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COURSE MATERIAL
TRAINING PROGRAMME IN SEMI-INTENSIVE SHRIMP FARMING

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COURSE MATERIAL OF TRAINING PROGRAMME IN SEMI - INTENSIVE SHRIMP FARMING

CONTENTS

GENERAL BIOLOGY OF PENAEID PRAWNS

BY
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INTRODUCTION

About 90 species of penaeid prawns are known to occur in the Indian waters, of which, 59 are littoral forms and the rest 31 are inhabiting deeper waters. Among the littoral species, 34 are commercially important. The average annual production of penaeid prawns from India during 1982 - 1991 is about 1.42 lakh tonnes, which formed 50% of the total crustacean landings. The average annual export of prawns during the same period is amounted to 59,207 tonnes, earning a foreign exchange of Rs. 538 crores. As the penaeid prawns are the major contributor in the seafood export industry, continued efforts were made to increase the overall catch by increasing the fishing pressure during the seventies and eighties. However, the annual catch remained static with minor fluctuations. To augment the overall shrimp production, culture practices for penaeid prawns were taken up during the eighties in different maritime states. In the context of rational utilisation of the wild resources and the expansion and sustaining of culture practices, an understanding of the biology of penaeid prawns is essential. The salient features of the biology of penaeid prawns are summarised below with brief notes and illustrations on the candidate species considered for prawn culture in India.

CONSTITUENT SPECIES

The Indian littoral penasids belonging to the Family Penahidae are systematically positioned in 10 genera, namely,

Solenocera (10 species), *Sicyonia* (1 species), *Penaeus* (8 species), *Metapenaeopsis* (8 species), *Parapenaeus* (1 species), *Metapenaeus* (12 species), *Atypopenaeus* (2 species). *Trachypenaeus* (4 species), *Trachypenaeopsis* (1 species) and *Parapenaeopsis* (12 species). Some of the species belonging to the genera *Penaeus* and *Metapenaeus* migrate to brackishwater areas during their juvenile phase, while the species in other genera are purely marine forms and complete the entire life cycle in the sea itself. Those species belonging to the genus *Penaeus* are known to attain larger size (above 200 mm in total length (TL). The species in other genera grow to a maximum size of 40 to 200 mm in TL.

MORPHOLOGY AND ANTOMY

The morphological features of penaeid prawn consist of carapace (head), abdomen (body) and telson (tail), of which, the flesh portion is mainly confined to abdomen. With the presence of secondary sexual characters, the sexes can be easily identified in the penaeid prawns. In the case of males, the endopods of the first pair of pleopods (swimming legs) appear initially as leaf-like and later develops into semi-cylinderical tsbe. The tube-like structures fuse together when the prawn attains maturity and it is called "Petasma". For females, the external genitalia is called as "Thelycum", which is situated between the bases of last three walking lengs. The thelycum is only a pouch, where the spermatophores are stored at the time of mating. The structure and shape petasma and thelycum varies distinctly in each species, which is used as an important and positive tool for specific identification of different species.

In the carapace, the anterior portion is a pointed structure called "Rostrum". In the case of *Penaeus* species, the rostrum is possessed with dorsal and ventral teeth, whereas, the dorsal teeth alone are present in the other genera of the family Penaeidae. A pair of stalked eyes are

present on either side of the rostrum, below which, the antennules and antennal plates with flagellum (feelers) are situated. The mouth parts consist of 1 pair each of mandible, first and second maxilla, first, second and third maxillipeds. For movement over the substratum, there are five pairs of walking legs, of which, the first three pairs are provided with chelate dactylus (pincer-shaped), which are used for catching and holing the prey and pass it on to the mouth. The five pairs of pleopods, situated below the abdomen are used for swimming. The vascular, nervous, digestive and reporductive systems are originating from carapace and extended to other parts of the animal.

HABITAT

The littoral penaeid prawns are found in the continental shelf region (inshore waters) up to a depth of 200 m, while those of deep water forms occur in the depth range of 200 to 600 m in the continental slope region (offshore waters). All the prawns dwell at the bottom of the sea, where the substratum is mud or sand or admixture of sand and mud. Some of them bury under the substratum during the day, emerge out at night for normal biological activities and do not undertake long distance migration. Those prawns which do not bury are active swimmers and at times undertake long or short range migration in the columnar waters. The early larval stages of the penaeid prawns are found in the surface and subsurface waters of inshore and offshore areas. The postlarvae belonging to some species of *Penaeus* and *Metapenaeus*, which can tolerate wide range of salinities (euryhaline forms) migrate into backwaters, estuaries, creeks and coastal lakes and inhabit the shallow shore areas. As they grow and attain juvenile stage, they move to deeper portion of the estuaries. The early juveniles of some species which can tolerate low salinities (more euryhaline forms) invade the upper reaches (freshwater zone) of the estuary, while those prawns which cannot tolerate low

salinities (less suryhaline forms) occupy the lower reaches (bar mouth area) of the estuary.

LIFE HISTORY

The life span for littoral penaeid prawns is about 2 years. Adults get matured in the marine environment during the first 3 - 6 months of life time and breed continuously till their death. Matured famales relaase simultaneously eggs from the base of the third walking legs and the stored spermatophore from the thelycum. Fertilization takes place in the sea water. While releasing the eggs, the mother prawns swim above the ground. The released eggs settle at the bottom. The larval phase includes 6 naupliar, 3 protozoeal, 3 mysis and several postlarval stages, before attaining the juvenile stage. For those species migrating into brackishwater environment, the nursery phase lasts for 3 - 4 months in the case of juveniles of *Metapenaeus* and 4 - 6 months in the case of *Penaeus* species. Those prawns which spend their nursery phase in the brackishwater medium, emigrate to the sea for attainment of maturity and subsequent breeding. However, the purely marine forms complete both nursery and adult phases in the sea itself.

FOOD AND FEEDING HABITS

In the larval phase, the naupliar larvae do not feed as they possess yolk on which they thrive. When they metamorphose into protozoeal stage, they become filter feeders. The mouth parts possess a series of setae, which serve as a screen in filtering microscopic algae floating in the sea water. By their active swimming, the larvae could move around and actively feed on phytoplankton, especially on diatoms. When they reach postlarval stages, they become carnivorous, as they possess a pincer-like structure (chela) in the distal portion of the first three walking legs. The poslarvae are able to catch small zooplanktors such as

copepods, rotifers, larval forms of other animals, etc. As soon as they settle down at the bottom of the estuary or sea or culture fields during their juvenile phase, they feed on bottom-living (benthic forms) animals, namely, polychaete worms, mollscs (bivalves and gastropods) and crustaceans (amphipods, isopods, smaller-sized prawns) and fish larvae. As they grow larger and attain adulthood, they feed on larger-sized benthic animals. Generally, penaeid prawns are termed as omnivorous feeders.

MOULTING CYCLE

As a rule in the crustacea, a penaeid prawn undergoes moulting. Prior to moulting, a layer of new shell is formed underneath the old shell. During the process of moulting, the old shell is casted off. After moulting, the body of the prawn is so soft and absorbs water to increase in size, as part of the physiological act. During the early and postlarval stages, the moulting takes place every day. When they become juveniles, the interval between moultings varies from 2 to 7 days. In the adolescent and adult phases, the intermoult period ranges from 15 to 25 days. When the prawns were well fed and in good health condition, the moulting process is quite normal. At every moulting, the energy stored in the body is utilised. Normally, the prawns do not feed prior to and after moulting. Once the body shell is hardened after moulting in 1 or 2 days, they resume normal activity. The starved prawns do not moult, as they utilise the stored energy for their survival. Generally, the moulting takes place around new moon and full moon periods. The newly moulted prawns are defenceless and it is likely that they become an easy prey to other prawns and fishes.

AGE AMD GROWTH

As said earlier, the life span of prawns is about 2 years. The time taken between the spawning and the attainment of postlarval stage is about 10 days and by the end of one month, they attain the early juvenile stage (10 - 20 mm in TL). The growth is so fast in the juvenile stage and as they grow larger, females grow faster than males. The estimated monthly growth rate for *Penaeus* species is about 20 to 30 mm in total length and 8 - 10 mm for *Metapenaeus* species. Based on the data collected from the size frequency sampling of the wild and cultured specimens, it was estimated that the size attained by the end of first and second year was 150 to 200 mm and 200 to 320 mm for *Penaseus* species and 80 to 120 mm and 130 to 200 mm for *Metapenaeus* species.

MATURATION AND SPAWNING

The secondary sexual characters appear when the penaeid prawns measure above 40 mm in TL. In males, the union of petasma lobes indicates the on-set of maturity. After 1 to 2 weeks, a white mass (spermatophores seen through the exoskeleton) is seen near the base of the last walking legs. Whereas, the complete occupation of anterior, median and lateral plates of thelycum in between the last three pairs of walking legs indicates the first maturity in females. Subsequently, the deposited spermatophores can be seen either over or inside the thelycal plates. Males mature at a smaller size than females. The minimum size at maturity was found at 105 - 170 mm for males and 115 - 180 mm for females of *Penaeus* species, while it was 55 - 100 mm for males and 75 - 120 mm for females of species belonging to other genera. Mating takes place between a normal male and freshly moulted female, usually at night. Male deposits spermatophores with the help of petasma over the thelycal plates.

Based on the size and structure of the ova, there are 5 stages of development, namely, immature, early maturing, late maturing, mature and spent recovering, which are described below. (Fig. 1 to 4)

IMMATURE : Ovaries are thin (diameter: 0.080-0.098 mm), translucent, unpigmented and confined to abdomen; not visible through the exoskeleton.

EARLY MATURING : Ovary increasing in size (Dia. : 0.08-0.25 mm); anterior and middle lobes developing; light yellow or yellowish green in colour; can be seen through the exoskeleton as a linear band.

LATE MATURING : Ovary in light green colour; Fully developed anterior and midlle lobes; Ova size: 0.14 - 0.32 mm; A some-what diamond shaped expansion of ovary seen through the first abdominal segment.

MATURE : Ovary in dark green colour; Clearly visible with a diamond-shaped expansion at the first abdominal segment; Size: 0.14-0.38 mm.

SPENT-RECOVERING : After the extrusion of eggs, the gonads revert to imature stage.

The fecundity is very high in penasid prawns. The number of eggs produced by females of different genera are given below.

	Number of eggs
Penaeus spp.	68.000 to 19,00,000
Metapenaeus spp.	34,000 to 3,63,000
Parapenaeopsis spp.	39,500 to 2,36,000

Spsawning takes place generally at night and the eggs are released while prawns are swimming in the coloumnar waters. At the same time, a portion of spermatophores is released into the sea water from the thelyeum, thus, paving the way for an external fertilization. Laboratory observations have shown that the spawning process lasted for about 30 minutes for smaller specimensss and up to 1 hour for larger prawns. After attaining the first maturity, it found that some species used to spawn five or more times during their life span. The interval between two spawnings is about 2 months.

LARVAL DEVELOPMENT

During the process of spawning, the eggs of penaeid prawns (diameter of eggs: 0.25 - 0.41 mm) are shed free in the sea water, which settle at the bottom of the sea. The eggs hatch out 8 - 17 hrs after they are laid, depending on the water temperature. At the time of hatching, the naupliar larvae come out of egg membrane by vigorous jerking movement and piercing the membrane. The salient characters of larval stages are given below.

Nauplius: (Size: 0.24 - 0.54 mm in TL) The body is pear-shaped with 3 pairs of appendages, which are used for swimming. The mouth and alimentary canal are not formed and the larvae do not feed, depending the internal yolk for development. Totally 6 naupliar stages are identified by the

increase in the number of setae in the caudal lobes. While the duration of each sub-stage is about 4 - 6 hrs, the 6th sub-stage (Nauplius VI) is extended for about 12 hrs. The total duration of nauplius stage lasts for 36 - 48 hrs.

Protozoea: This stage is characterised by a large carapace, a slender thorax and abdomen. The abdomen which is bifurcated posteriorly is possessed with 7 setae on each furca. The alimentary canal and feeding appendages (mandible, maxillule and maxilla) are present. The larva is a voracious filter feeder, feeding on phytoplankton. There are 3 sub-stages, which last for 3 days, depending on water temperature.

Protozoea I : Size 0.61-0.98 mm in TL; Eyes sessile; rostrum absent; abdomen unsegmented.

Protozeoa II : Size 1.0-1.5 mm in TL; Eyes stalked; rostrum present; 5 abdominal segments demarcated; uropods absent; telson not seperated.

Protozoea III : Size: 1.4-2.7 mm in TL; Uropods present; telson seperated.

Mysis: (Size: 1.8-4.4 mm in TL) In this stage, the carapace, abdomen and telson are demarcated distinctly. The 5 pereopods are functional, of which the first 3 have rudimentary chelae. The pleopods below the abdomen are rudimentary without setae. There are 3 sub-stages, which last for 3 days. The substages can be distinguished from one another based on the increase in size and length of pleopods.

Postlarva: (Size: 3.2-5.3 mm in TL) This is characterised by prawn-like body shape, development of swimming setae on the pleopods and fully developed chelae on the first 3 pairs of walking legs. The postlarvae loss the filter feeding habit and become capable of catching small prey with the help of chelate legs. The postlarval phase gradually transforms into juvenile phase after going through 20-30 successive moults, depending on the availability of food.

MIGRATION

Penaeid prawns undertake migration during their larval, juvenile and adult phases of life. In the early larval phase, larvae are carried away by oceanic currents and got disbursed in the coastal and offshore waters. The postlarvae of those adults which can tolerate low salinities are utilising the incoming tides (high tides) to enter the brackishwater environment. Those larvae that entered the nursery area do not emigrate during the subsequent low tides. They remain in the estuary till they reach adolescent stage and in the meantime they undertake a to and fro movement within the estuary. The lunar phases play an important role in the emigration of juveniles from the estuary. In the case of larvae belonging to those adults which can not tolerate low salinities do not migrate into estuaries, thus the salinity of the water medium acting as a barrier in the larval migration and distribution.

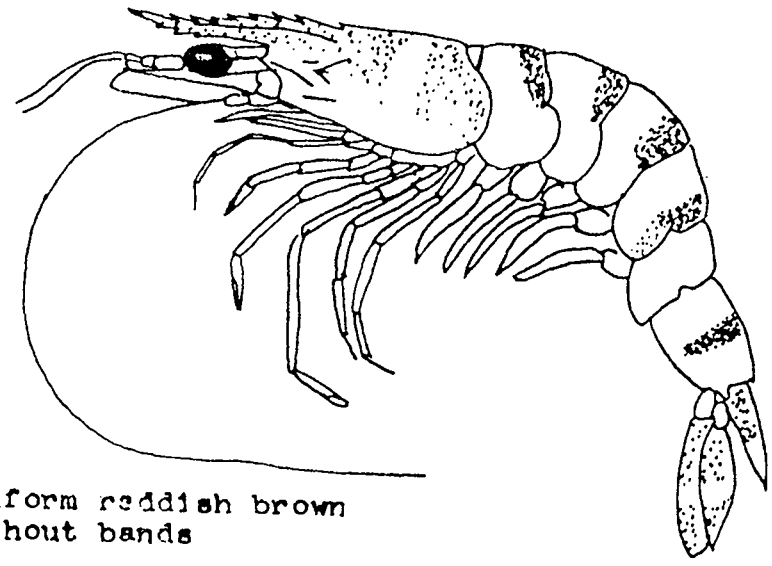
Contrary to the bottom-dwelling habits, adults of some penaeid prawns move in schools in the columnar waters either within the fishing ground or to a long distance. The recent tagging experiments conducted to study the movement and growth of some of the penaeid prawns have indicated that the tagged juvenile prawns did migration within the estuary and that of adults within the fishing grounds in the inshore sea. In the case of the Indian white prawn (*Penaeus indicus*), the

tagged white prawns released in Cochin on the southwest coast, were recovered near Tuticorin on the southeast coast after a period of 45 to 103 days. The distance covered was 220 - 380 kilometres, with an average speed of 2.9 to 5.6 Km per day. The migrations are related to breeding and also to escape from the environmental stress.

CANDIDATE SPECIES FOR PRAWN CULTURE

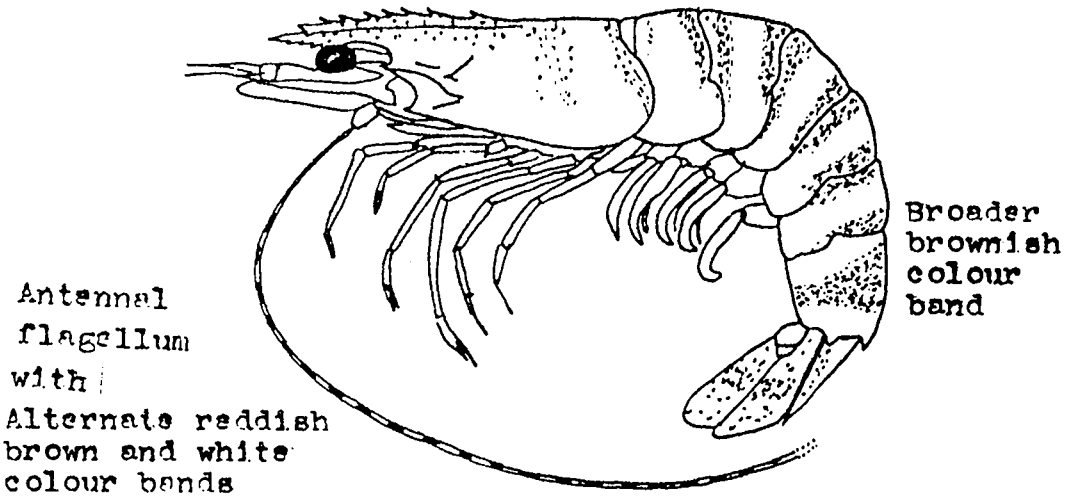
In order to create an awareness among the farmers, entrepreneurs and administrators concerned with prawn farming in India, a basic guide line on the candidate species is appended below.

1. GIANT TIGER PRAWN - *Penaeus monodon* Fabricius



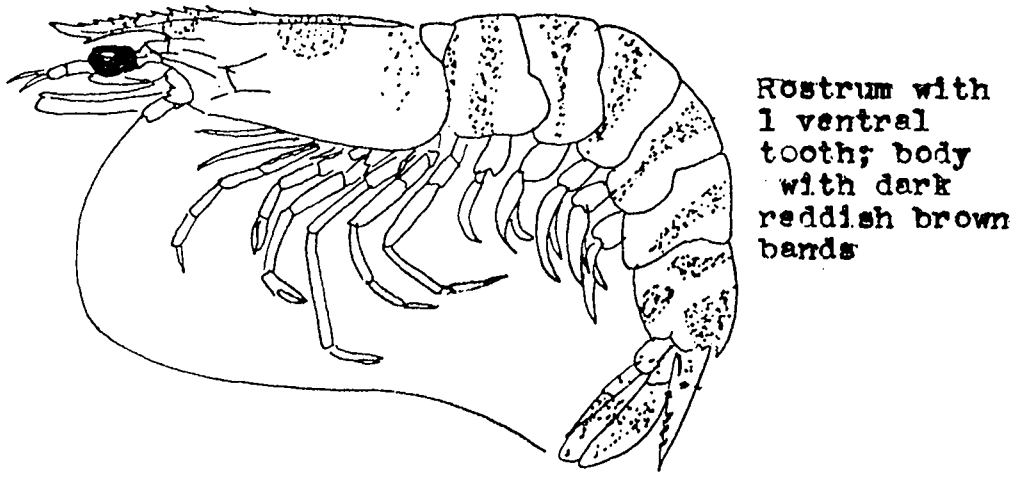
Largest species; prefers muddy bottom; do not bury in the substratum; tolerates wide range of salinity (2 - 50 ppt); grows fast in 15-25 ppt salinity; attainss a marktable size of 30-35 g in 15-25 ppt and 25 g in 35-47 ppt salinities; yields 4 to 5 tonnes/ha/4 months in semi-inttensive culture system; a number of hatcheries in private and government sectors to supply seed; susceptible to diseases.

2. GREEN TIGER PRAWN - *Penaeus semisulcatus* de Haan



Prefers sandy bottom; buries in the substratum during daytime and emerges at night for feeding; suitable for sea water (30-35 ppt salinity)) based culture system; experimental culture attempted in India; ideal species for sea ranching.

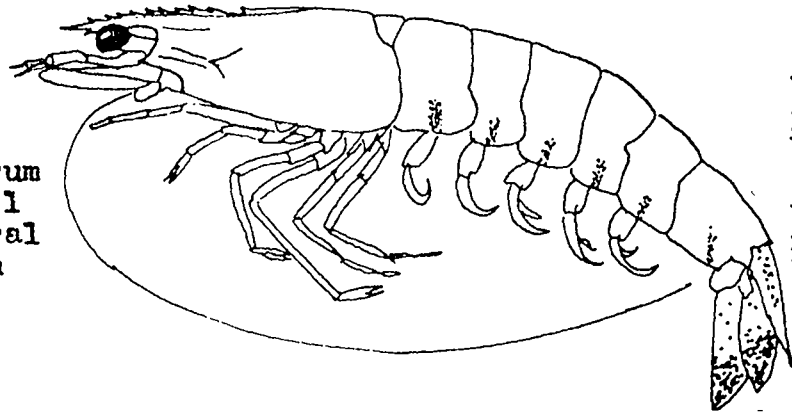
3. KURUMA PRAWN - *Penaeus japonicus* Bate



Prefers sandy bottom; buries in the substratum during daytime and emerges at night for biological activity; attains

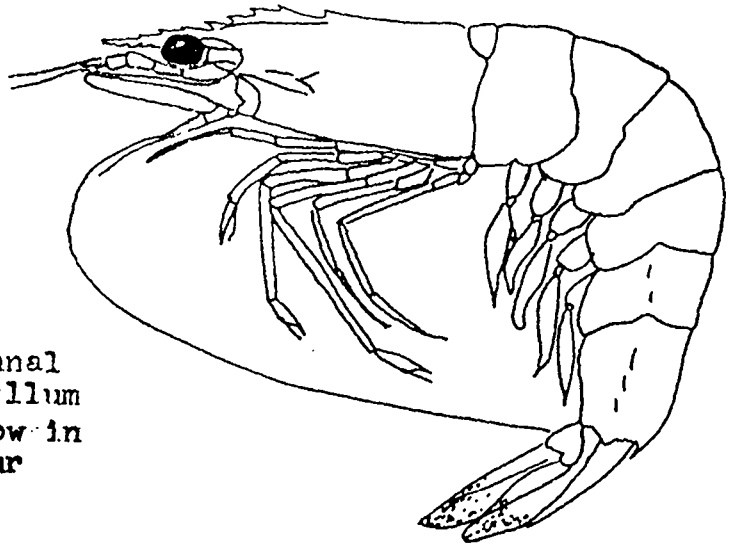
a marketable size of 15-20 g in 4 months in experimental trials; suitable for sea water (30-35 ppt salinity) based culture system; attains maturity in earthern ponds when the rearing period extended upto 8 months; suitable for sea ranching.

4. KING PRAWN - *Penaeus latisulcatus* Kishinouye



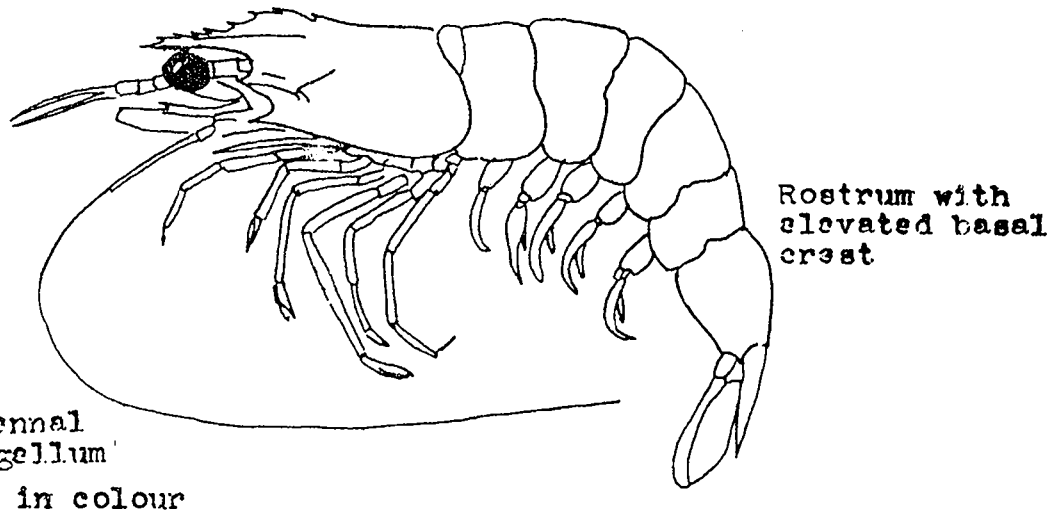
Burrowing form; attains a marketable size of 10-15 g in 3 months experimental trial and attains full maturity in the same period; suitable for sea water (30-35 ppt salinity) based culture system on sandy bottom; potential species for culture in sandy coastal areas and lagoons of Lakshadweep Islands.

5. INDIAN WHITE PRAWN - *Penaeus indicus* H. Millne Edwards



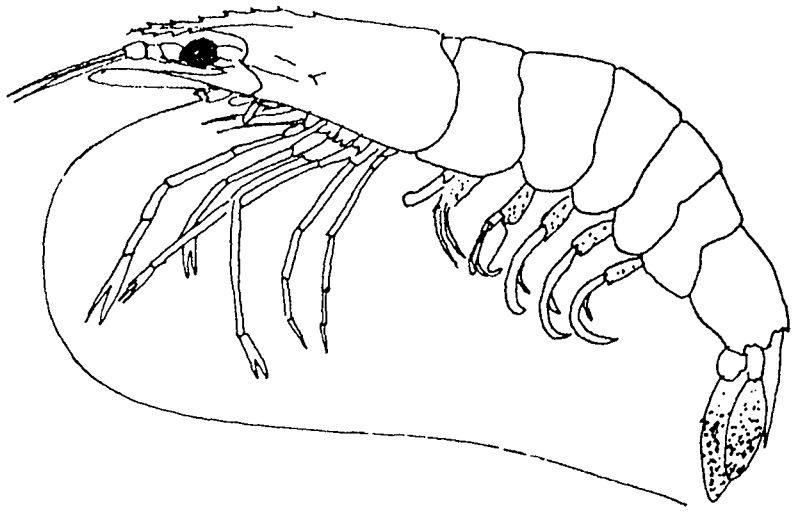
One of the fast growing species; prefers a sandy mud bottom; do not bury in the substratum; active both during day and night; optimum salinity range for culture 20-30 ppt; yields 2 to 3 tonnes/ha/3 months in semi-intensive culture system and a maximum yield of 8 tonnes/ha/5° months in intensive culture system; private and government hatcheries for seed supply.

6. BANANA PRAWN - *Penaeus merguiensis* de Man



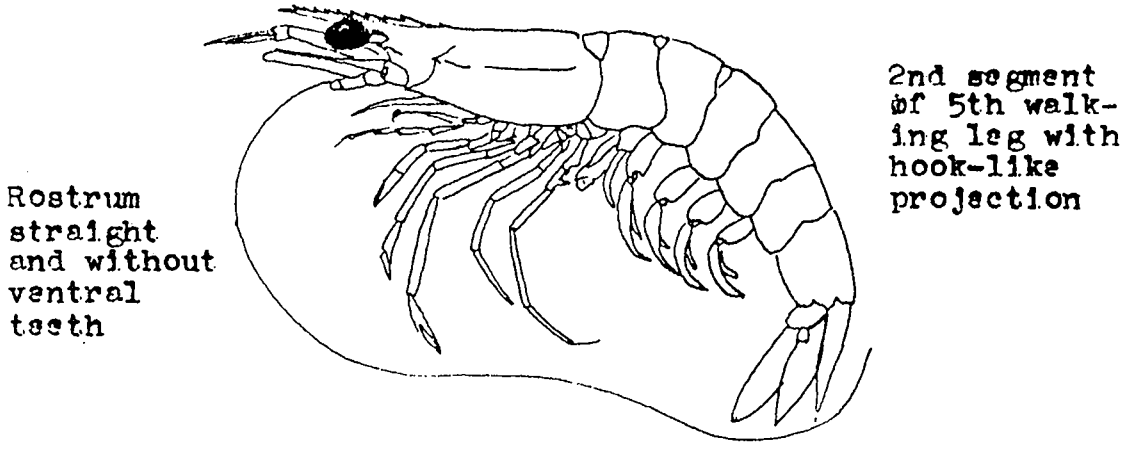
Prefers muddy sand bottom; active during day and night as in the case of *P. indicus*; attains 33-37 g size in extensive culture practice in the salt pan reservoirs; a potential species for culture in Gujarat, Maharashtra, Orissa and West Bengal coasts.

7. RED TAIL PRAWN - *Penaeus penicillatus* Alcock



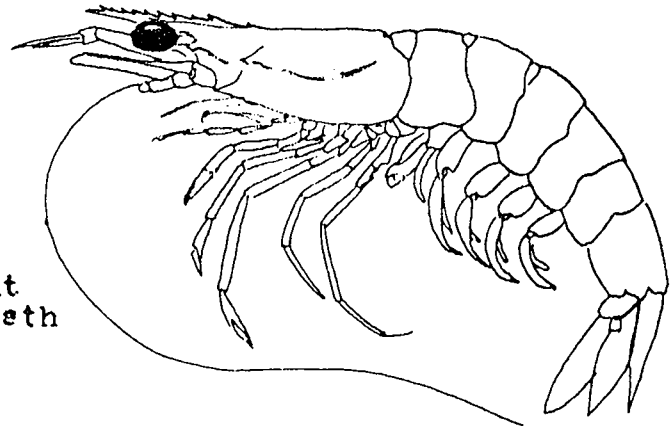
Prefers muddy sand bottom; do not bury in the substratum; active swimmers; attainss a marketable size of 21 g in 4 months time in experimental trails; suitable for culture in the north-western and north-eastern coastal regions of India.

8. **SPECKLED PRAWN - *Metapenaeus monoceros* (Fabricius)**



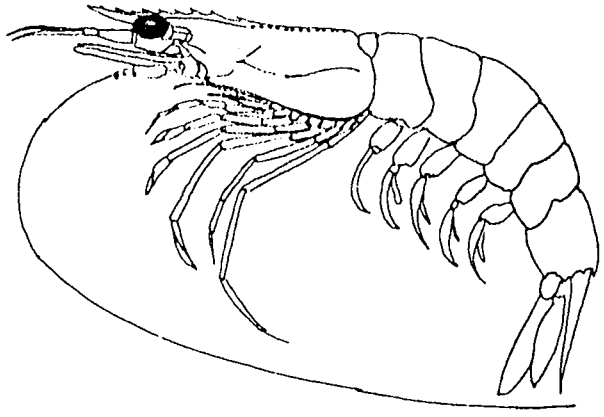
Prefers muddy bottom; buries in the substratum during daytime; more active during night; wide range of tolerance for salinity (1 to 35 ppt); one of the major components in the traditional prawn farming in Kerala; no monoculture at present in India; potential species for monoculture and polyculture with milkfish or mullets on the east coast of India.

9. GREASY BACK PRAWN - *Metapenaeus ensis* (de Haan)



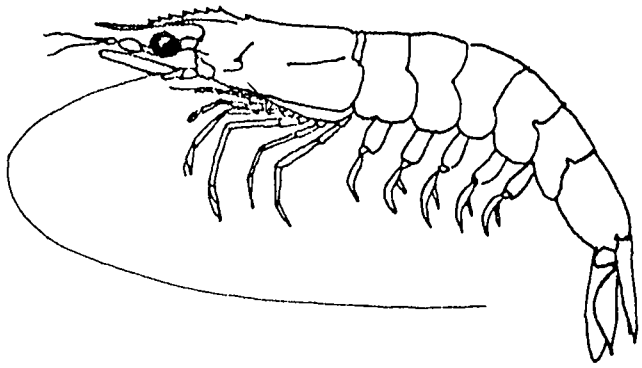
Prefers muddy bottom; buries in the substratum and more active during night; active swimmers; salinity tolerance similar to those for *M. moncoeros*: one of the components in the traditional prawn farming in West Bengal and attains a size of 100-120 mm in the bheries; Suitable for low saline areas, where the species of *Penaeus* cannot be cultured.

10. GINGER PRAWN -*Metapenaeus kutchensis* George, George and Rao



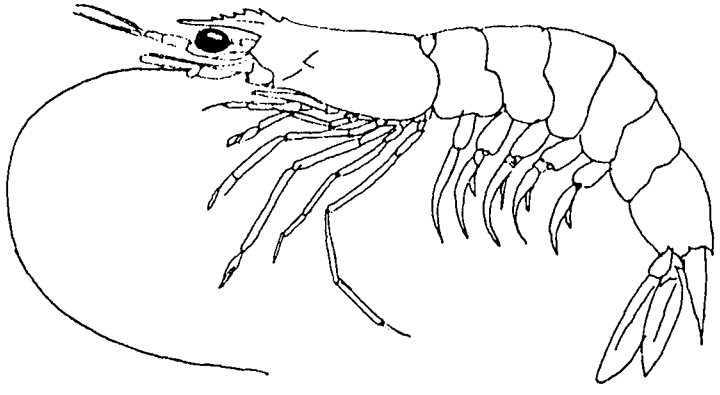
A burrowing species like *M. monoceros* and *M. ensis*; juveniles prefer lower salinites (10-20 ppt); adults and larger juveniles tolerate hypersaline conditions (upto 45 ppt); attains a size of 17 g in salt pan reservoirs in the experimental trails; potential species for extensive culture in the high saline salt pan reservoirs.

11. FLOWER TAIL PRAWN - *Metapenaeus dobsoni* (Miers)



Prefers muddy bottom and lies buried in the mud; highly tolerant to wide ranges in salinity (1-30 ppt) during juvenile phass; one of the major contributors to the traditional prawn farming in Kerala; attains maturity in perennial culture system in Kerala; a potential species for extensive culture in low saline areas.

12. YELLOW PRAWN - *Metapenaeus brevicornis* (H. Milne Edwards)



Prefers muddy sand bottom; active swimmer; juveniles tolerant to wide ranges in salinity (1-30 ppt); one of the components in the traditional prawn farming in West Bengal and attains 80-90 mm in estuarine condition; suitable for extensive culture system in the low saline areas.

CRITERIA FOR SITE SELECTION

BY
M.KATHIRVEL

CRITERIA FOR SITE SELECTION

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The selection of a suitable site is the deciding factor for the success or failure of shrimp farming. Before selecting the site, a detailed analysis of information on topography, ecosystem, meteorological and socioeconomic conditions, species compatiability and economic viability has to be made. In India, about 1.2 million ha of brackishwater area is available for shrimp farming. The background information and the criteria suggested for selection of site are given in the following account to serve as a guide line for rational utilisation of our vast brackishwater areas and increased shrimp production.

1. BACKGROUND INFORMATION

1.1 BRACKISHWATER AREA AVAILABLE AND AREA UNDER CULTIVATION:

Maritime Stae	Estimated Area (ha)	Area under Cultivation (ha)
West Bengal	4,05,000	33,918
Orissa	31,600	7,417
Andhra Pradesh	1,50,000	8,100
Tamil Nadu	56,000	480
Pondicherry	800	Nelgligible
Kerala	65,000	13,145
Karnataka	8,000	2,542
Goa	18,500	525
Maharashtra	80,000	1,869
Gujarat	3,76,000	231
Total	11,90,900	68,232

1.2 GEOGRAPHICAL FEATURE:

LOCALITY	SYSTEM
a) Estuaries and backwaters in Gujarat, Maharashtra, Goa, Karnataka, Kerala, Andhra Pradesh, Orissa and West Bengal	Perennial connection to the sea.
b) Estuarine areas in Gulf of Kutch (Gujarat), Tamil Nadu and Pondicherry.	Seasonal connection to the sea.
c) Low-lying areas of Chilka Lake (Orissa) and Pulicat Lake (Tamil Nadu/Andhra Pradesh).	Fringe areas inundated during the rainy season.
d) Gujarat and Tamil Nadu	Salt pan areas.
e) Southern Coast of Tamil Nadu	Low-lying areas adjacent to the sea shore.

1.3 TIDAL REGIME:

Tidal Amplitude in m.

Maritime State	Highest high tide	Lowest low tide	Period of Lowest tide
Gujarat	11.6	0.30	Oct - Dec Feb - Apr
Maharashtra	5.1	-0.02	Mar - May
Goa	2.5	-0.15	Apr - Jun
Karnataka	2.3	-0.18	Apr - Jun Sep - Dec
Kerala	1.2	0.02	Oct - Nov May - Jun
Tamil Nadu	1.4	-0.18	Feb - Apr Aug - Nov
Andhra Pradesh	2.0	-0.35	Feb - Jun
Orissa	3.1	0.35	Feb - May
West Bengal	6.6	0.22	Jan - Apr
Andamans	2.5	-0.07	Feb - May

1.4 CLIMATIC CONDITIONS:

Region	Period			
	Jan-Mar	Apr-Jun	Jul-Sep	Oct-Dec
		Air Temperature (OC)		
Northwest Coast:	15 - 29	20 - 40	20 - 38	18 - 37
Southwest Coast:	18 - 32	20 - 35	21 - 33	18 - 36
Northeast Coast:	13 - 31	16 - 40	21 - 40	17 - 39
Southeast Coast:	18 - 31	18 - 40	21 - 40	17 - 39
		Rain Fall (cm)		
West Coast:	1 - 3	3 -100	20 -150	5 - 30
East Coast:	1 - 3	0 - 20	0 - 50	10 - 30
		Direction of Wind		
West Coast:	NW TO SE	NW TO SE	SW TO NE	No data
East Coast:	NE to SW	SW TO NE	SW TO NE	No data

1.5 SPECIES AVAILABLE FOR CULTURE

Maritime States	Species
Gujarat	Penaeus merguiensis , P. penicillatus , Metapenaeus brevicornis and M. kutchensi
Maharashtra	P.penicillatus, P. merguiensis, P.japonicus M.monoceros, M. brevicornis and M.kutchensis.
Goa	P. merguiensis, P.indicus, M. monoceros and M. dobsoni.
Karnataka	P. indicus, P. merguiensis, P. monodon, M. dobsoni and M. monoceros.
Kerala	P. indicus, P. monodon, P. semisulcatus, M. dobsoni and M. monoceros.
Tamil Nadu	P. indicus, P. semisulcatus, P. monodon, P. japonicus, P. latisulcatus, M. monoceros and M. dobsoni.
Andhra Pradesh	P. monodon, P.indiucs, M.brevicornis and M. monoceros.
Orissa	P. merguiensis, P. monodon, P. indicus, M. monoceros and M. dobsoni.
West Bengal	P. monodon, P. penicillatus, P. semisulcatus M. brevicornis M. kutchensis and M. monocerous

1.6 CULTURE SYSTEM:

Extensive:- Traditional farming in Kerala, Karnataka and West Bengal; small-scale farming in monoculture with low stocking rates; conventional feeds; water exchange minimal.

Semi-intensive:- Selective and high density stocking; pump-fed system; greater inputs in the form of quality seeds, feeds and water management.

1.7 SPECIES CULTIVATED

Species	System
P. monodon	semi-intensive and extensive
P. indicus	- do -
P. merguiensis	extensive
P. penicillatus	- do -
P. dobsoni	- do -
M. monoceros	- do -

2. CRITERIA TO BE FOLLOWED

2.1 TIDAL REGIME :

While selecting the site in tide-effected areas, the following points may be considered:

a) In the greater tidal amplitude prevailing states like Gujarat, Maharashtra and West Bengal, the site should be selected in the upper reaches of the estuaries, creeks etc., where the elevation of land would reduce the effect of tidal amplitude. Moreover, the site near the mouth of estuary needs massive embankment, which would be more expensive.

b) A year round data on the seasonal variations in tidal amplitude at the proposed site should be gathered to determine the high as well as low water season, water exchange, water drainages, shape of the farm and the type of construction.

2.2 ELEVATION OF THE SITE:

It is one of the points to be considered in the light of the following points.

a) The elevation of the site should be determined in relation to the tidal amplitude at the site, for which, a contour survey of the area should be carried out.

b) The level of the bottom of the pond should be a little above the mean low tide level, so as to drain the water at any low tide and to fill the pond at every high tide.

c) The complete drainage of the pond at low tide would facilitate the sun-drying of the pond bottom, which would result in increasing the productivity of the soil.

d) The flood level in the area shoud be considered while fixing the height of the embankment of the farm.

e) The area with excess mounds or elevations and depressions should be avoided, as a lot of removal and filling of earth would become necessary, resulting in the increase of expenditure.

f) In the areas where the bottom of the site is equal to that of supply/drainage canal, the problem of filling and draining of the pond may arise. Such problems may be partly solved by the use of pumps, which would involve additional expenditure.

2.3 WATER RESOURCE:

Surface and ground water from estuaries, backwaters, coastal lakes and the inshore sea with a salinity range of 10 to 40 ppt can be utilised.

2.4 WATER QUALITY PARAMETERS:

Parameter	Range
Temperature (°C)	26 - 33
Salinity (ppt)	10 - 40
Transparency (cm)	25 - 60
Dissolved Oxygen (ppm)	3 - 12
pH	7.5 - 8.7
Total ammonia (ppm)	Less than 1.0
Free ammonia (ppm)	Less than 0.25
Nitrite (ppm)	Less than 0.25
Hydrogen sulphide (ppm)	Less than 0.25

Note: ppt - parts per thousand
ppm - parts per million

2.5 SOIL CHARACTERISTICS

The types and textures of the soil of the area should be analysed for physical composition acidity, amount of organic load and level of fertility. Clay soil is preferred as it is rich in organic matter and encourages the growth of benthic algae and the associated micro and macro organisms, which forms the main food of prawns. The soil used for construction of the bunds should have retension properties to avoid the loss of water through the seepage.

2.6 FLORA AND FAUNA:

The aquatic flora and fauna of the region should be investigated. The area should be free from dense plantation. Seed availability of the candidate species should be assessed using various types of sampling devices. This information would help solve the problem of stocking, in case, the seeds could not be procured from hatcheries in time.

2.7 POLLUTION:

The side selected should be away from the source of industrial, agricultural and domestic sewerage effluents. Otherwise, the pollution would affect not only the growth and survial of prawns but also make the farm products unacceptable to consumers.

2.8 ACCESSIBILITY:

The site should have free access for transportation of construction and operational materials and also it should be nearer to marketing and storage facilities.

2.9 LEGAL REGUALTIONS:

The prevailing policies regarding the utilisation of brackishwater areas for prawn farming should be gathered from the revenue and forest departments of state governments as well as from the department of environment of central governement.

2.10 SOCIO-ECONOMIC CONDITIONS:

Informations regarding the availability of farm labour, local wages paid for semi-skilled and skilled labour and the measures to be undertaken in relation to avoid poaching by native people should be gathered.

POND DESIGN AND CONSTRUCTION

BY
DR.P.RAVICHANDRAN

LAY-OUT, DESIGN AND CONSTRUCTION OF A SEMI-INTENSIVE BRACKISHWATER PRAWN FARM

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1. INTRODUCTION :

Brackishwater prawn culture systems are classified according to the level of management practices into extensive, semi-intensive, intensive and super-intensive. Semi-intensive culture system involves medium level water management with 5-10% water exchange and aeration. Proper designing of the farm, keeping in view the requirements of the species as well as the topography of the site will help in the smooth running of the culture operations.

2. MAJOR FARM COMPONENTS OF A SEMI-INTENSIVE FARM :

Design of a model semi-intensive prawn farm is given in Fig. 1 a & b. An aquaculture farm is considered properly planned if all the water control structures, canals and different pond compartments are properly proportioned and positioned within. The major components of the farm is discussed below.

2.1 Leading canal :

The farm may generally be located a short distance away from the source such as estuarine creek or backwaters. In such cases a leading canal is dug so as to

connect the water source with the main sluice of the farm or the suction side of the pump. The width and depth of such a canal depends on the topography, tidal fluctuation, quantity of water required and the velocity of wind and wave action.

2.2 Peripheral dyke :

The peripheral dyke of a farm is the most important structure since it protects the farm against flood, tidal thrust and cyclone. It also serves as a road around the farm. The dyke material ie., the soil should be tested for load bearing capability and compactability. In cases where the quality of the soil is not suitable for making dykes, other materials such as concrete or clay must be used as core materials to be placed at the pond bottom (Fig. 2).

Wherever the outer side of the peripheral dyke faces the water front, it should contain a berm and stone pitching or retaining wall should be constructed (Fig. 3).

The height of the peripheral dyke may range from 1.5 to 3 m depending upon the size and location of the farm. The height of the dyke is decided upon after considering the flood mark, highest high tide level, wind velocity, water depth required in the ponds and the soil type. A free board of 0.6 to 0.7 m over and above the highest high tide level should be provided. The following formula could be used to calculate the height of the dyke.

$$\text{Height of the dyke} = \frac{(\text{HHTL} - \text{Ground level over MSL}) + \text{free board}}{1 - \% \text{ Shrinkage}}$$

The slope of the main dyke is maintained at an average ratio of 2:1 or 3:1 (Fig. 4). External slopes facing the water front are made at a ratio of 2.5:1 or 3:1. Dykes with steep slopes are always subjected to erosion and require higher maintenance cost. The slope of the dyke essentially depends on the soil quality and the height of the dyke.

The top width of the peripheral dyke should be between 1.5 to 4 m so as to facilitate vehicular movement around the farm.

2.3 Water intake system :

Supply of good quality brackishwater in required quantities is the most fundamental requirement for running a successful aquaculture venture. The intake e system should be designed according to the topography of the land and should be cost-effective. The major water intake systems used in brackish water aquaculture are a) through tidal influence and b) through pumps.

2.3.1 Tide-fed system :

This system takes in water from estuarine brackishwater creek during spring tides through gravitation. It was for areas where the tidal amplitude at the farm is at least above 1 m. The advantage of this system is that it is very cheap. The disadvantages of this system are :

a) Water exchange possible only during spring tides - emergency exchanges cannot be made.

b) High silt load of the water leads to siltation of the ponds increasing the recurring expenditure.

c) Entry of unwanted predators and pests into the farm could not be avoided.

Because of these disadvantages, the tide-fed system is not advised for semi-intensive culture practice.

2.3.2 Pump-fed system :

In this system, water is taken into the farm through pumping from the estuary, tidal creek, backwater or even from sea. This system helps in locating the form in an elevated place above the mean sea level, so that draining of the ponds could be done gravitationally.

The advantage of this system are :

a) Water depth can be maintained at desired level all through the year.
b) Water change can be done any time as per requirement.
c) Entry of predators and pests could be prevented by placing suitable screens at various points of the supply system.
d) Continuous flow-through system could be used.
e) The system is very easy to operate.

Selection of a suitable pump of required capacity is essential to make this system functional. The following aspects should be taken into consideration before choosing the pump.

a) Maximum daily water requirement of the farm.

b) Distance from water source.

c) The depth from which water is to be lifted.

d) The height at which the water should be delivered.

e) Distribution, seepage and evaporation losses.

f) Availability of electricity at site.

Daily water requirement of a farm may vary depending on various factors and hence the total maximum water requirement should be fulfilled by using 3-4 pumps instead of a single larger one. Stand by pumps are also required to avoid the problems of breakdown of pumps.

Generally, the pumping requirements of a brackishwater aquaculture farm which has sea, estuary or backwater as its source, vertical mixed flow pumps or vertical axial flow pumps are more suitable. Vertical submersible or vertical turbine pump could be used for drawing ground water. Vertical pump is much preferred because it does not require prior priming and hence the switch can be located at a convenient place away from the pump.

2.4 Diffuser tank :

Diffuser tank is a concrete structure located between the delivery head of the pump and the supply canal (Fig. 5). This helps in preventing the erosion of supply channel due to the force of the water delivery. The size of the diffuser tank depends on the pump capacity and size of the supply channel. Appropriate sized velon screens are used in the

diffuser tank to screen the entry of unwanted pests and predators into the farm.

2.5 Supply canal :

The supply canal receives water from the diffuser tank and supplies it to the various culture ponds. The design of the supply canal mainly depends on the daily water requirement of the farm. The bed of the supply canal is just above the actual water level in the pond. For a prawn culture pond the bed is raised to about 1 to 1.5 m from the original ground level. The width and height of the canal depends essentially on the quantum of water required and water intake duration. Depending on the soil quality earthern or lined or concrete supply canals are designed (Fig. 6).

Dimensions of supply canals are calculated by using the following equation :

$$Q = AV$$

Where Q- volume of water exchange;
A- cross sectional area of the canal and
V- velocity of water flow.

2.6 Water inlet for culture pond :

In semi-intensive, pump-fed farms where the supply canal bed is elevated, PVC pipes of 6" diameter or more are used as water inlet for the culture ponds. The PVC pipes connect the supply canal bed with the culture pond with valve and filter arrangement (Fig.7).

In the tide fed farm where the supply canal bed is not elevated, traditional wooden or concrete sluice system with net filters and shutters are used for both inlet and

outlet structures. The width of such a sluice depends on the size of the culture pond and the quantum of water available in the supply canal (Fig. 8 & 9).

2.7 Culture pond :

Rectangular or square ponds are appropriate for shrimp culture. The longest axis of a pond should be parallel top the prevailing wind direction. This facilitates water movement generated by wind action thereby increasing dissolved oxygen in the water and minimizing water temperature fluctuation of warmer months.

A 0.5 ha pond with a pond length of 100m and 50 m width with inlet and outlet located diagonally opposite has been found ideal for a semi-intensive farm for ease of operation, management, water circulation, aeration etc.,

The rearing pond must have a minimum depth of 1 m. The pond bottom should have a slope of 1:2000 towards the outlet with an overall drop of 20 to 30 cm for a 1 ha pond. Wherever nursery rearing is practiced, ponds of 500 to 1000 sq. m should be used for the purpose.

2.8 Pond outlet :

The culture pond outlet receives water from the culture pond and discharges it into the drainage canal. The outlet are generally made up of reinforced concrete or wooden sluices with wooden shutters.

The outlet should be located diagonally opposite to the inlet to facilitate proper water exchange. The shutters are made up of wooden planks which can be used to drain

either the surface or the bottom water as per the requirements. The width of the sluice may vary from 0.3 m to 1.0 m depending upon the size of the pond and the percentage of water exchange.

2.9 Drainage canal and dyke :

Drainage canal bed should be at least 30 cm below the pond bed level with adequate slope towards the main outlet. The drainage canal might be located between two drainage canal dykes or between the drainage canal dyke and peripheral dyke depending on the design of the farm. The bottom width of the drainage canal should be 1 m or more (Fig. 10).

3. OTHER REQUIREMENTS OF A SEMI-INTENSIVE FARM :

3.1 Electrical distribution system :

Power requirements of the farm should be worked out in detail before installing the transformer. The control panel, switch gear and cabling system should be housed in a permanent building close to water pumping system to facilitate ease of operation.

Diesel generating sets of required capacity should also be erected with required change over system. A qualified electrician should be used for installation of the electrical net work.

3.2 Aerators :

Aerators are one of the most essential components of the semi-intensive culture system. Aerators are mechanical devices used to increase the rate at which oxygen enters water. Basically this can be achieved by two ways a) by

splashing water into air and b) releasing air bubbles into water. The first method is carried out by using paddle wheel aerators, while the second method is done by propeller-aspirator pumps using an air-blower or air compressor.

Paddle wheel aerators, which are generally used, consist of a paddle-wheel attached to the shaft of a motor, which when turns splashes water into air. The whole unit is situated over a float which is kept in position by iron rods passing through iron loops. 1 hp paddle wheel aerators are used @ 4 -6 nos/ha in semi-intensive farms.

3.3 Transportation and communication :

Proper approach road to the farm, conveyances for the transportation of men and materials, communication systems like telephones/ telex should all be developed for a proper functioning of the farm.

3.4 Farm shed :

A farm shed to accommodate farm level workers, feed, equipment vehicle should be constructed near the approach road. Live-in quarters for essential technicians is a must for a successful running of any farm.

4. CONSTRUCTION :

A well experienced construction team under the supervision of a qualified engineer is a prerequisite for completing a project of an aquaculture farm within the proposed time and estimated cost.

Approach road is the first item to be taken up for construction. Then feeder canal, feeder canal dyke, drainage canal and drainage canal dyke should be constructed simultaneously using earth moving machineries like bulldozers, scrapers, hydraulic shovel etc.

Construction of sluices should be done carefully since improper functioning of sluices can lead to many problem in farm management. The construction work should be carried out during winter or spring months avoiding the peak summer and monsoon months.

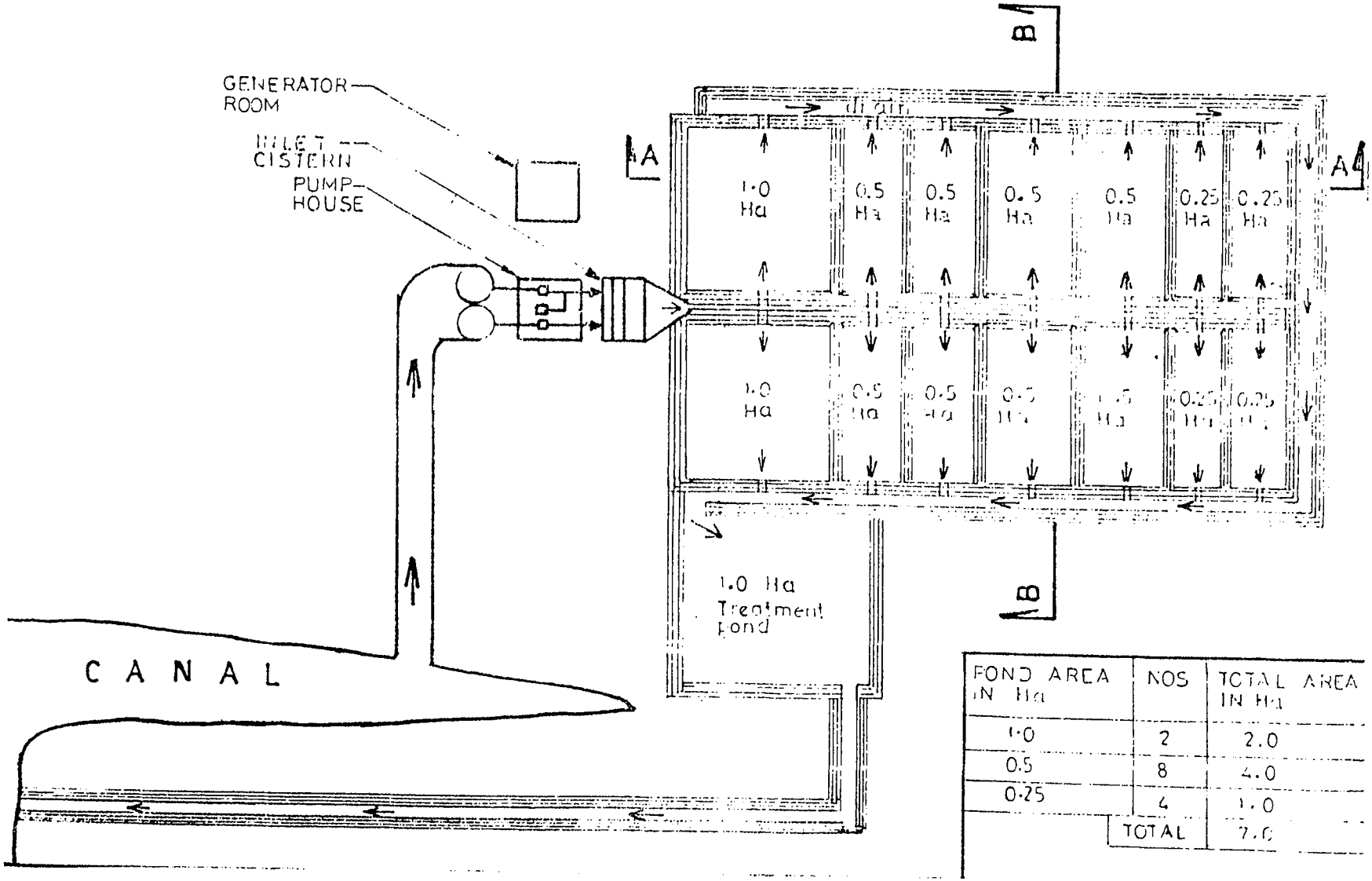


Fig. 1. Model lay-out of a semi-intensive Brackishwater Prawn Farm

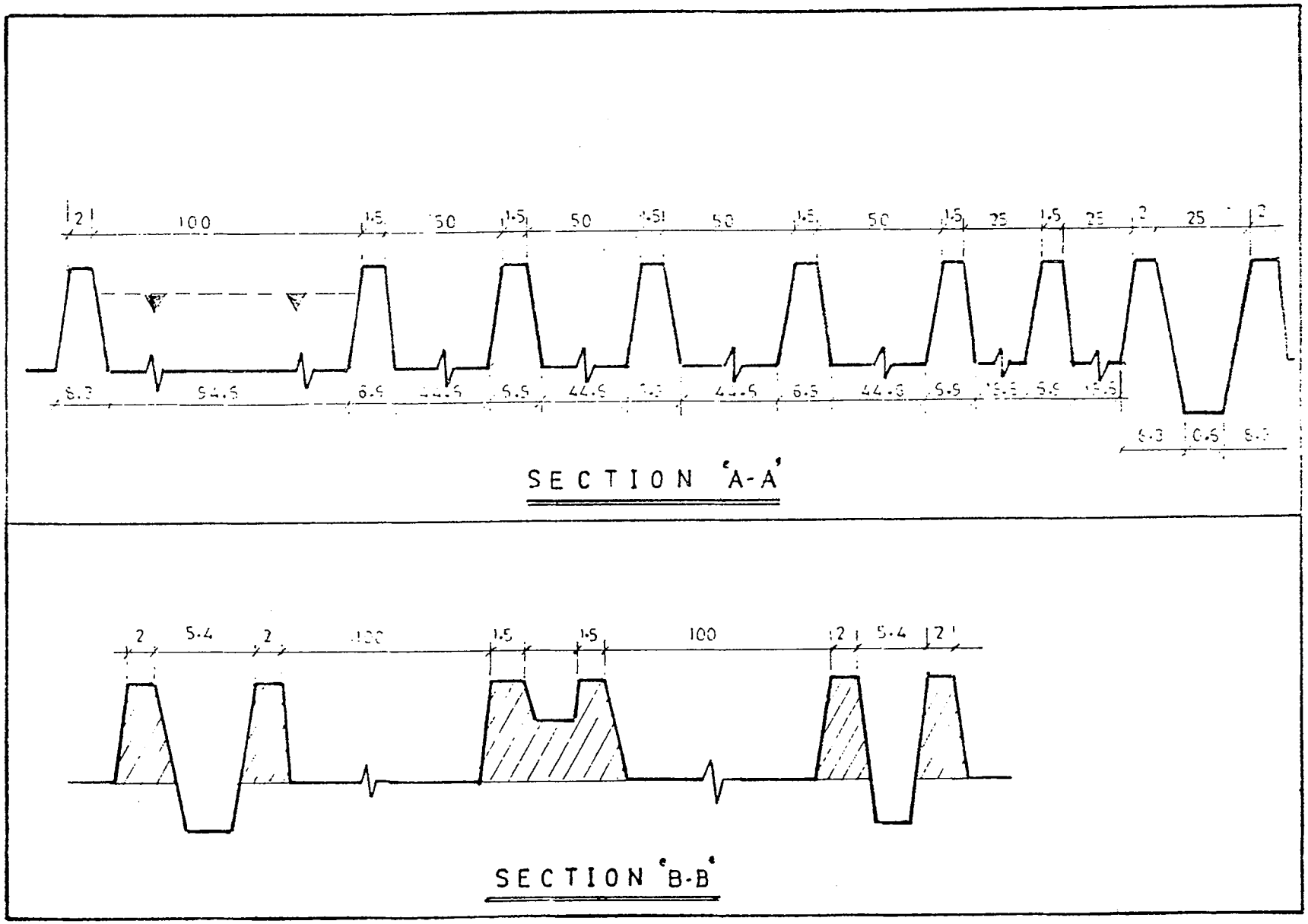
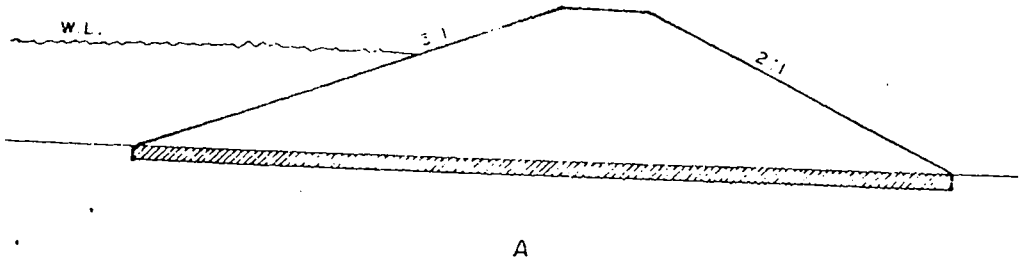
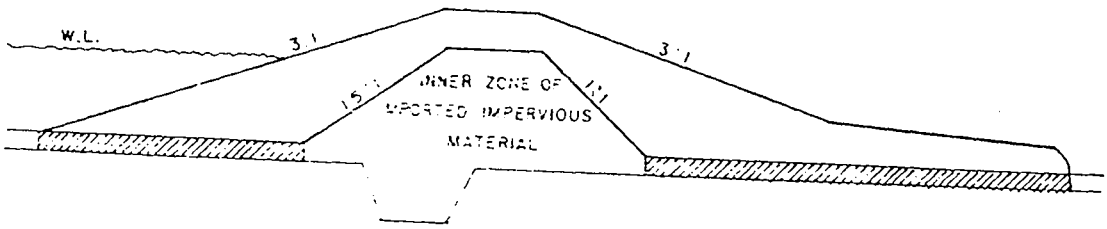


Fig. 1a. Cross-section at AA and BB



A



B

Fig. 2. Cross Section of Peripheral dyke

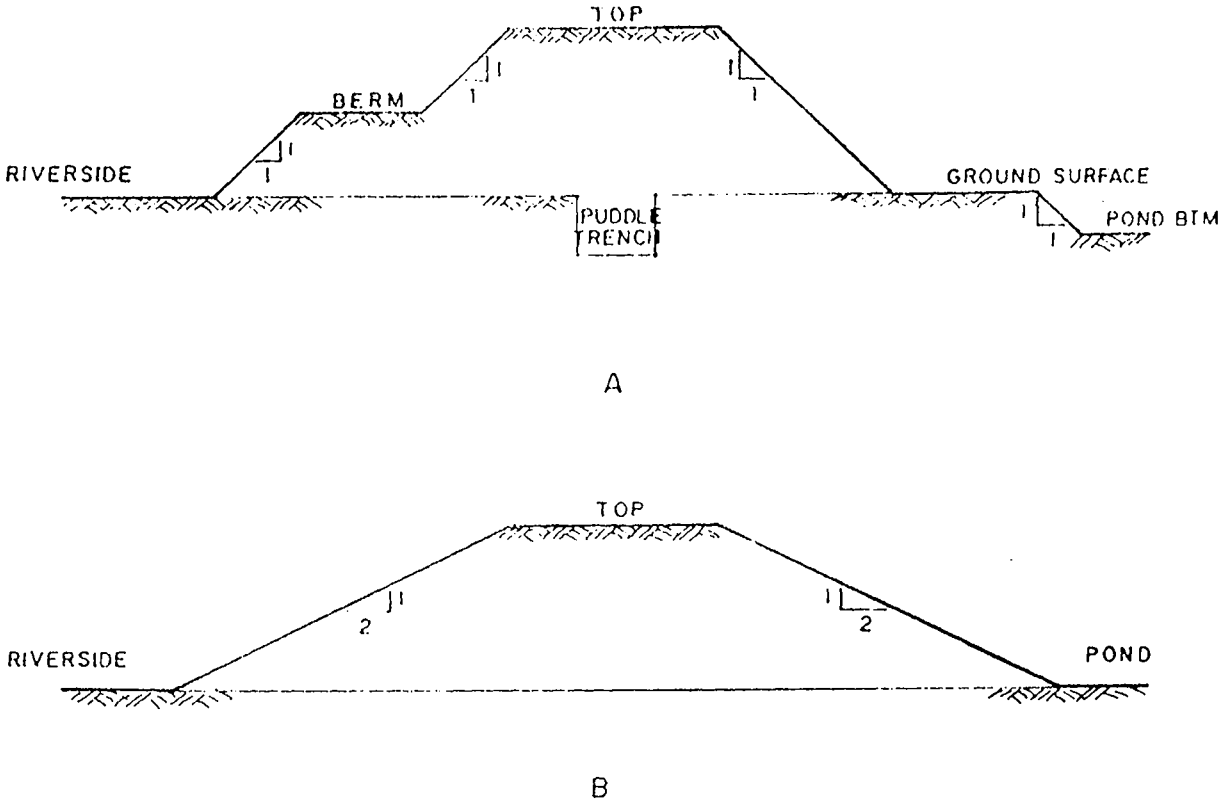


Fig. 3. Different designs of peripheral dyke

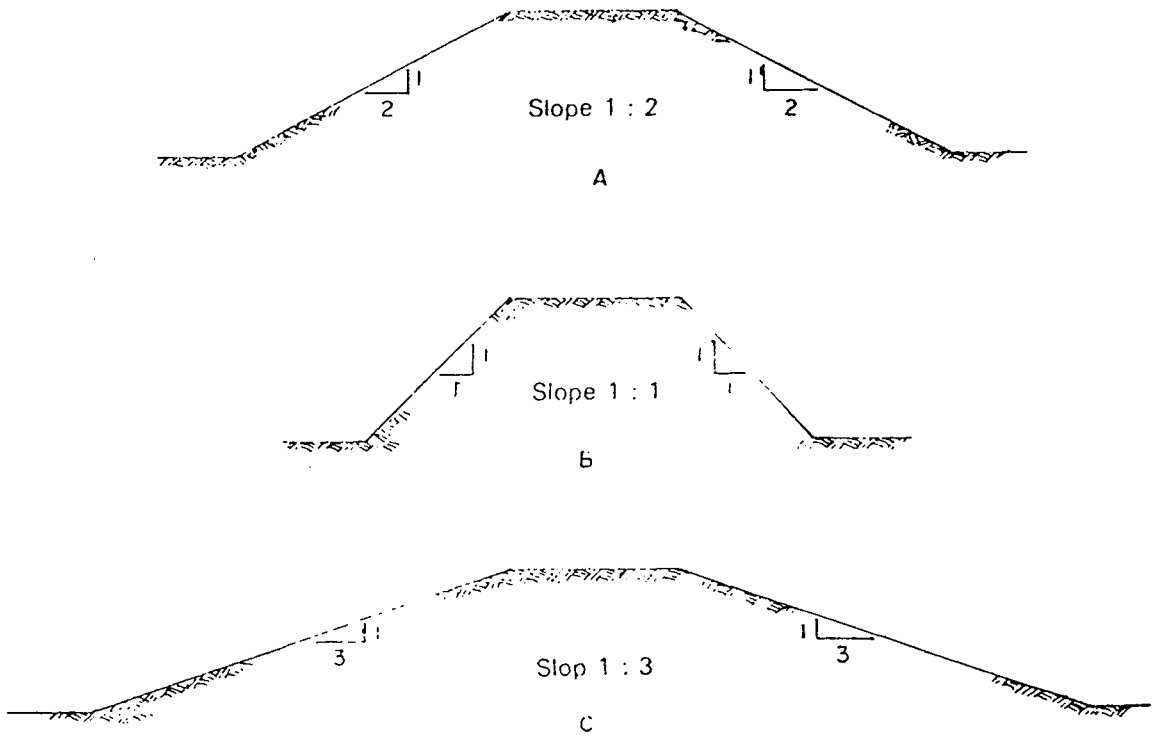


Fig. 4. Types of slopes in peripheral dyke

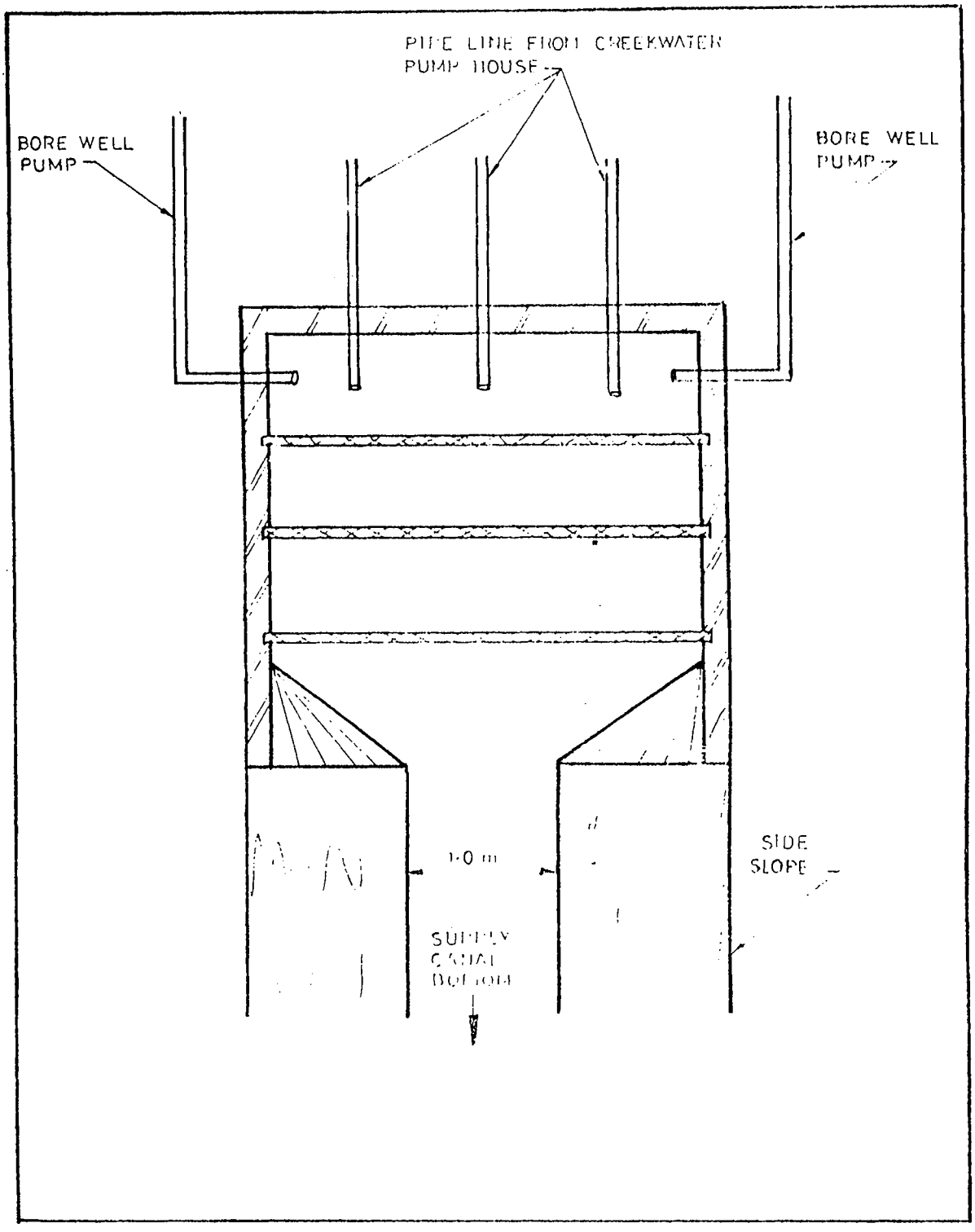


Fig. 5. Diffuser tank

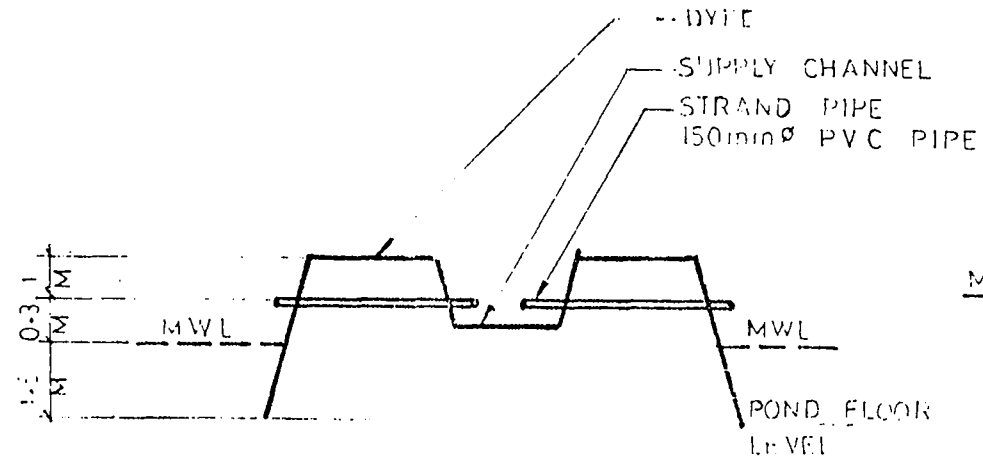
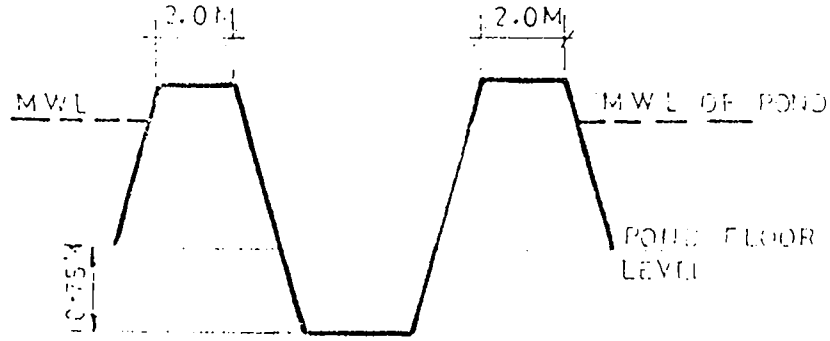
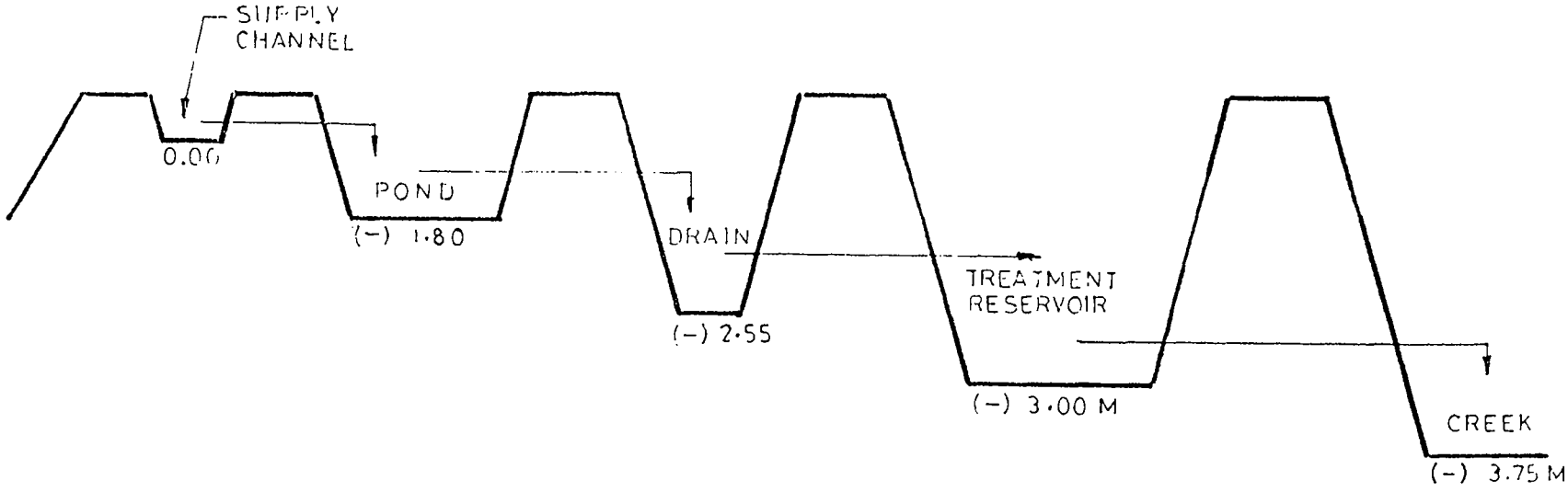


