PRAWN FARMING

Edited by

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(Indian Council of Agricultural Research)
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Bulletin No. 81 **March 1998**

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Foreward

Shrimp culture in the country has tremendous potential. During the last decade, the shrimp farming sector in the country has attained the level of an industry. Various technologies are now available for shrimp farming in the country and there is great potential for export earnings from this sector. Therefore, the development of shrimp farming industry is being considered with utmost priority.

However, recent trends in shrimp farming in the country has sent alarming signal. There is an urge among entrepreneurs to go for spectacular productivity by adopting intensive aquaculture practices, thereby endangering the proverbial goose which lays the golden eggs. The urgent need today, is to adapt eco-friendly sustainable shrimp farming.

To enrich the knowledge and skills of the extension functionaries of the country who in turn would motivate the ultimate users to adapt eco-friendly sustainable shrimp farming, the Institute, as part of its Golden Jubilee celebrations, organised a training course on shrimp farming at Barrackpore during 1996. This booklet is the compendium of lectures by experts in the respective field during the training course. It is hoped that this booklet on shrimp farming will be beneficial to the extension functionaries.

M. Sinha
Director

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SCOPE AND PROSPECT OF PRAWN FARMING IN INDIA

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INTRODUCTION

In India research and development of prawn farming have gained more importance during recent years due to its high export value. India is no longer the largest exporter of prawn in the world market, it lost its pre-eminent position due to undue dependence on marine capture fisheries. Large scale farming of prawns; especially, the prized brackishwater tiger shrimp, *Penaeus monodon* and freshwater prawn, *Macrobrachium rosenbergii*, is the only alternative to sustain the export trade. But due to diverse ecological conditions and soil characteristics, the yield rates vary from place to place. To encounter limiting factors and to modulate the ecosystem favourably for better productivity, measures like selective stocking of compatible species regulating size and number of stocking, proper use of manures and fertilizers, application of supplementary feed, maintenance of pond hygiene, aeration of the water bodies etc., requires to be adopted by the aquaculturists.

Thus, prawn farming in brackishwater as well as in freshwater under monoculture and in polyculture system, assumes greater significance as the induction of prawn into brackishwater/freshwater aquaculture system would give fillip to substantial improvement in the profitability of the operation, triggering its expansion and elevation into an industry as against present status as subsistence operation.

Resources

Prawns or shrimps form one of the most important and economically significant group in marine/brackishwater and freshwater fishery resources. Eleven out of twentyseven species of shrimps belonging to Penaeid group and nine out of more than 40 species of prawns belonging to genus *Macrobrachium* are found to be suitable for farming in brackishwaters and freshwaters of India respectively due to its high market prices, attractive sizes, growth and other biological factors.

Table 1. Global shrimp production in 1993

Country	Area under production (ha)	Production (Mt.)	Rate of production (kg/ha)
Bangladesh	1,10,000	30,000	273
China	1,40,000	50,000	357
Colombia	27,000	9,000	3,333
Ecuador	90,000	90,000	1,000
Honduras	8,000	9,000	1,125
India	80,000	60,000	750
Indonesia	2,00,000	80,000	400
Mexico	8,000	9,000	1,125
Philippines	40,000	25,000	625
Taiwan	7,000	25,000	3,751
Thailand	60,000	1,55,000	2,583
United States	900	3,000	3,333
Vietnam	2,00,000	40,000	200
Others	16,000	24,000	1,500
Total	9,62,600	6,09,000	6,33

Source : MPEDA.

At present an estimated area of 45,000 ha of 1.235 million ha brackishwater area in India is under traditional system of fish farming where trapping-holding growing operation produces on an average 200 kg/ha/yr of fishes and prawns.

In India, mostly traditional system for culture of giant freshwater prawn *(Macrobrachium rosenbergii)* is practised by the farmers in paddy plots, wetlands and ponds which does not ensure any steady and substantial, yield of species. But recently scientific prawn farming has received momentum and inland waterbodies like ponds/tanks, floodplain lakes, wetlands are presently being utilized for boosting prawn production.

Seed availability

Brackishwater

The seed of quality shrimps is the prime requisite in organising large scale shrimp farming operations in the country. All the penaeid prawns breed in the offshore waters at different depths and the larval or post larval stages enter the estuaries, creeks and brackishwaters along the coasts. These estuarine areas are suitable nurseries offering the required ecological niches for their growth.

Some of the recent works done at CIFRI have brought in the concept of catch/net/hour using a standard Midnapur shooting net uniformly to project the relative abundance of seed available in the Hooghly-Matlah estuary incorporating the calenders of availability of penaeid shrimp seed. Availability and abundance of the post larval penaeids have been related to several ecological and meteorological variables such as salinity, temperature, river discharges, rains, current, depth, substratum, suspended matter, plankton, seasons, lunar and diurnal cycles, mangroves, mudbanks, and pollution.

Important shrimp seed markets are situated at Namkhana, Hard wood point, Nazat, Sandeshkhali, Basirhat, etc. in West Bengal.

Freshwater

The river systems of the country which harbour good prawn fauna include both peninsular and extrapeninsular rivers with their own characteristics influencing the distribution pattern of freshwater prawns.

In West Bengal, the juveniles of freshwater prawn are available in river Hooghly and its tributaries at Ghatal in Midnapur district, Habra and Basirhat in district North 24 Parganas and Simurali in Nadia district where a small scale trade in seed collection and supply is in existence.

The present limited demand for the stocking material of giant prawns is, by and large, met by collection from nature. Large scale mortality of the seed and associated species occurs during collection, heading and transport, causing serious concern about the faunistic diversity in general and the populations of *M. rosenbergii* in particular.

Seed production in hatcheries

The need for hatcheries for commercial production of seed of prawn/shrimp for giving a thrust to its aquaculture has been belately realised. A number of hatcheries for production of seed of *P. monodon* and *M. rosenbergii* in Private Sector as well as in Public Sector have come up on East and West coast.

Aquaculture

The successful application of aquaculture technology for increased production of prawns/shrimps depends on the development of a viable culture system with a feasible, technical, economic, marketing and social approach.

Brackishwater

At present, about 44,200 ha are under traditional or extensive culture of which 30,000 ha are in West Bengal, 6,400 ha in Kerala, 4,800 ha in Karnataka, 1,200 ha in Goa and 1,800 ha in Maharashtra.

Central Marine Fisheries Research Institute (CMFRI), National Commission on Agriculture (NCA), Indian Institute of Management (IIM) etc. have made some approximate estimates regarding the total brackishwater area in the country which varies between 14 and 17 lakh ha. Ministry of Agriculture (MA) has considered 9 lakh ha. to be suitable for the purp;ose of development and project formulation.

State-wise brackishwater area (000 ha)

States	Estimated total area			Estimated potential area
	CMFRI	NCA	IIM	
Andhra Pradesh	200	200	150	123
Gujarat	376	376	376	187
Karnataka	8	80	95	85
Kerala	243	200	242	142
Maharashtra	81	80	80	70
Orissa	299	8	8	8
Tamil Nadu	80	80	80	72
West Bengal	405	400	405	210
Total	**1,712**	**1,424**	**1,456**	**902**

In West Bengal, the average production from brackishwater has been estimated at 775 kg ha^{-1} with a *P. monodon* component of 18 percent. In Kerala, the productivity is about 700 kg ha^{-1} with *P. indicus* 36-43 percent, *P.*

monodon 0.7 to 1.0 percent. In Orissa average yield is 633 kg ha^{-1} with *P. monodon* constituting 19.43 percent. These estimates, considered together would show that the traditional system produces about 32,000 tonnes yr^{-1} of which shrimp form about 10,000 tonnes.

Under new practices in pond culture, shrimps are produced exclusively by selective stocking with supplementary feeding. In Andhra Pradesh maximum production of 2-6 tonnes of *P. indicus* and 1.4 tonnes of *P. monodon* ha^{-1} $crop^{-1}$ have been achieved. In Orissa maximum production of *P. monodon* obtained was 1611.8 kg ha^{-1}. The highest production rate of about 5.5 tonnes ha^{-1} $crop^{-1}$ of *P. monodon* has been reported in a farm of a multi national agency in West Bengal under semi-intensive culture.

Freshwater

The giant prawn forms one of the minor components of the species mix in aquaculture in the eastern region of the country, where the seed is available in nature. However, dependable data on the production and economics of the operation are not available. No attempts on extensive, semi-intensive or intensive mono or poly-culture of the species, following normal aquaculture practices, have been documented in the eastern region of India. Commercial scale experiments conducted abroad under more or less similar agro-climatic and economic conditions in Bangladesh, Thailand and Mauritius have shown that a yield rate varying from 800 to 4,325 kg yr^{-1} can be obtained from the monocultue of prawn, with high survival rate up to 95.5%, depending on the stocking density, additional feed and management strategy. Low input polyculture of prawn with compatible species of carps has yielded about 400 to 1,250 kg of the former and 1,010 to 1,975 kg fish ha^{-1} yr^{-1} of the latter.

