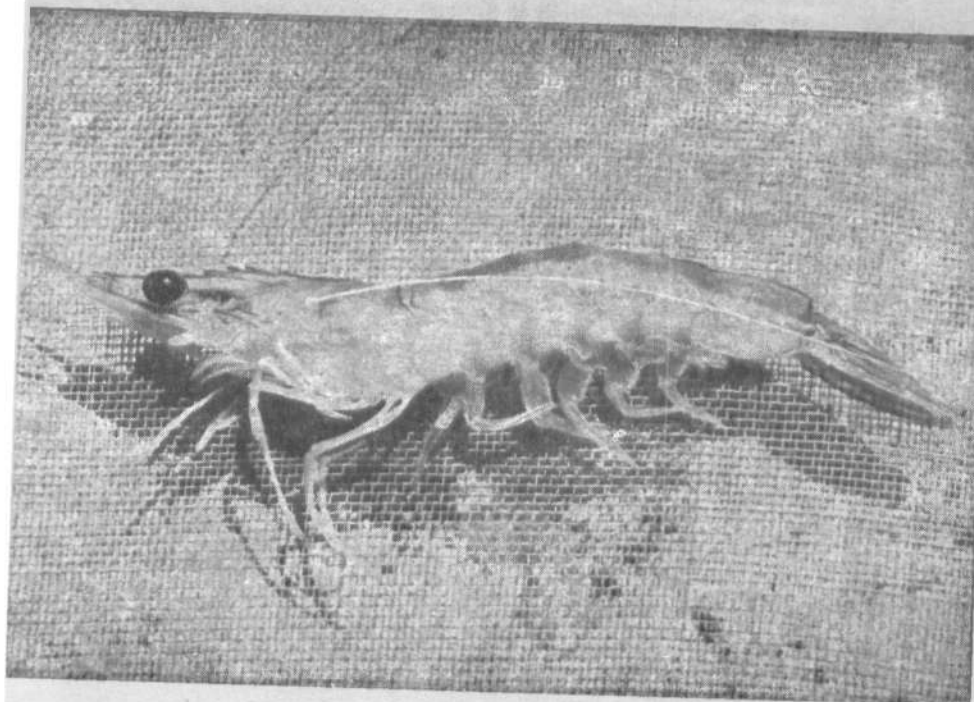




CMFRI SPECIAL PUBLICATION  
Number 21

A GUIDE TO  
**PRAWN FARMING IN KERALA**



CENTRAL MARINE FISHERIES RESEARCH INSTITUTE, COCHIN  
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*(Continued on back cover inside)*

# **A GUIDE TO PRAWN FARMING IN KERALA**

**K. ASOKAKUMARAN UNNITHAN**  
*Krishi Vigyan Kendra of CMFRI, Narakkal*



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## PREFACE

The development of coastal aquaculture and utilisation of brackishwater areas for productive purposes are receiving priority attention in our Fisheries Plan Schemes. Kerala has traditionally an established crop-cum-fish culture system in the pokkali paddy fields of the Ernakulam and adjacent Districts. However, in general the yield of the pokkali paddy strain is low being 700-1000 kg/ha/harvest. Similarly the production of fish and prawn from wild stocking through tidal effects from these fields is also low, yielding hardly about 400-700 kg/ha/season depending upon the location and other parameters.

The Central Marine Fisheries Research Institute has been investigating ways and means by which production of prawns and fishes from this system could be enhanced. Most of the pokkali areas may be classified as having acid sulphate soil with very high organic loads. Upgrading of the system by proper lime treatment and maintaining the natural productivity of the water is very important. Considerable amount of work on the micro-ecosystem of the pokkali paddy fields has been undertaken. In addition to this, by selective stocking of desirable species of prawns in the paddy fields during the prawn culture phase from October to April, it is felt the economic returns could be many fold. Until the late Seventies most of the farmers resorted to wild stocking by letting in tidal water which brought in the seeds of prawns and finfishes of both desirable and undesirable species. Through the Krishi Vigyan Kendra (KVK), an active programme for propagating selective stocking of seeds of desired species, particularly *Penaeus indicus* has been taken up espousing the advantages of extending the duration of stocking period and not harvesting every fortnight. These and other simple management measures have been imparted through the KVK to farmers and those working in the prawn farms in Ernakulam District. Other organisations such as State Department of fisheries and the Marine Products Export Development Authority have also taken up extension programmes in propagating prawn culture in pokkali fields.

In view of the importance given to prawn culture and the advantages of enhanced economic returns and job opportunities that the system could generate, it is felt that a detailed guide for prawn farming in Kerala should be prepared on the basis of past experience so that improved guidelines could be indicated. The present publication prepared by Shri K. Asokakumaran Unnithan, Senior Training Assistant of the Krishi Vigyan Kendra of CMFRI, Narakkal outlines the salient features of the prawn farming system as practised at present and the scope for improving of the same through low cost inputs. I feel that this publication with the fund of information given therein could help in accelerating the area development programme in prawn farming in the coastal and brackish water areas of Kerala, particularly the Ernakulam and adjacent Districts.

Cochin-682 018,  
3 May, 1985.

E. G. SILAS  
*Director,  
Central Marine Fisheries  
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## INTRODUCTION

Pearl culture is an art concerned with biological production of one of the finest gems, the pearl, nature's perfection of beauty and splendour. It is produced by the pearl oyster, a bivalve mollusc, living on an insignificant ground at the sea bottom. Man has known this gem right from the period of early human civilization and had adorned himself and his woman with pearls and had offered them to his gods. The soft colour and cool lustre of pearls produced by the oyster remain unmatched by any of the gems processed by man.

Ages ago, the ancient Greek philosophers gave explanations on the origin of pearl, the great explorers and travellers offered their opinions and the naturalists tried to unravel this mystery of nature through scientific theories. Carl Linnaeus developed a 'secret process' of forming pearls in a freshwater mollusc. The first practical work to produce pearls artificially was done by the Chinese in the 13th century, producing the classical pearly Buddha images in the freshwater mussel in Lake Tahu in central China.

However, the credit for the development of modern pearl culture goes to Japan. They developed and perfected the techniques of pearl culture in the marine pearl oyster in the early part of the present century, starting from the initial success achieved by late Mr. Kokichi Mikimoto in 1893. They also improved the Chinese techniques of freshwater pearl culture for production of the so-called 'natural' pearls. The Japanese marine cultured pearl production has dropped in the recent years from 127 tonnes (all-time peak) in 1966 to 34 tonnes in 1973 which has been stabilised at that level in subsequent years. The annual freshwater cultured pearl production has been around 7 tonnes recently. Pearl culture has spread to other countries, in all cases with the Japanese help perhaps with the exception of China. Australia has a sizable production but the other countries in South-east Asia such as Burma, Philippines, Malaysia, Thailand and Indonesia have very modest production limited by the availability of pearl oyster resource.

The major species of pearl culture in Japan is *Pinctada fucata* from the sea and *Hyriopsis schlegelii* from the lake. In Australia and South-east Asian countries it is the silver-lip pearl oyster *Pinctada maxima*. The black-lip *P. margaritifera* forms a small component at some centres as also black-winged pearl oyster *Pteria penguin*. The abalone *Haliotis* sp. is used in Japan at a few centres. Round pearls are produced in *P. fucata*, while both round and half-pearls are produced in *P. maxima*. Pearls produced in the freshwater mussels are largely baroque.

India's potential for pearl culture with its resource of *P. fucata* was realised long ago and efforts were made to develop the techniques since the early thirties. However, technological success came about only in 1973 in an experimental project of the Central Marine Fisheries Research Institute based at Tuticorin. With this breakthrough, further research at the Institute has been focused on several scientific and technical aspects of pearl culture and pearl oyster production.

The main objective of this manual is to present the basic techniques of pearl culture in simple language which could be easily understood and practised by those interested. The techniques for hatchery production of pearl oyster have not been included as breeding and larval rearing are multidisciplinary problems and cannot be covered here. The techniques given are those developed at the Institute which have proved successful in farming of pearl oyster and cultured pearl production. Surgical procedures vary from species to species and based on kinds of pearls. Only those relating to *Pinctada fucata* for the production of round cultured pearls have been given in the manual. Some data which are necessary for judging the success of production are given but these cannot be held true for all situations in view of several variable factors. Every technician or manager of pearl culture may be able to improve upon the results depending on his skill and judgement of the problems and their solutions. It should be appreciated that it is finally the pearl oyster which is responsible for pearl production and, being a biological process controlled by many variables, production cannot always be the same as targets fixed. Nevertheless, the three basic rules of right oyster, right surgery and right environment, if practised carefully, should ensure success of production.

# 2

## SELECTION OF SITE FOR PRAWN FARMING

### 2.1. *Topography*

Low-lying brackishwater areas including seasonal and perennial fields, ponds, canals in coconut groves, salt water lakes and salt pan reservoirs are suitable for prawn culture. The vast areas of estuarine marshes and tidal flats lying unutilised could also be converted into productive prawn farms (Plates 1 and 2). Farm site should be sufficiently away from the beach line so as to ensure protection from erosion. Excessively low areas may be avoided since effective draining is not possible and the cost of construction and maintenance will also be very high. Similarly highly elevated areas [require extensive excavation or the water has to be pumped ; both involve high expenditure. A moderately flat area sloping towards the tidal source will be ideal from the point of view of economy and productivity.

### 2.2. *Tidal flow*

The farm site should have free tidal water movements so as to have daily mixing of water throughout the period of culture. Tidal flow (i) brings in nutrients and live food organisms ; (ii) renews the water in the ponds avoiding stagnation ; (iii) helps in regulating the temperature of the pond water ; (iv) causes circulation of nutrients throughout the pond and (v) takes out biological wastes (metabolites).

In order to have tidal influence the farm water must be confluent with the sea, directly or indirectly.

Tides are brought about by the combined pull of the moon and the sun on ocean water and the centrifugal force due to the revolution of the earth causing a wave bulge of water to occur on both the nearest and farthest side of the earth opposite to the direction of the pull. Typically there will be two rises and two falls of water level in a lunar day (24 hrs. 50 minutes and

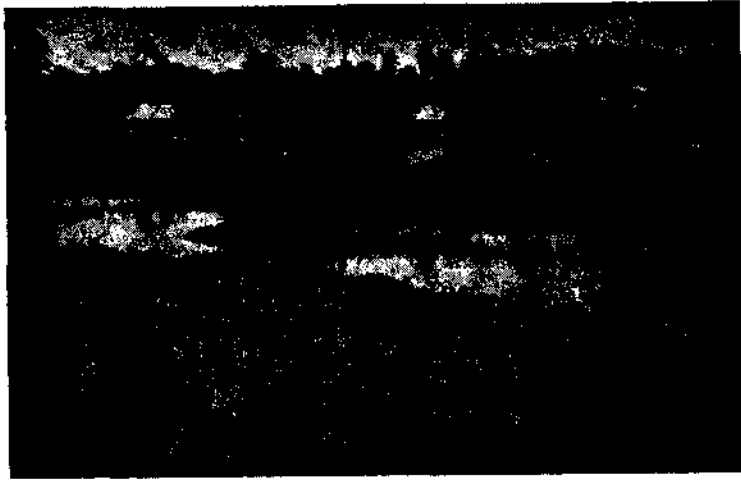


PLATE 1. Coastal marsh land, ideal for construction of prawn farm.



PLATE 2. Canal system in coconut grove, suitable for growing prawns.

28 seconds) which are called high tides and low tides respectively. The difference in height between the high and low tide levels is called tidal range or tidal amplitude. The average interval between successive high tides is 12 hrs. 25 minutes and 14 seconds.

Twice each month during the periods of the new moon and full moon when the sun, moon and the earth are in zytygy (three bodies in a line) the tidal amplitude is greatest, and Spring Tides occur. Twice each month, when the moon is at first or third quarter, the pull of the moon and the sun are at right angles to each other and are subtractive and therefore the tidal amplitude is least, and Neap Tides occur.

If the bottom of the pond is above the level of the lowest low tide it would facilitate the maximum draining and replenishment of tidal water. This would also help to drain the pond fully at the time of harvesting. Areas having a tidal range of 0.5 to 1.5 m can be economically made use of. In regions having higher tidal ranges as experienced along the coastal areas of West Bengal, Maharashtra and Gujarat where it is sometimes 3-5 m, the construction cost of farms will be very high, so also the management problems.

Tidal amplitude along the Indian Coastline declines from north to south. At Cochin region (10°N latitude) the mean tidal amplitudes of Spring Tide and Neap Tide are 0.63 m and 0.23 m respectively.

The Indian Tide Table published every year by the Survey of India, Dehra Dun contains details of day to day tidal amplitudes experienced along the coastline. Farmers are advised to buy a copy every year which would enable them to ascertain the suitability of the site for the purpose and also for the effective management of tidal flow when the culture operation is in progress.

### 2.3. *Pollution*

It is highly essential that the water and soil must be free from pollutants. The site must be free from industrial effluents, city

sewage or pesticide run off from agricultural farms. Coconut retting areas must be avoided where the soil and water will be highly decomposing and acidic. Hydrogen sulphide gas emanating from such areas is also toxic.

A general survey of the locality would enable the farmer to have an idea as to what industries function in and around the region and the path of their effluent channels, the periodicity of release of effluents and so on.

#### 2.4. *Silt*

Water must be free from high load of silt. Silting will lead to physical and biological problems in the pond. It will reduce the depth and make the pond shallow. Turbidity caused by silt will affect the productivity of the pond by hampering the penetration of sun light through the water column affecting photosynthesis. Silt also causes respiratory problems to prawns and fishes by clogging the gills. It also brings in large quantities of organic detritus which may lead to oxygen depletion on decomposition.

The problem of silt can be controlled by giving a break in the through flow system. Silt laden water can be first let into a reservoir pond for setting. The upper silt free water can then be let into the ponds. Silt deposition in the reservoir can be removed whenever required. In the absence of reservoir pond the main feeder canal can be used for the purpose.

#### 2.5. *Productivity*

The carrying capacity of the pond depends mainly on its primary productivity. Primary production is the organic matter produced in the pond in the form of microflora including phytoplankton, benthic algae and photosynthetic bacteria using the radiant energy of the sun and the nutrients available in the pond. The flora thus formed, is the food of the fauna of the pond directly or indirectly. Growth and production of prawns in the pond varies according to the level of primary production.

Based on the degree of primary production (Gopinathan *et al.*, 1982), prawn fields can be classified as :

highly productive	(> 1500 mg C/m <sup>2</sup> /day)
moderately productive	(500–1500 mg C/m <sup>2</sup> /day) and
low productive	(< 500 mg C/m <sup>2</sup> /day)

Productivity is mainly governed by soil and water characteristics.

## 2.6. *Water characteristics*

Tidal water feeding the farm should satisfy the optimal physico-chemical qualities required for the successful growth and survival of prawns.

### 2.6.1. *Height of water*

Ponds should have 0.75 to 1 m high water throughout the period of culture. If the height of the water is less than this, water will get over heated by the sun during peak summer affecting the survival of prawns. Ponds with a water depth not exceeding 2 m is considered congenial from the point of view of biological productivity (Sinha, 1983).

### 2.6.2. *Turbidity*

Suspension of silt and clay as well as planktonic organisms cause turbidity in the water. Turbidity due to planktonic organisms is an indication of high productivity. Suspended silt and clay particles will adsorb considerable amount of nutrients making them unavailable to primary production. Suspended particles above 4% by volume will have clogging effect on the gills (Sinha, 1983). Turbidity caused either by living or non-living objects greatly influences the transparency of water affecting photosynthesis.

### 2.6.3. *Water temperature*

Water temperature influences the bio-chemical reactions and microbial release of nutrients taking place in the pond ecosystem

as well as the physiology of the organisms, growing inside. In a pond having the optimum height of water, the bottom water will be less warm than the surface water exposed to the sun. Such variation will not be felt much in shallower ponds. As temperature increases, the ability of water to dissolve oxygen decreases. Water temperature, optimal for prawn farms is 25 - 30°C.

#### 2.6.4. Dissolved oxygen content

In a normal pond the oxygen producing and consuming processes keep a dynamic balance which maintains the concentration of dissolved oxygen within the tolerable range to all the organisms. Concentration of dissolved oxygen decreases with increasing temperature and salinity. In prawn farms the dissolved oxygen content should not go below 3.5 ml/litre (Susceelan, 1978).

#### 2.6.5. Salinity

The amount of salt in water is referred to as salinity (salts include chlorides of sodium, magnesium, sulphates of magnesium, calcium, potassium, etc. and many others in minute quantities). Sea water contains about 89 % chlorides and 10% sulphates. It is expressed as grams of salt per kilogram of sea water. The symbol used is ‰ or ppt (parts per thousand).

Farmers should have a thorough knowledge of the salinity profile of the tidal water of the site before selecting the site for construction of farm. It should also be ascertained that there is no chance of heavy fresh water influx to the farm which would cause sudden fall in salinity giving stress to the prawns.

Though *P. indicus* can survive in salinities below 5 ppt (George *et al.*, 1982) the salinity range ideal for the culture of the species is 10-35 ppt (Muthu, 1980).

#### 2.6.6. pH

Water contains dissociated or free hydrogen and hydroxyl ions which give an acidic, alkaline or neutral reaction to water



depending upon their relative concentration. The amount of free hydrogen ions is measured on a scale from 1 to 14 known as the pH value. Pure water has equal amounts of hydrogen and hydroxyl ions and has a neutral pH of 7. With a pH below 7, water is acidic. Acidity ascends as the pH descends from 7. With pH above 7 water is alkaline. Alkalinity increases as the pH ascends from 7. pH of the water is influenced by the soil pH and concentration of carbon dioxide, carbonates and bicarbonates in the water.