FIG. 6. DETAILS OF SUPPLY CHANNEL

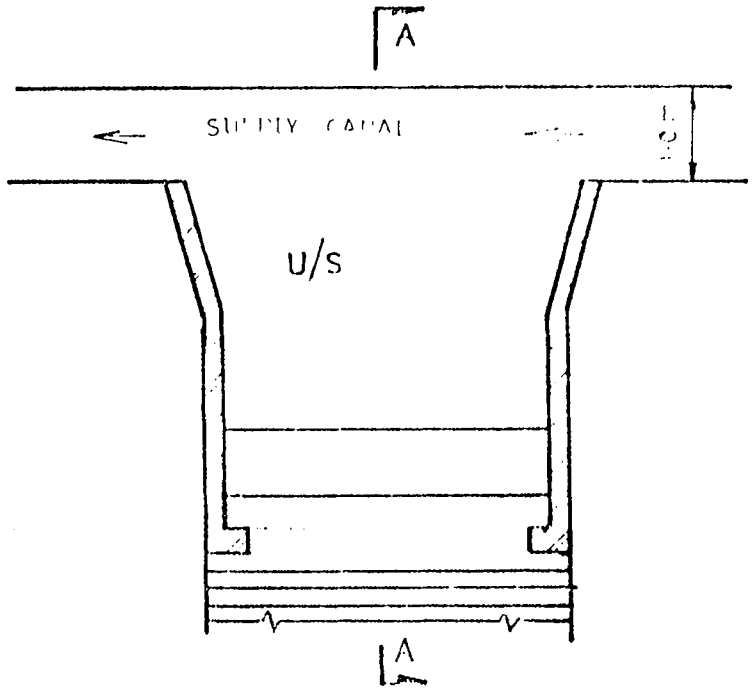


DETAILS OF DRAIN

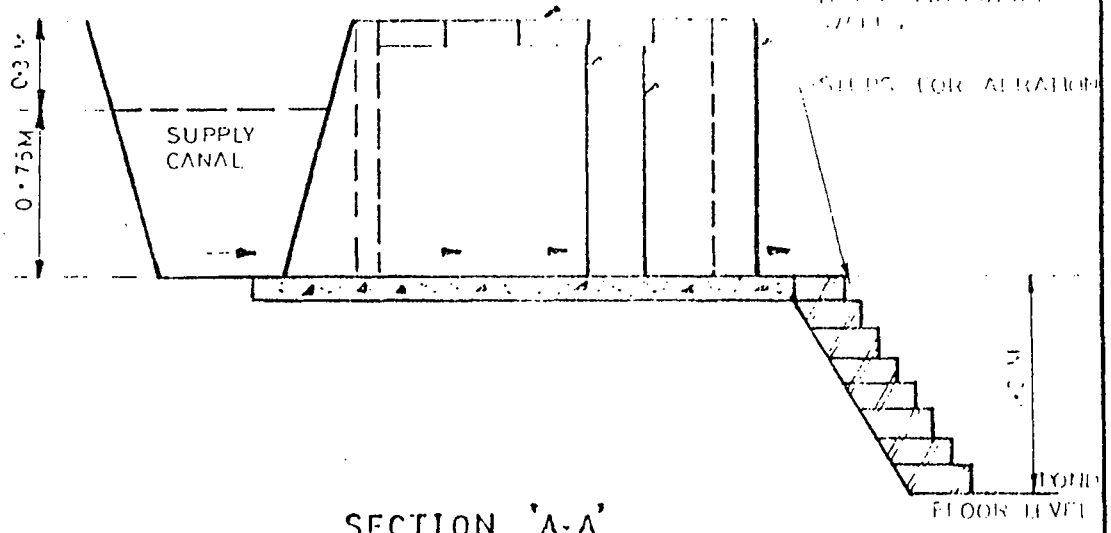


FLOW DIAGRAM

FIG. 7. DETAILS OF SUPPLY INLET STRUCTURE



PLAN



SECTION 'A-A'

(DETAILS OF INLET STRUCTURE)

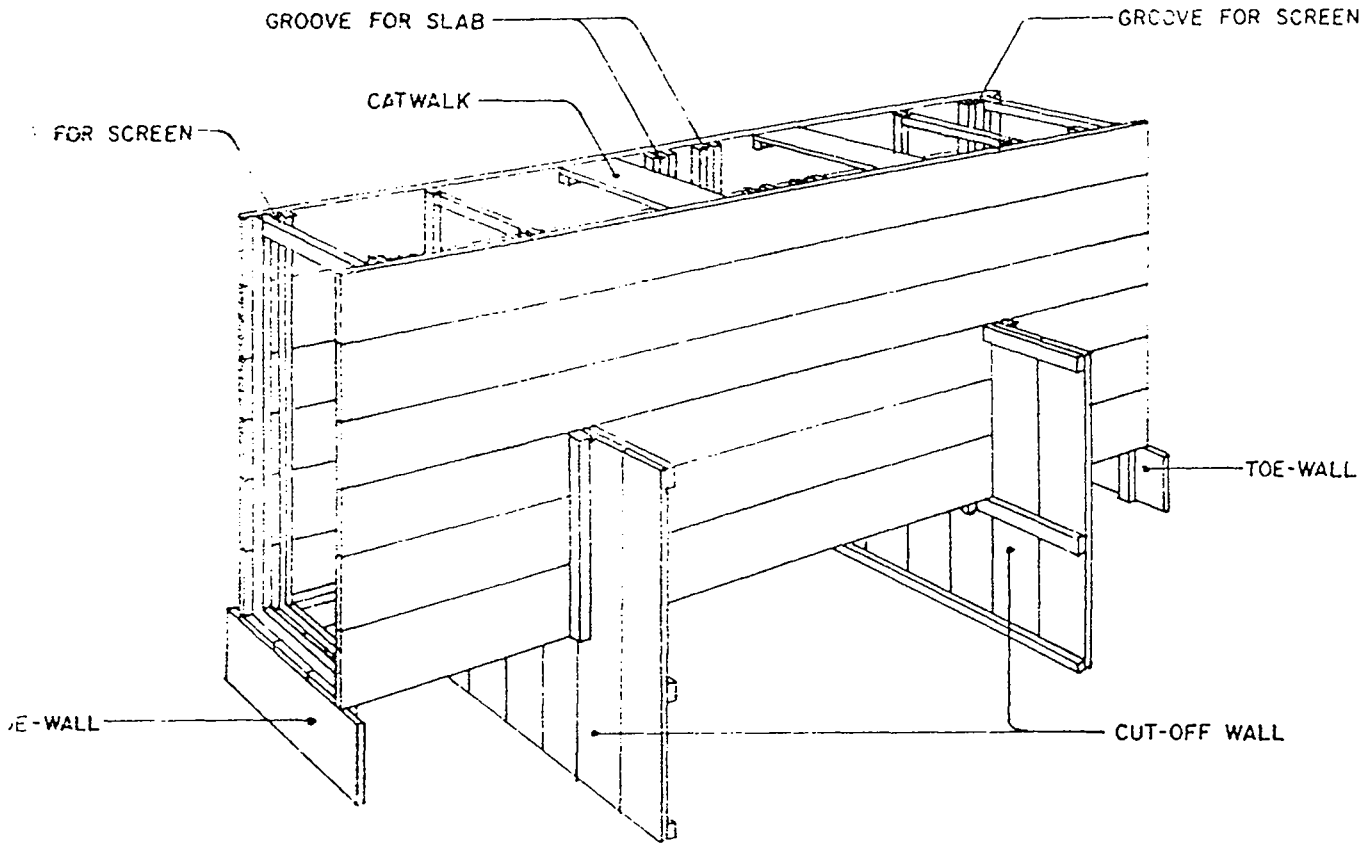


Fig. 8. Wooden sluice

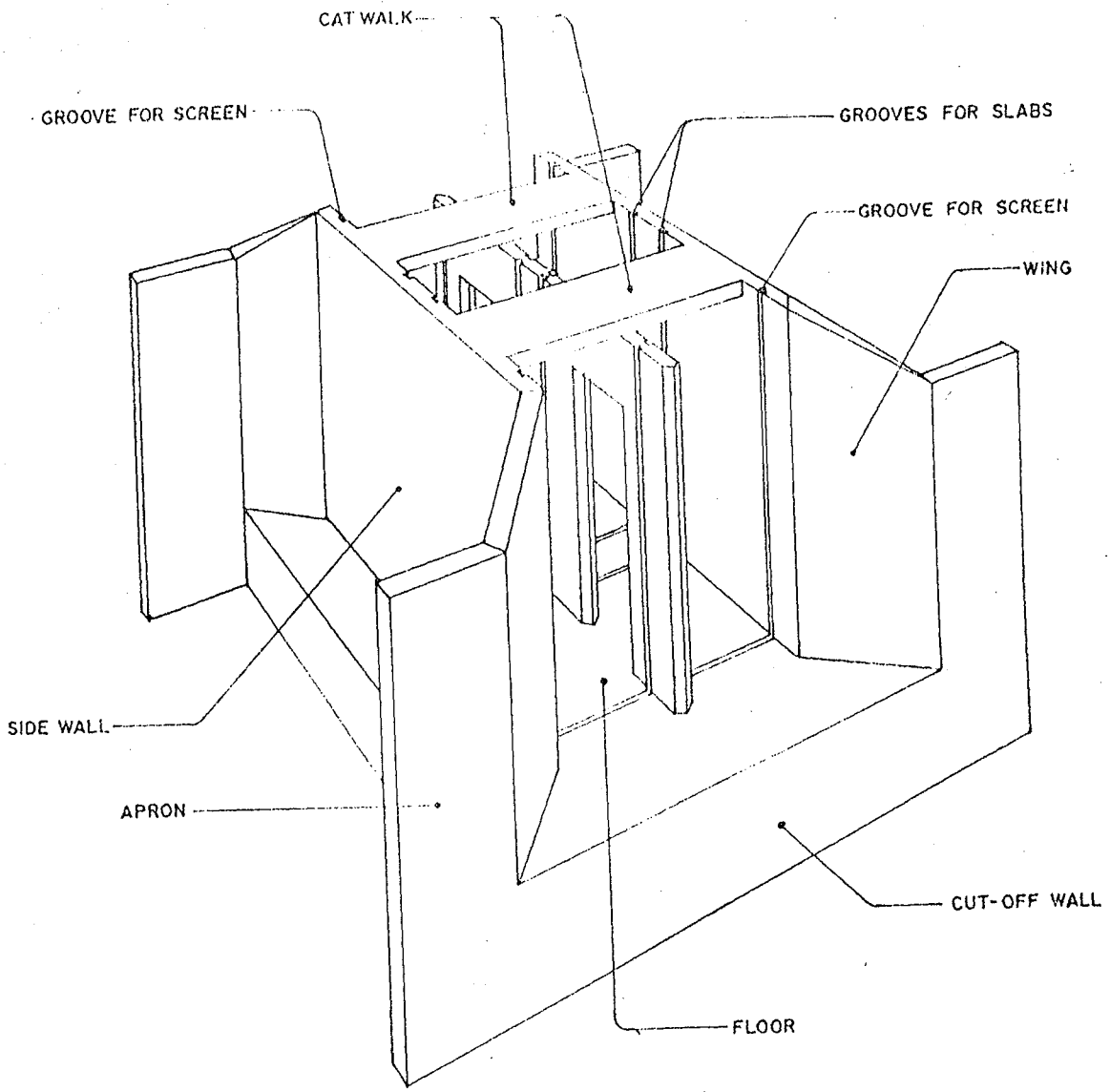
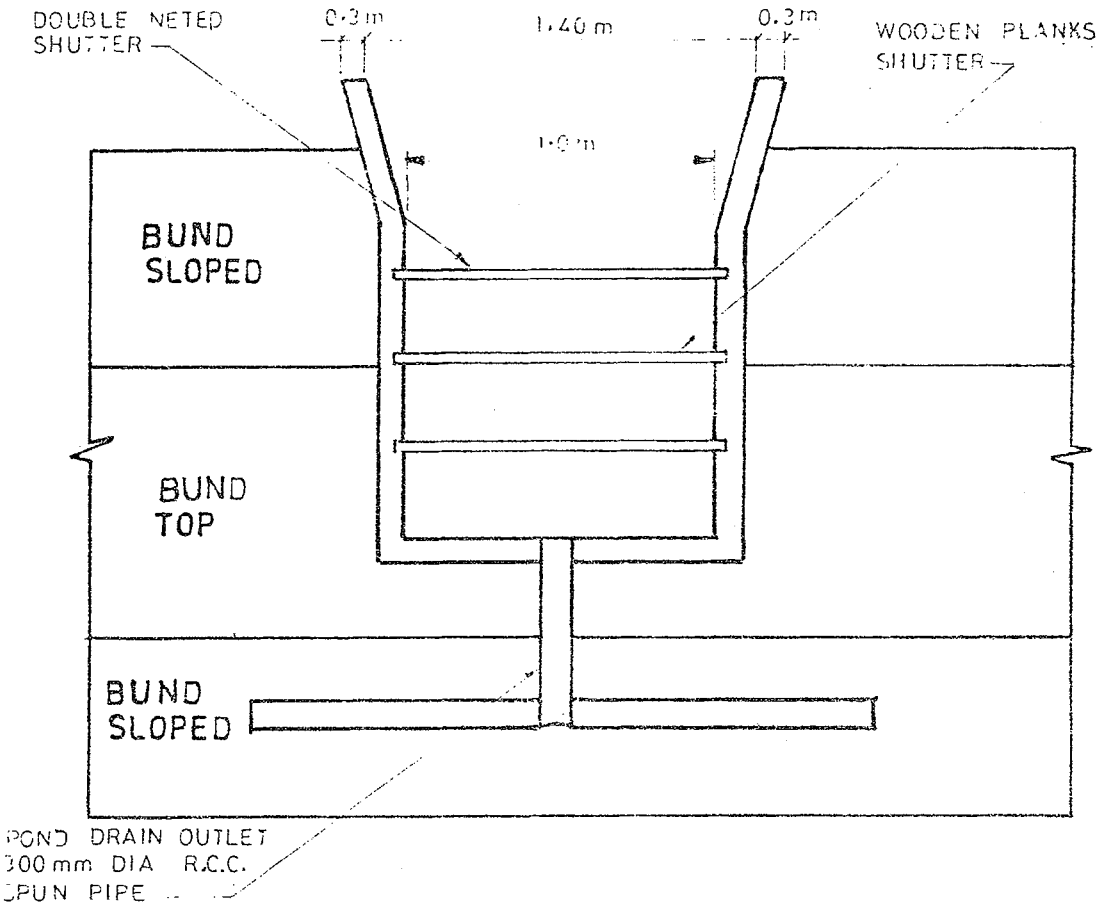
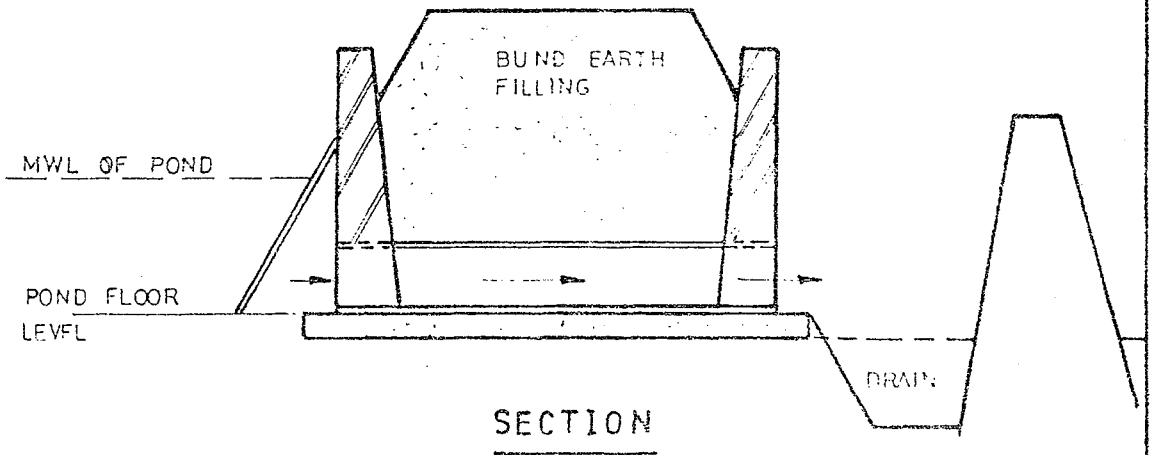


Fig. 9. Concrete sluice

FIG.10. DETAIL OF DRAIN STRUCTURE



PLAN



SECTION

POND PREPARATION

BY
DR.B.P.GUPTA

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(i) Draining

(ii) Drying

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(v) Liming

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(viii) Application of Tea seed cake

(ix) Application of BN10

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Tables 1-7

POND PREPARATION

1. INTRODUCTION

Shrimp farming in brackishwater ponds is an important and rapidly growing industry in many tropical countries. It has been developed a centuary ago in South East Asia, where the farming operations are still traditional. Such operational practice is characterized by low yield and also relatively low technical inputs. Due to high market demand of shrimp, the yield in pond can be increased by applying modern techniques, such as intensification of culture operation by regularization of pond size, scientific pond preparation, increased stocking density, better water management, provision of aeration and supplementary feeding etc.

In Asian countries, shrimp culture operation can be grouped into three major categories and they are:

Extensive culture: The traditional ponds are generally irregular in shape and are of variable sizes (3-20 ha). Usually, each pond has an inner peripheral ditch of 10-20 meters wide and 30-60 centimeters deep. Usually low stocking density (PL20 5000 - 10,000nos/ha) is carried out. No supplementary feed is given and the reared stocks has to depend entirely on natural food. Water management of pond is through tidal exchange. Production is generally less than 1 ton/ha/year.

Semi-intensive culture: Ponds are generally rectangular in shape with sizes ranging from 0.5 to 1.0 ha. Each pond has separate

inlet and outlet gates to facilitate water exchange. A diagonal ditch of 5-10 meters wide and 30-50 centimeters deep extending from inlet to outlet is also constructed to facilitate drainage of water.The water depth is maintained between 0.8 and 1.5 metres. Stocking density for this culture varies between 75,000 to 3,00,000 PL 20/ha/Crop. The stock depends on both natural food and supplementary feed. A daily water exchange of 20-30% is practiced. Production generally varies from 3 to 6 tons/ha/Crop depending upon the management practices.

This type of culture is practiced either in specially prepared ponds or in concrete tanks, where 20 - 30 % exchange of water is carried out daily.

Intensive-culture: The stock depends entirely on high nutritious artificial feed. Stocking density of PL20 are higher than semi-intensive culture. Production is generally above 10 ton/ha/crop.

In pond culture system, the bottom soil plays a major role in yield. High organic matter content in neutral soil often promotes higher primary productivitiy resulting in greater prawn yield. Natural food organisms of productive water bodies are one of the important food sources for the reared prawns. They are rich in protein, vitamins, minerals and other essential growth elements, where as simple supplementary feed can not compete. Sometimes, prawn yield in pond is affected by the presence of predators, poor water quality and improper pond management. Hence pond preparation is a first step towards ensuring a better production.

2. POND PREPARATION

The techniques of pond preparation can be classified into three groups:

A. For a newly constructed pond

B. For ponds constructed in areas of acid sulfate soils

C. For existing culture ponds after harvest

A. Preparation of newly constructed pond

(i) Soil sampling

Pond constructed on virgin soil requires proper investigation regarding the quality of soil. For this purpose, soil samples are collected from pond bottom and dikes using soil augur or an improvised sampler made of bamboo or PVC pipe. About 12 samples in an 'S' shaped pattern should be taken in one hectare pond. Only the top soil (0-15 cm) should be sampled. Stones, rubbish and coarse particles should be removed before taking the soil samples. The samples are mixed thoroughly and a representative portion is taken and labelled. This representative portion is then air-dried by spreading thinly on plastic sheet and protected from direct sunlight, wind and dust. The dried soil is then packed in labelled plastic bag and send for analysis in the soil laboratory.

(ii) Characteristics of soil

Soil samples collected from pond bottom should be analysed for texture, pH, Organic Carbon, $CaCO_3$, available Nitrogen, available Phosphorus and electrical conductivity. The values of different physico-chemical parameters of soil suitable for

brackishwater aquaculture are given in Table 1. Generally, heavier textured soils are prefered which can retain water for longer duration. With this view, sandy clay, sandy clay loam and clay loam are the examples of such soil. Stronger dikes are usually built from these type of soils which easily hardened and compacted. Clay loam or sandy clay loam or silty clay loam at pond bottom promotes growth of natural food organisms. Diking material made of decomposed plant matter and alluvial sediments should be avoided. Now-a-days, the use of coastal sandy soil such as loamy sand is carried out for the formation of earthern bunds and loss of water through seepage is compensated by using heavy duty pumps.

(iii) Characteristics of water

The samples of water should be collected from the source from where water is to be drawn to the ponds and should be analysed for the parameters as shown in Table 2. Besides, the water samples should be analysed for Heavy metals and pesticides. The safe levels of each parameters are given in the same table.

(iv) Liming of ponds

To keep the ponds environment hygienic for sustainable prawn production, liming of pond bottom is one of the most important items in pond preparation. The advantages of liming of the ponds are given below:

1. Kills most micro-organisms especially parasites due to its caustic reaction.
2. Raises pH of acidic water to neutral or slightly alkaline.

3. Increases the alkaline reserve in water and mud which prevents changes in pH.

4. Neutralizes the harmful action of certain substances like sulfides and acids.

5. Promotes biological productivity since it enhances the breakdown of organic substances by bacteria, creating a more favourable oxygen and carbon reserves.

6. Precipitates suspended or soluble organic materials, decreases biological oxygen demand (BOD), increases light penetration, enhances nitrification due to the requirement of calcium by nitrifying organisms.

(a) **Liming materials**

Various types of liming materials are available but three types are mostly used in aquaculture and they are:

1. Calcium Oxide (CaO): It is variously known as unslaked lime, burnt lime and quick lime. It is manufactured by roasting calcitic lime stone in a furnace. It is sold commercially in powder and grannular forms.

2. Calcium hydroxide, $Ca(OH)_2$: It is known as slaked lime, hydrated lime or builders lime. It is prepared by hydrating calcium oxide. It is sold commercially in powder and grannular forms.

3. Calcium Carbonate ($CaCO_3$): It is known as lime stone, Chuna or Carbonate of lime.

Their use in specific area depends upon its local availability. The amount of lime required depends on the ambient acidity level of the soil. For the benefit to the prawn farmers, the quantum of lime to be applied at given pH is given in Table 3.

(b) Methods of liming

Liming can be done in two ways:

- By broadcast over dried pond which includes the dike inner walls, and

- By mixing with water and spraying over the pond bottom.

In using the above methods, lime should be spread as uniformly as possible over the complete surface of the pond and should be ploughed upto 10-15 cm depth for thorough mixing. This should be done at least 20-25 days before fertilizer applications in minimum water column. This is important because liming materials will precipitate phosphorus if applied at or near the same time as fertilizers. However, once the liming material has reacted with the mud, greater availability of phosphorus will result. Further, once the pond has been limed, reduced applications @ 20-25% of initial application may be followed to rectify any pH imbalances.

(v) **Fertilization**

The usual way of increasing the carrying capacity of shrimp pond is to improve its natural fertility through the addition of organic and inorganic fertilizers. Pond fertilization is an

important and necessary step in extensive and semi-intensive methods of farming operations. Prawns being bottom dwellers, benthic organisms constitute their main food items. Hence, fertilization of soil instead of water is more effective. Fertilization of pond should be done after 20-25 days of liming. It should be broadcast/spread all over the pond bottom and mixed thoroughly.

(a) Organic fertilizers

The most common fertilizers are animal manures, rice bran, compost and sewage. Application of organic fertilizers especially in newly developed ponds is advisable because it serves as soil conditioner. Different forms of organic manures and percentage composition of available major nutrients are shown in Table 4.

The rate of application of organic manure in shrimp ponds ranges from 500 to 2,000 kg/ha as a basal dose. For definite amount of organic manure, Table 5 may be referred.

(b) Inorganic fertilizers

Inorganic fertilizers are synthetic fertilizers that generally contain an amount of at least one of the major plant nutrients like Nitrogen, Phosphorus and Potassium. These major nutrients are expressed on a percentage by weight basis. Nitrogen is expressed as % N and phosphorus as % phosphorus Oxide (P_2O_5). Different forms of nitrogen fertilizers are available in the market and some of them which are commonly used in brackishwater aquaculture are shown in Table 6.

Depending on the soil quality and nature of the crop, suitable fertiliser is to be selected. Nitrates (NO_3) are highly soluble in water and a portion of it leaches down to the reducing zone of the pond soil and gets reduced to nitrite form (NO_2) and ultimately lost to elemental nitrogen by the denitrifying bacteria present in the environment.

On the other hand, Ammonium (NH_4) carriers are better fertilizers as they are absorbed by the exchange complex and loss due to leaching is avoided.

Urea can be used in prawn culture pond at short intervals to get optimum result. It is concentrated and completely soluble fertilizer in water and hence the transportation and storage cost per unit of N for urea are considerably less than any other nitrogenous fertilizers. The conversion of urea into ammonical and nitrate form takes about 7 - 14 days. Urea is liable to be lost in leaching only for 3 - 4 days after application. Once urea is converted to ammonical form, it is absorbed by soil colloids and slowly released and nitrified to nitrates. Considering all the above factors, the use of urea in prawn culture ponds is suggested to sustain greater producitivity of water and soil.

Phosphate fertilizers

Single Superphosphate Ca $(H_2PO_4)_2$ and Ammonium phosphate $NH_4.H_2PO_4$ are the two main forms of inorganic phosphate fertilizers with available phosphate as P being 16 - 18% and 48 - 56% respectively are under great use in aquaculture. In Ammonium phosphate, 11% nitrogen is also available.

The rate of application of these fertilizers ranges from 25 to 100 kg/ha as a basal dose during pond preparation. For definite amount of fertilizers, Table 5 may be referred.

Organic manures and inorganic fertilizers are supplementary to each other and one cannot be exchanged for the other. It is often safe to apply both organic manure and inorganic fertilizers at a time, as the combined action generally yield better result. A comparision of organic and inorganic fertilizers for use in brackishwater ponds are given in Table 7.

(vi)Raising of Water level

The pond is then filled with water to a level of 30 - 35 cm and allowed to remain for 10 - 15days. With in this period, the colour of water may turn thick green with algal bloom and a layer of benthic algae along with associated food organisms will form at the bottom. The water level is then raised to about 80-100 cm and pond may be stocked with post-larvae.

(vii) Stocking of ponds

The post-larvae (PL20 - PL30) either from hatchery or wild should be acclimatized with the local pond environment and then stocked in early morning or late evening at the rate depending upon the type of culture to be undertaken. The rate of stocking density per hectare under different culture practices are given below:

Extensive culture:

P. mondon - 75,000

or

P. indicus - 1,00,000

Semi-intensive culture

P. mondon - 3,00,000

or

P.indicus - 5,00,000

B. Preparation of ponds constructed in areas of acid sulfate soils

(i) Nature of acid sulfate soils:

Shrimp farms sometimes are constructed in areas once covered by saline and brackishwater tidal swamps and marshes. When rivers with a heavy sediment load emptied into the sea, sediment was deposited near the shore. After the deposits rose above mean low water level, vegetation became established. As deposition continued, the coast slowly accreted, and a swamp forest developed. In the swamp forest, tree roots trapped organic and inorganic debries, and decomposition of dense masses of organic debries resulted in anaerobic conditions. As a result, sulfur reducing bacteria became abundant, and sulfide produced by the bacteria accumulated in pore spaces in sediment as hydrogen sulfide (H_2S) or combined with iron to form precipitates of iron sulfides. Iron sulfides underwent further chemical reaction to form Iron disulfide that crystallized to form Iron-pyrite.

As long as sediments containing pyrites are submerged and anaerobic, they remain reduced and change little. However, if

they are drained and exposed to the air, oxidation results, and sulfuric acid is formed. The summary reaction for sulfuric acid formation from iron pyrite is:

$$FeS_2 + 3.75\ O_2 + 3.5\ H_2O \rightarrow Fe(OH)_3 + 2SO_4^{2-} + 4\ H^+$$

The $Fe(OH)_3$ crystallizes as a reddish brown material in the sediment. After draining, a sediment containing pyrite is called an acid - sulfate soil or a "cat's Clay".

When aerobic, acid sulfate soils will have a pH below 4.0. The pH of acid - sulfate soils often will decrease as much as 3 units upon drying. The positive test is to measure pH before and after drying.

In ponds, the problem with acid sulfate soils - usually orginates on the levees. Pond bottom are usually flooded and anaerobic, so sulfuric acid does not form. However, levees dry and sulfuric acid formed during dry periods enter ponds in runoff after rains. Acidity on levees can be controlled by liming and establishing good cover with an acid resistant species of grass.

(ii) Reclamation of acid sulfate soils

Brinkman and Singh (1982) developed a method for rapid reclamation of ponds with acid - sulfate soils. The procedure is as follows:

1. In the early part of the dry season, dry the pond and harrow thoroughly.
2. Fill with brackishwater. Measure the pH of the water frequently. The pH will drop from that of sea water (7 to

9) to below 4. Once the pH has stabilized, drain the pond. Repeat this procedure until the pH stabilizes above 5. Often three or more drying and filling cycles may be required.

3. At the same time the pond is being reclaimed, acid must be removed from the surrounding levees. To achieve this, level the levee tops and build small bunds along each side of the levee tops to produce shallow basins. Fill basins with brackishwater. When the pond is drained for drying, also drain the small basins on the levee tops for drying. Repeat if necessary. Finally, remove the bunds and broadcast agricultural lime stone ($CaCO_3$) over the tops and sides of levees at 0.5 to 1.0 kg/m^2.

4. Once the last drying refilling cycle is completed, broadcast agricultural limestone over the pond bottom at 500 kg/ha.

(iii) Fertilization: After 20-25 days of liming of the ponds, the fertilization should be done. It should be either broadcast or spread all over the pond bottom and mixed thoroughly. Depending upon the soil quality, Organic manure @ 500 to 2000 kg/ha and inorganic fertilizers @ 25 to 100 kg/ha may be applied as a basal dose depending upon soil characteristics (Table 5).

(iv) Raising of water level: The pond is then filled with water to a depth of 30 - 35 cm and allowed to remain for 10-15 days. Within this period, the water may turn thick green with algal

bloom. The water level is then raised to about 80-100 cm and pond may be stocked with prawn seeds (PL20 - PL30). To prevent prawn kills by seepage of acid from levees, check pH frequently, and apply agricultural lime stone if necessary.

(v) Stocking of ponds: The ponds developed in the areas of acid sulfate soil are generally less productive and hence the decision on stocking density rate should be carefully examined. The rate of stocking density per hectare under different culture practices are suggested below:

Extensive culture:

P.mondon	5,000 - 10,000
P.indicus	6,250 - 12,500

Semi-intensive culture:

P.mondon	50,000 - 1,00,000
P.indicus	65,000 - 1,30,000

C. **Preparation of existing culture ponds after harvest**

After harvest of the crop, the pond has to be prepared for the next crop. This is important because shrimp spend much of their time on pond bottom and bottom conditions are more critical for shrimp than for any other aquacultural species.

(i) Draining of ponds: After harvest of the crop, the pond water should be fully drained out as far as possible. For this, pond should be designed in such a way that bottom must have a gradual slope from the inlet gate towards the drainage gate. The suggested ratio of the slope is 1 : 500 (SEAFDEC/NACA, 1986). As

the water bodies in coastal areas are often heavily laden with silt, the silt accumulated at the bottom of the pond should be removed, when the ponds are drained. It is often noticed the black mud at the pond bottom. The black color of mud usually is caused by an accumulation of ferrous iron, when the mud is depleted of oxygen. When the mud is Oxidized (contains oxygen), the ferrous iron changes to ferric iron and the mud will no longer be black in colour. In this context it is suggested that top 10 - 15 cm of soil should be removed manually. This will help in desiltation and removal of black soil/ mud from the ponds bottom.

(ii) Pond drying: The drying of the pond bottom is the next cheap and effective practical method of eliminating undesirable species in pond prior to the stocking. Drying Oxidizes harmful chemical substances especially sulfides and facilitates minieralization of organic matter. The pond is sun dried until the mud in the pond bottom cracks or when it is firm to hold one's weight without sinking more than 5 cm on walking over the surface.

During the process of drying the ponds, other activities must be undertaken. These include repair of dikes and gates, reconditioning of pond bottom trench, levelling and installation of screens.

(iii) Tilling: Tilling or ploughing of bottom soil improves soil quality by exposing subsoil to the atmosphere thereby speeding up the oxidation process and release of nutrients that are locked in the soil. Hence, this is also an important step in pond preparation.

(iv) Eradication of predators and unwanted species

After the crop is harvested, undesirable species like pests, competitors and predators remain in the ponds which should be removed. Brief description of undesirable species are given below:

Pests Pests are species that generally do not have direct harmful effects on the cultured stock. In most cases, however, pests are also competitors. Some pests for example are certain species of crabs that burrow into the dikes. These can destroy the dikes and cause leakage which may allow the entrance of undesirable species or the escape of cultured stock especially in nursery ponds.

Competitors: are species that compete for space, food, oxygen etc. with the cultured stock. Generally, there are different species competition arises out of the similarity in environmental demands which can pose limitations in the cultured species development. Both interaspecific and interspecific competitions prevail in any shrimp pond. It is essential to minimize such competitions by adequate management procedures in stocking of shrimp fry and prevention of undesirable species from entering the pond.

Predators: Predatory species on the other hand, are species that prey on the cultured stock. These species include finfishes, crustaceans and molluscs. The presence of predators is a serious problem for shrimp growers especially in nursery ponds.

Important undesirable species in shrimp pond

(a) Finfishes: Predatory finfishes are especially destructive to juvenile shrimp. The more voracious ones are seabass (Lates Calcarifer) and ten pounder (Elops sp.). Other common predatory species include Tilapia, threadfin bream (Polynemus sp.) and Therapon sp. which are very harmful to shrimp post larvae.

Finfishes that compete for food and space with the cultured stock are mullet (Mugil sp.) mud skipper (Periophthalmus sp.), Cluperiods sp. and Leiognathus sp.

(b) Crustaceans: Crabs are one of the competitors for food along with the stock in ponds. Their dike boring activities are the major causes of water leakage in ponds.

Methods of controlling undesirable species in shrimp pond

In order to get good harvest, one should control the undesirable species. There are two usual methods for control and they are:

a. Physical method

b. Chemical method

(a). Physical method: The most effective method in this category is drying the ponds. Other methods include installation of appropriate screens in the outlet/inlet gates to prevent entrance of undesirable species, proper maintenance of dikes and water gates to prevent leakage and to eradicate boring organisms like crabs. During culture period, selective harvesting or the use of cast net can be resorted to minimize the impact of undersirable species.

(b) Chemical Method: Eradication of undersirable species is very effective, less cumbersome, efficient and fast when chemicals are used. This is because chemicals act as contact or systemic poison. There are several types of chemicals used and collectively are known as pesticides.

The use of organic pesticides, such as Aquatin, Brestan, Endrin etc. is not recommended in shrimp farming because these have residual effects which destroy the fertility of the ponds as well as being non-selective or broad spectrum compounds in terms of biocidal activity.

In selecting pesticides, plant extracted compounds are recommended because these are biodegradable and in most cases also contribute to the fertility of the pond soil. The commonly used pesticides are:

(a) Mahua oil cake (Bassia latifolia): It is effective at 200-250 ppm (2000-2500 kg/ha). It also serves as a manure at later stage. Water soaked oil cake of mahua is broadcast all over the pond surface and mixed well with the pond water by dragging a fine meshed net. Pond water becomes fit for stocking prawn after 20-25 days.

(b) Saponin: It is extracted from tea seed cake which is a residue from oil processing of Camellia sp. seed. It continas 10-15% saponin. It is widely used to eradicate finfishes without toxic effect on crustaceans especially shrimps. The effectiveness of saponin decreases with decreasing salinity. The recommended levels

of application are 12 and 20 g/m^3 for salinities above and below 15 ppt respectively.

(c) Calcium carbide: It is applied into the crab hole and enough water is poured in the hole to activate the calcium carbide which kills the crab.

(d) Ammonium sulfate: This chemical compound which is also a fertilizer (21-0-0), is effective in eradication of undesirable species when used in combination with lime. Ammonia is released from the reaction of ammoinum sulfate with lime. This chemical is applied together with lime during pond preparation at the undrainable portions of the pond at a dosage of 1 part of ammonium sulfate to 5 parts of lime. Lime must preferably be applied first to raise the pH since the rapid release of ammonia from ammonium sulfate is dependent on high pH (above 8.0).

The selection of individual chemical treatment depends upon the type of undesirable species present in the ponds.

(v) Liming of ponds: After tilling and eradication of unwanted species, the ponds are treated with lime (Table 3) by broadcast over dried pond and the earthern dikes. The pond's bottom are ploughed upto 10-15 cm depth for thorough mixing. This is allowed to remain as such for 20-25 days. During this period, the liming material will react with mud and will result in greater availability of phosphorus at later stage when phosphatic fertilizers are applied. Once the pond has been limed, small applications (20-25% of initial application rate) may be used to

avoid large application of lime.

(vi) Fertilization of ponds: Fertilization of ponds in the form of organic and inorganic fertilizers should be done after 20-25 days of lime application. Raw cattle dung should be mixed with soil @ 500 to 2000kg/ha depending upon organic carbon content of the soil (Table 5). Higher doses may be applied to a new pond. Since decomposition of raw cattle dung is slow in brackishwater ponds due to saline nature, it is therefore Chicken manure application is advisable. The rate of chicken manure should be 1/3 of the rate of raw cow dung. The Chicken manure is broadcast throughout the pond. At this stage, superphosphate and urea @ 25 to 100 kg/ha each are applied as a basal dose to the pond bottom keeping minimum water level, say 10 - 15 cm depth. The definite amount of urea and single superphosphate to be applied is given in Table 5 (Based on available Nitrogen and Phosphorus).

(viii) Application of Health Stone:

'Health stone' is a mixture of inorganic salts containing SiO_2 (63.27%), Al_2O_3 (17.66%), Fe_2O_3 (3.93%), CaO (4.41%), MgO (2.68%), TiO_2 (0.32%), Na_2O (3.88%), K_2O (1.18%) and LOI (1.16%). It can be imported from Tong Kuwan Aquaculture Development Co., Ltd., RM4 5F 218 TA SHUN, 3rd KAOHSIUNG CITY TAIWAN, R.O.C. It is sold in 25 kg packet.

When aquatic plants or animals die, much of the materials in their bodies are in the form of organic compounds that cannot be directly utilized by the green plants for photosynthesis. Many of these compounds are quite stable and do not have a tendency to

break into simpler utilizable forms. Oxidation of these organic compounds/matter depletes the dissolved oxygen in the water and formation of toxic metabolities such as hydrogen sulfide (H_2S) and ammonia (NH_3) occur at pond bottom during the culture period, thus making serious situation that tremendously affects growth and survival rates of prawns. These situations can be minimized by the application of health stone. health stone is soil reactive, absorbs NH_3 and H_2S, maintains buffering activity of water and increases dissolved oxygen in the pond bottom due to the presence of SiO_2 and Al_2O_3 in health stone. It also helps in the production of phytoplankton due to mineral ions present in it. The Tong Kuwan Aquaculture Development Co.Ltd. has recommended 1 ton of health stone to be scattered evenly upon the pond bottom with in 1 hectare area at the time of pond preparation. During culture period 0.5 ton/ha of health stone may be scattered evenly into the pond water once in 20 - 40 days intervals.

However, our experiences show that health stone @ 350 - 500 kg/ha may be applied after fertilizer application at the time pond preparation.

(viii) Application of Tea seed Cake:

3 - 4 days later, tea seed cake and lime @ 25 - 30 kg/ha each may be applied. The tea seed cake is plant extracted compounds and is biodgradable, and in most cases it contributes to the fertility of the pond soil. Besides, it kills finfishes without affecting shrimps. The dead fishes are to be netted out.

(ix) Application of BN10:

It contains nitrobactor, nitrosomonas, sulfabacteria, Organic - analytical microorganisms. It is available in 1 kg pack. This can also be imported from Tong Kuwan Aquaculture Development Co., Ltd., Taiwan.

The Often problematic situation encounted in prawn farming is due to pond bottom pollution. The very slow natural degradation process undertaken by naturally occuring microbial cultures cannot cope up with the rate and bulk of waste accumulation. Ammonia, hydrogen sulfide, nitrites, nitrates, acidity and D.O. depletion are the major causes for diseases to occur, and once diseases break out, mortality sets in and results in great financial losses to prawn growers. The above problems can be minimized with the application of BN-10. Tong Kuwan Aquaculture Development Co., Ltd., Taiwan has recommended to spread 10 - 20 bags of 'BN10" powder equally in 1 hectare pond once every 20-30 days. However, our experiences show that supplementary dose of 100 kg/ha rate of health stone and 3 kg/ha BN10 were satisfactory to reduce the harmful bacteral load and helped in keeping ponds environment hygienic.

(x) Raising of water level:

At this stage, water level is slightly raised to around 50 cm. The water is continuously aerated with the help of paddle wheel aerator .Generally, 4 - 6 aerators are used in 1 ha pond water spread area. After 2 - 3 days, water is raised to 100 - 5 cm in a span of 5 - 6 days. Subsequently, small doses of organic

and inorganic fertilizers are applied based on the observations of algal (transparency with secchi disc about 30 - 40 cm) development in the ponds. Now, the ponds are ready for stocking.

Note: The water to be used in pond culture should be checked for its characteristics as given in Table 2.

(xi) Stocking density:

The post larvae (PL20) either from hatchery or wild should be collected and acclimatized with the local pond environment and then should be stocked in early morning or late evening at the rate given below for semi intensive culture.

P.monodon	3,00,000/ha
or	
P.indicus	5,00,000/ha

(xii) Water management:

Use of paddle wheel aerators and water exchange are two important steps in water management of the ponds. Generally, 4-6 paddle wheel aerators per hectare pond water spread area are employed in semi - intensive culture. It should be kept in mind that dissolved Oxygen level in the pond water should be maintained above 4.0ppm.

In semi -intensive culture where stocking density is high, the water exchange should be monitored very carefully. For guidance, the approximate water exchange schedule is given below:

Approximate water exchange schedule

Month	Water Exchange
One	Daily addition of 3-4 cm + 5% every 5th day (6 exchanges/month)
Two	10% every 5th day (6 exchanges/month)
Three	20% every 5th day (6 exchanges/month)
Four	30% every 3rd day (10 exchanges/month.)

(xiii) Literature recommended:

1. Shrimp culture: Pond design, operation and management. SEAFDEC/NACA Training manual series, No.2. Bangkok, Thailand, June 1986.

2. An improved traditional shrimp culture technique for increasing pond yield. SEAFDEC/NACA Technology series No.5, Bangkok, Thailand, June 1986.

3. Aquaculture systems and practices: A selected review ADCP /REP/89/43, UNDP, FAO, Rome, 1989.

4. Aqua farm News. Vol.VIII (6), 1990. Aquaculture Department, SEAFDEC, Phillippines.

5. Boyd, C.E. 1989. Water quality management and aeration in Shrimp farming, Fisheries and Allied Aquacultures Department series No.2, Alabama Agricultural Experiment station, Alburn University, Alabama.

6. Brinkman, R. and V.P. Singh, 1982. Rapid reclamation of Brackishwater Fish ponds in Acid Sulfate soils, p.318-330. In H.Dost and N.Van Breemen (eds.), Proc.of the Bangkok symposium on Acid sulfate soils, Internat. Inst. Land reclamation and Improvement, Publ. 18, Wageningen, The Netherlands.

Table 1

Soil characteristics of shrimp farming

1.	Texture	Sand %	Silt %	Clay %
	Sandy clay	45 - 65	0 - 20	35 - 45
	Sandy clay loam	45 - 80	0 - 28	20 - 35
	Clay loam	20 - 45	15 - 53	27 - 40
	Loamy sand *	70 - 90	0 - 30	0 - 15
		Minimum	Maximum	Optimum
2.	pH	6.5	8.5	7.0 - 8.0
3.	Organic carbon %	0.5	2.5	1.5 - 2.5
4.	$CACO_3$ %	-	-	> 5.0
5.	Available nitrogen (mg/100g soil)	25.0	75.0	50 - 75
6.	Available phosphorus (mg/100g soil)	3.0	6.0	4 - 6
7.	Electrical conductivity (mmhos/cm at 25_oC)	-	-	> 4

* Compensation for seepage is required on a daily basis by heavy duty pumps.

Table 2

Characteristics of water for shrimp farming

			Normal	Optimum	Critical
1.	Temperature	($_{o}$C)	17 - 33	28 - 33	< 14
2.	Water turbidity	(cm)	25 - 60	25 - 45	< 20
3.	pH		6 - 9	7.5 - 8.5	< 6
4.	Dissolved Oxygen	(ppm)	4 - 8	5 - 7	< 3
5.	Total alkalinity	(ppm)	50 - 300	200	< 20
6.	Salinity	(ppt)	7.5 - 34	15 - 25	< 5
7.	Nitrate - nitrogen	(ppm)	0.03	-	-
8.	Nitrite - nitrogen	(ppm)	0.01	-	> 1.5
9.	Ammonia - nitrogen	(ppm)	0.01	-	> 0.15
10.	Dissolved inorganic phosphorus	(ppm)	0.008-0.20	0.10-0.20	-

11. Heavy Metals

Metals (ug/L)	Safe level
Cadmium	10
Chromium	100
Copper	25
Lead	100
Mercury	0.1
Zinc	100

12. Pesticides (ug/L)

Aldrin / Dieldrin	0.003
BHC	4
Chlordane	0.01
DDT	0.001
Endrin	0.004
Heptachlor	0.001
Toxaphene	0.005

Table 3

Amount of lime (ton/ha) required to raise pH to 7.0

pH	Agricultural lime stone ($CaCO_3$)	Hydrated lime $Ca(OH)_2$	Quick lime (CaO)
6.5	2.5	1.9	1.4
6.0	5.0	3.7	2.9
5.5	7.5	5.6	4.3
5.0	10.0	7.4	5.8
4.5	12.5	9.3	7.2
4.0	15.0	11.1	8.7
Efficiency	100%	135%	173%

Table 4

Percentage composition of available major nutrients in organic manure

Manure	%		
	N	P	K
Raw cowdung	0.3 - 0.4	0.1 - 0.2	0.1 - 0.3
Raw poultry droppings	1.0 - 1.8	1.4 - 1.8	0.8 - 0.9
Sewage sludge (dry)	2.0 - 3.5	1.0 - 5.0	0.2 - 0.5
Village compost (dry)	0.5 - 1.0	0.4 - 0.8	0.8 - 1.2
Agri.farm waste (dry)	0.4 - 1.5	0.3 - 0.9	0.3 - 1.9

Table 5

Amount of Organic manure and inorganic fertilizers to be applied to pond bottom as a basal dose based on soil characteristics.

Organic carbon in soil	Amound of Raw cattle dung (kg/ha)		Amound of dry Chicken mannure (kg/ha)
1 %	500.00	or	167.00
0.5 %	1000.00	or	333.00
0.25 %	2000.00	or	666.00

Availble nitrogen in soil	Amount of urea (kg/ha)
12.5 mg / 100 g soil	100.00
25.0 mg / 100 g soil	50.00
50.0 mg / 100 g soil	25.00

Available phosphorus in soil	Amount of single superphosphate (kg/ha)
1.5 mg / 100 g soil	100.00
3.0 mg / 100 g soil	50.00
6.0 mg / 100 g soil	25.00

Table 6

Some of nitrogenous fertilizers commonly used in brackiswater aquaculture.

Form	Availability
Ammonium sulfate $(NH4)_2$ SO4	20 - 21 % as NH_3
Ammonium nitrate ($NH_4.No_3$)	17 - 18 % as NH_3 and 17 - 18 % as NO_3
Urea (NH_2 $CONH_2$)	46 % N

Table 7

Comparison of Organic and Inorganic Fertilizers for use in Brackiswater Ponds

ITEM	ORGANIC	INORGANIC
Concentration of N and P	Low. Average N ranges from 0.5 % to 1.1% while P ranges from 0.1% to 0.4%.	High. For 18-46-0 fertilizer, it contains 18% N and 46% P or 35 times more than the organic fertilizer.
Composition of nutrients as N and P	Variable. N and P concentrations depend on diet composition given to the producing animal. Nutrients concentration diminishes through prolong storage or exposure to the elements.	Consistent
Substrate for micro-benthos attachement	Does provide.	Does not provide.
Processing, store and transport including application	High cost in terms of money, labor facilities and general unpleasantness is greater than inorganic fertilizers.	Low cost in terms of money, labor facilities and general unpleasantness
Adverse effect on cultured stock	Mortality of stock commonly due to breakdown by microbial organisms leading to high BOD and low dissolved oxygen in the water	Rare.
Growth factors	Present. Enchhances algal production.	Absent.
Cost per unit of total N and P Nutrients	Most expensive. Requires large amount to attain high N and P level.	Lest expensive since N and P are in concentrated amount. Application requires only smaller dose as compared to organic fertilizers.
Feeds for the culture stock.	Can be used directly such as rice bran and chicken manure especially for species low in the food chain.	Cannot be consumed by aquatic animals

Source: Shrimp Culture: Pond design, operation and management, NACA Training manual series No.2. FAO/SEAFDEC, Bangkok, Thailand, June 1986.

PENAEID PRAWN HATCHERY OPERATION AND MANAGEMENT

BY
DR.L.HANUMANTHA RAO

PENAEID PRAWN HATCHERY OPERATION AND MANAGEMENT

1. INTRODUCTION

There is a great scope for the development of brackishwater prawn farming in India. One of the major constraints for expanding Penaeid prawn farming in India, is scarcity of quality prawn seed, particularly of Penaeus monodon, as and when required by the farmers. Availability of desired quality of prawn seed from wild is inconsistent and inadequate to meet the growing demand. It is estimated for developing 10,000 ha of brackishwater area under semi-intensive culture system, the seed requirement would be about 4 billions. A study supply of quality prawn seed is feasible only from the hatcheries. In India, few hatcheries have been in operation in public and private sectors with different levels of operation and seed production. This paper describes the techniques adopted for Penaeid prawn seed production in hatcheries and essential infrastructure facilities required for establishing a prawn hatchery.

Prawn seed production in hatchery demands technical expertise. Success of prawn seed production in hatcheries depends on 1) selection of site, 2) availability of clean and unpolluted sea water, 3) availability of spawner 4) aeration, 5) infrastructure facility and 6) management efficiency.

2. SELECTION OF SITE

The criteria of selecting a site for Penaeid prawn hatchery are given below:

i) Seawater (Salinity = 27-36 ppt, temperature 26-33^{o}C, pH=7.8-8.4) free suspended solids, pollutants and heavy metals,

ii) Site free from discharge of industrial effluents and domestic sewage.

iii) Hatchery site close to grow-out ponds for easy disposal of seed,

iv) Easy availability of broodstock,

v) Accessibility to near by towns,

vi) Availability of electricity to the site,

vii) Availability of freshwater and

viii) Site free from cyclone and flood.

Rocky and sandy coasts are suitable.

3. SEAWATER

Seawater is considered as one of the important inputs and decisive factor for successful and consistent production of prawn seed in hatcheries. The sea water can be obtained:

i) from the sea through an *in situ* filter box or surface seawater pumped from the sea to a settlement tank and later passed through a sand filter, or

ii) from a borewell sunk in the intertidal zone; A 3-4 metre length 90 mm diameter rigid PVC pipe closed one end bottom of the pipe with an end cap, perforated two metres length on the closed side and covered with fine much nylon screen in sunk in the intertidal zone. A foot value is fitted to the top of the PVC pipe and the suction line is connected to a suitable self priming, bronze impeller centrifugal pump. If the sea water requirement is more, three or four borewell may be inter-connected, or from open wells constructed on the seashore with antenna over wide area to draw seawater, or

iii) from backwaters or creeks. The seawater is pumped into reservoirs, where it is treated with calcium hypochlorite or sodium hypochlorite depending on the turbidity of seawater, to kill bacteria and vigorously aerated to expel chlorine; the residual chlorine is neutralised with required quantities of sodium thiosulphate and then passed through sand filters.

The seawater thus obtained, passed through fabric filters is used for broodstock, maintenance and larval rearing, 5 micron cartridge filters for spawning and hatching and 1 micron

cartridge filter membrane and UV filters for axenic cultures. Addition of Ethylene diamine tetraacetic acid (EDTA) @ 5-10 ppm to the seawater is desirable in further improving the quality

4. SPAWNER AVAILABILITY

In India, among penaeid prawns, Penaeus monodon and P. indicus are commercially important species. Of the two species, P. monodon is the fast growing species and tolerates wide fluctuations in salinity and hence it is the most preferred species.

Broodstock availability in the vicinity of hatchery is an essential prerequisite and cuts down the cost involved in transporting the broodstock. In the case of P. monodon, spawner availability from wild is a major constraint. In such conditions, it is necessary to develop broodstock facility in the hatchery.

5. AERATION

Roots airblowers (5-10 HP) are suitable to supply oil free air to all the tanks in the hatchery. The capacity of the airblower depends on the number of outlets. Blower with 0.2 - 0.3 kg per cubic metre of the air pressure and a volume of 4-5 litres/m^2/minute is usually sufficient for small and medium scale hatcheries.

6. INFRASTRUCTURE

The infrastructure facilities required for establishing a prawn hatchery is given in Annexure I.

7. HATCHERY OPERATION AND MANAGEMENT

A. Broodstock management:

For successful prawn hatchery operations, a regular and reliable supply of spawners of prawn is an essential perquisite. Getting required number of spawners particularly P.monodon at a given time poses problems. Thus, many hatcheries suffer from paucity of spawners from wild. In order to produce prawn seed continuously in the hatcheries, techniques to induce maturation in captive females have been developed the source of broodstock is either from wild or from ponds. It is desirable to collect broodstock from wild particularly in the case of P.monodon and maintain them in broodstock holding tanks. As the supply of broodstock from wild cannot meet the demand of hatcheries requirement, it is necessary to develop broodstock facility in the hatchery by rearing postlarvae in 0.05 ha - 0.10 ha earthern ponds in 3 phases at low stocking densities ($2/m^2$, $1/m^2$ and $0.5/m^2$) for a period of 12 months. The requisite conditions for rearing P.monodon broodstock in captive conditions are given in Table 1. Thus, females weighing above 90 g and males above 60 g are collected, disinfected with 50 ppm formalin treatment and maintained in broodstock holding tanks. The prawns are fed with fresh feeds such as clam, squid, mussel, crab, fish meat @ 15-25% of the total biomass per day. Everyday, 50-70% of water changed. The prawns may also be maintained in flow through system.

B. Induced maturation:

As females do not mature in captive, they are induced to mature by eyestalk ablation technique. The technique involves: a) endocrine control, b) providing nutritionally balanced diets and c) manipulation of environmental parameters.

a) Endocrine control:

In the eyestalk of decapod crustaceans a gonad inhibiting hormone (GIH) is produced by neurosecretary cells of x organ and transported to the sinus gland for storage and release. The unilateral eyestalk ablation helps to control GIH and accelerates ovulation process.

Methods of eyestalk ablation :

3 methods are employed. 1. Removal of eyestalk by cutting with scissors. 2) Removal of eyestalk using electrocautery and 3) Giving an incision to the eyeball with a sharp blade and squeeze out the contents of the eyestalk.

b) Feeds :

Studies on nutritional requirement for penaeid prawn maturation have indicated that lipid, polyunsatuated fatty acids (PUFA) concentration in P.monodon increased upon reaching maturity. Feeds that contain 60% protein and 10% PUFA showed promising results in inducing maturation in eye ablated prawns. Thus, fresh feeds such as clam, squid, mussel crab, fish, polychaete worms, Artemia biomass and dry pellets which contain 60% protein and 10% lipids (PUFA) from maturation feeds. Fresh feeds are given @ 15-25% while dry pellets are fed @ 3-5% of the total biomass everyday.

C. Environmental conditions :

The environmental parameters maintained in the maturation tanks are:

1. Reduced intensity of light by keeping the tanks in a closed shed;

2. Exposing a 40W / blue flourecent light for 12 hours;
3. Changing seawater 100-400% per day.
4. Maintaining water temperature 27-32^{o}C, salinity 27-36 ppt, pH 8.0-8.3.

Prophylactic measure :

The prawns are treated with 50 ppm formalin for 30 minutes at weekly intervals.

d) Technique of induced maturation :

Unilateral eyestalk ablation is done for females in the intermould period, with the presence of spermatophores in the thelycum and released in the maturation tanks kept in closed shed alongwith males in the ration of 2 females: 1 male or 1 female: 1 male at a density of 300-400 g per square meter. The prawns are fed with fresh feeds such as clam, squid, mussel, crab @ 15% of the total biomass distributed 3 times in a day and supplemented with polychaete worms @ 4-8% and beef liver @ 2% of the total weight once in a day. Water management include 90-200% change of seawater everyday. Dry pelleted feeds are used besides fresh feeds in commercial hatcheries. Uneaten food is cleaned everyday. Optimum conditions for maturation in captive females of P.monodon are given Table 2. The stages of maturity in female prawns is given in Annexure II.

E) Observations :

Ovary development is checked 3 days after eyestalk oblation. The gravid females in IV stage of ovary development are observed with the help of an under water light. Females in IV stage of ovary maturation can be identified by the presence of diamond shaped green ovary between the 1st and 2nd abdominal segments.

Females weighing above 100 g respond positively for eyestalk ablation. Wild P.monodon from the sea starts maturing 4-6 days after eyestalk ablation, while females collected from backwaters and brackishwater lagoons influenced by freshwater run off takes 20-30 days to mature and sometimes give unfavourable results. Maturation is found to be faster in P.indicus (5-10 days) after eyestalk ablation that in P.monodon (10-25 days). They remain productive for about two months. Each female matures and spawns 3-5 times at 3-5 days interval between two intermould.

Thus, with the adoption of eyestalk ablation technique, it is now possible to produce P.monodon seed at any given time.

f) Artificial insemination :

Females sometimes fail to mate under captive conditions. To overcome this problem, the spermatophores of mature males weighing above 50 g are removed by giving an electric shock with pair of electrodes (4-5 volts) at the base of 5th pair of walking legs and introduced into the thelycum of freshly moulted female.

C. Spawning :

The spawning tanks are filled with seawater passed through 5 micron filters and provided gentle aeration. The mature prawns are introduced at a rate of one prawn per tank. Spawning takes place usually on the same night during early hours. If the prawn did not spawn in two days, it should be returned to the maturation tank. Fertilisation is external. The eggs are collected and cleaned with seawater to remove scum and transferred to a 4 l capacity basin after giving 2 ppm tetracycline dip. After thorough mixing, two 10 ml samples are taken and the number of eggs counted visually and computed

the number to the total volume of water to obtain the total number of eggs per spawning. The incubation period is 15-18 hours at 27-29 C. About 100 eggs are observed under a microscope to determine percentage of fertilisation and viable eggs. The eggs are spherical and measures approximately 0.28 mm in diameter. The eggs are classified as normal, abnormal and unfertilised.

Fecundity :

The fecundity of eye ablated females ranges from 60,000 to 6,00,000 compared to 2,50,000 - 8,00,000 for wild specimens in the case of P.monodon.

D) Hatching :

The eggs are transferred into another tank where they hatch out into nauplii within 15-18 hours after spawning. After hatching, the larvae are distributed uniformly in the water column through aeration. Four 100 ml samples are taken and estimated the total number of larvae in the tank by multiplying the number of nauplii in 400 ml with the total volume of water. The hatching rate is estimated as:

$$\frac{\text{Total number of nauplii x 100}}{\text{Total number of eggs/spawning.}}$$

E. Larval Feeds:

Three type of larval feeds are used for rearing penaeid prawn larvae; 1. Live feeds, 2. Tissue suspension feeds and 3. Artificial feeds.

a. Live Feeds:

Pure cultures of diatoms (Chaetoceros calcitrans, C.affinis and Tetraselmis sp.) rotifers (Brachionus plicatilis) and brine shrimp nauplii (Artemia sp.) are widely used as larval feeds in hatcheries.

Mixed phytoplankton culture dominated by one or two species of diatoms are also used as larval diet. Medium used for diatom culture is given in Annexure-III.

b. Tissue suspension feeds:

Crustacean tissues (Sergestid shrimp - Acetes indicus, Mysid shrimp Mesopodopsis sp., Mantis shrimp - oratosquilla nepa) clam, mussel meat, egg yolk in suspension form and egg custard in particulate form are used for rearing prawn larvae, either exclusively or in combination with live feeds.

c. Artificial Feeds

The artificial feeds include dry pellets microencapsulated diets. pelleted feeds using ingredients of plant and animal origin are tried mostly on advanced postlarvae and juveniles. Pellet feeds using ingredients such as mantis shrimp, prawn head waste, ground nut oil cake, fish meal, tapioca, dried squid, soybean, rice polish, vitamin and mineral mix in different combinations and squilla (mantis shrimp) powder are used for rearing postlarvae of P. indicus.

In recent years, artificial dry microbound and microencapsulated feeds such as Frippak, Nippai, Hatchery encapsulation, Artificial plankton, Artemia flakes, developed in countries like Japan, U.K., U.S.A., Taiwan etc. are being used successfully as diets for larvae and postlarvae along with live feeds.

Methods employed for mass culture of diatoms and preparation of tissue suspension and custard feeds are given in Annexure IV.

F. Larval rearing techniqu·e

The larval rearing tanks are disinfected with 100 ppm calcium hypochlorite one day prior to stocking nauplii, washed thoroughly and dried. The tanks are filled seawater (30-31 ppt) and provided aeration. The nauplii are stocked at density of 100/L. During nauplii stages no feed is required, as they contain yolk, which serves as food.

During protozoeal stages, Chaetoceros calcitrans or C.affinis or Skeletonema costatum (40,000-50,000 cells/ml) or Tetraselmis sp. (10,000 cells/ml) form the feeds. In addition to live foods suspension feeds are also given in small quantities.

During mysis stages, besides algal feeds, the larvae are fed with Artemia nauplii (0.5-2/ml) and suspension feeds.

When the larvae metamorphoses into postlarvae, Artemia nauplii (3-4/ml) and custard feeds (5 g/1 ton/feeding) is given as post larval feeds.

The postlarvae-2 are stocked in nursery tanks at a density of 15-20/1. The larvae are fed with Artemia nauplii (3-4/ml) and custard feed @ 40g/1 ton/6 feedings initially and increased by 20% depending on feeding activity. From PL-11 onwards, the quantity of Artemia nauplii is reduced. In commercial hatcheries, the larvae are fed with imported microbound feeds along with live feed. The rate of survival from nauplii to PL-20 is 30%. At PL-20, the postlarvae are harvested and stocked in grow-out ponds.

Daily observation:

Temperature, salinity, pH, dissolved oxygen of the rearing medium is to be checked everyday. Ammonia and nitrite content of seawater is to be checked during critical stages. The larval populations in the rearing tanks are estimated on the basis of 5 random samples taken with one litre glass beaker. The average density computed to the total volume of rearing medium will be the basis for adjusting feeding schedules. Few larvae are examined under a microscope to assess the health condition and feeding activity of larvae.

Water Management:

In larval rearing tanks, it is necessary to change seawater everyday to ensure better survival of larvae. Partial change of seawater to the extent of 30-50% is sufficient in the tanks during protozoeal stages, which is later increased to 50-70% during mysis and postlarval stages. When large tanks are used for postlarval rearing 30% water change is sufficient. Cleaning the tank bottom is necessary to remove unutilised feed and faecal matter before change.

Prophylactic measures:

1. Chloramphenicol, tetracycline, terramycin @ 2-4 ppm should be given to the medium alternatively.
2. EDTA should be added to the seawater @ 5-10 ppm.
3. Calcium hypochlorite is to be added to the seawater @ 5 - ppm to kill bacteria.
4. All the tanks are to be disinfected with 100 ppm calcium hypochlorite after completing each cycle.
5. All the cleaning tubs, siphon tubes, plankton nets, filter nets and tubes used in the hatchery are to be dipped in 50 ppm formalin, washed and dried everyday.

G. Quality Control tests for P.monodon postlarvae

To assess the quality of prawn larvae for stocking in grow-out ponds, 3 tests are employed.

1. Muscle to gut ration
2. Stress test for salinity drops of 15 ppt and
3. Stress test for formalin concentration of 100 ppm.

The larvae with muscle to gut ratio is 4:1 and can withstand stress test for salinity drop of 15 ppt and formalin concentrations of 100 ppm for 2 hours and do not die are considered as healthy larvae for stocking in the grow-out ponds.

H. SEED PACKING AND TRANSPORT:

The prawn seed harvested from the PL rearing tanks are transferred into 100 L capacity tanks and provided aeration. Polythene bags measuring 60cm x 30 cm are used for transporting prawn seed. The required density of the seed if then introduced into the double polythene bag containing 6 1 of seawater (25^{o}C), filled with oxygen and sealed the end with a rope or rubber band. Two bags are packed in a carton (60 cm x 35 cm x 35 cm) lined inside/with thermacole sheets. The density of seed for different journey periods are:

Journey period	Density
12 hours	4,000/bag
12-24 hours	3,000/bag
24 hours and above	1,000/bag

8. TYPES OF HATCHERIES

Based on the size of operation, the hatcheries may be classified into 4 types :

1. Backyard hatchery: The production level is 1.5 to 2 million PL-20 per annum with an average rearing tank capacity of 40 t. (Approximate cost Rs.12 lakhs)

2. Small-scale hatchery: The production level is 10 million PL-20 per annum with an average rearing tank capacity of 250 t. (Approximate cost Rs.40 lakhs)

3. Medium-scale hatchery: The production level is 25 million PL-20 per annum with an average rearing tank capacity of 700 t. (Approximate cost Rs.80 lakhs)

4. Large-scale hatchery: The production level is more than 60 million PL-20 per annum with an average rearing tank capacity of 1600 t. (Approximate cost Rs.140 lakhs)

HATCHERY MANAGEMENT

Establishment of prawn hatchery is capital intensive and requires high managerial ability for its operation. Trained and dedicated personnel are required for operating different systems in the hatchery.

ANNEXURE-I

Infrastructure facilities for establishing prawn hatchery

After selecting a suitable site for hatchery, a layout design indicating sizes of tanks for maturation, larval rearing, algal culture, spawning, broodstock and storage and sheds, building, seawater intake system, aeration and drainage depending on the target fixed for the hatchery, is prepared and approximate cost of construction is estimated.

TANKS

(a) Maturation tanks:

Rectangular in shape with capacities ranging from 10 to 40 t. made of concrete or round fibreglass tanks measuring 12 feet diameter and 4 feet height are suitable. The tanks are kept in a closed shed and provided with running water facility.

(b) Spawning tanks:

500 litres round fibreglass tanks are suitable.

(c) Larval rearing tanks:

Rectangular or parabola cement concrete tanks with capacities ranging from 3 to 25 t or 2 to 10 t capacity round or parabola fibreglass tanks are suitable. In small scale hatcheries, 2 to 5 t capacity tanks while in medium and large scale hatcheries 5 - 25 t capacity tanks are used. The tanks are kept in a closed shed, the roof of which is provided with asbestos sheets interspersed with few translucent fibreglass sheets.

(d) Postlarval rearing ranks:

Rectangular concrete cement tanks with capacities ranging from 10 to 100 t are suitable. The tanks are kept open and provided with suitable covers.

(e) Diatom culture tanks:

Fibreglass tanks (1-5 t) or rectangular cement tanks of capacities 10-12 t are suitable.

(f) Artemia hatching tanks:

250 - 500 litre cylindro-conical fibreglass tanks, conical part made of translucent fibreglass are suitable.

(g) Broodstock holding tanks:

Rectangular cement concrete tanks of 50-100 t capacities are used for maintaining broodstock.

(h) Storage tanks:

50 - 400 t capacity cement concrete tanks are suitable.

(i) Overhead tanks:

20-50 t capacity 1 for seawater 5-10 t capacity 1 for freshwater.

The number and sizes of the tanks depend on the seed production target fixed to a hatchery. All the cement tanks should be coated inside with epoxy paint and should be cured repeatedly by filling with water, allow it to settle for two days and dewatering. The tanks should be provided gradual slope towards the outlet and fitted with bottom openings. The bottom opening are connected to the collection pits through PVC pipe.

ESSENTIAL EQUIPMENT

ITEM	Capacity	Nos.
Airblower	5 - 10 HP	2-3
Generator	30 - 100 KVA	2
Sandfilters	20 - 50 t/hour	2-4
Deepfreezer	1 t	1
Refigerator	165 lit	1-2
Airconditioner	1.5 t	2
Refractometer	0-100 ppt	2
pH meter	5 to 9	1
Thermometer	0 to 50 deg. cel	1
Balances	to weigh 200 g	2
Electrification		
Pumps		
5-10 HP		2
2 HP		2
1 HP		1
0.5 HP		2
Suitable covers for covering outside tanks Cartridge filters 2 / u and 1 micron		2

SHEDS

For maturation, larval rearing, Spawning, Artemia hatching, Axenic cultures, Seed packing, rooms for Generator, Airblowers, Pumps, Office, Laboratory, Duty room, Dining and kitchen and Watchman said.

Glassware and chemicals

Buckets, tubs, basins, filtration units

Cleaning pipes, Plankton nets fibre cloth ilters, etc.

OVARIAN MATURATION STAGES

On the basis of external examination of fresh ovaries, the following stages of maturation are recognised in P. monodon

Stage I

Ovary thin, transparent, not visible to the naked eye white in colour

Stage II (early maturing)

Ovary thick, increase in size, extends anterior and posterior lobes, white in colour.

State III (Maturing)

Ovary slightly swollen, increase in size from thoracle to abdomen region, visible to the naked eye, assumes diamond shape at the 1st abdominal segment, light green in colour.

StageIV (mature)

Ovary swollen and occupies full space of the body cavity from abdominal to thoracic region, visible to the naked eye, assumes distinct diamond shape between the 1st and 2nd abdominal segments, dark green in colour, granular.

Stage V (spent)

Ovary shrunken, looks similar to stage I,; partially spent ovaries, either anterior or posterior ovary remain unspawned.