. Studies on the prospects of growing the giant prawn in ponds fertilized with primary treated sewage have been undertaken in the Rahara fish farm near Calcutta. Diluted treated sewage was let into an improvised pond of 0.4 ha area, the margin of which was planted with paddy. After stabilization, the ponds was stocked with juveniles of prawn at the rate of 10,000 ha^{-1} along with a few silver carp (*Hypophthalmichthys molitrix)* for the biological control of the algal blooms. The prawn stock was given irregular, minimal supplemental feed of mustard cake and rice bran and an occasional diet of cooked trash fish and chopped meat of gastropods. Diluted sewage water was let in periodically for fertilizing the pond. A terminal production of c. 500 kg prawn, 163 kg silver carp, 85 kg paddy and 129 kg ha was obtained in 8 months.

Studies conducted in a sewage fed bheri indicates that by adopting appropriate management strategies, the giant prawn can be cultivated in such water bodies, availing the high productivity of such eutrophic waters, with minimal inputs.

Recently, the Central Inland Capture Fisheries Research Institute has successfully demonstrated the prospects of culturing the giant prawn in pens installed in beels. A pen erected in Akaipur beel in the Nadia district of West Bengal was stocked with juvenile prawns (size 4 g) at the rate 20,000 ha^{-1} of pen area. Additional feeding was done with a formulated pelleted feed (protein content 29%) at the rate 3% body weight, adjusted every fortnight. After 87 days, a total production of *c.* 1,300 kg ha^{-1} was obtained with a survival of 50%, the mean size of the individual prawns being 86 g.

The system provides scope for at least 3 crops a year and has opened up new vistas for providing additonal employment opportunities and attractive income to the rural people residing around such large water bodies. Pen culture can be undertaken by them on cooperative or individual basis, with institutional financing, if necessary, towards the cost of the pen structurals and inputs.

General remarks

Intensive researches carried out by various organisations on prawn/shrimp farming have considerably advanced our knowledge in recent years.

The States which have the direct responsibility for fisheries development programmes, have taken two important steps to promote brackishwater aquaculture. One is the formation of Brackishwater Fish Farmers' Development Agencies (BFDA) and other is the land lease policy for allotment of government owned brackishwater lands to the target groups. In tune with the social and political philosophy of the government, a large share of land has been apportioned for the fishermen cooperatives and the weaker sections of the society followed by technocrats and progressive entrepreneurs. This one policy is likely to bring about a faster rate of growth of shrimp farming, provided the beneficiaries are adequately supported by the government for infrastructural development, inputs, training and extension requirements.

Private enterprise is entering prawn/shrimp farming in a big way in some of the States and in many instances foreign collaboration is being sought.

Now, it is fully realised that inclusion of freshwater prawn in our aquaculture system will make it more productive and highly economical besides helping in creation of healthy ecosystem. This would, of course, require a proper managerial input keeping an eye on environment. Because of this and in view of the resources and potentialities available in our country for both capture and culture of giant freshwater prawn, a planned strategy need be chalked out for its scientific culture in different ecosystems.

Thus, there is ample scope for development of prawn farming both in fresh and brackishwaters of our country with desired water resources and market demand. Tremendous initiative by the aquaculturists have also been taken towards semi-scientific prawn/shrimp farming in the country in recent past. However, if this momentum is to be sustained for the present and accelerated in the future, a high level technological back-up and specialised trained core personnel, for extension work, are essentially required.

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IDENTIFYING CHARACTERS, MORPHOLOGY AND LIFE CYCLES OF COMMERCIALLY IMPORTANT FRESHWATER PRAWN, MACROBRACHIUM ROSENBERGII

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Prawns are among the most commercially important groups of animals contributing nearly 3% of the total fish production of the world. Presently the average yearly prawn production in India is of the order of 0.22 million tons as compared to world's production of 2.60 million tons. In India, besides its usefulness as a highly favoured table food it also supports a very valuable trade for export.

Commercially important prawns are broadly divided into two groups *viz.*, penaeid prawns and non-penaeid prawns. The penaeid prawns belong to the family Penaeidae while non-penaeid prawns come under several families *viz.*, Palaemonidae, Hippolytidae, Pandalidae, and Sergestidae. The members under families Penaeidae, Palaemonidae and Pandalidae grow to a large size and the term "prawn" should be applied for the members of aforesaid families and the term "shrimp" is denoted the smaller sized individuals under families Hippolytidae and Sergestidae as per the recommendations of the Indo-Pacific Fisheries Council (IPFC) meetings held in Tokyo in 1955. But according to recent recommendations of FAO, nomenclature freshwater palaeomonids are referred to as 'prawn'; marine penaeids, metapenaeids and palaemonids are called 'shrimp'.

In India, penaeids at present contribute the major share in exploitation and the only non-penaeid prawn, the giant freshwater *Macrobrachium rosenbergii* is also extensively exploited in various water bodies. Culture of *M. rosenbergii* has earned much popularity in many parts of the country for its bulk availability, fast growth rate, tolerance of wide range of temperature as well as high market value. The total production and export of *M. rosenbergii* from India was 3000 and 1170 tons respectively in 1991-92. Presently, the total average production from culture of *M. rosenbergii* in the world is around 2700 tons per year. Major producing countries are Thailand, Taiwan and Viet Num and their combined average production is about 25,000 tons per year. There are about 125 Macrobrachium species known at present through out the world. Many of the species attain good size and are used as food.

Before embarking on any culture system of the freshwater prawns it is felt that a comprehensive knowledge on the various species present in India along with their morphology is essential. With this end in view the present communication is only confined to the important indentifying characters, morphology and life cycle of *M. rosenbergii* species. However, the distinguishing characters of few allied *Macrobrachium* species occuring in the country are also discussed along with *M. rosenbergii* for comparative purposes.

Species	Distribution in India	Habitat	Maximum size
I. *M. rosenbergii*	Estuaries and rivers of east and west coasts. Abundantly available in Kerala backwaters, Hooghly, Narmada Tapti and Thane estuaries.	Freshwater, for hatching and nursery purposes it requires brackishwater	Male 32.00 cm Female 24.00 cm
II. *M. vellosimanus*	Rivers, canals and lakes of West Bengal	Freshwater	Male 14.60 cm Female 11.70 cm
III. *M. lamarrei*	Extensively distributed in Gangetic plain and also rivers of east coast	Mostly freshwater but can tolerate brackishwater	6.90 cm
IV. *M. malcolmsonii*	Mostly estuaries and lakes of south India and Orissa coast. Godavari, Narmada and Hooghly estuaries	Freshwater, for hatching and nursery purposes it requires brackishwater	Male 23.00 cm Female 20.00 cm
V. *M. rude*	Abundant in Gangetic detla and throughout the east and west coasts	Brackishwater and freshwater	13.00 cm
VI. *M. equidens*	Mostly Bombay coasts, estuaries of east and west coasts	Brackishwater	8.00 to 11.00 cm
VII. *M. idella*	Abundant in estuaries and rivers of Kerala and Tamil Nadu. Estuaries and rivers of east coast including West Bengal delta.	Brackishwater	Male 10.00 cm Female 15.00 cm
VIII. *M. mirabile*	Mostly Gangetic delta of West Bengal and some parts of eastern India	Mainly freshwater	Male 4.00 cm Female 6.00 cm

IX.	*M. birminicum choprai*	Rivers, streams of Gangetic plain. Particularly rivers of Ganga, Brahmaputra, eastern part of U. P. Bihar and Assam	Freshwaster	Male 20.00 cm Female 13.10 cm
X.	*M. birminicum birminicum*	Bihar (south of Rajmahal hill) water bodies of North Bengal close to Ganga river and parts of eastern India	Mainly freshwaster but can tolerate little brackishwater	Male 31.50 cm Female 14.70 cm
XI.	*M. scabriculum*	Gangetic delta of West Bengal, throughout - east and west coasts upto Kerala	Freshwater & brackishwater	Male 7.00 cm Female 8.4 cm
XII.	*M. dayanum*	Abundant in rivers, stream and wetlands of West Bengal. Punjab to Assam, Bihar, Orissa, Andhra Pradesh Gangetic plain, eastern Maharashtra & Godavari river	Freshwater	Male 9.20 cm female 8.40 cm

MORPHOLOGICAL CHARACTERS OF PRAWN

An intimate knowledge on distinguishing morphological characters (Fig. 1) such as size and shape of rostrum, carapace with various spines, appendages, chelate legs, telson, secondary sexual organs is essential for proper identification of the prawns.

Body laterally compressed and segmented. There is a hard cuticular exoskeleton covering the body. Body divided into cephalothorax and abdomen, The exoskeleton covering the cephalothorax is known as carapace. The anterior region of carapace is produced into a toothed prolongation, called rostrum. While the exoskeleton layer covering the abdomen is divided into six segments or pleurae, the sixth or the posterior most segment is known as telson. Head bears a pair of compound eye, five pairs of appendages *viz.*, i) the antennules ii) antennae, iii) mandibles, iv) Ist maxillae v) 2nd maxillae. The thoracic appendages are 3 pairs of maxillepeds which are directed forward for masticatory purposes and the rest five pairs are walking legs or pereopods. The abdominal appendages are the five pairs of swimming legs or pleopods. The sixth abdominal limb is the uropod. Each walking leg has basal portion which is attached to the body known as protopodite consisting of two segments-the proximal coxa and the distal basis. Besides antennule, other appendages are biramous, where two rami develop on the protopodite-the inner is the endopodite and the outer one the exopodite. The

endopodite is again divided into five segments. From the proximal to the distal extremity the segments are the ischium, merus, carpus, propodus, dectylus respectively.