Alkaline water with pH ranging from 7.5 to 8.5 is conducive to the culture of prawns (Muthu, 1980).

#### 2.6.7. *Dissolved nutrients*

Tidal water is one of the sources which supplies nutrients to the pond ecosystem. Land run off through river discharge and constant incursion of sea water have profound influence on the nutrient concentration of the tidal water. The important nutrients present in the tidal water are phosphorus, potassium, nitrogen, carbon, magnesium, calcium, sulphur, etc.

Prawn fields around the Cochin and Azhikode bar mouths are highly productive because of the influence of the Pampa and the Periyar rivers and the constant incursion of sea water through the two bar mouths. Whereas, the brackishwater ecosystems around Vaikom region, the south eastern part of estuary have lower production. Here, chances of sea water incursion are feeble due to the distance from the bar mouth, as also the discharge of nutrient laden fresh water is restricted (Gopinathan *et al.*, 1982).

#### 2.7 *Soil characteristics*

Bottom soil is considered as the laboratory of the pond where important biochemical reactions are taking place. Bottom soil plays vital roles in (i) the storage and release of nutrients into the water, (ii) the mineralisation of organic bottom deposits, (iii) providing shelter and food for bottom dwelling organisms and (iv) acts as a 'bed' for the growth of algal pasture. Fish, like agricultural crop, is primarily a product of the soil.

Soil characteristics such as its texture, composition and fertility are the major aspects which govern the productivity of the pond.

### 2.7.1 Texture and composition

The texture and composition of the bottom soil play a dynamic role in maintaining the productivity. Sandy soil will be porous and so less fertile since nutrients are easily leached off. On the other hand if it is more clayey, it will not be porous, but will be highly absorptive holding too much organic matter. This will lead to acidity and oxygen depletion due to massive putrefaction. Acidic soil should be avoided. Soil must be slightly alkaline, with pH between 7.5 and 8.5.

Bottom soil composed of sand, silt and clay (particle size—sand 0.2—0.6 mm; silt 0.06—0.002 mm and clay less than 0.002 mm) is ideal for the growth of *P. indicus*.

Peaty soils are acidic due both to humic acids and free sulphuric acid with little mineralisation of organic matter. Peats are also deficient in calcium, magnesium and potassium.

In brackishwater swamps with dense mangrove vegetation, there will be too much accumulation of organic debris in the soil because of their dense root system. Here, gradually anaerobic conditions become established. During the period, sulphur reducing bacteria become active. These bacteria utilise sulphate which is abundantly present in the water. As a result, sulphates are reduced to sulphides. The sulphides either accumulate in pockets in the soil as hydrogen sulphide gas or combine with available iron to be deposited as iron sulphide. The iron sulphide usually undergo further chemical reaction to form iron disulphide which upon crystallisation form the mineral, pyrite. Pyrite submerged in water remains reduced and is subject to little change. Upon drainage and subsequent oxidation, sulphuric acid is formed causing the soil pH to go down. The acid also attacks other soil minerals releasing iron, aluminium and manganese in active forms. The excess acidity and the active elements can become injurious to both

fish and fish food organisms. When pyrite containing soil becomes highly acidic it is called 'acid sulphate soil'. The term 'potential acid sulphate soil' is used to describe a soil which will become acid sulphate on oxidation. If pH drops below 4, it is a potential acid sulphate soil (De Los Santos Jr., 1978). This situation is prevalent in some of the pokkali fields which may need upgrading.

It is advisable to analyse the soil of a proposed pond site especially the subsoil to avoid acid sulphate or potential acid sulphate soil since it is highly expensive to develop such areas. However, the different measures suggested for neutralising acid sulphate soils include (a) drying and flushing with sea water repeatedly, (b) applying burnt lime in sufficient quantities (20-100 tonnes per ha) and (c) covering excavated pond bottoms with more suitable soil (De Los Santos Jr., 1978).

Percentage of sand, silt and clay in the bottom soil will be different in different habitats such as pokkali fields, perennial fields and canals in coconut groves. Among the three habitats, the bottom soil in pokkali fields composed usually of sand 58%, silt 18% and clay 24% is found to be most favourable (Easwara Prasad, 1982).

#### 2.7.2 Soil nutrients

Fertility of the soil depends on the availability of soluble forms of nutrients such as nitrogen, phosphorous, potassium, organic carbon, calcium, sodium, sulphur, magnesium and trace elements like zinc, manganese and cobalt.

Based on the degree of availability of soil nutrients, the nutrient status of soil with regard to each constituent can be categorised as low, medium and high (Table 1).

Among the different brackishwater ecosystems adjoining the Cochin backwaters, the seasonal pokkali fields have the highest fertility status followed by the perennial fields and the canals in coconut groves. The organic carbon content of the bottom soil of the three ecosystems is 4.44%, 2.37% and 1.67% respectively (Easwara Prasad, 1982). The abundance of organic matter in the pokkali fields including the paddy straws, stumps and other

Vegetation left after paddy cultivation largely contribute to the high fertility of the soil by decomposition. Content of organic carbon has direct correlation with the availability of other nutrients such as calcium, sodium, potassium.

TABLE 1. *Status of nutrients in the soil based on their degree of availability* (Tang and Chen, 1967)

Nutrients in the soil	Status of nutrient in the soil		
	Low	medium	high
Organic matter (per cent) ..	< 1.5	1.6-3.5	> 3.6
Nitrogen (per cent) ..	0.10-0.15	0.16-0.20	> 0.21
Phosphorus (ppm) ..	< 35	36-45	> 46
Potassium (ppm) ..	< 350	350-500	> 500
Calcium (ppm) ..	< 700	700-1,200	> 1,200
Magnesium (ppm) ..	< 300	300-600	> 600
Chloride (ppm) ..	< 2,000	2,000-5,000	> 5,000

### 2.8 Proximity to prawn seed

Transportation of prawn seed from distant places is expensive. It also causes stress to the seed, leading to mortality. Site must be selected in areas where the desired species and required quantities of prawn seed are available nearby, either from the wild or from hatcheries.

### 2.9 Man-power availability

Trained men are required for the effective management of prawn farms on scientific lines. Skilled personnel are required for farm construction and monitoring of water quality. Short-term training facilities in this field are available to the prawn farmers and landless farm labourers at the Krishi Vigyan Kendra of CMFRI at Narakkal in Ernakulam District.

### 2.10 Other facilities

Proximity of the pond site to road, ice plant and electric power lines (for installing flood lights at strategic points to avoid poaching) will be of great benefit with regard to the culture operation and marketing.

### 2.11 *Seasonal and perennial farms*

Farmers must be thorough with the categorisation of farms whether seasonal or perennial, before taking up culture operations.

### 2.12 *Leasing of farms*

In case the farmer has to take fields on lease for prawn culture, the culture operations have to be planned in such a way so as to conclude by the end of the lease period. As per the system in force in Kerala, the lease period of seasonal fields is 5 months, mid-November to mid-April; whereas perennial fields are leased out for one year, November 1st to 31st October.

### 2.13 *Legal aspects*

As per the legal Notifications of the Govt. of Kerala, prawn fishing in private waters and fields is regulated by issue of licence.

The following is the \*extract of the concerned Act' Kerala Gazette No. 21 dated 21st May 1974 PART I.

## GOVERNMENT OF KERALA

### Development (K) Department

#### NOTIFICATION

No. 4729/K I/73-I/DD

Dt.: Trivandrum  
4th May 1974.

S.R.O. No. 362/74—In exercise of the powers conferred by section 22 of the Travancore-Cochin Fisheries Act, 1950 (Travancore-Cochin Act XXXIV of 1950) the Government of Kerala hereby make the following Rules for regulating prawn fishing in private waters, namely :—

1. (i) These Rules may be called Regulation of Prawn Fishing in Private Waters Rules, 1974.

(ii) They shall apply to the whole of the State of Kerala excluding the Malabar District referred to in Section 5 of the States Reorganization Act, 1956 (Central Act 37 of 1956).

(iii) They shall come into force at once.

2. No kind of prawn fishing shall be conducted in any private waters and fields without a licence obtained from the competent authority in Form A.
3. Application for prawn fishing in any paddy field for any temporary period in a year or permanently will not be entertained except in cases when such fields are unused and unfit for paddy cultivation for such periods.
4. Application for a licence in Form B shall be presented a month before the commencement of fishing to the Inspector of Fisheries concerned in whose jurisdiction the lands are situated. The Form shall be affixed with a court fee stamp of Rs. 2.
5. Application for licence received after 15th December of the year for prawn fishing in fields generally used for cultivation will not be entertained.
6. In the case of application for licence to carry on prawn fishing in private waters and paddy fields presented by a person other than the Pattadar or Inamdar the licence will not be granted without the consent of the Pattadar or Inamdar as the case may be. The consent certified by the concerned Village Officer should be produced along with the application for the licence.
7. A licence fee at the rate of Rs. 15 per acre will be levied for every licence.
8. Complaints regarding the issue of licences shall be presented to the Director of Fisheries.

9. The licence issued under these rules are subject to the following conditions and restrictions :—

(a) Storing of water in fields by means of water proof shutters shall not be resorted to and the sluice fishing or stake net fishing alone shall be done ;

(b) Nets with meshes including cod ends of less than 20 mm (the length of mesh taken when the net is dry) shall not be used for fishing from paddy fields ;

(c) Fixed engines or other contrivances used for prawn fishing shall not cause any obstruction to navigation or water bound traffic ;

(d) The bunding up of areas or other works of the licencees shall not in any way cause any hindrance or inconvenience for paddy cultivation in the adjoining lands ; and

(e) Every licence issued under these rules shall be valid only for a period of one year from the date of issue or such lesser period as is specified in the licence.

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\* Particulars given in the original notification for the use of officials of the Department of Fisheries are not included in this extract.

## FARM CONSTRUCTION

## 3.1. General considerations

Full advantage of the existing natural conditions may be taken while preparing layouts for farms. Any depression present at the site can be economically made use of by proper designing. Ponds having a regular shape without undulations is more economical helping smooth operation and maintenance. If the topography of the area is such that an irregular shape of the pond is inevitable, sharp bends and corners should be avoided as far as possible to provide stability to the pond structure. A comparatively larger farm should have perimeter bund and smaller inner bunds dividing the farm into different compartments.

## 3.2. Plans, designs and size of ponds

Orientation, shape and size of ponds also determine the magnitude and cost of production by way of influencing water management and harvesting.

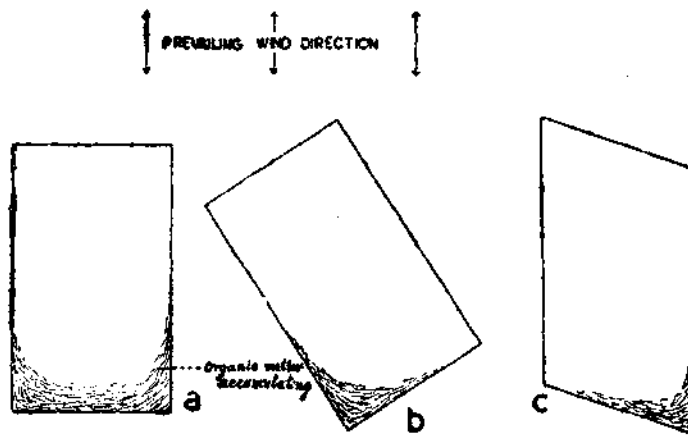


FIG. 1. Orientation pattern of ponds. (a) longitudinal orientation (b) diagonal orientation, (c) rhomboid orientation.



Rectangular ponds are more common. The shape of the pond may be designed so as to orient the long axis of the pond along the prevailing wind direction (Fig. 1 a). A better recommendation is to orient the pond diagonally along the wind direction (Fig. 1 b). Accumulation of nutrient rich detritus and other organic matter which usually takes place in high concentrations at either corner due to wind action could effectively be managed to disperse uniformly throughout the pond by providing the water inlets at the critical corners. These orientation patterns would also help to minimise the erosion of bund due to wave action. Ponds can also be designed rhomboidal instead of the usual rectangular shape (Fig. 1 c).

Two categories of ponds are to be constructed, nursery and grow-out ponds.

### 3.2.1. *Nursery ponds*

Usually prawn seed collected from the surf in the sea and also those obtained from hatcheries will be of postlarval or early juvenile stage. They have to be reared in a nursery till they attain the stockable size.

Nursery ponds can be provided either within the culture pond or at the hatchery premises. Size of the nursery pond depends on the space requirement in terms of the number of seeds to be stocked. In a nursery, provided within the pond ecosystem, one cubic metre of water body can hold 500 to 600 postlarvae of *P. indicus*, (M. S. Muthu, personal communication). At this rate a nursery pond having 0.01 ha is sufficient for a culture pond of 1 ha.

If the nursery is provided at the hatchery premises in the form of cement tanks or collapsible plastic pools where the maximum control over the physico-chemical characteristics of the water, artificial feeding etc. are possible, the stocking density can go upto 5000—6000 nos/cubic metre water (M. S. Muthu, personal communication).

### 3.2.2. *Grow-out ponds*

Large farm areas have to be divided into smaller ponds for effective management. Grow-out ponds, around 0.5 to 2 ha in area can be managed conveniently.

The farm should have a wide main canal leading from the source of water supply and smaller canals feeding water to individual ponds. Bottom of the canals should be below the level of the pond bottom. The canals can also be used for cultivating prawns. Provision must be there to regulate the tidal flow into main feeder canal as well as the individual ponds.

### 3.3. *Economically viable unit*

A farm to be economically viable should have a minimum water area. Economic viability could be defined as follows (Rajalakshmi, 1980)

- to be operated & managed by a single entrepreneur; the manager and operator being himself and his family members.
- The net profit from the farm should help in meeting the commitments to the financing agency.

However, small fragments of water areas even if it is only around one tenth of an hectare, can be used for growing prawns. Marginal farmers and landless farm labourers will be owning such small water areas in the form of ponds or canals which can be used as 'Kitchen Ponds' for rearing prawns and fishes.

### 3.4. *Construction*

#### 3.4.1 *Clearing of site and levelling*

All vegetation—trees, shrubs including submerged roots (particularly in mangrove areas) and also other hard objects like stones, which may hinder the construction work and also the management in future should be removed from the site.

Vegetation, on decay may cause cracks and holes in the bund. This would lead to leakage.

The pond bottom should be levelled by eliminating highly elevated portions as well as deep portions. Area must be made somewhat flat sloping towards the source of water.

#### 3.4.2. *Bund construction*

Brackishwater farms are constructed by putting up earthen bunds. Bunds must be broad enough to withstand the pressure of water during various tidal conditions.

If one hectare area is converted into a pond, the water area gained will be only around 0.84 ha. The remaining area will be occupied by the bund.

The soil available from the excavation can be utilized for putting up the bund (Plate 3). Strength and stability of the bund depend on the quality and texture of the soil. Highly clayey soil is impermeable to water and so highly water retentive but the disadvantage is that it swells up under wet condition and cracks while drying (Plate 4).



PLATE 3. Krishi Vigyan Kendra trainees constructing a bund in shallow backwater area.

Sandy soil is not suitable since it is not firm and water retention is very low.

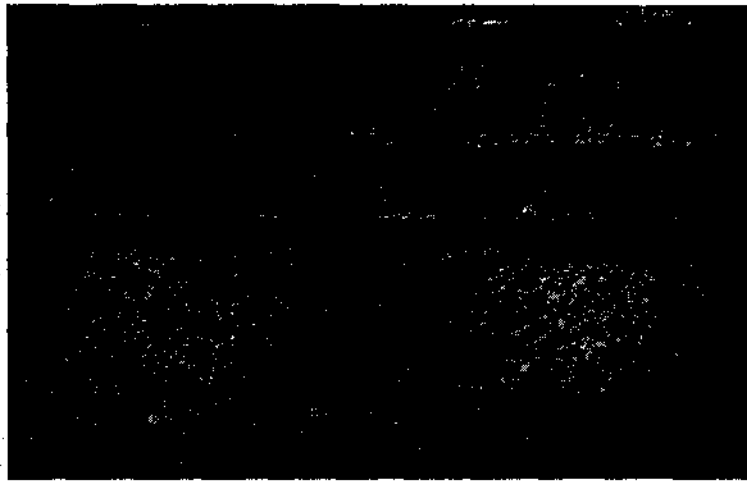


PLATE 4. Cracks formed on the bund made of highly clayey soil.

Soil containing a mixture of sand 60-80% silt 12-25% and clay 8-15% by weight (Sengupta, 1980) is considered ideal for a stable bund (Plate 5).

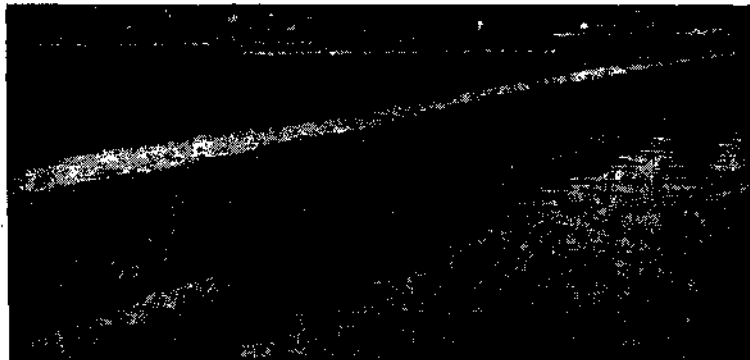


PLATE 5. A stable bund made of ideal combination of sand, silt and clay.