CULTURE OF DIATOMS

Axenic cultures of Chaetoceros calcitrans and Skeletonema costatum can be maintained in sterilised seawater under temperature controlled conditions (20-24^{O}C) using Walnes medium

at a light intensity of 1000 to 1500 lux. A maximum cell density of 5-7 x 10^6 cells per ml is achieved in 4 days with an initial inoculum of 50,000 cells per ml.

Mass culture: After disinfecting with calcium hypochlorite, the culture tanks are filled with filtered seawater and enriched with modified F medium @ 1 ml/L. Pre cultures of Chaetoceros calcitrans are inoculated @ 25,000 cells per ml. Vigorous aeration is provided. A maximum cell density of 0.5 million cells per ml is obtained in 24-48 hours. The tanks may be covered with translucent fibreglass sheets to prevent dust and excessive sunlight.

Skeletonema costatum is mass cultured in outdoor large cement tanks using modified 'F' medium or EMRL medium. A maximum cell density of 0.5 million cells per ml is obtained in 3 days.

Medium used for diatom culture

Walne's medium

Solution A

Sodium nitrate	10.0 g
Sodium dihydrogen phosphate	2.0 g
Ferric chloride	0.13 g
Manganese chloride	0.04 g
Boric acid	3.30 g
EDTA	4.50 g
Distilled water	100.00 ml.

Solution B

Zinc chloride	2.10 g
Cobalt chloride	2.00 g
Ammonium molybdate	2.00 g
Copper sulphate	2.00 g
Distilled water	100.00 g

Solution C

Cobalamine (B_{12})	5.00 g
Thiamine (B_1)	100.00 g
Distilled water	100.00 g

1 ml each of solution A,B, and C is added to 1 litre of seawater.

Modified 'F' medium

Potassium/Sodium nitrate	20.00 g
Sodium dihydrogen Orthophosphate	10.00 g
EDTA	10.00 g
Sodium metasilicate	10.00 g
Distilled water	1000.00 ml

Add 1 ml per litre of seawater

TMRL medium

Potassium nitrate	100 g
Disodium hydrogen phosphate	10 g
Ferric chloride	3 g
Sodium metasilicate	1 g

Add 1 ml. to 1 litre of seawater.

Preparation of tissue suspension

Fresh flesh of mussel or clam meat or juvenile prawns, or Acetes sp., or Mesopodopsis sp., or Oratosquilla sp., is washed thoroughly with freshwater, cooked in a pressure cooker for 20-30 minutes after adding little water. It is then grounded in a mixy and sieved through suitable meshes of nylobolt cloth.

Protozoea_ stages	30 - 50 micron
Mysis stages	100 - 250 micron
Post larvae	350 - 500 micron

Preparation of custard feeds

Four whole eggs contents is mixed with 1 spoon of milk powder and blended of clam, squid, mussel, prawn meat, beef liver, polychaete worms and Artemia biomass and cooked in a pressure cooker after adding little water for 30 minutes. The custard after colling, is added with Vitamin mix and kept in a freezer. The custard is seived through a suitable meshes and fed to the larvae.

Table 1

Optimum conditions for rearing P.monodon broodstock

	First Phase	Second Phase	Third Phase
Pond size	0.05 - 0.10 ha	0.05 - 0.10 ha	0.05 - 0.10 ha or large cement tanks.
Stocking density	2 PL-30/m^2	1/m^2	0.5/m^2
Aeration	Required	Required	Required
Salinity	20-30 ppt	20-35 ppt	30-35 ppt
Temperature	26-33^oC	26-33^oC	26-33^oC
pH	7.6-8.5	7.6-8.5	7.6-8.5
Dissolved oxygen	Saturation	Saturation	Saturation
Monitoring (Ammonia Nitrite, health condition pond bottom)	Necessary	Necessary	Necessary
Water depth	1-1.2 m	1-1.2 m	1-1.2 m
Water change	20-30%/day	20-30%/day	20-30%/day
Feed	Fresh 10% initially Pellets 3-5%	Pellets 3-5%	Pellets 3-5% Fresh 10%
Duration	5 months	5 months	3-5 months
Average weight attained	30-40 g	70-80 g	90-100 g

Table 2

Optimum conditions for P.monodon maturation in capacity

Tank size	12-15 t
Stocking density	300-400 g/m^2
Sex ratio	1 female : 1 male or 2 females : 1 male
Intensity of light	Reduced, tanks are to be kept in a closed shed.
Photoperiod	Exposure of one blue fluorescent light (40-60 W) for 12 hours
Temperature	28-30^{o}C
Salinity	28-36 ppt
pH	8.0-8.3
Dissolved oxygen	Saturation
Aeration	Necessary
Water change	200-400% /day - flowthrough system 100-200% / day using filters
Feeds	Fresh Feeds: Clam, squid, mussel, crab & 15-20% of the biomass, polychaete worms 4-8% of the biomass, beef liver @ 2% of the biomass / dat. Pellets: 3-5% of the total biomass/day.

WATER QUALITY MANAGEMENT IN BRACKISHWATER PRAWN CULTURE AND HATCHERY SYSTEMS

BY
DR.K.O.JOSEPH

TABLE OF CONTENT

WATER QUALITY MANAGEMENT

1. INTRODUCTION

Water quality is critical for survival, health and growth of prawns, especially in semi-intensive and intensive prawn culture systems and for the production of quality prawn seed in the hatchery. To maintain good water quality, the physical and chemical properties of water should be kept within certain safe levels.

The techniques for water quality management in freshwater aquaculture system are available, but they have not been much adopted in brackishwater prawn farming. Many of the methods used in freshwater aquaculture are applicable to brackishwater with some modifications. The purpose of this manual is to provide a simple account of water quality management for application to brackishwater prawn culture systems and hatcheires.

The water quality variables that affect production in brackishwater systems are : temperature, salinity, dissolved oxygen, water clarity, ammonia, nitrite, hydrogen sulphide and nutrient concentrations. The prawn farmer should try to maintain these variables within the optimum range as far as possible by suitable management techniques. Information provided below is largely based on experience which can serve as a useful guideline for water quality management for greater prawn production in the ponds and seed production in the hatcheries.

WATER QUALITY PARAMETERS

Temperature: Water temeprature plays a very important role in regulating the activities of cultured animals. The rate of chemical and biological reactions is said to double at every $10^{o}C$ increase in temperature. This means that aquatic organisms will use twice as much dissolved oxygen and chemical reactions will progress twice as fast at $30^{o}C$ than $20^{o}C$. Thus, the dissolved oxygen requirement of aquatic species is higher in warmer than in cooler water.

Temperature sets the pace of metabolism by controlling regular dynamics and biochemical reaction rates (diffusivity, solubility, fluidity, etc.). The low temeprature regime of water affects the metabolic and growth rates of prawn. Prawns typically have a linear growth curve related to water temperature.

In bracishwater shallow ponds, where regular exchange between the tidal water and the pond water is not maintained during the hot dry months, the temperature of pond water may shoot up beyond the tolerance limit causing mortality of reared prawns. The high rate of evaparation will also occur increasing the water salinity beyond the tolerance level. Similarly, during the winter season, the low temperature will have a chilling effect reducing metabolic and growth rates of cultured prawns.

On account of unequal distribution of temperature with higher temperatures near the surface layer and decreasing temperatures with depth, thermal stratification can occur in

deeper ponds. This can result in a reduced heat budget for the pond, since the heat is concentrated at the surface layer (Epilimnion) causing more evaporation and heat loss. Due to separation of cold layer (Hypolimnion) from the photosyntheti zone, algal and atmospheric aeration does not occur. Consequently, reductive products causing quality degradation effects result from the anaerobic organisms and formation of methane, hydrogen sulphide and ammonia occur. Under resuding conditions, Iron and Manganese that settle down from the aerobic zone in an oxidised insoluble form reverts back into solution.

In some ponds, the surface temperature goes beyond 35^{o}C. Partial shading can be thought of in such cases, so that prawns can take shelter under such extreme conditions. The planting of trees on pond dikes to give shade will reduce stratification but at the same time reduce the beneficial effects of wind mixing and restricts solar energy for photosynthesis. Operation of aerators during warm and calm afternoons help to break thermal stratification by mixing warm surface water with cool subsurface water.

Other management techniques adopted during winter is to reduce the fertilisation and feeding as growth rate of organisms will be low during the period. Although temperature can be adjusted to, optimum levels in controlled systems such as hatcheries, it is extremely difficult to do so at affordable cost in large farms.

Normally water temperature is measured with mercury filled celsius thermometer for surface water. Reversible thermometer or temperature probe is used to obtain subsurface water temperature.

Salinity : The term salinity refers to the total concentration of all dissolved ions in gms contained in 1 kg. of seawater written either as ' /.. or parts per thousand (ppt). Seven ions (Na,K,Ca,Mg,Chloride, sulphate and bicarbonate) contribute to the saline nature of water. Table-1 gives typical concentrations of major ions in seawater, brackishwater and freshwater.

TABLE – 1 Typical Concentrations of Major Ions (mg/1) in Seawate Brackishwater and Freshwater

Ion	Seawater	Brackiswater	Freshwater
Chloride	19,000	12,090	6
Sodium	10,500	7,745	8
Sulphate	2,700	995	16
Magnesium	1,350	125	11
Calcium	400	308	42
Pottasium	380	75	2
Bicarbonate	142	156	174
Other	86	35	4
Total	34,558	21,529	263

Source : Boyd (1989)

Salinity as a single factor plays an important role in prawn farming as it is responsible for many functions such as metabolism, growth, osmotic behaviour, reproduction etc. Prawns have an optimal range of salinity for better growth and survival, depending on the species. If the salinity is allowed to go beyond the optimal limit, the prawns refrain from taking normal food and hence are emaciated and become susceptible to disease. younger prawns appear to tolerate a wide range of salinity than the adults.

In pond condition, the tiger prawn Penaeus monodon can tolerate wide range of salinity from as low as 5 ppt to a high of 40 ppt, but white prawn P. indicus and banana prawn P.merguiensis generally prefer brackishwater (Salinity : 5 to 25 ppt). Salinities above 45 to 60 ppt can be lethal. Most species will grow best at salinities of 15 to 30 ppt.

Due to high evaporation rate in summer, salt concentration in ponds gradually increases. Salinity may increase to beyond 40 ppt which can affect the growth of prawns. Water should be exchanged frequently either by pumps or throgh tidal exchange. The groundwater with low salinity (2-5 ppt) can be utilised for reducing the salinity. Seawater (35 ppt) mixed with groundwater can be used for preparing water with required salinity for use or for exchange. Sudden fluctuations in the salinity associated with the heavy rains result in heavy mortality.

Prawn larvae are produced in waters with salinities of 28 to 35 ppt, but advanced post larval stages often are stocked in ponds where salinity is much lower. At the time of stocking they should be acclimated gradually to the salinity of pond water so as to reduce stress and mortality. The acclimation rate should not exceed 1 or 2 ppt per hour. Acclimation can be accomplished by gradually adding low saline water to the higher saline water in which prawns are held. The acclimation procedure can be done at the hatchery, if a source of low saline water is available and the salinity of pond water is known. If the acclimation procedure will take more than 6 or 8 hours, post larvae should be fed. Aceration of the acclimation tank is desirable.

Acclimation also may be accomplished in the pond where post larvae will be stocked. During night time, bags containing the post larvae can be floated in a pond and pond water can be poured gradually into the bags until the salinity in the bags equals the salinity of the pond water.

In the case of brackishwater prawn farming, the maintenance of proper salinity without fluctuation is of greate importance. Salinity should be measured at the source and pond before pumping. If there is adequate flow of freshwater in the estuary/creek, salinity will start rising during spring tide and will decrease during ebb tide. The time for pumping should be decided after measuring the salinity frequently. If there is a sudden rainfall, the water to be pumped may become less saline or freshwater. During such periods drawing water from such source should be avoided as far as possible.

4. DISSOLVED OXYGEN

Dissolved oxygen (DO) is the most critical water quality variable in aquaculture. If DO concentration is low, the culture organisms become inactive and they are susceptible to diseases. Further more, in ponds where DO cocentrations are very low, many or even all the culture organisms may die from lack of oxygen. In order to have good feed conversion efficiency, high survival and aqequate profits, an aquaculturist must maintain greater level of DO in pond waters.

Although atmospheric air contains 21% of oxygen and serves as a reservoir of oxygen, its solubility in water is limited. When water is in contact with the atmosphere, oxygen from the air

will enter the water until the pressure of oxygen in water and air are equal. This condition is known as equilibrium or saturation. The concentration of DO at equilibrium increases with increasing pressure and decreases with water temperature and salinity. The pressure in the ponds located near the sea level is normally about 760 mm of mercury. Therefore, the influence of pressure on DO concentration will be insignificant. The equilibrium concentration of DO at different temperatures and salinity is given in Table-2.

Dissolved oxygen in the pond water comes from two sources. Most of it comes as a by-product of photosynthesis. The other source is from the diffusion of atmospheric air. The amount of DO in the pond is affected by many factors particularly water temperature, respiration of plants and animals and the level of organic matter. In tropical prawn ponds, the DO level in the pond water is normally low because of the higher temperature. However, tropical species are able to adopt to lower oxygen concentration than their temperate counterparts.

4.1 Fluctuations in dissolved oxygen concentrations

Plankton blooms reduce light penetration and the heavier the bloom, the lesser light available for photosynthesis at given depth. As a result, photosynthesis occurs most rapidly in the surface layer of water, and dissoved oxygen concentrations decline with depth. In deeper ponds, dissolved oxygen concentration may fall to o mg/litter at depths of 1.5 m or 2 m. The rate at which dissolved oxygen declines with depth increases with greaty turbidity; in ponds, phytoplankton often is the major source of turbidity. For this reason, it is advantageous to have

shallow ponds (75 cm to 150 cm deep). It is especially important to have fairly shaloow ponds for prawn, because they dwell primarily on the bottom and low dissolved oxygen concentrations at the pond bottom would be harmful.

The use of aerators results in mixing of water at surface and bottom and breaks down dissolved oxygen stratification. Black mud at the interface between the pond water and bottom mud indicates a lack of disslved oxygen. This black colour results from reduced iron compounds which form in the absence of oxygen. Oxygenated pond muds have a lighter colour (natural soil colour or a brownish colour). Aerators can eliminate black mud.

Concentrations of dissolved oxygen exhibit a diurnal cycle. The lowest concentrations of dissolved oxygen occur at dawn. During day light, photosynthesis causes dissolved oxygen concentrations to increase, and maximum dissolved oxygen concentrations are reached in the afternoon. During the night, photosynthesis ceases and respiration by organisms in the pond consumes oxygen and causes dissolved oxygen concentrations to fall. The diurnal cycle in dissolved oxygen is most pronounced in ponds with heavy phytoplankton blooms. Light intensity at the pond bottom is less than at the pond surface, and dissolved oxygen concentrations some times are lower at the bottom than at the surface. The influence of the diurnal cycle of dissolved oxygen on growth of aquaculture species if poorly understood, but most workers feel that good growth can be achieved as long as the dissolved oxygen concentration does not fall below 25% or 30% of saturation during the night.

Cloudy weather profoundly influences dissolved oxygen concentrations. This results because dissolved oxygen concentrations do not increase much on a cloudy day when compared to clear day. However, much oxygen is consumed at night by the pond biota. The influence of cloudy weather is more pronounced in a pond with a heavy phytoplankton bloom than in a pond with less phytoplankton.

Photoplankton in ponds may suddenly die and decompose, causing depletion of dissolved oxygen. The dissolved oxygen concentration do not return to normal until a new phytoplankton bloom is established. Most phytoplankton die off involve species of blue green algae. During calm weather, blue green algae often form scums at pond surfaces. Intense sunlight may result in sudden death of algae in this scum.

Mats of filamentous algae which develop on pond bottom may, under certain conditions, float to the surface of a pond and die. This phenomenon also can cause depletion of dissolved oxygen.

Water supply canals for shrimp farms in some countries are polluted with organic substances. On occasion, unusally large quantities of organic matter enter canals. If highly polluted water is pumped into ponds, decomposition of organic matter by bacteria may cause dissolved oxygen depletion.

Aeration can stabilize dissolved oxygen concentrations during the night, during cloudy weather and after phytoplankton die-offs. Aeration also can prevent stratification of dissolved oxygen and oxygenless areas on the pond bottom.

4.2 Feeding and dissolved oxygen

It has been shown that phytoplankton abundance is controlled by nutrient supply and that dissolved oxygen concentrations are regulated to larger extent by photoplankton abundance. Feed applied for prawn results in pollution of pond waters by organic and inorganic metabolic wastes from prawn. Uneaten feed also decomposes, releasing nutrients into the water. Consequently, phytoplankton abundance increases as a function of increasing feeding rate. As phytoplankton abundance increases, the diurnal cycle in dissolved oxygen becomes more extreme. Concentrations of dissolved oxygen at dawn are lower and concentrations of dissolved oxygen in the afternoon are higher. Additionally, dissolved oxygen concentrations decline more rapidly with depth as phytoplankton abundance increases in response to higher feeding rates. If phytoplankton blooms are extremely dense, dissolved oxygen may be low on pond bottoms, even in ponds where the water depth does not exceed 1m. The probability of dissolved oxygen depletion during cloudy weather and the likelihood of phytoplankton die-offs are greater in ponds with high feeding rates and abundant phytoplankton.

Higher feeding rates may be used in ponds if aeration is applied.

Feeding is a proven technique for increasing production. However, feeding results in deterioration of water quality, in greater phytoplankton abundance and in lower dissolved oxygen concentrations during the night. If feeds are applied in excessive quantity, dissolved oxygen depletion can result in

mortality of prawn. One of the effects of overfeeding is to decrease the feed conversion efficiency. As feeding rate increases, dissolved oxygen concentration during the night declines. Chronically low dissolved oxygen concentrations have an adverse effect on the appetite and metabolism of prawn, and prawn do not use feed efficiently where dissolved oxygen concentrations fall below 2 or 3 mg/l during night.

The dissolved oxygen (DO) level in the pond affects the appetite of the prawn of its food intake and, consequently, its growth. The existence of a desirable level of DO 3-10 ppm, in the pond indicates that the pond system is functioning efficiently. DO concentration below the minimum range is harmful. For Penaeid prawns optimum concentration of water DO reported for maximum growth rate is 6 ppm, but at the level of 4 ppm, the feeding rate was found to be reduced. Prolonged exposure to the stress of low concentration of DO lowers their resistence to disease also. In the ponds, the principal cause of massive prawn kills is the decrease in the oxygen level attributed to sudden change in weather condition and development of plankton bloom. DO concentration of 0.0 to 1.5 ppm can be lethal to prawns depending on exposure time and other conditions. High levels of DO supersaturation are also potentially harmful.

Sudden change of water conditions such as extremely calm and hot weather in the morning and a sudden rainfall in the afternoon causes oxygen depletion in ponds due to the thermal and salinity stratification in the pond water. The DO supply of the lower layer of the water is not enough to sustain the respirato / needs

of the prawns, plankton and other living, organisms in the pond resulting in massive prawns kills. At the sight of incoming rain, flushboards should be kept at a water level to enable rain water to float over saline water.

In ponds where plankton are grown as food base for the prawn, calm weather allows these to float on the water surface where intense sunlight kills them. These plankton die-offs greatly reduces the photosynthetic input of DO in the pond and increase the respratory load. When this condition occrus, change the water immediately. If die-offs happen during the lowest tide when no water could be drawn for water exchange, the principle of water agitation or water movement to generate oxygen could be used. Agitate the water in the affected ponds using aerators. Freshen water for all ponds during the incoming tide. A transparency (Secchi disc vasibility) less than 20 cm indicates that there is excess plankton bloom, therefore, the water should be changed immediately.

A strategy to maintain optimum level of DO would be to take advantage of major factors that increase DO and put into check the factors that decrease DO.

The first indication of possible oxygen stress may be in the behaviour of prawns e.g. crowding near the inflow, gasping for oxygen at the water surface by jumping out of water etc. The likely fall of DO level below optimum level can be predicted. Graphical representation of the procedure is illustrated in Fig.1.

Supplemental aeration during the night increases the diffusion of oxygen from atmosphere to the water and increase DO level conversely, aeration during the afternoon helps to remove the oxygen super-saturation of surface water layer by mixing oxygen rich surface water with sub-surface water. When water is supersaturated with DO, the oxygen diffuses from water to atmosphere. Water exchange is best solution to prevent low DO problems in the pond water where aeration is not practical.

To maintain DO at optimum level on continous cloudy days and during phytoplankton die-off, providing additional aerators for extra hours may be necessary. Water exchange and flushing out of decaying phytoplankton also helps to maintain DO.

It is essential to consider maximal utilization of the natural environment to maintain higher DO content in pond water such as :

(i) Orientation of the long axis of the pond with the prevailin wind.

(ii) Construction of larger pond to allow a greater contact of water surface with atmospheric air.

(iii) Promote wind action on the pond in facilitating water movement and oxygen diffusion.

(iv) Avoid planting of trees on dikes.

4.3 AERATORS

Aerators are mechanical devices that increase the rate at which oxygen enters water. There are two basic technique for aerating pond water: water is spalashed into the air or bubbles of air are released into the water. Hence we have "splasher" and "bubbler" aerators.

Splasher aerators include vertical pump, pump-sprayer, and paddle wheeel aerators. A vertical pump aerator consists of a motor with an impeller (Propeller) attached to its shaft. The motor is suspended below a float with a centre opening and the impeller jets water into the air at low velocity. A pump-sprayer aerator employs a centrifugal pump to spray water at high velocity through holes in a manifold and into the air. A paddle wheel aerator splashes water into the air as the paddle wheel rotates.

Bubbler aerators include diffused-air systems and propeller-aspirator-pumps. In a diffused-air system, an air blower or air compressor is employed to deliver air through an air line and the air is released through air diffusers located on the pond bottom or suspended in the water. The propeller-aspirator-pump aerator has a high velocity, uncased impeller at the end of a hollow shaft and housing. In operation air flows down the shaft by the venturi principle and is released into the water in fine bubbles.

The ability of an aerator to transfer dissolved oxygen to water is expressed as the standard oxygen transfer rate (SOTR) and the standard aerator efficiency. The SOTR is the amount of oxygen that an aerator will transfer in 1 hour to clear fresh water at $20^{o}C$ which contains 0 mg/1 dissolved oxygen.

Salinity has little effect on oxygen-transfer efficiency of aerators. However, water with high salinity is corrosive. Therefore, aerators for salt water must be protected from corrosion. it is possible to use stainless steel or plastic construction to reduce effects of corrosion. An alternative is

to use mild steel construction and employ a hot-dip galvanization procedure to coat the steel with a layer of corrosion resistant material. After the galvanized-surfaces have aged for about 6 months, a coat of epoxy paint over the galvanized surfaces will afford further protetion against corrosion.

Although most types of aerators can be used successfully in aquaculture, paddle wheel aerators apparently are the best.

Farmers always should remember that the goal in aquaculture production is to achieve maximum profits instead of maximum production. The maximum production will seldom, if ever, yield the maximum profit.

Aerators should be placed in ponds so that they produce the maximum circulation of water. When only one aerator is used, the location of the aerator is not critical. However, when two or more aerators are used, they should direct water in the same direction so that one aerator is not working against the currents produced by another aerator. Many times, an aerator is placed in each corner of a pond and circular water flow is established. Central dykes with gaps at ends may be used to obtain a circular flow with single aerator.

There are three basic ways of using aerators in ponds :

1. Emergency aeration when dissolved oxygen concentration is critically low.
2. Nightly aeration to stabilize dissolved oxygen concentrations, and
3. Continous aeration.

Day time aeration is not necessary in ponds with moderate feeding rates and, in fact, it is often counter productive, because it increases diffusion loss of oxygen from supersaturated surface water. At night dissolved oxygen concentrations will steadily decline and aeration may be used for upto 8 hours each night to stabilize dissolved oxygen. However, in ponds with higher feeding rates, continuous aeration may be necessary to mix water and prevent oxygenless areas on the pond bottom.

Water circulation in ponds does not replace the need for aeration but it can move water from aerators to all parts of the pond, prevent stratification of dissolved oxygen and maintain oxygenated conditions at the pond bottom-water interface. Paddle wheel aerators and propeller-aspirator pump aerators are excellent water circulators. The propeller-aspirator pump is probably better at circulating water in deeper ponds (1.5 m or more) than paddle wheel aerators.

5. HYDROGEN ION CONCENTRATION (pH)

The pH gives an idea whether the water is acidic (<7) or alkaline (>7). This is one of the most common water quality parameters since it affects the prawns indirectly. The pH value is an indicator of the presence of metabolites, photosynthetic activity, and fertility of the pond water. It changes with the accumulation of residual feed, dead algae, and excreta. It is at is maximum when photosynthetic activity is vigorous and decrease where there is none. High pH value means pond water is too fertile, therefore, there is the possibility of plankton bloom; also, toxicity of ammonia is increased. If the pH value is low,

the water is infertile and plankton growth is also slow, hence, less oxygen is produced from photosynthesis. The toxicity of nitrite and hydrogen sulphide is also increased. The pH of pond water should be 6.5 to 9.0. Above or below this range the water should immediately be changed. The growth of Penaeid prawn is retarded if pH falls below 5.0. The best range is 7 to 9.

Water with low pH (acidic condition) can be corrected by the controlled application of lime. Overliming is also not advaisable as it may reduce the availability of native and added phosphate (fertiliser) and some trace elements like iron and manganese needed for aquatic productivity. The use of powdered clam and oyster is also suggested for rectifying low pH conditions.

There are few data on the effect of pH on prawns, but it is safe to assume that respond to pH in much the same way as fish. The effect of pH on aquaculture species is given below :

pH	Effect
4	Acid death point
4-6	Slow growth
9-11	Slow growth
11	Alkaline death point

Brackishwaters are well buffered against pH change, and pH will seldom fall below 6.5 or rise above 9. Therefore, adverse effects of pH on prawns are uncommon. There are instances where acedic soils are problematic in prawn farming. This can be corrected by the application of lime. Agricultural gypsum ($CaSO_4$) can be applied to correct alkaline soil pH.

6. TURBIDITY

In prawn ponds, turbidity can be caused either by planktonic organisms or by suspended soil particles, of which the former is a desirable indication.

Secchi disc is used to measure the plankton concentration. Generally a Secchi disc visibility reading between 30 cm and 60 cm, indicates presence of adequate quantity of phytoplankton. Optimum phytoplankton density are associated with Secchi disc value of 25-35 cm. A Secchi disc reading of less than 25 cm indicates high density of plankton and hence fertilization rate and frequency should be reduced. Water exchange should be carried out to flush out excess bloom. A Secchi disc reading of 60 cm or more indicates low population of phytoplankton and therefore water should be fertilized with 5 kg. of urea and 5 kg of diammonium phosphate placed in gunny bags and submerged in water. Secchi disc visibility is affected by all types of turbidity hence while taking Secchi disc readings one must decide whether the turbidity is from phytoplankton or suspended particle or both. Planktonic turbidity measurement are made daily at 11.00 a.m. Optimum Secchi disc visibility for prawn farm is 40 - 60 cm.

Suspended soil particle (clay and silt) interfere with the penetration of light and in turn affects the growth of benthos. Suspended clay particles restrict the growth of phytoplankton by interfering with light penetration and absorbing nutrients present in water. suspended clay particles (above 4% by volume) damage the gills of prawns by clogging it. Soil particles settle

over the pond bottom and smother food organisms. In certain cases, oxygen deficiency has also been reported as a result of sudden increase in turbidity. The use of turbid water in hatcheries may greatly, affect the hatching rate and rearing of larvae.

Methods for removal of turbidity due to suspended soil particles involve removal of bulk sediment before water is taken into production ponds by using settlement ponds or canals. Sediment ponds can be either constructed inside the existing production ponds (Fig.2) or outside. It is also possible to construct a larger water supply canal as a settling basin (Fig.3). The size and depth of the sediment ponds has to be determined based on the size of production ponds, settlement rate of solids and desired water exchange.

Saline water facilitates the flocculation and sedimentation of suspended soil particles, and water retention times 1 to 2 hours are adequate generally. The major factor favouring rapid sedimentation is reduction of velocity and turbulance of water. Baffle levies can be used to reduce velocity and turbulance where only a small area is available for sedimentation. if possible, water supply canals or sedimentation ponds should be paired. In this way, one canal is available to supply water to the farm while accumulated sediment is removed from the other.

Installation of a well/sump pit or embedded perforated pipes at intake point provides clean water suitable for hatchery use. Storage and sedimentation tanks have to be used, when turbidity be removed at intake point. Following sedimentation, water

should be filtered through sand filters as sedimentation is not adequate to get rid of the water of fine suspended solids. Besides sand filters, cartridge filters with pore size down upto 0.32 micron are also used to further purify water. A schematic diagram of removal of turbidity in water for hatchery is presented in Fig.4.

7. NUTRIENTS - NITRITE AND PHOSPHATE

Phytoplankton is the base of the food web in prawn ponds. In semi-intensive and intensive culture,prawns are provided commercial feeds. Phytoplankton use inorganic nutrients and sunlight to produce organic matter by photosynthesis. The photosynthetic process may be illustrated by the following equation.

$$6CO_2+6H_2O \xrightarrow[\text{inorganic materials}]{\text{light,pigments and}} C_6H_{12}O_6+6O_2$$

Photosynthesis is a phototropic reaction in which plant pigments such as chlorophyll utilise light energy to reduce inorganic carbon (CO_2) to carbohydrate. Oxygen is released in the process; photosynthesis is the primary source of dissolved oxygen (DO) in aquaculture ponds.

A large number of inorganic elements are required for phytoplankton growth. Most species require at least the following: carbon, hydrogen, oxygen, nitrogen, sulphur, phosphorus, chloride, boron, molybdenum, calcium, magnesium, sodium, potassium,zinc, copper, iron and manganese. Diatoms are also require silicon. Phytoplankton produce oxygen by photosynthesis and they obtain hydrogen from water. Carbon

dioxide enters water from the atmosphere, so it usually is present at sufficient concentration.

Nitrogen and phosphorus are most likely to limit phytoplankton growth. Generally there is less nitrogen and phosphorus in pond water relative to phytoplankton needs than for other elements.

In brackishwater ponds with moderate or high salinity, diatoms are the dominant phytoplankton. Diatoms require fairly large amounts of nitrogen, and nitrogen often is as important or even more important than phosphorus as a limiting factor. When salinity is low, blue-green algae may become abundant in prawn ponds. Many species of blue-green algae can fix elemental nitrogen (N_2), so they can grow well without a continued source of nitrogen(nitrite or ammonia) provided phosphorus is plentiful.

Optimum nutrient concentrations are undefined. Since coastal waters are polluted slowly, there is a possibility that prawn farms are supplied waters that are contaminated with domestic sewage. This water contains moderate to high concentration of nitrate, ammonia, and phosphate. when held in ponds, this water usually will produce phytoplankton blooms. In ponds where feeds are applied, excretory products from prawn add ammonia and phosphate to water. If ponds are constructed in areas where waters are not polluted with sewage, it will be necessary to apply inorganic fertilisers or manures to foster phytoplankton growth.

Frequent inspection of ponds for possible leakages in dikes can prevent leaching of nutrients. A water depth gauge installed in ponds helps detect leakages.

8. NITRITE

Nitrite (NO^-_2) is an intermediate product in the bacterial oxidation of ammonia to nitrate (NO^{2-}_3), a process called nitrification

$$NH_3 + 3\ O_2 \quad \underline{\text{Nitrosomanas bacteria}} \quad 2NO^-_2 + 2\ H^- + 2\ H_2O$$

$$NO^-_2 + O_2 \quad \underline{\text{Nitrobactor bacteria}} \quad 2NO^{2-}_3$$

The toxicity of nitrite is known to be affected by water pH, and the presence of chloride and calcium ions. Nitrite toxicity increases with increasing pH. It decreases with increasing calcium and chloride concentrations. Hence nitrite is more toxic in freshwater than in seawater.

Nitrite in prawn ponds is seldom at concentrations great enough to kill prawn, but growth may be adversely affected by concentrations above 4 or 5 mg/l. The desired level is less than 0.20 mg/l for maximum production in brackishwater ponds.

In ponds, effective removal of organic waste, adequate aeration and correct application of fertilisers are the methods to prevent the accumulation of nitrite to toxic level. In hatcheries, control of nitrite may be accomplished by installing biological filters.

9. Alakalinity and Hardness

Total alkalinity is defined as the total concentration of titratable bases in water. Primary bases in water are HCO^-_3 and

CO^{-}_{3} ions. Total alkalinity is usually expressed as milligram per liter equivalent calcium carbonate ($CaCO_3$).

Total hardness is defined as the total concentration of divalent cations in waters, also expressed as milligram per liter of $CaCO_3$. The major divalent ions in water are calcium (Ca^{2+}), magnesium (Mg^{2+}) or both.

Total alkalinity and total hardness values are normally similar in magnitude because calcium, magnecium, bicarbonate and carbonate ions in water are derived in equivalent quantities from the solution of limestone in geological deposits. However, in some waters total alkalinity may exceed hardness and vice versa.

Alkalinity primarily determines the magnitude of diel fluctuation of pH of water. Waters with low alkalinity (less than 20 mg/l) has low buffering capacity against pH changes. This results in wide fluctuations in pH value from 6 or 7.5 at dawn to 10 or even higher in the afternoon. Very high alkalinity (200 to 250 mg/l) coupled with low hardness (less than 20 mg/l) results in rise in the afternoon pH beyond 11 and cause death of cultured organism. Very high alkalinity water may also suffer from poor productivity due to a limitation of carbon dioxide for photosynthesis. pH of water with moderate to high alkalinity values (20 - 150 mg/l), normally fluctuate between 7.5 or 8 at dawn and 9 or 10 in the afternoon.

The importance of hardness is closely related to alkalinity. However, low hardness water contains insufficient calcium ions. Hardness and alkalinity are more important for the exo-skeleton of prawns. They require calcium levels of at least 50%, possibly

75% of the staturation values found in their natural environments. In intermoult estuarine prawns recovery from calcium depletion was only satisfactory in water containing over 160 mg/l of calcium.

Alkalinity and hardness of water is increased by addition of agricultural lime (calcite or dolomite). Gypsum is supplied when excessively high water pH is encountered during afternoon. The treatment rate may be determined from the following equation.

Agricultural gypsum (mg/l) = (Total alkalinity-total hardness) x 2.2

In freshwater aquaculture alkalinity and hardness often are important considerations. The concentration of each variable should exceed 20 mg/l as $CaCO_3$. In brackishwater, alkalinity and hardness are usually high, so these variables are seldom important in management of prawn farms.

10. Carbon Dioxide

High concentrations of CO_2 can be tolerated by aquacultural species, although fish are known to avoid CO_2 concentrations as low as 5 mg/l. Concentrations of CO_2 below 20 mg/l probably are not harmful for prawn, provided DO concentrations are high. When DO concentrations are low, the presence of appreciable CO_2 hinders uptake of oxygen. Unfortunately, CO_2 concentrations normally are high when DO concentrations are low. This results because carbon dixoide is released in respiration and utilised in photosynthesis. Dissolved oxygen concentration declines when photosynthesis is not proceeding as rapidly as respiration, thus, CO_2 accumulates because it is not removed for use in photosysthesis.

Because of the necessity of light for photosynthesis, CO_2 concentrations increase at night and decrease during the day. High concentrations of CO_2 also occur in ponds during cloudy weather and following die-offs of phytoplankton or of filamentous algae.

It seldom is practical to remove CO_2 from pond waters. However, it sometimes is necessary to remove CO_2 from tanks or other containers in which prawn or fish are reared or held. Removal may be effected by applying calcium hydroxide ($CaOH_2$) or calcium oxide (CaO). For calcium hydroxide, apply 0.84 mg/l to remove 1 mg/l CO_2. Less calcium oxide is needed. 0.64 mg/l of calcium oxide will remove 1 mg/l of CO_2.

For example, water in a 25-m^3 tank contains 20 mg/l CO_2. To remove 20 mg/l CO_2 with calcium oxide will require 20 mg/l x 0.64 = 12.8 mg/l calcium oxide. On a cubic meter basis, 12.8 mg/l calcium oxide will require 12.8 g/m^3 of the substance. Hence, 320 g (25m^3 x 12.8 g/m^3) of calcium oxide must be applied to the tank.

11. Ammonia

Ammonia reaches pond water as a by-product of metabolism by animals by decomposition of organic matter by bacteria. In water, ammonia nitrogen occurs in two forms, un-ionized ammonia (NH_3) and ammoniam ion (NH^+_4), in a pH and temperature dependent equalibrium.

$$NH_3+H2_O = NH^+_4+ OH^-.$$

As pH rises, un-ionized ammonia increases relative to ammonium ion. Water temperature also causes an increase in the proportion

of un-ionized ammonia, but the effect of temperature is less than that of pH. analytical procedures for ammonia nitrogen measure, both un-ionized and ionized ammonia. Percentages of un-ionized ammonia at different temperature and pH values are available in the literature.

The toxicity of ammonia nitrogen is attributed primarily to the un-ionized form. As ammonia concentrations in water increase, ammonia excretion by aquatic organisms diminishes and levels of ammonia in blood and other tissues increases. The result is an elevation in blood pH and adverse effects on enzyme - catalyzed reactions and membrane stability. Ammonia increases oxygen consumption by tissues, damages gills and reduces the ability of blood to transport oxygen. Disease susceptibility also increases in organisms exposed to sublethal concentrations of ammonia.

The tolerance of a aquatic organisms to ammonia varies with species, physiological condition, and environmental factors. Lethal concentration for short-term exposure (24 to 72 hours) are between 0.4 and 2.0 mg/l of un-ionized ammonia. Concentrations of total ammonia nitrogen necessary to give 0.4 mg/l un-ionized ammonia at 30°C and different pH values follows :

pH	Concentration of total ammonia nitrogen to give 0.4 mg/l NH_3
7.0	49.38
7.5	15.62
8.0	5.32
8.5	1.93
9.0	0.89
9.5	0.56
10.0	0.45

ponds seldom contain more than 2 or 3 mg/l of total ammonia nitrogen. Obviously, ammonia toxicity will be a greater problem of high pH. It is difficult to evaluate ammonia concentrations in ponds. Because of the daily cycle in pH, un-ionized ammonia concentrations change continuously. Ammonia toxicity usually is expressed by reduced growth rate, inctead of mortality.

Concentrations of un-ionized ammonia (NH_3) above 1 mg/l are potentially lethal, concentrations greater than 0.1 mg/l may adversely affect growth of prawn. At pH 9.0 and salinity 20 ppt, about 25% of total ammonia is un-ionized. Therefore, total ammonia concentrations above 0.4 mg/l could negatively affect growth of prawn where pH is high.

The toxic effect of ammonia may be minimised in several ways.

1. Maintaining sufficient level of DO facilitates oxidation of ammonia to harmless nitrate by nitrifying bacteria.

2. Providing suitable slope to the pond bottom facili collection and removal of organic wastes.

3. Periodic partial removal of cyanobacterial and algal blooms by flushing or scooping out the scum facilitates optimum density and prevents sudden die-off of the bloom.

4. Application of materials like health stone powder (500 kg/ha) and BN_{10} (10-20 kg/ha) facilitates absorption of ammonia from the bottom sediments particularly when sediment is saturated. For reproduction suggested guidelines are NH_4-N, < 0.1 mg/l and NO_2-N, < 0.05 mg/l.

12. Hydrogen Sulphide

Under anaerobic conditions, certain heterotrophic becteria can use sulphate and other oxidized sulphur compounds as terminal electron acceptors in metabolism and excrete sulphide as illustrated below:

$$SO_4^{2-}{}_3 + 8H^+ = S^{2-} + 4H_2O$$

Sulphide is an ionization product of hydrogen sulphide and participates in the following equilibria.

$$H_2S = HS^- + H^+$$
$$HS^- = S^{2-} + H^+$$

The pH regulates the distribution of total sulphide among its forms(H_2S,HS^-, and S^{2-}). Un-ionized hydrogen sulphide is toxic to aquatic organisms;the ionic forms,however,have no appreciable toxicity. Analytical procedures measure total sulphides,Valves given below show the percentrages of un-ionised hydrogen sulphide at different pH values at 20^oC .

pH	Hydrogen sulphide,pct.
5.0	99.0
5.5	97.0
6.0	91.1
6.5	76.4
7.0	50.6
7.5	24.4
8.0	9.3
8.5	3.1
9.0	1.0

The percentage of hydrogen sulphide decreases as the pH increases. A water containing 0.01 mg/l total sulphide would have an H_2S concentration of 0.009 mg/l at pH 6 (0.01 x 0.911 =

0.009); the same total sulphide concentration at pH 8.5 would contain only 0.0003 mg/l

H_2S(0.01 x 0.031 = 0.0003).

Concentrations of 0.01 to 0.05 mg/l of H_2S may be lethal to aquatic organisms. Any detectable concentration of hydrogen sulphide is considered undesirable. The presence of hydrogen sulphide may be recognised without water analysis, for the "rotten-egg" smell of hydrogen sulphide is detectable at low concentration.

Using iron oxide (70% of ferrous oxide) to treat the bottom soil (@ 1kg/m^2) containing high levels of H_2S would not be economical. The cheaper means is by frequent exchange of water or aeration to prevent building up of H_2S in the ponds. Once H_2S has formed, it can be removed by oxidation with potassium permanganate (6.19 mg/l to remove 1 mg/l of H_2S) or it can be diluted by water exchange. The toxicity of H_2S can be counteracted through liming to raise the pH and ionize H_2S to non-toxic forms.

Removal of the organic waste accumulated at the pond bottm and/or application of health stone powder (500 kg/ha) and BN_{10} (10-20 kg/ha) to absorb H_2S are being practised. These "bioaugmentation" materials are said to remove H_2S, NH_3 and methane, and speed up organic decomposition.

Another product "NS series ER-49" which is supposed to function as mentioned above, should be applied after harvesting and dewatering. The recommended rate of application is as the following:

Depth of black soil after harvest	Dosage
0 - 3"	1 kg/ha
4" - 6"	2 kg/ha
7" - 8"	3 kg/ha
9" - 10"	4 kg/ha
11" - 12"	5 kg/ha

13. Residual Chlorine

Chlorine in various forms is commonly used in prawn hatcheries to disinfect seawater, usually as a batch process (5-10 ppm). This may cause toxicity problems. The residual chlorine if allowed to remain in water can form highly toxic chloramines with nitrogenous organic compound present in hatchery water.

Chlorine residuals in the range of 0.01 to 0.02 mg/l may have significant chronic effects on larvae and postlarvae of prawns. Residual chlorines can be allowed to decay in th storage tanks or it can be chemically removed by treating it with sodium thiosulphate pentahydrage (hypo). It is observed that hypo required to nuetralise 1 mg/l of residual chlorine gas will vary between 0.5 - 2 mg/l, due to the influnce of various factors specific to site and chemicals. Sodium thiosulphate is also toxic to penaeid prawns at concentrations above 0.5 mg/l. Without effective dechlorination and monitoring, chlorination of source water for hatchery purpose should be avoided.

14. Heavy metals

Fairly high concentrations of heavy metals have been reported in estuarine waters in many nations. thus, there is interest in the toxicity of heavy metals to prawn and other

...al species. the toxicity of heavy metals to a variety of species of freshwater and marine animals, mostly fish, were obtained from various publications and summarised below :

Metal	Range of 96 hr.[1] LC-50 (mg/l)	Safe level recommended by U.S. Environmental protection Agency (ug/l)
Cadmium	80-420	10
Chromium	2000-20000	100
Copper	300-1000	25
Lead	1000-40000	100
Mercury	10-40	0.10
Zinc	1000-10000	100

1= The 96 hour LC-50 is the concentration of a substance which will kill 50% of the organisms in a laboratory toxicity test within a 96-hr. exposure time.

The safe levels recommended by U.S. Environmental protection Agency are conservative estimates, which are 10 to 100 times lower than the lowest concentration which have been reported to harm organisms in laboratory toxicity tests.

The procedure for heavy metal analysis (atomic absorption spectrophotometry) measures the total concentration of a particular metal. Waters for shrimp ponds contain suspended clay particles and organic matter. Heavymetals are absorved onto clay particles and chelated by organic matter. some of the heavy metals also form complexes with oxides, hydroxide, and carbonates in water. The toxicity of heavy metals is related primarily to the dissolved, ionic form of the metal, eg., Cu^{2+} or Zn^{2+}, rather than to absorbed, chelated or complexed forms.

15. **Pesticides**

A number of pesticides are used on agricultural crops in tropical countries, and pesticides enter rivers runoff. Chlorinated hydrocarbon insecticides have the greatest potential for harming prawn and fish. Pesticide contamination can induce chronic soft shell syndrome in prawns. Toxicities of some selected insecticides to a wide range of freshwater and marine animals are summarized below :

Metal	Range of 96 hr.[1] LC-50 (ug/l)	Safe level recommended by U.S. Environmental protection Agency (ug/l)
Aldrin/Dieldrin	0.20 - 16	0.003
BHC	0.17 - 240	4
Chlordane	5 - 3000	0.01
DDT	0.24 - 2	0.001
Endrin	0.13 - 12	0.004
Heptachlor	0.10 - 230	0.001
Toxaphene	1 - 6	0.005

Again, the recommended safe level is well below the lowest concentration of an insecticide reported to harm aquatic organisms in laboratory toxicity tests.

Apparently, the use of pesticides with long residual lives is delcining in most countries, and many pesticides that are used today degrade to non-toxic forms within a few days. However, pesticides are potentially harmful until they are degraded.The use of pesticides in prawn farming areas should be discouraged. Pesticides sprayed into fields may drift over considerable areas and reach ponds or canals. Key factor for protecting ponds from

pesticides are as follows : locate prawn farm a considerable distance from pesticide - treated fields; plant trees or other high-growing vegetative cover between ponds and pesticide - treated fields to intercept airborne drift of pesticides; construct topographic barriers (ditches or trenches) to prevent run off from fields from entering ponds; finally, use proper methods of pesticide application to fields. The disposal of pesticides and pesticide containers should be done in such a way that pesticides do not contaminate waterways.

16. Water circulation and water exchange

There is a consensus among aquaculturists that water circulation in prawn culture ponds is beneficial. Water circulation prevents thermal and chemical stratification. this makes the entire pond area habitable and eliminates oxygen depletion at the mud-water interface. High concentration of oxygen at the pond bottom is especially important in prawn ponds, because prawn spend a lot of time at the bottom.

Prawn farmers often exchange water in ponds on a daily basis. The water exchange schedule for semi-intensive culture is given in the Table-3.

Table - 3. **Approximate Water Exchange Schedule for Semi-intensive Prawn Culture (For stocking density of 25/m^2**

Month	Water Exchange
One	Daily addition of 2-3 cm + 5% every 6th day (5 exchanges / month)
Two	10% every 5thday (6 exchanges / month)
Three	20% every 5th day (6 exchanges / month)
Four	30% every 3rd day (10 exchanges / day)
Average	5% per day

Though water exchange flushes out fertilizer nutrients, it causes some water circulation in the pond. there are many ideas about how to fix extrance gates and exit gates to achieve the best water circulation, but definitive answeres are not available.

Aeration of pond water causes water circulation and paddle wheel aerators are more efficient than other types in circulating pond water. There have been some studies of devices designed to circulate pond water. water circulation devices create surface turbulane and this effects a small degree of aeration. However, water circulators should not be considered as aerators. The greatest influence of water circulators on oxygen concentration results because these devices blend surface water with subsurface water. During daylight hours, surface water in ponds often are supersaturated with DO, and water at greater depths may have low DO concentrations. By mixing pond water, a uniform DO profile can be established. Oxygen produced by phytoplankton is

conserved by water mixing, because the high degree of DO supersaturation normally found at pond surface during daylight is eliminated by mixing. the total Do content of pond can be increased by mixing.

17. Pond sediment and water quality

Pond bottom soil resets with water and influence water quality. It plays an important role in the storage and release of nutrients to water and mineralisation of organic matter. Hence soil features such as its texture, composition and fertility govern water quality and pond productivity.

Nutrients easily leach off from sandy soil affecting the pond fertility. On the other hand clay soil can absorb to much of organic matter. The heavy putrification of organic matter may lead to acidity and Do depletion. When native fertility of soil is low, it tends to absorb nutrients from water and requiring higher fertilizer application. Heavy metals and pesticides absorb on the organic and inorganic solids and consequently settle down to the pond bottom. Polluted soils can reduce the growth of benthic organisms or have direct effects on burrowing animals such as prawns. Polluted soil can release toxic substances back into the water if disturbed, with harmful affects.

17.1 Redox Potential

In sediment, when input of organic matter exceeds the supply of oxygen needed for decomposition of organic matter, anaerobic condition can develop. This reducing condition can be measured as the redox potential (E_h). Redox potential indicates whether

the water or soil is in reduced condition (E_h with '-' value) or oxidised (E_h with '+'ve values) condition.

Reduced or anaerobic sediment may occur at the pond bottom of heavily stocked ponds with heavy organic load and poor water circulation. Under anaerobic condition of pond bottom, reduced substances such as H_2S, NH_3, CH_4 etc. are formed which are toxic to benthic organisms.

In prawn ponds, development of highly reducing conditions at the surface of the pond mud is a highly undesirable event. water circulation caused by water exchange, wind or aeration tends to move water across the mud surface and prevent the development of highly reduced conditions. bottoms should be smoothered and sloped to facilitate draining of organic waste and toxic substances. Draining at the centre of pond, as is being practised by some farmers, is an ideal remedy for the prevention of formation of highly reducing condition during the last phase of culture period.

18. Effluent Water Management

The waste water from the pond may be allowed into a small reservoir befor letting it into the environment so that the harmful minerals and waste may settle at the bottom. Periodically the sludge can be removed., This system will drastically remove or reduce the chances of pollution of the incoming wate especially in the case of brackishwater farming system where there is shunting of water (high tide and low tide).

Aquaculture effluents are rich in nutrients such as nitrogen and phosphorus and can be utilized by integration with other aquaculture or agriculture production systems. Culture of finfish, molluses and seaweeds in the effluent from prawn ponds have been tried with success for removal of dissolved nutrients and particulate organic matter from the effluent. Another alternate method for removal of nutrients and suspended solids from aquaculture effluents is retention of existing swamps/mangroves buffer zone close to the ponds or by replanting the same for deliberate purpose of waste treatment.

19. WATER QUALITY MANAGEMENT IN CULTURE SYSTEM

In water quality management, two types of water quality criteria may be specified: screening criteria and production criteria. The screening criteria are used to screen sites or water sources. if measured water quality does not satisfy the screening criteria for all components, small-scale rearing experiments may be needed prior to construction or more extensive water treatment will be needed prior to use. High concentrations of ammonia, nitrite pesticide residuals and heavy metals may make a site unacceptable as they are expensive and difficult to remove. On the other hand, low dissolved oxygen and high concentration of hydrogen sulphide, though not desirable, can sometimes be economically treated. The production criteria are the criteria used in the culture systes. The screening and production criteria for crustaceans and fish for use with seawater are presented in Table-4.

Table - 4 Preliminary water quality screening and production levels for seawater applications

Parameter	Screening level	Production level
Ammonia	< 1 ug/l NH_3 - N	< 10 ug/l NH_3 - N
Nitrite	< 0.05 mg/l NO_2-N	< 0.10 mg/l NO_3-N
DO	90% of saturation	6 mg/l
CO_2	5 mg/l CO_2	< 10 mg/l
H_2S	2 ug/l as H_2S	1 mg/l as H_2S
Chlorine residual	10 ug/l	< 1 ug/l
pH	7.9 - 8.2	< 7.9 - 8.2
Metals (Total)		
Cadmium	< 1 ug/l	< 3 ug/l
Chromium	< 10 ug/l	< 25 "
Copper	< 1 ug/l	< 3 "
Iron	< 300 ug/l	< 100 "
Mercury	< 0.04 ug/l	< 0.1 "
Manganese	< 50 ug/l	< 25 "
Nickel	< 2 ug/l	< 5 "
Lead	< 2 ug/l	< 4 "
Zinc	< 10 ug/l	< 25 "

Source : Huguenin and Colt 1989

There are relatively few economical management operations in prawn farming. Pond water can be fertilized, aerated, exchanged and mechanically circulated. fertilization can increase nutrient concentrations, enhance plankton growth, and increase natural productivity. Aeration can improve dissolved oxygen

concentrations and prevent mortalities. waterexchange has several effects including reducing nutrient concentrations and excessive plankton abundance, lowering concentrations of toxic metabolities, preventing excessive salinity in the dry season, providing water circulation, and improving dissolved oxygen concentrations. Mechanical water circulation provides greater uniformity of water quality variables throughtout the pond area, helps maintain oxygenated conditions at the mud surface and increase bottom temperatures. Suspended sediments can be removed from effluent water before it enters the pond to reduce sedimentation rates, or it can be allowed to accumulate in ponds and removed between crops. Pond bottom treatment between crops may improve bottom conditions and water for each new crop.

20.WATER QUALITY MANAGEMENT IN HATCHERIES

Because organisms tend to thrive well in its natural medium, it is the job of the culturist working with reproduction of penaeid prawns to provide seawater of basically oceanic character. Seawater is a complex medium consisting of primary (Table 1) and trace metals. Table 5 provides values for selected trace metals. these values are useful to assess non-oceanic water sources such as deep borewells or for evauation of contaminants in seawater systems. Reported values of trace elments in seawater are sometimes suspect, due to use of obsolete techniques, interferences, or lack of familiarity with curren methods of preconcentration of metals.

Appropriate water quality criteria are important for hatchery site selection and for hatcheries with water reuse

systems. Because water quality is so important to hatchery success, and because of the relative low flow rates, very conservative water quality criteria should be used in the hatchery. Suggested water quality criteria for penaeid prawns under hatchery conditions are presented in Table 6. Important parameters such as dissolved oxygen carbon dioxide and total gas pressure must be measured on-site and special techniques must be used to preserve samples for other analysis.

Water quality criteria are primarily based on single-factor laboratory experiments with selected life stages and species. Therefore, these criteria may under-estimate biological effects under production conditions where prawns are exposed to a number of compounds simultaneously.

Metals criteria are based on total metals (Particulate+dissoved forms), as the toxic mode of iron and manganese may be physical blocking of the gills by particulate matter. The addition of 1 - 10 mg/l of EDTA can significantly reduce the toxicity of heavy metals. In areas where heavy metal concentrations exceed the criteria in Table-4, it may be prudent to conduct pilot-scale rearing trials before finalizing hatchery design or starting construction.

In order to ensure good quality of seawater for the hatchery the water drawn from subsoil filter arranged below beach sands in the inter-tidal zone and should be treated as shown in Fig.4. The treatment involves the following steps

a) Filtration in intake system: This system removes most of the particulate matter.

b) Chlorination : Chlorinate @ 5-10 ppm for 1-2 hrs. This chlorination kills all pathogenic microbes, and also chemically removes iron by forming a red precipitate with it.

c) Filtration : The seawater should be recirculated through a rapid sand filter (50 u) till all the particulate matter and other precipitates are completely removed.

d) Dechlorination: The residual chlorine available in the treated seawater should be estimated with chlorine test kits by using 0-toludine. the residual chlorine thus estimated can be chemically neutralised by treating with sodium thiosulphate. This chemical reaction is as follows :-

$$2Cl_2 + 2Na_2S_2O_3.5\ H_2O \longrightarrow 2NaCl+Na_2S_4O_6+10\ H_2O$$

It is observed that sodium thiosulphate (hypo) required to neutralise 1 ppm of residual chlorine gas will vary between 0.5 - 2 ppm, due to the influence of various factors specific to site and chemicals.

e) Treatment with EDTA: It is safe to add 10 mg/l EDTA and allow to settle for one hour to remove heavy metals and fine debris.

f) Ultraviolet radiation : This treatment kills all the harmful gems in the water.

20.1 Dissolved Organic Substances

Water may be trated, before it enters the hatchery by filtration and sterilization, but unexplained mass mortalities

and periods of poor growth and survival may still occur, and it is generally supposed that some forms of dissolved organic matter are often responsible. Natural blooms of phytoplankton often (e.g. an acrylic acid-like substance from Phaeocystis and materials release by red tide algae) and bacteria produce harmful substances.

Dissolved yellow organic matter is ubiquitous in natural waters and may include soluble humin or dissolved humic acids or plant origin. Other sources may be melanoids of animal origin form feeds. some toxins and dissolved organics are highly resistant to biological oxidation, but many are destroyed by ozone fractionation.

Uncontrolled, these organics may form an excellent substrate for bacteria, fungi and protozoans which can either be pests or potential pathogens. Additionally, it is possible, that excessive organic loading is associated with lack of mating sometimes reported, either from buildup of metabolities or by masking of pheromones required for courtship.

20.2 Water quality conditions required broodstock maintenance

In order to achieve best production results and for production on a year round basis broodstock animals must be provided with quality seawater all times as given below :

1) Salinity - 26 to 32 ppt
2) Temperature - 28 to 32^{o}C
3) pH - 7.8 to 8.5

For maturation tanks, filtered, disinfected seawater is used, while for the spawning tanks and hatching tanks water filtered to 1 micron level using cartridge filters is used. Water level in the maturation tanks is kept at the level of 60 cm with a constant flow at about 10 liter per minute which provides 200% exchange per day. the water in the maturation, spawning and hatching tank should be aerated continously. Noise in the maturation section should be kept to a minimum. In general, the broodstock animals should be handled at a minimal level.

20.3 Water quality required for larval rearing

The environment in which the prawn larvae live is oceanic. The characteristic environmental parameters of seawater which acocunts for its quality are :

i) Salinity
ii) Temperature
iii) pH
iv) Turbidity
v) Dissolved oxygen content
vi) Nutrients
vii) Pollutants

Turbidity can be checked by filteration. Pollutants can be removed by seawater treatment. Deficiency of nutrients can be done away with, by enrichment in live feed cultures. The DO level could be maintained close to saturation by continuous aeration. Salinity, temperature, and pH are the three factors to be taken care of in a hatchery

i) Seawater salinity: This is a natural parameter, for which greater importance is given during site selection, since artificial manipulations to increase the salinity are laborious and uneconomical. However,

salinity can be brought down by adding freshwater. Salinity should be maintained from 28 to 36 ppt. Optimal salinity by species has not been experimentally determined, but this range is widely used in paeaeid research and commercial laboratories. This range is also generally matches the oceanic water character to which penaeids are exposed during breeing. In the hatchery, salinity should be checked everyday.

ii) Seawater temperature: While many aspects of temperature regimes have not been tested, the range of 28 to 32^{o}C is widely recommended. Generally, temperature below 26^{o}C will greatly reduce reproductive performance in most species. Low temperature problems can be overcome to some extent by using the following methods

* By providing natural light with translucent fibre glass sheet roofing.
* By covering the culture tanks with PVC/plastic sheets
* By using thermostatically controlled insulated immersion heaters in the culture tanks.
* By using room heaters.
* By using solar water heating systems.
* By passing the seawater through thermostatically controlled electrical heating system before filling the tanks.

High temperature can be checked by 1) providing shade cloths over the tanks and 2) providing proper ventilation to the culture rooms. Temperature should be recorded twice a day at 6 A.M. and 4 P.M.

iii) Seawater pH: The pH should be within the range of 8.2 to 8.5 for larval rearing operation. pH should be recorded along with the salinity once in a day.

21. WATER QUALITY MANAGEMENT BY MANIPULATING WATER COLOUR

Taiwanese prawn farmers pay much attention to the colour of the pond water. The major objectives associated with water colour manipulations in ponds are :

1. To increase dissolved oxygen and decrease Carbon dioxide,Ammonia, Hydrogen Sulphide and Methane in pond water.

2. To stabilize water quality and to lower the content of toxic compounds.

3. To make use of plankton as a natural feed.

4. To provide shade and to decrease cannibalism.

5. To increase and stabilize water temperature.

The principle behind this method of water quality management is, "some type of water colour are desirable, some are not". In order to achieve a particular colour, the steps adopted are

a) Application of fertilisers - ammonium salts are good for green algal growth while urea is good for brown algae/diatoms.

b) When the water colour becomes undesirable owing to over-blooming of algae/diatoms, bacteriocides and algicides may be used to control them.

c) Increasing aeration and/or partial water exchange with clear water may also resorted to.

d) Feeding also influences water colour. Avoid over-feeding.

The differnent types of water colour and the associated indicative water quality characteristics are given below :

Water colour	Main Causative	Indications
1. Reddish-brown to Pinkish Red.	Blooming of diatoms	6 to 15 tonnes/ha/ of P.monodon can b produced.
2. Light or Bright Green	Growth of green algae	This waters colour quite stable and mortality of praw low.Not difficult produce 4-8 tonne P. monodon in su conditions.
3. Dark Green algae high	Bloom of Blue-Green but growth rate sinks.	Survival rate of p
4. Dark brown and Soysauce colour brown algae	Rapid growth of Dinoflagellates & management.	Conditions are un rable. Poor pond
5. Yellowish colour	Growth of Chrysophyta and in addition green flagellates moderately	Growth of prawns inhibited. Mortal may be high
6. Turbid water	Clay, detritus & Zoo-Plankton suspension	Can be beneficial or harmful depend on the quality of suspended materia
7. Clear water	Lack of nutrients, the presence of heavy metal pollution like copper, manganese, iron or acid bottom clay.	Prawn growth poor Water not ideal f culture of P.mono

Source : Nutrient requirements feeding and culturing practic Penaeus monodon: A review by Jan Lung Chung - Taiwan.

Trouble indicators and remedial measures

Remarkable development in shrimp culture has been taking place all over the world and since beginning of this decade India has also atepped into Blue Revolution. although in genral there is rapid course of development in different parts of country as a whole, still there are many problems that are encountered by shrimp farmers. Taking precautionary/preventive measures on knowing the possible detrimental factors is one of the effective management measures for successful culture operation aiming at higher production.

Viewing this in mind, a complied account on vrious problem indicators and possible remedial measures are tabulated below. for the convenience of the readers this is divided mainly into three parts as :

1) Change in water colour
2) Swimming behavour against Oxygen content.
3) Genralised indicators in association with parasites and dise

Trouble Indicators Vs. Remedial Measures

General Index : Presence of dead/shrimp/fish

1. Change in water colour

Observation	Reasoning	Remedy
1. Water becoming clear	Death of phytoplankton and shortage of natural food	Exchange of water. Adding fertilizer and if possible algal inoculam.
2. Abrupt change of Water colour. Milky coloured water	Death of Algae and/or High decomposition	Exchange of water
3. Water turns reddish	Due to Algae giving off Toxin into the system	Exchange of water
4. Truns to Bright Green colour - Highly turbid cannot sea white coloured object even in 25 cm depth	Due to Blue Green Algae/ Bloom leads to O_2 depletion/release toxin into the system	-do- Reduce dosage or No supplementary fertilization.

Swimming Behaviour Vs O_2 Depletion

	Observation	Reasoning	Remedy
1.	Erratic swimming at the surface/frequently breaking the water surface at early morning hours.	Under stress due to low O_2	Exchange of water/ aeration by paddle wheels etc.
2.	Active swimming at the surface in day light hours	-do- and/or high temp.	-do-
3.	Active swimming at the edge of the pond in day light hours	Lack of food in the pond	Supplementary feeding
4.	Gobies swimming in stress or concentrated on the sides of the dykes.	Low dissolved O_2 content in the water	Exchange of water and/or aeration
5.	Snails climing out of water	-do-	-do-

Other indications

	Observation	Reasoning	Remedy
1.	Heavy concentration Rotifer and/or Zooplankton	Leads to O_2 depletion Building up of organic matter by decomposition or by heavy growth of bacteria. May be due to diseases.	Exchange of water
2.	Prawn with black gills.	Due to decomposed mud in which it burries.	Keep it in clean water for 2 days if the colour goes it is due to debris if not due to parasitic diseases. To start antibiotic treatment
3.	Prawn with white discolouration on their tail.	Due to disease or low O_2 and/or temperature (shows signs of stress and some may even jump out of water)	If the white spot disappears when placed in water wit good aeration, due to less O_2 / temp. or to start antibiotic treatment
4.	Prawn with papery shell(Not soft shell)	Usually due to lack of food	Supplementary feeding
5.	Shrimp with fuzzy growth on its shell	Bacteria/Protozoans/or Algae-first two related to water with high organic content-Indicates slow growth-delayed/no moulting	Antibiotic treatment with frequent exchange of water
6.	Black spots-look like an old injury	By bacterial diseases Associated with water of high organic content	-do-

	Observation	Reasoning	Remedy
7.	Bottom fauna dominated by chironomid worms	Indicator of pollution and very less O_2 content	Exchange of water
8.	Abrupt lowering of salinity	Due to heavy rain-Fresh water floats on the top of salt water and forms as a barrier-Results in deficient oxygen at the bottom layers	-do- and Mixing/Aeration
9.	Temperature above ^{o}C	-	-do- and to provide artificial shade
10.	pH variations	Usually not a threat-ening problem unless it lowers below 6	Application of lime

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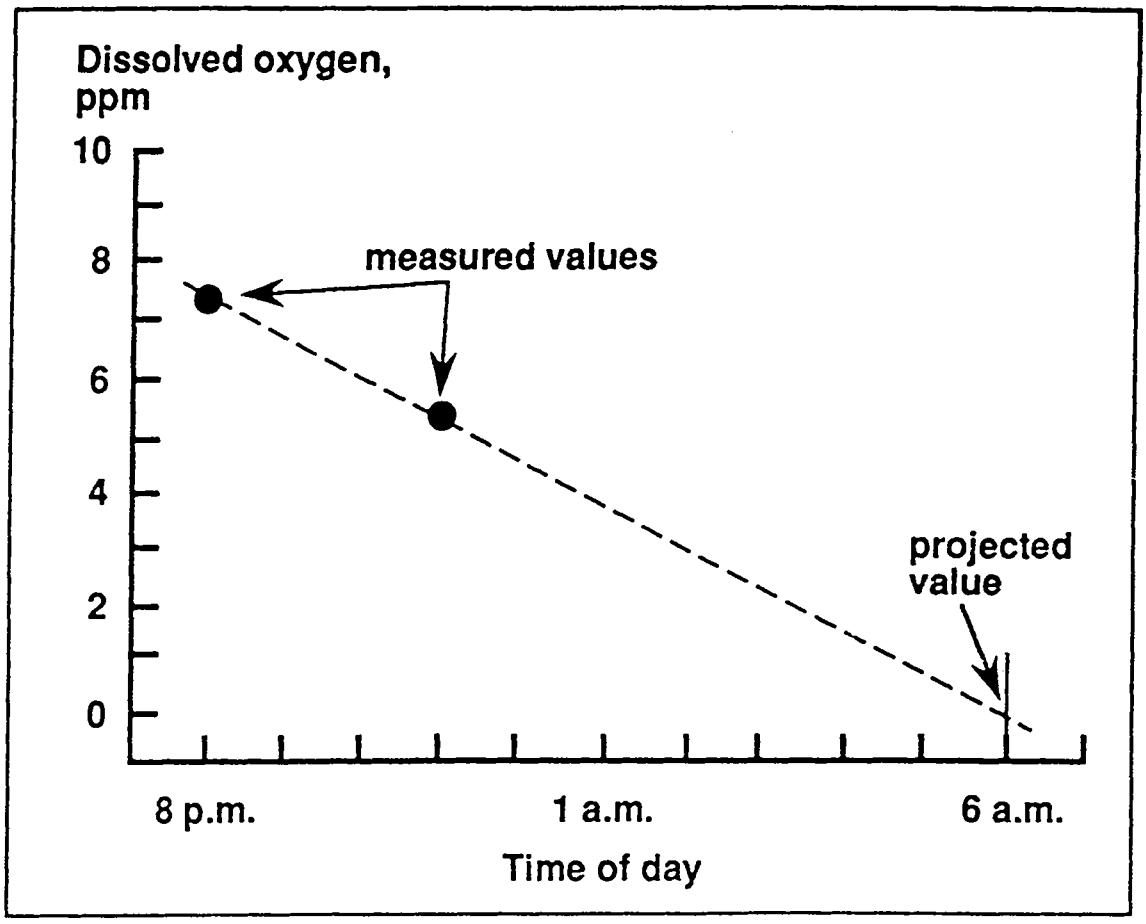

FIG. 1. Graphical representation of a procedure for predicting the nighttime decline in dissolved oxygen in a pond.

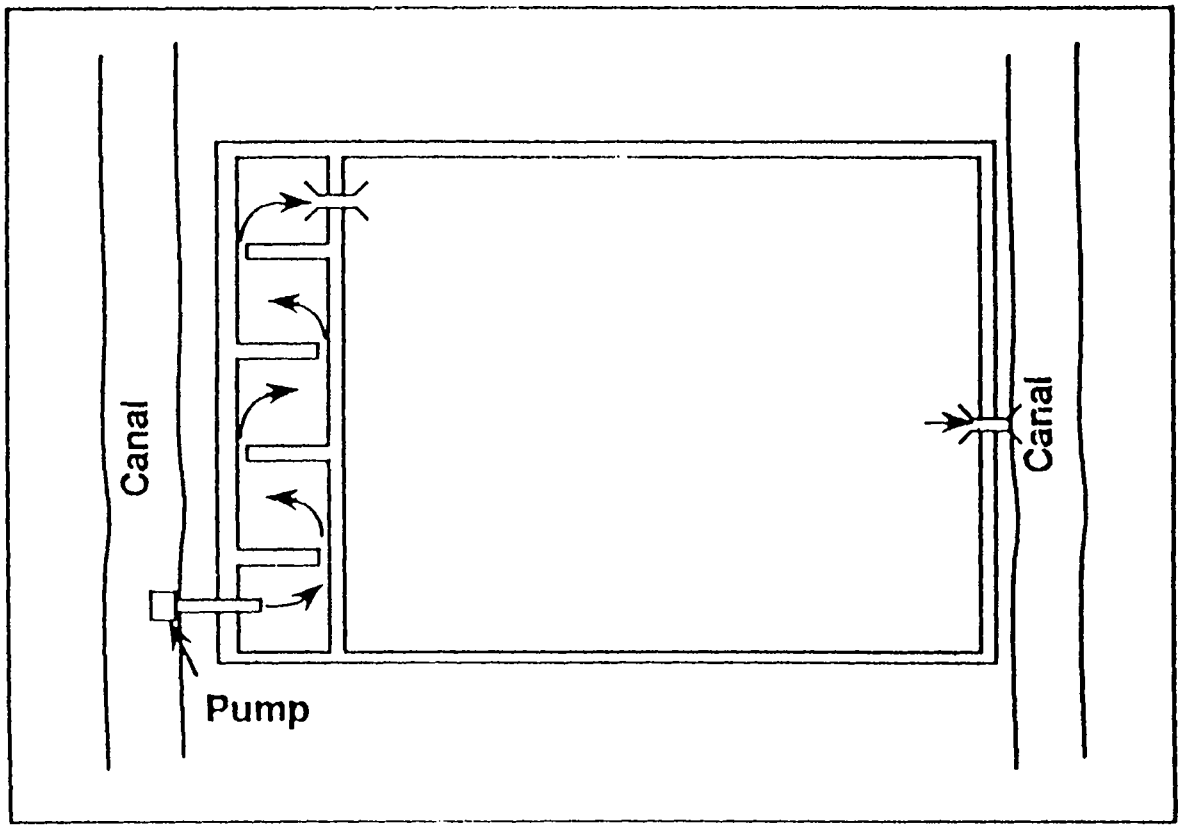

FIG. 2. Sediment pond installed in an existing shrimp culture pond.