TAXONOMY

Phylum - Arthropoda
Class - Crustacea
Subclass - Malacostrace
Order - Decapoda
Super Section - Natantia

Infraorders- Penaeidea Caridea Stenopodidea

Family, Penaeidae Family, Palaemonidae

Genus Genus, *Macrobrachium*

1. *Penaeus*
2. *Metapenaeus*
3. *Parapenaeopsis*

KEY TO THE FAMILIES AND GENUS

Super Section: *Natantia*

Infraorder: **Penaedea**	**Caridea**	**Stenopodidea**
1. Pleura of 1st abdominal segment not over-lapped by that of 2nd.	1. Pleura of 2nd abdominal segment noticeably overlap those of first and 3rd segments.	1. Peura of 2nd abdominal somite do not overlap those of the 3rd somite.
2. 3rd pair of perio-pods are not stouter than 1st and 2nd periopods.	2. 3rd pair of periopods are never chelate.	2. 3rd pair of periopods are stronger than 1st and 2nd pairs of periopods.

3. 3rd periopods are chelate.	3. No pincers on third pairs of periopods.	3. 3rd periopods are chelate.
4. Males with petasma.	4. Mostly freshwaster	4. Males are without petasma.
5. Marine		5. Marine
Family	**Family**	
Penaeidae	***Palaemonidae***	
1. Antennules with-2 flagella.	1. Antennules with 3 flagella.	
2. 1st 3 pair of walking legs are chelate.	2. 1st 2 pairs of walking legs are chelate.	
3. Pleura of 2nd abdominal segment overlaps those of first segment only.	3. Pleura of 2nd abdominal segment overlaps those of first and third segments.	
Genus	**Genus**	
A) Penaeus	***Macrobrachium***	
1. Rostrum serrated on both margin	1. Hepatic spine present	
	2. Branchiostegal spine absent	
	3. Dectylus of last three walking legs simple	
B) *Metapenaeus*		
1. Teeth on dorsal margin		
2. Exopodite absent on 5th leg		
C) Parapenaeopsis		
1. Teeth on dorsal margin only		
2. Exopodite present on the basis of 5th leg		

IDENTIFYING CHARACTERES OF DIFFERENT MACROBRACHIUM SPECIES

I. *M. rosenbergii* (Fig. 2)

i) Carpus of 2nd periopod longer than merus.
ii) Rostrum with a distinct elevated basal crest
iii) Rostrum very long with a distinct naked portion in the distal half of the upper margin. Usually extending distinctly beyond the antennal scale.
iv) Rostrum as long as or longer than carapace
v) The 2nd pair of periopods in the male is thicker than in other species
vi) Tips of telson reaching beyond the tip of the longer posterior spines
vii) Rostral formula $\frac{11\text{-}14}{8\text{-}14}$
viii) Length of fingers of 2nd walking leg is half of the length of palm.
ix) Largest among the freshwater prawn

II. *M. villosimanus* (Fig. 3)

i) Carpus of 2nd periopod longer than merus
ii) Upturned rostrum with distinct elevated basal crest
iii) Dorsal margin of rostrum armed with 13 teeth and ventral margin with 8-9. Usual rostral formula $\frac{12\text{-}14}{7\text{-}10}$
iv) Teeth on the rostrum are uniformly distributed
v) Length of fingers of 2nd walking legs is slightly smaller than the half of length of palm.

III. *M. lamarrei* (Fig. 4)

i) Rostrum equal to or slightly longer than antennal scale
ii) Rostrum more or less straight
iii) Rostral formula $\frac{5\text{-}9}{6\text{-}9}$
iv) Teeth are not uniformly arranged
v) Second chelipeds slender, equal and a little more than 1/3rd body length
vi) Chela always longer than half but shorter than 3/4th of carpus
vii) Palm invariably shorter than half of carpus
viii) 3rd, 4th and 5th pairs of walking legs are almost equal
ix) Second pleopod of male with a characteristic appendix masculina which is almost non-hairy, long, slender reaching upto or beyond endopod.

IV. *M. malcolmsonii* (Fig. 5)

i) Rostrum straight
ii) Rostrum shorter than carapace
iii) Rostral formula $\frac{7\text{-}11}{4\text{-}7}$
iv) Distal portion of rostrum without dorsal teeth
v) Tips of telson overreached by the longer posterior spines.

V. *M. rude* (Fig. 6)

i) Rostrum usually straight and distinctly narrowing distally and with a distinct elevated basal crest
ii) Rostral formula $\frac{10\text{-}17}{3\text{-}8}$ usually $\frac{10\text{-}15}{3\text{-}6}$, and size of teeth are more or less equal
iii) Large chela of 2nd leg of adult male with tubercles at both sides of the cutting edge.
iv) Carpus of 2nd walking leg in adult male shorter than the chela
v) All joints of 2nd legs in adult male pubescent.

VI. *M. equidens* (Fig. 7)

i) Rostrum curved upwards
ii) Rostral formula $\frac{9\text{-}13}{4\text{-}7}$ usually $\frac{10\text{-}11}{5}$
iii) 2nd pair of walking legs are cylyndrical in shape
iv) Fingers covered with velvetty hairs on the entire surface or in the proximal part
v) 2nd pair of walking legs are provided with tortoise shaped mountings on the palm and fingers.

VII. *M. idella* (Fig. 8)

i) Rostrum usually slightly longer than antennal scale
ii) Carpus of 2nd walking leg in adult male larger than chela
iii) 2nd chelipeds equal, smooth, slender and shorter than body in young ones and females but in adult males it is stout and longer then body length.

VIII. *M. mirabile* (Fig. 9)

i) Rostrum short, and high with many dorsal teeth
ii) Rostral formula $\frac{14\text{-}16}{3\text{-}4}$

iii) 3rd, 4th & 5th pairs of walking legs are unusually longer and not seen in any other members of *Macrobrachium* genus. Particularly 5th legs are conspicuously longer than the 4th

iv) 2nd legs of adult males smooth.

IX. *M. birmanicum choprai* (Fig. 10)

i) Rostrum short, not reaching upto distal end of antennal scale but conspicuous dorsal crest on the basal two third of the upper edge of rostrum.
ii) Rostral formula $\frac{9\text{-}14}{4\text{-}6}$
iii) Very long and stout second chelipeds in adult males
iv) Chela in males longer than carpus
v) Fingers more than half the length of palm.

X. *M. birmanicum birmanicum*

i) Rostrum very short, extending up to antennal spine
ii) Rostrum has a conspicuous dorsal crest
iii) Rostral formula $\frac{9\text{-}14}{4\text{-}6}$
iv) Periopods are smaller than 'Choprai' but strong and are provided with spine.

XI. *M. scabriculum* (Fig. 11)

i) Small sized prawn
ii) Looks like *M. rude*
iii) 2nd walking legs stout and strong
iv) Rostral formula $\frac{12\text{-}15}{2\text{-}3}$ usually $\frac{12\text{-}14}{2}$
v) Length of 5th walking legs are same as fourth
vi) Entire surface of chelipeds beset with minute spinules.
vii) Second chelipeds stout, exhibiting sexual dimorphism in adult-in males unequal in size and shape
viii) Fingers much longer than palm.
ix) Fingers of second walking legs of the adult male with numerous teeth
x) Large chela of adult male with numerous felt like or woolly hairs on the palm or fingers or on both.

XII. *M. dayanum* (Fig. 12)

i) Rostral formula $\frac{8\text{-}9}{5\text{-}6}$

ii) 5th walking legs are of the same length as the fourth

iii) 2nd chelae of the adult male equal or subequal in shape.

LIFE CYCLE OF *M. ROSENBERGII*

There are four stages in life of *M. rosenbergii viz*, egg, larva, juvenile and adult (Fig. 13).

Habit: Adult *M. rosenbergii* are mostly found in riverine freshwater areas but they require brackishwater in the initial stages of their life cycle. Adults prefer turbid water instead of clear water. During day time they are sluggish but active during night. Water temperature between 28 and 34 °C is preferred by the species. The species are omnivorous showing noctornal feeding habit. Adults can tolerate a wide range of estuarine saline waters varied between O and 25 ppt while eggs, larvae and juvenile can tolerate the range betwen 6 and 15 ppt.

AGE AND GROWTH

The species is known to grow to a maximum length of about 34.00 cm. Male grows faster than female. Based on length frequency analysis, the growth of this species in Hooghly estuary in West Bengal is as follows:-

	Male	*Female*
Year	*Length (mm)*	*Length (mm)*
1	113.7	83.3
2	142.0	127.0
3	226.0	157.7
4	261.0	221.0

In the Kerala brackishwaters growth is much faster when females attain 200 mm in one year and males slightly larger. While under well managed culture system, the species could be grown to an average length/weight of 150 to 175 mm/35 to 68 g in 5 to 6 months period.

MOULTING

Periodic shedding of exoskeleton is a natural phenomenon in the life cycle of any prawn species. Two types of moulting are observed i) growth moulting, and ii) pre-mating moulting.

Growth moulting: Growth and size increase take place during each moulting time. The periodicity of moulting varies according to different conditions such as light, temperature, food supply etc. In *M. rosenbergii*, eleven times moulting take place during larval development from egg to post larva. All the larval stages metamorphose from one to the next stage by the process of moulting. In case of juveniles moulting takes place at every 5 to 10 days interval, while it is once in month for adult stage. No moulting is observed when the species reaches four years of age.