Bund should be put up on a firm foundation. In marshy brackishwater swamps the top soil will be loose and loamy. In such places a longitudinal trench must be dug by excavating the top soil till a relatively hard substratum is reached. This trench must be packed with firm soil and upon this basement the bund must be raised. This technique would help to minimise the seepage and also would keep the bund in position avoiding dislocation. Bunds should be raised layer by layer, each layer with a height of about 25 cm. Each layer must be trampled well to give stability and firmness. Surface of bund should be rammed or rolled well to effect compaction. Each layer is exposed to the sun before the next layer is put. Before laying the next layer, the top of the previous layer should be slightly moistened. By this method, compaction is made layer by layer so that the earth would not fall apart in due course. It should be observed that the bunds are at least 50 cm above the highest tide level when finished to prevent overflow. Digging a narrow trench about 0.5 m wide along the centre of the bund as deep as the pond depth and filling it with gravel will obstruct boring organisms like eels and crabs.

The upper surface of the perimeter bund must be broad enough to allow the transportation of farm implements. The inner dykes must be broad enough to walk along, not more than 1 m breadth. For stability, bunds must be sloping at its sides. Degree of side slope depends on the nature of soil used. Side slope need not exceed the natural slope which the bund makes when exposed to weather for some time. Side slopes of different proportions are illustrated in Fig. 2. Generally a slope of 1 : 1 is found to be sufficient where the soil is moderately firm. If the bund is constructed properly, then the slight oozing of water which might be noticed at first, disappears little by little once the pond is filled with water and the bund becomes water tight.

For constructing bunds in open backwater areas, two rows of split coconut poles are erected longitudinally on either side bordering the proposed foundation bed. The poles are erected in such a way as to lean inwards in accordance with the desired degree of slope. In order to keep the poles in position while filling, all the poles of one side are connected with the corresponding poles of the opposite row by a metal wire. Then

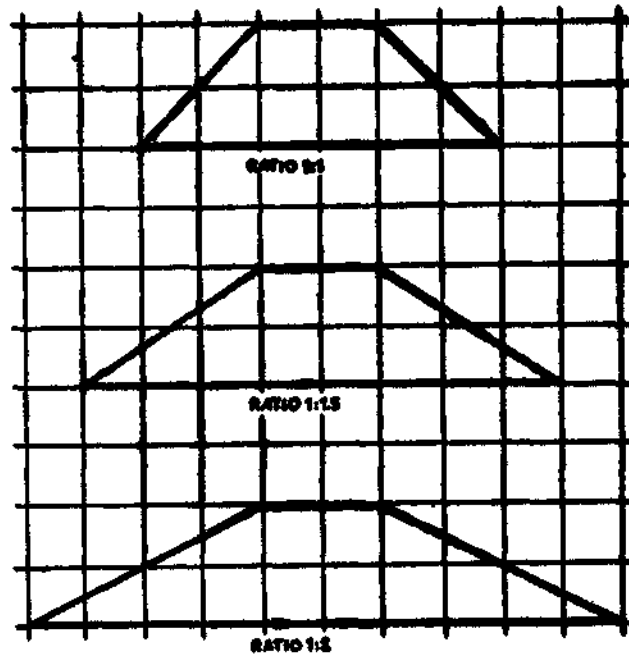


FIG. 2. Different slopes for the bund.

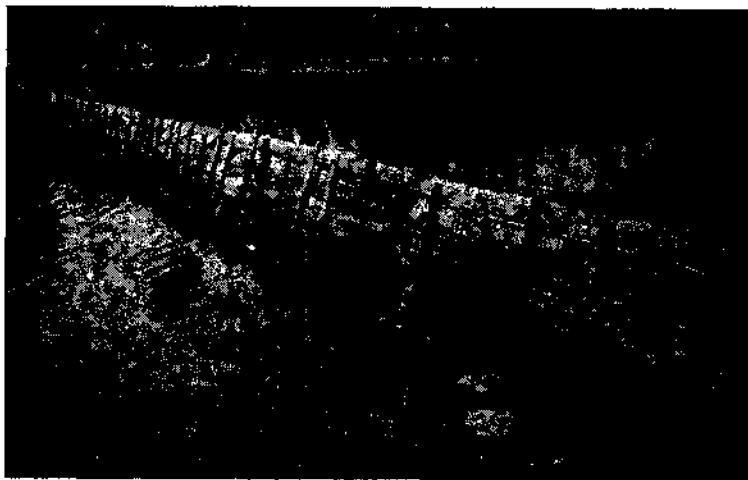


PLATE 6. Bund constructed in open backwater area protected by split coconut stem stakes and woven coconut leaves.

bamboo mats or closely woven coconut leaves are tied to the poles longitudinally, enclosing the water area above the foundation bed. The enclosed area is then packed with soil (Plate 6). This sort of protection provided at the sides helps to put up the bund at the desired profile and it also avoids wastage of mud during construction. In due course the bamboo mats or woven coconut leaves supporting the sides decay and the bund takes its natural slope. The outer slope can then be strengthened

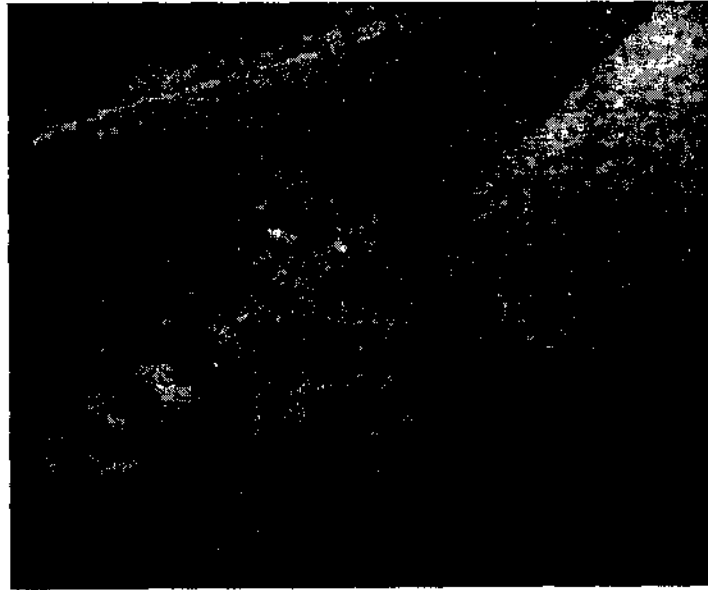


PLATE 7. Outer side of the perimeter bund protected by granite pitching.

either by granite or hard laterite pitching (Plate 7) and the other exposed portions of the bund including the inner slope protected by turfing (Fig. 3. & Plate 8). The inner slope need not have pitching. If done, it would interfere with the complete harvesting by way of providing shelter for prawns within the crevices. It would also cause problems during the eradication of predators,

### 3.4.3 *Berm*

Berm is an horizontal narrow ledge left between the toe line of the embankment and the water edge of the pond (Fig. 4 & Plate 6).

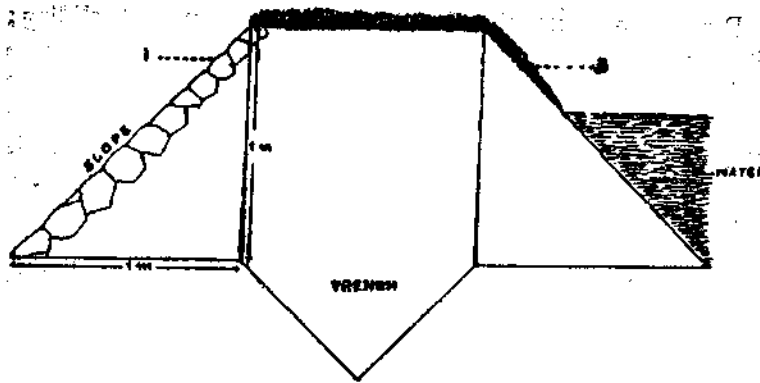


FIG. 3. Cross section of the bund showing 1:1 side slope and (i) granite pitching, (ii) turfing.



FIG. 4. Cross section of the bund showing berm on either side.



PLATE 8. Bund protected by turfing.



Berm (i) protects the bund against erosion and sliding ; (ii) helps to reduce seepage ; (iii) provides additional strength to the bund safeguarding against breaches ; (iv) helps to break the flow of rain water down the bund slope and thus prevent guttering (v) helps to maintain a gradual slope inside the pond which is convenient for operation of net : (vi) can be used as a space for people to stand and move along while dragging nets.

In the case of perimeter bunds where the outer side is protected by granite or laterite pitching, berm need be provided only along the inner side.

#### 3.4.4 Pond bottom

Bottom of the pond should be sloping towards the sluice gate to facilitate maximum drainage when required. In shallow fields, channels are to be cut from different directions at the field bottom converging at the sluice site. In addition, a channel is cut in the pond all along the inner side of the bund. Channels would provide shelter for prawns when water gets warmed up in summer and also would help effective drainage at the time of harvesting.

### 3.5 Sluice gate

Tidal flow of water in the field is regulated through a properly designed and erected sluice gate. Generally two types of sluice gates are in use, concrete and wooden. Concrete sluice gates are permanent structures whereas the durability of wooden sluice gates which are more common in Kerala, varies with the type of wood used.

#### 3.5.1 Wooden sluice gate

Wooden sluice gates are built of hard timber such as Kanjiram (*Strychnos nuxvomica*), Anjili (*Artocarpus hirsuta*), Maruthu (*Terminalia paniculata*), Thembavu (*Terminalia tomentosa*), Thambakam (*Hopea parviflora*), Irul (*Xylia xylocarpa*), etc.

The size of the sluice gate is determined in accordance with the extent of field, depth, direction of tidal flow, size of bund, etc. The length and height of the sluice gate depend on the breadth and height respectively, of the bund.

A typical sluice gate has got four components—a bottom board, two lateral boards and a top frame. Different parts of each component are shown in the figures 5, 6 & 7 which will provide guidance for construction of sluice gates of desired size.

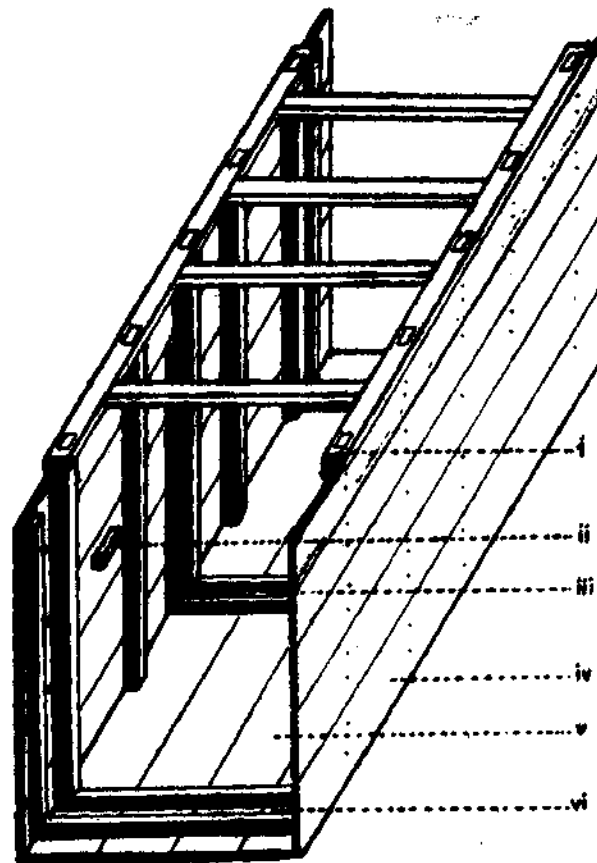


FIG. 5. Wooden sluice gate assembled. (i) top frame, (ii) foot rest, (iii) provision for inserting shutter planks, (iv) lateral board, (v) bottom board and (vi) provision for inserting nylon mesh screen.

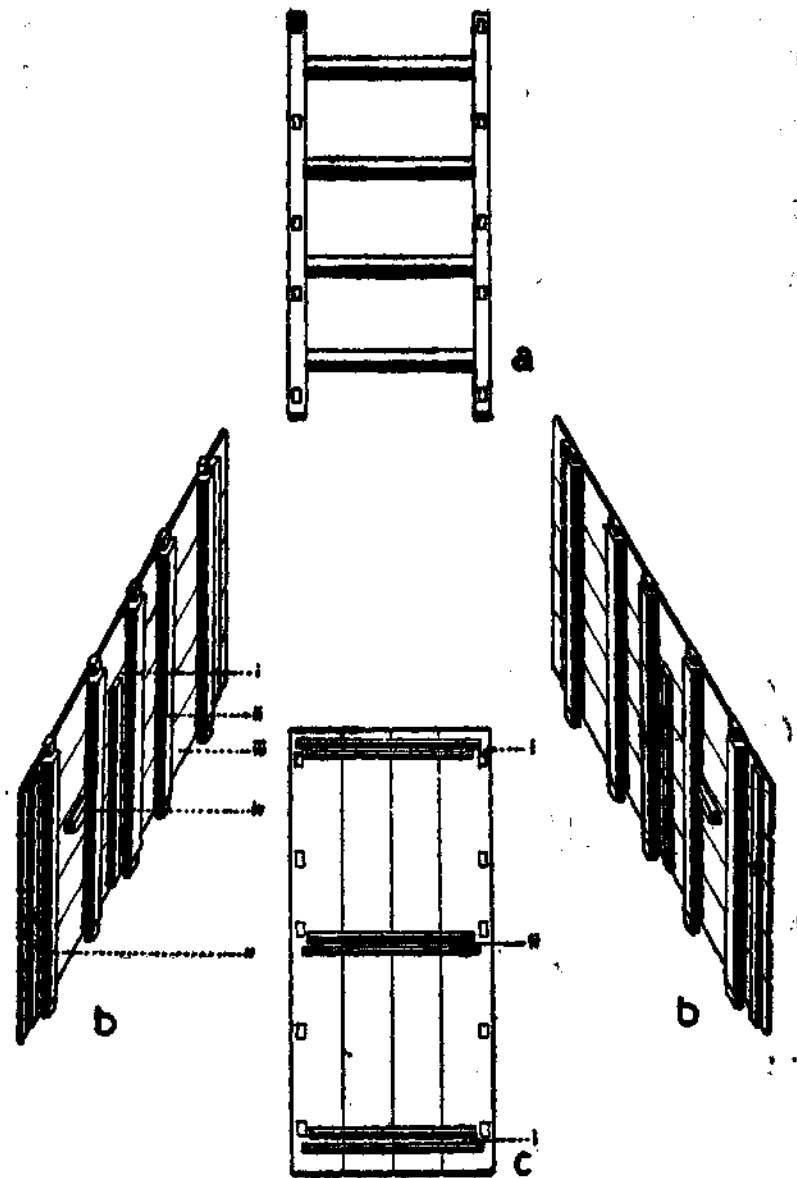


FIG. 6. Sluice gate components separated. (a) top frame, (b) lateral board, (i) provision for inserting shutter planks, (ii) vertical support, (iii) horizontal planks, (iv) foot rest, (v) provision for inserting nylon mesh screen, (c) bottom board, (i) provision for inserting nylon mesh screen and (ii) provision for inserting shutter planks.

The lateral board usually has five vertical supports (10 cm  $\times$  5 cm thickness) and planks nailed to them horizontally. Usually, these planks are 25 cm broad and 2.5 cm thick. Their number and length depend on the size of the sluice gate. Smaller sluice gates meant for inner dykes will have only three vertical supports. Provision for inserting shutter planks (20 cm broad and 2.5 cm thick generally) is given at the centre of the sluice gate by nailing a reaper vertically by the side of central support as shown in the figure to form a groove to slide the shutters. Channels are provided along the outer side of the terminal supports at both ends of the sluice gate by nailing a reaper vertically for inserting nylon mesh screens. Sometimes grooved reapers are also nailed on the terminal supports for this purpose. Here mesh screens will rest across the space between the opposite terminal supports. Another method is also practiced. Cuts are made on the longitudinal beam of the top frame, close to the terminal vertical supports, opposite to each other and the nylon

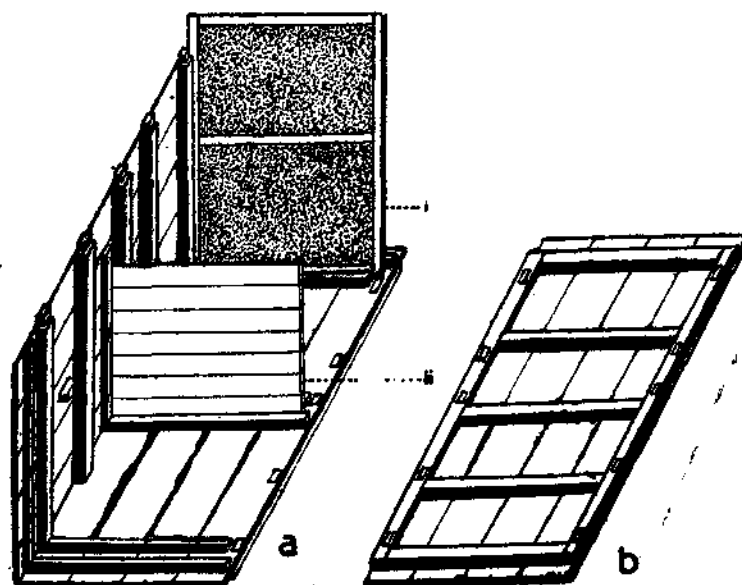


FIG. 7. Sluice gate. (a) top frame and right lateral board removed to show (i) nylon mesh screen and (ii) shutter planks. (b) bottom board showing its reverse side.

screens are inserted through the cuts. The screen will be held in position by vertical support on one side and a reaper nailed to the board on the other side as in previous cases.