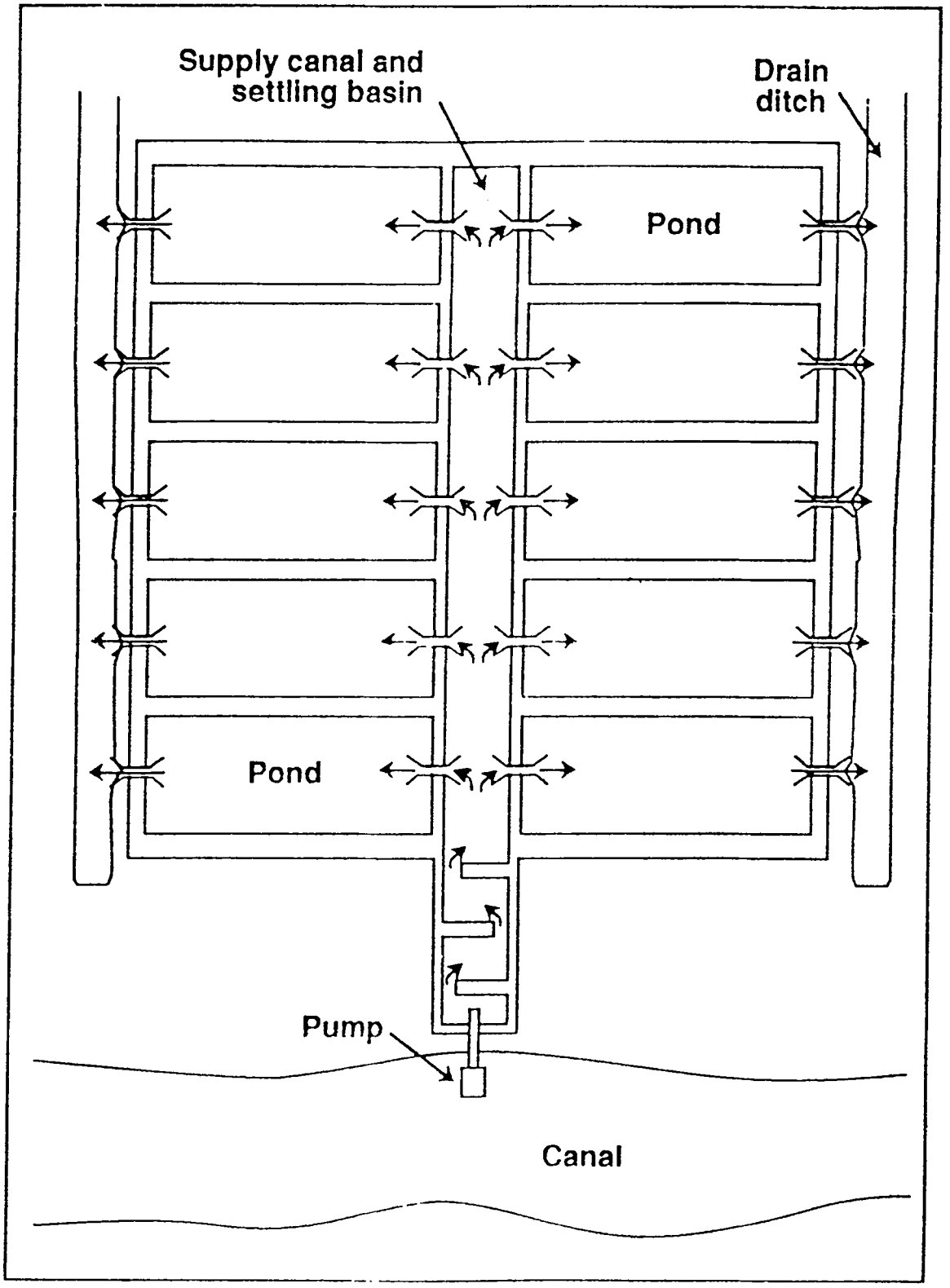

FIG. 3. Use of water supply canal as a sediment pond.

WATER AND SOIL ANALYSIS

BY
DR.K.O.JOSEPH

WATER AND SOIL ANALYSIS

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WATER AND SOIL ANALYSIS

1.WATER ANALYSIS

1. GENERAL ADVICE ON METHODS

Sampling Design:

The design of a sampling programme and the choice of parameters (water quality factors) for analysis will depend on the objectives of the investigation. This is best illustrated with a few practical examples of objectives and some considerations regarding sampling.

(a) Evaluating the suitability of a water supply for establishing a farm: Water quality is more critical for certain sensitive species such as prawns, or certain stages, such as maturation, hatching and larvel rearings where more thorough sampling may be necessary. Waters draining the mangrove swamps should be examined for seasonal variations in disovlved oxygen(D.O), in low pH and, hatchery water supplies for heavy metal and pesticide residues.

(b) Routine water quality monitoring on a prawn farm to ensure prawn health: Timing of sampling is important for critical conditions, e.g. just before dawn for minimum D.O., after feeding for maximum ammonia and chemical oxygen demand (C.O.D) and for suspended solids after rainstorms.

(c) Assessing natural productivity of a water body, as a basis for stocking and feeding in extensive systems: Important physical (such as temperature), as well as chemical factors such as salinity, dissolved solids and nutrients such as nitrate and phosphate.

Choice of parameters for analysis and sampling frequency

When deciding the sampling programme, it is useful to distinguish between "conservative" and "variable" properties in the water.

Conservative properties are the major constituents such as major ions (Na, Ca, Mg, chloride, bicarbonate and sulphate) and the related conductivity, total dissolved solids, hardness and alkalinity of the water. These properties are usually correlated with productivity. Infrequent sampling e.g. at 3 months intervals, should be adequate.

Variable properties include pH, D.O. COD, carbon dioxide suspended solids, ammonia (NH_3) and nitrite (NO_2) which are the most important as they are closely correlated with stress (often reflected in loss of appetite, poor growth and food utilization) and incidence of disease. Nutrient ions such as nitrate and phosphate, which often limit natural productivity, are also highly variable. All these variable properties require much more frequent sampling, such as weekly or even daily.

A guide for parameters to be measured and the frequency of sampling in a number of practical situations is given in Table.1.

Table 1.

Recommended sampling requirements for Water quality in aquaculture systems.

System	Parameters	Sampling Frequency	Time of sampling
Extensive prawn farming	Temperature, salinity pH, transparency, D.O. NH_3, No_2 & H_2S CO_2, PO_4, NO_3, B.O.D. & C.O.D.	Daily Weekly.	Morning & Evening
Semi-intensive prawn farming,	Transparency, salinity, COD, BOD, NH_3, NO_2 H_2S, alkalinity & hardness	Daily	------do---
	Temperature (surface & bottom), D.O. (surface and bottom) and pH. Phosphate and Nitrate	Twice a day weekly	----do---
Hatchery	Temperature, salinity, transparency, pH, D.O. NH_3, NO_2, COD & CO_2	Daily	-----do---

Sample collection and preservation

For surface water or in a well mixed system, a bucket sample is adequate. For subsurface samples, weighted bottle can be used, whose stopper can be removed by jerking a line which is attached as shown in Fig.1.

The following parameters can be analysed in the field itself.

	Parameter	Instrument
1.	Salinity	Salinometer(Refractometers)
2.	pH	pH meter (pen type)
3.	Temperature	Thermometer
4.	D.O.	D.O. Meter (membrane electrode type)
5.	Transparency	Secchi disc
6.	H_2S	Hach's H_2S Test kit.

The details regarding the volume of water to be collected, containers to be used and methods of preservation of water samples are given in Table 2.

Table 2

Details of proceedures for water sampling

Parameters	Volume of water to be collected (in ml)	Container	Preservation
1. D.O.	100	Glass stoppered bottle	Add first two Win reagents (A & B) immediately, prov that organic matt minimal. Exclude air bubbles.
2. NH_3,NO_2, NO_3 & COD	250	Polythene bottle	Add 1.25 ml 2 M H_2 SO_4
3. pH, CO_2, Hardness & Alkalinity	250	Polythene bottle	Add 5ml/1 of chlo (CH Cl_3) Exclude light & a
4. PO_4	250	-do-	Add above quantit of CH Cl_3, or H_2 if Fe precipitate
5. Heavy metals	500	Polythene bottle (for Hg, use glass bottle)	Add 2.5 ml conc.N
6. Pesticides	500	Low density polyethylene bottle	Freeze.

PARAMETERS

TEMPERATURE: Generally temperature of a water body is determined by the help of a centigrade thermometer graduated in 0.01° C scales or for more accurate readings in 0.01° C scales.

Temperature of surface water may be obtained by dipping the thermometer directly in the water for about one minute and then reading the temperature scale of the thermometer. Subsurface temperature of a deep water system may be determined by the help of a reversible thermometer. This termometer may be placed at any desired depth and the mercury column indicating the water temperature made fixed by means of a trigger arrangement. It can be hauled up and the temperature can be noted and afterwards the thermometer may be reset for further observations.

TURBIDITY: Among different methods available for turbidity dertermination, the method using Secchi disc (FIg.2) is used for field studies and gives fairly accurate results. A standard Secchi disc is a circular metal plate having 10 cm. radius. The upper surface of the disc is divided into four quadrants, painted in black and white colours alternatively, while the lower surface is painted with black. The disc is gradually lowered into the water and the depth (cm) at which the upper surface just

disappears is noted (d_1). Now the disc is slowly lifted upward and the depth at which the disc reappears is noted (d_2). The value $\frac{d_1+d_2}{2}$ in cm gives a measure of light penetration in the water body and is known as Secchi disc transparency.

Imhoff cone (Fig.3) is used to measure the quantity of solids settled (suspended matter that settles quickly). It holds 1 litre of water and the lower end of the cone is graduated. Throughly mixed water sample is poured into the cone. The volume of the sediment that has settled is read in millilitres per litre (ml/l) after one hour. Volume of solids settled greater than 20ml/l would result in rapid silting of the pond and decreasing of water depth.

HYDROGEN ION CONCENTRATION (pH): The pH of a system can be measured either colorimetrically or potentiometrically. Colorimetric determination with colour comparision is widely used in the fields. The principle of such estimation lies in developing colour in the sample with an indicator dye and comparing the colour with that of colour charts, colour discs, etc. Potentiometric method with electrically or battery operated pH meter with the help of suitable electrodes is used for determination of pH values for greater accuracy.

Reagents:

Any of the following indicators may be used for brackishwater environment depending on the expected pH ranges of the water:

Indicator	pH range
a. Bromothymol blue	6.0 - 7.6
b. Phenol red	6.8 - 8.4
c. Thymol blue	8.0 - 9.4

Procedure:

a) Colorimetric: Place 10 ml of the sample in a small glass tube and add 0.5 ml of indicator depending on the expected pH range of the solution, shake it gently and match the developed colour against colour disc or colour chart of the same indicator.

b) Potentiometric: Take the water sample in a clean beaker and dip the electrodes of the pH meter into it. The indicator of the pH meter shows the pH readings directly. Such pH meter gives the greatest accuracy. The meter should be calibrated routinely at pH 7.0 and then accuracy verified by testing a pH 9.2 buffer.

DISSOLVED OXYGEN: Dissolved oxygen in water can be determined to a fairly accurate extent by using Winkler's method. The principle behind the method is oxidation of divalent Mn^{++} ions to basic hydroxides of higher valency state by reaction with dissolved oxygen. When the solution is acidified in presence of iodine ion,

the oxidised Mn^{+++} again reverts to divalent state and iodine, equivalent to the original dissolved oxygen content of the water, is liberated. This iodine is titrated with standard Sodium-thiosulphate ($Na_2S_2O_3$) solution.

Reagents:

(Winckler's 'A' Solution)

a) Alkaline iodide: Dissolve 700 g pure potassium hydroxide (KOH) and 150 g potassium iodide (KI) in 1 litre of distilled water.

(Winckler's 'B' Solution)

b) Manganous Sulphate: Dissolove 480 g. of manganous sulphate ($MnSO_4$ $4H_2O$) in 1 litre of distilled water.

c) Concentrated sulphuric acid (H_2SO_4)

d) 0.1 (N) Potassium dichromate: Dry crystaline potassium dichromate ($K_2Cr_2O_7$) in an oven at 125 C, cool in dessicator, and weigh accurately 4.904 g. Dissolve in distilled water and make up the volume to 1 litre.

e) 0.025 (N) Sodium thiosulphate: Dissolve 24.82 g of crystaline sodium thiosulphate ($Na_2S_2O_3$ $5H_2O$) in 700 ml of distilled water, add 4.0 g of borax as a stabiliser and make the volume up to 1 litre. Standardise the strength of this solution to exactly 0.1

(N) by titrating against 0.1 (N) $K_2Cr_2O_7$. Take 25 ml of $K_2Cr_2O_7$ in a conical flask, add 1 ml of alkaline iodide, 2 ml of conc. H_2So_4 and titrate with 0.1 (N) $Na_2S_2O_3$ solution using starch as indicator near the end point. Achieve the end point as soon as blue colour turns colourless. Dilute 125 ml of this standardised stock solution of 0.1 (N) $Na_2S_2O_3$ to 500 ml.

f) Starch Solution: Add 2 g powdered starch and 30 ml 20% NaOH solution to about 350 ml distilled water. Stir until a thick, almost clear, solution is obtained. Neutralise the alkali with HCl and acidify with 1 ml glacial acetic acid to get a stable starch solution.

Procedure: Collect the water sample in 100 ml bottle and add immediately 1 ml of $MnSO_4$ and 1 ml of alkaline iodide reagents. Mix the solution thoroughly to develop a flocculant precipitate. Add 2 ml of concentrated H_2SO_4 to dissolve the precipitate and titrate 50 ml of the dissolved solution with 0.025 (N) $Na_2S_2O_3$ using starch as indicator. If the water sample is rich in organic substances, nitrite may occur in sufficient amount and interfere with the analysis. In such cases sodium azide modification should be used by adding 10 g NAN_3 in 1 litre of alkaline iodide reagent.

Calculations:

Dissolved oxygen (ppm) = quantity (ml) of 0.025 (N) $Na_2S_2O_3$ required for titration x 4

D.O. concentrations can be measured with water analysis kits or with polarographic oxygen meters when more measurement ought to be taken. Membranes and batteries of the meter should be changed routinely and readings should be checked for accuracy.

FREE CARBON DIOXIDE: This gas being liable to escape easily from the sample, the analysis should be done immediately after collection.

Reagent:

a) (N/44) Sodium hydroxide: Dissolve 4 g analytical NaOH in 1 litre of water and standardise it with 0.1 (N) H_2SO_4 using phenolphthalein as indicator to exactly 0.1 (N) strength. Dilute 100 ml of this standard 0.1 (N) NaOH with 440 ml distilled water to get N/44 NaOH.

b) Phenolphthalein indicator: Dissolve 0.5 g phenolphthalein in 100 ml of 50 per cent alcohol.

Procedure:

To a 50 ml sample, add 2 to 3 drops of phenolphthalein indicator. If pink colour develops, there is no free carbon dioxide. If colourless, titrate with N/44 NaOH till the colour turns pink.

Calculations:

free CO_2 = quantity (ml) of (N/44) NaOH required for titration x 20.

SALINITY: Salinity of brackishwater can be calculated to a fairly accurate extent from the chlorinity of water either by using Knudsen's hydrographical table or by the salinity and chlorinity relationship formulae. The chlorinity is generally estimated by precipitating the Cl-ions in water as AgCl by titrating with standard $AgNO_3$.

Reagents:

a) Silver nitrate: Dissolve 5.99 g of pure $AgNO_3$in 250 ml of distilled water. Standardise the solution by titrating against standard sodium chloride solution following the same method described below, so that 1 ml of $AgNO_3$ can be equivalent 1 to 5 mg.Cl^-.

b)Sodium Chloride: Dissolve 2.06 g analytical NaCl in 250 ml of distilled water. Each ml of this NaCl containe 5 mg.of Cl-ions.

c) Potassium Chromate: Dissolve 5 g. K_2CrO_4 in 80 ml of distilled water, add saturated $AgNO_3$ solution drop wise with constant stirring, until a red precipitate is formed. Filter the solution and dilute to 100 ml.

Procedure:

To a 5 ml of sample, add a few drops of K_2CrO_4 indicator. Titrate with standard $AgNO_3$ to the first appearance of permanent red colour.

Calculations: Chlorinity (ppt) = quantity (ml) of $AgNO_3$, used for titration.

Salinity (ppt) = Chlorinity (ppt) x 1.805 + 0.03.

ALKALINITY: Alkalinity is a measure of acid comibing capacity of the water and can be measured by titrating the water sample with a standard acid using suitable indicators for different types of alkalinity. For all practical purposes, however, total alkalinity, obtained by titration using methyl orange indicator, gives a satisfactory measure.

Reagents:

a) 0.02 (N) Sulphuric acid: Dilute 30 ml of concentrated H_2SO_4 to 1 litre with distilled water to get approximately 1 (N) stoc solution. To make 0.02 (N) H_2SO_4, take 20 ml of this stock solution and dilute to 1 litre with distilled water. Standardise this solution against 0.02 (N) Na_2CO_3, using methyl orange as indicator.

b) 0.02 (N) Sodium Carbonate: Dissolve 5.3 g. anhydrous Na_2CO_3 in 1 litre distilled water. Dilute 50 ml of this stock solution to 250 ml to get 0.02 (N) Na_2CO_3 solution.

c) Methyl orange Indicator: Dissolve 0.05 g Methyl orange in 100 ml of distilled water.

Procedure:

Add 2 drops of methyl orange indicator to 50 ml of water sample. If the sample remains colourless no alkalinity is there. If it is yellow, titrate with 0.002 (N) H_2SO_4 till the colour turns faint orange.

Calculations:

Total alkalinity (ppm of $CaCO_3$) = quantity (ml) of 0.02 (N) H_2SO_4 required for titration x 20.

HARDNESS: The concentration of calcium plus magnesium expressed as equivalent calcium carbonate is the total alkalinity. Calcium and magnesium ions are titrated with the complexing agent ethylenediamine tetracetic acid disodium salt (EDTA) to form the stable complexes CaEDTA and MgEDTA.

The end point of the titration is signalled with an indicator called eriochrome black-T.

Reagent:

Buffer Solution: Dissolve 67.5 g of NH_4Cl in 570 ml of concentrated NH_4OH. Dilute to 1,000 ml in a volumetric flask with distilled water.

Eriochrome black-T indicator: Dissolve 4.5 g of hydroxylamine hydrochloride and 0.50 of eriochrome black-T in 100 ml of 70% ethanol. Prepare fresh solution every 2 to 3 months.

Standard calcium solution 0.010 M: Transfer 1.000 g of anhydrous $CaCO_3$ to a 1000 ml beaker. Add 1:1 HCl slowly to dissolve the $CaCO_3$ and dilute to about 200 ml with distilled water. Boil for 5 to 10 minutes to expel carbon dioxide, cool and adjust to pH 7 as determined with a pH meter, with 3 N NH_4OH. Transfer to a 1000 ml volumetric flask and dilute to volume with distilled water.

Standard EDTA solution: Dissolve 4.00 EDTA disodium salt and 100 mg of $MgCl_2$ $6H_2O$ in distilled water and dilute to 1000 ml. The solution must be standardised against the standard calcium solution. Pipette 10 ml of the standard calcium solution into a 250 ml beaker and add 90 ml of distilled water. Titrate the calcium solution with EDTA solution according to the procedure given below. Compute the molarity of the EDTA solution with the equation: $NV = N'V'$.

Procedure:

Measure a 100 ml water sample into a 250 ml Erlenmeyer flask. Add 2.0 ml of the buffer solution and mix. Add 8 drops of eriochrome black-T indicator and titrate with the EDTA solution. At the end point, the solution will change from wine red to pure blue. Calculate the total hardness with the equation:

$$\text{Total hardness (mg/litre as } CaCO_3) = \frac{(T)(M)\ (100,100)}{S}$$

Where T = volume in millilityres of EDTA solution:

M = molarity of EDTA solution;

S = volume in millilitres of sample.

Comment:

For samples rich in hardness, e.g., sea water, dilute a 1.0 to 10.0 ml water sample to 100 ml with distilled water. Use the actual volume of sample in the calculation.

PHOSPHATE: Amount of inorganic phosphorus dissolved in water may be determined colorimetrically by developing phosphomolybdic blue colur. The intensity of this blue colour, which depends on the concentration of phosphorus in the solution, may be determined either visually or more accurately by the help of a photo-electric colorimeter or spectrophotometer and the concentration of phosphorus known from standards. Brackishwater may sometime contain considerable amount of fluoride ions to interfere with the estimation procedure and such interference may be minimised by using boric acid.

Reagents:

a) 2.5% Sulphomolybdic acid: Dissolve 25 g pure ammonium molybdate in 200 ml of distilled water by warming at 60° C

In another glass container, dillute 275 ml of phosphorus free concentrated H_2SO_4 to 750 ml with distilled water. After both the solutions have cooled down, add $(NH_4)_6$ Mo_7 O_24 (ammonium molybdate) solution to the dilute H_2SO_4 slowly by constant stirring. Cool down the mixture to room temperature, make up the volume to 1 litre with distilled water and store in an amber coloured bottle.

b) 2.5% stannous chloride: Dissolve 2.5 g of reagent grade $SnCl_2$, $2H_2O$ in about 5 ml of concentrated HCl with warming if necessary. Dilute to 50 ml with recently boiled distilled water and ultimately make up the volume to 100 ml with about 1.2 (N) HCl. Keep the reagent in a dark coloured bottle under a thin layer of pure liquid paraffin.

C) Standard Phosphorus solution: Dissolve 0.2195g of dried monobasic potassium dihydrogen orthophosphate in 400 ml phosphorus free water. Add 25 ml 1:5 H_2SO_4 water mixture and make up the volume to 1 litre with distilled water. This will give a stock solution of 50 ppm concentration of P. Keep this stock solution in a brown coloured bottle. Dilute 20 ml of this solution to 500 ml to prepare 2 ppm solution of P. When diluted to 50 ml volume for development of phosphomolybdic blue colour, this 2 ppm P solution gives the following values under different concentrations.

Vol.of 2 ppm Solution (ml)	Conc.of P (ppm) at 50 ml.volume
0.50	0.02
1.00	0.04
2.50	0.10
5.00	0.20
10.00	0.40

d) (0.8M) Boric acid: Dissolve 50 g H_3 BO_3 in 1 litre of distilled water.

Procedure:

a) Visual estimation: Place 25 ml of filtered water sample in a Nessler's tube, add 5 ml of H_3BO_3 solution, 2 ml of acid molybdate reagent and mix by gentle shaking. Add 5 drops of $SnCl_2$ solution make up the volume to 50 ml, shake gently and wait for 5 minutes for maximum development of blue colour. Compare the colour with the standards prepared with known concentrations of P.

b) Instrumental estimation: Develop blue colour with different known concentrations of P in a number of Nessler's tubes or 50 ml volumetric flasks by following the above-mentioned procedure and making the total volume of solution upto 50 ml. Find out the respective optical density readings by the help of a photoelectric colorimeter or a spectrophotometer and plot the readings against the corresponding concentrations of P to prepare a standard curve. Now take

25 ml of the unknown water sample and develop the blue colour by the above mentioned procedure for a total volume of 50 ml. Match the optical density reading for the solution with that of the standard curve and find out the corresponding P concentration.

Calculations: Dissolved inorganis P (ppm) = ppm of P in 50 ml solution x 2

BIOCHEMICAL OXYGEN DEMAND: The demand of oxygen in a water body may be exerted by (a) carbonaceous organic materials, (b) oxidizable nitrogenous compounds, and (c) certain chemically reducing compounds which react with dissolved molecular O_2 and thus creates oxygen tension in the water. This biochemical oxygen demand (BOD) has a direct bearing on the oxygen balance of the host water body particularly when the ecology is disturbed with fresh introduction of any organic material. Complete stabilisation of a given waste may require a period of incubation too long for practical purposes but a 5-day period has been accepted as standard.

Reagents:

a) (N) Sulphuric acid: Prepare approximately (N) H_2SO_4 by following the method described earlier in the determination of alkalinity.

b) (N) Sodium hydroxide: Prepare approximately (N) NaOH by dissolving 4 g NaOH in 100 ml of distilled water.

c) Seeding material: The selection of a proper seed is an important factor in BOD determination. Best way of preparing seed is from the place where the particular waste is dominant.

d) Reagnts for dissolved oxygen estimation: Use all the reagents required for the determination of D.O. with azide modification.

Procedure:

a) Saturate the distilled water meant for dilution with dissolved oxygen either by shaking a partially filled bottle or with a supply of clean compressed air keeping the temperature as near as possible at 20^{o} C.

b) Neutralise the pH of sample water to about 7.0 with H_2SO_4 or NaOH, if the initial alkalinity or acidity is high. Select a suitable seeding material, wherever necessary, depending on the nature of the waste present and inoculate it in the sample.

c) If the sample water is super-saturated with D.O. due to algal infestation or otherwise, shake it in a partially

filled water bottle to reduce the concentration to saturation.

d) Make, several dilutions of the prepared sample (seeded, if necessary) with the saturated dilution water in a graduated cylinder so as to obtain required depletions (almost 50%). Siphon out the mixed samples into two sets of specially designed BOD bottles, one set for incubation and the other for determination of initial D.O. The set for incubation should be waterlogged and kept for 5 days at $20^{o}C$ temperature. Prepare succeeding dilutions in the same manner. The dilution showing about 50% depletion should be considered for BOD estimation and the rest discarded.

Calcuations:

$$BOD_5 = \frac{Do - D}{P} \times 100$$

Where D_o = Initial D.O. of the mixture.

D = D.O. after 5 days of incubation

P = Dilution percentage.

NITRATE: Nitrate is the final product of nitrification which is a major nutrient required for phytoplankton. It is the least toxic of inorganic nitrogen components.

Pre-treatment and storage:

Samples should be filtered and are then stable for several hours in refrigerator in the dark. For longer delays, they should be deep frozen after filteration, and may be stored at $-20^{o}C$. Less satisfactorily 5 ml of concentrated 2 MH_2SO_4 may be added to each litre of sample as a preservative. (neutralise to pH 7 before analysis).

Principle: Nitrate is reduced to nitrite and it is determined using the sulphanilamide/NED method.

Reagents:

1. Phenol solution - 23 g phenol in 500 ml distilled water.
2. NaOH - 1.25 g in 500 ml distilled water.
3. Buffer reagent - mix equal volumes of phenol solution and NaOH solution.
4. $CuSO_4$ solution - 0.1 g in 1000 ml distilled water.
5. Hydrazine sulphate - 3.625 g in 500 ml distilled water.
6. Reducing agent - 5 ml of $CuSO_4$, solution to 5 ml of hydrazine sulphate.
7. Acetone
8. Sulphanilamide solution - Dissolve 5 g of sulphanilamide in 50 ml conc. HCl and make upto 500 ml with distilled water (stable for several months).

9. NED - Dissolve 0.5 g of N-(1-napthyl) - ethylenediamine dihydrochloride (NED) in 500 ml distilled water and keep in amber coloured bottle.
10. Standard Nitrate solution - Dissolve 0.36119 of KNO_3 in 250 ml distilled water. Dilute 100 ml of this solution to 1 litre with distilled water. This final solution contains 2 mg/litre NO_3-N.

Procedure:

Take 10 ml of sample and add 0.4 ml buffer and mix and then add 0.2 ml reducing agent and keep the tube in the dark for 24 hrs. Then add 0.4 ml of acetone and after 2 minutes add 0.2 ml of sulphanilamide. After 3 minutes, add 0.2 ml of NED solution and after 10 minutes, measure the absorbance at 540 nm in a spectrophotometer.

NITRITE: Nitrite is an intermediate product in the nitrification of ammonia to nitrate. It is toxic to fish/prawn and therefore it is important for aquaculturist.

In strongly acid medium, nitrite reacts with sulphanilamide to form a diazonium compound which reacts with N-(1-napthyl) - ethylendiamine dihydrochloride (NED) to form a strongly coloured azo compound.

Reagents:

1. Sulphanilamide (NH_2 C_6 H_4 SO_2 NH_2). Dissolve 5 g of sulphanilamide in 50 ml of concentrated HCl and make upto 500 ml with distilled water (stable for months).
2. N-(1-napthyl) ethylene diamine dihydrochloride (NED) - 0.1% solution (coupling reagent). Dissolve 0.50 g of NED in 500 ml of distilled water. Sotre in amber coloured glass bottle away from direct sunlight. Stable for one month if kept in dark bottle and stored in a refrigerator.

3. Standard Nitrite Solution:

a) Sodium nitrite ($NaNO_2$). Dissolve 0.345 g of $NaNO_2$ in 1 litre of distilled water (Add few drops of $CHCl_3$) ie. 70 mg nitrite - N/1. It should be stored in a borosilicate glass vessel in a refrigerator.

b) 1 ml of (a) dilute to 100 ml.
i.e. 1 ml = 0.7 mg/1 NO_2-N.

Procedure:

To each 50 ml of sample, add 1.0 ml of sulphanilamide, mix and after 2-8 minute, add 1.0 ml NED solution and mix. After 10 minutes, measure the absorbance at 540 nm in a spectorophotometer. The colour is stable for 2 hours.

Interference: When the water sample has a pH of greater or less than 7, it should be neutralized with IN HCl or IN NaOH respectively before adding the reagents.

AMMONIA: Ammonia is an important nutrient for phytoplankton. It is also the major end-product of protein metabolism excreted by aquatic animals. Ammonia in water consists of an unionised (NH_3) and ionised form (NH^+_4). Unionsed ammonia can be toxic to fish and other aquatic animals and is therefore of considerable significance in aquaculture. The temperature and pH of water should be measured at the time of sampling so that the percentage of unionised ammonia can be calculated.

Pre-treatment and Storage of sample:

Filter the sample and analyse them within three hours. For longer storage periods, the samples after filteration should be deep frozen. The sample may also be stored less satisfactorily, by adding 0.8 ml concentrated (18M) H_2SO_4 per litre (Neutralise with NaOH or KOH before making determination).

For the determination of ammonia in sea water, the method involving indo-phenol blue reaction is well known.

Reagents:

1. Phenol solution: dissolve 20g. phenol in 200ml of 95% v/v ethyl alcohol.
2. Sodium nitroprusside solution: dissolve 1.0 g sodium nitroprusside in 200 ml distilled water. Store in an amber bottle in the refrigerator. The solution is stable for at least one month.

3. Alkaline reagent: dissolve 100 g sodium citrate and 5 g sodium hydroxide in 500 ml distilled water.

4. Sodium hypochlorite: commercial bleach solution.

5. Oxidising solution: Mix 100ml of reagent (3) and 25 ml of reagent (4). This solution should be made up fresh before use and is stable for less than one day.

6. Ammonia stock solution: dissolve 0.9433 g of ammonium sulphate, $(NH_4)_2\ SO_4$ (A.R. dried in desiccator) in 1 litre distilled water. The solution contains 200.0 mg/litre and should be stored in glass vessel in a refrigerator.

Procedure:

To a 50 ml sample, add 2 ml phenol solution (1), mix by swirling and then add 2 ml sodium nitroprusside solution (2) and 5 ml oxidising solution (5). Cover the top of the flask and keep the sample out of direct sunlight. Read the absorbance at 640 nm in a spectrophotometer, after one hour at room temperature with a 10 cm length cuvette.

All the glassware used must be cleaned by washing initially with warm dillute hydrochloric acid and rinsing throughly with distilled water.

Dilute the standard stock solution to get working standards of lower concentrations (0,2,4, and 6 mg/l). Develop the color, as in the sample, following the same procedure. Measure the absorbance at 640nm in a spectrophotometer (10 cm cell) and draw a calibration graph. Compare the absorbance of the given sample and calculate the ammona concentration from the calibration graph. Reagents blank made up from distilled water should be run before each series of test and the values of samples adjusted accordingly.

Calculation of percentage unionised Ammonia:

The above mentioned method gives the total ammonia which is comprised of NH_3 and NH_4^+. The proportion of NH_3 depends on the pH and temperature of the water at the time of sampling. It may be calculated from the following equation.

$$\% \text{ unionised ammonia} = \frac{100}{1 + \text{antilog}(pKa - pH)}$$

where pKa = negative logarithm of the ionisation constant which depends on temperature.

Valuer of pKa of ammonia at temperature between 5 and 30° C.

Temperature (°C)	5	10	15	20	25	30
pKa	9.90	9.73	9.56	9.40	9.25	9.09

CHEMICAL OXYGEN DEMAND: The chemical oxygen demand of a water sample is a measure of the oxidisable organic material present in that sample.

Reagents:

1. M/80 Potassium Permanganate solution.

This should be made up as required by diluting a stock M/10 solution, containing 3.161 g $KMnO_4$/1, which should be standardised from time to time by any of the standard methods given in text books on volumetric analysis, eg.APHA (1980) 1 ml contains 0.1 mg of available oxygen.

2. M/80 (approx) sodium thiosulphate, $Na_2S_2O_3$ $5H_2O$ solution. Dissolve 24.82 g of $Na_2S_2O_3$. $5H_2O$ in distilled water and make up to 1 litre. Dilute 125 ml of this to 1 litre before use.

3. Dissolve 50 g K1 in 1 litre of distilled water.

4. Starch solution: To 100 ml of boiling distilled water add a slurry of starch (10 g in 10 ml) while stiring. Cool and filter and store in a refrigerator. Alternatively, use a solution of the readily soluble sodium starch glycollate.

5. 25% v/v sulphuric acid, H_2SO_4.

Procedure: Add 10.0 ml of permanganate solution (1) to 100 ml of sample in a 250 ml flask. Add 10 ml of sulphuric acid (5). As a

control, add the same reagents to a 100 ml sample of double-distilled water. place the sample and control in a boiling water bath for 30 minutes, remove and leave to cool. Add 1 ml iodide solution (3), shake and titrate the iodine produced with thiosulphate solution (2) from a 10-ml buratte using decoloration of starch solution (4) for the end point as in the Winkler method for D.O.

Calculation: If, V is the volume of thiosulphate titrated for the control, and V_2 is the corresponding titre for the sample, then the amount of oxygen absorbed by the sample is:

$$10 \frac{(V_1 - V_2)}{V_1} \quad \text{mg } O_2\text{/litre.}$$

IRON: Iron is an important micronutrient for phytoplankton and occurs in natural water in both oxidised (ferric) and reduced (ferrous) states, the later predomnating in oxygen-deficient water. Ground water supplies are often saturated with dissolved ferrous iron which is not toxic, tends to react with air to form a floc of hydrated ferric oxide which can smother developing eggs and larvae. The method given below is the simplest for the analyse of total iron.

In this procedure, iron is brought to solution, reduced to the ferrous state by boiling with acid and hydroxylamine and trated with 1, 10 phenanthroline at pH 3.2 to 3.3. Three

molecules of phenanthroline chelate each atom of ferrous iron to form an orange red complex which is measured spectrophotometrically at 508 nm.

Reagents:

1. Hydrochloric acid: Concentrated, 12 M.HCl containing less than 0.5 ppm of iron.

2. Hydroxylamine solution: Dissolve 10g.NH_2OH. HCl in 100 ml distilled water.

3. Ammonium acetate buffer solution: dissolve 250g $NH_4C_2H_3O_2$ in 150 ml distilled water and add 700 ml concentrated glacial acetic acid.

4. Phenanthroline solution: dissolve 100 mg 1, 10-phenanthroline monohydrate, $C_{12}H_8N_2$. H_2O in 100 ml distilled water (containing 2 drops of 12M HCl) by stirring and heating. Do not boil.

5. Standard iron solution: add slowly 20 ml of cone. H_2SO_4 50 ml distilled H_2O and dissolve 1.404 g. ferrous ammonium sulphate, $Fe(NH_4)_2(SO_4)_2.6H_2O$. Add a solution of potassium permangnate, $KMnO_4$ containing 3.2 g/litre, drop by drop until a faint colour persist. Dilute to 1000 ml with iron-free distilled H_2O and mix. This solution contains 200 mg/1.

Procedure: Measure 50 ml of sample into a 125 ml conical flask. Carry a blank and standards through the same procedure (if the sample contains greater than 2 mg/litre dilute the sample so that 50ml contains less than 100 mg Fe). Add 2 ml concentrated HCl and 1 ml hydroxylamine solution. Add some glass beads or boiling chips and heat to boiling and continue untill the sample volume is reduced to 25-20 ml. Cool to room temperature and transfer to a 50 ml volumetric flask. Add 10 ml ammonium acetate buffer solution and 2 ml phenanthroline solution and dilute to the mark with distilled H_2O. Mix throughly, place out of sunlight and measure the absorbance against the reagent blank at 508 nm after 15 minutes.

SOIL ANALYSIS

Collection of soil sample:

Collection of representative soil samples for different analysis merits great attention since any error at the time of sampling cannot be corrected at a later stage. Methods of sampling depend largely on the purpose for which the sample is drawn. Where one sample is taken to represent a given area, it is necessary to take a number of sub-samples from points scattered uniformly over the area (preferably along a zig-zag pattern) to be examined. After collection, the sub-samples should be combined together and mixed thoroughly. The entire sample should be spread into a layer and small portions of soils should be collected, at random, so that the sample taken (about 1/2 kg) is representative of the original material. The sample, thus collected, should be air-dried, ground to fine powder with the help of a wooden hammer, passed initially through a 2 mm sieve and finally through a 80 mesh sieve and sotred in a air-tight polythene bag for subsequent analyses.

Any of the tools such as tube auger, screw-type auger, post-hole auger, or spade can be used for digging the soil. Spade or tube auger is satisfactory for moist and soft soil. Screw-type auger is convenient for hard or dry soil, while post-hole auger is useful for wet soil. For collecting depth-profile core samples (0

to 30 cm, 30 to 60cm, 60 to 90cm and 90 to 120 cm), soil-core sampler available in the market can be used.

SOIL TEXTURE: The aim of textural analysis of soil is to determine the percentage of soil material contained in different size fractions and this can be done by means of mechanical analysis. Mechanical analysis consists essentially of two distinct operations, namely dispersion of the soil to ultimate soil particles and grading the dispersed particles according to their size groups.

Reagents:

a) 6% Hydrogen peroxide: H_2O_2 is generally available at 30% concentrations. Dilute 20 ml of this to 100 ml with distilled water before analysis.

b) 2 (N) Hydrochloric acid: Dilute 100 ml of concentrated HC1 to 600 ml distilled water to give approximately 2 (N) HC1.

c) 2(N) Sodium hydroxide: Dissolve 40 g of NaOH in about 300 ml distilled water and dilute upto 500 ml with distilled water.

d)5% Silver nitrate: Dissolve 5 g silver nitrate in 100 ml of distilled water.

Procedure:

Take 20 g soil in a 500 ml beaker, add 250 ml of water and boil for 10 minutes, allow the suspension to settle and decant the supernatent water. Now, digest the soil with 35 ml of 6% H_2 O_2 on a water bath adding more H_2 O_2 till no frothing takes place. Add 30-35 ml of 2 (N) HCl and 100 ml of distilled water and allow to stand for 1 hour with occasional stirring to make the soil free from carbonates. Filter the soil and wash free of HCl with hot water by testing with $AgNO_3$ solution. Transfer, the suspension to a suitable glass container, add 5 ml of 2 (N) NaOH and shake for half an hour. Transfer the content to a 1000 ml tall cylinder, make up the volume, shake for 1 minute and allow to stand. After 4 minutes lower a 20ml pipette at 10 cm depth and collect 20 ml of the content, dry it in a 50 ml beaker and find out the weight of clay + silt. Repeat the same procedure after 6 hours get the weight of clay alone.

Calculations:

If weight of clay + silt be x g

and that of clay only be y g

then, % of clay = y x 250

% of silt = (x-y) x 250

% of sand = 100 - (x X 250)

HYDROGEN ION CONCENTRATION (pH): Principles for estimation of pH of soil samples are basically the same as in case of water analysis viz., colorimetric and potentiometric. In both the cases, however, a soil-water suspension is used to determine the pH values of soils.

Reagents:

a) Indicators: As decribed in the water analysis methods.

b)Neutral Barium Sulphate: Analytical quality reagent should be procurred from the market.

Procedure:

a) Colorimetric: To a 1 cm thick layer of neutral $BaSO_4$ (Barium Sulphate) in a 50 ml clean dry test tube, add 10 g of air dry soil sample and 25ml of distilled water. Shake well and keep it for settling for about half-an-hour. Then take out 10 ml of supernatent water and determine the pH value colorimetrically as stated in the water analysis methods.

b)Potentiometric: Take 10 g of prepared soil sample in a clean 50 ml beaker, shake with 25ml of distilled water and keep for about half-an-hour with occasional stirring. Then find out the pH value of soil water suspensions by the help of a pH meter following the method described under water analysis.

ELECTRICAL CONDUCTIVITY (EC): Electrical conductivity is commonly used for indicating the total concentration of the ionized constitutents of a system. It is closely related to the sum of cations (or anions), as determined chemically and usually correlates with the total water soluble solids. It is a rapid and reasonably precise determination that does not alter or consume any of the sample.

Instrumentation:

Conductivity meter

Procedure:

The same soil-water (1:2.5) suspension for pH estimation may be used for electrical conductivity determination also. Rinse the cell with the soil-water suspension to be measured and then read the conductivity using the sample suspension.

ORGANIC CARBON: The rapid titration method of Walkley and Black has an advantage that it excludes the less active elementary carbon and includes those parts of organic carbon of soil which play an important role in nutrient availability. This method is widely used for estimating the organic carbon content of freshwater fish pond soils and with some modifications may be used for brackishwater fish pond soils also.

Reagents:

a) (N)Potassium dichromate: Dissolve exactly 49.04 g of solid $K_2Cr_2O_7$ in distilled water and make the volume upto 1 litre.

b) Sulphuric acid with silver sulphate: Dissolve 5.0 g of $AgSO_4$ in 100 ml of concentrated H_2SO_4.

c) 85% Orthophosphoric acid: Available in the market.

d) Diphenylamine indicator: Dissolve 0.5 g of ragent grade diphenylamine in 20 ml water and 100 ml of concentrated H_2SO_4.

e) (N)Ferrous ammonium sulphate: Dissolve 392.2 g of $Fe(NH4)_2.6H_2O$ in 800 ml distilled water containing 20 ml concentrated $H_2\ SO_4$ and dilute to 1 litre with distilled water.

Procedure:

Place 1 g of soil sample in a 500 ml conical flask and moisten it with a few ml of distilled water. After about 10 minutes, add exactly 10 ml of (N) $K_2Cr_2O_7$ and 20 ml of $AgSO_4$ mixed H_2SO_4. Mix by gentle rotarion and allow to stand for 30 minutes. Then dilute the mixture with 200 ml of distilled water and add 10 ml of phosphoric acid. Titrate the entire volume with (N) $Fe(NH_4)_2.(SO_4)_2$ using 1 ml diphenylamine as indicator. The colour is dull green at the beginning which turns to a turbid blue as the

titration proceeds and at the end point sharply changes to a brilliant green. Carry out a separate standardization blank in the same way using all the reagents except soil.

Calculations:

Organic carbon (%) = (titration value (ml) blank-titration value (ml) with soil) x 0.3

AVAILABLE NITROGEN: Among different methods of estimating available soil nitrogen, the alkaline permanganate method of Subbiah and Asija (1956) which includes the easily oxidizable organic nitrogen, has been reported to have good correlation with productivity of brackishwater fish ponds.

Reagents

a) 0.32% Potassium Permanganate: Dissolve 3.2 g of $KMnO_4$ crystals in distilled water and make the volume upto 1 litre.

b) 0.02 (N) Sulphuric acid: Prepare 0.02 (N) H_2SO_4 following the method described in water alkalinity test.

c) 0.02 (N) Sodium hydroxide: Prepare a standard 0.1(N)NaOH solution by following the method described under determination of carbondioxide. Dilute 50 ml of this stock solution to exactly 250 ml with distilled water to get 0.02 (N) NaOH.

d) Methyl red: Dissolve 0.1 g of methyl red indicator powder in 15ml ethyl alcohol and make up the volume to 50 ml with distilled water.

e) 2.5% Sodium hydroxide: Dissolve 25 g of pure NaOH pellets in 1 litre of distilled water.

Procedure:

Take 10 g of soil sample in a 500 ml Kjeldahl's flask, add 100 ml of 0.32% $KMnO_4$ and 100 ml of 2.5% NaOH solution. Distill the mixture after adding 2 ml of liquid paraffin and 10-15 glass beads to avoid frothing. Collect 75 ml distillate in the receiving flask containing 20 ml 0.02 (N) H_2SO_4 with a few drops of methyl red indicator and titrate with 0.02 (N)NaOH to a colourless end point.

Calculations:

Available nitrogen (mg/100 g soil) =

(20 - ml of 0.02 (N) NaOH required for titration) x 2.8

AVAILABLE PHOSPHORUS: Different methods are available to determine the amount of available soil phosphorus and the choice for a suitable method depends largely on the nature and properties of the soils. Due to slightly alkaline reactions of majority of brackishwater fish pond soils, extraction of available phosphorus eithr by Bray's solution No.2 or Olsens reagent may be considered

suitable for such soils. The method involving reaction with Bray's No.2 extractant is described here due to the simplicity and rapidity of the procedure.

Reagents:

a. Bray's No.2 extractant: Dissolve 1.11 g of ammonium fluoride in 1 litre of 0.1 (N) HCl.

b) 1.5% Chloromolybdic acid: Dissolve 15 g of $(NH_4)\ MO_7\ O_{24}$ in 300 ml distilled water with warming. Cool the solution and add slowly 350 ml of 10 (N) HCl with rapid stirring. Dilute the solution with distilled water to 1000 ml volume, mix thoroughly and keep in an amber coloured bottle. This 1.5% chloromolybdic acid should be replaced every 2 months.

c) 2.5% $SnCl_2$: Prepare the reagent following the method described in phosphate analysis in water above.

d) Standard P Solution: Follow the procedure described under Phosphate water analysis in water above.

e) 0.8(M) Boric acid: Follow the procedure described under phosphate analysis in water above.

Procedure:

Take 2.0 g of prepared soil sample in a test tube, add 15 ml of Bray's No.2 extractant and shake for 40 second by hand. Filter the suspension immediately on a moist Whatman No.42 Filter paper. Take 2 ml of the clear filtrate and find out the concentration of P in that solution by following the method described in water

phosphate analysis above with the only exception that chloromolybdic acid should be used instead of sulphomolybdic acid.

Calculations:

If the concentration of P in solution (2 ml filterate diluted to 50 ml) be x ppm

Amount of available phosphorous (mg/100 g soil) = x X 18.75.

IRON:

Reagents:

1.Sodium dithionite ($Na_2S_2O_4$) powder

2.Sodium citrate-sodium bicarbonate buffer solution.

Mix 800 ml 0.3 M trisodium citrate solution with 100 ml 1 M sodium bicarbonate solution.

3.Saturated sodium chloride solution. Use analytical grade salt.

4.Orthophenanthroline solution, 0.4%. Dissolve 1 g of 1,10 phenanthroline monohydrate in 250 ml water. Warm if necessary to dissolve the reagent.

5.Standard Fe solution, 500 ppm. Dissolve 0.250g analytical grade iron wire in 50 ml 0.6(N) HCl plus 5 ml concentrated nitric acid, both analytical grade, and dilute to 500 ml. To prepare a working standard, 20 ppm Fe, dilute this solution twentifive-fold; prepare fresh every week.

6. Thioglycollic acid solution, 4% in water.

7.Sodium acetate-acetic acid buffer solution, pH 5.0.Dissolve 82 g anhydrous sodium acetate or 136 g of the trihydrate in water, add 27 ml glacial acetic acid, and dilute to about 900 ml. Adjust the pH to 5.0, and dilute to one litre.

Instrumentation

Photoelectric colorimeter.

Procedure:

Weigh 5.000 g airdry soil into a 100 ml centrifuge tube and add 50 ml citrate-bicarbonate solution. Keep the tube in a water bath at 80° C. When the contents have reached about 75°C temperature, stir the suspension and add 1 g sodium dithionite. Stir immediately and continue stirring for one minute. Then stir occasionally for 15 min. Do not allow the temperature to exceed 80°C, or elemental sulphur may precipitate.

Remove from the water bath, add 10 ml saturated NaCl solution, mix, cool and centrifuge clear. Collect the supernatant in a 500 ml volumetric flask.

Repeat the extraction and washing (twice if the soil contains more than 5 per cent extractable iron), adding the centrifuged solution to the same flask. Wash the residue twice with 20 ml citrate-bicarbonate and 10 ml NaCl, stirring well each

time, and collect the washings in the volumetric flask. Dilute to volume with water. Record the total volume of citrate-bicarbonate and NaCl used.

Prepare a blank solution with the same volume of citrate-bicarbonate and NaCl solutions.

Pipette 0,1,2,3,4, 6 and 8 ml of the Fe working standard (20 ppm) into each of six 50 ml volumetric flasks. Add 10 ml sodium acetate buffer solution to each, followed by 1 ml thioglycollic acid solution. Mix, add 2 ml 1,10 phenanthroline solution, and dilute to volume. After 5 min determine the transmittance of each of the Fe solutions at 515 nm against the zero Fe solution. This will give a standard curve in the range 0 to 0.160 mg Fe.

For the test samples, pipette a suitable aliquot containing 0.015 to 0.150 mg Fe into a 50 ml volumetric flask and develop the colour as above. Run an equal volume of the blank solution simultaneously. Determine the transmittance of both solutions at 515 nm against the same colour blank as the standards. Calculate the Fe in the sample aliquot and the solution blank from the standard curve.

Calculation:

Extractable Fe in soil, %

$= E\ (S-B)/V \times 1/1000 \times 100/w \times (100 + m)/100$

where S = Fe in sample aliquot, mg

B = Fe in blank aliquot, mg

E = Volume of original extract, ml

W = Weight of airdry soil, g

m = airdry moisture content, %

The division by 1000 is to convert mg into g.

Note that S and B are in mg.

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STOCKING

BY
DR.L.HANUMANTHA RAO

STOCKING

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STOCKING

INTRODUCTION

Prawn seed, for stocking in grow out ponds is obtained either from wild or from hatcheries.

Species

The criteria for selecting suitable species of prawn for culture in brackishwater ponds are:

1. ability to tolerate fluctuations in salinity
2. ability to accept artificial feeds.
3. high conversion ratio of feed
4. high survival and good growth
5. adequate availability of seed
6. high market demand.

Several species of prawn seed is available in estuaries, backwaters, creeks, brackishwater lagoons in India. Of the penaeid prawns, penaeus monodon and penaeus indicus are suitable species for culture in grow out ponds.

SEED FROM WILD

Penaeus monodon: It is commonly known as 'Tiger prawn'. It forms a sizable fishery in Andhra Pradesh, Orissa and West Bengal. The post-larvae occur in the lower zone of estuaries and mouth of lagoons with peaks during March-June and juveniles are collected during June-September.

P.Monodon accepts artificial feed, food conversion rate is very

high. It grows to 25-35g of in 4 months in culture systems and tolerates wide fluctuations in salinity.

Penaeus indicus: It is commonly known as 'white prawn'. The seed is available abundantly all over the east and west coast of India in estuaries and lagoons with peaks during January-March and August-September. It prefers higher salinity when compared to P.monodon. It accepts artificial feed. It grows to 15-20 g in 3-5 months in grow out ponds.

Drag nets, scissor nets, shooting nets are employed for collecting prawn seed from wild. The seed collected from wild is a mixture of several species and needs to be segregated. Seed collected from wild is stocked in ponds under extensive culture. Availability of wild seed is inconsistent and inadequate to meet the growing demand.

SEED FROM HATCHERIES

For rapid expansion of brackishwater prawn farming, a regular and steady supply of quality prawn seed is essential. Semi-intensive prawn farming needs large quantities of quality seed at a given time for stocking. To meet this requirement, the prawn seed is produced in the hatcheries and supplied to farms.

METHODS TO DETERMINE QUALITY OF SEED

It is an established fact that the seed is important critical input and success of prawn farming depends on stocking quality prawn seed. Stocking poor quality seed results in low yields.

The methods for selecting quality seed are: 1.visual observations, 2.muscle to gut ratio and 3.stress tests.

1. Visual observations: A batch of seed is transferred to a 10L container and visually observed. If the seed have dark pigmentation on the uropods or telson and the seed comes to sides of the container, the seed is considered to be good.

2. Muscle to gut ratio: The ratio of the diameter of the tail muscle, measurement taken halfway between the telson and the last tail segment, and gut diameter is 4:1 and rostral teeth varies from 4-7, the seed is considered as quality seed.

3. Stress tests: A batch of post larvae are exposed to 100 ppm formalin concentrations and salinity drops of 15 ppt for a period of 2 hours. The post larvae that could withstand the stress tests, do not show mortality and revive after keeping them in seawater are the best seed for stocking in grow out ponds.

SEED COUNTING

The post larvae -20 are transferred to 100 L drums and provides vigorous aeration. 3000 post larvae are visually counted and transfer them into a basin containing 6L of sea water (standard basin). Identical basins with 6L of water are kept in a row adjacent to standard basin. The temperature of sea water is reduced to 25^{o}C by keeping ice. blocks (kept in a polythene bag) in the basin. The post larvae are added to each basin and estimated visually, that they contain same number of post larvae as standard. The post-larvae are emptied into plastic bags.

SEED TRANSPORTATION AND PACKING

Prawn seed is transported, from hatcheries in plastic bags under oxygen packing. Double plastic bags measuring about 65 cm x 35 cm are used. The density of post larvae-20 in each bag depends on duration of travel.

Duration	density
upto 12 hours	4000/bag
12-24 hours	3000/bag
24 hours and above	1000/bag

After seed is transferred, the polythene bags are filled with oxygen and the end portion is twisted and tied with a rope or rubber band. Two plastic bags are packed in each carton measuring 60 cm x 35 cm lined inside with thermocole sheets.

SEED ACCLIMATISATION

The ideal time for transporting the seed is during early morning hours to avoid heat. After reaching the pond site, few polythene bags are opened randomly to estimate survival. The bags are then floated in the pond water to acclomatise the seed to the pond water temperature. The bags are opened and added the pond water in small quantities. The whole acclimatisation process takes 2-3 hours. It is desirable to reduce the salinity to the pond water condition in the hatchery itself before packing the seed.

STOCKING DENSITY

The stocking density of prawn post-larvae in grow out ponds depends on the management practices employed.

In extensive system, the seed is stocked in ponds varying in size 0-1-5.0 ha, at a density of 20,000 to 50,000/ha. The yield from this system ranges from 200-600 kg / year for P.indicus and 300 - 1.2 t/ha year for p.monodon.

Technological improvements in the management practices of prawn farming resulted in increasing prawn production per unit area. Following the improved management practices two technologies have been emerged: semi-intensive and intensive prawn farming.

Under semi-intensive prawn farming, the seed is stocked at densities varying from 15 /m^2 to 30/m^2. The yield varies from 4 to 5 t/ha /crop for p.monodon and 1.6 t/ha /crop for p.indicus.

In intensive culture, the seed is stocked in ponds varying from 0.1 to 1.0 ha earthen ponds or 0.03 - 0.1ha concrete tanks, at densities ranging from 50/m^2 to 100/m^2. A total yield of 10 t/ha/crop is reported. In the case of P.indicus, seed stocked at a density of 70/m^2 a production of 8 t/ha/5 1/2 months is reported.

LIVE FEED *ARTEMIA*

BY
DR.S.KULASEKARAPANDIAN

LIVE FEED - ARTEMIA

CONTENTS

LIVE FEED - ARTEMIA

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1. Introduction :

Extensive literature reveals that only very few organisms have been utilized as live feed in aquaculture and among them, the brine shrimp Artemia is the most important one. All its life stages, such as cysts after decapsulation, freshly hatched nauplii, juveniles and adults are used as live feed according to the feed size requirement of the predator. Artemia decapsulated cysts and freshly hatched nauplii form as ideal food for the larvae of shellfish and finfish in their hatchery phase while juveniles and adults form as suitable diet for prawn/fish juveniles in their nursery phase. Further, reproductively active adult Artemia form as food to induce maturity in the broodstock of prawn and fish. A great demand exists for Artemia cysts in the growing aquaculture industry since it forms as dried inert food source. This demand is continued to increase with the development and progress of aquaculture. However, the Artemia cyst supply, available through natural sources, is inadequate. Hence, nowadays, scientific culture of Artemia, for its cysts and biomass, gains importance.

In India, man-made saltpans, which occur all along the coast line, offer excellent scope for Artemia culture. Many of these saltpans have most of the infrastructures required for this purpose. Further, Artemia produced in the

saltpans, will form as a byproduct to salt-farmers. In addition, the presence of Artemia in the saltpans will improve the quality of salt. Hence it is of interest to study Artemia culture in the saltwater pond and in the laboratory for cysts and biomass.

2. Biology of the brine shrimp :

Genus Artemia is found to possess both bisexual and parthenogenetic strains. Parthenogenetic strains, which are found in Asia and Europe, have been commonly designated as Artemia parthenogenetica eventhough they have important differences in ploidy level and isoenzyme pattern. Among the bisexual strains, mainly five sibling species have been described. The adult Artemia measures about 10 mm in total length. (However, in some polyploid parthenogenetic strains, it is upto 20 mm in length). It is characterised by an elongated body which can be divided into three portions, namely head, thorax and abdomen. Antennules, antennae and stocked eyes, a pair each, are present in the head region while thorax has eleven pairs of thoracic appendages (known as thoracopods) and the abdomen ends in a furca, covered with spines. The antennules and antennae are sensory in function in females while in males of the bisexual strains, the antennae will be developed into a clasper, thereby forming as a secondary sexual character. An unpaired uterus (or brood sac) is present in the female. In bisexual strains, males have penis and copulation, to transfer the sperm into uterus of the female, is a necessity to achieve fertilization in the uterus. In the case of parthenogenetic strains, fertilization will not take place and embryonic

development starts as soon as the eggs reach the uterus (from paired ovaries, through oviducts, both of which are present in the abdomen). The embryos develop into nauplii or are coated with shell to form cysts, in the uterus, as per the prevailing environmental conditions. The liberated cysts are about 200-300 microns in size while the newly emerged nauplii measure about 400-500 microns in length. Brine shrimp can live for about 6 months. It grows from nauplius to adult size in about two weeks. During this short period of development, nauplius with about 0.4-0.5 mm in length and about 0.002 mg in weight grows into an adult with about 8-10 mm in length and about 1 mg in weight thereby ensuring 20 fold increase in dimension and 500 fold increase in biomass. During development, thoracic appendages are differentiated in relation to their function as locomotory, respiratory and filter feeding appendages. After attaining adult stage, the brine shrimp produces nauplii/cysts (according to the prevailing environmental conditions) at the rate of upto 300 number per batch and goes on producing at an interval of 5-7 days throughout its life period (Fig. 1).

3. **Distribution in India**

Existence of Artemia, as natural population, was reported in the Sambhar lake in Rajasthan and saltpans in Vadala, Bombay, Veppalodai near Tuticorin, Karsewar Island off Tuticorin, Gulf of Kutch, Gujarat, Kelambakkam near Madras and Vedaranyam. Except in Sambhar lake (which is inland in origin), all other areas are in the coastal belt which is in the migratory route of flamingos.

LIFE CYCLE

Cyst (200-300 microns in size)

Temperature-
26 - 30°C
pH above 8.0

- 24-48 hrs for hatching in less than 70 ppt salinity.
- Initial hydration
- Aeration 10-20 litre air/minute
- Light minimum 1000 lux.

E 1 stage

Umbrella stage

Freshly hatched nauplii

One day old nauplii

Non-selective filter feeder feeding with particulated feed of less than 50 microns in size(bacteria, planktonic algae, etc.,)

14-20 culture days.

Predator (fish/crustacean) free medium

Under optimal culture conditions.

Adult (about 10 mm in total length)

Upto 150 ppt salinity (favourable conditions)

150-250 ppt salinity (unfavourable conditions)

250-350 ppt salinity

Dying phase

Ovoviviparity release of 60-300 nauplii/adult/in about 5 days

Oviparity (60-300 cysts/ adult/about 5 days

4. **Brine shrimp culture in solar saltpan :**

4.1. Site selection :

In a classic type of solar saltpan, water enters the first evaporation pond from the reservoir. After increasing slightly in salinity by solar evaporation, water flows from the first evaporation pond to the next of the series and this continues until the water becomes brine i.e., saturated with sodium chloride. The brine is then introduced to the crystallizing ponds where sodium chloride precipitates (Fig. 2). Artemia can be intensely cultured with minimum inputs in evaporation ponds of the solar saltpans. The area, selected for Artemia culture, should have suitable climatic conditions such as moderate temperature (ranging from 25 to 35^{o}C) and salinity (with a range of 70 ppt to 200 ppt). It should have a high evaporate rate with little rainfall and be closer to sea from where water can be easily drawn to the reservoir either by pumping or through tidal influence. The water source should be free from pollution and then the pond should maintain the water level without having any seepage or leakage.

4.2 Pond preparation :

Artemia culture pond has to be deepened to assure a desirable water depth of 70-100 cm in which the water temperature never exceeds the lethal level of 40^{o}C. This can be achieved either by pond excavation or by increasing the dyke height. Initially, the pond has to be dried and exposed to sun for a period of 7-10 days. Soil pH should be 7-7.4 and if it is below 7 (acidic), soil has to be treated with lime at the rate of 1,000 kg/ha.

4.3 Water intake :

Though Artemia perform very well in natural seawater and even in brackishwater, they will be eliminated very soon by predation as they do not have any defence mechanism. However, Artemia have a very efficient physiological adaptation to media with very high salinity where predators and competitors cannot survive and hence the salinity of the pond has to be maintained higher or closer to 100 ppt throughout the production period. Hence, 70-75 ppt water has to be taken initially. Further, the intake water has to be screened to prevent the entry of predators. If the pH of the water is below 8, lime (CaO) has to be added at the rate of 500 kg/ha.

4.4 Fertilization:

Eventhough the intake water is productive and it may provide enough food to Artemia in the beginning, it can't support a dense population in later stages. Hence, pond should be fertilized either with inorganic fertilizers or with organic manure or with both.

Among organic manures, chicken droppings is preferred. If the pond is going to be fertilized solely with organic manure (chicken droppings), it should be done at the rate of 1,000 kg/ha as basal dose and half of the rate should be given as subsequent doses at regular intervals of 10-15 days. Urea, superphosphate and diammonium phosphate form as satisfactory combination in the case of inorganic fertilizers. They should be used at the rate of each 50 kg/ha as basal dose and half of it as subsequent dose. Manure/fertilizer should be broadcasted and the basal dose should be provided 3-5 days prior to stocking. When

both, organic and inorganic, are going to be used, organic manure should be given as single basal dose at 1,000 kg/ha while inorganic urea, superphosphate and diammonium phosphate will be given as basal (each 50 kg/ha) and subsequent (each 25 kg/ha) doses. In this case, it is better to keep the manure in gunny bags, immerse them in water and thereby allow them for leaching out slowly. In addition to these inorganic fertilizers, mono ammonium phosphate (NPK ratio of 16:20:0) at the rate of 100-200 kg/ha, together with ammonium nitrate (30:0:0 NPK ratio) at 50-100 kg/ha will also form as suitable combination. Periodically 50 kg of the former and 25 kg of the latter have to be applied once in every week. Manuring/fertilization has to be modified according to the intensity of phytoplankton bloom, present in the pond and the water fertility.

4.5. **STOCKING**

4.5.1. Strain selection:

As bisexual San Francisco Bay strain of Artemia sp. has small sized cyst and nauplius, high fecundity and desirable growth rate, it forms as a suitable candidate strain for stocking. If the culture-pond is a newly constructed one and is devoid of any natural population, San Francisco Bay strain can be transplanted in it. On the contrary, if Artemia culture-pond is a converted evaporation pond of a saltpan which has a natural population of the local strain, stocking is preferred with the existing local strain as it adapt themselves to the prevailing environmental features and thus has better survival. Further, introduction of exotic strain, along with the existing one, will

result in the imbalance and subsequent dominance of anyone of them which sometime causes the disappearence of the local strain.

4.5.2 Rate and time of stocking :

Stocking has to be done at nauplii stage and the stocking density should be 35-40 nauplii per litre of water in the culture-pond. Quantum of nauplii, required for stocking , has to be worked out with the water level and the hatching efficiency of the cyst, to be used. Required quantity of cysts have to be kept for hatching either at the culture-site or in the laboratory. For good hatching, seawater or diluted seawater of about 30 ppt with pH 8, has to be taken in conical containers at the rate of about 2 g/l of hatching medium and moderate aeration (10-20 litres of air per minute) and illumination (minimum 1,000 lux or start hatching at day time) have to be provided. Within 20-36 hours (for San Francisco Bay strain) or 36-48 hours (for parthenogenetic strain), nauplii will be hatched out and these nauplii have to be transferred to the culture pond and stocked during late evening or early hours of the day in order to avoid temperature stress. Stocking can be done at any salinity as acclimatization is not necessary.

4.6 Water Management :

Adult Artemia will reproduce by ovoviviparity during favourable environmental conditions while unfavourable conditions will induce them to oviparity. Dissolved oxygen content is the main factor which influences the mode of reproduction in Artemia. Simplest way of manipulating oxygen content of the culture-pond is changing the salinity as both have

inverse relationship. In order to maintain ovoviviparity and thereby population multiplication, salinity has to be retained around 100-120 ppt during the first two months of the culture period. Third culture-month is for inducing the shift to oviparity for which the salinity has to be slowly increased to above 150 ppt. Salinity of above 150 ppt but below 200 ppt has to be maintained for the continuation of cyst production and this aspect has to take place during the last two months of the culture.

4.7 Growth monitoring :

Growth of the population has to be monitored by collecting data on the population composition which can be carried out by analysing the population samples after grouping them as nauplii, juveniles and adults. Changes in the population composition can be correlated with the overall production status of the population. For example, presence of only adults reflects the status of no recruitment. Reproductive status of the adults, which can be found out by observing the presence of nauplii/cysts and shell gland in the brood sac, will also indicate whether the population is in growth phase or in stationary phase (Determination of population density through sampling procedure will not help in view of strong heterogenic distribution of Artemia). Data on the parameters such as minimum-maximum water temperature, rainfall, salinity levels and water turbidity have to be daily collected. These informations are necessary to monitor the population structure by adjusting the intensity of fertilization, harvest and water management.

4.8 Harvest techniques :

4.8.1 Biomass harvest :

When the population is mostly of adults and attained an approximate density of above 200 numbers/litre, biomass can be manually harvested with a dip-net or drag-net whose cod end should have less than 200 micron mesh size. The net should be emptied at about quarter of an hour intervals to avoid the death of the accumulated Artemia in the cod end. Biomass harvesting should be stopped when the population attained an approximate density of 100 numbers/litre.

4.8.2 Cyst harvest :

If the intention is cyst harvest, salinity has to be maintained at above 150 ppt but below 200 ppt by careful water management. Artemia become weak and finally die at above 250 ppt. The liberated cysts will float and due to wind action, they will be driven towards the shore of the pond, where they accumulate. Cysts, thus accumulated, must be harvested as soon as possible. Otherwise, they will get dried up on the shore and be carried away by wind. Further, they have to face repeated hydration and dehydration due to high humidity and rain fall and thus loose their energy reserve which ultimately leads to non-viability. Contamination with impurities can be avoided by harvesting the cysts when they are in the water surface. To ensure this, cyst-barriers should be installed in the pond-water, close to shoreline.

4.8.3 Storage of harvested products :

4.8.3.1 Storage of biomass :

The biomass, harvested, has to be cleaned by washing with freshwater which will eliminate the adhering salt. Then it has to be frozen for which the live biomass has to be spread out in thin layers in plastic bags/ice trays and subsequently transferred to - 25°C in a quick freezer.

4.8.3.2 Cyst storage after processing and dehydration :

The harvested cysts can be stored temporarily in saturated brine. For long period of storage, they have to be cleaned, processed and dehydrated. Collected cysts may have dead Artemia, algae, debris, etc. These debri should be removed to ensure the purity of the cysts. In addition to purity, quality of the cysts will be improved by bringing down the water content to less than 10% for which the cysts have to be adequately dried after cleaning. Different mesh-sized sieves are used to remove the corresponding sized impurities while cleaning and cleaned cysts will be collected with 100 micron sieve. The contaminants, which are equal in size with the cysts, will be removed by the biphase floatation technique in which cysts will be initially suspended in brine. In brine solution, cysts and lighter debri will float while heavy dirt particles will sink. Subsequently, floating cysts will be collected with 100 micron net and transferred to freshwater/seawater in which lighter debri and non-viable cysts will float while viable cysts will sink

thereby ensuring the separation. Settled cysts have to be collected and subsequently dried until the cysts attain constant weight. While processing, treatment in freshwater/seawater has to be completed within 15 minutes. Dried cysts have to be packed in vacuum containers or in containers with nitrogen atmosphere.

4.9 Rate of production and economics :

About 20 kg of dry Artemia cysts and about 100 kg live biomass/ha/6 months can be achieved as average production.

The economics of culturing Artemia in 1 ha. pond is given below:

Economics of *Artemia* culture

CAPITAL COST : Raising the bund by 1.5 feet — Rs. 20,000/-

Equipment :
5 HP Diesel pump with accessories. — Rs. 20,000/-

OPERATIONAL COST :

	(in Rupees)
Cyst for inoculum	500.00
Fertilizers	4,200.00
Power & Diesel	2,000.00
Maintenance	5,000.00
Manpower	3,000.00
Total =	14,700.00

COST OF PRODUCTION

Production per ha. = 20 kg of cyst & 100 kg biomass

Cost of producing 20 kg of cyst	=	Rs. 14,700.00
Cost of producing 1 kg cyst	=	Rs. 735.00
Cost of packing/kg of cyst	=	Rs. 10.00
Total cost of production/kg		Rs. 745.00
Total cost of production for 20 kg of cysts.		Rs. 14,900.00

SALE PROCEEDS :

Sale of 20 kg of cysts @Rs.1250/kg	=	Rs. 25,000.00
Sale of 100 kg Biomass @Rs. 40/kg	=	Rs. 4,000.00
Total sale proceeds	=	Rs. 29,000.00

GROSS PROFIT from a 1 ha pond in 5 months culture = Rs. 14,100.00

5. PRODUCTION OF BIOMASS UNDER CONTROLLED CONDITIONS :

Biomass production under controlled conditions can be carried out either in batch or in flow-through culture systems. In both culture systems, provisions are made to maximize oxygenation of the medium and to ensure food availability to all the larvae while culturing at high density.

5.1 Biomass production by batch culture system :

In batch culture system, nauplii were reared upto adult stage, without any water renewal, in air-water-lift (AWL) operated raceway (Fig. 3), which provides continuous aeration, almost homogenous circulation of the medium and uniform distribution of the added feed within a short time. Raceway system further keeps all particulate matter in suspension thereby minimizing sediment accumulation. An Artemia raceway consists of a rectangular tank with a central partitioning. Water depth of the tank should not exceed one metre to ensure optimal water circulation with the help of axial blowers. Various materials such as concrete, marine plywood and fibreglass, can be used to construct raceway tanks. PVC pipes and elbows are used to construct air-water-lifts which have to be fixed to the central partitioning with screws to keep them in well defined position in the raceway. For optimal water circulation, the elbow outflows should make an angle of 45^{o} with the central partitioning. The interval between successive air-water-lifts should be 25 to 40 cm. The inner diameter of air-water-lift should be 40 mm which will provide 6.6 l/min/AWL of air to displace 12.5 l/min/AWL of water. 3 - 6 mm diameter polythene tube can serve as aeration line and it can be mounted in the AWL through a hole at the top

of the PVC elbow. To ensure the best water-lift-effect, the aeration lines should extend as deep as possible in the AWL.

It is convenient to carry out batch culture in raceway system in 50-70 ppt salinity because contamination with ciliates and other competitors can be avoided in saline media. Stocking has to be done with freshly hatched nauplii and rate of stocking depends upon the feed availability and water management. 10,000 instar I nauplii per litre can be stocked if feeding is maintained at 15-20 cm transparency with rice bran. As Artemia is non-selective filter feeder, it can be cultured by feeding them with a wide range of feed, both live and inert materials. However, the feed should be squeezed (if inert feed) or passed (if algal feed) through 50 microns sieve. Soluble products are not taken up by Artemia and hence the feed if an inert one, should be properly prepared to get rid off the dissolved matter. This can be achieved by aerating the feed solution for 1-2 hours and subsequently allowing the feed particles to settle by cutting off the aeration for half an hour. Dissolved matter will be in solution and it will be discarded while only the settled product will be used as feed. As Artemia is a continuous filter feeder, medium must contain adequate food at all times and hence food distribution is very important. Transparency of the culture medium is found to be a very useful parameter for determining the food level present in the medium. During rearing, particulate wastes such as faecal pellets and exuviae will form and they have to be continuously removed from the culture medium from the 4th culture-day onwards, as they affect the water quality and hamper the food uptake by Artemia.

This can be achieved by pumping the water from the tank with the help of an air-water-lift to a plate separator (Fig. 4) which is nothing but a sedimentation tank having several plates to facilitate effective settlement of heavy particles. When the water is passed through the plate separator, with a retention time of 20-30 minutes, faecal pellets and exuviae settle down at the bottom of the separator and on its plates while water with smaller particles in suspension drain back into raceway. A filter screen system with aeration collar is used in order to ensure that no Artemia will be pumped to the plate separator.

Eventhough aeration collar reduces the clogging, it is better to clean the filter bag daily (with a jet of tap water) in order to have an effective prevention from clogging. As the animals grow, the filter bags should be changed by new ones with progressively larger mesh size. When inert products will be given as feed, the pH of the culture will go down and if it goes below 7.5, the pH should be raised by adding sodium bicarbonate at the rate of about 300 g/ton of water. The brine shrimp has to be frequently observed under microscope to understand whether it is fully fed or in healthy condition. Further, the growth of the animal should be periodically checked by estimating the biomass which can be calculated by taking wet weight of Artemia present in a litre of medium and calibrating to the total volume.

The culture period varies with temperature and the strain selected and it is generally about 2 weeks. Harvesting is facilitated by taking advantage of Artemia's special surface respiration behaviour. All Artemia concentrate in

the surface when oxygen concentration drops to a critical minimum and this condition is achieved by just switching off the aeration for about 30 minutes. Artemia, congregated in the surface, can be easily scooped off with a net.

Average biomass production amounts to 5 kg wet weight/cubic metre when culture is carried out with stocking density of 10,000 nauplii per litre and rice bran as feed to the intensity of 15-20 cm transparency.

5.2 **Biomass production by flow-through culture system :**

In flow-through culture system, the medium is continuously renewed as against the batch culture system. Continuous inflow of fresh culture-medium with food (algal/inert product, such as rice bran suspension) to the culture tank is to be maintained. Initially a filter bag with 100 microns mesh size is to be used as screen to retain the animal but at the same time allow the drainage of water and faecal pellets. As the animal grows, the filter bag has to be changed to 200, 350 and 450 microns respectively on 3rd, 6th and 9th culture-day onwards. In the initial stage, the water retention time should be 4 hours while it should be kept at about 1 hour from 10th culture-day onwards. The continuous water change, in flow-through system, results in removal of all metabolites and hence Artemia culture can be carried out with intensive stocking i.e., double the stocking rate, practiced in batch culture. In all other aspects, the flow-through system resembles the batch culture system. By flow-through system, Artemia can be reared by stocking 20,000 nauplii per litre and feeding with rice bran, to achieve a production rate of 25 kg/Cubic metre/2 weeks.