Pre-mating moulting: Moulting before every mating season by a female is a must. The species does not moult while undergoing gonadal maturation and particularly during incubating the eggs.

MATURITY: The attainment of first maturity in *M. rosenbergii* from Hooghly estuary and koleru lake recorded at 135 mm and 140 mm respectively. However, in aquaculture system the species grows to maturity when their sizes are around 150 mm (25 g) in females and 175 mm (35 g) in males. Maturity can be obtained earlier under better brood stock management.

SEXES AND SEXUAL DIFFERENCES

The species is heterosexual.

MALE:

i) The mature male is larger in size than the females
ii) Cephalothorax and 2nd pair of thoracic legs are comparatively larger.
iii) The second pair of periopods (walking legs) is quite long and has many spines
iv) The cephalothorax of the male is also proportionally larger and the abdomen narrower than the females.
iv) The genital pores of the male are situated at the base of fifth pair of walking legs
vi) In immature males, there is a raised hard point in mid-ventral of first segment of the abdomen (Fig. 2b).
vii) The appendix masculina is situated in the second abdominal appendags

FEMALE:

i) The 2nd pair of thoracic legs is not so long and is spineless
ii) The abdominal pleurae of the female are comparatively longer and the abdomen wider
iii) In the ventral side of abdomen, brood chamber is formed with the help of enlarged pleurae and four pairs of appendix interna situated on the endopodites of swimming legs for incubating the fertilized eggs.
iv) Matured females can be easily differentiated by the presence of orange-coloured gonads
v) The genital pores are situated at the base of the third periopods.

BREEDING SEASON

In the wild, mating of this species takes place throughout the year. The species spawns in the Hooghly estuary during December to July with a peak in February to May. In Kerala waters, the spawning season extends from July to January with a peak in October to November. A female can spawn more than once in a year.

BREEDING AND SPAWNING

A female prawn, with matured gonad, copulates just after moulting with a prawn having a hard shell. During copulation, a gelatinous sperm mass is deposited by a male on the underside of the thorax (near the gonopore) of the female between walking legs. The female releases eggs a few hours to few days after copulation. Females are reported to lay from 1,50,000 to 5,00,000 eggs during one spawning. The number of eggs depends on the size of the female. At first maturity, due to the female's small size it leys only 5000-20,000 eggs.

Fertilization is external, eggs are being fertilized with the help of semen attached to the exterior of the female's body. Mating and fertilization of eggs are completed in freshwater conditon. The fertilized eggs are then transferred to a brood chember on the ventral side of the abdomen of female. Eggs are being aerated by vigorous movements of the pleopods (swimming legs). The eggs are slightly elliptical, the longer axis being 0.6 to 0.7 mm in length. The eggs are bright orange colour but just before hatching time the colour becomes slate gray. In laboratory condition, incubation period is found to be ranged between 18 to 23 days at 25^{0}-32 ^{0}C temperature.

The larva passes through eleven distinct larval stages to attain post larva stage (Table 1). The period of metamorphosis from larva to post larva varies from 30 to 43 days. The post larva measures about 7 mm. Post larvae exhibit good tolerance to a wide range of