### 3.5.2 *Cost of wooden sluice gate*

Normally a wooden sluice gate destined for a one hectare pond will have 3 m length, 1.5 m height and 1 m width. A sluice gate having this size made of moderate quality wood like Anjili may cost Rs. 3750. This may vary according to the type of wood used.

### 3.5.3 *Fixing of sluice gate*

Bottom bed should be levelled properly ensuring a comparatively firm nature. The bottom board is then placed in position and trampled firmly by the collective effort of men. Then the lateral boards are fitted in position so as to fit the same properly into the slots provided on the bottom board. Finally the top frame is fixed in accordance with the provisions given. When properly articulated, the whole structure will function as a single unit (Plate 9). It must then be firmly thrust into the



PLATE 9. Wooden sluice gate assembled.

bottom bed. This is done by a group of men standing on the top frame and trampling in a rhythmic manner. After fixing the sluice gate firmly, the adjoining portions of the bund must be set right. Starting from the sluice gate, a row of bamboo poles or split coconut stems are erected upto a certain distance on either side of the bund. Then woven coconut leaves or bamboo mats are tied to the poles longitudinally at the inner side so as to enclose the area to be filled up. The space between the sluice gate and the broken end of the bund is then packed tightly with firm mud mixed with dried paddy straw. This type of reinforcement with paddy straw offers firmness to the bund and also prevent boring organisms like eels, crabs, etc. from piercing through it. The portions so filled up are rammed well so as to have a flat surface. The sluice gate will then be firmly tied to the adjoining poles so as to avoid any dislocation while drying and setting.

#### 3.5.4 Concrete sluice gate

Concrete sluice gates for perimeter bunds or the master sluice gates have to be relatively bigger and stronger depending on the width of the bund. It must be constructed over a Reinforced Cement Concrete (R.C.C.) platform. In order to give strength and durability in saline conditions the whole structure must be R.C.C. built (Fig. 8 a) except the shutters as well as the frames of nylon

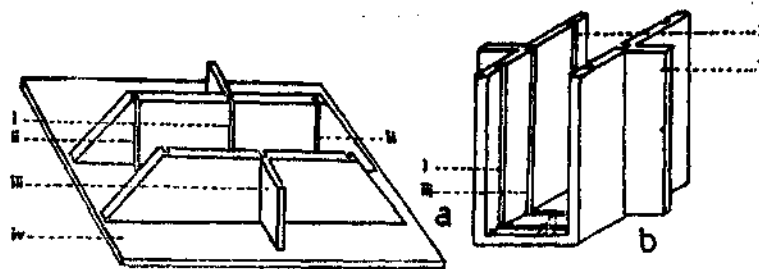


FIG. 8. Concrete sluice gates. (a) sluice gate meant for perimeter bund : (i) provision for inserting shutter planks, (ii) provision for inserting nylon mesh screen, (iii) portion of the sluice gate projecting into the bund and (iv) concrete basement and (b) Simple type of concrete sluice gate meant for inner dykes : (i) provision for inserting nylon mesh screen, (ii) portion of the sluice gate projecting into the bund and (iii) provision for inserting shutter planks.

screens which should be wooden. Channels provided for inserting the shutter planks and nylon screen must be given wooden lining to effect tight seating and smooth operation. The wing like expansion of the sluice gate which will go into the bund on either side will help to provide firmness and also prevent seepage and penetration of boring organisms and also help to prevent any dislocation of the sluice gate in due course. In the case of bigger concrete sluice gates destined for larger water displacement, operation of shutters and screens cannot be done manually. Here, shutters and screens are operated mechanically along metal channels.

Concrete sluice gates meant for smaller inner dykes can be of smaller size with shutters and nylon screen frames made of wood (Fig. 8 b).

Sluice gates must be fixed preferably at the side of the pond which facilitate the maximum circulation of water. The orientation of the sluice gate must be along the direction of the tidal flow to the maximum possible degree. It is advantageous if the sluice gate is fixed at the corner where plankton and other floating organic matter accumulate due to the wind pattern. This would help the dispersal of nutrient rich matter throughout the pond. For 0.5 ha to 1 ha ponds only one sluice gate, 1 m wide is sufficient. For ponds less than 0.5 ha in area, one sluice gate having  $\frac{1}{2}$  m width is sufficient.

## PREPARATION OF POND

All sorts of decaying organic matter including vegetation and also the predatory organisms present in the water must be removed. Vegetation can be removed manually.

### 4.1 Eradication of predators

Eradication of predators can be effected by the following methods.

#### 4.1.1 Draining out the pond

Draining and drying the bottom mud until it cracks ensures the best result. This would also cause the escape of harmful gases present in the bottom mud.

If the pond cannot be drained fully, eradication can be effected by the application of wild toxic substances like lime, mahua oil cake ('Ilippa pinnakku' in Malayalam) or ammonia. Before the application, water level in the field should be reduced to the minimum and the sluice gate must be fully closed.

#### 4.1.2 Application of lime

After draining out the water to the maximum extent, uniform spreading of quick lime ( $\text{CaO}$ ) @ 100-600 kg/ha throughout the pond would destroy predatory organisms (Yap *et al.*, 1978). Quick lime absorbs water and transforms into calcium hydroxide which increases pH value of water and releases heat (exothermic reaction) so as to kill the organisms (Jamil Ahmed, 1982). Milk of lime prepared by dissolving quick lime in water so as to form a thick solution can be applied in water-containing portions like ditches and depressions. In acidic ponds, dosage of quick lime may be enhanced to 1000-2000 kg/ha (Yap *et al.*, 1979). For ponds, which are not drainable, the dosage of lime required for the purpose is 1875-2250 kg/ha/metre deep water (Jamil Ahmed, 1982).



#### 4.1.3. Application of mahua oil cake

Mahua oil cake is obtained when oil is extracted from mahua (*Bassia latifolia*) seeds. The cake contains 4-6% saponin (mowrin) which has a toxin in it. Mahua oil cake must be ground well and spread in the field. After spreading, water must be thoroughly agitated. Rate of application of the cake is 200 ppm or 2000 kg/ha (Table 2). Mahua oil cake when applied in water produces lather. Saponin is soluble in water and acts like a detergent on fishes, removing the mucous layer of the body and gill membranes thereby affecting their normal locomotion and respiration in water. It also enters the blood stream through the gills and buccal tissues and haemolyses the red blood corpuscles resulting in death (Karthi, 1984). Dead fishes are not poisonous and are consumable. The harmful effect of the oil cake persists for about 10 days and after that it acts as a manure and promotes the productivity of the pond. After 10 days tidal flushing can be allowed inside the field across a nylon mesh screen provided in the sluice gate and stocking can be done on the next day. The cost of eradication by mahua oil cake will be around 25 paise per cubic meter of water.

TABLE 2. Dosage of mahua oil cake and ammonia required for eradication in different fields of varying depth

Area of field	Depth (m)	Quantity of mahua oil cake required (kg)	Quantity of ammonia required (kg)
1 hectare	1.0	2,000	100
	0.5	1,000	50
	0.25	500	25

#### 4.1.4. Application of ammonia

Even though traces of ammonia normally formed in the pond by bacterial action are harmless, anhydrous ammonia when applied directly into the pond bottom have toxic effect on organisms resulting in their death. Application of ammonia is more economical and effective and also ensures quick results. The

rate of application of ammonia is 10 ppm (Table 2). The appliance consists of a short perforated PVC pipe of about 2 cm wide and 1 m long. Both ends of the pipe are closed by PVC plugs (Fig. 9). A long flexible polythene tube connected to the centre of the pipe carries the ammonia released from the cylinder

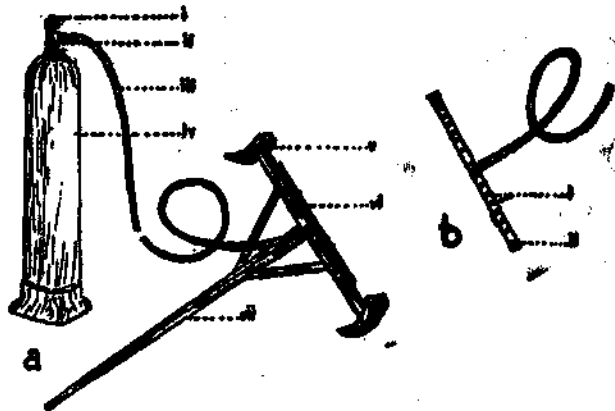


FIG. 9. Equipment for application of ammonia.

(a) (i) valve control, (ii) hose collar, (iii) plastic hose (iv) cylinder containing anhydrous ammonia, (v) this structure facilitates smooth pushing of the equipment along the bottom, (vi) perforated PVC pipe and (vii) wooden handle and (b) PVC pipe portion of the equipment showing the perforation. (i) perforation and (ii) PVC plug.

kept in vertical position. The PVC pipe is tied to a 'T' shaped wooden handle as shown in the figure. After immersing the PVC pipe portion of the device in water the nozzle of the ammonia cylinder is opened to the required degree with the help of a spanner. All the joints must be thoroughly checked for any leakage. Then one person should push the equipment forward along the bottom of the pond as shown in Plate 10. When one round is completed throughout the pond, animals in the pond start showing distress by jumping due to suffocation, when they could easily be collected either by hand picking or by operating a drag net or cast net. These fishes are fit for human consumption. A week after the treatment, tidal flushing can be allowed through a nylon mesh screen. Stocking can be done on the next

day. Anhydrous ammonia is available with commercial fertilizer plants. A cylinder containing 40 kg of ammonia costs nearly Rs. 350. Cost of eradication using ammonia will be around ten paise per cubic meter water area. Instead of administering anhydrous ammonia directly, another method of ammonia treatment



PLATE 10. Application of ammonia.

is successfully done in fresh water ecosystems. Here, solutions of calcium hydroxide and ammonium sulphate mixed in a ratio of 1:1.8 is applied in water. The ammonia released at a concentration of 15 ppm kills the organisms in the water (Subramanian, 1983).

#### 4.2 *Improvement of bottom soil*

##### 4.2.1 *Porosity*

Ponds having porous soil can be protected with impervious materials to prevent seepage of water and leaching off of nutrients. Generally this is done by clay puddle lining, brick lining or plastic lining. Among these methods clay puddle lining is more economical and satisfactory in wet conditions. A layer of clay puddle is uniformly spread on the pond bed as well

as on the sides, consolidating it compact. Then another layer of silt is spread on it uniformly and consolidated (Plate 11).

On the other hand if the soil is too clayey it can be improved by spreading a layer of sand at the bottom.

#### 4.2.2. Acidity

If the bottom soil is acidic, it can be improved by applying quick lime (calcium oxide). The rate of application of lime can be regulated depending on the soil pH (Tripathi, 1983) as follows :

Soil pH	Quantity (kg/ha) of lime required
5.5 — 6.0	800
6.0 — 6.5	500
6.5 — 7.0	200

#### 4.2.3. Fertilization

Bottom soil which is low in productivity can be improved by applying organic and inorganic fertilizers. Productivity study of the pond and nutrient analysis of the soil must be undertaken before attempting fertilization. In ponds having productivity of  $> 2000 \text{ mg C/m}^2/\text{day}$ , no fertilization is needed usually (Gopinathan *et al.*, 1982). The pokkali fields adjoining the Cochin Backwaters normally do not require fertilization. Newly dug out ponds, ponds situated in a sandy areas and in areas far off from bar mouth, certain perennial fields and the canals in coconut groves may require enrichment of nutrients. Generally, prawn fields in the coastal areas of Trichur, Kottayam and Alleppey Districts are less fertile than those in Ernakulam District.

If mahua oil cake or ammonia is used for eradication of predators manuring need not be done during the first 1 or  $1\frac{1}{2}$  months of culture. Both act as fertilizers also. Mahua oil cake contains Nitrogen (2.51%), Phosphorus ( $\text{P}_2\text{O}_5 = 0.8\%$ ) and potassium ( $\text{K}_2\text{O} = 1.85\%$ ) in addition to saponin. The residual portion of the cake settling at the bottom decomposes releasing

the nutrients. This would promote the growth of benthic algae and diatoms.



PLATE 11. Lining of pond by clay puddle.

Application of ammonia will intensify the nitrogen fixation process. Within a day of the application of ammonia, pond water becomes crystal clear indicating the total destruction of organisms. Within a week the water gets luxuriant growth of microflora.

#### 4.2.3 a *Inorganic fertilizers*

The commonly used inorganic fertilizers are lime such as quick lime ( $\text{CaO}$ ) slaked lime ( $\text{Ca}(\text{OH})_2$ ), limestone ( $\text{CaCO}_3$ ),

etc. and nitrogenous fertilizers like Urea, ammonium sulphate, ammonium nitrate, ammonium carbonate and calcium nitrate. Lime containing fertilizers can be applied @ 400—500 kg/ha (Thirunavukkarasu, 1983). Lime containing fertilizers applied for the improvement of soil will influence the pond ecosystem in the following way :

- i. Supplies Calcium, one of the essential nutrients.
- ii. Corrects the acidity of the soil. Regulation of soil pH is essential for the microbial release of nutrients by the decomposition of organic materials. Lime, by neutralising the bottom sediment also causes the release of bound nutrients into the water. The release of phosphorus ions is effected as a result of weakening of phosphorus ion bond, on application of lime.
- iii. Lime improves the productivity of water by taking up excess of carbondioxide from the water.
- iv. The calcium bicarbonate formed when lime is added in the water, acts as a buffer, preventing a wide variation in pH. It also acts as a reserve for  $\text{CO}_2$  (carbon dioxide) since it releases  $\text{CO}_2$  when required.
- v. Lime counteracts the possibly harmful effects of excess magnesium, sodium or potassium ions and the fixation of harmful organic acids like sulphuric acid.
- vi. Lime is also a powerful disinfectant and render the prawns less liable to diseases.

Urea ( $\text{NH}_2$ )<sub>2</sub> CO, when contains 45—60% pure nitrogen can be applied as a nitrogenous fertilizer. In water it is hydrolysed to ammonia and carbondioxide. Since aquatic plants assimilate both ammonia and carbondioxide, urea can be applied as a physiologically neutral fertilizer. It can produce 78 kg  $\text{CO}_2$  per 100 kg fertilizer (Pawel Wolny, 1967). Urea can be applied @ 50—100 kg/ha in a phased manner, once in every fortnight. Urea and superphosphate mixed in the ratio 4 : 1 can be applied @ 100 kg/ha in a phased manner at the interval of 20 days (Venkatesan and Victor Chandra Bose, 1982).

#### 4.2.3 b. *Organic fertilizers*

Application of organic fertilizers such as cow dung or poultry manure will increase the abundance of zooplankters. Cow dung contains about 0.3% Nitrogen, 0.15% Phosphorus ( $P_2O_5$ ) and 0.2% Potassium ( $K_2O$ ) (Gupta, 1981). It can be applied at the rate of 1000-4000 kg/ha (Thirunavukkarasu, 1983). Poultry manure which contains 1.6% Nitrogen, 1.5% Phosphorus and 0.9% Potassium can be applied at half the rate of cow dung. Cow dung or poultry manure if uniformly spread on the bottom, may lead to oxygen depletion in the pond due to sudden and widespread decomposition. Therefore they can be heaped at different locations in the pond allowing the nutrients to leach out gradually into the ecosystem.

Manuring should not be done when there is excess planktonic bloom in the water. When both organic and inorganic fertilizers are to be used, they can be applied alternately.

## PRAWN SEEDS AND STOCKING

### 5.1. Life Cycle of *Penaeus indicus*

Detailed knowledge of the life cycle of *P. indicus* is essential to use the natural seed resources of the marine and backwater habitats and in developing techniques for producing prawn seeds under controlled conditions in hatcheries.

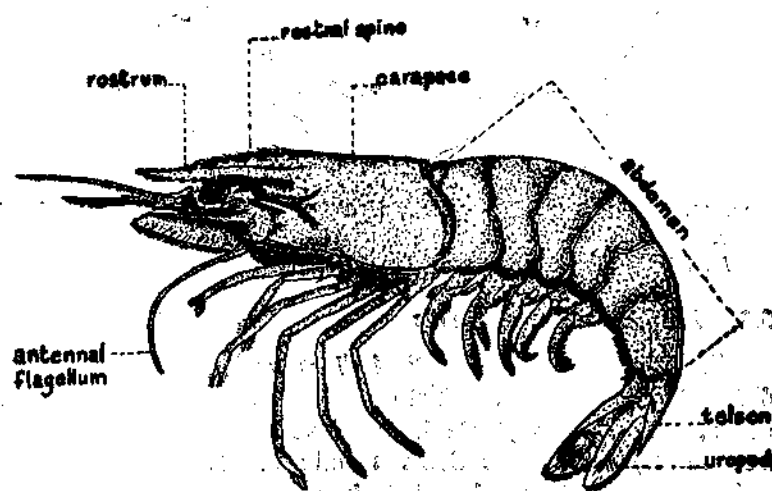


FIG. 10. *Penaeus indicus*

*P. indicus*, representing the penaeid group of prawns occurs in the sea. The hatchlings develop through different larval stages such as nauplius, protozoa, and mysis and reach the postlarval stage within a period of ten days. Postlarvae migrate to backwater areas and undergo further development to become juveniles. After about 6-7 months they migrate back to the sea for breeding (Fig. 11).