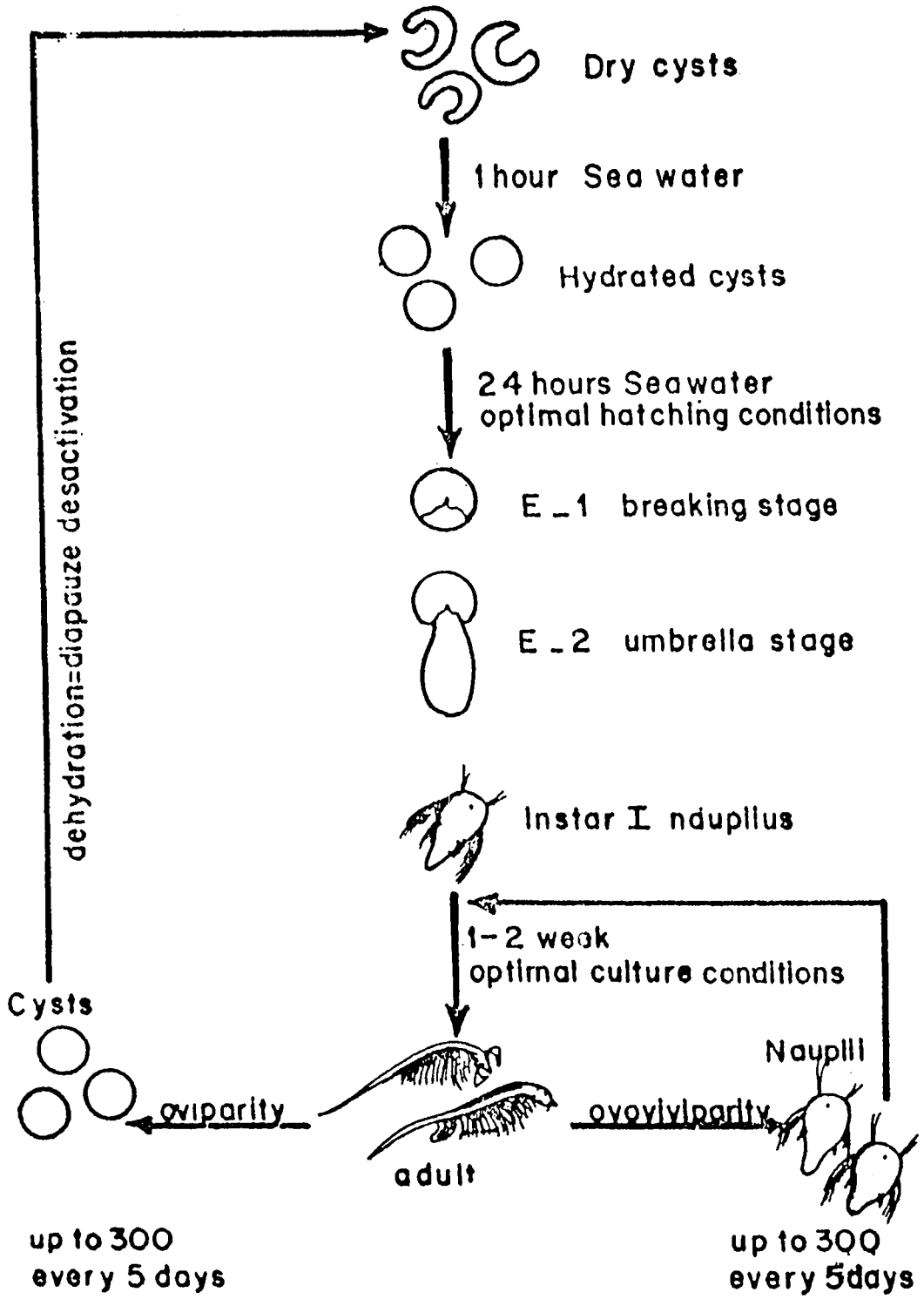


Fig. 1. Schematic diagram of *Artemia* life cycle.

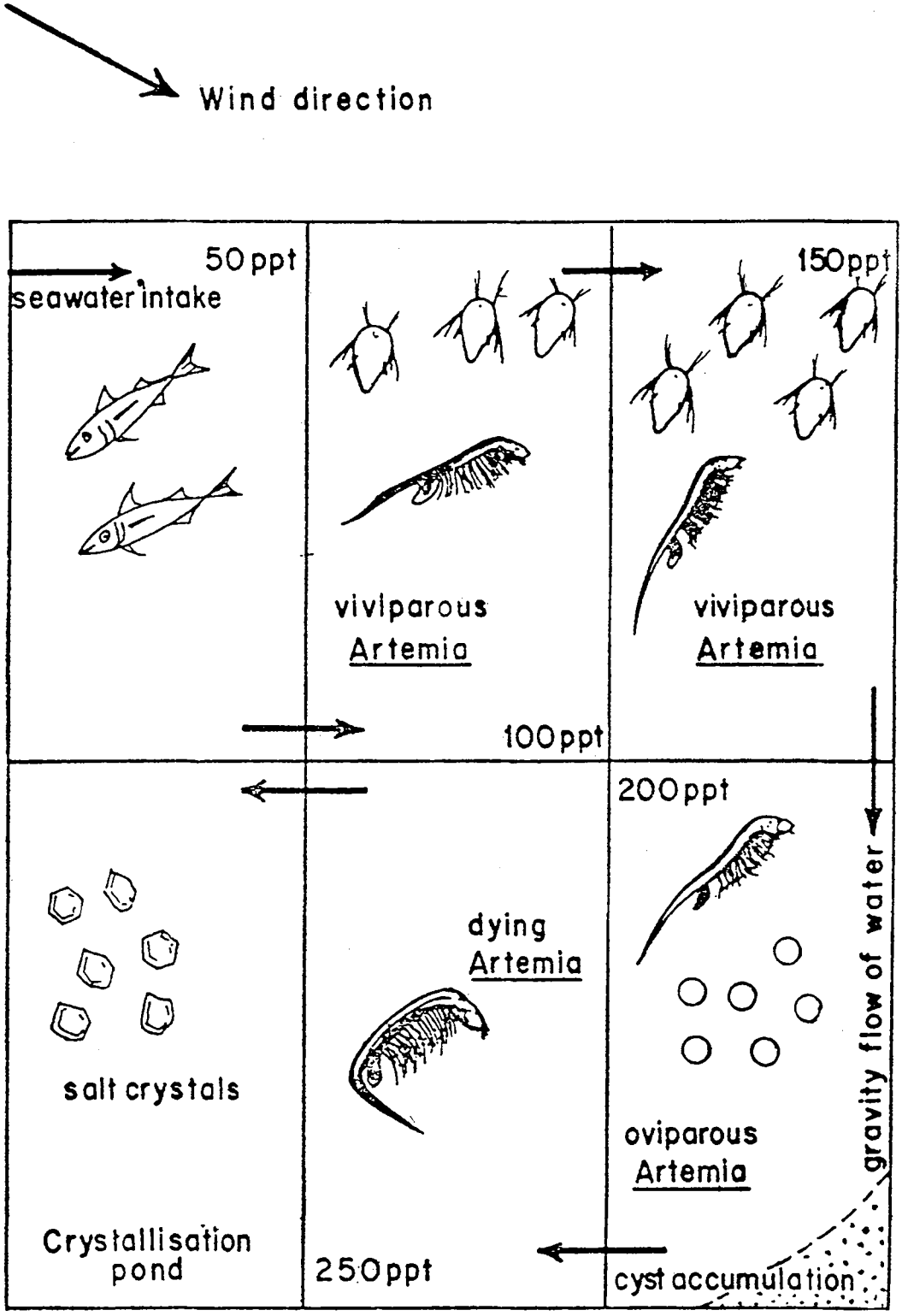


Fig. 2. Schematic diagram of solar salt operation with natural occurrence of *Artemia*.

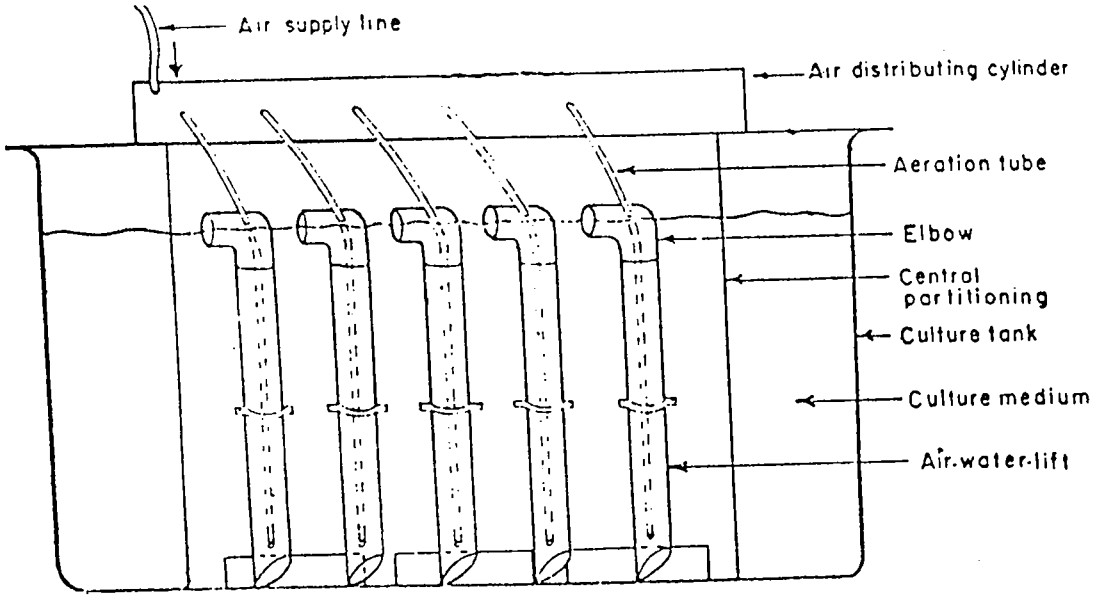


Fig. 3. Raceway

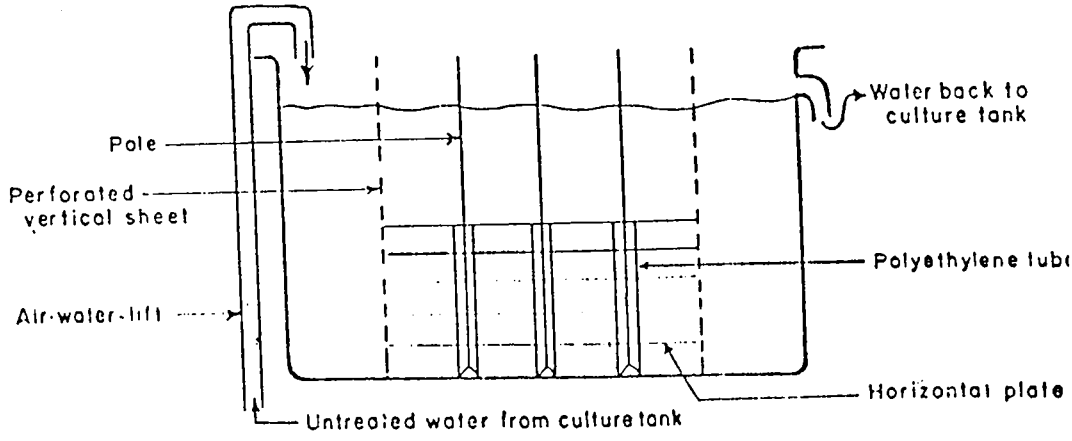


Fig. 4. Plate separator

LIVE FEED II

BY
K.DEVARAJAN

LIVE FEED: MICRO-ALGAL CULTURE

K. DEVARAJAN

The floating microscopic plants or phytoplankton are the micro-algae which form the basic food for most of the animals in aquatic ecosystem. Most phytoplankton organisms are unicellular and are primary producers of organic matter in aquatic habitats. Mass culture of unicellular micro-algae such as diatoms (Fig.1)(species of Chaetoceros and Skeletonema) and nannoplankters (Fig.2)(species of Isochysis Tetraselmis and Chlorella) is pre-requisite for feeding the larvae of crustacean molluscs and fishes for attaining good survival rate as is well known, the success of any hatchery operations depends mainly on providing the required species of micro-algae. The larvae of prawns and fishes prefer the diatoms as basic food while molluscan larvae live on flagellates measuring less than ten micron during early stages.

The various aspects of the micro-algal are: the collection of phytoplankton, isolation of the required species, identification, preparation of culture media, stock culture maintenance and mass production.

A. Collection

Plankton are usually collected by towing specially made nets (Fig.3) through water. The fine mesh net is made of bolting cloth, silk or nylon materials. The newly collected samples are illuminated to keep the specimens alive. Then the samples are treated with enriched medium suitable for the growth of particular algal species.

B. **Isolation and Purification**

Isolation of specific phytoplankton from the collected crude sample is a pre-requisite for the establishment of unialgal culture. Several methods are employed in the isolation of single cells depending upon algal size and characteristics of the desired species.

1. Biological Isolation

This type uses the positive photoactive response of the organisms. The organism would tend to concentrate towards the light source. The concentrated organisms are collected and transferred to sterile sea water. This process may be repeated several times until unialgal cells are attained.

2. Serial Dilution

Crude sample is diluted by means of series of transfer in tubes containing culture medium(Fig.4 a). When greatly diluted the tube may contain only one cell. The diluted sample is then exposed to ambient temperature and light condition. Usually the dominant species in the mixed population are the ones that are successfully isolated

3. Repeated subcultures

The principle of this type is the same as that of serial dilution. The collected mixed population is diluted to lower the number and kinds of organisms. The diluted sample is then exposed to several media, different conditions of temperature, light intensities. The species that favours certain culture conditions will grow

successfully in each culture vessel. This process can be repeated until unialgal culture is achieved. (Fig.5)

4. Capillary Pipette Method

A dish top is used as an isolation dish. A small amount of crude sample (10-15 drops) is placed in the centre of the dish. The sample is encircled with 6-8 drops of suitable medium. The desired algal unit is transferred from the crude sample to one of the 6 drops using a sterile capillary pipette while looking through an inverted microscope or a stereoscopic microscope. It is transferred from one drop the next drop until a single algal unit free from contaminants is present in a drop of medium. Finally the single algal unit is transferred to tubes containing the sterile medium.

5. Streak Plating

This type of isolation is recommended for small unicellular algae with firm cell walls (e.g. Chlorella and Chlamydomonas).

Plated agar enriched with a water medium is inoculated with 1-2 drops of crude sample near periphery of agar. Parallel streaks are made by sterile wire loop or glass red. After several days of incubation, colonies are examined through a stereoscopic microscope and transferred into a drop of sterile medium on a cover glass. Samples are checked under high power compound microscope to make sure of the isolation of the desired species. The streaking procedure may be repeated when needed and the

desired colony may be transferred to liquid or agar media.

C. Purification

Starting from unialgal culture, pure culture can be obtained by using some of the isolation techniques with only slight refinements. It is suggested that one should start from young culture in liquid media in which the algal cells are robust and growing actively.

Suggested methods to obtain pure culture:

a. Repeated streak plating the agar plate with or without antibiotic.

b. Purification by repeated micropipette washing.

c. Centrifugation-cells are concentrated and transferred repeatedly into a new liquid medium.

d. Antibiotic treatment-this method involves serial transfer of cells at 1-3 days interval through nutrient solution containing penicillin, streptomycin, chloramphenicol or a suitable mixture of three antibiotics. It should be noted that preliminary test should be done to determine the tolerance levels of each antibiotic.

D. Culture Techniques

1. Technical considerations

(i). Water treatment

Water which serves as the base for culture medium must be free of toxic or unwanted sediments. Filtration is done by using membrane filters (0.45 um millipore) or cartilage filters (0.28 um and 3 um pore size). Sand filter is used for large volume of water. A filter bag of 0.5 um is widely used to filter fine sediments. In case of the unavailability of the above mentioned filters sea water can be treated with 10 ppm chlorine and neutralized with equivalent amount of sodium thiosulphate.

(ii). Sterilisation of culture vessel and other materials

Glasswares and other materials are sterilized in autoclave or dry ovens. Glasswares are provided with cover (aluminium foil, cotton, gauze) to minimize air contamination. Used glasswares are soaked with dilute muriatic acid.

(iii) Culture Medium

For proper growth and propagation, phytoplankton require a number of mineral elements classified as macro-nutrients (N,P,S,K, Mg) and micronutrients (Fe, Mn, Cu, Zn, Mo, Sl). These mineral elements are added to sea water (enriched-se water media) or in distilled water in sufficient amounts. Although artificial sea water media showed constant results in algal cultures, enriched sea water media are preferably used, as it is cheaper and simpler.

The chemical composition of a defined medium have been derived and modified from basic formulation depending upon the nutrient requirement of the cultivated algal species. The important culture media used for culture of micro-algae are:

a. Guillard and Ryther's (1962) Modified F Medium
b. Walne's (1974) Conway Medium
c. Liao and Huang (1970) Modified TMRL Medium.

The chemical composition of the media are:

A. Guillard and Ryther's modified medium

$NaNo_3$	84.148 mg
$NaH_2PO_4H_2O$	10.000 mg
$FeCL_3\ 6H_2O$	2.900 mg
Na_2EDTA	10.000 mg
$Na_2SiO_39H_2O$	12.000 mg
Vitamins:	
B_1 (Thiamin Hcl)	0.200 mg
B_{12} (Cobalamine)	1.000 mg
H (Biotin)	1.000 mg
Trace metals:	
$CuSo_4\ 5H_2O$	0.196 mg
$ZnSO_4\ 7H_2O$	0.440 mg
$CoCl_2\ 6H_2O$	0.2000 mg
$MnCl_2\ 4H_2O$	3.600 mg
$NaMoO_4\ 2\ H_2O$	0.0126 mg
Sea Water	to 1 litre

B. Walne's Conway Medium:

$NaNo_3$	100.000 mg
$NaH_2PO_4H_2O$	20.000 mg
Na_2EDTA	45.000 mg
H_3BO_3	33.600 mg
$FeCl_3$ $6H_2O$	1.300 mg
$MnCl_2$ $4H_2O$	0.360 mg
Vitamins:	
B_1	0.100 mg
B_{12}	0.005 mg
Trace Metals:	
$ZnCl_2$	0.021 mg
$CoCl_2$ $6H_2O$	0.020 mg
$(NH_4)_6$ MO_7O_{24} $4H_2O$	0.009 mg
$CuSo_4$ 5 H_2O	0.020 mg
Sea Water	to 1 litre

C. Liao and Huang's Modified TMRL Medium

KNO_3	100.00 mg
$Na_2HPO_4 6h_2O$	10.00 mg
$FeCl_3$ $6H_2O$	3.00 mg
$Na_2SiO_3 9H_2O$	2.00 mg
Sea water	to 1 litre

D. Enrichment of out door culture

Super phosphate lime (16-20-0)	12/15 g/ton
Urea (46-0-0)	12-15/ g/ton
Ammonium sulphate (20-0-0)	100 g/ton
or	
14-14-14	30 g/ton

E. Modified Yashima Medium for culturing Chlorella

Ammonium sulphate (21-0-0)	100 g/ton
Superphosphate lime (16-0-0)	10 g/ton
Urea (46-0-0)	10 g/ton

Phytoplankton cultivated at the laboratory are classified as follows:

a. Maintenance cultures:

Natural collection of algae kept in culture containers. Possible multiplication may occur and succession of dominant species may take place.

b. Enrichment cultures:

Crude collection which are treated with selected media that may favour the rapid increase in number of desired species.

c. Unialgal culture:

Refer to population of a single algal species all other microorganisms may be associated.

d. Axenic algal culture:

Refer to population of a single algal species all other living organisms absent.

e. Clonal culture:

Refer to population of organisms having descended asexually from single individual.

Growth characteristics

Knowledge of algal growth phase is necessary to predict time of harvest. One must see to it that algae are harvested for cultures at the exponential growth phase and at early stationary for feeding purposes.

The population growth of algae is characterised by a sigmoid curve and is divided into 4 distinct phases.(Fig.6).

a. The log phase: characterise by zero growth. The population remain unchanged. The newly added inoculam adopts culture condition.

b. Logarithmic or exponential phase:
The cells in this phase divide fast in constant geometric progression and cells have active metabolic rate.

c. Stationary phase: Population remains constant or steady. This may be caused by nutrient limited medium and aging of cells.

d. Death phase: this is the phase of declining growth. Usually algal culture collapse and nutrient in the medium is already exhausted.

Routine for maintenance and mass production:

Stock cultures are kept in agar slant or unaerated smaller volumes of cultures (50-100 ml) depending upon the type of species. Scaling up on each species is done according to demand. Before

scaling up cultures are monitored to check for contamination and to select a new seed or starter for a new batch based on cell quality. Transfer is always done when cultures are at log phase of growth.

The volume of starter depends upon the species, the volume of culture tank and demand date. Usually diatoms require little inoculam compared to green algae. For starter/stock culture, a small volume of inoculam is needed while for large scale culture 10-20% of the total volume is the suggested amount of inoculam.

Continuous culture system is usually adopted at smaller culture volumes (300 1 or less). For larger volumes (500 1 to tons) semicontinuous culture system is adopted. This is sometimes called sustenance culture. A portion of culture is withdrawn at certain periods and replaced with an equivalent amount of sea water and nutrients to retain the original culture volume.

II. ZOOPLANKTON CULTURE

Zooplankton are the animal component of Plankton. They are often referred as herbivores or grazers feeding mainly on phytoplankton. Zooplankton in turn serve as essential food organisms for marine fin fish and crustaceans. Brachionus Plicatilis(Fig.7) and is the common zooplankton used for fish, shellfish and prawn hatcheries.

Cultivation

The techniques of mass cultivation of B.Plicatilis have gradually developed based on food and feeding habits of this organisms. Three methods were developed for main cultivation or rotifer based on Japanese system.

1. Daily Tank Transfer

The tanks are initially cultured with Chlorella Rotifer is introduced when Chlorella cells reached the density of about 10-20*10^6 cells/ml. When chlorella is consumed or rotifer have multiplied significantly, rotifer is harvested and either used or transferred to another tank where the second population of Chlorella had bloomed. The newly vacated tank is now prepared for chlorella culture for the next rotifer transfer. This process is repeated daily.

2. The 'Drain-off' system or Thinning out method:

Chlorella is first cultured using a modified Yashima medium and rotifer seed are added. Tanks are refertilized with the same medium when Chlorella cells reaches the stationary phase. Baker's yeast is then introduced at a 1/g/million/rotifer/day when Chlorella cells are almost consumed. When rotifer population reaches 100-150 ind/ml, 20-30% of the culture is harvested and transferred to another tank. This process is done daily.

Marine yeast culture:

The utilization of marine yeast (Fig.8) for feeding of zooplankton and shrimp larvae has been well demonstrated. Mass culture and production started when Kawana (1968) was successful in mass culturing the strain of Saccharonyces sp. and tested its practical application to aquaculture. The use of yeast as food paved the way for mass production of rotifers. Marine yeast served not only as food but as biological filter of excess nutrients in the culture water.

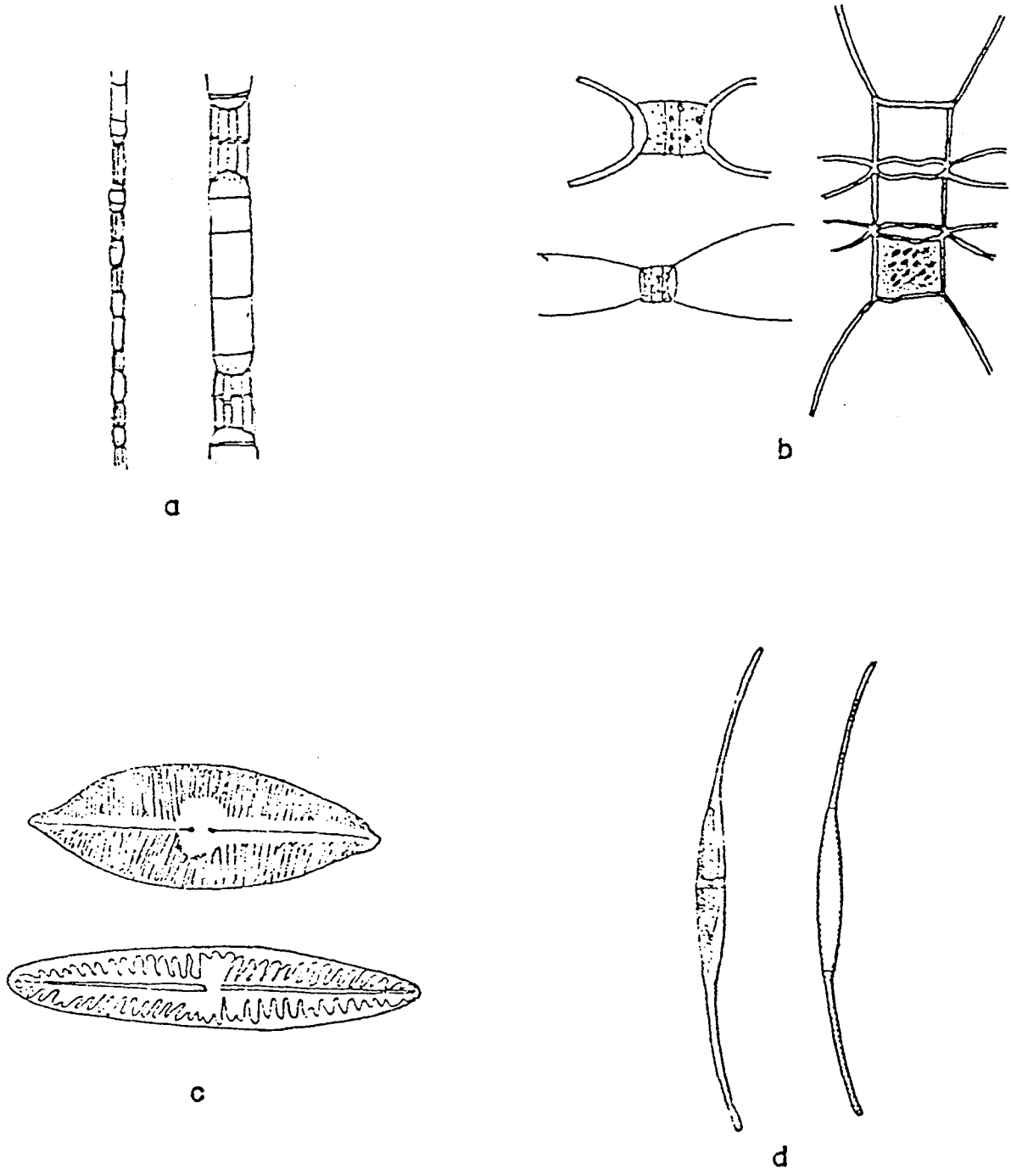


Fig. I. Some common diatom species use as food for larvae of molluscs, crustaceans and fishes. a). skeletonema costatum b). Chaetoceros sp. c). Navicula sp. d). Nitzchia closterium

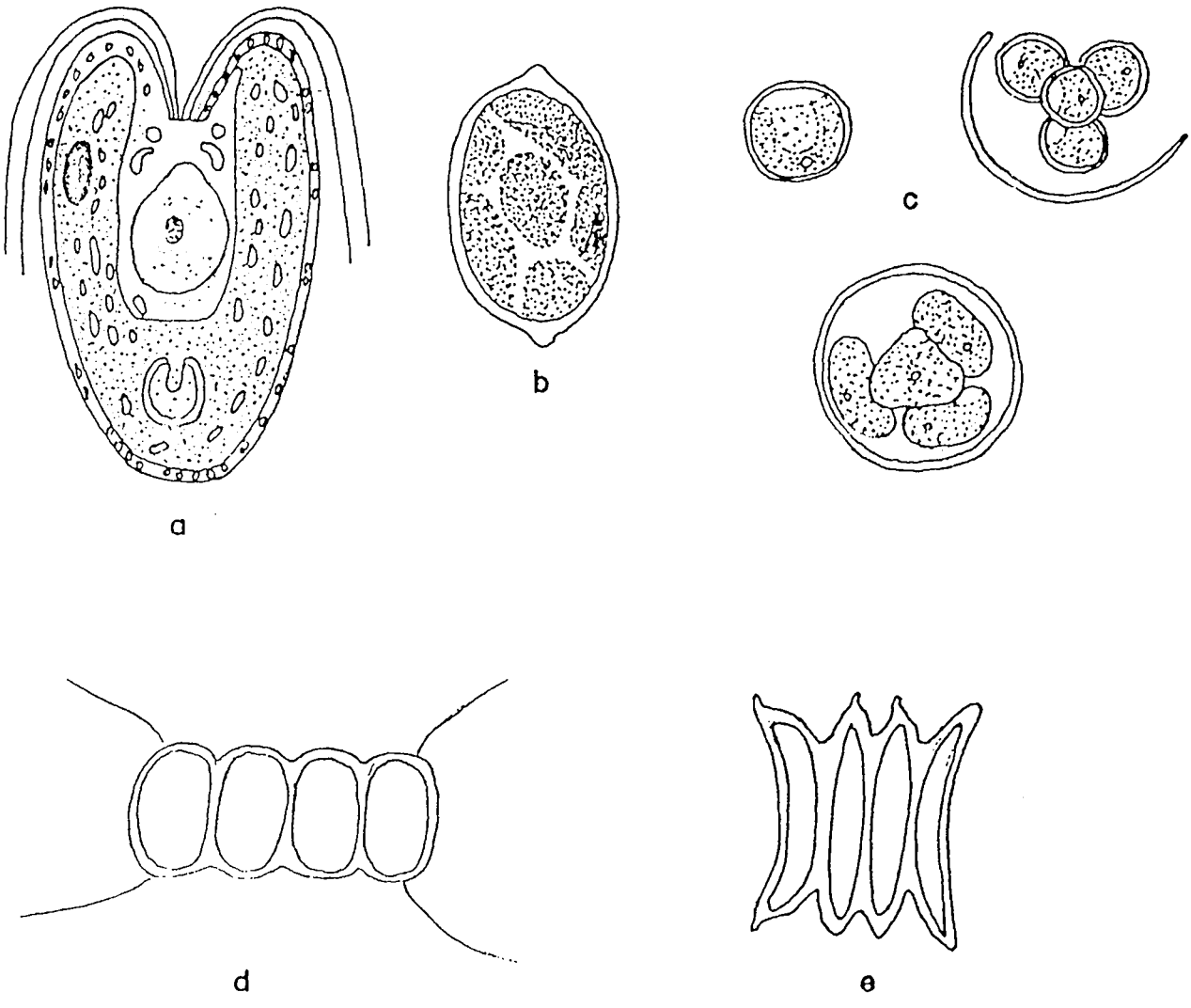


Fig. 2. Some common green algae use in aquaculture practices.
a). Tetraselmis sp. b). Oocystis crassa c) Chlorella vulgaris
d). Scenedesmus armatus e) Scenedesmus obliguus

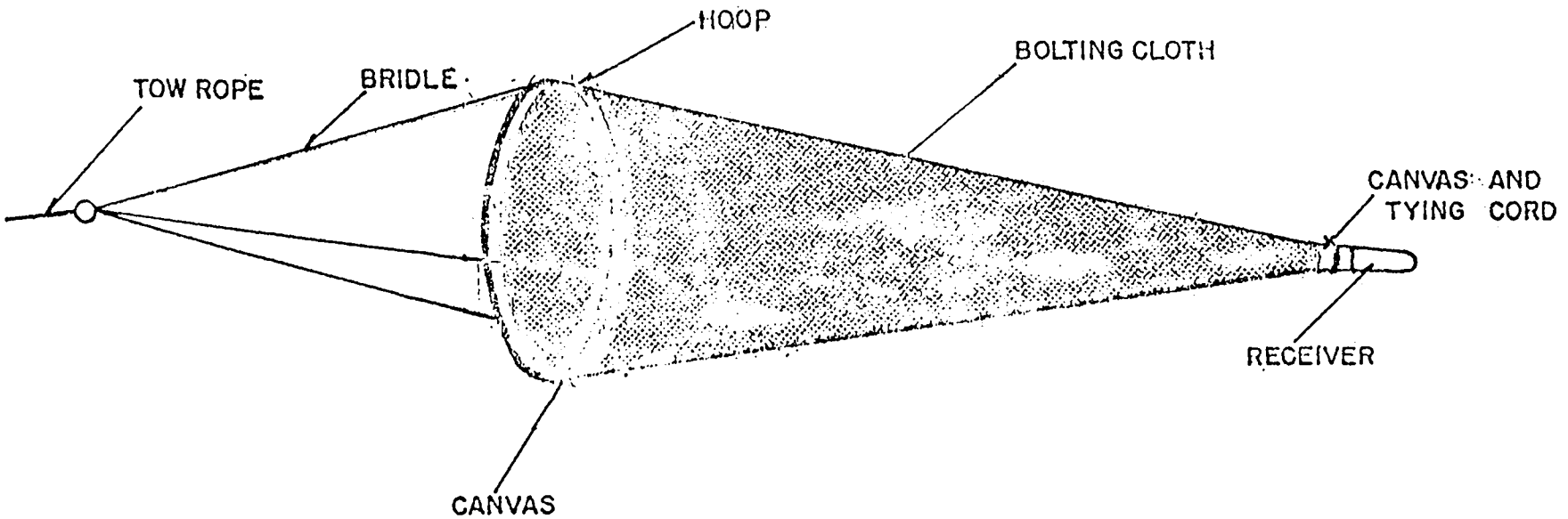


FIG 3. A SIMPLE PLANKTON NET

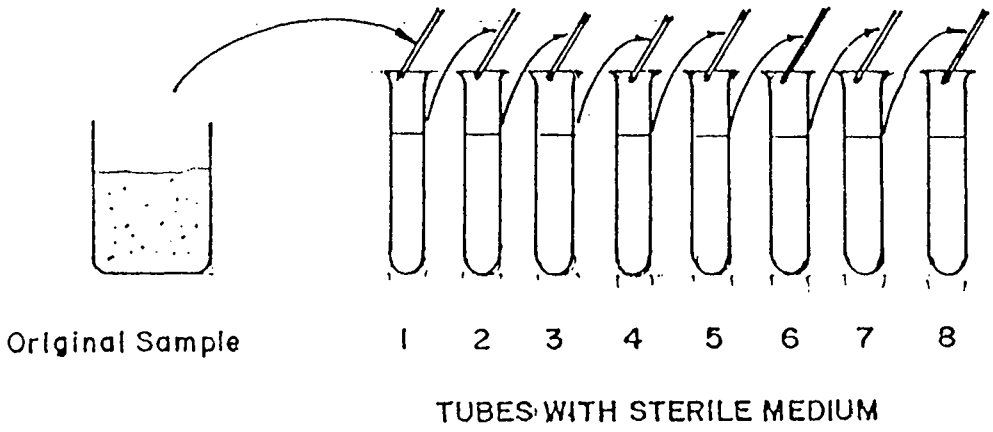


FIG. 4a. SERIAL DILUTION

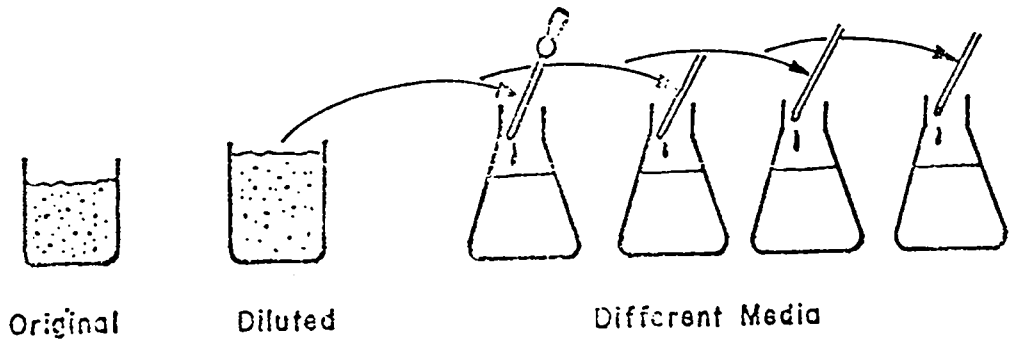


FIG. 4b. REPEATED SUBCULTURES

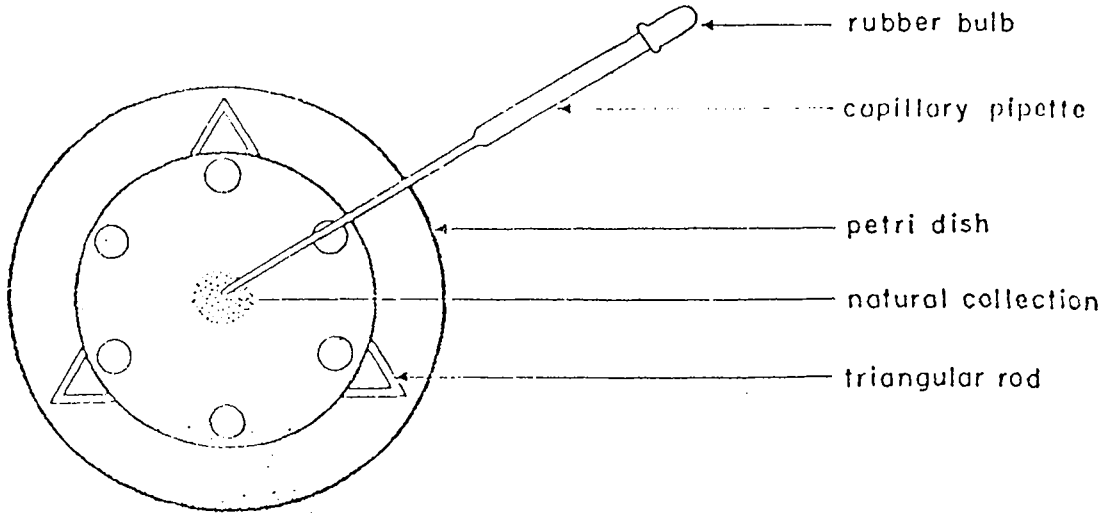


Figure 5. Capillary Pipette Method

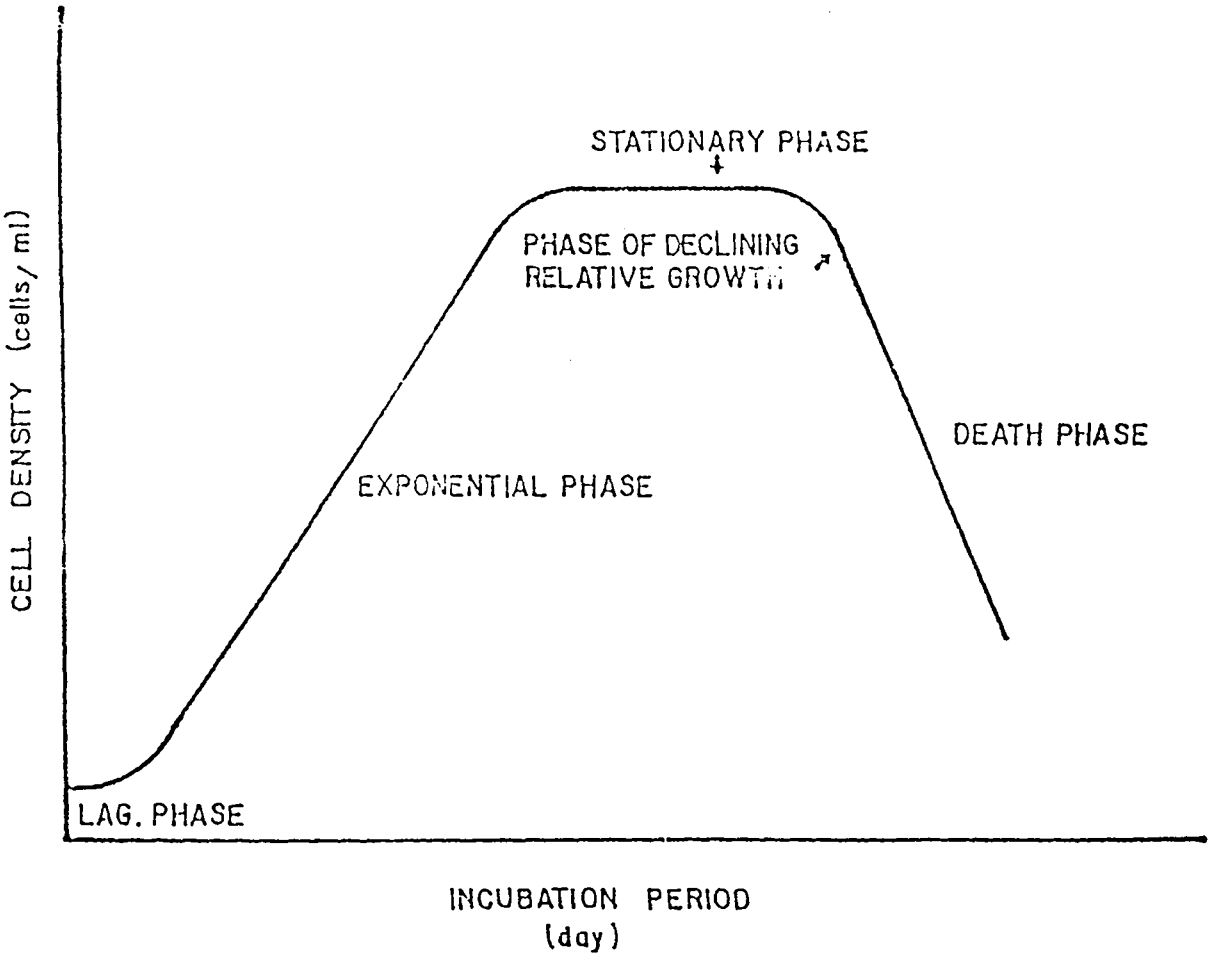


Fig 6. The characteristic pattern of growth shown by a unicellar algae in a culture of limited volume.

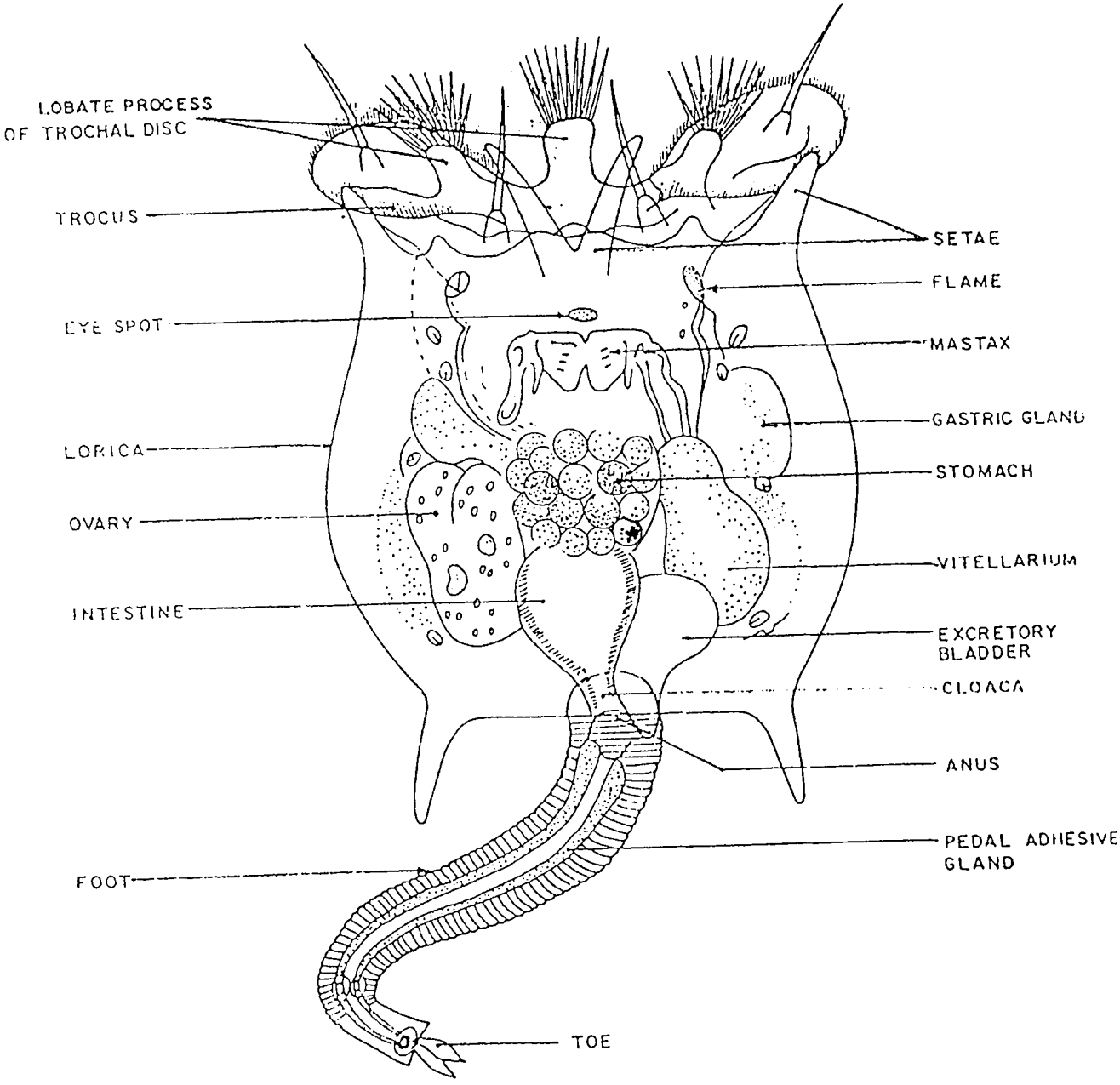


FIG. 7. BRACHIONUS

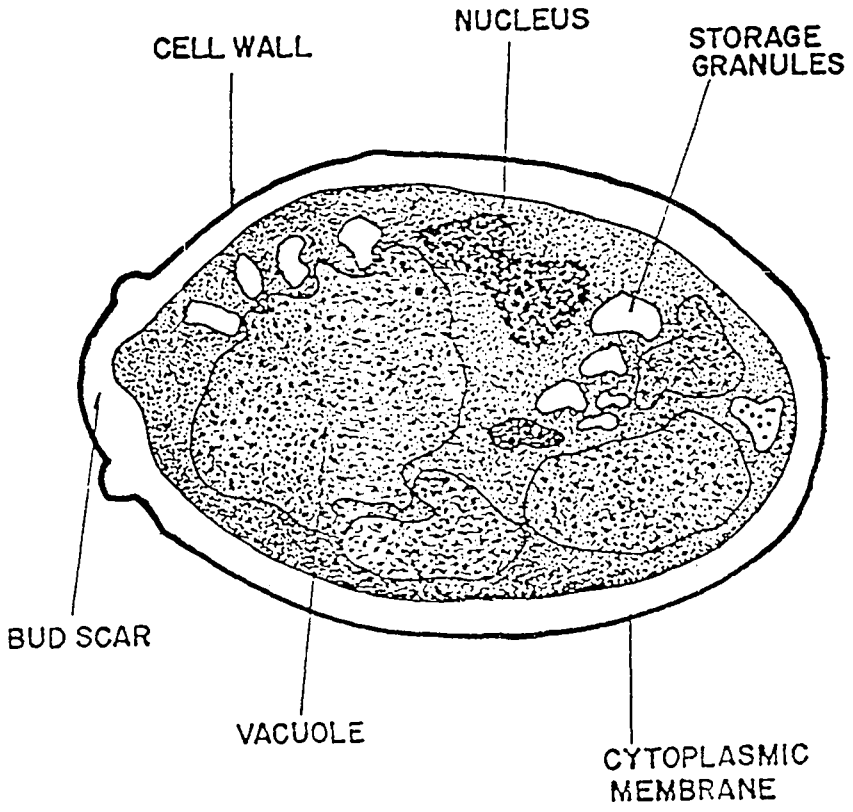


FIG. 8. A TYPICAL YEAST CELL

NATURAL FOOD IN THE PONDS

BY
P.S.SUDHEESH

NATURAL FOOD IN PONDS

PRIMARY PRODUCTION

The primary production can be defined as the amount of organic material which by the activity of organisms in unit time is synthesized in a unit volume of water ie, production/unit volume ($gc/M^3/day$) or in unit time is synthesized from inorganic substances in a water column of unit area, extending from the surface to the water. (Production/unit area) ($gc/m^2/day$)

The phytoplankton are the source of primary production in the sea. They remove CO_2 and micronutrients from the seawater and using solar energy convert them into complex organic compounds of high potential energy by the process of photosynthesis. The word production is synonrimously used for standing crop as well as organic production. It is basically a measure of the photosynthetic activity of autotrophic organisms like phytoplankton, benthic algae and photosynthetic bacteria.

Primary production is estimated by

1) light and dark bottle technique,
2) c^{14} technique and
3) chlorophyll technique.

Factors affecting primary production:

The factors affecting primary production are divided into

a) Abiotic and
b) Biotic factors:

a) Abiotic factors:

Abiotic factors include

1) light, 2) temperature, 3) CO_2, 4) salinity,

5) Nutrients, 6) Seasons and 7) Unused feed.

Of these balance of nutrients is the easiest to be controlled. Nature and quantity of fertilizers added affect the species composition of the primary producers and the rate of primary production. For example, as the phosphate content of the water increases, the density of phytoplankton increases and the species composition changes. At lower concentration diatoms are common, but with increase in phosphate concentration green algae becomes more frequent, eventually giving way to blue-green algae at higher concentrations. Nitrates and silicates are the most important nutrients required for the growth of diatoms and other algae. In addition to this some trace metals like zinc, manganese, molybdenum, magnesium, silicon, iodine, iron etc. are essential for the growth of algae.

Primary production is highly dependent on light energy. Hence light energy should be made use of to the maximum. In turbid waters, more light is scattered or absorbed, the light penetrates only to shallow depths. The rapid extinction of light in such waters affects adversely the growth of more beneficial diatoms. The lower layer of water being devoid of photosynthetic plants and also being in close contact with the decaying organic matter, suffers from oxygen depletion.

Plankton productivity varies according to the changing seasons: Plankton production is maximum after monsoon rains during upwelling in some seas. Tropical waters are productive compared to temperature waters because of more diversity of species and increased temperature. Species like Skeletonema sp. grows well in temperatures below 28^{O} C and Chaetoceros sp. grows well in temperature above 28^{O} C.

In the culture ponds, large quantities of feed are loaded into the pond bottom. Excess feed, fecal matter and other metabolites become available in large quantities for the growth of algae and microorganisms. This is because only about 20% of feeds convert to prawns on a dry basis (feed and prawn typically have 90% and 27% dry matter respectively and FCR would typically be 1.5).

Biotic factors:

The major biotic factors which affect plankton concentration in water are the following:

1.Reproduction,

2.Grazing by zooplankton and shrimps, and

3.Mortality

Plankton

Plankton denotes collectively all free floating and suspended bodies, both plants and animals, living or dead that essentially move passively or on the mercy of water currents in a body of water. The plant components the phytoplankton and animal

components are zooplankton. Phytoplankton forms the first level in food chain. Phytoplankton is having chlorophylls a, b, c and other characteristic pigments such as xanthophylls, carotene, phycocyanin (blue green), fucoxanthin and phycoerythrin.

The important components of phytoplankton are called

a) Diatoms (Bacillariophyceae),

b) Dinoflagellates (Dinophyceae),

c) Bluegreen algae (cyanophyceae),

d) Silicoflagellates,

e) Coccolithophores and

f) Nannoplankton.

Based on size they are classified as:

	Components	Size
1.	Macroplankton	> 1mm
2.	Microplankton	< 1mm
3.	Nannoplankton	5 - 50
4.	Ultraplankton	1 - 5
5.	Picoplankton	< 1

Most phytoplankton organisms are unicellular. Some planktonic green and bluegreen forms are filamentous and in some diatoms and dinoflagellates colonial and chain forms can be seen.

Colour of Water:

For the semi-intensive culture of shrimps, low plankton density is desirable in the culture ponds. The desired colour of

the water is light green. When the colour of water is light green, diatoms and green algae predominate in the phytoplankton population. To achieve this, about one week before stocking fertilizers like super phosphate, urea, calcium ammonium phosphate etc. are added to the water for algal growth. Moderate plankton curtails the penetration of intense sunlight into the water, thus preventing heating up of water during peak summer.

During the second half of culture period, because of available nutrients, the increase in population of algae and microorganisms become exponential. The algal/microbial population increases until a factor required for growth becomes limiting. Then a sudden decrease in the population can occur because of its short life. This is referred to as collapse or die-off of plankton. The sudden increase or decrease in algal population can cause drastic changes in water quality parameters which may affect growth.

When ponds contain high density of blue-green algae, that forms dense surface scums on a clear calm and warm days. When this happens pondwater changes from bright green to grey or brown colour.

Collection and analysis:

Phytoplankton is generally collected by a 50 u mesh size conical bag net.The phytoplankton sample is preserved in 3 - 5 % formalin.The number of plankton cells are counted by a haemocytometer.

In shrimp culture ponds the plankton density is estimated by secchi disc visibility. Secchi disc visibility is the average of the

depth at which a disc, 20 cm in diameter with alternating black and white quadrants, disappear and reappear from view when sunlight is intense. Sechi disc visibility between 30 and 60 cm is suggested for shrimp culture.

Zooplankton

The animal components of the plankton is zooplankton. They are the secondary producers in the aquatic ecosystems. They graze on phytoplankton and forms the food for shrimps and other tertiary producers/secondary consumers. Zooplankton is represented by almost all phyla of the animal kingdom. Some of the important groups encountered in zooplankton collections are given below:

Components of Zooplankton:

Medusae, siphonophores, ctenophores, chaetognaths, polychaetes, cladocerans, amphipods, ostracods, calanoid copepods, cyclopoid copepods and harpacticoid copepods, mysids, rotifers, hyperiids,euphausids, isopods, decapods, cumaceans, salps, doilids, prosobranchs, pteropods, appendicularians, polycheate larvae, nauplii, caridean larvae, palinuran and anomuran larvae, pagurid larvae, coenobitid larvae, brachyuran larvae, megalops and zoeas, gastropod larvae, lamellibranch larvae , echinoderm larvae, fish eggs and larvae.

Collection:

100 - 200 mesh size conical bag net is used for the collection of zooplankton. From a culture pond 50 liters of water

is filtered through the net from a sampling point. Four such samples are taken from a pond using a plankton Net . The filtered plankton is stored in 3-5 % formalin (37% formaldehyde).

The total sample from a point is divided into 4 equal parts by a plankton divider. From this one sample is taken and volume determined by the zooplankton volume determiner. The number of animals present in the sample is estimated using a sadgwick-grafter counter.

Benthos

Benthos constitute the organisms both plants and animals which are living on the pond bottom surface (epifauna / flora) as well as those burrowing fauna in the sediments of both rocky and sediment grounds, together with associated bottom living fin fishes and shell fishes.

Macrobenthos:

Macrobenthos are those animals and plants which are retained on a 0.5. mm mesh sieve.

Meiobenthos:

Meiobenthos are the smaller metazoans retained on a 62 mesh sieve but pass through a 0.5. mm mesh.

Microbenthos:

Microbenthos are the smallest forms which pass through 62 mesh, composed of protozoans and organisms of bacterial size.

Components:

Crustaceans : Mysids, Amphipods, Emertia sp., Dotialla sp., Ocypods Matuta sp., Isopods.

Polychaetes: Nerics sp.,Microneries sp., Onuphis sp., Lumrineries sp.Nephthys sp.,Diopatra sp.,Prionopsis sp ,

Capitellids: Tomopteris sp.

Gasrtropods: Cerethidia sp.

Others : Nimiertineans, Bryozoans, Nematodes, Terebellids etc.

Collection

From a pond 5 samples are collected. Van-veen grab is generally used for benthos collection. Corers, rectangular frames and dredges are also used for benthos collection. The samples preserved in 3-5 % formalin and stained with rose bengal or eosin for contrast.

Natural Food of Shrimps

Shrimps are omnivorous in habit. They feed on many varieties of planktonic and benthic organisms and also detritus. They are more active during night (nocturnal) and hence they feed more during evening and night. They are more chemotactic and attracted towards food particles by smell. The nauplius larva doesnot feed and depend entirely on stored food material. The protozoea and mysis are planktonic in existence and hence are filter feeders. They feed on algae and microscopic organisms. Postlarvae and adults are carnivorous and predatory and hence feed on zooplankton, benthic organism and detritus.

Food Organisms: Phytoplankton: Chaetoceros sp., Skeletonema sp., Thalassiosira sp., Isochrysis sp., Tetraselmis sp., Navicula sp., Nitzschia sp.

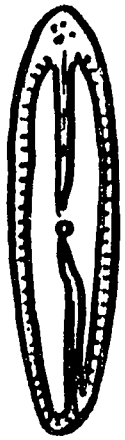
Zooplankton: Rotifers, cladocerans, nauplius, crustacean particles, amphipods, copepods, larvae

polychaetes, lamellibranchs, gastropods, echinoder
fishes,etc.

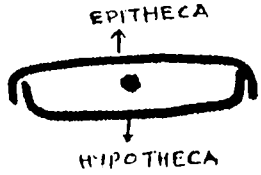
Others: detritus, lab-lab & lumut.

Production of lab-lab in Ponds:

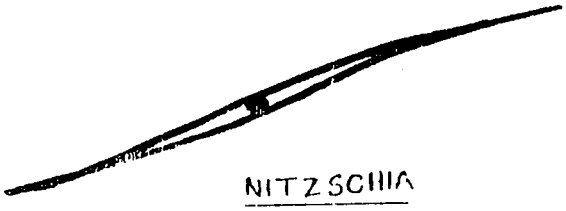
Lab-lab is the term applied to the natural food in culture pond formed of detritus, benthic algae, some crustaceans and other microscopic organisms. It is an ideal natural food for shrimps. For the production of lab-lab in the ponds the salinity should be above 30 ppt., the depth should be very low (20 -40 cm) and the pond should be fertilized. Within a week green coloured mat like growth appears on the pond bottom, which is lab-lab.



NAVICULA - GIRDLE VIEW



VALVES

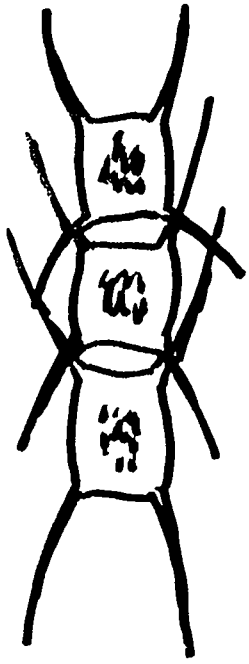


NITZSCHIA

COSCINODISCUS

COCCONEIS

SKELETONEMA



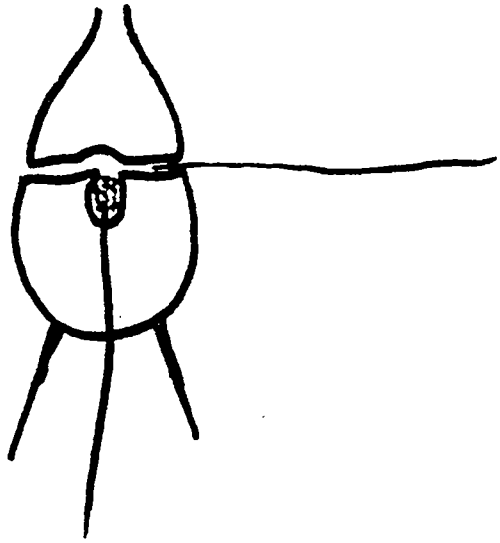
CHAETOCEROS

FRAGILARIA

PLEUROSIGMA

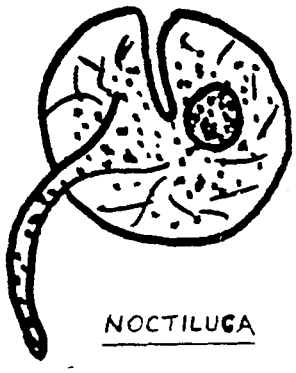
RHIZOSOLENIA

DIATOMS

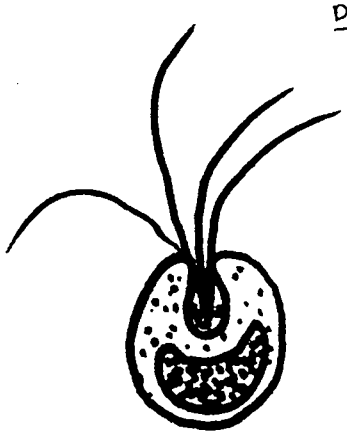


PERIDINIUM

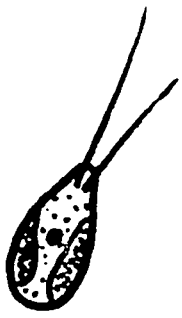
DINOPHYSIS



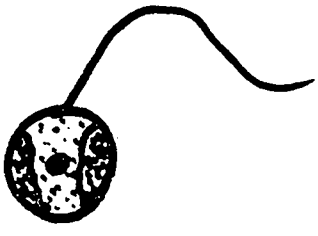
NOCTILUCA



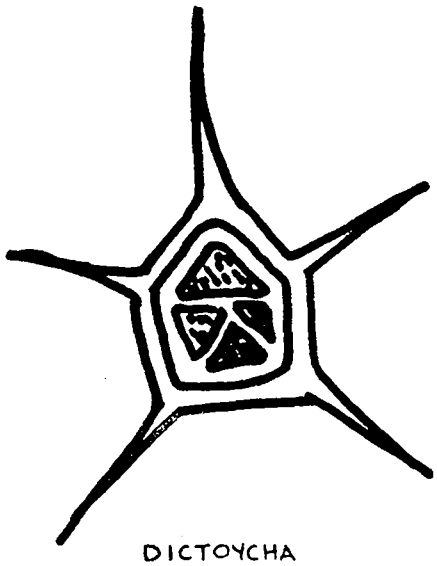
TETRASELMIS



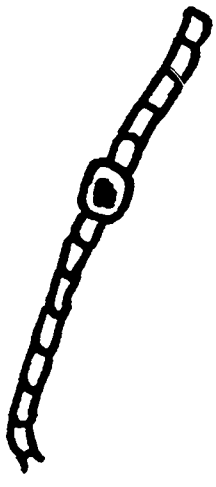
ISOCHRYSIS



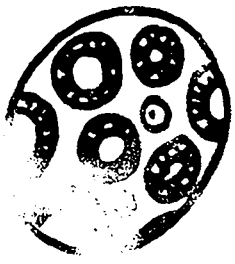
CHROMULINA



DICTOYCHA

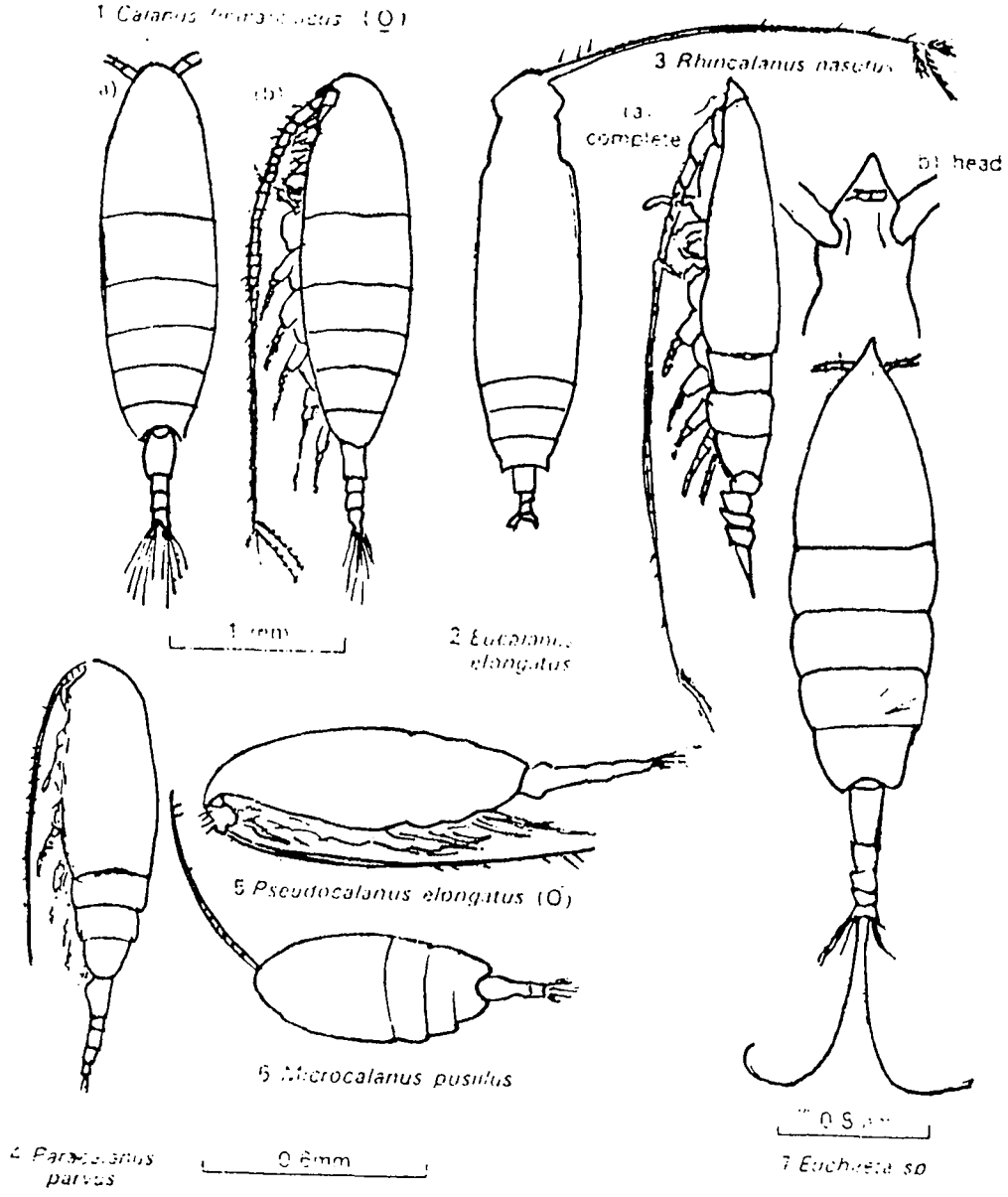


TRICHODESMIUM

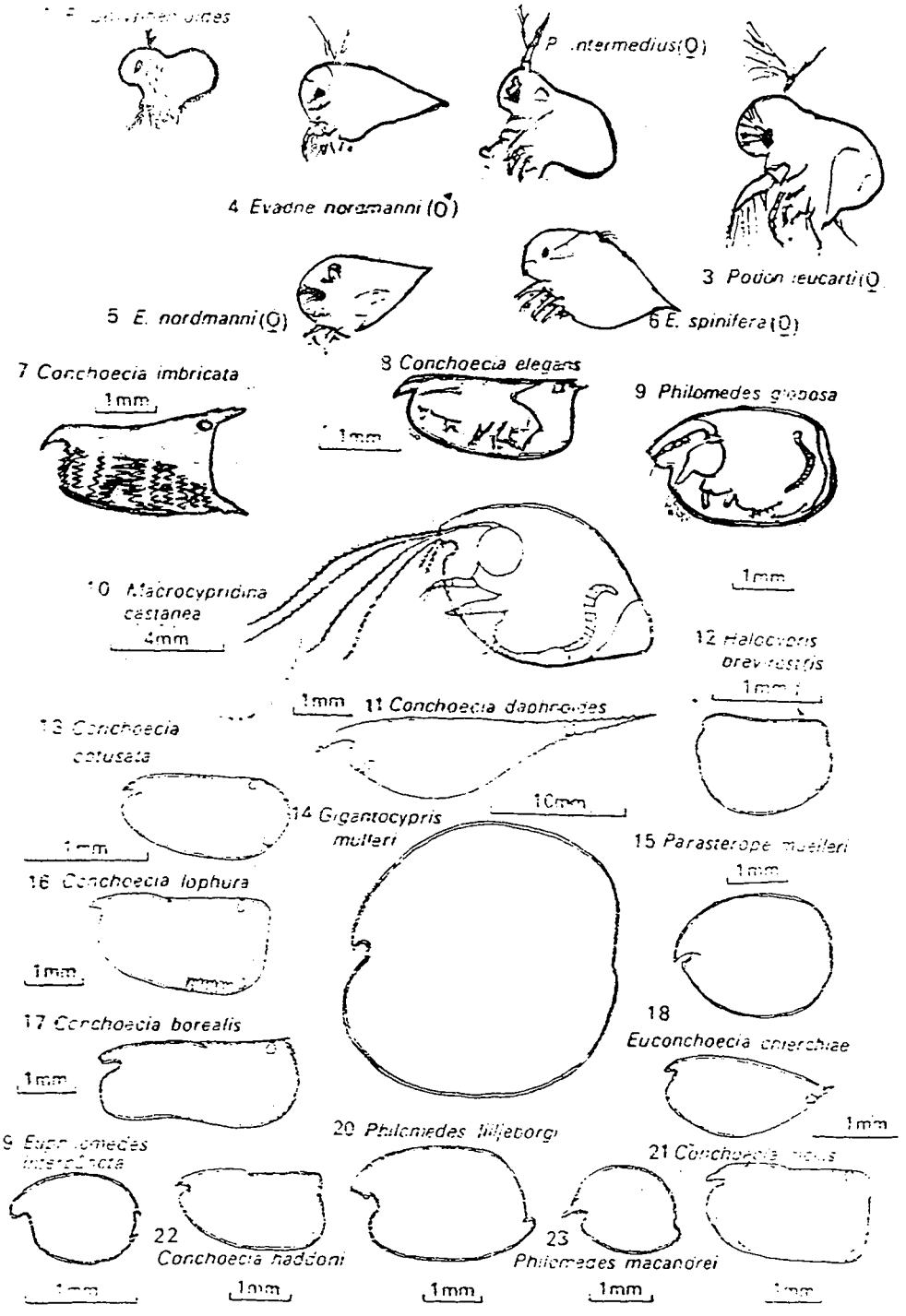


PHAEOCYSTIS

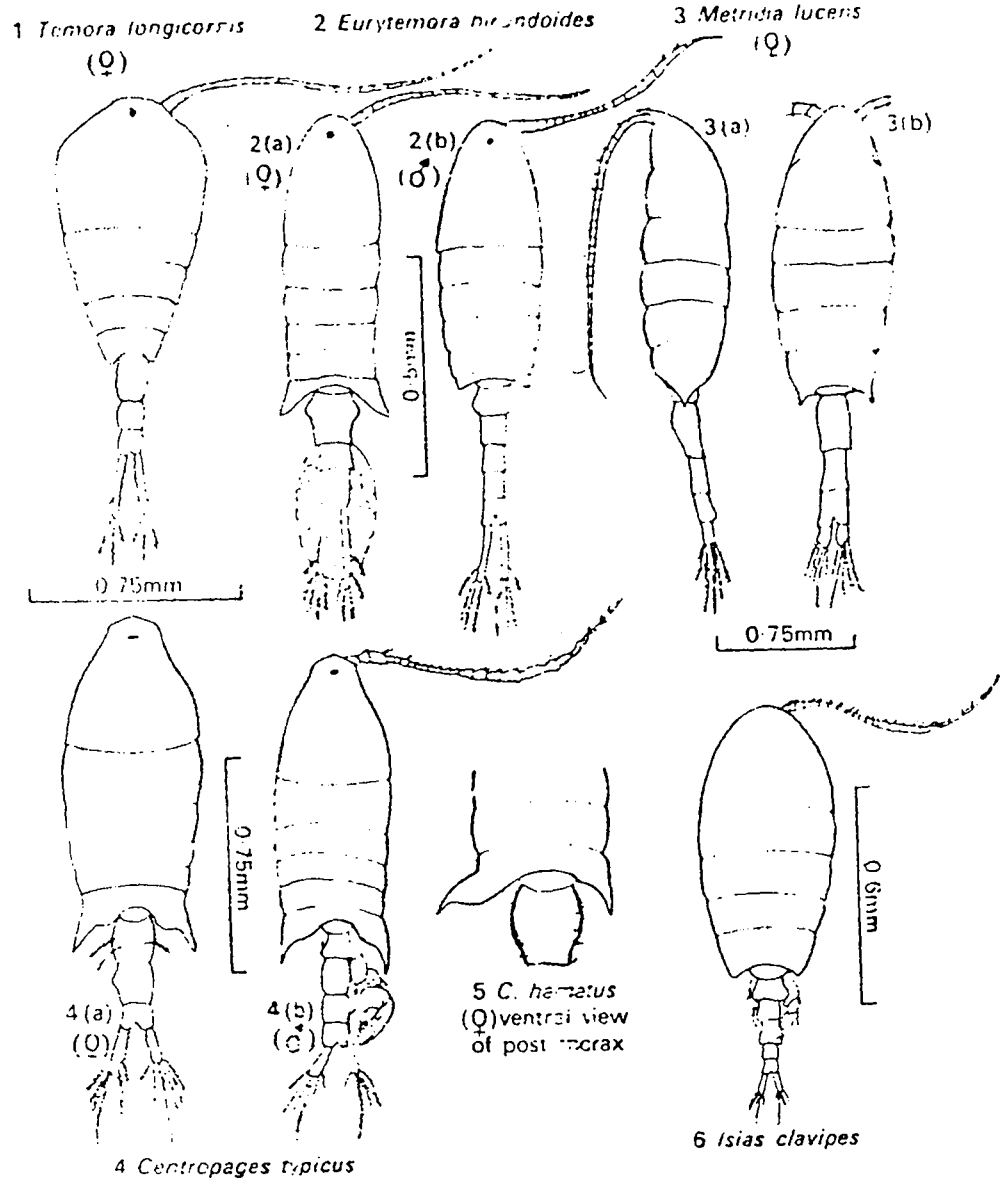
DINOFLAGELLATES SILICOFLAGELLATES COCCOLITHOPHORE AND BLUE GREEN ALGAE



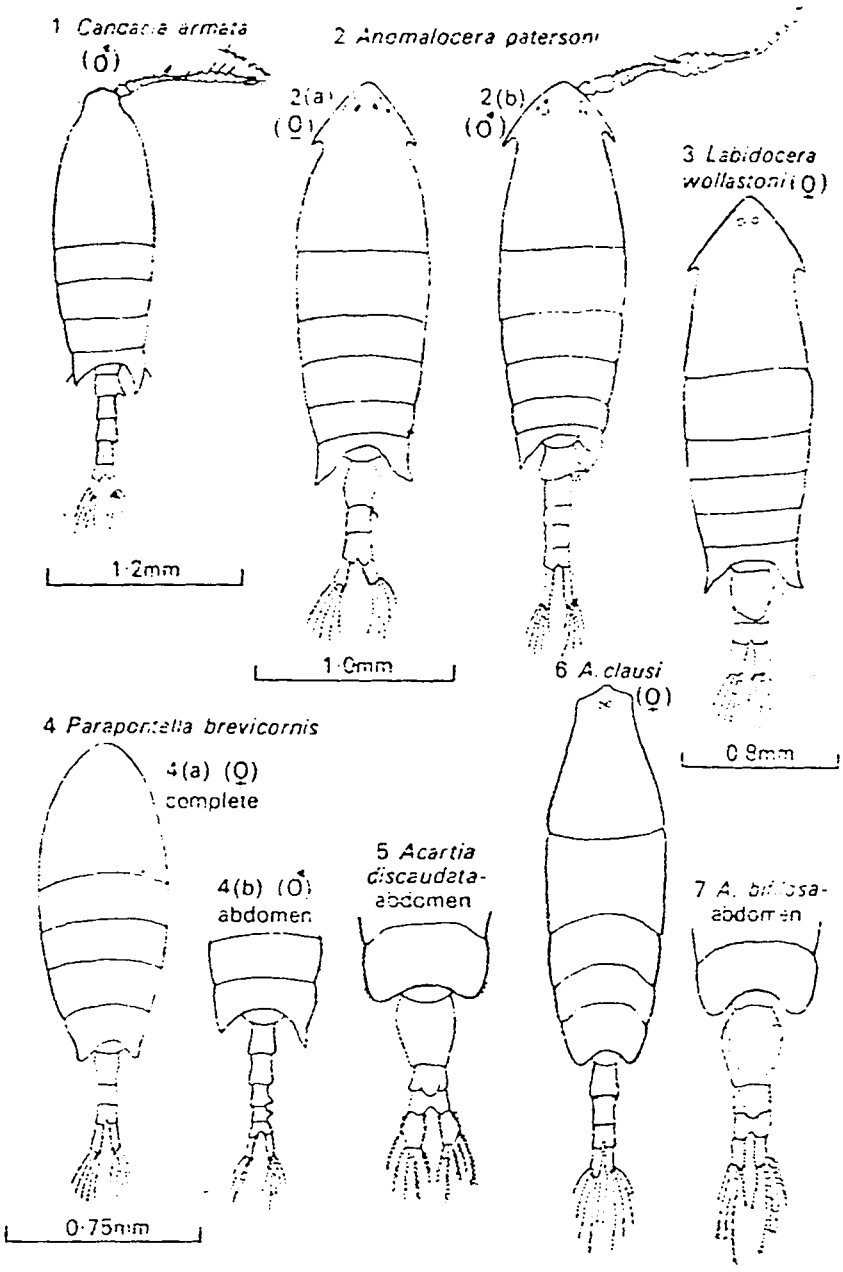
Calanoid Copepods



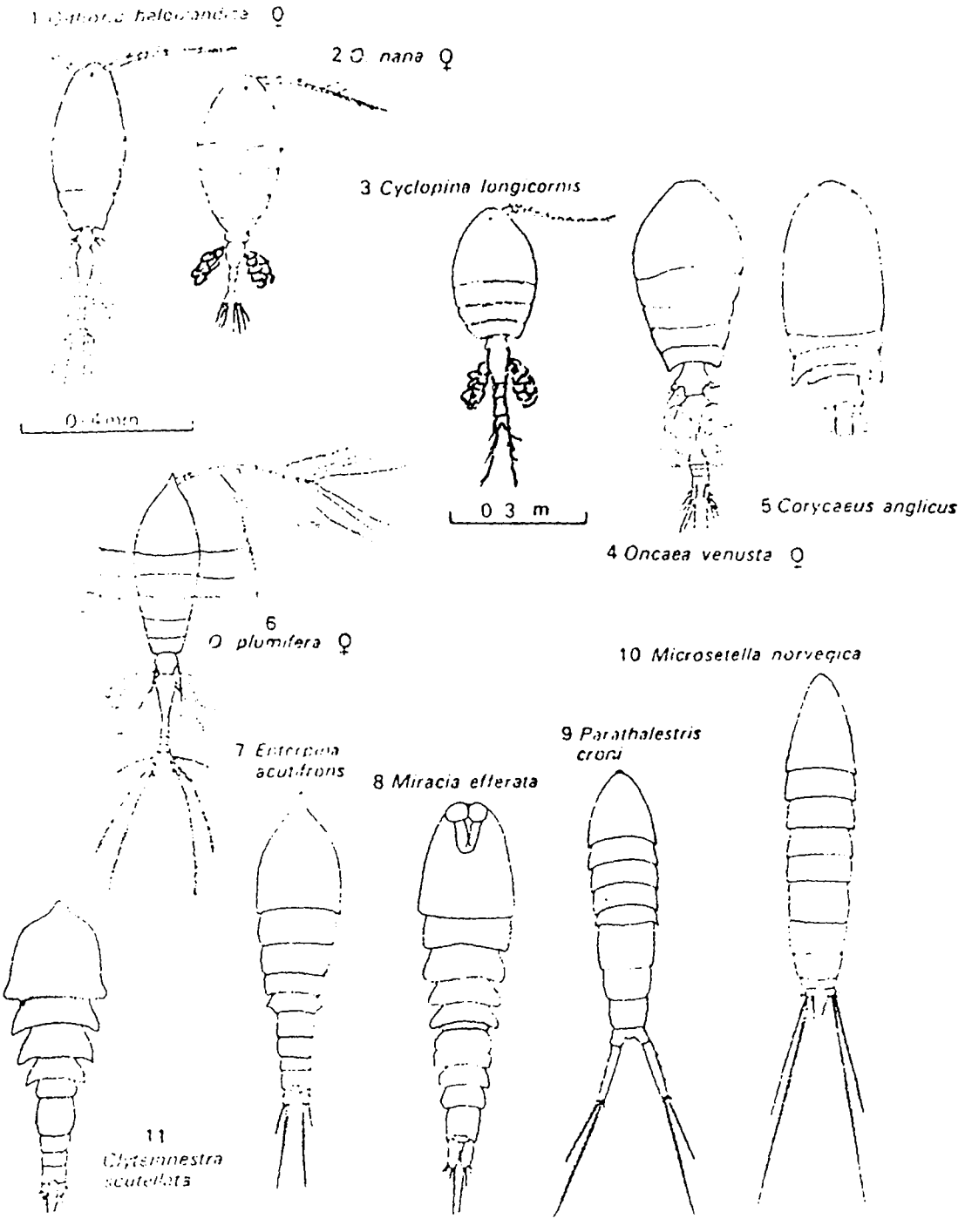
Cladocera and Ostracods



Calanoid Copepods



Calanoid Copepods


1 Oithona haleyandica ♀
2 O. nana ♀
3 Cyclopina longicornis
0·3 m
4 Oncaea venusta ♀
5 Corycaeus anglicus
6 O. plumifera ♀
7 Enterpina acutifrons
8 Miracia efferata
9 Parathalestris croni
10 Microsetella norvegica
11 Clytemnestra scutellata