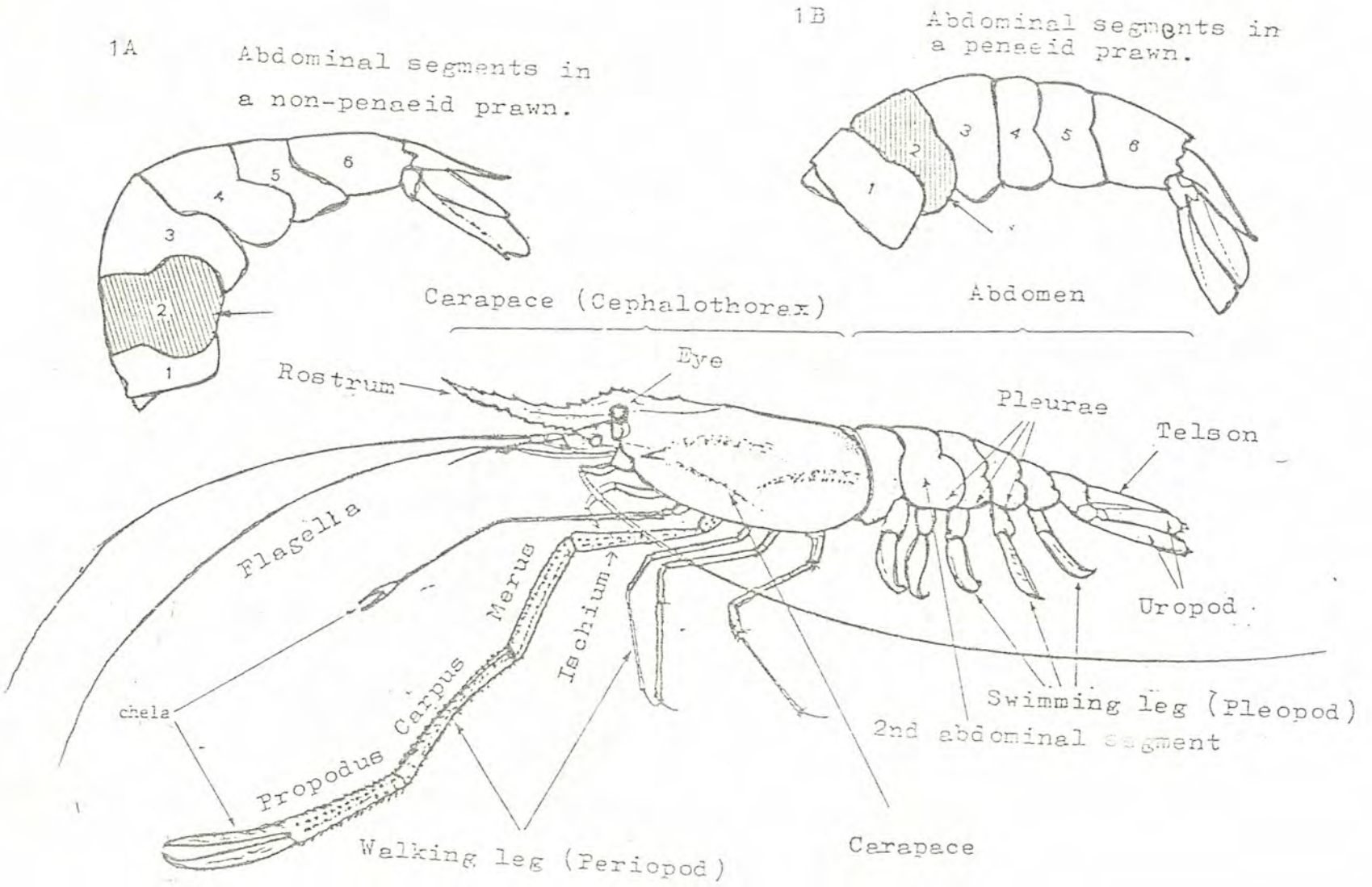


FIG 1. Different body parts of an adult Macrobrachium rosenbergii

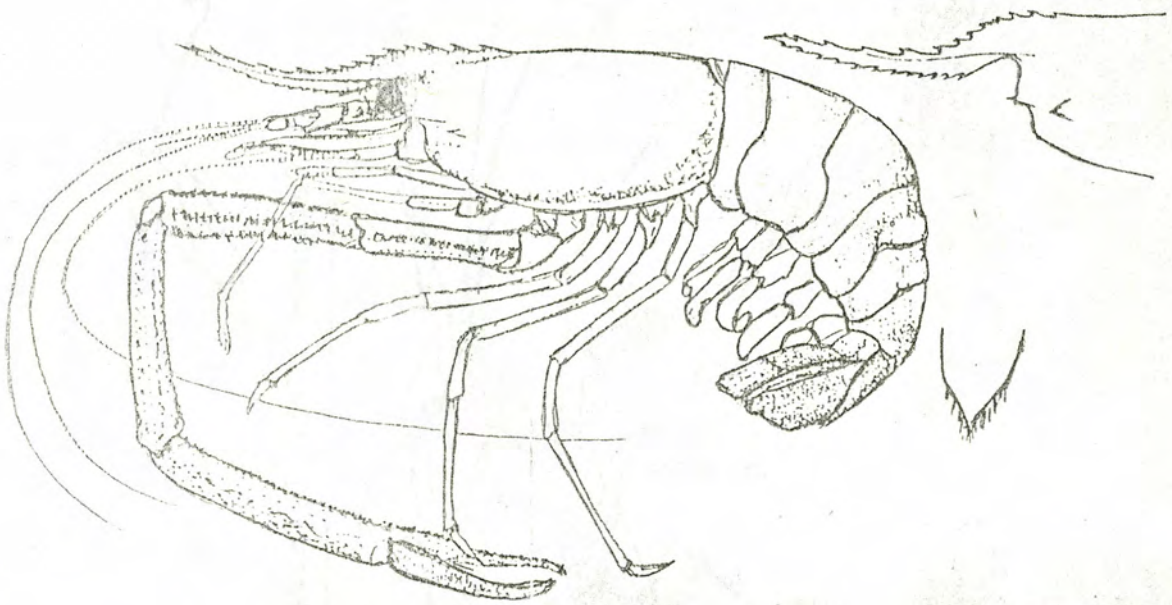


FIG 2 Adult M. rosenbergii

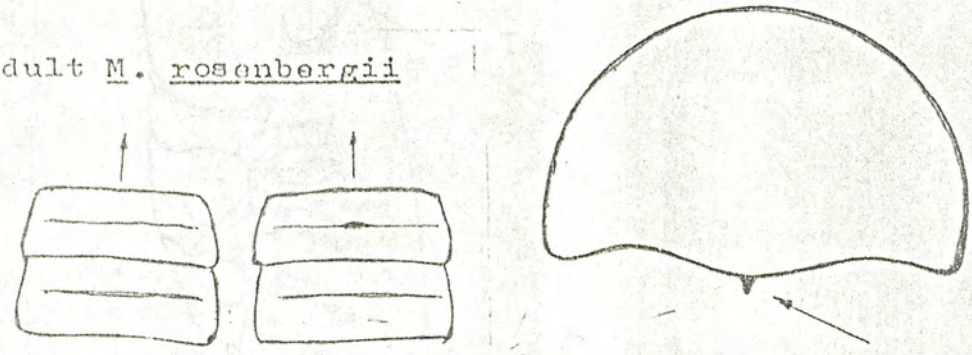


FIG 2A A raised hard point in mid-ventral of first segment of male abdomen.