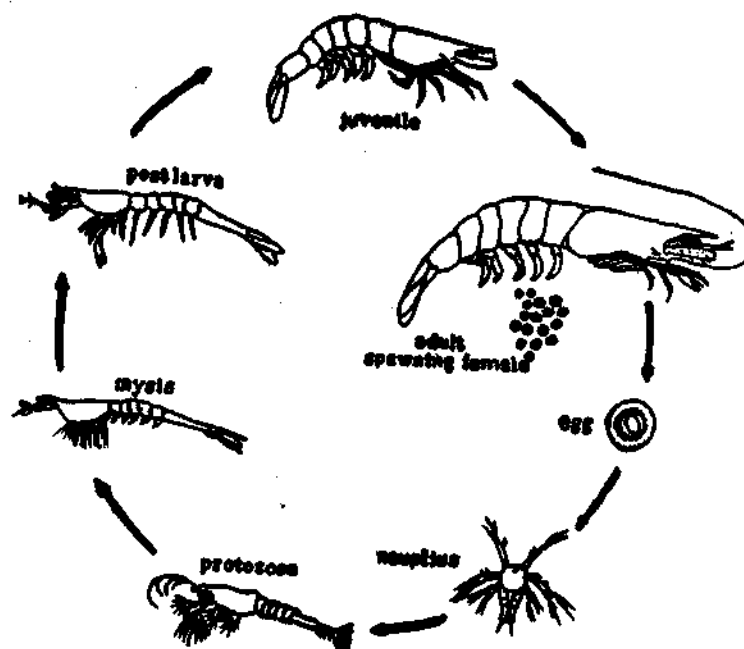
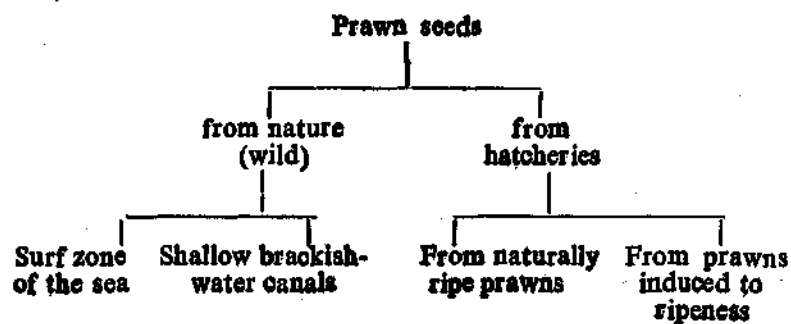


FIG. 11. Life cycle of a Penaeid prawn. (After Forster, J. R. M. and Wickens J. F., 1972. Prawn culture in the United Kingdom : its status and potential. *Lab. Leaf. Fish. Lab. Lovestof*, No. 27).

### 5.2. Food and feeding habits

The food preference of *P. indicus* varies considerably at different stages of its life history. Larvae feed on planktonic items; mainly the phytoplankton. Juveniles and adult prawns feed mostly on organic detritus and a variety of small animals and plant material available at the bottom.

### 5.3. Prawn seed resources



5.3.1. *Distribution and abundance of P. indicus seed in the wild in different regions (Rao, 1980).*

Region	Season of abundance
Gujarat	February–April
Goa	February–May
Karnataka	December–January
Kerala	October–May
Tamil Nadu	February–May and August–September
Andhra Pradesh	October–December
Orissa	April–July and November–January
W. Bengal	February–April

5.4. *Collection of seeds from the wild*

Prawn seeds can be collected from the surf zone in the sea as well as from brackishwater canals having tidal flow. They are abundant during full moon and new moon days at low tide. Seeds available in the surf zone are in the postlarval stage, 8–12 mm in size. Seeds available in canals would be juveniles, in size ranging from 20–40 mm generally.

5.4.1. *Identification characters of postlarvae and juveniles of penaeid prawns (Muthu, 1978).*

Seeds of penaeid prawns often encountered in field collection may be of different species such as *Penaeus indicus*, *P. monodon*, *Metapenaeus dobsoni* and *M. monoceros*.

*Penaeus monodon* (Fig. 12 a)

Post larvae vary from 6 to 14 mm in total length. Body very slender and elongated. Not easily distinguishable in turbid water.

Rostrum just reaches end of eye. Eyes are smaller and eyestalk shorter than in *P. indicus*. A red streak is present along the entire ventral side of the abdomen. In larger specimens over 15 mm reddish streak turns pink and then green.

13 to 18 chromatophores maroon in colour in live specimens are on the ventral side of the sixth abdominal segment. Chromatophores on telson present from base to distal end. Very rapid and straight swimming movement along the edges of the container. Tend to attach themselves to any twig or algal mass.

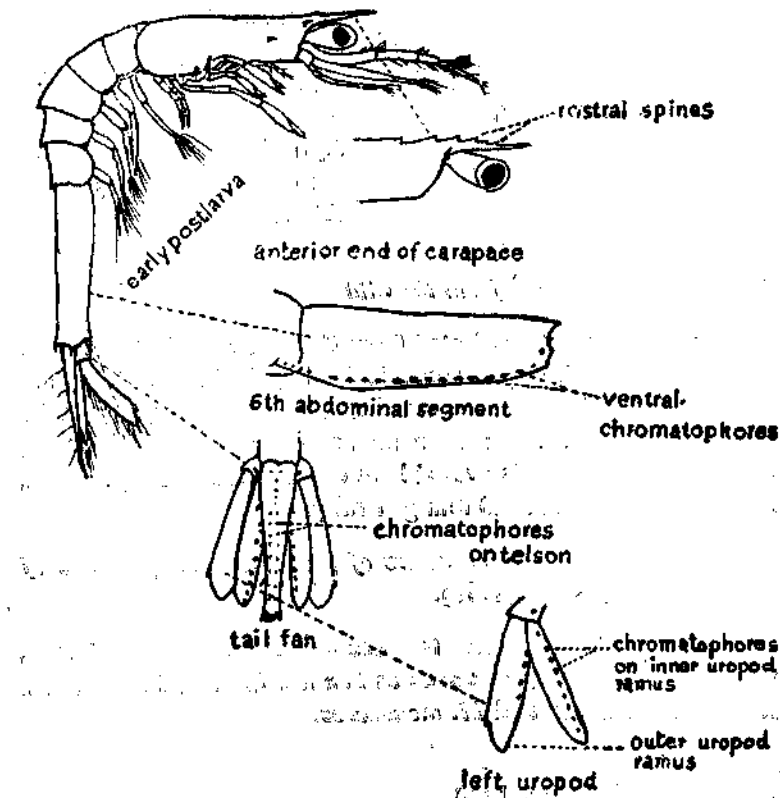


FIG. 12 a. *Penaeus monodon*. Distinguishing features of postlarva. Individual parts shown are of late postlarval stage encountered in field collection. (After Muthu, 1978 a).

In juveniles, beyond 20 mm size the green colour spreads to the entire body with a prominent streak on the ventral side. As the size increases the entire body becomes dark green. Rostrum will have serration both on dorsal and ventral side extending beyond the tip of the antennules.

*Penaeus indicus* (Fig. 12b)

Postlarvae ranges from 5 to 10 mm in total length. Transparent white excepting pink at the tips of the rostrum and telson. Antennular peduncle tipped by light reddish colouration. Light yellow colour on eyestalks. Chromatophores red in live condition. Chromatophores on telson present in distal half only.

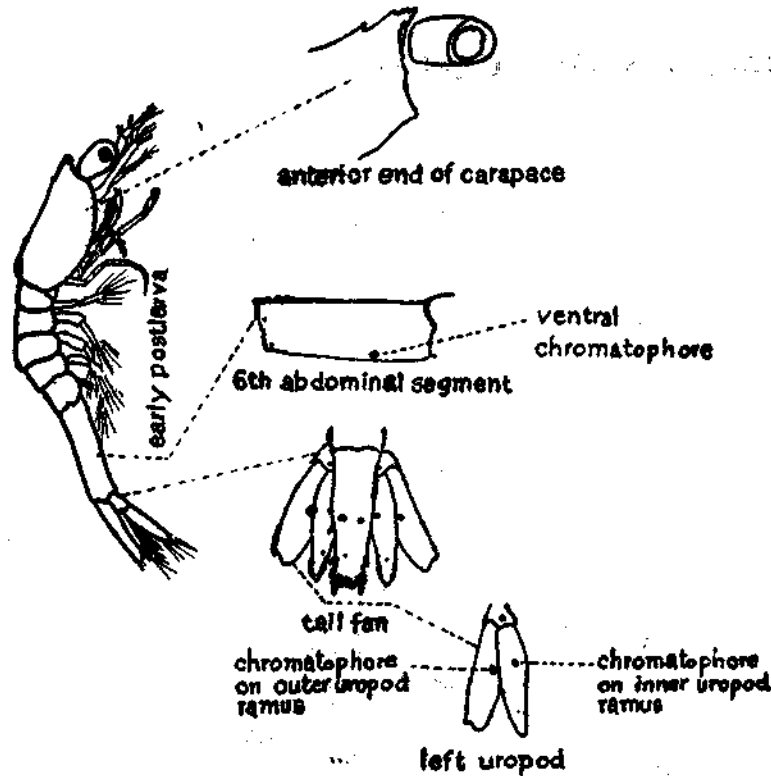


FIG. 12 b. *Penaeus indicus*. Distinguishing features of postlarva. Individual parts shown are of late postlarval stage encountered in field collection (After Muthu, 1978 a).

Anterolateral chromatophore present on the 6th abdominal segment. Ventral chromatophores 6 in numbers present on the 6th abdominal segment. Rostrum reaches end of eye.

Postlarvae swim fast, moving along edges and surface of container. When disturbed they try to jump out. In swimming position, a prominent mid-dorsal bend is very characteristic.

In juvenile, body remains transparent upto a length of 25 mm. Red spot at the tip of the rostrum continues to be present. Rostrum with a spine on the upper edge and 7 spines on the lower edge. The elongated slender rostrum is an important identifying feature. Antennal flagellum light yellowish and elongated.

*Metapenaeus dobsoni* (Fig. 12 c)

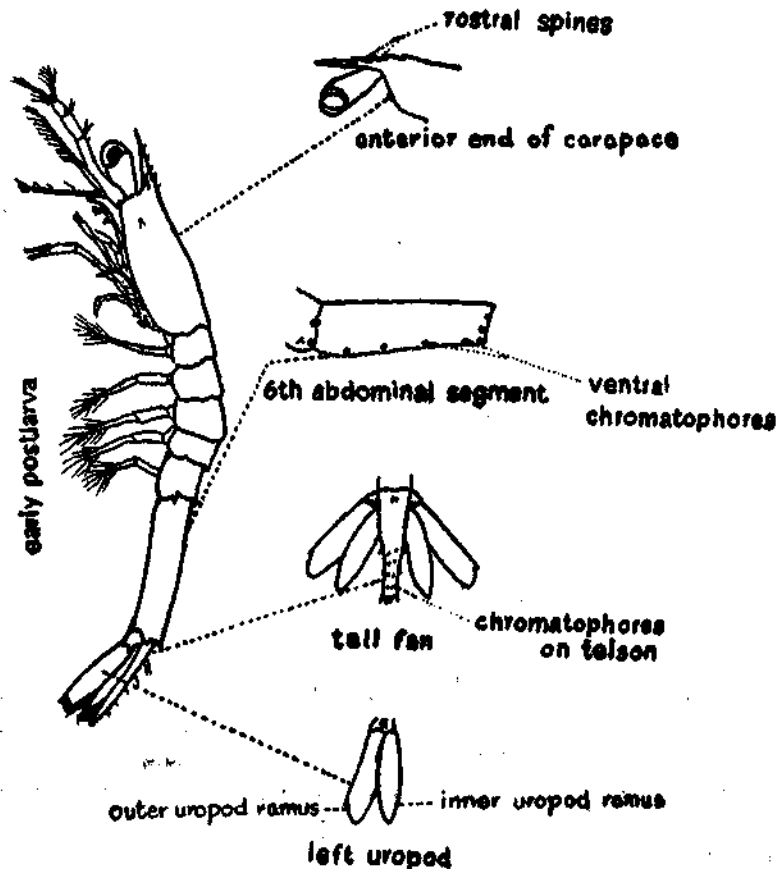


FIG. 12 c. *Metapenaeus dobsoni*. Distinguishing features of postlarva. Individual parts shown are of late postlarval stage encountered in field collection (After Murty, 1978 a).

Postlarvae ranges from 3 to 3.5 mm in total length. Rostrum is very short and blunt. General body colour is cream white. Slight brownish colouration on antennular peduncle. Colour of chromatophores brown in live specimens. 2 prominent chromatophores in the middle of telson. One prominent chromatophore each in the middle of inner and outer uropod ramus. 6th abdominal segment has single ventral chromatophore. Antennal spine on carapace present.

In juveniles, brownish antennal flagella show a sharp bend towards the middle while swimming. Body light brown.

*Metapenaeus monoceros* (Fig. 12d)

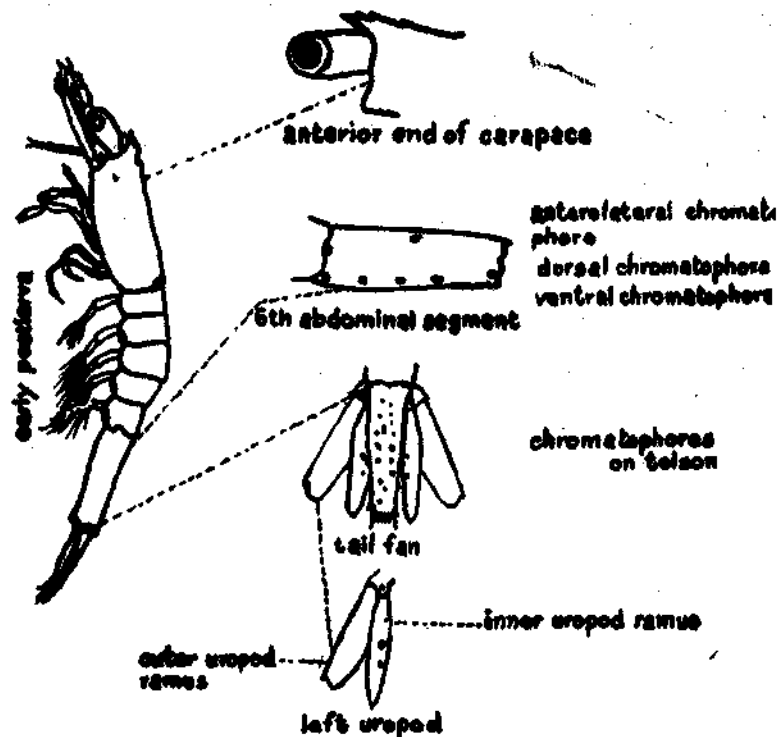


FIG. 12d. *Metapenaeus monoceros*. Distinguishing features of postlarv. Individual parts shown are of late postlarval stage encountered in fish collection (After Muthu, 1978a).

Postlarvae 3.75 to 4mm in total length. Rostrum very short and acutely pointed. Postlarvae can be identified by the characteristic brown colour. Reddish brown pigmentation on antennular peduncles, ventral side of the abdomen and on the telson gives total dark brown appearance. Telson has chromatophores from base to distal end. 2-3 chromatophores present on the inner uropod ramus. Chromatophores absent on the outer uropod ramus. 6th Abdominal segment has anterolateral chromatophores. 4-5 ventral chromatophores and single dorsal chromatophore on the 6th abdominal segment. Antennal spine present.

In juveniles, reddish brown antennal flagella show a sharp bend towards the middle while swimming as *M. dobsoni*. Slow movements in straight line, usually rest at the sides of the container. Body reddish brown.

Along with the seeds of penaeid prawns, seeds of another group of prawns known as carideans may also be present. They can be easily identified by the pleura of the second abdominal segment overlapping the first and the third segments (Fig. 12e).

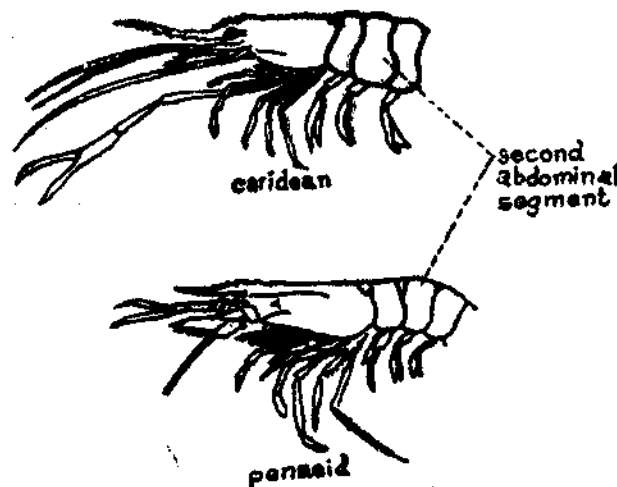


FIG. 12 e. Caridean and penaeid characteristic second abdominal segment (After Rajyalakshmi, 1980).

#### 5.4.2. *Collection of post larvae from surf*

**Materials required:** Seed collection equipment include a close-meshed nylon net of 2 m  $\times$  1m size, one plastic basin, one bucket, one plastic hose of about 3 m length and 2 cm diameter and a plastic seive.

**Collection technique:** The technique is very simple. A team of 3 persons can carry out the collection. 2 persons drag the net in the surf zone, parallel to the shoreline. The upper margin of the net should move well above the water surface. Lower margin need not touch the bottom (Plate 12).