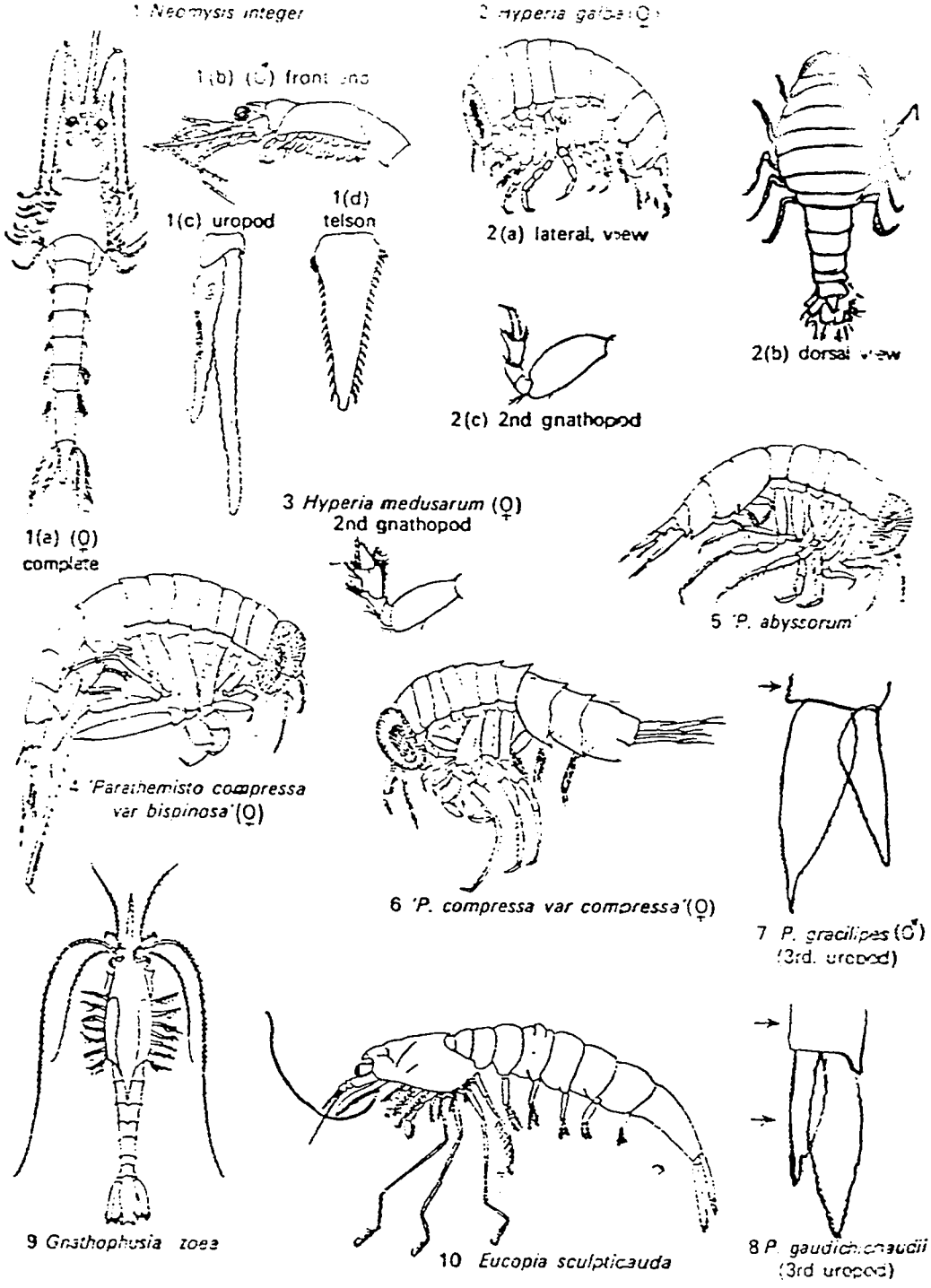
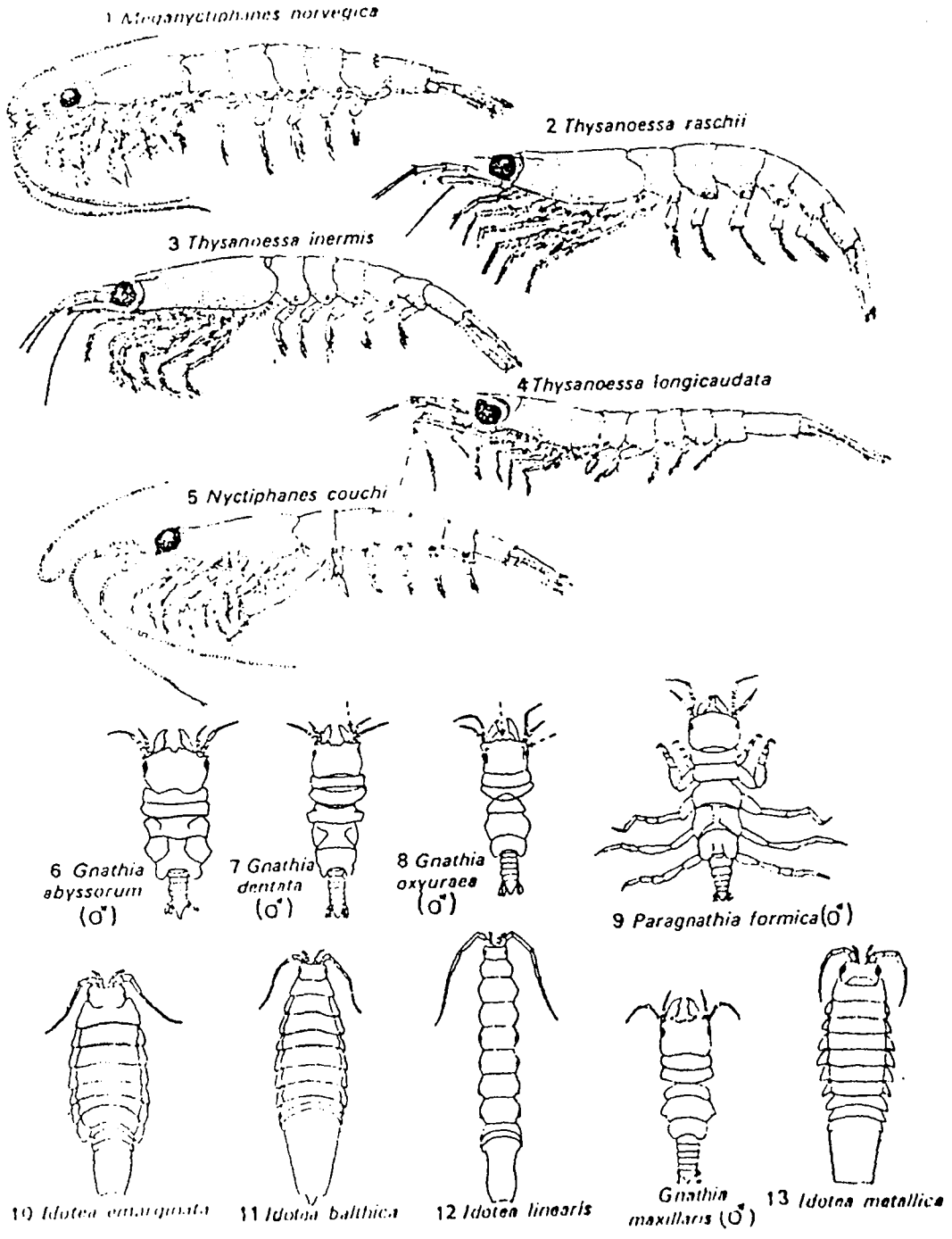
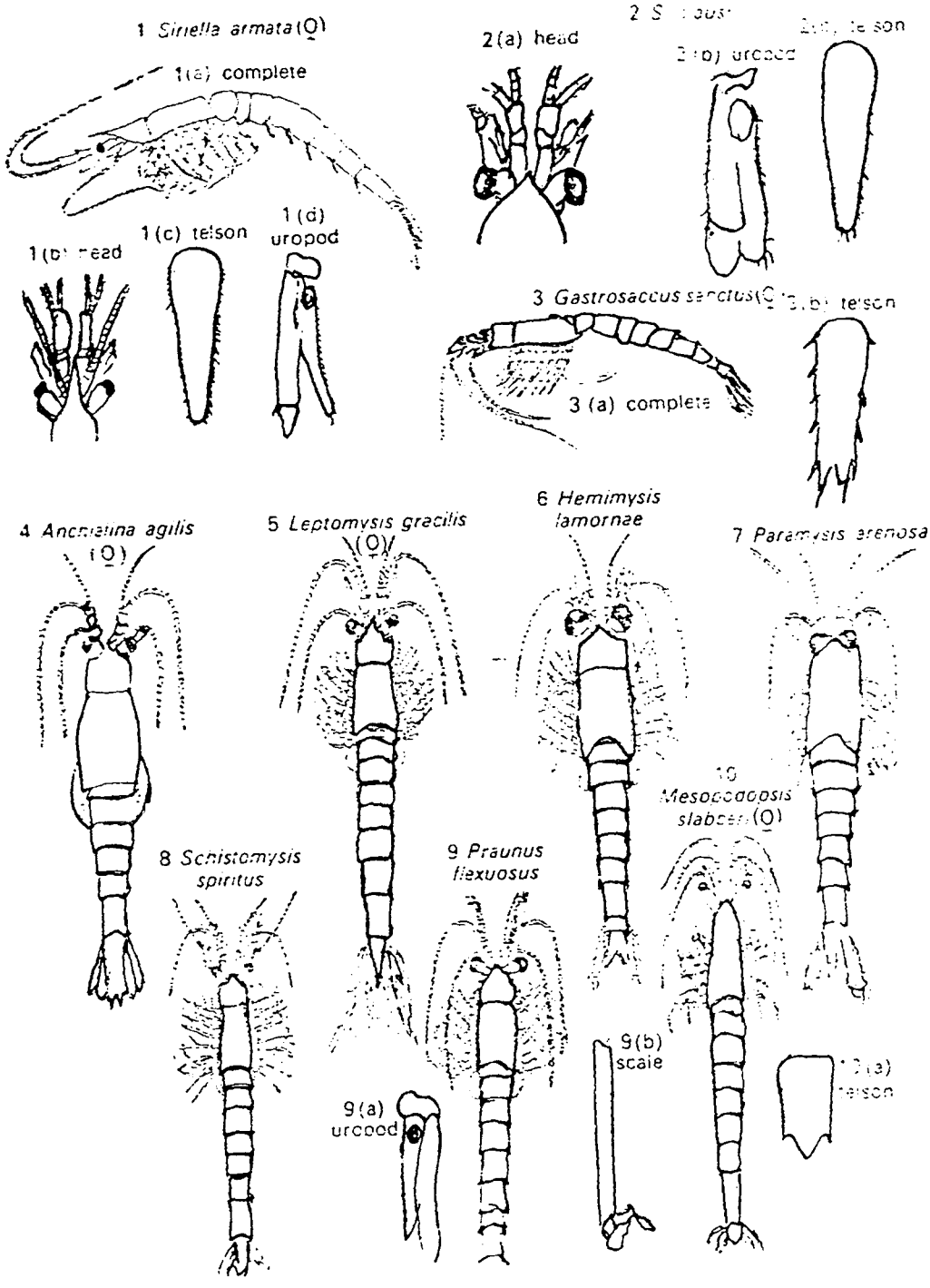
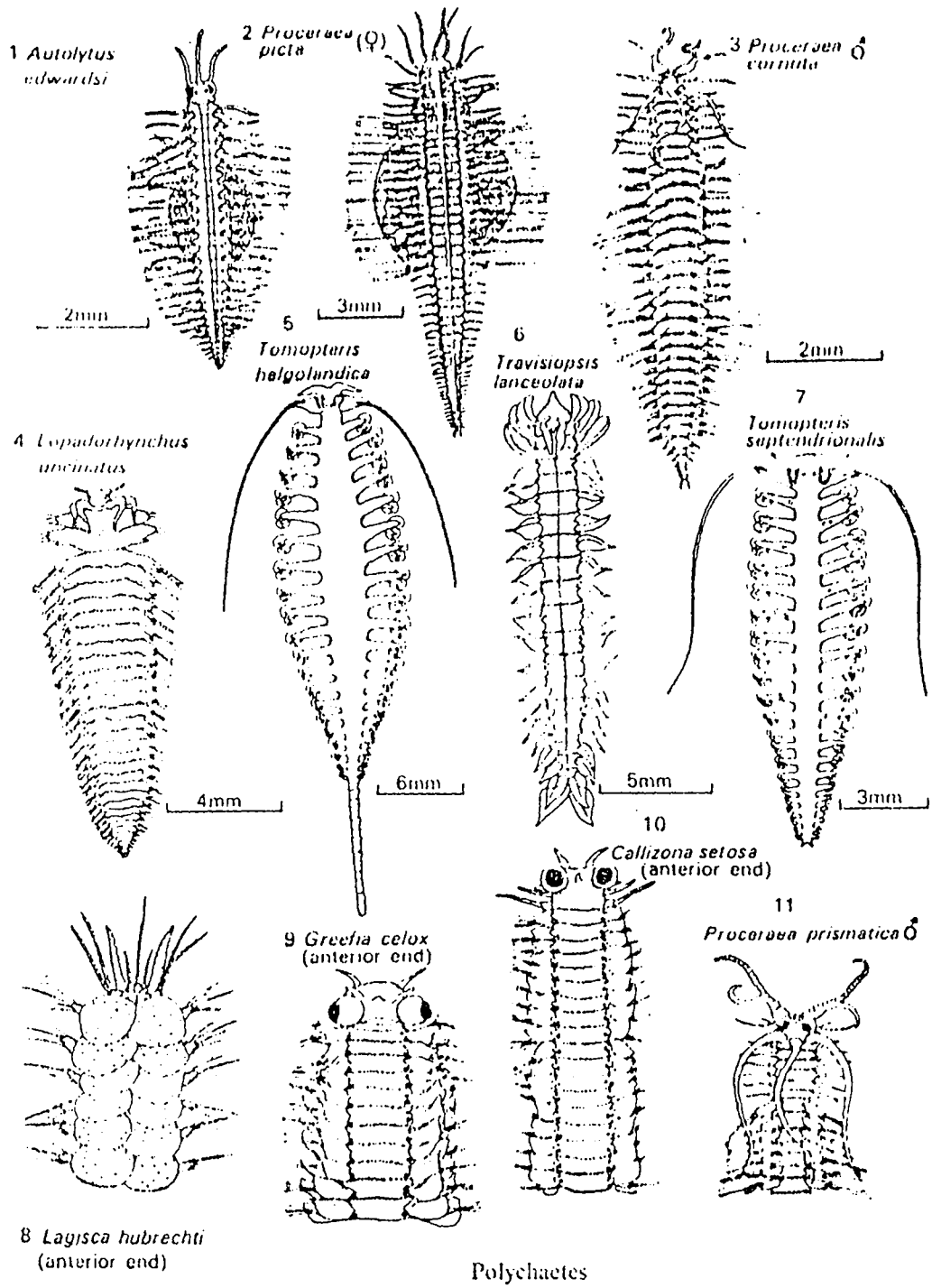


Plate 31. Mysids and Hyperiids

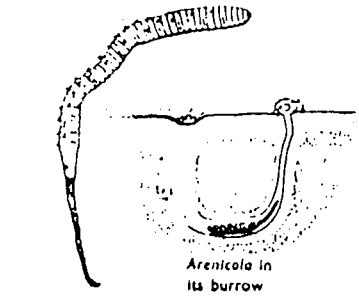


Euphausids and Isopods


1 Siriella armata (♀)
1(a) complete
1(b) head
1(c) telson
1(d) uropod
2(a) head
3 Gastrosaccus sanctus (♀)
3 (a) complete
3(b) telson
4 Anchialina agilis (♀)
5 Leptomysis gracilis (♀)
6 Hemimysis lamornae
7 Paramysis arenosa
8 Schistomysis spiritus
9 Praunus flexuosus
9(a) urcpod
9(b) scale
10 Mesopodopsis slabberi (♀)



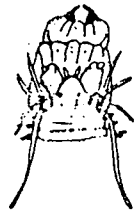
Polychaetes



Arenicola in its burrow

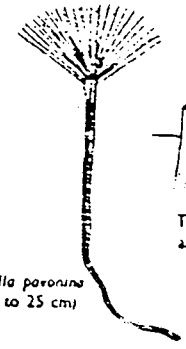
Arenicola marina (15 cm)

Neanthes (= Nereis) virens (20 cm)

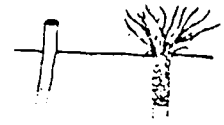


Head and proboscis of: N. virens | Nephtys hombergii | Glycera convoluta

Aphrodite aculeata (10 cm)



Sabella pavonina (up to 25 cm)



Tubes of Sabella and Lanice

SHRIMP FEEDS AND SUPPLEMENTARY FEEDING

BY
DR.S.A.ALI

SHRIMP FEEDS AND SUPPLEMENTARY FEEDING

CONTENTS

SHRIMP FEEDS AND SUPPLEMENTARY FEEDING

1. INTRODUCTION

Feeding the prawns with suitable feed is very important for growing them successfully. The feeding habits and type of food eaten by prawns in their natural environment will form very useful guidelines towards the development of feeds suitable to their liking as well as growth. Penaeid prawns generally live at the bottom of the culture pond. They feed on a variety of plant and animal materials. The early larval stages (Protozoea and Mysis) are filter feeders and consume algae (phytoplankton) such as Chaetoceros and Skeletonema. They also feed zoo-plankton such as rotifers and brine shrimp (Artemia) larvae. Once the prawn larvae become postlarvae they can catch and hold the food and nibble at it at their convenience. Because of this feeding behaviour it is found that pelletized feeds are very much suited for the prawns to hold and carry the pellets and continue the feeding activity with minimum loss of feed. For early larval stages micro-particulate and micro-encapsulated feeds are more suitable to supplement the natural foods.

Before embarking on the development of feed, it is necessary to understand the dietary requirements of candidate species. Through constant research, fairly good information is available in literature on the nutritional requirements of some penaeid prawn species. Still the knowledge is incomplete especially on the

precise needs of vitamins, minerals and other critical nutrient factors. However, with the existing information, practical feeds have been formulated ,developed and produced in many countries of the world. The details of feed composition ,method of preparation and management of feeding in hatchery ,nursery and grow out ponds are presented in this manual .

2 .NUTRITIONAL REQUIREMENTS

Like any other animals, prawns have their specific nutritional requirements for healthy and faster growth.Prawn diet should have sufficient levels of energy, vitamins and minerals. The main sources of energy in the diet are protein, fat and carbohydrate. For preparing a nutritionally balanced feed, the qualitative and quantitative requirements of these nutrients should be known.

2.1.Energy requirements:

Penaeid prawns require about 3500 to 4500 kcal of digestible energy per kilogram in their diet. One gram of protein provides 5.6 kcal of energy whereas 1 gram of lipid is equal to 9.45 kcal of energy. The energy equivalent of carbohydrate is 4.2 kcal/g.

2.2.Protein requirements:

Protein is made of amino acids. It is the most important and also expensive component in prawn feed. Penaeid prawns require 30% to 40% of high quality protein in their diet. Proteins rich in essential amino acids such as arginine,

histidine, isoleucin, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine should be used in the feed. Animal protein from marine resources are rich in these amino acids. Plant protein materials can be used to balance the deficient amino acids.

2.3.Lipid requirement:

The lipid requirement in the diet of prawn is between 6% and 8%. But the lipid supplied in the diet should be rich in polyunsaturated fatty acids (PUFA) such as linoleic acid (18: 2w6), linolenic acid (18: 3w3), eicosapenatoenoic acid (20: 5w3), docosahexaenoic acid (22:6w3). These fatty acids are found to be essential for prawns and should be supplied through the diet. In addition to the simple fats, phospholipids (lecithin), steroids, carotenoids, vitamins D,E and K are essential for growth and survival of prawn larvae and juveniles. Lecithin should be provided at 1-2% level in the diet. Similarly, prawns require about 0.5% of cholesterol in their diet. Even though the quantitative requirements of vitamin D,E and K in the diet of prawn are not fully known these are included in the diet.

Lipids derived from marine animals (fish oil) are found to be rich in PUFA. Plant oils, on the other hand, are good sources of phospholipids and other fatty acids.

2.4.Carbohydrate requirement:

Carbohydrates are classified as monosaccharides (glucose), disaccharides (sucrose) and polysaccharides (starch). Among them prawns are found to utilize disaccharides and polysaccharides better. In practical feeds, starch is generally used as source of carbohydrate. According to the requirement of energy, carbohydrate level in the diet of prawn can be between 20% and 40%. Apart from this, the diet should also contain cellulose fibre (roughage) which should not be more than 6%. This is found to be necessary for healthy grown of prawns and better conversion efficiency of feed.

2.5.Mineral requirements:

Inorganic elements like calcium, phosphorus, sodium, potassium, magnesium, iron, manganese,, copper, chlorine, iodine, cobalt, zinc etc. are generally known as mineral elements. These are required in small quantities in the diet and therefore are categorised as minor nutrients (or trace elements). The mineral nutrients are important and essential in the diet of prawn. Their deficiency in the diet often causes diseases. The requirement of calcium and phosphorous is about 1% and 1.2% respectively. The requirement of other minerals may be as follows: Magnesium 0.3%, potassium 0.9%, copper 0.06% and zinc 0.07%. In addition to these, cobalt, iodine, iron and manganese may be required in trace quantities which are not yet established.

Suitable salts of these elements can be used for preparing mineral mixture and should be used at appropriate levels in the diet.

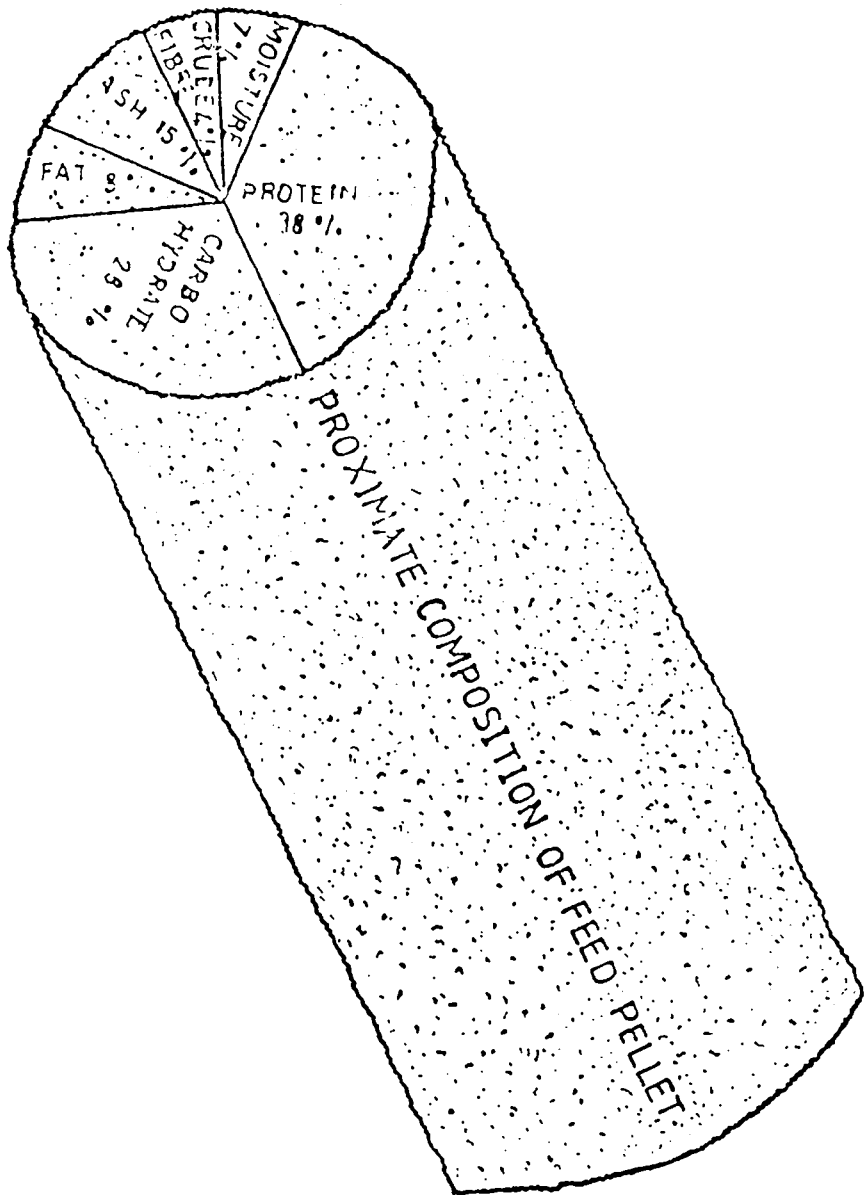
2.6.Vitamin requirements:

Vitamins are essential in the diet of prawn and their absence in diet leads to deficiency diseases. Prawns require most of the vitamins of B-group, vitamins C and E. The quantitative requirement of thiamine is 6-12 mg and that of pyridoxine is 12 mg per 100 g of diet. The diet of prawn requires 60 mg of choline, and 200-400 mg of inositol. Vitamin C (ascorbic acid) is required in higher amounts which is about 0.5 to 1.0%. Its deficiency in the diet is found to cause a disease syndrome called 'black death'. B-carotene should be supplied in the diet and the prawns are capable of converting it into Vitamin A. The requirement of Vitamin D and K for prawns is not established.

TABLE.1 Dietary requirements of tiger prawn (Penaeus monodon) and Indian white prawn (P.indicus)

S.No	Name of the nutrient	% requirement in diet	
		P.monodon	P.indicus
1	Energy(kcal/Kg)	2800 - 43	3500 - 4000
2	Protein	30 - 40	30 - 43
3	Fat	3.5 - 8.0	6 - 9
4	Phospholipid (Lecithin)	0.1 - 2.0	0.1 - 2.0
5	Cholesterol	0.5 - 1.0	0.5
6	Carbohydrate	20 - 35	25 - 30
7	Crude fibre	3 - 6	3 - 6
8	Minerals		
	Calcium	2 - 2.5	0.5 - 1.0
	Phosphorous	1.2 - 1.4	1.05
	Potassium	0.7 - 0.9	1.26
	Magnesium	0.8 - 0.15	Trace
	Manganese	0.004 - 0.005	Trace
	Iron	0.06 - 0.08	-
	Zinc	0.008 - 0.01	0.07
	Copper	0.00100	0.06
	Cobalt	0.00100	-
	Iodine	0.00050	-
	Chromium	0.00008	-
	Selenium	0.00002	-
9	Vitamins		-
	Thiamine	0.01200	0.01
	Riboflavin	0.00400	0.008
	Pyridoxin	0.01200	0.02
	Pantothenic acid	0.01000	0.075
	Niacin	0.01500	0.025
	Folic acid	0.00050	-
	Biotin	0.00010	-
	Cyanocobal	0.00001	-
	Choline chloride	0.06000	0.5 - 0.75
	Inositol	0.20000	0.3
	Vit.C	1.00000	0.4 - 0.8
	Vit.A	500.00	-
	Vit.D	100.00	-
	Vit.E	0.02000	-
	Vit.K	0.00400	-

Fig. 1


MOISTURE 7 %
CRUDE FIBRE 1 %
ASH 15 %
FAT 8 %
PROTEIN 38 %
CARBO HYDRATE 29 %
PROXIMATE COMPOSITION OF FEED PELLET

3. FORMULATION OF COMPOUNDED FEEDS

After understanding the nutritional requirements of candidate species of prawns, compounded feeds are formulated by balancing the requirements with natural feed materials available in the region. The ingredient composition of a feed is made through balancing the major nutrients protein, lipid and carbohydrate. The feed formula is completed by incorporating adequate levels of mineral and vitamin mixtures. For formulating good quality feeds, the raw materials available in the region should be identified and selected after testing for their nutritional quality.

3.1. Selection of raw materials:

The feed materials required for formulating prawn feeds are protein sources (animal and plant materials), lipid sources and carbohydrate sources. The criteria for selection of a raw material is that the selected material should have good quality and should be available in large quantities whenever it is required and at reasonable price.

3.2. Protein sources:

The typical animal protein sources are fish meal, squid meal, prawn head meal, squilla meal, cuttle fish meal, clam meal and crab meal. In addition to these, materials like meat,and blood meal and feather meal may also be used wherever available, after testing their suitability for prawns.

The important plant protein sources are soybean meal,

groundnut cake, gingelly cake, mustard cake, coconut cake and any other residues of oil seeds after extraction of the oil. Care should be taken in using the plant protein sources since some of them contain toxins or growth inhibiting factors. For example soybean cake contains a trypsin-inhibiting factor and mustard cake contain thiocyonates which are toxic to animals. Suitable methods should be employed either to destroy them or removed before they are used in feed preparation.

There are also some single cell protein sources such as Spirulina and yeast which can be used in the feed formulae.While yeast is a good source of vitamins,spirulina is rich in pigments.

3.3.Lipid sources:

Some of the important lipid sources which can be used in the prawn feeds are cod liver oil, shark liver oil, sardine oil, soybean oil and soybean lecithin. Most of these lipids are rich in PUFA and should be preserved from oxidation. This can be done by adding antioxidants such as butylated hydroxyanisole or ethoxyquin at 100 ppm. Cholesterol can be used for supplementing its requirement in the feed.

3.4.Carbohydrate sources:

The important carbohydrate sources are wheat flour, rice flour, jowar and tapioca powder. All these materials are good sources of starch in the feed and can also act as binders if appropriate method of preparation is adopted.

The proximate composition of some selected feed materials is given IN Appendix-1.

3.5.Feed Formula:

After selection of the raw materials a feed formula can be evolved by balancing the nutrients in the feed at required levels. One of the simplest methods by which a feed formula can be obtained is the 'Square' method. In this method either the protein or energy of the feed can be balanced. The method is illustrated by the following example.

Example:

To the prepare a feed with 35% protein using four ingredients, fish meal (protein 60%), prawn head meal (protein 35%), soybean cake (protein 48%) and tapioca (protein 2%). In this case the ingredients are grouped into protein supplements (having more than 20% protein), and basal feeds (having less than 20% protein). The protein content in each group is averaged as follows:

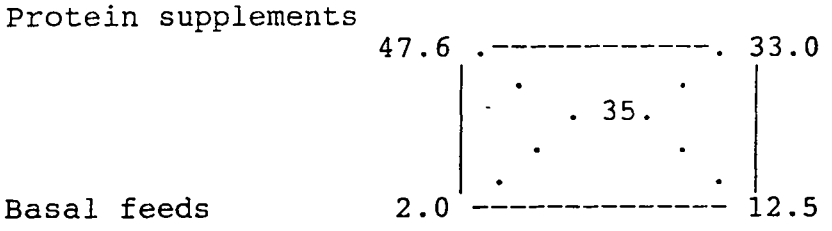
Protein supplements -	fish meal	- 60.0
	Prawn head meal	- 35.0
	Soybean cake	- 48.0
		143.0

$$\text{Average } \frac{143}{3} = 47.6$$

Basal feeds: tapioca = 2.0%

Now a square is constructed and names of the feed materials are written on the two left corners along with the protein content. The required protein level is written in the middle of

the square. Next, the protein level of the feed is subtracted from that of the ingredients and the answer is placed in the corner opposite to the corresponding feed stuff ignoring the positive or negative sign as given below:



Add the figures on the right hand side of the square 33.0+12.6 = 45.6. Now to make the feed with 35% protein we must mix

Protein supplements $\frac{33.0}{45.6} * 100 = 72.37$

Basal feeds $\frac{12.6}{45.6} * 100 = 27.63$

The protein supplements are 72.37% in the feed and basal feed is 27.63%.

The feed formula using these materials can be written as follows:

Fish meal $\frac{72.37}{3} = 24.1\%$

Prawn head meal	$\frac{72.37}{3}$	= 24.1%
Soybean cake	$\frac{72.37}{3}$	= 24.2%
Tapioca powder		= 24.6%
	Total	=100.00

For adding Vitamin and mineral mixture, appropriate amount of tapioca may be replaced. The feed thus formulated above contains 35% of crude protein.

3.6.Feed Binders:

Prawn feeds, when put in water should not dissolve and disintegrate immediately. The feed should be stable in water for at least three to four hours. For making the feed water stable, suitable binding material should be used, which keeps the feed ingredients together. Many chemical substances can be used as binders. Some examples of binding materials are agar, carboxy methyl ceullulose (CMC) gelatin, gum, polyvinyl alcohol (PVA), sodium alginate and starch. Any natural source of starch can be used as binder. In such a case the feed should be cooked at 100 ^{0}C for 5-10 minutes in order to gelatinize the starch. In practical feeds starch is a good and economical binder.

4.MICRO-PARTICULATE FEEDS FOR FEEDING POST-LARVAE IN HATCHERY AND NURSERY

The early stage of Prawn larvae, protzoea and mysis are successfully reared using single or mixed cultures of diatoms. The postlarvae have to be reared for 15 to 20 days until they

become stockable in size. For post larvae, diatoms alone are not adequate. These are supplemented with live feeds such as rotifers and Artemia nauplii or micro particulate prepared feeds or both. Feeding prepared feed to post larvae have many advantages. These feeds are readily available and can be used off the shelf. They are nutritionally well balanced and are easy to dispense to post larvae whenever the wherever required. Considering the small size of postlarvae, these feeds are prepared as micro-particles/micro capsules of size ranging from 200 to 1000 microns. The following feed may be used for feeding post larvae of prawns.

TABLE 2

Composition

Fish meal	24.0%
Squid meal	6.0%
Prawn Head meal	16.0%
Soybean cake/groundnut cake	20.0%
Yeast	1.0%
Tapioca	24.99%
Alfalfa	2.0%
Lecithin (Soybean)	2.0%
Vitamin mix 1	2.0%
Mineral mix 2	2.0%
Butylated hydroxyanisole (BHA)	0.01%
Total	100.00

1. Vitamin mixture

Vitamin A	0.01 g
Vitamin C	0.50 g
Choline Chloride	0.20 g
Niacin	0.05 g
Pantothenic acid	0.02 g
Pyridoxine	0.05 g
Thiamine	0.01 g
Inositol	0.20 g
Riboflavin	0.02 g
Vitamin B_{12}	0.000015 g
Folic acid	0.002 g
Filler (cellulose)	0.937985
	2.0000 g

2. Mineral mixture

Calcium carbonate	0.5 g
Potassium dihydrogen orthopshosphate	1.0 g
Potassium iodide	0.002 g
Zinc sulphate	0.07 g
Copper sulphate	0.06 g
Cobalt sulphate	0.0006 g
Magnesium sulphate	0.1 g
Manganese chloride	0.004 g
filler (cellulose)	0.2634 g
Total	2.0000

The proximate composition of the feed is as follows:

Moisture	5.2%
Crude protein	39.5%
Lipid	8.0%
Carbohydrate	27.3%
Crude fibre	5.7%
Ash	14.3%

4.1.Processing of ingredients:

All the ingredients are obtained in dry form. Fish meal, groundnut cake and tapioca powder are available as dry materials. Prawn head waste and squid may be collected in fresh condition an dried in an electrical dryer at 70°C. The dry ingredients are powdered individually in an electrical grinder and are passed through 0.2 mm sieve.

4.2.Preparation of stock feed:

Powdered ingredients are mixed according to the formula and thoroughly homogenised with 400 - 500 ml of water per kg of dry feed. The dough so obtained is steamed in a cooker (without pressure) for 10 minutes. The feed is pelletized using a 2 mm diameter die and dried in an electrical dryer at 70°C till the moisture is less than 10%. The dry feed is stored in polythene bags kept in good containers. This is the stock feed.

4.3.Preparation of micro particulate feed:

For preparing micro-particulate feed, the pellets from the stock feed are taken and powdered in an electrical grinder with controlled speed. The powdered mash is sieved through 100 and 200 micron sieves. The particles passed through 200 micro sieve but

retained by 100 micron sieve are taken as 200 micron particles. Similarly the particles of 500 and 1000 microns are prepared by passing through these two respective sieves.

4.4.Rate of feeding and feeding schedule:

The micro-particulate feed is introduced to mysis-III or postlarvae I in hatchery and continued upto PL 20 and beyond in nursery. The details of particle size, feeding rate and frequency of feeding of the post-larvae in hatchery and nursery are summarised below:

TABLE 3

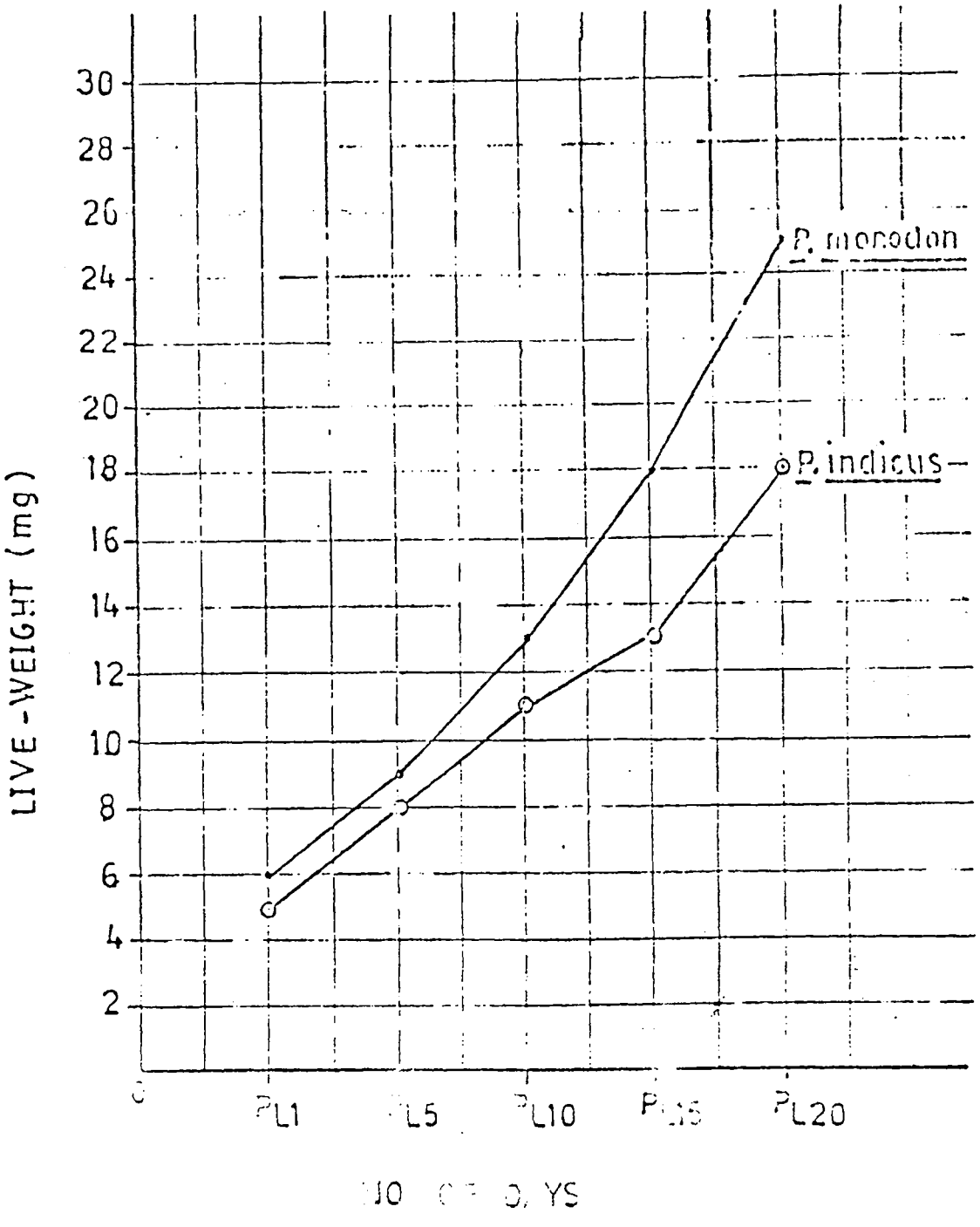
Stage of larvae	particle size (microns)	Qty.of feed per day per 1000 larvae	Schedule & time of of feeding
Mysis III upto postlarvae PL 10	200	200 mg	Divide the feed in three equal parts & broadcast in the larval tank in the morning, afternoon and evening.
PL 11 to PL 20	500	1000 mg	---do---
PL 20 and above	1000	2-3 g	---do---

5.MICRO ENCAPSULATED FEEDS:

Micro-encapsulated feeds are prepared by encapsulating a feed material with a suitable coating wall. The size of capsules range from 10 microns to 500 microns. Micro-encapsulated feeds are primarily meant for feeding prawn larvae. The central feed mixture is called the core and capsulating material is called the

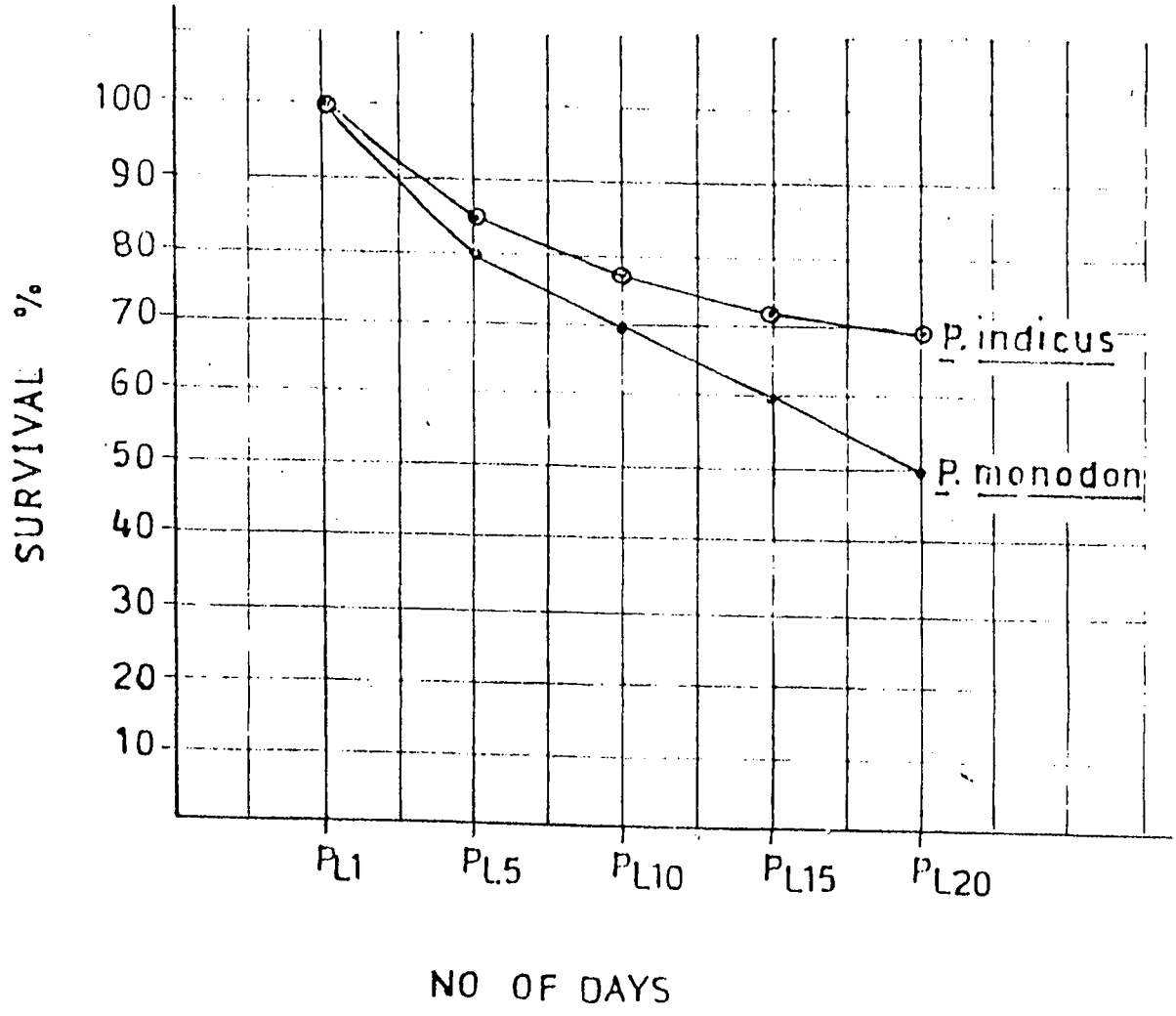
GROWTH OF POSTLARVAE OF PRAWN
IN HATCHERY AND NURSERY

Fig. 2



SURVIVAL OF POSTLARVAE OF PRAWN
IN HATCHERY AND NURSERY

Fig. 3



outer wall. Micro-encapsulation is achieved by different methods. These are nylon-protein encapsulation, gelatin-gum, sodium algi nate , calcium chloride, zein and carrageanan encapsulation techniques. Both liquid and solid materials can be encapsulated. The greatest advantage of micro-encapsulation is that leaching of the nutrients from the diet into the water is prevented. When these capsules are ingested by the larvae, the capsule wall is ruptured by the digestive juices and the core material is released into the stomach. A typical example of micro-encapsulation of a diet is described below. The principle involved in this method is that a chemical, diamine, reacts with another chemical sebacoyl chloride, in solvent medium and forms nylon-protein wall to encapsulate a diet mixture.

The materials required are:-

1. Any diet mixture (liquids are preferable)

2. Diamino hexane solution: prepare by dissolving 0.92 g of 1,6 -diaminohexane + 20 ml of 0.45 m sodium bicarbonate-sodium carbonate buffer (pH 9.8).

3. Mixed solvent : Mix chloroform and cyclohexane in 1:4 ratio.

4. Sebacoyl chloride

5. Sucrose monolaurate

6. Span 85 (a detergent).

5.1. **Procedure**

Take 25 ml of mixed solvent and 0.5 ml of span 85 , to this add 0.5 ml of diamine solution and the diet mixture, homogenise for 3 minutes. Take another 10 ml mixed solvent and 0.2 ml of sebacoyl chloride. Mix both the mixtures, stir well and add another 30 ml of mixed solvent. The micro encapsulated diet is precipitated. The particle size of capsules depends upon speed of stirring. Wash the capsules so obtained with 100 ml of mixed solvent 2 or 3 times, and add 7 ml of sucrose, monolaurate and stir for 10 minutes. Filter and take the capsules and keep them in liters of distilled water for 24 hours. Wash the capsules with water twice. The micro-capsules so obtained should be stored in molar sodium chloride solution.

Micro-encapsulated diets can also be prepared by spray drying technique.

6. **QUALITY CONTROL AND STORAGE OF FEEDS :**

Checking the quality of the raw materials and the final product is very essential. The raw materials and feeds should conform to the nutritional composition required. Analysis of proximate composition of feeds and feed materials reveals their quality. The proximate composition consists of estimating moisture, crude protein, lipid, carbohydrate, crude fibre and ash. These can be determined by standard AOAC methods.

Proper storage of feeds and feed materials is very important. Improper storage of feeds leads to deterioration of quality. It may often lead to large scale mortalities of cultured

animals. During storage feeds are subjected to attack by insects, moulds and rodents. This can be effectively controlled by storing feed in proper containers.

Moisture content in feed plays an important role. If the moisture content is more than 10%, mould growth may occur. This can lead to production of afflatoxin in feeds and feed materials which is very toxic to prawn larvae and juveniles. Oil cakes such as groundnut cake, coconut cake, soybean cake etc. are more prone to afflatoxin contamination. Mould growth can be prevented by controlling the moisture in the feed and also by using preservatives such as sodium benzoate or salts of propionic acid at about 100 ppm.

Since prawn feeds contain lipids with polyunsaturated fatty acids, these are easily oxidised when exposed to atmospheric air. This reduces the nutritional quality of the feed. It can be controlled by storing the feeds in air tight containers and using some antioxidants such as butylated hydroxy anisole (BHA), butylated hydroxy toluene (BHT) and ethoxyquin at 100 ppm.

7. PELLETIZED FEEDS FOR PRAWN FARMING

There are three different types of prawn farming, 1) Extensive/traditional farming, 2) semi-intensive farming and 3) Intensive farming. These culture systems differ mainly in the number of prawns stocked in unit area and the relevant water management procedures to be adopted. Similarly the feeds used for feeding prawns in these culture systems are also different. In extensive or traditional culture systems, the stocking density is

low (20 to 50 thousand per hectare). The ponds are connected to sea through canals and the water exchange takes place through tide water. The stocked prawns feed on natural food available in the pond and grow. Some farmers use supplementary feeds to increase the production. In semi-intensive and intensive farming intensive water management is done through continuous pumping of filtered water. As a result of this there is very little natural food available to the stock. Hence the prawns should be fed with well balanced high quality feeds for faster growth and targeted production of prawns.

7.1.**Supplementary feeds**:

In extensive/traditional culture systems, apart from the natural food available to the prawns in the ponds, additional feeds are supplemented to improve the growth and production of prawns. These supplementary feeds also include the local feed used by the farmers. Materials which are available in the region on regular basis at a reasonable price can be used as supplementary feeds. Some examples of supplementary feeds used by farmers are clam meat, mussel meat, snails (pila), trash fish, silk worm pupae, beef, chicken entrails, mixtures of oil cakes such as groundnut, soya bean, gingelly and cotton seed cakes , rice bran small prawns and crabs. These feeds are used either as single item or a mixture of them according to the availability. Besides these, formulated pelletized feeds are also used as supplementary feeds. Supplementary feeds generally provide extra energy (protein, fat and carbohydrate) to the stocked prawns in addition to the natural food. Therefore supplementary feeds may not be

completely balanced feeds. The following feed formulations can be used as supplementary feeds for tiger Prawn and Indian While Prawn.

TABLE 4

Composition of supplementary feeds

Name of ingredient	For Tiger Prawn	For Indian While Prawn
Fish meal	18	10
Prawn head meal	10	18
Squid waste meal	7	06
Squilla meal	10	18
Groundnut cake	--	28
Soyabean cake	28	--
Tapioca powder/wheat flour/rice flour	25	18
Vitamin and mineral[1] mixture	02	02
	100	100
Crude proteins	37.0	36.0
Fat	6.0	5.0
Carbohydrate	18.0	20.0

1. Vitamin and Mineral mixture:

2 g of vitamin and mineral mixture consists of vitamin A 8000 IU; thiamine hydrochloride 20 mg, riboflavin 4 mg, niacin 20 mg, pyridoxine hydrochloride 6 mg. Calcium pantothenate 20 mg, cyanocobalamine 2 mcg, ascorbic acid (Vitamin C) 100 mg,

calciferol 800 1.U, Vitamin E (acetate) 3 mg, biotin 0.1 mg, calcium phosphate 0.418 g, ferrous sulphate 21.14 mg, magnesium sulphate 96 mg and manganese chloride 1.2 mg.

NOTE:

'ROCHE' Multivitamin tablets can be used at the rate of 3 tablets (powdered) per kg of feed in case it is not possible to prepare the above vitamin and mineral mixture.

7.2.Balanced feeds:

For semi-intensive and intensive farming of shrimp, nutritionally balanced, high quality feeds should be used for faster growth and expected production. Balanced feeds are formulated by carefully selecting good quality feed ingredients. The protein and the essential amino acids, the fat and the essential fatty acids and carbohydrate to provide the required calorific value are balanced by choosing the feed ingredients. Essential lipids such as lecithin and cholesterol may be added to the formula. The full complement of all the vitamins and minerals and the trace elements should be incorporated.

In addition to these, the feed formula also contains permitted growth promoters, feed attractants, digestive enzymes, binder and preservatives. The feeds are produced at least in three grades, 'Starter', 'Grower' and 'Finisher' mainly to suit the different size groups of prawn. Starter feed is used for the first forty five days after stocking, the 'Grower' for the next forty five days and after that 'Finisher' grade until the Prawns are harvested.

These three grades of feeds differ in their physical properties. Starter feed is in the form of granules of 1.0 mm in diameter. While 'Grower' is a pelleted feed with 2.0 mm diameter and the Finisher being 2.0 - 2.5 mm diameter pellet having a length of 3 to 5 mm. Apart from the physical properties the three grades of feeds also differ in their nutritional composition. While the energy (calorific value) is practically same, starter will have higher protein and less fat and carbohydrate. The protein level gradually decreases from starter to 'finisher' with a corresponding increase in fat and carbohydrate. The difference in protein level between 'starter' and 'finisher' is in the range of about 5%.

7.3.Growth Promoters:

Some natural materials or chemical substances are added to feed for promoting faster than normal growth in Prawns. These are squid protein, Yeast, Spirulina (fresh water alga), Duck weed (wolfia), Alfalfa (Lucerne grass) Chitin and glucosamine. These are added to the feed from 1 to 5% depending upon the cost of the feed to be produced. Steroid hormones and antibiotics should not be used in the feed as growth promoters. These are harmful substances because the residues of these substances in the body of cultured prawns will lead to health hazards in human beings consuming such Prawns. If such residues of steroids and drugs (antibiotics) are found in prawns exported to other countries they may be rejected.

7.4.Feed 'Attractants':

Prawns recognise their food with the help of what are called Cheamoreceptors' which are situated all along the body of prawn. These Cheamoreceptors recognise certain chemicals released by the food into water and the prawn is guided to the food immediately. These chemicals released by the food are called feed attractants. In nature these attractants are found to be certain amino acids. Therefore synthetic aminoacids such as alanine, glycine, glutanic acid, methionine and serine and water extracts of fresh clam meat, mussel meat and prawn head are used as feed attractants. Feed attractants help in quick consumption of feed by prawns and make the Prawn grow faster.

7.5.Digestive additives:

Some times digestive enzymes such as papain and bromelain are added in prawn feeds to improve the digestibility of feed and there by improve the feed conversion ratio. These are generally incorporated at 0.1 to 0.2% in the feed.

7.6.Feed Conversion Ratio (FCR):

Feed conversion ration (FCR) is the quantity of feed required to produce one kg of prawn. This is calculated by the formula.

$$FCR = \frac{\text{Quantity of feed consumed (dry wt.)}}{\text{Quantity of prawn harvested (kg)}}$$

Thus if the FCR is 2, it means two kilograms of feed is required to produce one kg of prawn. Therefore the smaller the FCR, the better is the feed. A good quality feed should give a FCR of 1.5 to 2. The FCR of a feed depends upon many factors such as

nutritional quality, and processing technology used, water stability, feeding method and feeding schedule and also the water quality management in the pond. A best feed may give very poor production if the water quality in the pond is not good for long time. FCR also plays an important role in cost of production of prawns. For example, a feed costing Rs.40/- per kg with a FCR of 1.5, the feed cost for producing 1 kg of prawn is Rs.60/- where as a feed costing Rs.25/- with a FCR of 2 will cost only Rs.50/- to produce one kg of prawn. Thus the cost of feed, FCR and Cost of Production of prawn are inter linked and this should be understood clearly by the prawn farmers.

7.7.Preservatives:

Since shrimp feeds contain fats with unsaturated fatty acids, these are easily oxidised leading to rancidity. These unsaturated fatty acids can be protected with the help of antioxidants such as butylated Hydroxy Anisole (BHA), Butylated Hydroxy Toluene (BHT) and Ethoxyquin. The antioxidants are added to the oil and also to the feed mixture at the rate of 100 ppm. Feeds absorb moisture on storage. This will lead to mould (fungus) growth on feed. Some of the fungi can produce afflatoxin which is harmful to prawn. To prevent mould growth sodium propionate or sodium benzoate may be added at 0.01% to the feed.

7.8.Water stability of feed:

Feed has to be offered to the prawn under water. Prawn feed should not dissolve or disintegrate before it is eaten by Prawn. The feed should be stable in the water for sometime. This is called water stability of feed. Prawn feed should remain in its

shape for 2 to 4 hours under water, during which it will be eaten. Making feed pellets too hard also is not desirable, because it is difficult to be digested by prawns.

7.9. Feed formulations:

The following feed formulations can be used for semi-intensive farming of tiger prawn and Indian White Prawn.

TABLE 5

Name of ingredient		Tiger Prawn	Indian white Prawn
Fish meal		30.0	26.0
Squid meal		5.0	5.0
Prawn head meal		5.0	5.0
Squilla meal		---	5.0
Soyabean meal		20.0	26.0
Gingelly cake		10.0	---
Fish oil		4.0	3.0
Wheat flour		16.49	---
Tapioca Powder		---	19.49
Lecithin		1.0	1.0
Yeast		2.0	2.0
Alfalfa		---	1.0
Vitamin mix[1]		1.0	1.0
Mineral mix[2]		5.5	5.5
Butylated hydroxyanisole (BHA)		0.01	0.01
	Total	100.00	100.00
Estimated protein	%	38.0	35.0
Fat	%	7.0	6.0
Carbohydrate	%	18.0	20.0

Vitamin mixture		mg/kg of feed
Vitamin A	10,000 1.U.	6.0
Vitamin D	2,000 1.U.	0.05
Vitamin E	200 1.U.	100.00
Vitamin K		20.00
Choline chloride		1500.00
Niacin		100.00
Riboflavin		40.00
Pyridoxine		50.00
Thiamine		30.00
Pantothenic acid		100.00
Biotin		2.00
Folic acid		5.00
Vitamin B_{12}		0.10
Inositol		250.00
Vitamin C		1200.00
Filler (Cornflour)		5896.85
	Total	10,000.00

Mineral Mixture	g/kg of feed
Calcium phosphate (Monobasic)	8.50
Calcium carbonate	6.25
Pot.dihydrogen orthophosphate	35.50
Magnesium sulphate	2.50
Manganese chloride	0.06
Copper sulphate	0.02
Zinc chloride	0.10
Ferric Citrate	0.05
Potassium iodide	0.007
Cobalt chloride	0.0009
Selenium chloride	0.0005
Chromium chloride	0.0005
Filler (corm flour)	2.0111
Total	55.0000

8.FEED PROCESSING:

8.1.Raw Materials:

Good quality raw materials are obtained in dry form. Feed ingredients which are contaminated with sand, stones and other materials should be avoided. Feed materials should be as fresh as possible and should not be from old stock. Raw materials received should be properly stored until they are processed. The quality of feed depends upon the quality of raw materials used.

8.2.Grinding:

The solid materials may be powdered in a hammer mill/pulverizer so that the powder should pass through 0.5 mm mesh sieve. All the materials are powdered to uniform particle size before mixing.

8.3.Mixing (Homogenising):

The feed can be mixed in batches of 50 kg at a time. The powdered materials are weighed according to the formula and mixed together. The liquids such as fish oil and lecithin may also be added. Vitamin mixture and yeast need not be added at this stage. The feed mixture is thoroughly homogenised in horizontal/vertical mixer. Depending upon to the feed formulation, 20-25% of water may be added and further homogenised. This wet mix is steam cooked (without pressure) for ten minutes and allowed to cool. Yeast is soaked in 5% of water and this along with vitamin mixture is added to steam cooked feed mix after cooling and mixed again thoroughly. During steam cooking the starch present in the feed gets gelatinised

and gives binding effect to the feed particles. This dough feed is ready for pelletization.

8.4.Pelletization

Pelletization can be done by using either a pelletizer or extrusion cooking technology.

8.5.Pelletizer:

The dough prepared as described above is fed to the pelletizer with 2.5 to 3.0 mm diameter die for producing pellets. Pellet mill with three stage steam conditioning for geletinising starch to bind the feed, is needed for producing pellets on large scale. In such case precooking by steam is not necessary.

8.6.Extrusion cooking technology

New generation extrusion technology can be employed for pelleting shrimp feeds. In this process the feed mixture is forced through a die at high pressure. Due to friction, heat is generated raising the temperature of feed to 140^{o}C. This cooks the feed thoroughly as the feed pellets come out. Since this high temperature condition lasts only for a few seconds, no damage is done to the feed; on the other hand it improves the digestibility of feed. But since expansion of pellets takes place in this process, the pellets may float instead of sinking. This can be overcome by employing twin-screw excruders, through which sinking pellets can be obtained.

8.7.Drying:

Feed pellets are dried in an electrical dryer at 70 - 80^{o}C

to remove the excess moisture , until it is reduced to less than 10% .

8.8.**Crumbling**:

For making granular feed with a particle size of about 1.0mm, 2.5 - 3 mm Pellets can be crumbled in a crumbler and sieved through 1 mm mesh sieve. The finer particles thus obtained can be used either for feeding smaller size postlarvae or it can be recycled with new batch of feed under preparation.

8.9.**Packing and Storage**:

The dry feed is properly packed in air tight polythene lined bags or in plastic bins until it is used. This is done mainly to prevent absorption of moisture by feed and oxidation of unsaturated fats. The feed should be stored in a hygienic place with proper ventilation. It is advisable to use the feed within three months from the date of preparation. Storing for longer period may lead to deterioration of quality of feed.

9.**FEED MANAGEMENT**

9.1.**Rate of feeding and Feeding schedule**:

Quantity of feed offered every day and time of feeding play important role in successfully taking crop. Generally,prawns are more active feeders during night. But they also feed during day time. Therefore the entire quantity of feed required for a day should not be given at one time.

It is advisable to offer feed to Prawns, 3 to 6 times in divided doses in a day. Feeding in excess always leads to pollution of water, causing reduction in dissolved oxygen (DO) in the water. Mortality of prawns may occur. This may finally lead

to loss of crop. To prevent this, the guidelines given by feed suppliers / manufactures on feeding methods may be followed. Otherwise the following guidelines may be used in determining rate of feeding.

9.2.**Rate of feeding**:

9.3.**Extensive/Traditional system**

At the time of stocking the average weight of Prawn should be noted. From this the total weight of Prawn (called biomass) in the Pond may be estimated. If the feed given is dry feed, 5% of body weight should be calculated as total feed to be given in a day. If a local feed is used which is a wet material such as clam, mussel, snail, trash fish having 75% of water content, then 20% of body weight should be calculated. The following example may illustrate the calculation.

Let us assume that

Total no. of seed stocked in 1 ha pond is 50,000

Average weight of seed is 0.1 g

Total weight of biomass = 0.1 x 50,000

= 5000 g

- 5 kg.

For dry feed 5% of 2 kg is

5/100 x 5 = 0.25 kg. i.e. 250 gm.

If it is wet feed 20% of 5 Kg = 20/100

= 1.0 kg or 1000 gm.

This should be divided into three doses and fed into the pond three times a day, morning, afternoon and evening. Thus every 15 days, the total biomass present in the pond can be

estimated with the help of a cast net. the number of Prawns caught in one haul and the area covered by the net in pond can be obtained. From this no of Prawns present in a given area can be estimated.

For 1 to 45 days the feeding rate can be continued at 5% (dry feed) of body weight (or 20% of wet feed).

For 46 to 90 days, the rate of feeding can be 3% dry feed and 12% in case of wet feed of body weight. Subsequently the feeding rate may be brought down to 2% of body weight for dry feed and 8% in case of wet feed until the crop is harvested.

9.4. Semi-intensive culture systems

for semi-intensive farming, generally three grades 'Starter', 'Grower' and 'Finisher' feeds are employed. Feeding charts supplied by feed manufacturers may be followed for obtaining desired production. the following guidelines may be useful in determining rate of feeding in these systems.

TABLE 6

Type of feed	Particle size of feed	Weight of shrimp	Quantity of feed to be given per day (% body weight)	Frequency of feeding (No.of times)
Starter granules	1. O mm	0.1-3.0 g	10-8%	3
Grower pellets	2. 0 mm	3.0-15.0 g	8-5%	3
Finisher	2.5 mm pellets	15 -35 g	5-3%	3

The biomass present in a pond may be determined by knowing average weight of shrimp. When switching over from starter to grower, 10% of natural mortality may be given for calculating total number of Prawns present in the pond. Similarly 5% mortality may be given while computing the biomass for changing over from 'Grower' to 'finisher'. The following example may illustrate the calculation.

Example

Total no.of shrimp stocked per ha 2,00,000

Average weight at stocking 0.1 g

Total biomass 0.1 x 2,00,000

= 20,000 g

= 20 kg.

Starter feed 10% of 20 kg = 2 kg feed/day

After 45 days Mortality 10%

Therefore total stock in the pond 200,000 -20,000

=1,80,000

Average weight 5.0 g

Total biomass = 5.0 x 1,80,000

= 900 kg

'Grower feed 8% of 900 kg 72 kg. of feed/day

If it is 5%, 5/100 x 900, 45 kg feed/day

After 90 days

Mortality 5%

Total stock in the pond = 1,80,000 - 9,000 = 1,71,000

Average weight 10 g

10 x 1,71,000 = 1,71,000

= 1,710 kg.

Finisher feed 3 % of 1710 kg = 51 kg of feed per day

if it is 5% = 85.5. kg feed per day.

9.5.Method of feeding

Feed can be offered to Prawns in two ways.

1. By broadcasting the feed into pond and
2. by keeping feed in trays.

9.6.Broadcasting:

The feed can be easily broadcasted into the pond for evenly distribution at the pond bottom. This will avoid congregation of prawns in a particular place. The disadvantages of this method are that it is not possible to assess whether the feed is accepted by the prawn and also its consumption. The left-over (uneaten) feed at the bottom will decay and foul the pond bottom.