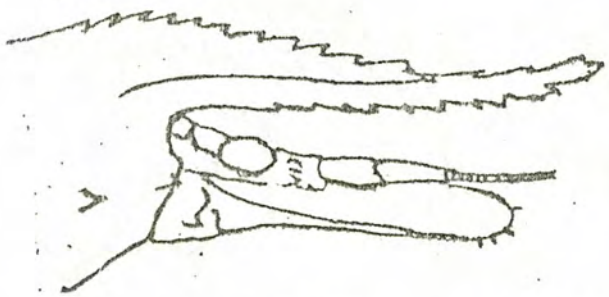


FIG 3 Rostrum of M. villosimanus

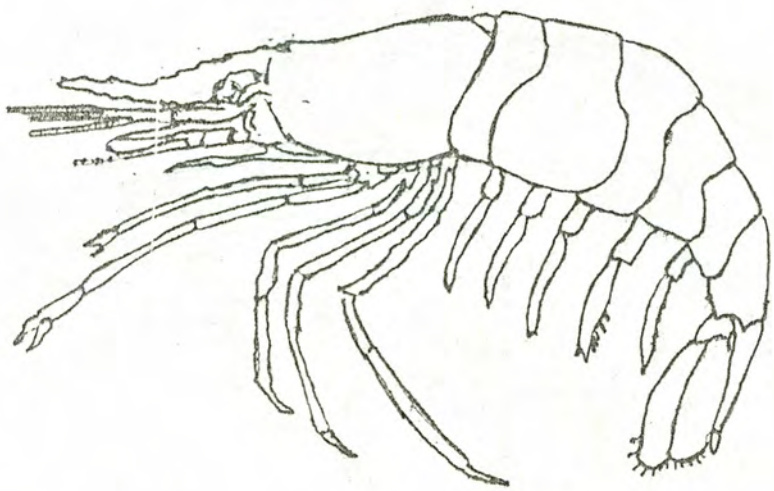


FIG 4 Adult M. lamarrei

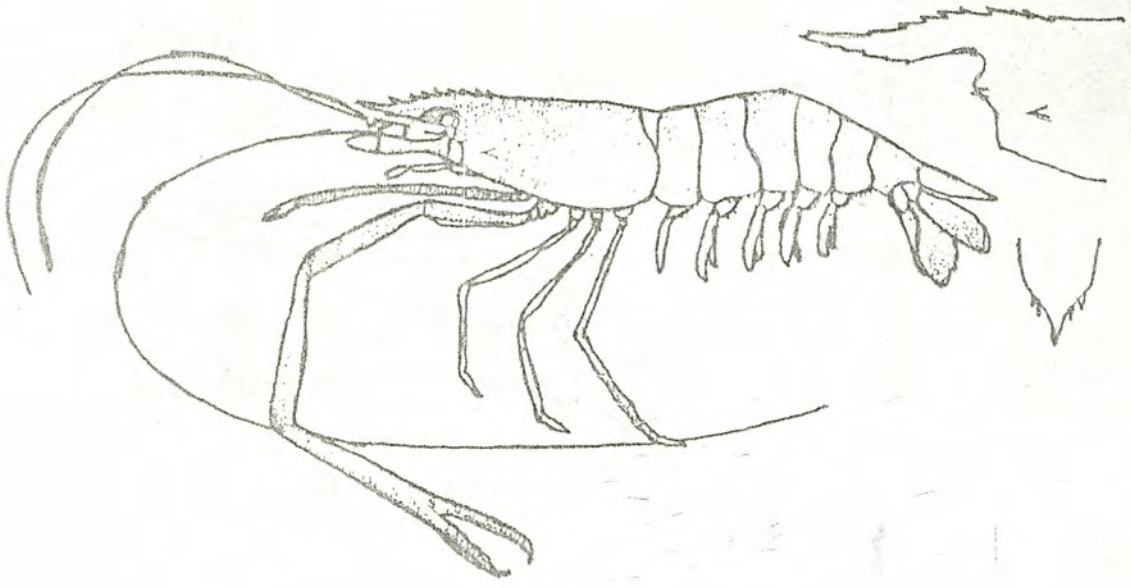


FIG 5 Adult M. malcolmsonii

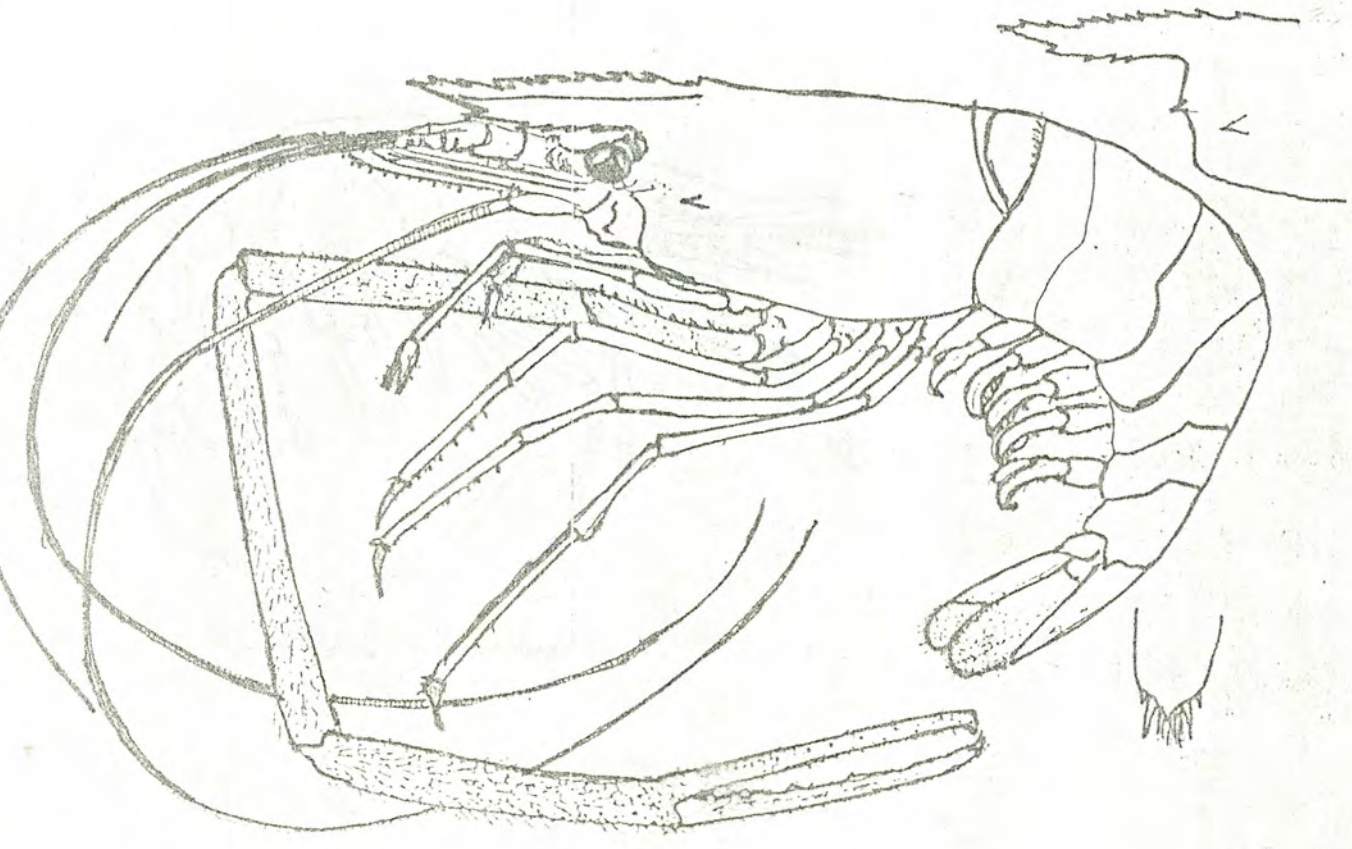