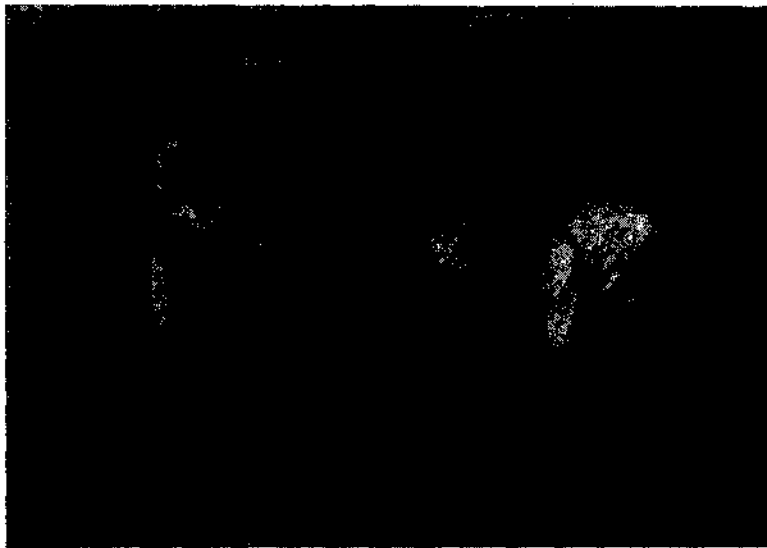


PLATE 12. Collection of postlarvae from the surf zone.

After dragging for few minutes the net is lifted. The post-larvae sticking to the net at different places are brought to the centre by folding the net twice, one across the other and dipping in water twice or thrice. The third person then receives the seed by transferring them to a basin containing water by dipping the central portion of the net into it after unfurling.



**Clearing and sorting:** The collection may contain other organism such as fish larvae, crabs, amphipeds etc. and also dirt and debris in addition to prawn larvae. There is a simple mechanism for sorting out the prawn larvae. The water in the basin containing the collection is whirled fast by hand. The basin is kept undisturbed till the water becomes still. The postlarvae of *P. indicus* moving along the periphery could easily be observed by a trained farmer. Fish larvae accumulated at the centre along with dirt and debris can be siphoned out using the plastic tube. The seed can be further cleaned by segregating them with the help of a plastic sieve.

**Counting:** Counting of the seed can be done while scooping them out using tumblers or beakers and transferring to another container (Plate 13).

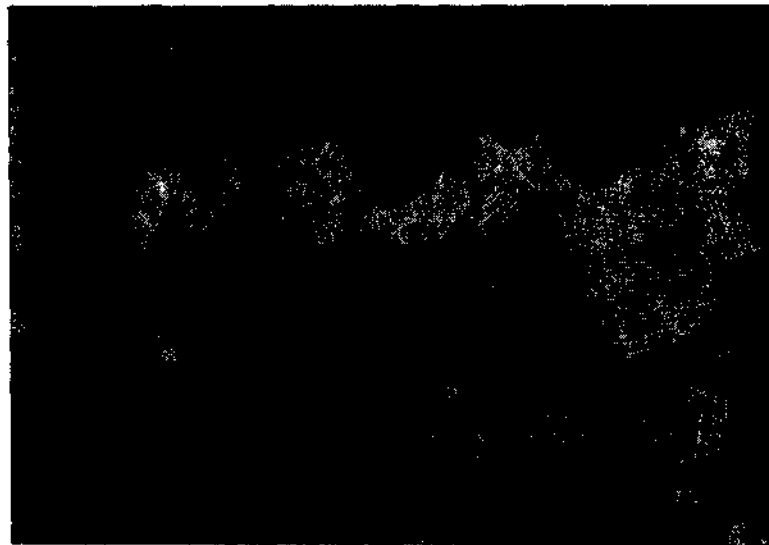


PLATE 13. Counting of postlarvae by KVK trainees.

Postlarvae collected from the surf have to be reared in nursery, till they become early juveniles (about PL 25) before stocking in grow-out ponds-

#### 5.4.3. Collection of juveniles

Collection technique: The same equipment used for collection of postlarvae can be utilized for collecting juveniles from brackishwater canals. Dragging of net has to be done from the centre of the canal towards the shore, touching the bottom (Plate 14). Net should be lifted only when it reaches the shoreline. Juveniles so collected can be transferred to a basin as done in the case of surf collection.



PLATE 14. Collection of juveniles from shallow brackishwater canal.

Clearing and sorting: The collection can be dumped into a hapa (a piece of nylon netting stretched and tied to four poles erected in the canal) where the desired species could be sorted out (Plate 15). Juveniles of *P. indicus* could be easily identified.

Seed counting: Counting can be done while scooping out small numbers of them every time by a plastic sieve and transferring to another container. After clearing and sorting the juveniles are scooped out in a plastic sieve and immersed in water taken in another container. Counting can be done as the juveniles swim out of the sieve into the container.

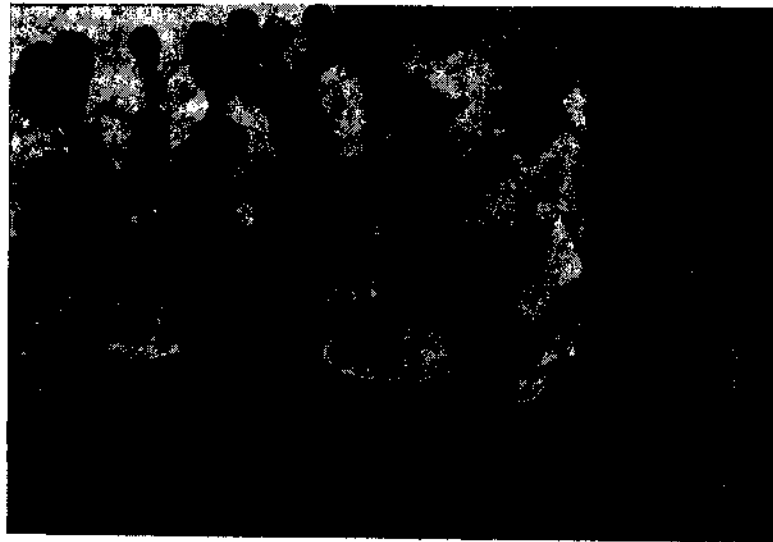
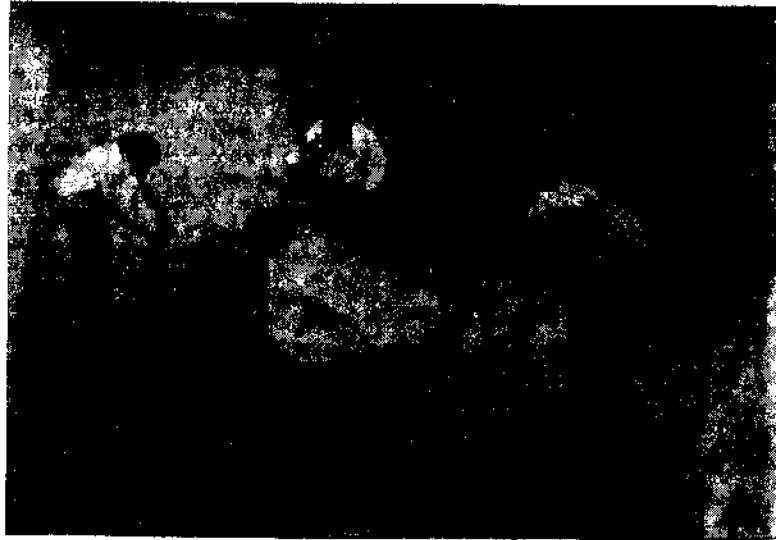


PLATE 15. Clearing and sorting of early juveniles.

### 5.5. Seed suppliers

Farmers trained by the Krishi Vigyan Kendra of CMFRI have started prawn seed collection and sales at different centres in Ernakulam District. They collect seed of *P. indicus* from the wild and sell them to the farmers, at a rate ranging from Rs. 10-20 per 1000 numbers depending on the abundance.

### 5.6. Hatchery production of seed

In hatchery there are two methods of prawn seed production.

- i. Ripe prawns are collected from the sea and allowed to spawn in the hatchery and
- ii. Prawns induced to ripeness by eye-stalk ablation are allowed to spawn in the hatchery. This method has been standardised in the Narakkal Prawn Hatchery Laboratory of CMFRI.

#### 5.6.1. Hatcheries in Kerala

- i. Narakkal Prawn Hatchery Laboratory of CMFRI at Narakkal in Ernakulam District, the first in the country.
- ii. Regional Shrimp Hatchery of Govt. of Kerala at Azhikodu in Trichur District.
- iii. A hatchery (Crescent Hatchery) in private sector near Kodungallore in Trichur District.

### 5.7. Seed transportation

Containers suggested: Plastic bags, bins, buckets, collapsible plastic pools, fibre glass tanks, earthenware pots etc. Open containers should have lids to avoid spilling. Earthenware pots should be protected externally by coir mesh.

## Seed density in open containers (without oxygen packing)

Postlarvae	250 Nos./litre upto 2 hrs without aeration.
	100 Nos./litre upto 12 hrs with frequent aeration or change of water twice.
Juveniles	51 Nos./litre upto 2 hrs without aeration.
	25 Nos./litre upto 12 hrs with frequent aeration or change of water twice.

For periods above 12 hours seed have to be transported in oxygen packed plastic containers placed in hard board boxes. Usually prawn seeds supplied from hatcheries will be of postlarval or early juvenile stage of *P. indicus* measuring less than 20 mm in length. They can be transported at the rate of 250/litre for periods upto 24 hrs. and at the rate of 100/litre for periods above 24 hrs. under oxygen packing in closed containers.

For periods above 12 hrs. if there is facility for changing water and removal of sediments, seed can be supplied with live food organisms like *Moina*, *artemia* etc. which would help to avoid cannibalism. If water change and sediment removal are not done when feeding is adopted, there will be mortality due to oxygen depletion.

Maintenance of temperature during transportation is very important. Maintaining the temperature below 20°C will yield better survival rate. Since metabolic rate gets reduced under low temperature, oxygen consumption and excretion will be less. Temperature maintenance can be done by keeping ice blocks wrapped in polythene sheets inside the container (open containers) or by packing ice blocks and saw dust all around, outside the container (closed containers).

5.8 *Acclimatisation of seeds before stocking*

Since prawn seed are transported in the water taken from the collection site, they have to be acclimatised with the pond water before stocking in it. This is to minimise the probable stress on the seed while transferring from one habitat to another. The temperature and salinity of the pond water and water in the seed container should be known. If the salinity difference of the

two media is within 5 ppt, the seed can be released into the pond directly after equalising the temperature by allowing the container to remain inside the pond for some time.

If there is more difference in salinity, enough pond water should be introduced into the container gradually until the salinity difference is reduced to less than 5 ppt.

If the farmer does not have the facility for measuring salinity, he may mix the transport water gradually with pond water up to four times its original volume which would bring the salinity difference within the tolerable limits (Yap *et al.*, 1979).

#### 5.9 Time and mode of stocking

It is always better to stock when water temperature is low (before 9 a.m. or after 9 p.m.) on sunny days, at any time during a rainy day and when fresh tidal water is entering the field.

The water containing the seed should not be poured from a height. After ensuring that the temperature and salinity of the water in the seed container and pond water are agreeable, the container is gently tilted and the pond water is let in and the contents gradually released into the pond. Dead seed if any remaining at the bottom are counted so that the desired allowance for the mortality due to transportation could be given.

#### 5.10 Nursery rearing

Usually, prawn seed supplied from hatcheries and those collected from surf require nursery rearing before releasing into grow-out ponds. (For stocking rate see 3.2.1). Minced clam meat or compounded artificial feed could be given at the rate of 5% of the body weight of seed daily, apart from the naturally available food in the water. The stock can be periodically sampled for determining growth using a closemeshed nylon net. When they reach the stockable size (above 25 mm) they can be released into the grow-out pond by breaking the dyke.

### 5.11 *Stocking rate in grow-out ponds*

Generally, stocking rate of *P. indicus* in grow-out ponds is 5 nos. per square metre area of the pond. However, stocking rate can be increased upto 20 Nos. per sq. m as per the productivity of the pond (Rao, 1980), based on technical advice.

**FARM MANAGEMENT****6.1. Water management**

A depth of not less than 0.75 metres (2.5 ft) is maintained in the pond throughout the period of culture. This can be done by adjusting the height of shutter planks provided at the sluice gate. If the depth exceeds 2 m it will affect the photosynthesis at the bottom.

Care must be taken to maintain the quality of water including hydrological parameters and productivity. Water must be sampled at intervals of ten days and analysed for temperature, oxygen, salinity and pH. Daily flushing of water must be allowed for keeping up the quality of water.

As spring tide approaches, i.e., 5-6 days every two weeks during the full moon and new moon periods, pond should be partially drained to a level which the high tide of the day is estimated capable of replenishing. Draining, more than what an expected tide can replenish should not be done. Draining the pond during day time especially in warm weather is to be avoided. Draining of the pond may be done late in the evening or in early mornings preferably 2-3 hrs. before an expected incoming high tide.

In between the full moon and new moon period, i.e., during the first and third quarters, neap tides occur. During this period water should not be drained off but flushing of water must be allowed by adjusting the height of the shutter planks taking care to retain the optimum quantity of water always.

**6.2 Sluice gate care**

It may be ensured that there is no leakage by the sides of the sluice gate. See that the shutter planks and nylon screens are seated firmly on the bottom board of the sluice gate and tightly



fitting in to the grooves provided at the side pannels, giving no room for the passage of organisms in and out of the pond.

Debris, garbage, weeds and other organic objects coming along with the tidal water should be blocked against approaching towards the sluice gate by allowing two bamboo poles tied to each other at the ends so as to have an inverted 'V' shape to float pointing against the incoming tide (Plate 16). Otherwise these objects may obstruct the free movements of water through the sluice gate.



PLATE 16. 'V' shaped bamboo pole structure allowed to float to keep off floating weeds and other objects.

Both the nylon screens provided at the inner and outer ends of the sluice gate should be brushed clean daily to avoid clogging. See that the screen is not getting torn while brushing. A fibre brush may be used. Get into the water and brush it keeping it intact. Occasionally the screens should be checked against any damage. If found defective, it may be replaced immediately. Always keep two numbers of spare nylon screens. In order to resist the attack of otter, crabs etc., the outer nylon screen can be strengthened by fixing a metallic wiremesh also to the frame.

Silt accumulating at the bottom of the sluice gate should be removed frequently.

### 6.3 *Monitoring of growth*

After stocking, growth and survival of the prawns should be observed at regular intervals by sampling with the help of a cast net. First sampling can be done 15 days after stocking and thenceforth at the interval of 10 days. Sampling time, location of sampling and the specifications of the cast net should not be altered throughout the culture period, except in the case of the mesh size of the net used for the first sampling, when a comparatively close meshed net is used.

#### 6.3.1 *Sampling*

Cast net is the ideal gear for sampling. Suppose a cast net with a radius of 2.25 m is used for the purpose, then the maximum area that the net can encircle when it is fully unfurled and stretched is 15.89 sq m; say, 16 sq m. Actually this much area will not be covered when the net is operated; normally only half of this area may be taken into account to have been covered by the net, and so 8 sq m. It should also be considered that the density of population of prawns will not be uniform throughout the pond bottom. Concentration of prawns will be more near the sluice gate, in the bottom channels and in shady places due to favourable conditions viz., good shelter, availability of food, oxygen, etc. Therefore netting has to be done at different representative locations in the pond and the average number of prawns caught per net operation has to be calculated by dividing the total number of prawns caught by the total number of operations. Since stocking rate is 50,000 per hectare, on an average, one square metre area of the pond should be holding 5 numbers of prawns; giving an allowance of 20% for the mortality, it will be 4 numbers per square metre. At this rate the average number of prawns caught per net will be around 32 ( $8 \times 4$ ). If this figure is decreasing on the consecutive dates of sampling, it may be an indication of mortality. It is advisable to seek technical advice under such conditions.

In order to study the growth rate, the size (total length, tip of rostrum to tip of telson) of prawns caught during the sampling must be measured and the figures pooled together to take the average. Normally the average size will show an increasing trend during the consecutive sampling. On an average *P. indicus* grow at the rate of 30–40 mm per month. Growth is faster during the first two months of culture and from thence slows down. If the above growth rate is not observed during sampling it may be a symptom of unsatisfactory growth. The situation can be improved by pond manuring or by supplementary feeding. Technical advice may be sought before trying this.

#### 6.4 Blooms and their control

During peak summer when the salinity and temperature increase, pond water may sometimes become coloured brown or red ('Red tide'). This happens mainly in ponds having unsatisfactory circulation. Colouration, starting in localised areas, may spread throughout the pond within a week. This is due to the excessive multiplication of certain micro organisms, mainly diatoms and dinoflagellates which may become harmful to the prawns. In case the bloom is concentrated only inside the pond it can be controlled by pumping bloom-free water into the pond preferably to the corner opposite to the locations of the sluice gate and letting out bloom-water through the sluice gate. Spreading of powdered lime on the water surface @ 40–50 kg/ha is effective in causing the bloom organisms to settle down by flocculation (M. S. Muthu; Personal communication).

If the bloom is found appearing first in feeder canals, the sluice gate should be closed immediately and reopened only after the disappearance of the bloom. Excessive growth of filamentous algae is also harmful; prawns may get entangled amidst the algal mass. Filamentous algae can be removed manually. Excessive growth of flora if not controlled may also cause oxygen depletion in the pond water during the early hours of the day and prawns start swimming near the surface in distress. In normal case the oxygen produced by plants by photosynthesis during day time is sufficient for the respiration of plants and animals and there exists a dynamic equilibrium between the production and

consumption of oxygen. Excess vegetation if present will produce too much oxygen during day time to a point of saturation beyond 150% of the normal level due to the photosynthetic activity (Sinha, 1983). This oversaturation is harmful to animals. At night the same vegetation may consume oxygen bringing down the dissolved oxygen content to lethal levels. This situation may be encountered just prior to sun rise. Under these circumstances maximum quantity of water allowing the maximum tidal exchange also may be maintained.