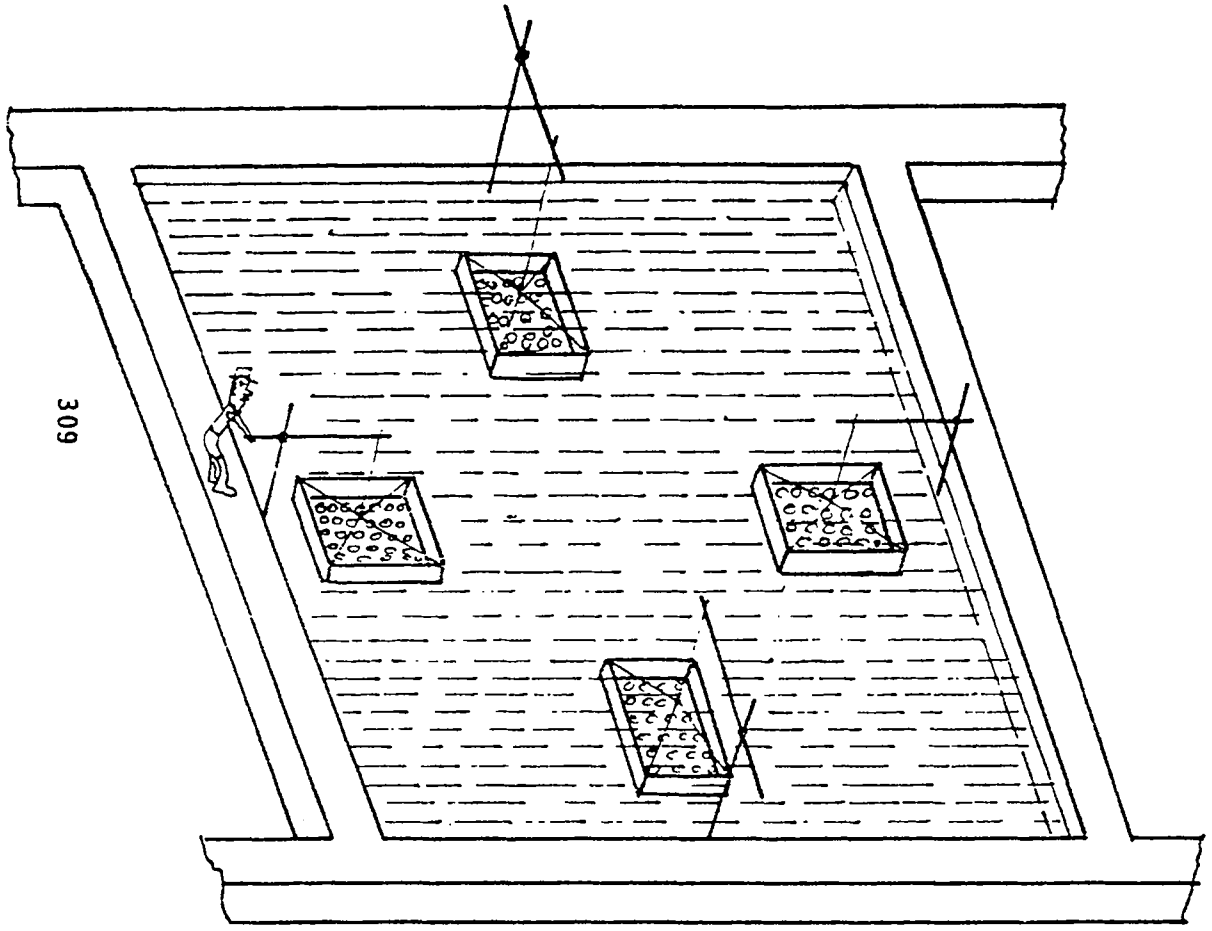
9.7.Tray feeding:

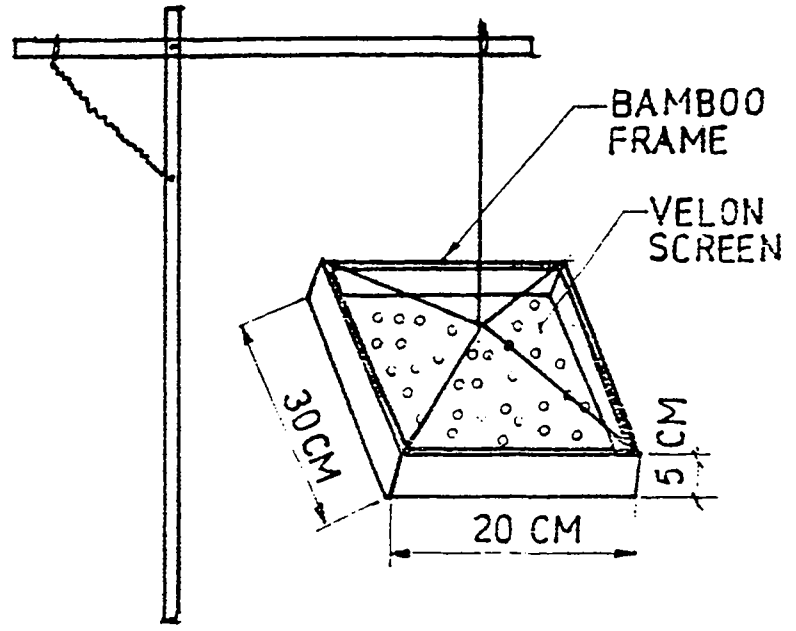
Trays (30 cm x 25 cm x 4 cm) made of bamboo frame and mat or bamboo frame with velon screen are suspended at different places in the pond. Feed is offered to Prawns in these trays. Commercial feeding trays are available in market. The advantages of tray feeding are that it is possible to observe acceptability and feeding activity of prawns. The feed can be offered only when it is necessary by periodically checking the trays. There are no chances for bottom fouling due to left-over feed. The disadvantage is that, keeping the feed in trays manually has practical difficulties and involves more labour input.

The feed rates and schedules shown above are only guidelines. Nevertheless with experience, it is possible to standardise the feeding rates and feeding schedules by the farmers themselves suitable to their farm situations.

FEEDING PRAWNS IN TRAYS IN CULTURE PONDS

Fig. 4





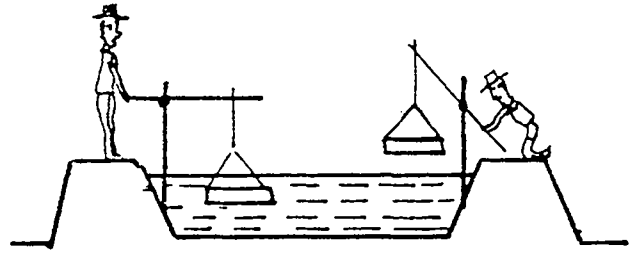


TABLE - I. Some raw materials and their composition, used for compounding feeds.

Name of raw material	Percent on dry basis				
	Crude protein	Fat/ lipid	Carbohydrate	Crude fibre	Ash
1	2	3	4	5	6
I. Energy feeds:					
Barley	9.9-20.29	2.17	16.34	5.81	2.36
Corn (Maize)	6.2- 9.6	4.3-5.5	69.6-70.7	1.4	1.4
Oats	12.0	2.4	63.7	5.0	—
Rice (whole)	8.4	2.1	76.7	0.7	0.8
Rice (broken)	7.5	0.5	79.9	0.3	0.5
Rice bran	13.24-15.80	18.2	47.43	9.0	14.8
Rye	11.6	1.7	69.8	1.9	2.0
Sorghum (Milo)	11.0	2.8	71.6	2.0	—
Tapioca	2.0	0.54	68.50	—	1.45
Wheat grain	13.07	1.95	63.61	3.91	3.85
Wheat flour	10.80	1.10	74.60	0.20	0.5
Wheat bran	13.90	4.20	55.60	10.50	5.3

TABLE - I (Continued)

	2	3	4	5	6
II. Protein Supplements:					
(a) Plant materials.					
Brewer's grains	26.0	6.0	41.8	15.0	—
Coconut cake	25.96	11.2	22.19	—	8.88
Cottonseed cake	42.0	2.0	30.0	11.0	—
Distiller's grains	27.0	—	41.0	12.0	—
Gingelly cake	34.03	10.8	24.76	—	12.52
Gluten (wheat)	25.0	2.0	48.0	8.0	—
Groundnut cake	48.42	7.56	28.18	—	6.03
Linseed	35.0	2.0	39.0	9.0	—
Malt sprouts	26.0	1.0	44.0	14.0	—
Rapeseed cake	46.0	1.0	28.0	14.0	—
Soybean cake	46.0	1.0	31.0	5.0	—
Sunflower cake	47.0	3.0	24.0	11.0	—

TABLE - I (Continued)

1	2	3	4	5	6
(b) Animal materials:					
Blood meal	80.0	2.0	—	—	0.52
Clam meat (*Sunneta scripta*)	48.10	13.55	16.69	—	7.62
Crab meal	30.0	1.7	—	—	—
Fish meal (Brownfish meal low protein; white fish meal high protein)	52-74	1.0-10.0	—	—	14.0-31.(
Mantis shrimp (*Squilla*)	44.06	7.55	1.27	—	23.63
Meat meal	53.0	10.0	—	—	12.03
Meat and bone meal	51.0	10.0	—	—	16.07
Mysid meal	76.05	2.72	5.57	—	15.66
Prawn waste meal	35.20	6.60	0.97	—	23.95
Silkworm pupa (i) whole	55.91-57.5	24.5-29.7	5.58	—	2.98
(ii) defated	75.36	1.75	8.40	—	5.59
Shrimp meal	36.0-48.0	3.0	—	—	—
Squid meal	81.38	9.63	5.33	—	3.66

TABLE - I (Continued)

1	2	3	4	5	6
III Non-conventional feed ingredients					
House fly larvae	45.0	15.0	—	—	8.0
Poultry feather meal (Hydrolysed)	80-85	2.5	—	1.5	3.0
Single cell protein					
(i) Krill	55.0	10-15	—	—	15.2
(ii) Marine yeast	25.63	2.69	63.50	4.27	3.91
(iii) Petrolium yeast	61.22	2.10	26.24	3.9	6.54
(iv) Sludge	43.0	0.43	15.0	28.0	3.0
(v) Spirulina	60.89	9.0	6.63	—	13.0
Snail (Vivipara)	64.93	2.40	—	—	—
Worms :					
(i) Limnodrilus	47.21	24.15	—	—	—
(ii) Tubifex	64.48	16.0	15.40	—	0.91

DISEASES OF PRAWNS - DIAGNOSIS,PREVENTION & CONTROL

BY
S.V.ALAVANDI

DISEASES OF PRAWNS - DIAGNOSIS, PREVENTION & CONTROL

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DISEASES OF PRAWNS - DIAGNOSIS, PREVENTION & CONTROL

1. INRODUCTION

Aquaculture of prawns in recent times has undergone rapid progress in India, and in other countries with private and government agencies venturing into this field owing to its high profits. With the transition from extensive type of aquaculture methods to the modern semi intensive and intensive methods the shrimp farming is facing problems due to disease out-breaks, either during seed production in hatcheries or during growout culture in the earthern ponds.

The early larval stages of prawns, viz., nauplius, zoea, mysis and post-larvae are relatively more susceptible to diseases than the juveniles and adults. Several factors, such as environment, water quality, inadequate nutrition, presence of virulent pathogens etc., play an important role in disease induction in cultured prawns. The diseases occurring in prawns may be broadly classified as (1) Infections type, that are caused by viruses, bacteria and fungi and (ii) non-infection type, caused by filamentous bacteria, and some cilitates, and (iii) diseases due to nutritional imbalance, poor environment and toxins of some algae. Mortality of prawns due to diseases of non-infectious etiology may

not be significant. The diseases caused by viruses, bacteria, fungi, nutritional inadequacy, adverse environment and toxins may lead to large scale mortalities both in hatcheries and grow-out ponds causing heavy losses to shrimp aquaculturists.

1.1 Sources of Infection

The micro-organisms causing diseases in prawns constitute part of natural microbial flora of coastal and marine water and soil. Hence the sea water used in the hatcheries and grow-out ponds is one of the main sources of shrimp pathogenic micro-organisms. Other inputs such as, the Artemia cysts, feed, and the personnel in the hatcheries and feed used in the grow-out phase may also carry certain pathogenic micro-organisms.

The spawners and larvae with sub-clinical infection (carriers) may be the means of transmission of viral diseases in prawns.

2. DISEASES OF PRAWNS

2.1 Viral Diseases: Eight viruses are known to infect penaeid prawns (Table 1). They are (i) monodon - type baculovirus (MBV), (ii) baculovirus penaei (BP), (iii) baculoviral midgut gland necrosis virus (BMN), (iv) infectious hypodermal and hematopoetic necrosis virus (IHHNV), (v) hepatopancreatic parvo-like virus

(HPV), and (vi) REO - like virus. (vii) Lymphoidal parvo like virus (LOPV) ,and (viii) Type C baculovirus (TCBV). Viral diseases of prawns have been reported from several countries, namely, America, Philippines, Thailand, Brazil, Japan, Panama, Costa Rica, Equador, Tahiti, Singapore, Israel and France. Viral diseases of prawns are yet to be reported from India. The viral infections spread through transport of diseased post larvae and broodstock for culture purposes. So far, no control measures have been evolved for viral diseases.

2.2 Bacterial Diseases: The bacteria causing diseases of penaeid prawns constitute part of the natural microbial flora of sea water. Accumulation of unutilized feed and metabolites of prawns in the culture tanks/ponds enrich the water with organic matter that support the growth and multiplication of bacteria and other micro-organisms. Bacterial infections of prawns are primarily stress related particularly to adverse environmental conditions or mechanical injury, when the bacteria gain entry into the body of prawns and produce the disease. Most common prawn pathogenic bacteria are Vibrio alginolyticus, Vibrio parahaemolyticus, Vibrio anguillarum and other Vibro spp. Other gram negative bacteria such as Aeromonas spp., Pseudomonas spp., and Flavobacterium spp., are also seldom implicated in the shrimp diseases. Information on the bacterial diseases of penaeid prawns are tabulated in Table 2.

2.3 Fungal diseases: One of the most important diseases in shrimp hatcheries is caused by phycomycetous fungi, Lagenidium sp., Sirolpidium sp., and Haliphthoros sp. called as larval mycosis, characterized by sudden onset of mortalities (Table 3). These fungi are filamentous nonseptate and coenocytic. Upon infection, the fungal mycelium replaces the larval tissues and ramifies into all parts of the body. Vegetative propagation of these fungi is through production of biflagellate zoospores which are released into the rearing medium. These zoospores further infect fresh prawn larvae. These fungi can be isolated on PYG agar or Saboraud's dextrose agar. Fungi such as Fusarium sp. cause infections in nauplii, protozoea, juveniles and adults. Black gill disease is often caused by this fungus. The fungus can be identified by its characteristic canoe shaped micro-conidia. Other oomycetous fungi such as Saprolegnia sp. and Leptolegnia sp. are also known to affect shell of prawns and produce dark necrotic lesions causing gradual mortality. Different types of fungal diseases occuring in penaeid prawns are summarised in Table 3.

2.4 Protozoan and Parasitic Diseases : The protozoans affecting prawns are ectocommensals, gregarines and microsporidians. The ectocommensal protozoan fouling of prawns is very common in the hatcheries. Microscopic examination of the prawn larvae reveal the identity of protzoans and their morphology. The most common

ciliate fouling protozoans are Zoothamnium sp., Vorticella sp., Epistylis sp., Acineta sp. etc. These are known to affect all life stages of prawns (Table 4). When heavily affected, the juvenile and adult prawns will have fuzzy mat like appearance on them inhibiting their movement. Protozoan infestation of gills causes hypoxia to prawns leading to death. General body and appendage fouling affects molting process of prawns also.

The other group of protozoans, the microsporidians invade and parasitize the prawns and cause a condition called cotton shrimp or milk shrimp disease. The affected tissues of prawns appear white and cooked. The microspordian spores can be observed in the affected tissue by microscopic examination. Many of the microspordian infections may cause atrophy of gonads and render the prawns sterile. Mortality rate may reach upto 16% of the stock due to microsporidosis.

Trophozoites of some gregarine parasites may be seldom found attached to the gut of prawns. Some invasive protozoa such as Pauronema and Leptomonas are also known to affect the prawn larvae. Certain worms (trematodes, cestodes and nematodes) are also found to occur in various tissues of prawns. However these protozoan parasities are not considered to be of serious pathological importance. Details on protozoan and other parasitic infections of prawns are given in Table 4.

2.5 Diseases due to nutrition deficiency, adverse environment and toxins: Prawns cultured in the grow-out ponds develop disease syndromes whenever environmental conditions deteriorate or nutrient inadequacy prevails in the pond ecosystem or certain toxins are present in the water. Many of these diseases are yet to be throughly studied and understood. Among these diseases, the soft shell syndrome of penaeid prawns is an important disease causing heavy losses to traditional extensive shrimp farms (Table 5).

3. DIAGNOSIS OF DISEASES

3.1 Viral diseases: Viral diseases of prawns can be diagnosed based on gross signs of the disease and microscopic demonstration of characteristic inclusion bodies and associated histopathology of the affected tissues (Table 1). Squash preparation of hepatopancreas from fresh specimens may be observed under phase contrast microscope or after straining with 0.1% aqueous malachite green under bright field microscope for intranuclear inclusion bodies. Confirmatory diagnosis of viral infections may be made by electron microscopic observation of target organs. Certain immunodiagnostic tests have been reported for diagnosis of MBV infection such as enzyme linked immunosorbent assay (ELISA), and acridine arrange fluorescence methods.

3.2 Bacterial diseases: Bacterial infections of prawns can be tentatively diagnosed by microscopically demonstrating swarming

bacteria and hemocytes in wet mount of fresh hepatopancreas squash preparation, in the hemolymph or in the affected tissues. Definitive diagnosis of bacterial diseases may be made by isolation of pathogenic bacteria (Annexure-1) on suitable culture media such as zobell's marine agar 2216 (ZMA) or Thiosulfate citrate bile salts sucrose (TCBS) medium. The bacteria are identified based on their morphological and biochemical characteristics.

3.3 Fungal diseases: The fungi causing diseases of prawns can be identified based on their morphology and method of sporogenesis by microscopic observation. The zoospores of Lagenidium sp. are released from a terminal vescicle which is formed at the distal end of the discharge tube. In case of Sirolpidium and Haliphthoros, the discharge tube is shorter than that of Lagenidium and the terminal vescicle is absent.

4. GUIDELINES FOR DISEASE PREVENTION

The saying that prevention is better than cure also holds true in aquaculture since application of chemical or antibiotic treatment when the shrimp larvae are affected with disease may not work always to improve the health of prawns as they are already under stress due to the disease. Hence, certain minimum management measures must be taken in order to avoid proliferation of pathogenic micro organisms, there by keeping the stock healthy.

A. In Hatcheries:

(i) Location of the hatchery: The hatchery should be located in a place where good quality water is ensured for maintenance of broodstock, spawning, larval rearing, phytoplankton culture and all other hatchery activities.

(ii) Water treatment: The sea-water used in the hatchery should be filtered (e.g. sand filter) and preferably be sterilized by UV treatment. The sea-water should be disinfected with Calcium Hypochlorite (20-30 ppm) or Sodium Hypochlorite (150ppm) for 1-2 days ensuring thorough mixing to eliminate pathogenic microorganisms. Before using the seawater for hatchery activities, excess chlorine should be removed by neutralising with Sodium Thiosulphate.

(iii) Cleanliness of hatchery facilities: The tanks used for broodstock, spawning, larval rearing etc. should be kept thoroughly clean by scrubbing, disinfecting and rinsing to completely remove excess detergent.

(iv) Treatment of Broodstock: The brood shrimps should be treated with Formalin (100 ppm) plus Oxytetracycline (10 ppm) for 30 minutes before stocking into broodstock tanks to reduce the population of epibiotic microflora.

(v) Care at the time of spawning: The scum formed due to spawning if not removed encourages growth of bacteria. Hence, the scum should be removed.

(vi) Stocking of nauplii: Stock only healthy clean nauplii at an optimal stocking density. Healthy nauplii can be identified by their phototactic nature.

(vii) Care during larval rearing: The unused feed, sediments, debris, algal, growth and wastes accumulated at the bottom or sides of the culture tanks should be removed by siphoning as these wastes encourage bacterial proliferation.

(viii) Feeding: The larvae should be fed with optimal amounts of good quality balanced feed as the defence mechanism of the larvae to a great extent depends upon their nutritional status.

(ix) Use of chemicals and antibiotics: The antibiotics should be used carefully at right doses. Low doses of antibiotics leads to development of antibiotic resistant mutants of bacteria and higher doses may be toxic to the prawn larvae.

(x) Monitoring of larval health and water quality during culture: The larvae should be examined every morning before changing water microspically for any abnormality and for the presence of fouling protozoa, filamentous bacteria, fungal infections, presence of swarming bacteria within the

haemocoel, and bioluminuescence of rearing water and prawn larvae in dark. This helps in understanding the health status of the prawn larvae and thereby take appropriate remedial measure if needed. The water quality should be monitored to maintain important parameters at optimal levels (Temp. 27-30^{o}C, Salinity 27-31 ppt, DO 7.5 ppm, pH 7.8-8.5; Ammonia-N:< 0.5 ppm).

Since treatment of viral diseases of prawns is not known, disease outbreaks due to viral infection may be avoided by quarantine measures and destroying carriers and contaminated animals. Once viral infection is detected in a hatchery, all activities should be stopped and all the contaminated facilities should be thoroughly disinfected before restarting hatchery activities.

B. In Shrimp farms:

(i) Location of the prawn farms: The prawn farms should be located in areas free from industrial or domestic pollution.

(ii) Pond preparation: Before prawn culture is started, the ponds should be thoroughly drained, black layer of soil formed during the previous crops should be removed, the soil should be tilled and lime should be applied at the rate of 200 - 600 kg/ha depending on the type of soil.

(iii) Stocking: Maintain optimum density of prawn larvae. Overcrowding should be avoided. Stock only healthy post larvae.

(iv) Water quality: Always maintain good water quality in the pond. Visual examination of pond water reveals health of the prawns to a great extent. Light green colouration of the pond water is known to be ideal. Very clear water is known to be stressful for the prawns. A minimum of 10-15% water exchange should be routinely done.

(v) Routine checking of pond environment: Colour, turbidity, DO, pH, NH_3 & H_2S content in the pond water, and pH and redox potential of soil should be routinely checked. Whenever abnormal conditions are noticed, prompt action should be taken to keep the pond water and soil in good condition.

(vi) Feeding: The prawns should be fed with balanced diets at optimum quantities. Care should be taken to avoid accumulation of unutilized feed in the pond. This will help in proliferation of pathogenic micro-organisms. Do not feed old, rancid and moldy feeds.

(vii) Health check up: A routine check should be carried out on the status of health of the prawns. Frequent microscopic examination of gills, hepatopancreas and hemolymph for

microbial infections or any disease symptoms should be done to assure the health of the prawns. Diseased and infected prawns should be destroyed, preferably burried into the soil away from the prawn farms, in order to avoid spreading of infection within the stock.

5. TREATMENT OF DISEASES

In spite of the best sanitary management measures taken in the prawn hatcheries, disease outbreaks may occur. The microbial diseases in hatcheries may be treated using several chemicals and antibiotics. One should be cautious when applying these treatments since the prawn larvae are already under stress due to disease and many of the chemicals may be toxic to the prawns themselves. The antibiotics may be used at proper doses only after ensuring its effectiveness on the pathogens by in-vitro antibiotic sensitivity testing. The recommended doses of chemicals/ antibiotics should be applied for treatment till the prawn larvae recover from the disease. After treatment with the drug, water exchange should be done only after the mortality of prawns stabilizes. Since sudden exchange of water may put the prawns under stress. The antibiotics/chemicals may be incorporated in the feed (e.g., oxytetracycline 1.5/kg feed) and fed to the prawns. However feeding of prawns with medicated feeds needs thorough investigation on the aspects like acceptability of such feeds, and

withdrawal period, and fate of these drugs in the pond ecosystem. Low doses of antibiotics and indiscriminate use of antibiotics should be stopped since this leads to development of antibiotic resistance in bacteria.

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ANNEXURE I

METHODS IN SHRIMP DIAGNOSTIC BACTERIOLOGY

The methods of microbiological examination of prawns are essentially similar to those followed for the higher animals. The first step in shrimp diagnostic bacteriology is to isolate the pathogen from the diseased prawns and then identify the same based on its morphological, and biochemical characteristics. The essential methods required for isolation and identification of shrimp pathogens are described here. However, for more details, the readers are advised to refer Austin (1988).

List of Essential Equipment for Shrimp Diagnostic Bacteriology

(i) Autoclave

(ii) Hot air oven

(iii) Bacteriological Incubator

(iv) Laminar flow bench

(v) Refrigerator

(vi) Compound microscope

(vii) pH meter

(viii) Distillation apparatus

(ix) Physical balance

Glassware:

(i) Petridishes

(ii) Conical flasks

(iii) Beakers

(iv) Measuring jars

(v) Reagent bottles

(vi) Culture tubes

(vii) Pipettes etc.

Methods_of_Isolation_of_Bacteria_and_Fungi:

(i) Inoculate the infected larvae/affected tissues/hemolymph on the culture plates with the help of sterile bacteriological loop and streak the inoculum to get isolated colonies. Commercially available dehydrated culture media may be used for culture and isolation of microorganisms in order to save time, expense, shelf space, uniformity of composition etc. The culture media routinely employed for isolation of bacteria from shrimps are Zobell's Marine Agar 2216 (ZMA) and Thiosulfate Citrate Bile Salts Sucrose (TCBS) agar. The ZMA favours the growth of all the heterotrophic bacteria occurring in the brackish and marine environments, whereas, the TCBS medium is selective for isolation of prawn pathogens such as Vibrio spp. Mycological agar/Sabouraud's dextrose agar is used for isolation of fungi. A selective medium for isolation of luminescent bacteria is used whenever required.

(ii) Incubate the inoculated agar plates at optimal temperature ($30^{o}C$) for 48 h and observe for development of bacterial colonies.

(iii) Examine morphological characteristics of the bacterial colonies.

(iv) Obtain pure culture of bacteria by picking up morphologically distinct colonies with the help of a sterile bacteriological loop and subculture on ZMA.

Gram Staining of Bacteria

Prepare smears of bacteria on clean glass slide using sterile nichrome loop by mixing with a drop of sterile normal saline. Fix the smears by air drying or by gently passing the slide over the Bunsen flame. Stain the smears with Crystal Violet solution for 1 minute. Wash in tap water for few seconds. Flood the smears with Iodine solution for 30 seconds. Wash in tap water for 15 seconds. Decolourize with 95% Ethyl Alcohol for 30 seconds. Wash with tap water. Counterstain with Safranin solution for 10 seconds. Wash in tap water. Blot dry and examine under oil immersion objective.

Interpretation: Gram positive - Violet coloured bacteria
Gram negative - Red coloured bacteria

Biochemical and Physiological Methods:

(i) a. Metabolism of Carbohydrates (Hugh & Leifson's Method)

Inoculate the bacterial isolate in duplicate to Marine Oxidation and Fermentation medium (MOF) tubes by stabbing the deeps using sterile nichrome wire. Overlay one tube with sterile mineral oil. (e.g. Liquid Paraffin). Incubate at 30°C. Observe the tubes at 24, 48 and 72 h intervals.

Interpretation: Acid production in open tube indicates oxidative metabolism and acid production in the tube overlayed with mineral oil indicates fermentative metabolism of bacteria.

b. Hydrolysis of polysaccharides (Starch hydroloysis test);

Inoculate ZMA containing 0.2% soluble starch plates. Incubate till growth is obtained.

Flood the plates with Lugol's iodine solution. A clear zone around the colonies indicates positive reaction.

(ii) Nitrogenous Metabolism

a. Lysine decarboxylase, Orinithine decarboxylase and Arginine dihydrolyse test: Inoculate the tubes with bacterial isolates. Incubate.

Interpretation: Alkaline reaction indicates decarboxylation of lysine and ornithine and positive reaction for arginine dihydrolase.

b. Nitrate reduction: To log phase broth cultures of bacteria, add 1 ml each of alpha-napathylamine solution and Sulfanilic acid solution. Positive reaction (NO_3->NO_2) is indicated by development of pink colour. When there is no development of pink colouration, add a pinch of zinc dust. Absence of colouration indicates positive result for the reaction NO_3->NO_2.

c. Gelatin liquifaction:

Inoculate bacterial culture with sterile bacteiological loop on to ZMA supplemented with 0.4% gelatin plates.

Incubate till growth is obtained.

Flood the plates with $HgCl_2$ solution. Liquifaction of gelatin is indicated by clear zone around colonies of bacteria.

(iii) Miscellaneous tests:

a. Kovac's oxidase test:

Place a strip of whatman No.1 filter paper in a petri dish. Add 2-3 drops of 1% solution of N,N,N',N'-tetramethyl paraphenylene diamine dihydrochloride.

Smear the test colony of bacteria on the filter paper using a sterile platinum loop.

Interpretation: Positive reaction is indicated by development of a deep purple colour of the smear.

b. Catalase production:

Make a heavy smear of test culture of bacteria on a slide. Place a drop of 10% hydrogen peroxide solution over the smear.

Interpretation: Production of gas bubbles (effervescence) indicates positive reaction.

c. Indole test: Add 0.5 ml of kovac's reagent to log phase broth culture of bacteria. Shake gently. Development of pink colour indicates positive reaction.

d. Methyl Red and Voges Prauscaur's test (MRVP): Culture the bacteria in tubes containing MRVP broth. Test for methyl red in one tube and Voger Prauscaur's in another tube. To test for Methyl red (MR), add 5-6 drops of MR reagent to 5 ml culture of bacteria. Postive reaction is indicated by bright red colour. To test for Voges Prauscaur's reaction, add 1 ml of 40% NaOH solution and 3 ml of alcoholic alphanaphthol solution to a 5 ml

bacterial culture. Development of red/crimson colour indicates positive reaction.

e. Citrate Utilization: Inoculate the test culture of bacteria on to Simon's Citrate agar slants and incubate. Utilization of Citrate is indicated by development of bright blue colour on the slant.

f. Salt tolerance of the bacteria: Inoculate bacterial culture into nutrient broth tubes containing 0, 3, 6, 8 and 10% NaCl. Incubate and observe for growth which is indicated by turbidity of the broth, compared to uninoculated control.

g. Motility test: Place a very small drop of log phase broth culture of bacteria with the help of sterile inoculating loop (2 mm dia) at the centre of a cover glass. Place small drops of water on the corners of the cover glass. Invert the cover glass over the cavity of slide, so that the drop of culture is hanging at the centre of the cavity slide. Observe the hanging drop of bacterial culture under the microscope for mortility of bacteria. Darting or zig-zag motility indicates that the bacteria may have polar flagellation

and slow motility or vibratory motility peritrichous flagellation of the bacteria.

h. Antibiotic / Drug sensitivity testing of bacteria: The antibiotic/drug sensitivity testing method employed is Kirby-Bauer's disc diffusion technique. Commercially available antibiotic discs are used for this purpose. The culture medium used for antibiotic sensitivity testing is Muellers-Hinton agar. However, Zobell's Marine agar 2216 has also been found to be equally useful.

Preparation of the Inoculum:

Inoculate pure culture of bacteria into 5 ml zobell's marine broth tubes with the help of sterile inoculation loop. Incubate for 2 to 8 h at 30°C till moderate growth is obtained.

Note: Obtain turbidity of broth culture (by diluting) equivalent to 0.5 ml of 1.175% $BaCl_2$ 2 H_2O solution added to 99.5 ml of 0.36 N sulfuric acid. for dilution of the culture, use sterile sea water or sterile zobell's marine broth.

Inoculation: Dip a sterile swab into the inoculum and squeeze off the excess fluid by pressing the swab

against the inside wall of the tube. Streak the entire agar plate thoroughly.

Application of antibiotic discs: Apply discs onto the plates aspectically using sterile forceps. Press the discs firmly on the agar to enable smooth diffusion of antibiotic. Place the antibiotic discs at least 20 mm apart. Incubate the plates at 30°C.

Examine the plates after 24 h. Measure the zone of inhibition and record. See the zone interpetative chart given by the supplier of antibiotic discs and record as sensitive or resistant.

CULTURE MEDIA, REAGENTS AND STAINS

Culture Media:

1. Zobell's Marine Agar
2. Zobell's Marine Broth
3. Thiosulfate Citrate Bile Salts Sucrose (TCBS) Agar
4. Mycological agar
5. Sabauraud's dextrose agar
6. Marine Oxidation Fermentation medium (MOF)
7. Decarboxylase base (for testing decarboxylation of amino acids)
8. MRVP medium

9. Simon's Citrate Agar

10. Nutrient broth.

items 1-10 can be obtained as dehydrated powders from Himedia Co., Difco labs and other sources.

11. Medium for isolation of bioluminescent bacteria:

Peptone 5.0 g

Yeast extract 3.0 g

Glycerol 3 ml

Agar 15 g

Distilled water 250 ml

Aged sea water 750 ml

Adjust pH to 7.8. Autolave at 15 lbs for 15 min, cool to 48^{o}C, pour plates.

12. Medium for arginine dihydrolase test:

Peptone 10 g

K_2HPO_4 0.3 g.

NaCl 5 g

Arginine HCl 10 g.

Agar 3 g

Phenol red 1 ml (o.1% solution in 0.1 N NaoH)

Distilled water 1l.

Dissolve the ingredients in distilled water. Aged sea water

may be used without adding NaCl. Adjust pH to 7.2. Heat the medium till the ingredients dissolve. Dispense 2 ml in screw capped 5 ml vials or culture tubes. Autoclave at 15 lb for 15 min.

Reagents:

1. Reagents for nitrate reduction test:

   Solution A : alpha-napathylamine 1 g
   Distilled water 20 ml
   Dissolve, filter and add 180 ml of
   5 N acetic acid.

   Solution B : Sulfalinic acid 0.5 g
   5 N acetic acid 150 ml.

2. Mercuric chloride solution for gelatin liquifcation test:

   $HgCl_2$ 15.0 g
   Conc. HCl 20 ml
   Distilled water: 100 ml

3. Kovac's reagent for Indole test:

   n-amyl or n-butyl alcohol 150 ml
   para dimethyl amino benzaldehyde 10 g
   Conc. HCl 50 ml
   Dissolve the aldehyde in alcohol and
   Slowly add acid.

4. Reagent for methyl red test:

Methyl red 0.1 g

Ethyl alcohol 300 ml

Dissolve the dye in alcohol and make upto 500 ml with distilled water.

5. Reagent for Voges Prauscaur's test:

A : 5% alpha-napthol in absolute alcohol

B : 40% KOH or NaOH.

Stains (For Gram's) staining of bacteria)

1. Solution A : Crystal violet 2 g

ethyl alcohol (95%) - 20 ml

Solution B : Ammonium Oxallate 0.8 g

Distilled water 90 ml

Mix both solutions.

2. Gram's iodine:

Iodine 1 g

KI 2 g

Distilled water 300 ml.

3. Safranin solution:

Safranin (2.5% solution in 95% ethyl alcohol) - 10 ml.

Distilled water 100 ml.

Identification of Bacteria:

After examining the morphological and biochemical characters of the bacterial isolates, identify the bacteria by referring to Bergey's Manual of Systematic Bacteriology (Krieg and Holt, 1984).

Table 1
Viral diseases of prawns

Sl. No.	Disease	Species affected	Life stages affected	Signs and symptoms of the disease	Target Organ(s)	Pathology	Preventic co
1.	Monodon-type Baculovirus disease	P.monodon P.semisulcatus P.merguiensis	PL5 to adults	Prawns lethargic, anorectic darker colouration, increased surface and gill fouling cumulative mortality upto 70% of affected prawns.	Hepatopancreas	Hypertrophied nuclei, diminished nucleolar chromatin, displaced nucleolus, multiple oval shaped intranuclear	Avoid the dis by quarantine contaminated Disinfect all contaminated
2.	Baculovirus Penaei (BP) disease (Nuclear polyhedrosis disease)	P.duorarum, P.aztecus, P.setiferus, P.vannamei P.stylirostris P.marginatus	Larvae to Juveniles	Reduced feeding, reduced growth rate, increased surface and gill fouling, high mortality rates.	Hepatopancreas	Presence of polyhedral intranuclear inclusion bodies in the epithelium, margination of chromatin, degenerated nucleous, necrosis and loss of epithelial cells	—do
3.	Baculoviral midgut gland necrosis (BMN) disease (White turbidity liver disease)	P.japonicus	Mysis to PL-20	The midgut gland appears white and turbid, severely affected larvae float on the surface of water. High mortality rate, upto 98% byPL-20.	Hepatopancreas	Hypertrophied nuclei, necrosis of tubule epithelium, marginated chromatin, dissociation of nucleolus. No inclusion bodies.	—do
4.	Infectious hematopoetic and hypodermal necrosis (IHHN) disease	P.stylirostris, P.vannamei P.monodon	juveniles	Presence of white or buff coloured spots (giving prawns mottled appearance) on abdomen. Affected prawns bluish in colour with opaque abdominal musculature abnormal swimming behaviour. Prawns rise to the surface and sink to the bottom with their ventral side up.	Epithelium of foregut, hindgut, nervechord, hemo-topoetic organs, antinnal gland, mandibular organ, connective tissue, straited muscles etc	Multifocal necrosis of tissues, marginated chromatin, hypertrophied nuclei, oval shaped inclusions.	—do
5.	Hepatopancreatic parvo-like virus (HPV) disease	P.merguiensis, P.semisulcatus, P.orientalis, P.esculentus, P.monodon	juveniles	Poor growth rate, anorexia, increased surface and gill fouling, cumulative mortalities reach 50-100% of affected prawns in 4-8 weeks.	Hepatopancreas	Hypertrophy of tubulule epithelium, displacement of nucleolus due to single prominant basophilic intranuclear inclusion body. Margination of chromatin. Necrosis and atrophy of the hepatopancreas.	—do
6.	REO - like virus disease	P.japonicus	adults	Poor growth rate, lethargy, heavy surface and gill fouling, reddish appendages.	Hepatopancreas	Necrosis and atrophy of the hepatopancreas.	—d
7.	Type C baculo virus disease (TCBV)	P.japonicus P.monodon	—	—	—	Necrosis of hepatopancreatic tubule epithelial cells, hypertrophical nuclei, chromatin margination, no inclusion bodies.	
8.	Lymphoid organ Parro-like Virus (LOPV) disease	P.monodon P.merguiensis P.esculentus	—	—	—	Multinucleated giant cells in hypertrophied lymphoid organ containing basophilic intranuclear	

Table 2

Bacterial diseases of prawns

S.No.	Disease	Life stages affected	Signs and symptoms of the disease	Cause	Method of diagnosis	Prevention and control
1.	Necrosis of appendages	Larvae and PL	Browning and necrosis of tips of appendages, damaged setae, twisted antennae.	Vibrio spp. Pseudomonas spp. Aeromonas spp. Flavobacterium spp.	Isolation of pathogenic bacteria on zobells marine agar and identification.	Antibiotic bath (therapeutic): Erythromycin 1-10 ppm, or Tetracycline 0.1-1 ppm or Chloramphenicol 1-10 ppm or Nitrofurazone 2-5 ppm or EDTA 10-50 ppm or Malachite green 10-25 ppm applied on alternate days For prophylactic purposes, antibiotics may be given at 1-3 ppm levels.
2.	Vibriosis	Larvae and PL	Larvae off feed, no fecal strands, necrosis of tips of appendages and their browning.	Vibrio alginolyticus, V.parahaemolyticus, V.anguillarum, Vibrio spp.	Microscopic observation of Larvae reveals presence of swarming bacteria within the body cavity. Isolation and identification of pathogenic bacteria.	Same as above
3.	Luminescent bacterial disease	Nauplii, Protozoea, Mysis, Post Larvae	Affected larvae and rearing water exhibit bioluminescence under darkness. Heavy mortality rates.	Vibrio harveyi, V.splendidus, V.fischeri	Based on gross signs of the disease and isolation and identification of pathogenic bacteria.	Erythromycin 2-5 ppm or Furazolidone 0.5-1 ppm or Nitrofurazone 5-10 ppm. Chlorination of rearing water, frequent exchange of water, UV sterilization and pressure sand filtration of water may be helpful in preventing the disease.
4.	Filamentous bacterial disease	Larvae and Post Larvae	Mortality of larvae due to impairment of respiration, locomotion and feeding. Growth of filamentous bacteria on the body surface, cuticular setae, appendages and gills.	Leucothrix mucor	Microscopic examination of larvae reveals presence of filamentous bacteria attached to appendages.	Copper chloride: 1 ppm or Potassium permanganate 2-5.5 ppm, for 4h. in static culture or Formalin 25 ppm; or Formalin 50-250 ppm for 4-8h in static treatment or Malachite green 5 ppm 2 min dip. Aquatrine: 0.2-0.5 ppm static treatment.
5.	Shell disease (Brown spot disease or burned spot disease or rust disease)	Juveniles to adults	Brownish or black single or multiple eroded spots on the exoskeleton, gills or appendages	Vibrio spp. Pseudomonas spp. Flavobacterium spp.	Based on the signs and symptoms of the disease, and isolation and identification of pathogenic bacteria from the lesions.	Feeding prawns with antibiotic fortified diets: Oxytetracycline 3-15g/kg feed fed at 2-10% of biomass for 10-14 days. Furanace 0.5g/kg feed.

6. Bacterial septicaemia	adults	Prawns lethargic, abnormal swimming behaviour, reddish appendages, dorsal flexure of the abdomen, flared up and eroded gill covers, colourless or black blisters on the carapace/exoskeleton.	*Vibrio* spp.	Based on gross signs of the disease, isolation and identification of pathogenic bacteria from the hemolymph and lesions.	Same as above.

Table 3

Fungal diseases of prawns

S.No.	Disease	Life stages affected	Signs and symptoms of the disease	Cause	Method of diagnosis	Prevention and control
1.	Larval mycosis	Protozoea, mysis, and larvae	Sudden onset of mortality within 1-2 days the zoea and mysis may be totally wiped out.	Lagenidium calinetes, Sirolpidium sp., Haliphtoros sp.	Microscopic examination of affected larvae reveals extensive, nonseptate, branched fungal mycelium throughout the body and appendages. Isolation of pathogenic fungi on PYG agar or mycological agar.	Malachite green 6-10 ppb (prophylactic dose) Disinfection of spawners with treflan at 5 ppm for 1h. Furanace 1 ppm for 6h. Treflan 10-100 ppb (therapeutic)
2.	Fusarium disease (Black gill disease)	Nauplius, Protozoea, Juveniles to adults	Black spots on gills followed by mortality of prawns.	Fusarium sp.	Microscopic examination of gills reveals canoe shaped micro-conidia. Isolation of the fungus on mycological agar or Sabouraud's dextrose agar.	Not known.

Table 4

Protozoan and Parasitic diseases of prawns

S.No.	Disease	Life stages affected	Signs and symptoms of the disease	Cause	Method of diagnosis	Prevention and control
1.	Ciliate infection (protozoan disease)	All stages	Reduced feeding, mortality of larval stages due to respiratory and locomotory difficulties. Adults and juveniles may have fuzzy mat like appearance.	Zoothamnium spp. Vorticella spp., Epistylis spp., Ephelota spp., Acineta spp., Lagenophrys spp.	Microscopic examination of larvae, gills appendages of scrapings from the carapace reveal the protozoa.	Formalin 50-100 ppm 30 min. dip. For ponds, 15-25 ppm formalin, may be repeated if needed or 25-250 ppm formalin treatment for 1-4h as often as needed.
2.	Microsporidosis (Cotton shrimp)	juveniles to adults	Muscle of prawns appears cooked. White tumour like swellings in the gill, and subcuticular tissues. Blue black discolouration of the exoskeleton, enlarged white gonads, low level mortalities.	Agmosoma spp., (Thelohania), Ameson sp., (Nosema) Pleistophora spp.	Based on the signs and symptoms of the disease Demonstration of microsporidia in affected tissues by microscopic examination.	Isolation and destruction of infected prawns. Disinfection of culture system. Control measure not known.
3.	Gregarine disease	Larvae	Reduced digestive capacity due to presence of parasite in the gut. Erratic swimming behaviour	Gregarines	Microscopic demonstration of trophozoites or gametocysts of parasite in the gut.	Elimination of molluscan intermediate host by application of tobacco dust at the rate of 200 kg/ha.
4.	Bopyrid parasitic infestation	juveniles to adults	Lateral bulging of carapace due to presence of the parasite in the branchial cavity.	Bopyrid Isopod sp.	Based on the gross signs of the disease.	Formalin 25-250 ppm 1-4h

Table 5

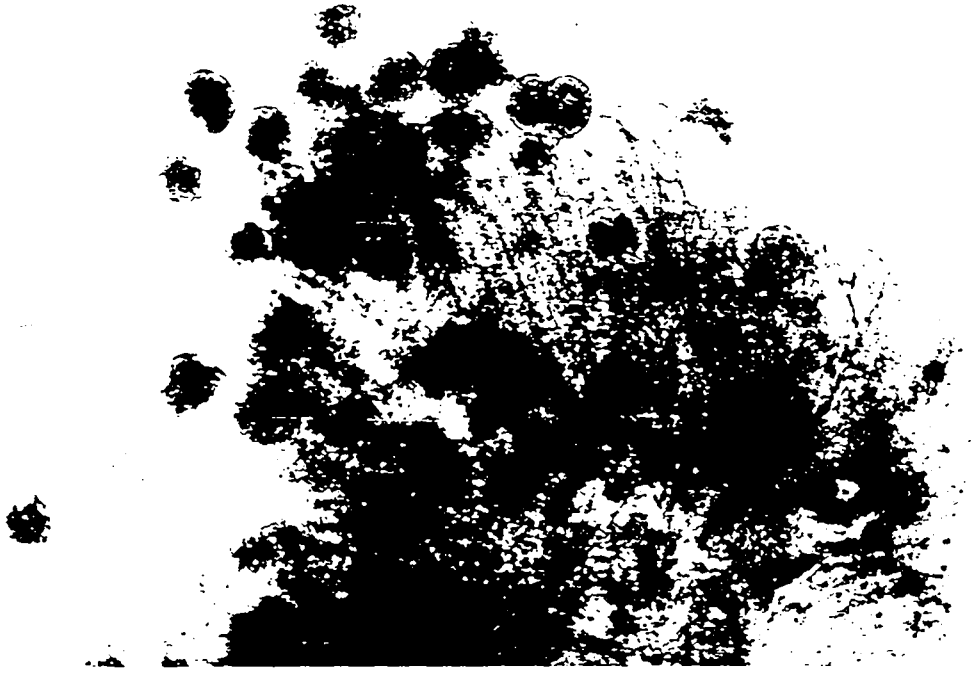
Diseases of Prawns due to nutritional deficiency, adverse environment and toxins.

S.No.	Disease	Life stages affected	Signs and symptoms of the disease	Cause	Method of diagnosis	Prevention and control
1.	Soft shell syndrome	Juveniles to adults	Persistantly very thin and soft shell which is loose and papery for several weeks. In acute cases, lesions or blisters may be seen. The white prawns, P.indicus show undulating gut. Generally prawns are very weak. Disease is common in traditional extensive prawn farms. The disease occurs during Feb-March, May to July and occasionally in September.	High water temperature low salinity High soil pH, highly negative redox potential, low organic matter content in the soil, low phosphate content in water, pesticide pollution and inadequate nutrition.	Based on the signs and symptoms of the disease.	The disease may be controlled by (i) restoring good water quality with increased water exchange, (ii) feed the prawns adequately: feeding with clam meat at 14% body weight or with diets containing calcium and phosphorus (ratio:1:1), and '(iii) removing organic debris and metabolites from the pond.
2.	Black gill disease	Juveniles to adults	Brownish to black gills followed by mortality	Presence of toxic levels of Cu,Cd,acids crude oils, ozone, ammonia,nitrite,H_2S,etc. Heavy siltation in the pond, microbial infections.	Based on gross signs of the disease.	Restore good water quality by increased water exchange. If the disease is due to microbial infections, antibiotic treatment may be given.
3.	Red disease	Juveniles to adults	The disease starts as yellowish discolouration of the body, then the appendages turn red. Cephalothorax may have excessive fluid accumulation with foul odour. Necrosis of the hepatopancreas.	Feeding prawns with rancid trash fish, or presence of mycotoxins in the feed.	Based on the signs and symptoms of the disease.	Not known. Avoid using old, rancid feeds.
4.	Hemocytic enteritis (HE)	Juveniles	Prawns lethargic, off feed, with bluish cuticular discolouration. Poor growth. Buff coloured spots may be near the joints of the abdominal segments. Opacity of abdominal muscles. Necrosis of hepatopancreas. The disease is more prevalent in the shallow ponds.	Injestion of benthic blue green algae such as Schizothrix sp. and Spirulina sp. or due to bacterial toxins.	Based on the gross signs of the disease. Histological demonstration of necrosis and hemocytic infiltration of mucosal epithelium of midgut, multifocal necrosis of hepatopancreas.	Not known. Maintain adequate algal blooms in the pond to avoid growth of benthic microalgae.

....Table 5 contd.

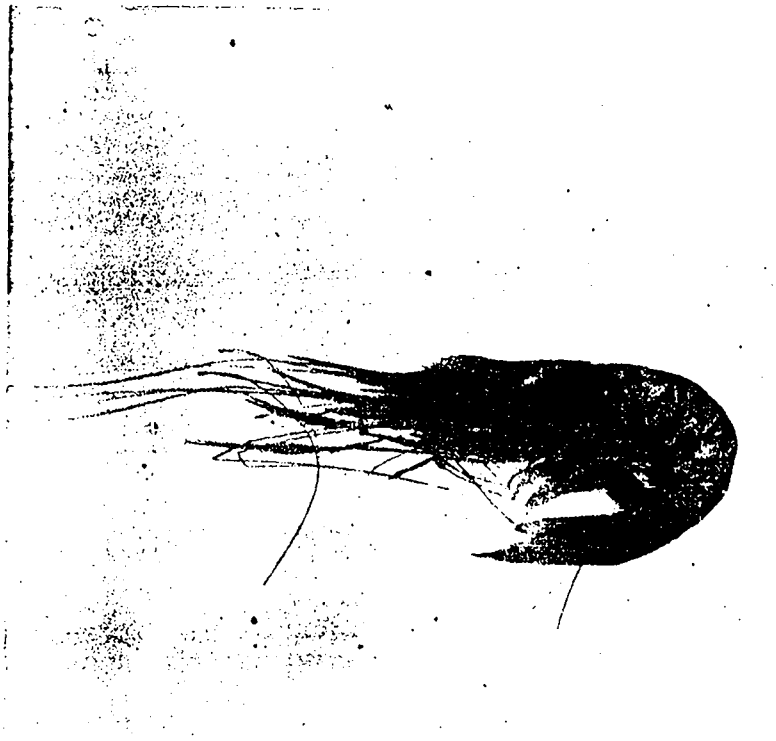
5. Cramped trail disease (Body cramp)	Juveniles to adults	Rigid flexed abdomen, prawns lie on their sides at the bottom of the ponds. Susceptible to cannibalism.	Unknown, sudden rise in the temperature may cause the disease.	Based on signs and symptoms of the disease.	Avoid handling of prawns in hot climate.
6. Ascorbic acid deficiency syndrome (Black death/ shrimp scurvy)	Post larvae to Juveniles	Lack of appetite, opacity of abdominal musculature, black patches under the cuticle, low mortality rates, reduced stress resistance, terminal bacterial septicaemia.	Feeding prawns with diets deficient of ascorbic acid.	Based on gross signs and symptoms of the disease. Histological demonstration of melanized and hemocycle infiltrated tissues.	Feed prawns with diets containing 2g ascorbic acid per kg. of feed.
7. Gas bubble disease	All stages	Presence of gas bubbles in the gills, below the exoskeleton, prawns appear whitish. In early phase of the disease prawns show erratic swimming behaviour. Severely affected prawns float on the surface of water	Super saturation of atmospheric gases in the rearing water.	Based on the gross signs of the disease. Microscopic observation of fresh larvae/tissues of affected prawns reveals gas bubbles.	Vigorous mechanical aeration of ponds water reduces the level of dissolved gases in the water and hence this may help in reducing the incidence of the disease.
8. Muscle necrosis	Juveniles to adults	White opaque areas on the abdominal segments. Abdominal segements appear cooked due to necrosis.	Over crowding, low O_2 level in water, sudden fluctuations in salinity and temperature, or body, cramp disease or gas bubble disease	Based on gross signs of the disease.	Dependends on the cause. Avoid handling of prawns, overcrowding and stress to prawns. Improve water quality by exchange with good quality water.

1. Larval mycosis of the tiger prawn, Penaeus monodon

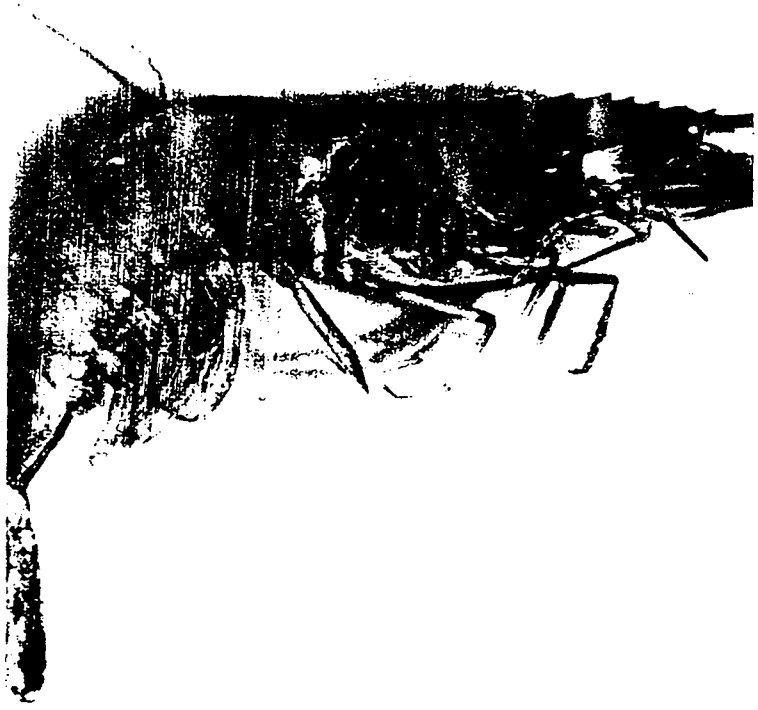


2. Protozoan gill fouling of the tiger prawn, Penaeus monodon

3. Protozoan fouling of the tiger prawn, Penaeus monodon



4. Parasitic infestation of Palaemon stylifera



5. Black gill disease of the tiger prawn, Penaeus monodon

6. Shell disease of the tiger prawn, Penaeus monocon

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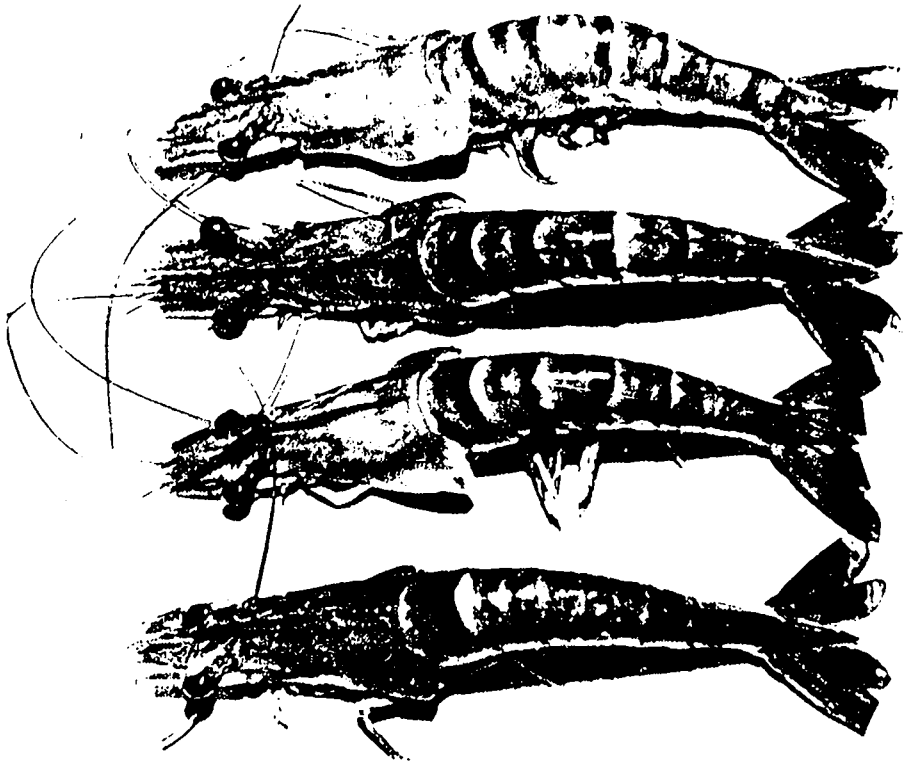

2.

7. Bacterial septicaemia of the tiger prawn, Penaeus monodon
(i) Black blisters on the carapace
(ii) Flared up branchiostegites.

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ENVIRONMENTAL PLANNING FOR SHRIMP AQUACULTURE

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ENVIRONMENTAL PLANNING FOR SHRIMP AQUACULTURE

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1. INTRODUCTION

India is poised for a major breakthrough in shrimp farming, which is considered one of the "extreme focus" areas of economic development. It receives adequate policy support from the government in the form of favourable terms of lease of public lands, credit support and incentives of cash and kind. There exists a range of farming systems, from the traditional to the intensive, each interacting with the environment of its setting. Since aquaculture is part of the environment, changes in external environment can affect aquaculture, and aquaculture itself has potential for positive and negative impact on the environment.

The experience of some of the leading shrimp farming countries of Asia-Pacific Region during the last five years has been revealing with regard to the interactions between aquaculture and environment. Self-pollution of shrimp aquaculture can be illustrated with several examples in Taiwan, Thailand and the Philippines. Rapid growth of intensive

farming in the Samut Prakan - Samut Sakhorn - Samut Songkhram area of Thailand took place in 1987, and by 1989 there was an estimated 8,000 ha of intensive ponds. The water supply canals were small, intertwined and polluted with nutrients, organic matter and suspended solids and water exchange with estuary was poor (Boyd, 1987). Severe deterioration of water quality in the supply canals caused by effluents from ponds led to massive mortality of shrimp and by 1990 most farms in the area had closed (Boyd, 1990). The shrimp crash of Taiwan from the production level of about 80,000 tonnes in 1987 to about 20,000 tonnes the very next year due to environmental degradation and diseases is well known (Lin, 1989). Land subsidence, salinization and social conflicts have been faced in the Philippines.

Economic losses in aquaculture due to deterioration of water quality have been estimated in some cases (M.J.Phillips, per.com.). The estimates suggest an economic loss of at least US $ 1.4 billion in Asia each year. Red tides caused losses of over US $ 100 million in lost aquaculture production (contamination and mortalities) in eight countries in Asia over the past five years. In Thailand, US $ 50 million per year of lost export value has been attributed to environmental deterioration leading to outbreaks of shrimp disease in just one province.

These experiences brought in an awareness and concern for environment. The trend towards higher productivity with intensive and hyper intensive culture technology got reversed towards semi-intensive and improved extensive technology with

respect to environment. The shrimp stocking density which reached a maximum of 100/m^2 got reduced to around 20/m^2. The term "sustainable aquaculture", gained currency in the minds of planners and aquaculture managers. Research on aquaculture environment has begun to receive due importance and environment management has become one of the significant topics for discussion at global, regional and national levels (Holmgren, 1993). The problems of potential environmental hazards associated with aquaculture development have been repeatedly addressed at international expert consultations, for example, by the Indo-Pacific Fishery Commission (IPFC), the European Inland Fisheries Advisory Commission (EIFAC), the International Council for the Exploration of the Sea (ICES), the Asian Fisheries Society (AFS), the International Centre for Living Aquatic Resources Management (ICLARM), the World Aquaculture Society (WAS), the European Aquaculture Society (EAS) and the IMO/FAO/UNESCO/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on the Scientific Aspects of Marine Pollution (GESAMP) (Barg, 1992). Currently, the Network of Aquaculture Centres in Asia-Pacific (NACA) is deliberating the issues under the project FAO/TCP/RAS/2253, with India as one of the Member countries of NACA. The status of environmental assessment and management of aquaculture development in India has been reviewed recently (Alagarswami, 1993).

2. WATER QUALITY IN SHRIMP CULTURE FARMS

The water quality in the pond is determined by 3 main factors, namely (i) the quality of the source water, (ii) stocking density and (iii) management practices relating

to feed, pond aeration, water exchange and use of chemicals and drugs.

(i) Source water

The quality of source water depends on the quality of the background environment which includes physico-chemical factors such as rainfall, floods, sediment load, temperature, salinity, hydrogen-ion concentration of soil and water, nutrients, pesticides from agricultural drainage, domestic sewage from human habitations, hydrocarbons and industrial pollutants. The biological factors would include "red tides", algal blooms etc. The quality of water is site specific and would show seasonal and annual variations. All these parameters would have an impact on shrimp culture. The coastal seawater has more stable conditions as compared to the brackishwater from estuaries, creeks etc. and water quality of the latter source is subject to fluctuations due to almost all factors listed above.

Heavy sediment load and siltation of ponds is a common phenomenon; for example, in the 24-Parganas district in West Bengal due to Hooghly influence and in East Godavari district in Andhra Pradesh due to Godavari influence. We will have similar problems to contend with in shrimp culture in the regions of all major rivers such as Mahanadi in Orissa and Narmada in Gujarat. Another issue of concern is the discharge of untreated or semi-treated sewage into the rivers and estuaries.

The immeasureable quantities of organic matter added to these water bodies increases the BOD and hence cause depletion of dissolved oxygen levels. The total volume of sewage discharge from the environs of Bombay has been estimated to be around 365 million tonnes per year and of Calcutta around 350 million tonnes. The Mahim Bay of Bombay receives around 64 million tonnes of industrial effluents every year. The Kulti estuary of Calcutta is another major recipient of domestic sewage.

As a major agricultural country, India uses 5 million tonnes of fertilisers, 55,000 tonnes of pesticides and 125,000 tonnes of synthetic detergents. It is estimated that nearly 25% of all these ultimately find their way through the rivers into the marine environment. Andhra Pradesh coastline is heavily dotted with shrimp ponds and, being a leading agricultural State, the source water for shrimp culture is likely to receive heavy doses of agricultural pesticides and nutrients.

Pollutants present in the industrial effluents show a great diversity in composition. They range from toxic heavy metals such as cadmium, lead, mercury and arsenic released from electroplating, chemical and metallurgical industries to effluents rich in organic substances from sugar factories, distilleries, breweries and leather tanneries. Industrial effluents discharged into the sea by coastal industries has been estimated at 0.39 billion cu.m. per year (Sen Gupta and Kureishy, 1989). India has some of the hot spots of

industrial pollution such as Mandovi estuary in Goa (WWF, 1992), around Bombay and also Madras.

It would be seen from the above that, primarily, the quality of pond water is a reflection of the quality of source water, including temperature, salinity and pH fluctuations, besides the other factors detailed above. Hence the importance of site selection for shrimp farms.

(ii) Stocking density

All other problems of water quality that get compounded in the pond arise from the stocking density as the management practices are directly related to this factor. The range of stocking density is from 2 PL/m^2 to 100 PL/m^2, the former in the extensive and the latter in the hyper intensive culture system. The higher range of 50-100 PL/m^2 has been responsible for the collapse of shrimp farms in Taiwan and Thailand as already mentioned. In India, the large-scale operators use 20-30 PL/m^2, but there are instances of using upto 80 PL/m^2 following the Taiwan model. But, by and large, the Indian farmers using extensive/improved extensive use 4-10 PL/m^2.

Higher the stocking density, greater is the concentration of toxic metabolites in the pond water. As a result of metabolic activity by organisms in ponds, carbon dioxide, ammonia and hydrogen sulphide sometimes may reach harmful concentrations (Boyd, 1989).

(iii) Management practices

The third, and the most significant factor that influences water quality in shrimp ponds is the management

practices aimed at increasing production. Feed management is a critical aspect which helps improve production as well as impacts water quality by way of nutrient and organic enrichment. The problem is the greatest with intensive farms, although still exists for semi-intensive ponds. It has been estimated that, in intensive culture in southern Thailand, at least 70-80% of nutrient (nitrogen and phosphorous) added to ponds is lost into the environment (Fig.1). Only 20-30% is removed in the form of harvested shrimp. As most of the nutrient input comes from feed, this leads to increasing problems with water pollution as feed inputs increase with more intensive farming.

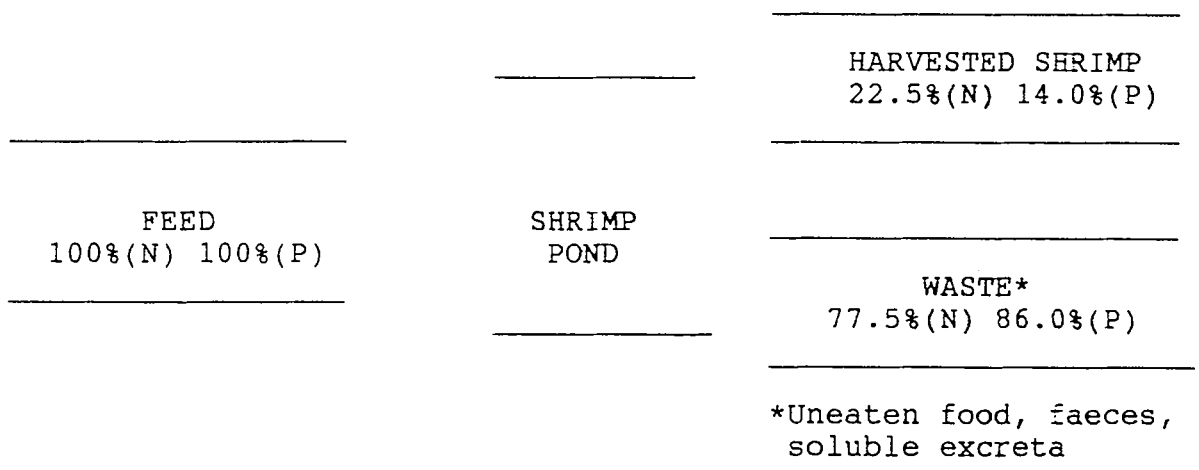

Fig.1 A nitrogen and phosphorous budget for intensive shrimp culture, based on field studies in Southern Thailand (From M.J.Phillips)

In super-intensive culture, with stocking densities of 171-286 shrimp/m^2 and high feeding rates, concentrations of nitrogenous metabolites were high in spite of intensive aeration and copious water exchange (Chen et al., 1988). Peak values were: total ammonia-nitrogen, 46.1 mg/litre; unionized ammonia-nitrogen, 0.87 mg/litre; nitrite-nitrogen,

0.84 mg/litre and nitrate nitrogen, 1.80 mg/litre.

Drugs and chemicals, including antibiotics, and cakes of plant origin such as teaseed, mahua etc., and bacterial amendments are used for various purposes in shrimp culture - as piscicides, herbicides, fungicides, against diseases, growth promoters and for improvement of pond soil and water quality. In fact, not enough scientific data are available to prove the merits and demerits of these and their application and dosages for shrimp culture, although much work has been done with regard to their application for culture of catfish, carps and tilapia in the West, and these are followed in shrimp culture. But their overall impact on water quality has been felt. The need for use of bacterial amendments in pond has been questioned.

Pond aeration and water exchange are the two mitigating factors against deterioration of water quality. Aeration with paddlewheels not only elevates dissolved oxygen levels but also circulates water in the pond. Adopting data on channel catfish ponds for shrimp ponds, Boyd (1989) concluded that where a large degree of water exchange is impractical, aeration can best be used with moderate feeding rates (50-60 kg/ha/day) to eliminate night time DO problems and increase production through enhancement of feed conversion efficiency. For extremely high feeding rates (60-100+ kg/ha/day) which are required in intensive system with production rates 5-20 t/ha, aeration alone is not sufficient and water exchange or water treatment is necessitated to reduce concentration of metabolites. Water exchange, then,

depends on quality of source water. Given some of the examples where the intake and effluent water are at the same point of the creek and crowding of ponds in the same area, the use of such water for exchange will have limited mitigatory effect; on the other hand will compound the problems. In such situations water treatment at both ends of intake and outlet would become necessary to maintain pond water quality.

3. PARAMETERS AND CONCENTRATION LEVELS

Some of the significant parameters of water quality in shrimp ponds, as extracted from available literature are presented in this section. Data are not readily available for the Indian shrimp farms.

Effluent water quality in intensive shrimp ponds in Thailand was compared to other effluent types (M.J.Phillips) and it was seen that the levels of the parameters considered were far below in the case of former (Table-1).

TABLE-1. Effluent quality from intensive shrimp ponds in Thailand compared to other effluent types.

Parameter	Shrimp pond effluent	Domestic waste water (untreated)	Fish processing waste water (untreated)
BOD (mg/l)	4.0 - 10.2	300	10,000 - 18,000
Total N (mg/l)	0.03 - 3.40	75	700 - 4,500
Total P (mg/l)	0.01 - 2.02	20	120 - 298
Solids (mg/l)	30 - 225	500	6,880 - 7,475

The optimal water quality for tiger shrimp culture is given in Table-2 (From M.J.Phillips).

TABLE-2. Optimal water quality for P. monodon culture

Water quality parameter	Optimal range
pH	7.5 - 8.8
Dissolved oxygen (mg/l)	>5.0
Temperature (^{o}C)	28 - 32
Nitrite (mg/l as N)	<0.25
Total ammonia (mg/l as N)	<1.0
Hydrogen sulphide (mg/l)	<0.002

Wide ranges of effluent water quality parameters have been recorded during a 5-month grow-out intensive culture of shrimp in Thailand (Phillips et al. cited by Barg, 1992) and the data are presented in Table-3.

TABLE-3. Range of effluent water quality in an intensive shrimp farm in Thailand.

Parameters	Range
Pond size (ha)	0.48 - 0.56
Pond depth (m)	1.5 - 1.8
Salinity (ppt)	10 - 35
Temperature (^{o}C)	22 - 31
pH	7.5 - 8.9
Total phosphorus (mg/l)	0.05 - 0.4
Total nitrogen (mg/l)	0.50 - 3.4
Total ammonia (mg/l)	0.05 - 0.65
Dissolved oxygen (mg/l)	4.0 - 7.5
Chlorophyll a (ug/l)	20 - 250
Total suspended solids (mg/l)	30 - 190
Water exchange frequency (%/day)	5 - 40

Very little information is available on heavy metal toxicity to aquatic life. Available data was summarized by Boyd (1990) (Table-4). He considered that although shrimp ponds in the vicinity of Bangkok, Thailand, received considerable industrial pollution, the heavy metal concentrations seldom exceeded the safe levels.

TABLE-4. Toxicity of selected heavy metals to aquatic life.

Metal	96-hr LC50 (ug/l)	Safe level (ug/l)
Cadmium	80 - 420	10
Chromium	2,000 - 20,000	100
Copper	300 - 1,000	25
Lead	1,000 - 40,000	100
Mercury	10 - 40	0.10
Zinc	1,000 - 10,000	100

Chlorinated hydrocarbon insecticides have the greatest potential for harming shrimp. Boyd (1990) summarized the toxicities of some selected chlorinated hydrocarbon insecticides to a wide array of freshwater and marine animals and the data are presented in Table-5.

TABLE-5. Toxicity of selected chlorinated hydrocarbon insecticides to aquatic life.

Pesticide	96 hr LC50 (ug/l)	Safe level (ug/l)
Aldrin/Dieldrin	0.20 - 16	0.003
BHC	0.17 - 240	4.000
Chlordane	5 - 3000	0.010
DDT	0.24 - 2	0.001
Endrin	0.13 - 12	0.004
Heptachlor	0.10 - 230	0.001
Toxaphene	1 - 6	0.005

For fish hatcheries, Pillay (1990) gave the following levels of maximum permissible concentration (mg/l): ammonia, 0.05; DDT, absent; magnesium chloride, 20; magnesium nitrate, 15; magnesium sulphate, 50; manganese (nitrate, chloride, sulphate), 5; copper (compounds), 0.005; cadmium, 0.003; rotenone, absent; sulphides, 0.1; hydrogen sulphide, 0.1; phenol, 0.0005; tannin, 5; chlorine, absent; and zinc (compounds), 0.005. These values could be broadly applied to shrimp hatcheries.

4. ENVIRONMENTAL IMPACT

Shrimp culture suffers from the influence of environment and also causes an impact on the environment. The interactions are both positive and negative. But in the latter case, the interaction is by far on the negative side when practised on an intensive scale. Some of the issues have already been discussed in the earlier sections. The negative impacts of intensive shrimp culture, as experienced by countries such as Taiwan, Thailand and the Philippines,

and coming under closer examination in India, are briefly discussed below.

4.1 Clearance of mangroves

It has been a common practice in the early days of aquaculture to clear mangroves and establish farms. The Philippines lost 206,525 ha of mangroves to aquaculture (Saclauso, 1989). India has already lost considerable mangrove area in the Sunderbans originally for agriculture and now converted to aquaculture. Conversion continues to be done on a limited scale in the Godavari mangrove region.