FIG 6 Adult M. rude

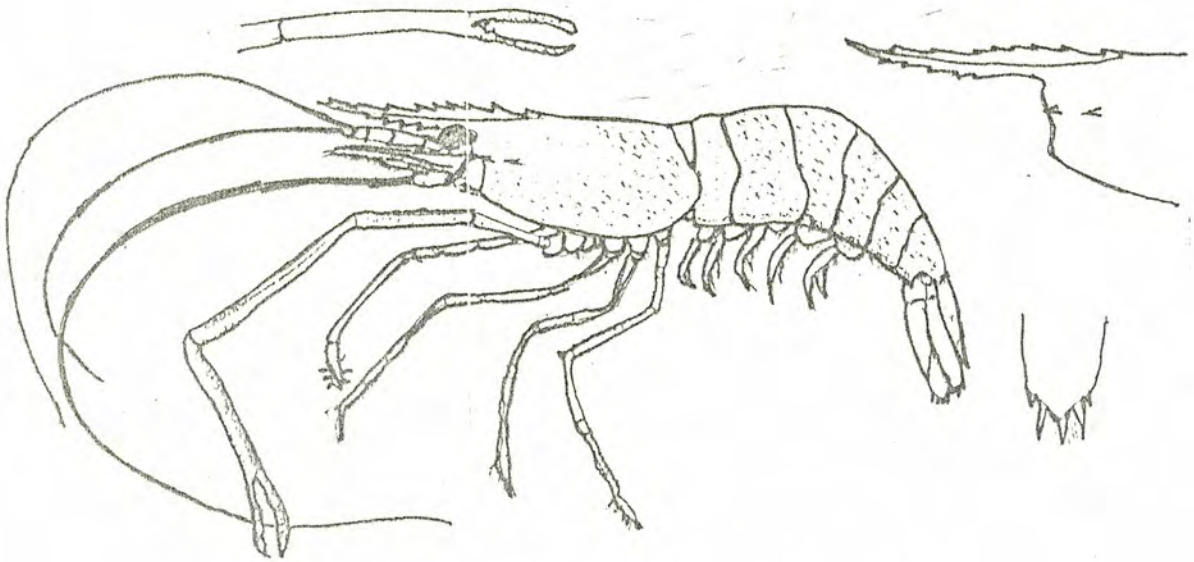


FIG 7 Adult M. equidens

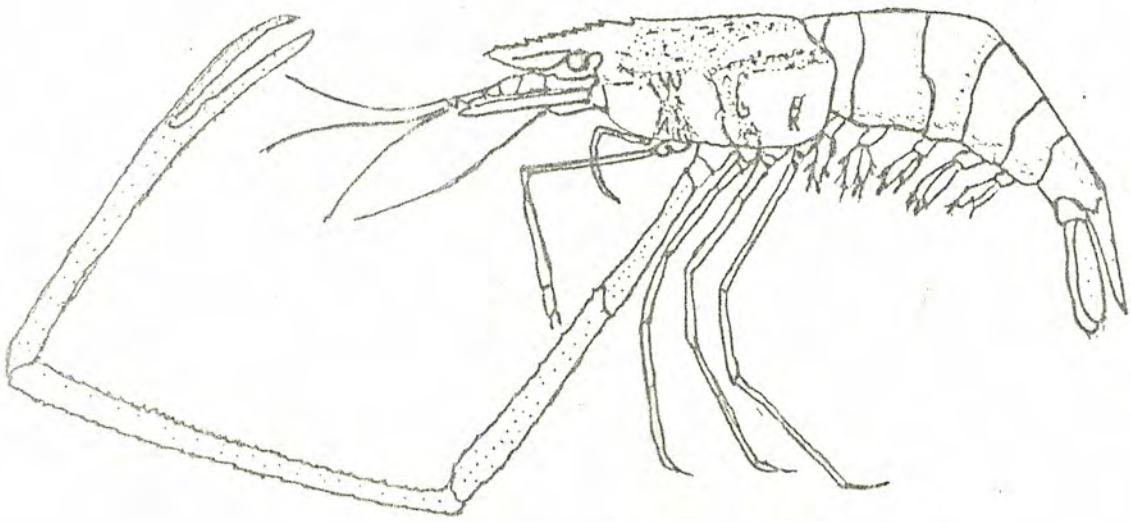


FIG 8 Adult M. idella

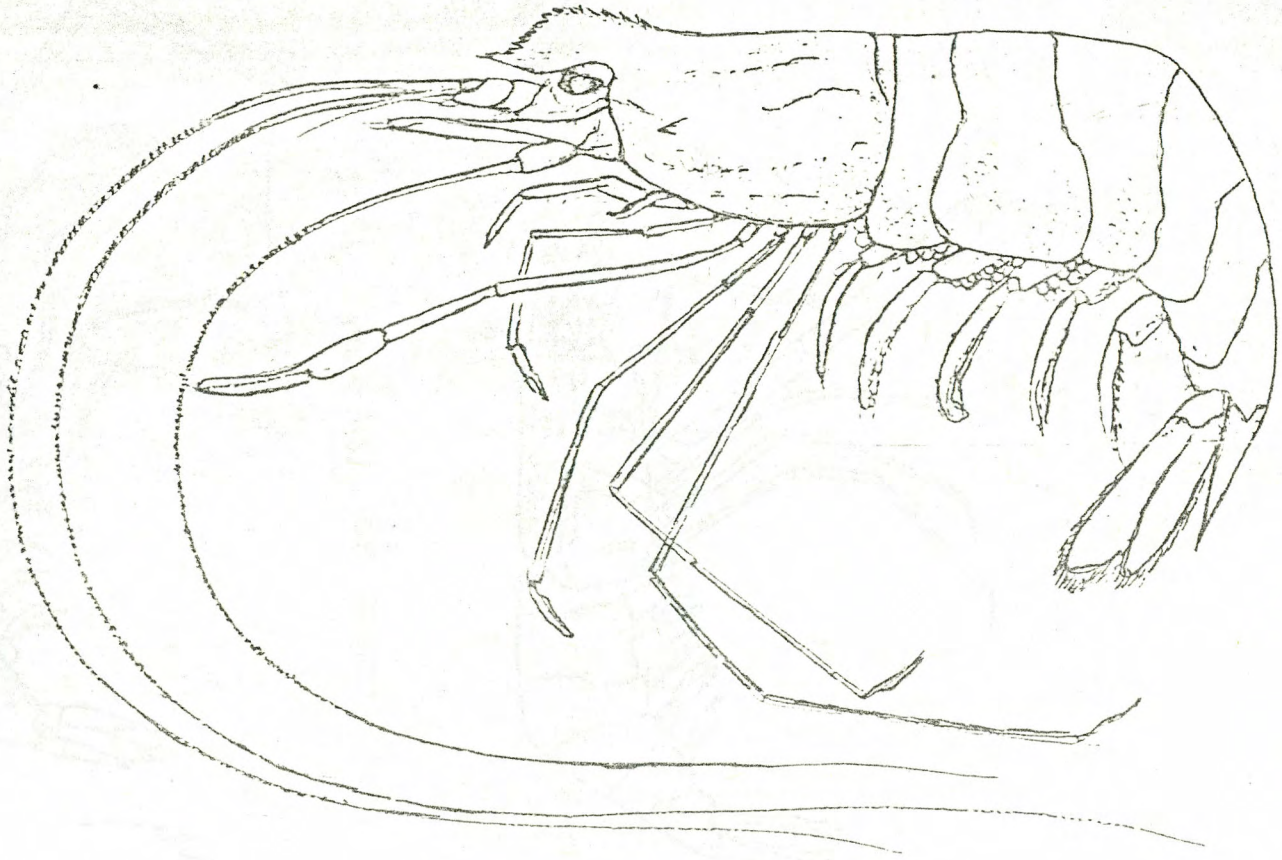
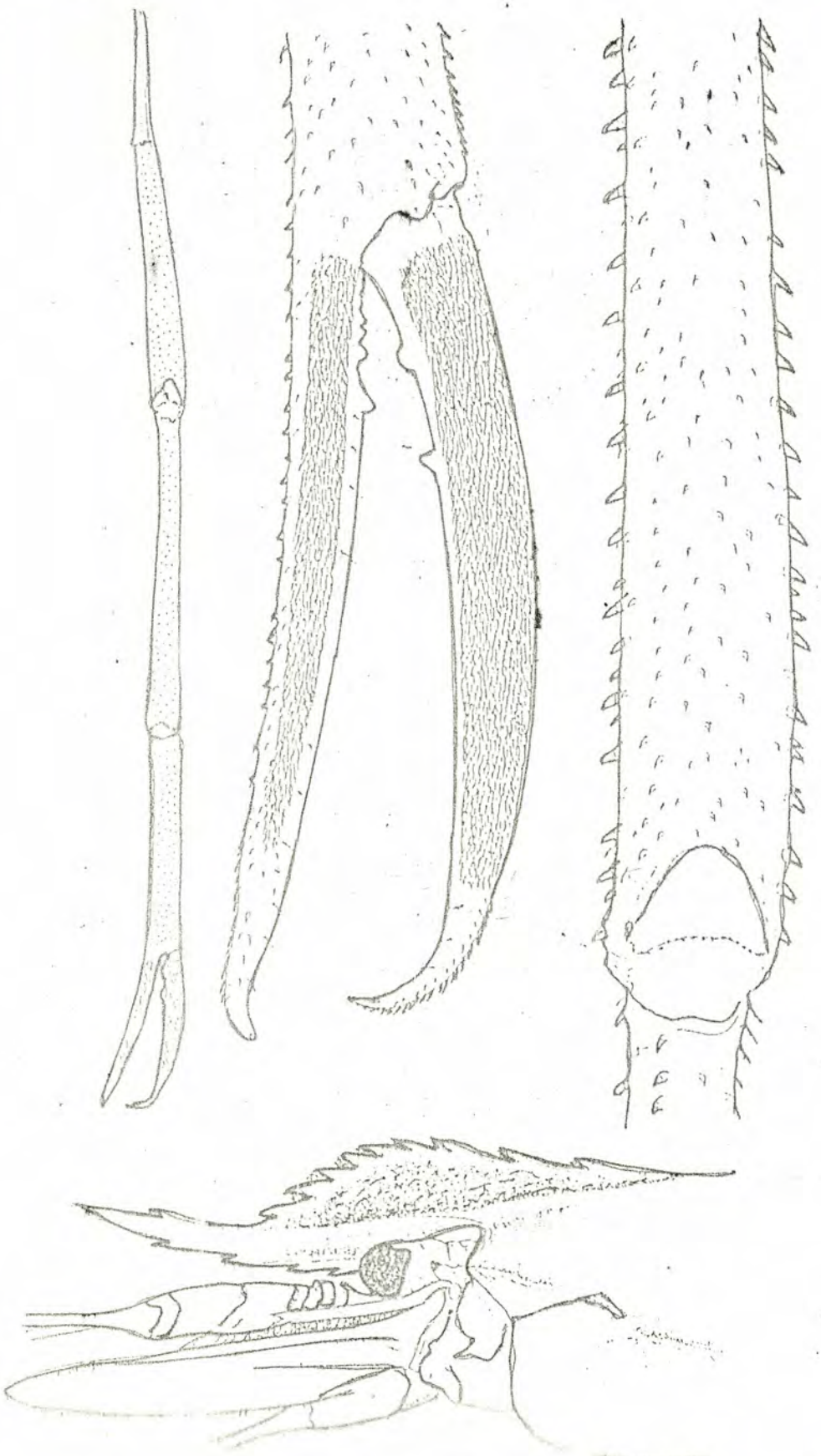