#### 6.5 Diseases and their control

Diseases may be due to environmental factors, pathogenic organisms (such as certain algae, fungi, bacteria etc.) nutritional deficiency in the body and so on. Pathological conditions are generally observed when :

- i. Water temperature and salinity go very low or very high.
- ii. Algal blooms are observed.
- iii. Pond is overstocked.
- iv. Food is scarce.
- v. Grow-out period is prolonged beyond 3 months and
- vi. Water becomes polluted.

The pathological conditions sometimes observed in prawns in the brackishwater farms of Kerala is 'Softness' (Rao, 1983). Soft prawns loose weight and become flabby and feels soft to touch resulting in mortality. The real causative agent of this condition and the remedial measures are yet to be traced. CMFRI has taken up investigations in this line on a priority basis.

When wide-spread softening is observed, it is to be tested whether it has any correlation with moulting. If so, all parts of the exoskeleton will be soft. If it is pathological, rostrum will be hard as usual and the alimentary tract will be wavy (Visible along the dorsal side). This is to be ascertained with the help of technical experts. If identified as a pathological condition, it is advised to harvest the stock at the earliest.

### 6.6 *Problems of poaching*

Watch and ward arrangements must be provided day and night to avoid poaching, especially during the second and third months of culture period. Poaching is a sociological problem which has to be tackled carefully. Flood lights may be installed at strategic locations of the farm. Watchman's shed must be built preferably near the sluice gate. Dried twigs or any other obstacles could be placed in the pond all along the borders to prevent cast netting (They have to be removed at the time of harvesting) from the bund.

Apart from human intervention, farm birds such as ducks and wild birds such as crows, egret and herons may pose problems. Entry of ducks into the ponds can be prevented by keeping them under proper fencing. Water birds can be chased by using crackers or by installing 'Scare-Crow' or any other effective scaring device.

### 6.7 *Emergencies and remedies*

- i. If any breach or hole is noticed on the bund or at the sluice site it should be repaired in no loss of time.
- ii. If the nylon mesh screen or shutter planks provided at the sluice gate is found to be defective, it may be replaced immediately.
- iii. In the case of flood, avert overflow by adjusting the height of shutter planks. Rain water run off from surrounding areas should not be allowed into the pond which may cause sudden fall in the salinity level.
- iv. In case of drought, if tidal water does not reach the pond, water may be pumped in from outside. The sluice gate must be closed to prevent the least loss of water. Prawns moving through the shallow water areas may attract predatory birds; such birds must be kept off as suggested above. Prawns stranded in the exposed portions may be hand-picked and released into water areas or pave way for them to escape to the bottom channels meant for the purpose.

- v. If formation of unusual water colour, smell or symptoms of softness in prawn or any other abnormal condition is observed, the nearest station of CMFRI or any other organisation concerned, may be contacted for advice.
- vi. If prawns are seen swimming near the surface during day time, oxygen deficiency may be suspected. Technical advice may be sought. If necessary, pond water can be aerated by agitating with the help of an air compressor.
- vii. If any occurrence of industrial or agricultural pollution along the source of tidal water is observed, the sluice gate must be closed immediately; open it only after the menace is over.

## PRODUCTION, HARVESTING AND MARKETING

### 7.1 Production

Usually the grow-out period for *P. indicus* is 85-90 days. However, there are instances where they have reached marketable size within two months of stocking. Normally survival rate is found to be 80%. Within 90 days *P. indicus* will reach 110-120 mm in total length weighing 10-12 gm. Estimated production rates of prawn from farms of various sizes are presented in the Table 5.

TABLE 5. Estimated production rate per harvest of *P. indicus* in culture pond

Area	Seed to be stocked (No.)	Size at stocking (mm)	Period of culture (Days)	Size at harvesting (mm)	Estimated production (kg)
1 Hectare	50,000				400
0.5 "	25,000	25-30	85-90	110-120	200
0.25 "	12,500				100

### 7.2 Harvesting

Eventhough the grow-out period is observed to the 90 days farmers need not wait for the completion of the period. As soon as prawns reach marketable size (110-120 mm) harvesting has to be done.

The water level may be reduced to the maximum possible extent. While draining, ensure that the prawns stranded at the exposed portions are not taken away by predatory birds. Keep the required quantity of ice blocks ready to avoid spoilage of the catch. Give enough publicity among the prawn merchants to create a competitive market.

### 7.2.1 *Gears to be used*

- i. Conical sluice net.
- ii. Bottom drag net.
- iii. Cast net.
- iv. Round scoop net ( ' Vatta vala ' in Malayalam).

If the date of harvesting is coinciding with the period of spring tide, sluice net can be operated. On the previous day of the proposed date of harvesting, hold the maximum quantity of incoming spring tide water in the pond by adjusting the height of shutter planks. Install a light at the inner mouth of the sluice gate to attract the prawns. When water starts receding



PLATE 17. A cast net unit—the net operator and his helper.





PLATE 18. Hand-picking



PLATE 19. Operation of drag net

(beginning of low tide) fix the sluice net in the sluice gate and remove the shutter planks. Water will rush out into the net and the prawns moving out along with the current will be collected in it. When the buoy tied to the tail end of the net sinks due to the weight of prawns, lift the end portion of the net and transfer the catch into a container. Operation of net can be continued till the tidal flow becomes weak. Then fix the nylon screen in its position and remove the sluice net. Allow the maximum drainage of water from the pond. Prawns left in the pond will be aggregating mainly at the sluice site and in the bottom channels. Harvesting can be continued by cast netting (Plate 17) and finally by scoop netting and hand picking. Hand picking is mainly done by women. They stand in a row at one end of the pond and gradually move to the opposite end covering the entire stretch. As they advance, any prawn or fish that passes them will be caught. This is a skilled operation commonly seen in Cochin region (Plate 18). They can do it even in hip-deep water. If the pond is not fully drained, operation of drag net can be adopted (Plate 19). Drag net should be long enough to reach end to end of the pond. Usually two hauls, up and down will be sufficient, followed by cast netting.

Problems in harvesting is often encountered in ponds which are not fully drainable. The complete retrieval of the stock is not effected often with the existing types of gears. Further research in this line is needed.

#### 7.2.2 *Post-harvest care*

A prawn farm should have a roofed area which can serve as a post-harvest processing shed. Floor area must be cemented. The shed should contain a work table for sorting, beheading, grading and packing. Facilities for water supply, good drainage and storage of ice are also needed.

Newly harvested prawns must be taken to the shed and washed thoroughly with clear pond water to remove mud and debris. The prawn head and intestine are the centres of bacterial populations which could bring about rapid decomposition. Therefore, if immediate disposal is not planned, beheading and deveining

may be done followed by grading and storage with crushed ice in separate containers.

### 7.3 Marketing

Marketing arrangements have to be done prior to harvesting to avoid delay in disposing and the resultant spoilage of the commodity.

Harvested prawns have to be graded according to the count (Number per kg). Normally scientifically cultured prawns will not vary much in size since stocking size is almost uniform (Plate 20).

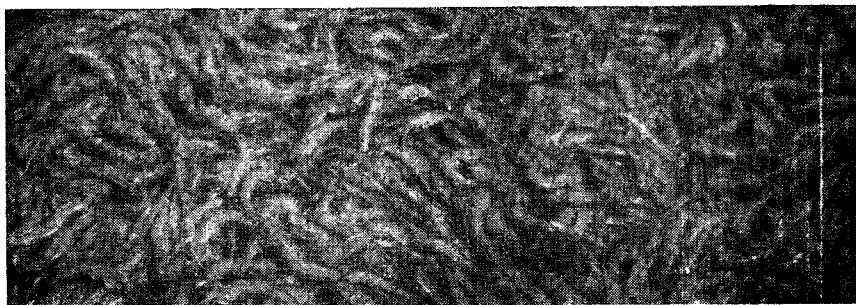


PLATE 20. Cultured prawns (*P. indicus*).

Based on the facilities available, prawns can be disposed head-on or head-less. Open auction will normally fetch better price.

#### 7.3.1 Price pattern

If possible it is better to sell the prawns headless which will ensure the maximum return. Harvested prawns weighing 10–12 gm per specimen, head on, may weigh 7–8.5 gm in headless condition (Weight of the head portion is found to be about 30% of the total body weight). At this rate about 120–150 prawns (Head-less) may weigh 1 kilogram. The ruling price of this grade of prawns at Cochin region is about Rupees 35–40.

## CROP MANIPULATION

### 8.1 *Single crop*

If the farmer intends to have only one crop in a season, plan it in such a way as to have the culture operation during the most favourable period of the season. In Kerala, especially in Trichur and Ernakulam Districts, December-March is the ideal period in seasonal fields.

### 8.2 *Multiple crops*

It is always more economical to have more than one culture operation than a prolonged single culture period, in a season. After the third month of culture, prawns will not grow substantially. In Cochin region, first culture can be done from mid-November to Mid-February and a second operation from mid-February to mid-April, where the lease period legally ends.

### 8.3 *Continuous stocking and fractional harvesting*

The practice involves intermittent harvesting of only the grown-up ones and replenishing the stock then and there. This method can be adopted in perennial fields when

- i. Stocking is done with seeds of varying size collected from the wild.
- ii. The farmer is reluctant to wait till the end of grow out period and
- iii. The farmer desires to have frequent return out of his venture.

Here, first partial harvesting can be done after two months of stocking and thenceforth at the interval of one month or so as desired by the farmer. This method is being successfully continued by many of the marginal farmers trained by the Krishi Vigyan Kendra of CMFRI.

# 9

## ECONOMICS OF PRAWN FARMING

### 9.1 Operational expenditure and income from a 1 ha seasonal field

Any farmer intending to take up prawn farming as a business would be eager to have an idea of the anticipated expenditure and income of the venture. In the case of a new farm the capital expenditure involved in the construction work may vary from half a lakh to one lakh per hectare depending on the physical features of the site. The expenditure and income involved in carrying out two operations of prawn culture during a period of 5 months in an already existing seasonal field of one hectare area taken on lease (lease period of seasonal field is 5 months) is presented below.

I. Crop (mid-Nov. to mid-Feb.)	Rs.
Capital expenditure :	
Lease value of field ..	5,000
Cost of constructing a temporary shed for Watchman ..	200
Repairing cost of bund (wages to 8 labourers @ Rs. 25 per head) ..	200
Cost of deepening and shaping the bottom channels leading to the sluice gate (Wages to 12 labourers) ..	300
Repairing and fixing cost of sluice gate ..	200
Cost of 500 kg of mahua oil cake required for eradication (water level is reduced to 0.25 m) including the cost of application ..	800
Recurring Expenditure :	
Cost of 50,000 seeds of <i>P. indicus</i> @ Rs. 20 per 100 seed ..	1,000
Wages of watchman @ Rs. 250 per month ..	750
Expenditure on harvesting and marketing ..	1,000
Miscellaneous expenditure ..	150
Total ..	<u>9,600</u>

*Income :*

Sale proceeds of 400 kg (estimated production) of <i>P. indicus</i> @ Rs. 35 per kg (Head - on)	..	14,000
Net Profit	..	14,000
		9,600
		<u>4,400</u>

*I. Crop (mid-Feb. to mid-Apr.)*

The capital expenditure mentioned above is for the entire lease period of 5 months.

*Recurring expenditure :*

	Rs.
Wages of Watchman	.. 500
Cost of 50,000 seeds of <i>P. indicus</i>	.. 1,000
Expenditure on harvesting and marketing	.. 700
Here, the expenditure on harvesting is lesser than on the first operation because the effort required is less. Because of the wide tidal amplitude effective at this time, maximum drainage of the field is possible necessitating only lesser harvesting effort	..
Miscellaneous expenditure	.. 150
Total	.. <u>2,350</u>

*Income :*

Since the period of culture involved is only less than 60 days the harvested prawns would be of the size, 90-100 mm length, weighing about 7 gm per specimen. A production of about 280 kg can be expected. This would fetch not less than Rs. 20 per kg (head-on) as per the current price pattern.

Sale proceeds of 280 kg of prawns @ Rs. 20 per kg (head-on)	..	5,600
Net Profit	..	5,600
		2,350
		<u>3,250</u>

Total income realized out of the two crops	..	14,000.00	
		5,600.00	
		<u>19,600.00</u>	
Total expenditure involved in the two culture operations.	..	9,600.00	
		2,350.00	
		<u>11,950.00</u>	
Net profit out of the two operations	..	19,600.00	
		11,950.00	
		<u>7,650.00</u>	

## 9.2 *Credit facilities for prawn farming*

In view of the great scope for extending prawn farming operations to more areas, different agencies such as Land Mortgage Bank, Fish Farmer's Development Agency, Commercial Banks, Block Development Office, etc. have come forward to provide financial aid for development of prawn farms.

### **Land Mortgage Bank**

The bank has been implementing different schemes for the development of land for establishing prawn farming in the Cochin Region.

Farmers possessing 25 cents to 5 acres of land are eligible for a loan of Rs. 17,900 per acre towards the construction of prawn farms. The loan is repayable in 12 annual instalments (due on 1st of every March) starting from the third year of receipt of the amount.

Farmers who own at least 1 acre of land are eligible for loan upto Rs 19,050 per acre for developing half of the area for prawn culture and the remaining half for coconut plantation.

The scheme for the integrated development of Vypeen Block provides credit facilities for (i) designing and developing the land (ii) planting cocount (iii) fish/prawn culture (iv) dairy development and vegetable cultivation in Vypeen Block. The total capital investment for all the components put together is worked out to be Rs. 32,750 per acre. For each component, separate repayment schedules are fixed, taking into account the nature of investment and time taken to derive the income. Proportionate loans can be granted for a cultivator who holds even 10 cents of land.

### **Fish Farmers' Development Agency**

The fish farmers' development agency (F.F.D.A.) functioning under the directions of Department of Fisheries of the Government of Kerala is the main agency extending financial aid for prawn/fish culture in Trichur District. F.F.D.A. arranges

payment of loan through Commercial Banks. Loan upto Rs. 10,000 per hectare is granted for construction and establishment of prawn farms (interest : 10.25% payable in half yearly instalments). The loan is repayable in seven annual instalments. The scheme allows a subsidy of 25 % of the loan.

#### **IRDP Scheme**

Under the Integrated Rural Development Programme there are provisions for availing loan facilities for creating self employment opportunities, through the Block Development Office.

A family having annual income not exceeding Rs. 3,500 is eligible for the loan. There is no limit for the amount of loan, but will be restricted on the basis of the input requirement of the Project proposed to be undertaken. One third of the loan, limited to a maximum of Rs. 3,000 is allowed as subsidy in ordinary case whereas in the case of a Scheduled Tribe family a subsidy of 50 % limited to a maximum of Rs. 5,000 is granted. The loan is repayable in five years. Extending this loan facility to 600 families per Block area per year is the current target of this scheme.

#### **Commercial Banks**

Nationalised/Commercial banks such as Canara Bank, Union Bank of India etc. have provisions for extending financial aid for prawn farming. The Canara Bank is associating with the FFDA in Trichur District in this field.

Under the agricultural finance scheme the Union Bank of India in Vypeen Island provides loan for development of prawn farms. The amount of loan is variable according to the input requirement of the project. The Loan is repayable in 5 years with an interest of 10%.

#### **Project Report**

In order to facilitate the sanctioning of loan, a Project Report of the scheme proposed to be undertaken is required, which is



prepared by the financing agency. The Project report will contain details regarding the available resources including the site plan, objectives and scope of the proposed Scheme, technical feasibility, economic viability, organization and phased programme of the Scheme, financial requirement, loan/credit requirements, repayment schedule, security/guarantee and so on.

### *9.3 Input requirement for the construction of a prawn culture pond*

New entrepreneurs will be eager to have an idea of the major inputs required and their cost in constructing a prawn culture pond. The inputs and costs involved in the development of a prawn culture pond of 1 ha area taken as a model is presented below for guidance. The inputs and their costs as mentioned here is location specific and is applicable to such a situation as is prevailing in Vypeen Island.

#### *Description of the site*

Brackishwater marsh, 1 ha in area with sparse vegetation including small shrubs and grass. rectangular in shape-subjected to year round tidal influence with a tidal amplitude of 0.5 m, soil composed of sand, silt and clay-pH 7.5 to 8.5 salinity profile 10 to 35 ppt—dissolved oxygen content above 3.5 ml.

#### *Description of the work to be done*

The site must be excavated to 0.5 m depth from the ground level. The soil, cut from the site is to be put along the boundary so as to raise a bund having 1 m height, 5 m wide at the bottom and 3 m wide at the top and 1 : 1 side slope. The pond, after construction, would be rectangular in shape, about 125 m long and 80 m broad. Peripheral and radiating channels having 0.5 m depth and 2 m width have to be cut along the bottom leading to the sluice gate. A wooden sluice gate, 3 m long, 1 m wide and 1.5 m high must be erected for regulation of tidal flow, at a place nearest to the source of tidal water.

66 coconut saplings may be planted on the bund, each 6 m apart. A permanent shed for watchman is to be constructed near the sluice gate.

After the construction of the pond, the relevant steps for the establishment of the first culture operation may be undertaken.