4.2 Natural seed resources

Pressue on wild shrimp seed resources is on the increase as the hatchery production does not meet the demand. The shrimp seed trade which has grown in West Bengal during the last 15 years is a classical example of the impact shrimp culture exerts on wild seed resources. More than 50,000 people are engaged in shrimp fry collection in 24-Parganas North and South districts. The percentage composition of P. monodon fry is only 1.5% at Najat centre which is the biggest shrimp fry market in India and the enormous quantities of by-catch comprising 49 species of finfish and 11 species of other crustaceans comprising 98.5% of the total fry catch is destroyed (Banerjee and Singh, 1993). Same thing happens in Andhra Pradesh and Orissa.

4.3 Impact on ground water resources

It has been reported that Taiwan suffered serious subsidence of coastal lands due to excessive extraction of groundwater, with some sections in Pingtung and Taitung countries experiencing sinkage as much as two metres (Anon, 1990). The extraction of groundwater amounted to 4.2 billion m^3 as compared to 4 billion m^3 of rain water seeping into the water table. There are some shrimp farms in India which emulates the Taiwan example in extracting groundwater for mixing with seawater for P. monodon culture.

4.4 Effluent from shrimp culture

This is the most significant of all factors that contributes to the degradation of environment and causes 'self-pollution' within the system. The nutrients and organic wastes influence the quality and quantity of effluent discharged from the shrimp farms, and the subsequent impact on the environment. The effluent quality during cleaning of intensive shrimp ponds in Thailand is given in Table-6.

TABLE-6. Effluent quality during cleaning of four intensive shrimp ponds in Thailand.
(Data from C.K.Lin as cited by M.J.Phillips)

Parameter	Pond 1	Pond 2	Pond 3	Pond 4
Total Nitrogen (mg/l)	2600	1900	2400	2600
Total Phosphorus (mg/l)	110	60	40	70
Organic Carbon (%)	13.6	7.3	10.4	13.7

The data show extremely high concentrations of both nutrients and organic matter. The loadings at this time are substantially more than instantaneous loadings during the culture period, because of discharge of materials previously bound to sediment particulate matter (Phillips et al., 1990). This has potential to reduce dissolved oxygen in receiving waters due to BOD/COD; to cause hypernitrification and eutrophication of receiving water; and increased sedimentation. However, there is little evidence as yet, to show that such impact exists in tropical and sub-tropical environments supporting shrimp culture (Phillips et al., 1990). The current study at the Central Institute of Brackishwater Aquaculture in shrimp farms shows severalfold concentration of nutrients and organic matter in the effluent at harvest time as compared to the grow-out period. The effluent at time of pond cleaning through bottom drains is black in colour with a heavy load of suspended solids.

There is concern that coastal environments are being subject to hypernutrification and eutrophication as a result of shrimp culture, but so far such impacts have not been quantified (Chua et al., 1989).

4.5 Use of drugs and chemicals

To revert back to the Taiwan shrimp crash of 1988, the use of drugs and chemicals in shrimp farms was widespread because no legal registration was required for their use. Most drug distributors were trained as livestock veterinarians, unable to provide advice on the use of drugs on aquatic animals. This abuse of drugs damaged shrimp health and water quality, and increased the resistance of pathogens

to antibiotics (Lin, 1989). Saclauso (1989) listed 14 chemicals reportedly used for aquaculture in the Philippines. Phillips et al. (1990) observed that chlorinated hydrocarbons which are highly toxic and non-biodegradable and organotins pose a threat to shrimp health, product quality, human health and the wider environment and that their use should be discouraged. In some areas of Andhra Pradesh, it has become a common practice to use veterinary and poultry grade drugs in shrimp culture.

Formalin (against parasites) and malachite green (against fungal diseases) are common chemotherapeutants used in shrimp hatcheries. Potential exists for these two compounds to adversely affect the pond ecosystem and, through effluent discharge, external waters.

The use of antibiotics in shrimp culture raises several issues relating to human health, product quality and acceptance and the environment. In Asia and Latin America there is concern that overuse of antibiotics has resulted in development of drug resistant shrimp pathogens. Use of chloramphenicol in hatcheries is of particular concern as the chemical is used to control human infections. Use of oxytetracycline, another common antibiotic, has resulted in development of resistant strains of Vibrio which causes serious disease problems in shrimp grow-out culture. The spread of resistant strains in S.E.Asia has probably been made easier by the inter-mixing of effluent and influent water in many highly congested culture areas. However, the

wider effects on the environment remain to be studied (Phillips et al., 1990).

4.6 Salinization of aquifers and land

One of the socio-economic considerations and deep concern associated with shrimp culture is its impact on salinization of underground water and land due to saltwater intrusion (which reduces agricultural productivity) and reduction of freshwater supply (for agricultural, industrial and municipal/domestic uses) (GESAMP, 1991). Public opinion on these issues has already been voiced in some parts of India, such as Tuticorin and Nellore, with high concentration of shrimp farms. The problem has been faced in several countries including Taiwan, Thailand, Bangladesh, Indonesia and the Philippines.

5. ENVIRONMENTAL MANAGEMENT PLAN FOR AQUACULTURE

5.1 Formulation of coastal aquaculture management plan

The Department of Environment and Forests, Government of India has issued Notification dated 19 February 1991, under the Environment (Protection) Act, 1986, declaring coastal stretches as Coastal Regulation Zone (CRZ) and regulating activities in the CRZ. The said Notification has imposed certain restrictions on the setting up and expansion of industries, operations or processes etc. in the CRZ. The Notification has directed the coastal States and Union Territory Administrations to prepare Coastal Zone Management Plans (CZMP) identifying and classifying the CRZ areas within

their respective territories in accordance with the guidelines given and obtain approval of the Central Government in the Ministry of Environment and Forests.

Accordingly, each State/UT may prepare the CZMP, integrating coastal aquaculture plans with the overall development and management plans, using present exemptions, and seeking approvals wherever required. The thematic maps for different land uses prepared by the Space Application Centre using satellite data and the macro/micro-level survey data already available, to be supplemented with fresh data as required, may form the basis for the aquaculture plans. The concept of zonation of environment to avoid conflicts of aquaculture with other land uses and to exclude areas which have the potential to affect aquaculture may be applied at this stage. Buffer zones wherever required may be planned and uses of such zones for mutual benefits may be considered.

5.2 Environmental Impact Assessment (EIA)

For the first time in fisheries in India, a detailed environmental assessment was made for the World Bank-supported Inland Fisheries and Brackishwater Aquaculture Project for West Bengal, Orissa and Andhra Pradesh in 1991. It formulated an Environmental Action Plan (EAP), divided into two parts namely, (i) an Environmental Monitoring Plan that will provide baseline information both on the fisheries project impacts on the environment, and the environment's impact on the fisheries projects, and (ii) an Environmental Management Plan which would describe the management inter-

ventions that are necessary to directly mitigate possible negative environmental impacts from project activities. The Department of Environment and Forests insists upon the imperative need to undertake detailed EIA of all large-scale aquaculture projects encompassing physical resources, biological resources, hydrology and water quality, socio-economic aspects and human use values, and legal aspects. All activities (including shrimp farming) with investment exceeding Rs 50 million will require environmental clearance from the Ministry of Environment and Forests. Those with less capital investment are to be cleared by the concerned State Government. The principles of EIA and EAP should be followed carefully both for the benefit of aquaculture and security of the environment.

5.3 Preparation of master plans for all suitable sites

Haphazard and unplanned development of shrimp farms will not be in the interest of aquaculture itself, besides coming into conflict with other uses. Technical suitability, economic viability and socio-cultural acceptability of the areas proposed for shrimp farm and their impacts should be assessed and, accordingly, master plans should be prepared for allocation of sites. In the case of target people-oriented programmes of Government, it is much more important to allot sites/ponds after the master plan has been prepared.

5.4 Sustainable aquaculture plans

Analysing the fundamental causes of the collapse of Taiwan's shrimp industry in 1988, Lin (1989) concluded that most of the factors that led to the mass mortality of the tiger shrimp caused by the virulent diseases were man-made and could be averted. Essentially it was a case of abuse of environment with the highest productivity targets from super-intensive culture. The carrying capacity of environment was far exceeded. The lesson thereof is to fix levels of sustainable production with reference to the carrying capacity of the environment and manage aquaculture at that level for long term benefits. The term semi-intensive farming itself is considered too broadly to include stocking densities as high as 30-50 shrimp/m^2 which should not be the case. The National Workshop held at Bangalore in 1989 placed production rates of 2-5 t/ha/year under the semi-intensive farming category which should be considered as sustainable.

5.5 Improvement of management of operations

No matter how carefully the plans are made, finally it is the operator who has to ensure proper implementation and management of the farm. He has to choose the appropriate technologies and management practices which would reduce environmental impacts. The stocking density, biomass, feed type, rations and schedules, water quality and exchange, algal blooms, aeration and effluent management are important factors the farmer should bestow attention. In Thailand, settlement ponds covering 10% of farm area are required for all farms over 50 rai (8 ha) area. During normal operations

the water discharged is suitable for filter feeding animals (mussels and oysters) and the need for technologies for 'secondary' aquaculture in the settlement ponds is being stressed. In polluted areas, shrimp farmers in some countries are also treating inflowing water, by using a reservoir coupled with other biological methods of treatment.

5.6 Regulations

There is need for framing and implementing certain regulations to safeguard aquaculture and the environment. It should start with siting of farms and include effluent treatment and permissible levels of chosen water quality parameters such as suspended solids, nutrients, organic matter and BOD/COD, for farms of certain size and above to be fixed for the purpose. For tropical brackishwater shrimp culture, reliable data are meagre and necessary database should be created through special effort. There should also be regulations on use of drugs and chemicals, the basis for which is again to be worked out through a study. These issues cannot be rushed through without any scientific basis. Monitoring and implementing agencies at different levels should be identified and responsibilities entrusted with laws and mechanisms for enforcement.

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FINANCIAL MANAGEMENT IN AQUACULTURE

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Financial Management in Aquaculture

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This paper addresses itself to providing the basic concepts and tools of financial management of an aquaculture farm firm.

1. Financial Functions:

Financial functions includes judgements about whether a company should hold, reduce, or increase investment in various assets. This involves corporate planning.

1.1 **Corporate planning** deals with the futurity of present decisions in terms of setting goals, developing strategies to achieve them, translating strategies into detailed operational programmes and assuring that plans are carried out.

Corporate planning is based on corporate objectives and goals

1.1.1 Objectives are broad and general statement of purposes. They are pursued but not always realised. For example, the basic objective of an aquaculture farm firm is to break even (survive) and grow.

1.1.2 Goals are targets or description of things to be achieved in a given span of time. With a given resource base to achieve an yield of 1 tonne of shrimps per hectare of water spread area could be a goal. Goals change overtime. On achieving the first goal, it could be revised to 2 tonnes per hectare of WSA. But the basic objectives remain stable.

1.2 **Determination of an objective:** The objectives of the farm firm needs to determined initially. This helps to decide what it wants and how to achieve the same. This also helps the farm firm to organise itself, judge priorities and evaluate their progress. For example, the objective of an brackishwater shrimp farm may be to adopt the extensive system of cultural operations. This objective helps it to organise the scale of its operations (organisation) with respect to inputs necessary (judge priorities) and revise its goals from time to time based on scientific financial analysis (evaluation). Thus determination of the objective of the farm firm plays a crucial role in its finacial and operational stablity.

1.3 **Preparation of forecast** : A financial forecast enables the farm firm to take proper judgement of its priorities. A financial forecast is based on some basic premises like a given level of prices for the product overtime. Thus these forecasts are near approximations of the future. Incorporation of changing levels of prices and resource availability are beyond the scope of this paper. Thus forecasting is based on the four components of:

1. Fixed costs involved in the setting up of the farm firm.
2. Variable costs involved in the operation of the farm firm.
3. Selling price of the product.
4. Volume of production per unit area.

This forecasting enables us to find out about the inter-relationships of cost and revenues to output.

Costs can be distinguished into fixed and variable costs.

1.3.1 Fixed costs are those that are related to the creation of capacity rather than to the conduct of an activity within an existing

productive capacity. Eg. The construction of ponds, permanent farm sheds, purchase of vehicles and laying of roads etc., are fixed costs ie. they are involved in the productive activity irrespective of the levels of output.

1.3.2 Variable Costs are those related to the productive activity directly and its level corresponds to the goals set by the farm firm management. Eg. Shrimp seed cost, feed cost, fuel cost etc.vary with the levels of production and hence are called variable costs.

Fixed costs do not change with the level of production and the amount of fixed cost remains the same during any designated period regardless of the level of output for that period.

Variable costs vary with the levels of production.

2. **Mechanics of break-even analysis:** The break-even analysis or the cost-volume-profit analysis helps in finding out the relationship of cost and revenue to output. The break even analysis helps us in answering the questions like, for example,

(1) How to decide on the system of aquaculture to be adopted given the available set of resources and biological parameters ?

(2) Will reducing costs instead of increasing volume of production help in increasing profits of the aquaculture farm firm ?

2.1 Assumptions:

1. Biological parameters of the farm location are ideal for brackishwater aquaculture.
2. The elasticities of demand and supply of shrimps remain the same.
3. Fixed cost for an aquaculture farm practicing extensive system of culture : Rs. 11,575.00
4. Variable cost for producing an output of 1 tonne per hectare of WSA : Rs. 14955.00
5. Farm harvest price per tonne of shrimps: Rs. 2 lakhs.

2.2 Steps in performing the break even analysis are:

1. The cost- profit structure for 1 tonne/hectare is worked out in the conventional manner.
2. Cost-profit structure at yield levels less than and more than 1 tonne per hectare are considered.
3. Scaling down/enhancing the requirements of the variable inputs costs level have been done considering the economies of scale.

Table 1 gives the changes in costs- profits structure as a result of changes in the level of output.

Table 1: Break even analysis of brackishwater shrimp farm practicing extensive farming system.

Fixed cost: Rs.11575.00 Variable cost :Rs.14955.00
(estimated for expected yield of 1 ton/ha)
Farm harvest price/ton : Rs.2.00 lakhs.

Yield/hectare (tonnes/ha)	0.1	0.5	1.0	1.5
Gross returns	20000.00	100000.00	200000.00	300000.00
Variable Costs	10305.00	12677.00	14955.00	19375.00
Total Costs	21880.33	24252.00	26530.00	30950.00
Profits (Loss)	(1880.33)	75748.00	173470.00	269050.00

2.3 Observations from break even analysis

1. The profit levels at 100 Kgs., 500 Kgs., 1000 Kgs., and 1500 Kgs., of output per hectare have been considered.

2. At an yield level of 100 Kgs. per hectare the firm makes lossses.

3. Absolute profits are highest when yield level is at 1.5 tonnes/ha.

4. The relative increase in the proportion of variable costs is greater at outputs over 1 tonne per hectare (ie. it takes 23 increase in variable costs to increase output from 0.1 tonne to 0. tonne and it takes 17 % increase in variable costs to increas output from 0.5 tonne to 1 tonne per hectare and it takes 30 increase in variable costs to increase output from 1 tonne to 1. tonne)

5. The costs and revenue break even at an ouput between 0.1 tonne an 0.5 tonne per hectare (ie. costs equal revenue and the firm make neither profits or losses at an ouput level between 0.1 and 0. tonne per hectare) (See graph)

6. The farm firm is ideally endowed in terms of resources fo producing 1 tonne of shrimps per hectare of water spread area.

3. Conclusions

1. This analysis helps in making an rough approximation of financia scenario in successive periods of investment in an aquacultural far firm.

2. It enables the management to take the right decision on the level o output commensurate with available resources/ price of output.

3. The basic limitation of this approach is that it is not dynamic i formulation. Features incorporating changing output prices an varying availablity of resources could enhance the reliability o the estimates but would entail necessarily the use of compute modelling.

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PROJECT EVALUATION TECHNIQUES FOR AQUACULTURE

BY
T.RAVISANKAR AND M.KRISHNAN

PROJECT EVALUATION TECHNIQUES FOR AQUACULTURE

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PROJECT EVALUATION TECHNIQUES FOR AQUACULTURE

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INTRODUCTION

Once a lucrative investment opportunity is found the entrepreneur collects more information on costs and returns of that particular enterprise. He calculates roughly what will be the expected profit per annum. This process is the crudest way of doing project evaluation. Oflate, more reliable techniques have been devised by the economists. An exposure to some of these recently developed techniques would help in preparing better project proposals for aquaculture farms, in such a way that farmer gets a more realistic figures of probable costs and returns. The lending institution could also be enlightened about likely cash flows and risks. These techniques place importance on time value of money concept.

COST OF WAITING (OR) TIME VALUE OF MONEY

Money at hand and the money due after five years differ in real value even if their face value are equal say Rs.1000/-. Even government deposit schemes offer to double your money after 5-6 years when private companies promise to do the same in 3-1/2 years. So, the returns the entrepreneur is likely to receive after certain time need to be reduced in real value. This process is called discounting. Discounting can be defined as the process of weighing the cash flow according to the year in which they occurred. The rate used

to weighing the cash flow is called discount rate. In other words, discount rate is the percentage difference between the value of Rs.100/- now and its value a year later from now is called discount rate. It may be the market rate of interest or opportunity cost of the capital i.e., the percentage return from the next best alternative.

CASH FLOW STATEMENT AND NET CASH FLOW

For any financial analysis, it is essential to prepare a cash flow statement considering costs or investment and benefits or returns of each investment opportunity.

Net Cash Flow (NCF) of the project can be calculated as follows:

NCF = Cash inflow - Cash outflow

(or)

= Project returns - Capital expenses
- other expenses except depreciation
- income taxes

EVALUATION TOOLS FOR INVESTMENT PROPOSALS

The important methods of evaluation of investment proposals are given below:

(i) Un discounted Cash Flow Methods:-
   a. Pay Back Period (Pay out period) (PBP) method.
   b. Average Rate of Return (ARR) method.

(ii) Discounted Cash Flow Method
   a. Benefit - Cost Ratio (BCR) method.
   b. Net Present Value (NPV) method.
   c. Internal Rate of Return (IRR) method.

UN DISCOUNTED CASH FLOW METHODS Un discounted cash flow methods ignore time value of money. They are easy to calculate and understand.

PAYBACK PERIOD (PBP) METHOD

After the annual cash flow statement is prepared for the whole life period of the project, the PBP is calculated using the following formula:-

$$P = I/C$$

Where P = Payback period.

I = Initial investment

C = Yearly net cash flow i.e. profit after tax + depreciation

E.g. Let us assume the farmer is thinking of purchase of a machine for ice making which will be used for packing shrimps. Two models say, electricity and diesel operated (A & B) are available for this purpose. Both cost the same i.e., say, Rs.50,000/-. Annual earnings (after taxation) are the following:

Year	Machine A	Machine B
1	5,000	5,000
2	15,000	15,000
3	25,000	24,000
4	12,000	30,000
5	10,000	20,000
	67,000	1,10,000

By the Pay Back Period method, one can identify option B

is better among the two. While machine A pays back the investment in 3 years and 5 months, machine B pays back the investment in 2 years and 5 months. Hence machine B will be chosen.

This method can be used for judging the period required for repayment of investment when there are few alternatives only.

ADVANTAGES

1. Easy to compute and simple to understand.
2. Emphasises liquidity and reveals nothing about profitability.
3. Enables quick ascertainment of degree of risk.
4. Enables the firm to select a project that will yield a quick return of cash if it is short of cash.
5. When the enterprise is developing in a fast pace, this method reduces the possibility of loss through obsolescence.
6. Short cut technique while dealing with the problem of uncertainty.

DISADVANTAGES

1. Ignores the time value of money.
2. Does not take into account the cash outflow for entire life period i.e.,it ignores the returns received after Pay Back Period.
3. Puts over emphasis on liquidity.

2) AVERAGE RATE OF RETURN (ARR) METHOD

ARR is the value arrived by dividing average net annual revenues by initial cost. The formula used for calculation

of ARR is as follows:-

$$ARR = \left[\sum_{i=1}^{n} R/n \right] C_o \quad *100$$

Where R = Returns in the i^{th} year

I = Investment in the i^{th} year

n = Project life in no. of years

For e.g., let us assume a farmer buys a portable kit for soil and water quality testing at the cost of Rs.30,000/- which will last for 5 years. By using this kit, he can save his laboratory fees on testing plus he can do same business by testing neighbouring small farm's water and soil, so his investment and return schedule for the next 5 years will be the following:-

TAB:2 INVESTMENTS AND RETURNS (RS)

Year	Investment	Return
1	30,000	6,500
2	-	7,300
3	-	8,100
4	-	11,000
5	-	10,780
Total	30,000	43,680

Net Income over the period = 43,680 - 30,000 = Rs.13680/-

Average Annual Income = $\frac{13,680}{5}$ = Rs.2736/-

ARR = $\frac{2,736}{30000} \times 100$ = 9.12%

ADVANTAGES

1. ARR takes into account cash flows for entire life of the project.
2. Easy to calculate from readily available information from accounting records.

ii) DISCOUNTED CASH FLOW METHODS:

The undiscounted cash flow method evaluate what is the amount the farmer pays out and receives, but not what is the amount he realises in true or real value. So 'time value of money' concept are incorporated in discounted cash flow methods.

a) BENEFIT - COST RATIO:-

It was the most popular criterion for some time. Benefit cost ratio is the ratio between total discounted benefits and total discount costs of the B>C. Ratio is above 1, it is accepted. While comparing between the projects, the project with higher B.C. Ratio will be giver high ranking.

ADVANTAGE

Easy to calculate and understand.

DISADVANTAGES

1. BCR does not take into account the project size.
2. It does not consider incremental costs and benefits of the project.
3. BCR will give different answers on how costs and benefits are aggregated.
4. It should not be used as the sole, project selection criterion.

b) NET PRESENT VALUE (NPV)

NPV is the difference between the present value of the future benefits and present value of the costs. The interest rate reflecting the cost of capital is used for discounting costs and benefits. Then, the projects with highest NPV is

ranked as first choice and so on. The projects with negative NPV are rejected. This NPV criterion gives us an estimate of expected returns over the cost of capital i.e., the discount rate.

The formula used for computing NPV is the following:-

$$NPV = \sum_{t=1}^{n} \frac{R_t}{(1+r)^t} + \frac{S}{(1+r)^t} - \sum_{t=0}^{n} \frac{O_t}{(1+r)^t}$$

Where r = Interest rate or opportunity cost of capital

R1, R2...Rn = Cash inflows in the year 1, 2, ...n.

S = Salvage value of the asset in the year n.

n = Life period of the asset in years.

O1, O2,..On = Cash outflows at year 0, 1, 2, ...n

ADVANTAGES

1. NPV considers the time value of money.
2. NPV takes into account the return from the project in its entirely in evaluation of a capital expenditure project.
3. Interpretation of the measure is easy and there is a clear acceptance criterion.

DISADVANTAGES

1. This method is difficult to compute and understand.
2. Entrepreneur should know exactly the cost of capital or discount rate.

c) INTERNAL RATE OF RETURN

IRR is the rate of discount at which present values of future benefits and costs are equal i.e., the discount rate which brings the sum of future cash flows to the same level

of original investment.

IRR is arrived at by a short cut method as given below:

$$\text{IRR} = \text{Lower Discount Rate (LDR)} + \text{Difference between two Discount Rates} \times \left\{ \frac{\text{NPV at LDR}}{\text{Diff. between Two NPV's}} \right\}$$

Decision rule is the following. If IRR is greater than cost of capital (discount rate) or opportunity rate of interest, accept the project otherwise reject.

ADVANTAGES

1. IRR considers the factor time productivity of the money.
2. It ranks the projects according to the profitability.
3. It is the most accurate method available for appraising capital projects.
4. It takes into account all the cash inflows and outflows.

DRAWBACKS

1. It is not based on the cost of capital i.e., a realistic discount rate could not be fixed.
2. Under rapid change of technology, this may fail to provide solution. In such cases, the payback period is very helpful.
3. It is difficult to calculate. Some trial calculations become necessary.
4. May not give unique answer in situations like recession followed by prosperity.

MODEL CALCULATION

PROJECT :A HATCHERY UNIT FOR PRODUCING TIGER PRAWN SEEDS.

TABLE.1 CASH FLOW STATEMENT

YEAR	CAPITAL EXP RS	WORKING EXP RS	TOTAL COSTS RS	TOTAL BENEFITS RS	NET BENEFITS RS
1	2750000	1818000	4568000	2740000	-1828000
2		1818000	1818000	2740000	922000
3		1818000	1818000	2740000	922000
4		1818000	1818000	2740000	922000
5		1818000	1818000	2740000	922000
	2750000	9090000	11840000	13700000	1860000

TABLE.2 DISCOUNTED CASH FLOW

YR	TOTAL COSTS DF 18%	TOTAL BENEFITS DF 18%	TOTAL COSTS DF 35%	TOTAL BENEFITS DF 35%	TOTAL COSTS DF 40%	TOTAL BENEFITS DF 40%
1	4006136	2402980	3384888	2030340	3261552	1956360
2	1398042	2107060	998082	1504260	927180	1397400
3	1227150	1849500	738108	1112440	661752	997360
4	1076256	1622080	547218	824740	472680	712400
5	943542	1422060	405414	611020	338148	509640
	8651126	9403680	6073710	6082800	5661312	5573160

TABLE.3 NET PRESENT VALUE

YEAR	NET BEN.(RS)	NPV(18%)	NPV(35%)	NPV(40%)
1	-1828000	-1603156	-1354548	-1305192
2	922000	709018	506178	470220
3	922000	622350	374332	335608
4	922000	545824	277522	239720
5	922000	478518	205606	171492
	1860000	752554	9090	-88152

PROFITABILITY INDICATORS:

1.PAY BACK PERIOD : TWO YEARS AND 11.93 MONTHS

	DISCOUNTING RATE	18%	35%	40%
	GROSS RETURNS	9403680	6082800	5573160
	GROSS COSTS	8651126	6073710	5661312
2.B/C	RATIO(DISCOUNTED):	1.087	1.001	0.984
3.NET	PRESENT VALUE(RS):	752554	9090	-88152

4.INTERNAL RATE OF RETURN: 35.58%

* * * * *

AUDIO VISUAL EXTENSION TECHNIQUES

BY
D.DEBORAL VIMALA

AUDIO-VISUAL EXTENSION TECHNIQUES

AUDIO VISUAL EXTENSION TECHNIQUES

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1. INTRODUCTION

With the technological advancement in the field of aquaculture, there is accumulation of knowledge which needs to be transferred to the shrimp farmers who will be benefited from it. To facilitate the farmers to understand the information, it is important that extension workers should use audio-visual aids.

The need of the hour is to create change in the thinking of the extension workers who are connected with the transfer of technology. They should think of using audio-visual aids on the process of communication. However, use of words alone cannot provide vivid learning experiences. The teaching and learning process can be made more meaningful by proper selection and use of audio-visual aids. It will provide learning experience to the learners and develop their understanding.

In common usage, some forms of educational aids are loosely called audio-visual material some of these are specifically visual, some audio and a few are true audio visual media. It must

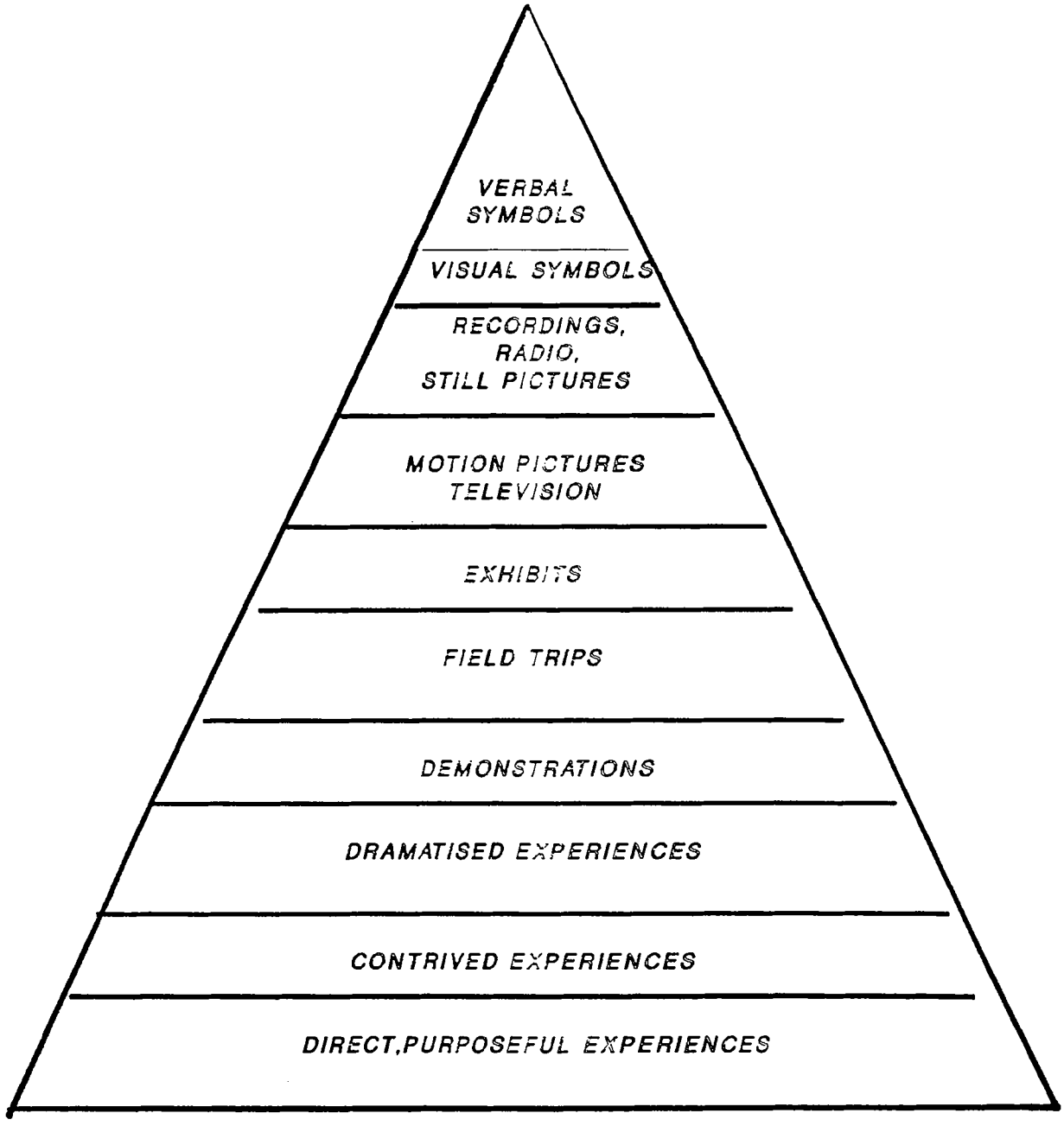


FIG.1 THE CONE OF EXPERIENCE
(TYPE OF AUDIO VISUAL AIDS)

be remembered that audio-visual aids can only supplement the teacher but can never supplant him.

Figure 1 shows the "**cone of experience**" devised by Edgar Dale in explaining the inter relationships of the various types of audio-visual materials to learn faster, to learn more, to learn thoroughly and to remember longer.

PRINCIPLES IN USE OF AUDIO-VISUAL AIDS

2.1 Planning

a) Teaching Objective: Objectives should be clear and should be planned in advance. The types of behaviour change (ie) whether gaining information, skill or attitude should be considered.

b) Audience: The nature of learners can be known from their age, educational level, interest, experience, knowledge of the subject, and intelligence.

c) Availability: When the teaching aid what the extension worker like to use is not available, he can make use of indigenous materials.

d) Cost: Effective aids need not necessarily be expensive. Variety of colourful visual aids can hold audience interest.

e) Teacher: The extension worker using the aid should be familiar with its preparation and use. He should develop skills in development and use of aid.

f) Variety: To avoid monotony and hold interest of the learners, use various aids having different colours and sizes. One should use the aid that one feels the best for a particular situation.

2.2 Preparation

After deciding the purpose of the aids it should be prepared nicely. The "ABC" principle should be remembered while its preparation.

a) Attractiveness: The visual aid can be made attractive by using appropriate colours. As far as possible use natural colours which will please sense. It will also help for identifying the real objects in its natural setting. Secondly, the size of the aid should be proportionate to the surrounding in which it is being presented. A symmetrical, irregular shapes are more eye catching than routine formal designs.

b) Brevity: The message to be delivered through aids should be brief. For this purpose select the message with caution by keeping the audience in view. Screen out, difficult

concepts that are beyond the experience and understanding of the learners. List out essential facts necessary to cover the angle of the subject which you intend to emphasize.

c) Clarity: The message should be clear. Decide the actual message to be delivered. Then think of the code for communicating message words, pictures, diagrams and other symbols. Prepare rough sketches of the aids and select the most suitable design out of them. Then get the necessary material and prepare the aid.

In brief, the aid should be simple in design understandable conveying upto date ideas, stimulating action, accurate and pleasing to the senses.

The aid should be planned before the time and place of showing. Visit the place of presentation if possible. Arrange the sitting area in such a way that all audience can hear/see the aid properly. Check all physical facilities including lighting, ventilation and possible distractions. Test all the equipments before use. Have a trial of the aid before its final presentation. Arrange the aids for presentation. If necessary hand out may be prepared for distribution of the presentation of the aid.

2.3 Presentation:

Before starting the presentation of aid, see that the audience is at ease. Introduce the topic and use the aid at appropriate movement. If the audience is prepared and knows what to look for in the aid then they learn more. Once a documentary movie was shown explaining the necessity to boil water to prevent communicable diseases. At the end of this film when asked whether the audience have understood the principle behind boiling water. One man replied that he understood everything about moving hens. The reason for such an answer was that a hen was walking in the background of the water boiling scene which distracted the attention of the audience. To avoid such instances, it is better to help the audience is knowing and interpreting the aids for easy understanding.

The purpose of using aids is to transfer the ideas to the learners effectively. The teacher should be sincere in the use of the aids. The sincerity in presentation will bring liveliness in teaching. No aid will be of real value unless it is presented with enthusiasm. Avoid too rapid presentation of visual material. Adjust the speed of delivery depending on the understanding of the audience. The speaker should face the audience and not the aid Display one aid at a time by standing beside the aid but never in from of it. Present the ideas in a logical sequence. Avoid any misunderstanding by discussion at the end of presentation.

AUDIO VISUAL AIDS

Audio aids:

An audio aid is an instructional device in which the message can be heard but not seen.

1) Radio
2) Tape-recorder
3) Recordings

1. Radio: It is a very good information tool. It is a mass medium of conversation and can reach large numbers of people at any given time.

Immediacy, realism, conquest of space and time, emotional impact, authenticity, inexpensiveness are the advantages of radio. Radio can be used for:

1. Announcements
2. Intimation or information regarding availability of materials, prices, places etc.
3. Warnings relating to weather, outbreaks of diseases, pests
4. Seasonal hints
5. News stories
6. News reviews - about shrimp farmers & farming
7. Interviews

8. Questions and answers

9. Short talks

10. Documentaries.

It is relatively cheap. It reaches illiterate audiences also. It builds enthusiasm and maintains interest. The medium has its own limitation too. The broadcasting facilities are available only in limited places. It is difficult to check on results. The time assigned for the talks is usually limited. Its influence is limited to people who can listen intelligently.

2. Recordings: Tape Recorder: It is an audio equipment for recording sound on magnetic process. It is used to capture original sound and preserve it for later reproduction.

It can report spotnews or accomplishments. it can extend the voice of a well known person or a person of authority. it can be used to reproduce information in regional languages or dialects. Operation cost is low as the same tape can be used over and over again. Editing is easy and it can be played back without undergoing any processing.

Recording can facilitate two way communication by slopping when required and discussing or playing it over and over again if necessary. Recordings can be pre-heard and evaluated. Recordings can be made according to the audience needs and convenience.

3.2 Visual aids

1. Non-projected
   a) Models, specimens
   b) Flannel graphs
   c) Flash cards
   d) Photographs
   e) Illustrations
   f) Charts
   g) Posters
   h) Chalkboard
   i) Bulletin board

A visual aid is an instructional or communicating device in which the message can be seen but not heard.

1. Non projected

a. Models, Mock-ups, specimens, objects

Model: is essentially a recognizable imitation or replica of the original, whether workable or not, and whether differing or not from the original in size, e.g. Models of pond construction.

Purposes:

1. To get over the disadvantages in the size of the original from instructional view point. e.g. too big a size for the eye to take in, as in the case of pond preparation or too small for study as in the case of prawn seeds e.g. causal agent for a particular disease.

2. To make the past or the future visibly real. e.g. an outdated implement or a new implement likely to be introduced in future.

3. To get over physical inaccessibility e.g. seasonal varieties.

4. To circumvent "**unusable**" reality e.g. to explain the internal organs of the animal.

   Mock up (working model)

   e.g. Feed Mill

Specimens: e.g. Specimens of animal shown at a meeting or exhibition preserved or mounted specimens of animals.

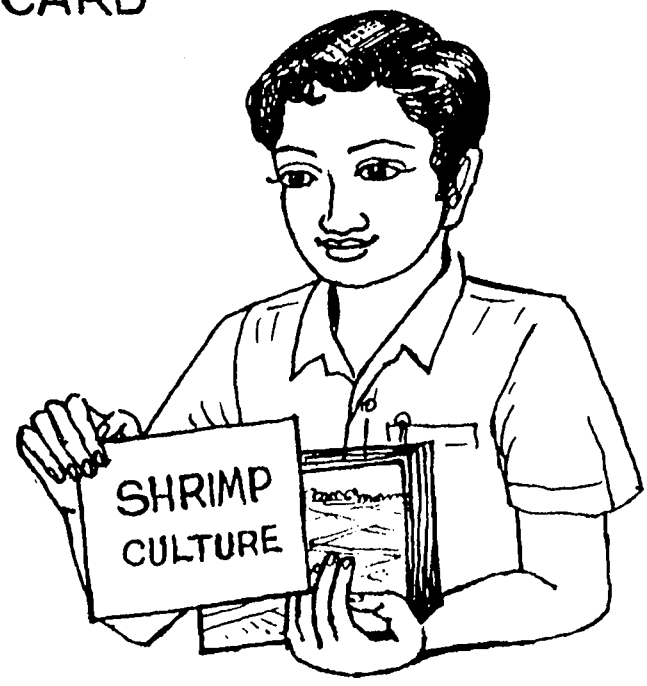
Objects: Pieces of reality or sample

e.g. diseased parts of prawn.

b. **Flannel Graphs**:

A flannel graph or Khadder graph is a visual teaching aid. Pieces of flannel felt or sand paper having rough surfaces, or nap will stick to another piece of flannel stretched on a firm flat surface called "**flannel board**". When you attach pieces of flannel felt or sand paper to the back of pictures, photographs, drawings, letter etc., these objects will also stick to the flannel board. This device is called a "**flannel graph**".

FLASH CARD



The size of flannel graph to use depends on the size of the audience. A flannel graph 30 by 40 inches can be used to tell a story to about 150 people if the parts are sufficiently bold. The message should be developed in a logical, step by step sequence. It is well to practice your presentation two or three times before you give it before an audience.

c. **Flash cards**:

Flash cards are a series of illustrated cards which when flashed or presented (before a group) in proper sequence tell a complete story. The story is simple and tells about one theme.

It is adapted to local conditions. It can be used in group not over 30 people, with simple line drawings, photographs or cartoons.

For effective teaching with flash cards, the subject on the card must be familiar to the extension worker. Simple words must be used. cards must be hold against the body so that audience can see clearly. Cards must be stacked in order. As one card is finished it is slid behind the other so that it will be in order the next time it is used.

d. **Photographs**:

"One picture is worth a thousand words".

Photographs are exact visual recordings of things. They may be mounted or unamounted photographic prints or reproductions of

photographs taken from a magazine, newspaper or book. they may be in black and white or coloured. They may be used in personal teaching situations or as display type visuals in exhibitions or bulletin boards. They may be projected with an opaque projector.

To be an effective teaching aid a photograph must:

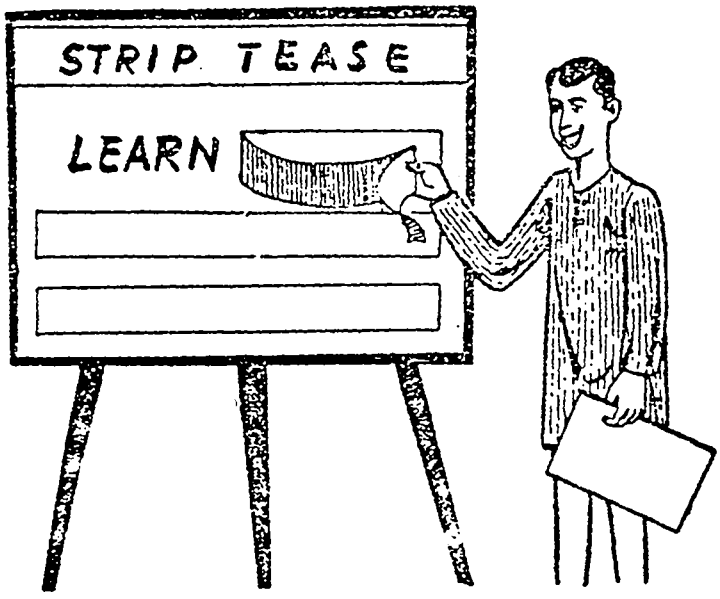
1. Tell a story
2. Illustrate only one point
3. Have plain and simple background
4. Show the main subject prominently

e. **Illustrations:** are non-photographic reconstructions of reality, e.g. drawings, paintings, etchings etc. These are used much in the same way as photographs.

f. **Charts**

Charts are visual symbols for summarising, comparing, contrasting or performing other services, in explaining subject matter. In other words, they are diagrammatic presentations of facts or ideas.

1. Pull charts: consist of written messages which are hidden by strips of thick cardboard or plywood. The message can be shown to the viewer, one after, another by pulling out the concealing strips. These strips can again be restored to the concealing position after the presentation or whenever needed.


STRIP TEASE
LEARN

2. Strip tease charts: It "teases" the interest and imagination of the audience. The information on the chart is covered with thin paper strips to which has been applied wax, or other sticky substance at each end of the strip. Pins or tacks also can be used. The strip tease chart adds sparkle to what might otherwise be a drab presentation. It centres attention on the most important fact at any one time. The technique increases learning and aids recall.

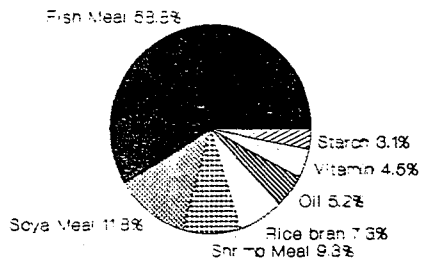
3. Organisation or Flow charts: These are diagrams used to show organizational or administrative relationships. Boxes connected with lines show levels and lines of authority. You could use organizational charts to show administrative relationship in a ministry.

4. Bar charts/Bar graphs: These are used to compare quantities at different times or under different circumstances. They are composed of measured blocks spaced along a clearly marked scale. For instance, the effect or fertilizer in increasing crop yields on test plots in three successive years might be shown in a bar chart.

5. Time (or Table charts

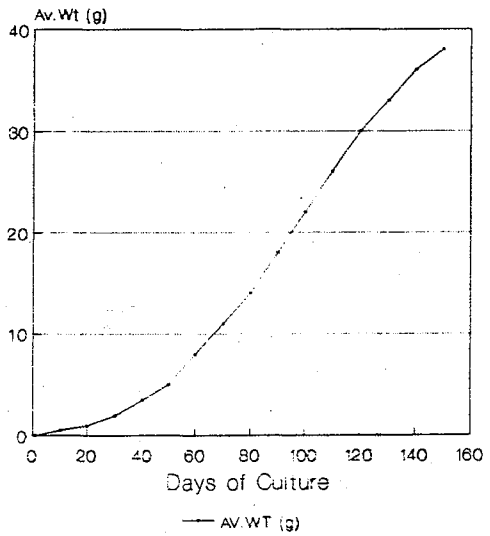
6. Job charts: e.g. Extension worker's job chart.

Pie Chart
Percentage Composition of a Formulated feed



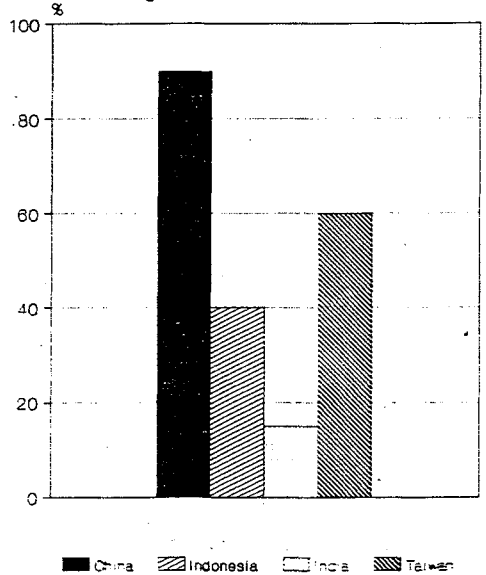
Source:Meade,J.W.,(1989) 'Aquaculture Management' Van Nostrand Reinhold,New York.

Line Graph
Growth of P.monodon



Source:TASPARC Report 1991.

Bar Chart
Percentage of Semi-intensive farms in S.E.Asia



Source:Fishing Times July,1993

7. Tree chart/stream charts: are used to show the development or growth of something in the shape of a tree or stream.

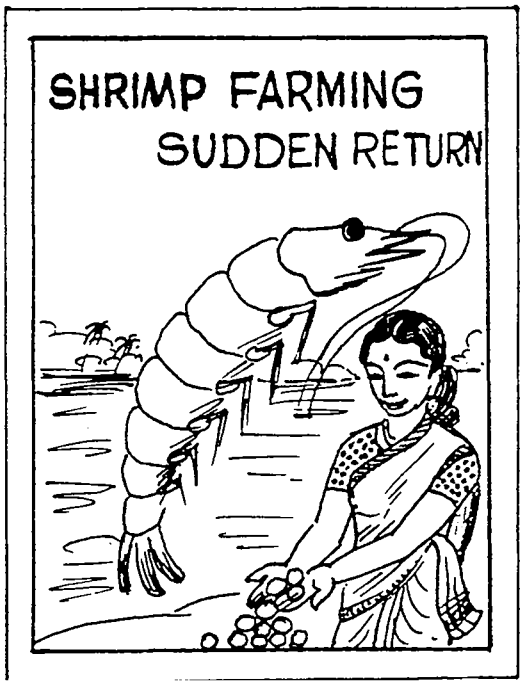
8. Flip charts: Consist of series of individual charts which are tacked or bound together and hung on a supporting stand. These individual charts carry a series of related messages in sequence. The extension worker flips them.

9. Over-lay charts: Consist of a number of illustrated sheets which can be placed one over the other conveniently and in succession. The drawing or illustration of each individual, sheet forms a part of the whole picture. This enable viewers to see not only the different parts but also see them against the total perspective. When one is placed over the other, when the final over-lay is placed the ultimate product is exposed to view.

10. Pie charts/Pie graphs: These are in the shape of circles and used to show how several parts makes up the whole. A pie chart might be used to show the relative proportion of different crops produced by a country. Each section of the pie should have its own colour. A colour key or code in the margin will help the audience remember what the different sections represent.

11. Line charts/Line graphs: These are particularly useful in showing trends and relationships. A single continuous line may

POSTER



represent growth or expansion. Multiple lines may show the relation between market price and quantity of a farm product.

12. **Pictorial graphs/Pictographs**: To give the viewers a vivid picture and to create a rapid association with the graphic message, cartoons and other types illustrations may be used. Each visual symbol may indicate quantity.

g. **Posters**: A good poster arouses or urges people to immediate action and highly suggestive. It makes them feel a part of the work at hand.

Poster should contain dramatic pictures that will stop people and make them look. It must have few and simple words. It should have single idea with pleasing colors and bold letters. It should be at least 20 by 30 inches in size and must be timely.

A poster should be attractive brief and clear.

h. **Chalk board**: It is most universally used. It is one of the cheapest, most effective, most versatile and easiest to use of all the visual aids.

Using clean eraser, writing with coloured chalks in large letters, facing group after writing and continuing the discussion, avoiding clutter and abbreviations, keeping simple drawings are some of the suggestions for using the chalkboard.

i. **Bulletin board**: It is simple inexpensive device that can be placed either outdoors or indoors. Items generally used on a bulletin board include photographs, cut on illustrations from publications, drawings, specimens, notices posters and wall news papers.

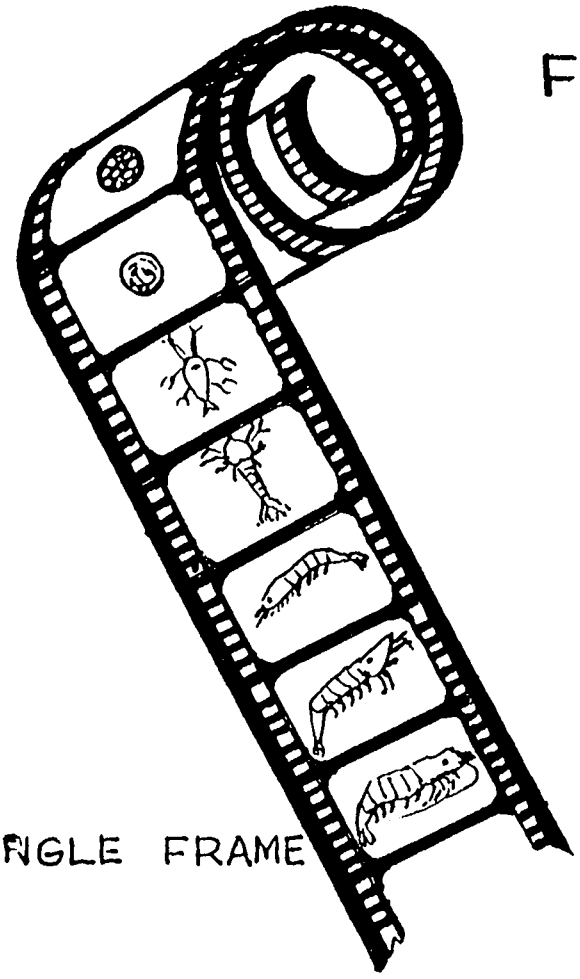
Material on the bulletin board should be regular. Packing the bulletin board with full of information, cluttering the board with small illustrations and captions can be avoided.

j. **Dust and Mud sketching :** In sand, dust, soil and mud, nature has provided us with highly effective, unexpensive and readily available visual materials. Using a pointed stick, a sharp stone, or one's own finger, it is possible to illustrate many different ideas such as new layouts for shrimp farms.

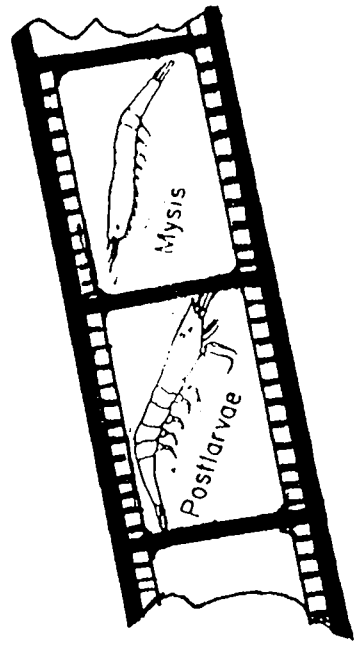
It is to be remembered that there is far less chance for misunderstanding if people can see the things that are being explained. Sand, dust, soil and mud sketching can help the extension worker visualisze his subject.

2. Projected:
   a. Slides
   b. Film strips
   c. Silent films/Motion pictures/Opaque
   d. Projector
   e. Overhead Projector

FILM STRIP



SINGLE FRAME



DOUBLE FRAME

a. Slides: The slide is one of the most popular and versatile visual in extension education. It is a transparent picture which is projected by focusing light through it from electric bulb, petromax or lantern.

Slides can be made at low cost and in natural colour or in black and white.

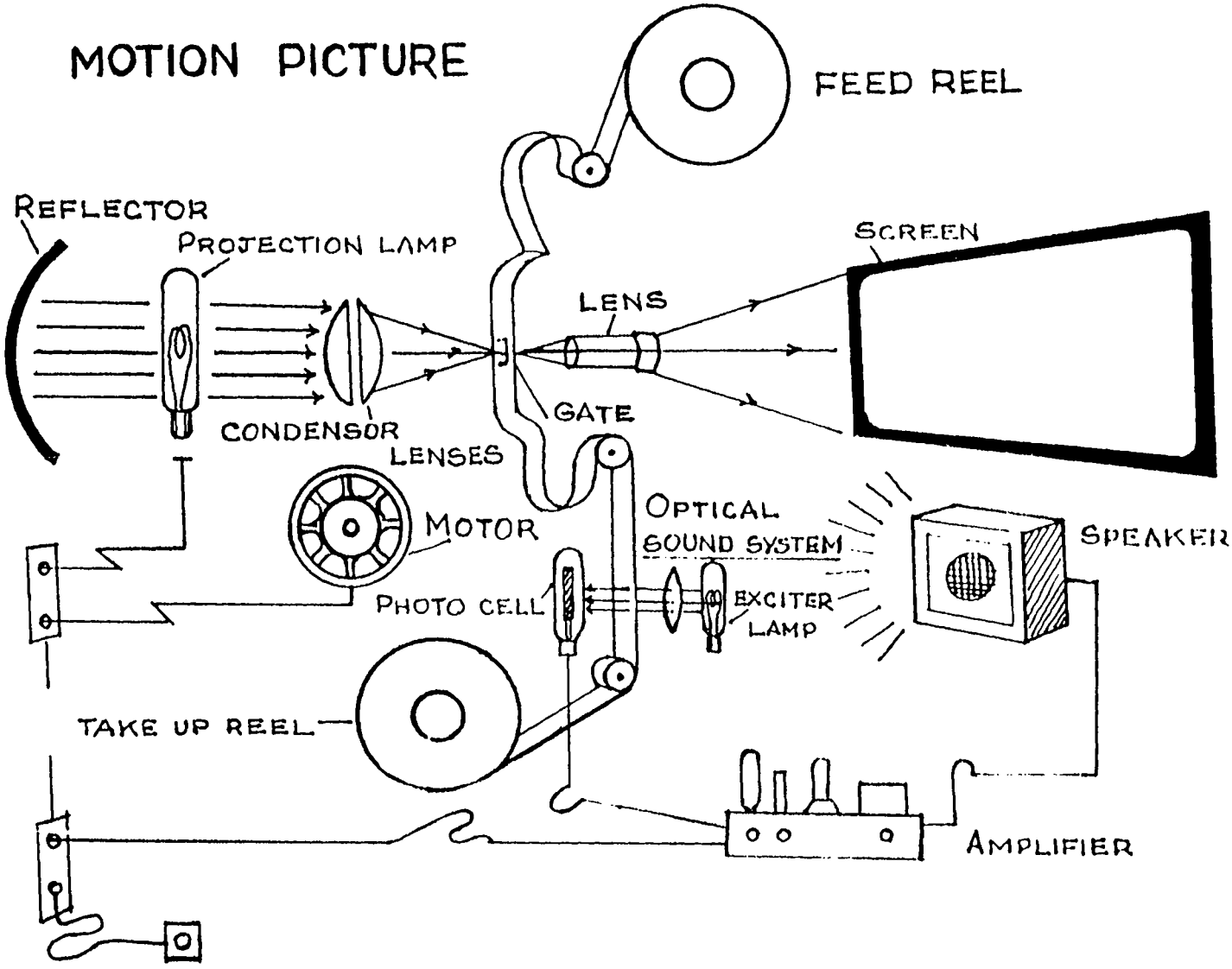
Projection equipment are relatively light and easily transported. Slide sequences can be readily changed to keep them timely and localized. Slides can be retained for any length of time. Slides require "**live**" narration unless synchronized with tape recorder.

b Film strips: A film strip is a series of still photographs, diagrams drawings or letterings on a strip of 35 mm. It may be of 2 types.

a. Single frame

b. Double frame

The number of frames in a strip may range from 30 to 60. Perforated edges of the film fit over projector sprockets. Once adjusted to project the first frame, each succeeding image will be in focus and in proper position on screen. When audience participation is desired projection can be paced at a speed suitable to the speaker. When accompanied by a carefully prepared


MOTION PICTURE
FEED REEL
REFLECTOR
PROJECTION LAMP
SCREEN
LENS
GATE
CONDENSOR
LENSES
MOTOR
OPTICAL
SOUND SYSTEM
SPEAKER
PHOTO CELL
EXCITER
LAMP
TAKE UP REEL
AMPLIFIER

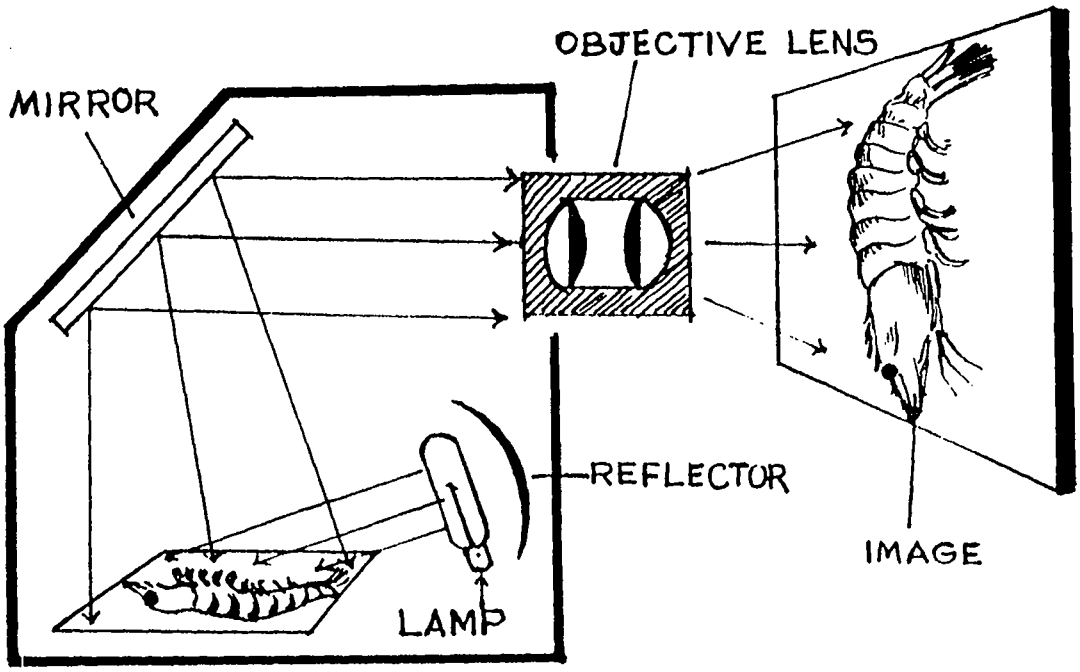
script or talk, new ideas can be presented forcefully and dramatically.

Film strips are light, easily stored and condense much information in a small package. Film strips and film strip projectors are less expensive. It takes little space and can be carried easily. The prawn farmers can participate through discussion on each picture, as presentation can be stopped without breaking sequence. A film strip, when projected can be accompanied with commentary or music played back by a tape recorder or gramophone.

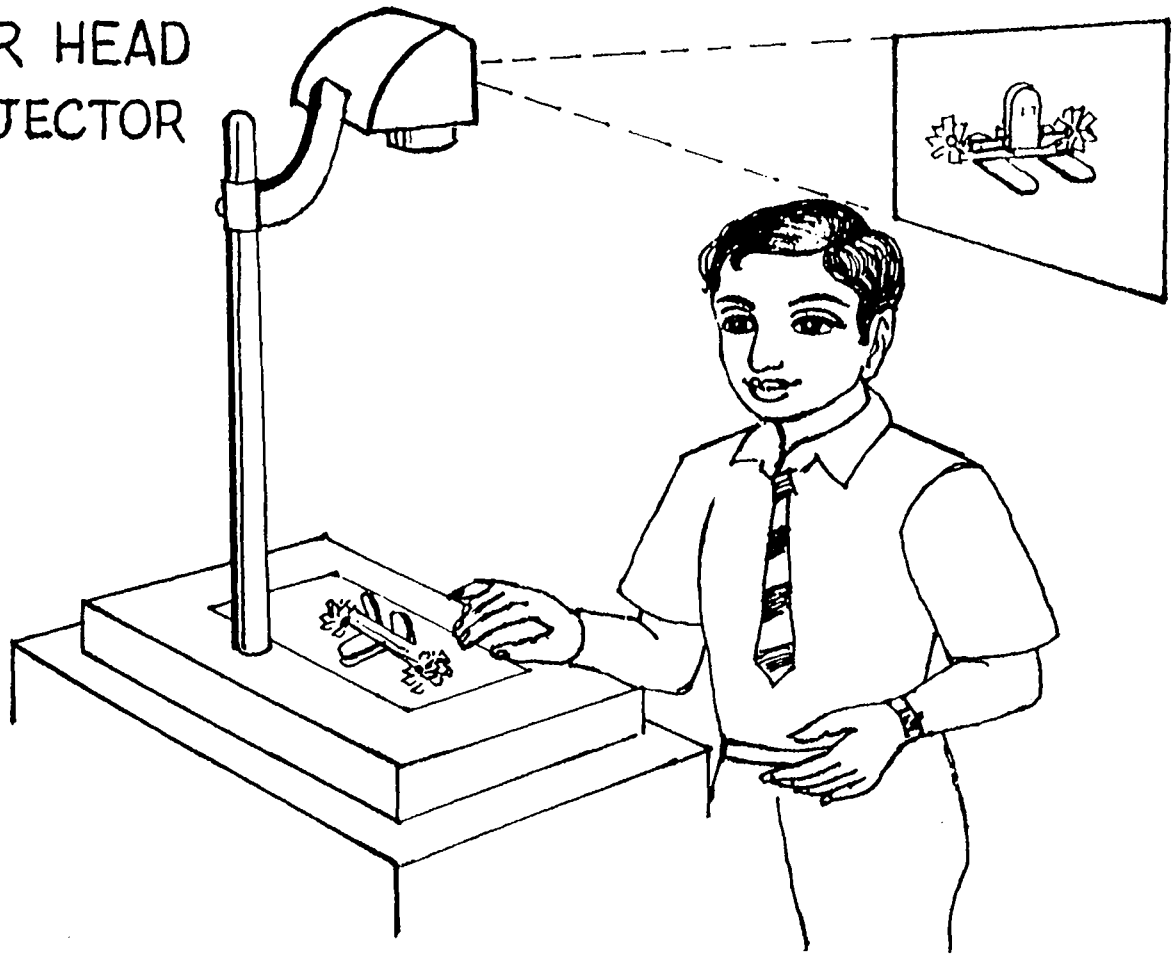
c. Silent films or Motion pictures: Motion pictures are really a series of still pictures on a long strip of film. Each picture is flashed momentarily on the screen and the rapid succession of still pictures gives an illusion of movements. Usually 70 mm and 35 mm films are used for commercial entertainment, 16 mm film for educational movies and 8 mm film for domestic pictures.

Awareness about operating the projector is essential. Electrical connections, extension wires can be checked well in advance. Without cutting off ventialation rooms can be darkened. projectors should be high enough to project over the heads in the audience and the screen high enough from the floor for all to easily see the bottom of the picture. A suggested seating arrangement according to the "2-6" formula (ie) front row to be 2

OPAQUE PROJECTOR



OVER HEAD PROJECTOR



screen width away from the screen and hind row to 6 screen width away from the screen.

d. Opaque Projector: It is also known as the episode. It permits non-transparent materials such as flat pictures, book illustrations, tables, drawings, photographs and even certain specimens and objects to be shown on a screen for group observations.

The opaque projector works on the principle of reflecting light from an opaque surface to the screen. The flat picture which is to be shown on the screen is placed in the projector through an opening of about 6" * 6". A strong light from the projector lamp is thrown on this picture and the picture is reflected on a screen with the help of mirrors. The screen image is normally less brilliant than in the case of a slide or other transparency where light passes directly through the picture.

d. Overhead Projector:

The overhead projector projects an image from a slide or transparency back over the operator's shoulder to a screen. Rays of light are reflected upwards to a projection stage and onto an objective lens, which is centrally supported above the stage. The light strikes the mirror and is reflected to a screen located at the back of the operator. The lens and the mirror stand above the machine in periscope fashion. The machine may rest on extension

worker's table or it may be on the projection stand. The extension worker may sit or stand before the class.

The advantage of the overhead projector is that the extension worker can always face the class. The illuminated image is visible can operate the projector while teaching and hence no extra projectionist is required.

The following steps are necessary in operating the over-head projector.

1. The projector should be placed at the front of the room with the focussing lens facing the screen and approximately two metres away from the screen.

2. After the switch is turned, transparency can be placed on the glass top in proper position.

3. The projector lens can be adjusted till the image is sharp and in focus.

4. Lamp should be switched off whenever the projection is not required and let the fan seen. This will help in increasing the lamp life and keeping the projector cool.

5. Before switching off the projector it can be ensured that cool air comes out of the exhaust fan to indicate the lamp and the interior of the projector have been cooled.

3.3 Audio-Visual Aids

1. Sound films
2. Television
3. Dramas and puppet shows

Another way of classification is as:

A. Display type: e.g. posters, bulletin boards, model, exhibits etc.

B. Presentation type: e.g., Flash cards, Pull charts striptease charts, slides and film-strips etc with running commentary.

1. Sound Films

Film is important and popular channel of Mass communication. Film related shrimp culture and fisheries can be screened in the villages. It has been observed that it is easier to learn things if film as a medium of communication has been properly and timely screened.

Research studies have indicated that the films screened in a drab style. The message should be treated in a humourous style and keeping in mind the entertainment value of medium. It is desirable that the actors and situation should not be foreign to them.

TELEVISION

2. **Television**

Television is one of the important mass media for dissemination of information in the rural areas. It provides words with pictures and sound effects like the movies, it scores over the latter by its high intimacy and reaches the largest number of people at the shortest possible time. Television can deal with topical problems, and depict known persons who can provide the solutions. people learn through the eye, and will remember things better if they see them.

The important steps in television programme are timing, frequency and length, format, content, treatment, research before production, need for rehearsals and personnel.

It must be remembered that aquacultural programme in television is primarily for imparting information and no attempt can succeed in making it a substitute for direct contact on imparting detailed instruction because of the time limitation and absence of actual farm situation. However, farmers can very well be persuaded to attend training courses. In this regard T.V. and radio are excellent auxiliaries.

3. **Dramas and Puppet Shows**:

Long before anyone devised lectures as a means of education, knowledge and understanding were conveyed from one generation to

another through songs and ballads, dramas and dances, puppet shows and festival. These combine entertainment with education, and have much fascination especially for village people.

Advantages of Audio-Visual aids:

The audio visual aids facilitates the learner to learn faster, more thoroughly and to remember longer. The ideas presented can be clarified and impressed indelibly on the mind. It makes teaching vitalise and more real. It overcomes the language barrier and holds attention. It arouses and sustain interest. Stimulates thinking and motivates action. It changes the attitude, saves time because they make learning easier and faster.

3.4 Others: a. Exhibits
b. Demonstrations
c. Literature

a. Exhibits: (or Exhibition:) is a planned display of models, specimens, charts posters etc presented to public view for instruction judging in a competition advertising or entertainment.

To influence group to adopt better practices by a) arousing interest b) by stimulating thought and c) getting action. Participation can be promoted. Enables people to give recognition

to display their products. Creates market for certain commodities.

Exhibits must be well prepared such that your message is understood by the visitors in the short time taken. Considering the needs of audience and the specific purpose types of exhibit can be decided. Local leaders should be consulted. Making the exhibition simple, timely, durable and attractive are essential. One idea per section can be limited. The exhibit can play a role as an interpreter. If interpreters are engaged let them be thoroughly informed and precise in their explanation Distribution of relevant literature, adequate publicity both in advance and after the exhibition is over are necessary. Exhibits must be kept at a height not less than 2 ft and not more than 7 ft from the floor. The effectiveness of exhibition can be evaluated by analysing attendance, enquires and requests.

b. Demonstrations: Demonstrations show proving advantages of improved practices in terms of their worth and potentialities by teaching an example. It upholds the principle of "Seeing is believing" and "learning by doing". It brings research to the doors of users. Fires imagination by providing convincing results. Builds confidence in scientific facts and extension workers. It is being used as vital media for communication

dissemination and diffusion of information. It accelerates and provides subject matter for framing on the form and use of extension methods. A good demonstration can be defined as that which provides the greatest acceptance of a practice in the shortest period of time or that which speedily bridges the gap between the research and adoption of new innovations.

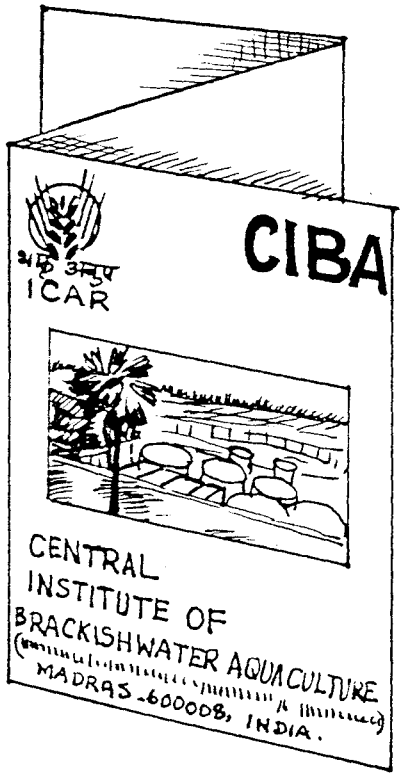
Demonstrations are mainly can be specified into two namely method demonstrations and result demonstrations.

Method Demonstration: It not only enables the prawn farmers to acquire new skills or to improve upon the old skills in order to save time or labour and increase efficiency and satisfaction, but also gives confidence that a particular recommended practice is a practicable proposition.

Result demonstration:

A result demonstration is a way of showing people the value of an improved practice. This is done by comparing the improved and the old practice so that villagers may see and judge results for themselves. This way may be used by the village worker to teach villagers the value of practice such as:

FOLDER


ICAR
CIBA
CENTRAL
INSTITUTE OF
BRACKISHWATER AQUACULTURE
MADRAS-600008, INDIA.

1. Using improved seed
2. Using fertiliser
3. using aerators
4. Using improved cultural methods

To be successful in the use of result demonstration the extension worker must demonstrate only those practices which he thinks are good and which are based on a real need of the villagers.

c. **Literatures:**

Literature is the basis of any teaching programme. In extension teaching simple leaflets and pamphlets are valuable and essential tools in the hands of the intelligent extension worker.

Phamphlets, leaflets, folders and handbills

A Phamphlet or bulletin, on the other hand, may contain many pages and treat a number of topics or steps in a given problem. The best pamphlets are brief and simple.

Leaflet is a single sheet of paper, generally printed on both sides and folded to make a four-page piece of printed matter containing accurate and specific instructions on how to do a job.

Folder is a single sheet of paper generally printed on both sides with two or more folds conveying an idea or giving instructions on doing a job. Leaflets are more economical to produce and easier

to read than are folders.

Handbill is a loose printed sheet announcing some information of immediate importance, written in a brief, simple and lucid style to be distributed by hand.

Phamphlets, leaflets, folders and handbills should publish facts and results in a form carefully and concisely written and to the point. Illustrations or photographs may use much of the space. Subject matter of such publications is usually limited to one problem or sometimes one aspect of the problem.

The Media Mix Approach:

It is a well know fact that no one communication method/source/channel could be effective for all situation. It is always exposure to the same idea through proper combinations of suitable media and methods in logical sequence which increases the communication efficiency. some of such media mix based upon recent work done at I.A.R.I. are summarised in the table.

Suitable Media Mix (Singh & Singh), 1978.

Media Mix	Overall effectiveness	Rank	Remarks
Radio & Slide show + Field trip	14.59	1	
Wall painting + Slide show + Field trip	14.45	2	
Poster + Slide Show + Demonstration	14.25	3	
Exhibition + Group discussion + Demonstration	12.96	4	
Film + Group discussion + Demonstration	12.60	5	
Wall painting + Group discussion + Demonstration	11.76	6	
Radio + Folder + Demonstration	11.64	7	
Film + Folder + Demonstration	11.25	8	

These are just a few of the examples, there could be many more of 3 or 2 or sometimes. 4 media mix combinations depending upon the situation and technology. It, however, might be mentioned here that though there are variations in the effectiveness of channels, their effectiveness could be optimised by taking steps towards making qualitative changes in content, mode of presentation, quality and relevance of the message to various categories of people.

4. Disadvantages of Audio-Visual aids:

Learners may sometimes form mistaken or distorted impressions, unless audio-visuals are supplemented with required explanation. It temptates the extension worker to narrow down the teaching to only a few big ideas, not giving the complete picture of a subject. Some extension workers acquire the mistaken idea that they have little to do when audio-visual are used. It is a possible risk of spectatorism, instead of the attitude of thoughtful enquiry.

5. Conclusion:

The most successful extension worker utilises from the entire teaching effort the best combination of the teaching methods available to him in such a manner as to ensure the possible accomplishment. Teachers in extension methods all over the world have concluded that the principles and techniques fundamental in extension methods are applicable to any country, community, locality or village. However, adjustments or variations in the selection and use of methods have to be made to fit existing conditions and situations.

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