### INPUTS & COSTS

<i>Fixed Cost</i>	<i>Rs.</i>
i. Land value (land value is accounted in terms of the interest @ 10% on the purchase value or market value of the land for the crop period of 3 months. The land value as is prevailing in the brackishwater marshy areas in Vypeen island will be around Rs. 500 per cent, and hence the market value of one hectare area will be Rs. 1,25,000.	3,125
ii. Cost of excavation upto 0.5 m depth in an area of 8,050 sq.m @ Rs. 5 per sq.m (exclusive of the area of 1950 sq.m occupied by the bund) and depositing the soil at the boundary to raise the bund.	40,250
iii. Cost of cutting peripheral and radiating channels (Rate same as above).	8,000
iv. Cost of turfing the side portions above low water level of the bund @ Rs. 7 per sq.m.	5,460
v. Cost of sluice gate—3 m long, 1 m wide, and 1.5 m high—made of Anjili wood, including the expenditure of fixing it.	4,000
vi. Cost of 2 cast nets to be used for sampling.	1,000
vii. Cost of Watchman's shed.	2,500
viii. Cost of 66 Nos. of coconut saplings and planting charge	750
<b>Total</b>	<b>65,085</b>

*Working capital for the first culture operation*

	Rs.
i. Cost of fertilizer (1000 kg cowdung @ Rs. 0.15 per kg). Newly dugout ponds may require manuring to establish productivity. Cow dung may be heaped at different locations and the nutrients allowed to leach out into the pond gradually. This would cause the establishment of microbenthos for the prawns (manuring, subject to the advice of the technical experts only). Newly dugout ponds do not require eradication of predators. In case the pH of bottom soil is to be conditioned, the cost of lime required for the purpose also has to be accounted.	150
ii. Cost of 50,000 seeds of <i>P. indicus</i> @ Rs. 20 per thousand.	1,000
iii. Salary to watchman @ Rs. 250 per month for 3 months (One crop period).	750
iv. Expenditure on harvesting and marketing.	1,000
v. Miscellaneous expenditure	150
Grand Total	<u>68,135</u>

## POLYCULTURE &amp; INTEGRATED FARMING

## 10.1 Polyculture

The space, food and feeding facilities available in the pond ecosystem may not be completely utilized by the prawns. Such situations could be taken advantage of to the maximum level by allowing suitable mix of compatible nonpredatory fishes also to grow along with prawns. This practice of mixed culture involving different species is referred to as Polyculture. Fish species suitable for culturing along with prawns are the milkfish (*Chanos chanos*), known as 'Poomeen' in Malayalam; mullets (*Mugil spp.*) known as 'kanampu', 'thirutha', 'malan' etc. in Malayalam and the pearlspot (*Etroplus suratensis*) known as 'karimeen' in Malayalam. (Plates 21, 22 & 23).



PLATE 21. Harvested cultured milkfish.

In seasonal fields *P. indicus* seed (50,000/ha) and seed of milkfish or mullet or both can be stocked (at 2,000/ha—both the species inclusive) by mid-November. The prawns could be harvested by mid-February retaining the fish stock. Again

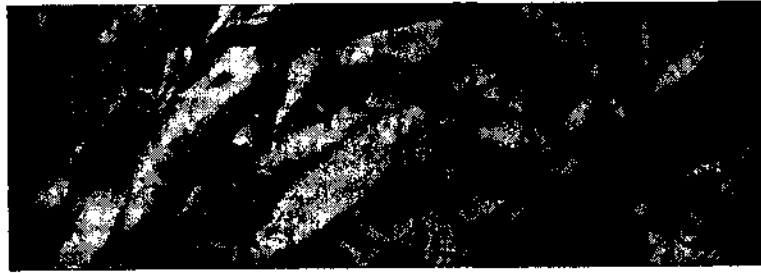


PLATE 22. Harvested cultured mullets.

prawn seed can be stocked immediately and their harvesting can be arranged by mid-April along with the fish stock. The total production of fish at the end of the 5th month would be around

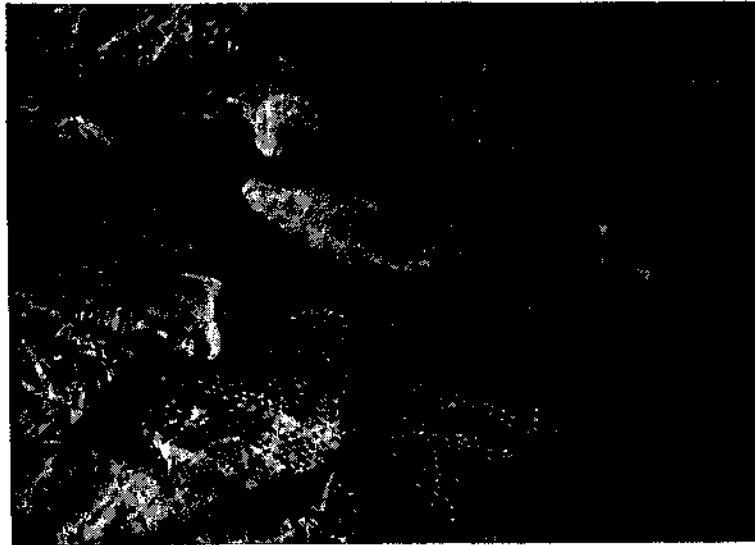


PLATE 23. Harvested cultured pearlspot.

300 kg fetching not less than Rs. 3,000. Cost of fish seed will be about Rs. 200 only.

## 10.2 *Integrated farming*

The concept of integrated farming with focus on marine prawn culture is new. The Central Marine Fisheries Research Institute has taken up investigations in this line. The system when developed will ensure the maximum utilisation of the land and water area available at the farm site.

Integration of prawn farming with agriculture and animal husbandry have great relevance both for subsidiary occupation and large scale commercialisation. Integrated farming would create opportunities for diversification of farm produce increasing cash income, improving the quality and quantity of the products and in exploiting the unutilised resources available to the farmer.

### 10.2.1 *Paddy field prawn farming*

The paddy field prawn farming method prevalent in Kerala is a good example of integration of prawn with an agriculture crop. The seasonal prawn fields where paddy is grown during monsoon months stand first in productivity and offers the best niche for the growth and survival of prawns when compared with other brackishwater prawn farms where no such rotation of crops is practiced.

### 10.2.2 *Prawn—Horticulture—Plantation crop—livestock*

During the monsoon season vegetables can be grown on the bunds of prawn farms. Vegetables suitable for the brackish-water areas of Kerala State include Lady's finger (ventaka), Brinjal (vazhuthananka), Pappaya (pappakka), Garden Pea (payar), Cucumber (vellarikka), Bitter gourd (pavakka), Amaranthus (cheera), Ridge gourd (peeckanka), etc. Cultivation of vegetables on the bund would also protect the bund from erosion during monsoon.

If the crest of the bund is at least 3 m broad, a row of coconut seedlings can be planted especially in the case of the perimeter bund (plate 24). If hybrid varieties of saplings are planted, they will start yielding from the 5th year onwards.

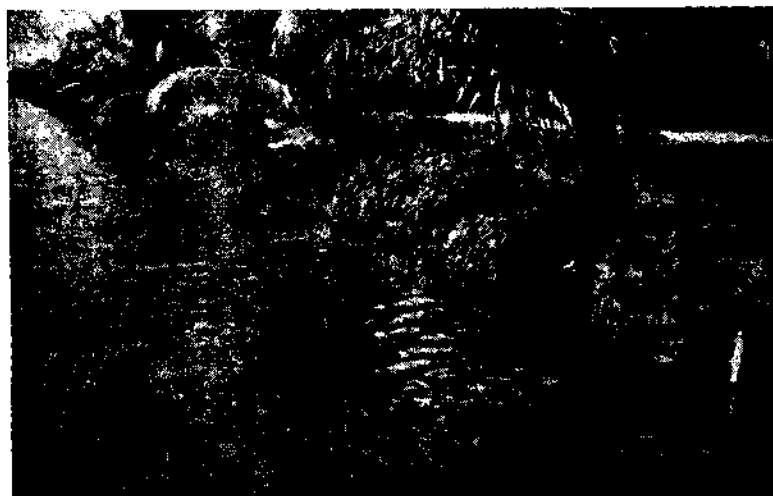


PLATE 24. Coconut seedlings grown on the bund.

There is great scope for integrating prawn farming with poultry, duckery or piggery. Production of prawn can be substantially increased by this. The poultry, duck, pig and cattle manure if let into the pond will ensure the sustained production of prawn feed organisms, necessitating no supplementary feeding or extra manuring in the pond under semi-intensive culture. It is understood that the manure produced by 20-30 pigs in an year's time is equivalent to 1,000 kg of ammonium sulphate applied to soil (Sharma, 1982).

Integration of prawn farming with other systems of farming will also help in improving the nonproductive or low productive brackishwater areas which are presently lying unsuitable for intensive prawn and fish farming.

TABLE 6. *Nutrient content of manures from different farm animals (Gupta, 1981)*

Manure from farm animals	Percentage of nutrients contained in the manure					
	Nitrogen		Phosphorus		Potassium	
	faeces	urine	faeces	urine	faeces	urine
Cattle	0.3	0.8	0.15	0.10	0.2	1.4
Pig	0.6	1.5	0.5	traces	0.5	1.8
Poultry/Ducks	1.6	..	1.5	..	0.9	..

The three major interactions possible in the integrated farming system are (a) crops on pond dyke as vegetable or coconut for human consumption or fodder for livestock (b) livestock manure as pond fertilizer and (c) pond bottom sediment as crop fertilizer.

#### EXTENSION SERVICES AVAILABLE

Apart from organizing Symposia, Seminar and Workshops and releasing extension literature in English and local languages, the Central Marine Fisheries Research Institute provides consultancy and extension service for benefit of farmers. The Institute also conducts short-term training course on prawn farming integrating with poultry, duckery, livestock, horticulture, plantation crops and post harvest technology at its Krishi Vigyan Kendra at Narakkal.

Extension services in prawn farming are also available with (i) The Marine Products, Export Development Authority, Collis Estate, M. G. Road, Cochin-16, (ii) Office of the Deputy Director of Fisheries (Extension), Govt. of Kerala, Panampilly Nagar, Cochin-16 and (iii) College of Fisheries, Kerala Agricultural University, Panangadu, P.O., Ernakulam Dist.



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## GLOSSARY

<b>Ablation</b>	removal
<b>Acclimatisation</b>	adjusting to a new environment or climate
<b>Adsorb</b>	to attach superficially.
<b>Algae</b>	unicellular or multicellular, chlorophyll-bearing plants with no true roots, stems and leaves, predominantly water-living. They may be free-swimming, free-floating or attached to other objects; include phytoplankton and sea weeds.
<b>Algal pasture</b>	growth of algae, grazed by animals.
<b>Amphipod</b>	a tiny crustacean.
<b>Anhydrous</b>	completely lacking in water.
<b>Anaerobic</b>	oxygenless condition.
<b>Artemia</b>	a tiny crustacean living in salt pans, commonly called 'brine shrimp'.
<b>Backwater</b>	a stretch of water held back from the main course of a river, fed by backflow.
<b>Bacteria</b>	simplest and smallest form of living organisms existing in air, water, soil and in living and dead organisms.
<b>Benthic</b>	bottom of a water body.
<b>Berm</b>	horizontal narrow ledge left between the toe line of the embankment and the water edge of the pond.
<b>Biology</b>	the science of life
<b>Biological waste</b>	wastes of metabolism.
<b>Bloom</b>	dense growth of microorganisms.
<b>Bound nutrients</b>	nutrients in unusable form.
<b>Brackish</b>	salty.
<b>Brine</b>	water containing a higher concentration of dissolved salts than ordinary sea water.
<b>Cannibalism</b>	eating the flesh of one's own species.
<b>Chromatophore</b>	colouring pigment.

Clay puddle	thick paste formed of a mixture of wet clay and sand.
Compaction	the decrease in volume or thickness of a sediment under load through closer crowding of constituent particles and accompanied by decrease in porosity, increase in density and squeezing out of water.
Copepods	minute crustaceans forming an important component of the plankton.
Crop rotation	the technique of growing different crops alternately in a field to avoid exhausting the field of one kind of nutrient.
Crustacean	a group of invertebrate (without backbone) animals with a hard close-fitting shell which is shed periodically; includes copepods, amphipods, prawns, crabs, lobsters etc.
Debris	material thrown away as waste and useless.
Detergent	surface-active agent capable of removing dirt and greasy substances.
Deveining	removal of intestine in prawns.
Diatom	single-celled microscopic plants which form a large proportion of plankton.
Dinoflagellates	microscopic algae with two flagella (hair-like structures helping in movement). Possess characteristics of both plants (chlorophyll) and animals (capacity to move). Peridinium is a common dinoflagellate,
Disinfectant	which destroys disease-causing germs.
Ecology	the study of the relationship between living organisms and their environment.
Ecosystem	a natural complex of plants and animals and the environmental conditions in which they live.
Estuary	a semienclosed, tidal coastal body of saline water with free connection to the sea; commonly the lower end of a river.
Exothermic	releasing heat.
Fauna	animals present in a particular place.
Flocculation	process of aggregation into small lumps.
Flora	plants present in a particular place.

Fungus	simple plants without chlorophyll; includes molds, mushrooms etc.
Garbage	useless or unwanted matter.
Grow-out ponds	ponds where prawns, after the nursery stage, are reared upto marketable size.
Haemolysis	destruction of red blood corpuscles with the liberation of haemoglobin.
Hatchery	place where eggs are allowed to hatch out and the early larval stages are reared.
Humic acid	acid formed from humus. Humus is a complex organic matter of the soil resulting from the decomposition of plant and animal tissue.
Hybrid	offspring of a cross between two different species.
Hydrogen sulphide	a colourless gas with a characteristic foul smell of rotten eggs.
Impervious	not permitting passage, especially of fluids.
Impoundment	water area held within the limits of bunds.
Industrial effluent	outflow of industrial waste.
Inorganic	not of plant or animal origin.
Inputs	the amount money, material, effect etc. put into a project.
Juvenile	young immature animal.
Larva	an young, immature stage of an animal which greatly differs in appearance and behaviour from the adults.
Leaching	process by which organic matter and minerals are washed out by percolating water.
Mangrove	salt-tolerant plants growing in marshy areas.
Marsh	an area of soft and wet low land; swamp.
Metabolism	the overall biochemical reactions taking place in living things.
Microbenthos	microscopic organisms living at the bottom of a water body
Microbial	of bacteria or fungus
Microflora	microscopic plants.

Mineralisation	to break up and convert organic matter into inorganic constituents.
Moina	a tiny freshwater crustacean found in plankton.
Moulting	periodical shedding of the outer shell of prawns, crabs, lobsters etc.
Neap tide	lowest range of the tide occurring during the first and third quarter of the moon.
Niche	a general term referring to the environmental space occupied by a species; a position specially adapted to its occupant.
Nitrogen fixation	conversion of gaseous nitrogen into oxides (nitrates) usable by plants.
Nursery	place where very young stages of organisms (larvae in the case of fishes and prawns) are reared till they are transferred to grow-out ponds.
Nutrients	constituents required by plants for growth.
Optimum	most favourable.
Organic	of plant or animal origin (containing carbon or compounds of carbon).
Organic detritus	fragments of plant or animal matter formed by disintegration or decomposition.
Organism	a living individual, plant or animal.
Overstocked	a situation where the pond contains more number of fishes or prawns than what is required.
Pathogenic	disease-causing.
Peat	partially decomposed vegetation especially that of marshy area, which has become compacted. Sometimes dried and used as fuel.
Pennaeid	a family of crustaceans represented by most of the commercially important marine prawns.
Perimeter	outer boundary of an area.
Periphyton	plants growing on other submerged plants.
Permeable	permitting passage, especially of fluids.
Photosynthesis	synthesis of food in plants utilising sun's energy.
Phytoplankton	the plant organisms of plankton.
Pitching	to fix or set at a particular point, level, degree etc.

Plankton	animals and plants of minute size living suspended or floating in water and largely incapable of independent movement and are passively transported or drifted by water currents and wave action.
Polyculture	mixed culture of different species of prawns or fishes or both.
Post-harvest	after harvest.
ppm	parts per million (e.g., 10 ppm means, 10 parts per 1 million parts, i.e., 10 grams per 1 million grams or 10 grams per 1000 kilograms).
ppt	parts per thousand.
Predator	organism that kills and eats another organism.
Primary production	the amount of organic matter produced in the form of plants from inorganic substances.
Ripe	ready to spawn.
Red tide	red or reddish brown discolouration of water caused by the high concentration of certain microscopic organisms, particularly dinoflagellates.
Saline	containing salt.
Salinity	number of grams of dissolved salts in 1000 g of water.
Salt pan	impoundments where water is allowed to evaporate for getting salt.
'Scare Crow'	a figure of a man etc. made with sticks, clothes etc put in a field to frighten birds away from crops.
Silt	an unconsolidated sediment of inorganic granular material with particle size ranging between that of sand and clay.
Sluice gate	a device for regulating the flow of water.
Spawning	shedding or releasing of eggs, with reference to animals living in water.
Species	natural groups of individuals which closely resemble each other and are interbreeding.
Spring tide	tides of increased range which occur about every two weeks at times of the new moon and full moon.
Surf zone	the area between the outermost (wave) breaker and the limit of the wave uprush.

Suspended matter	materials in a liquid which can be separated by sedimentation or filtration.
'Thakkom'	a vernacular Malayalam word used to denote the period of five to eight days around the full moon and new moon days when increased tidal ranges are experienced.
Tidal amplitude/range	the difference in height between the consecutive high and low tide levels.
Tidal flat	marshy or muddy areas which are submerged and exposed by the rise and fall of the tide.
Tide	the periodic rise and fall of the ocean level in response to the gravitational interaction of earth, moon and sun.
Tide Tables	tables that give daily predictions of times and heights of the tide, usually an year in advance.
Toxic	poisonous.
Turbidity	cloudy condition of water or reduced water clarity resulting from the presence of suspended matter.
Turfing	surface layer of earth containing grass with their matted roots. Pieces of this layer are cut and fixed on embankments for protection.
Understocking	a situation where the pond contains lesser number of prawns or fishes than what is required.
Zooplankton	animal plankton.

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*Back cover* Pōkkali paddy field being deepened for prawn culture.