FIG 9 Adult M. mirabile



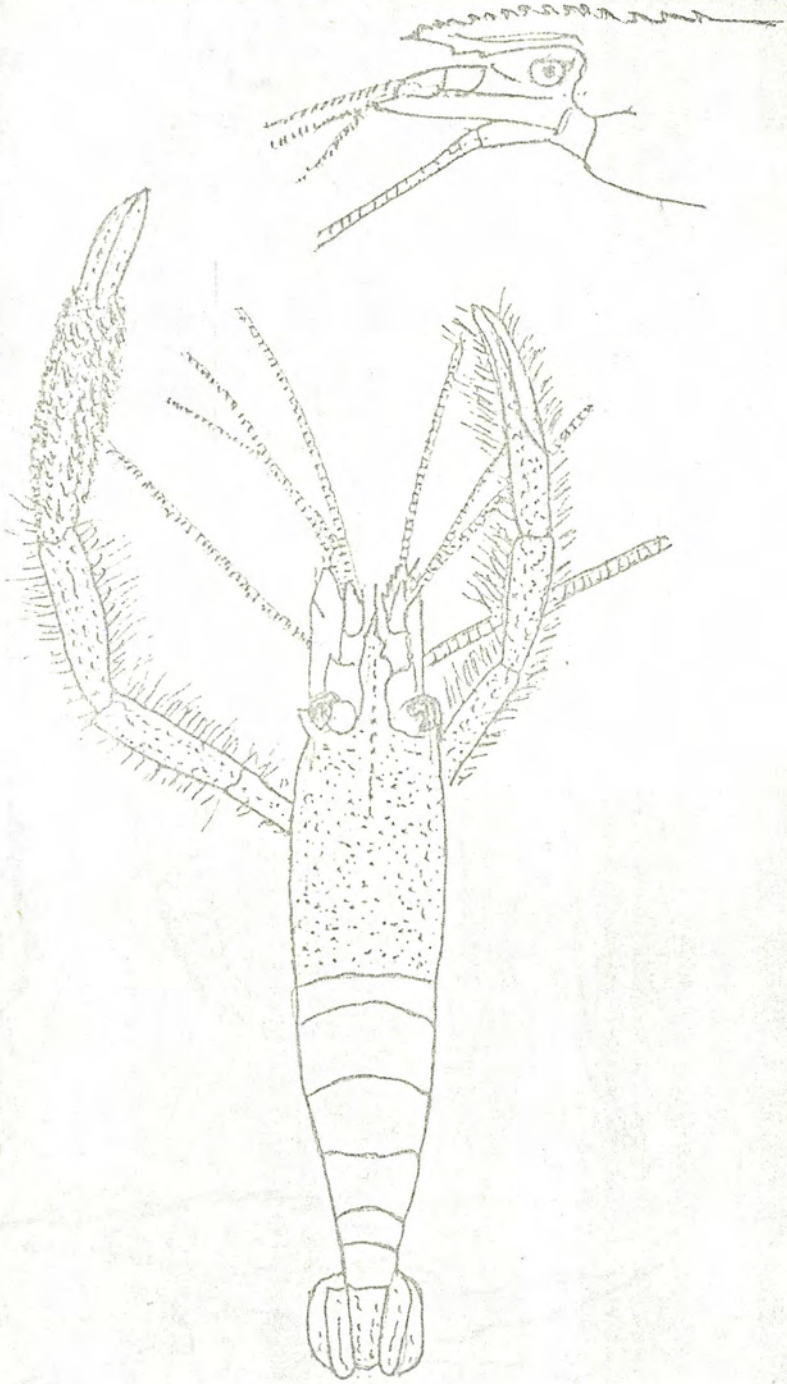


FIG 11 Adult *M. scabriculum*

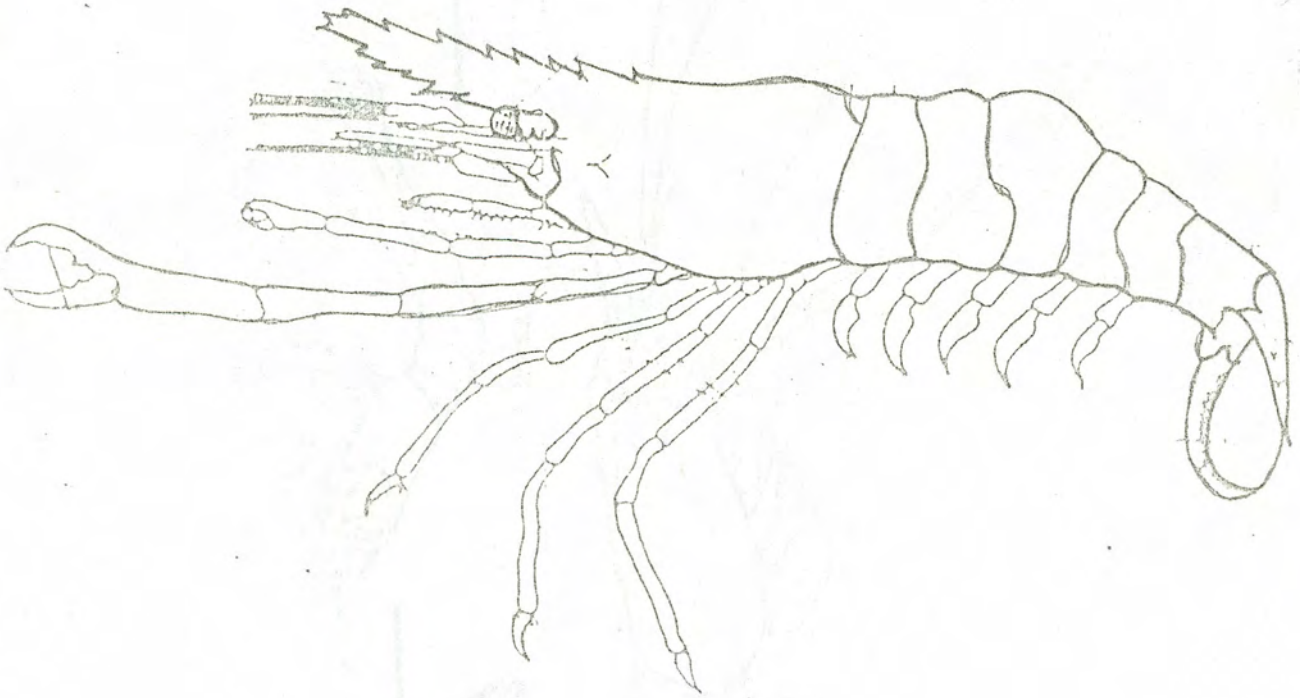


FIG 12 Adult M. dayanum

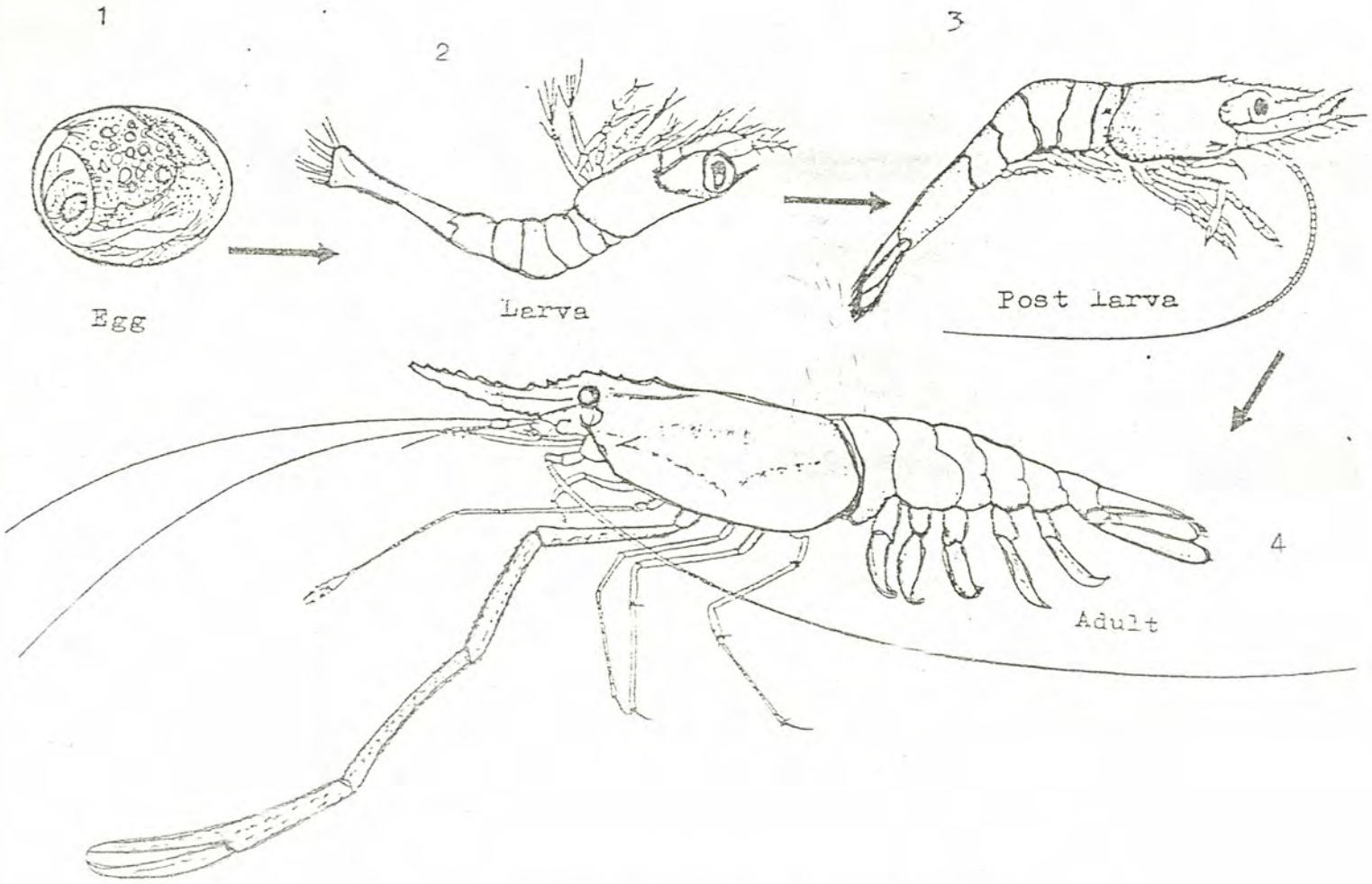


FIG 13 Life cycle of M. rosenbergii

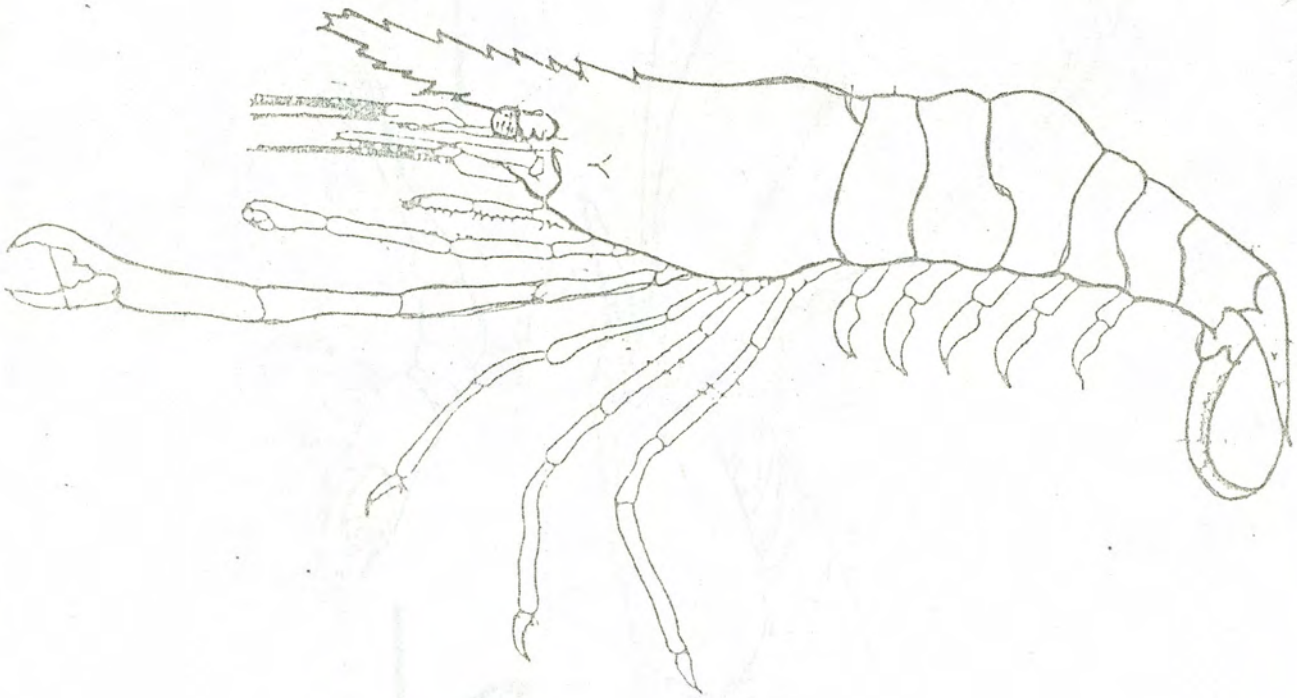
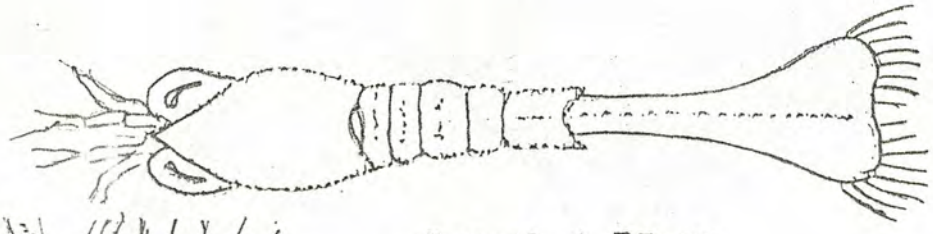
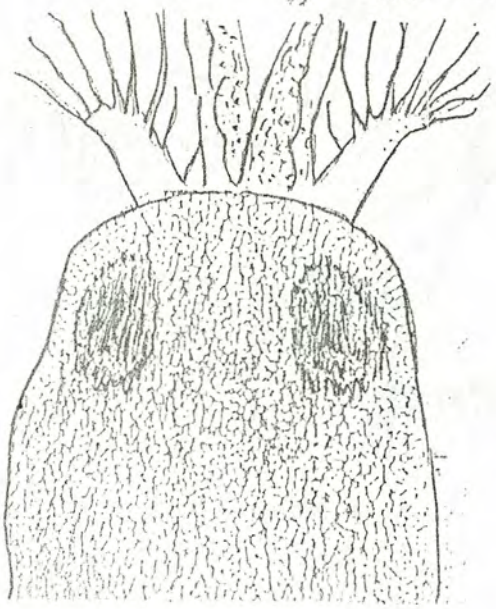


FIG 12 Adult M. dayanum



Length 1.73 mm



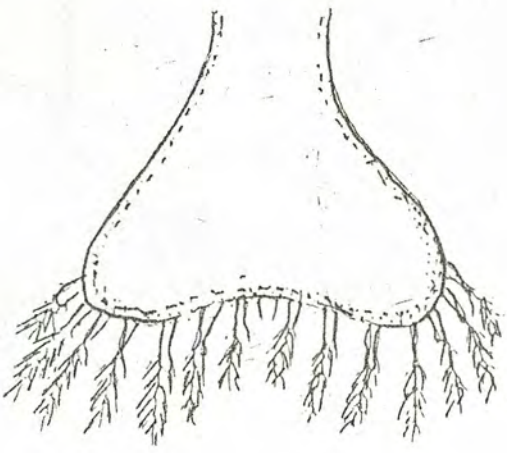
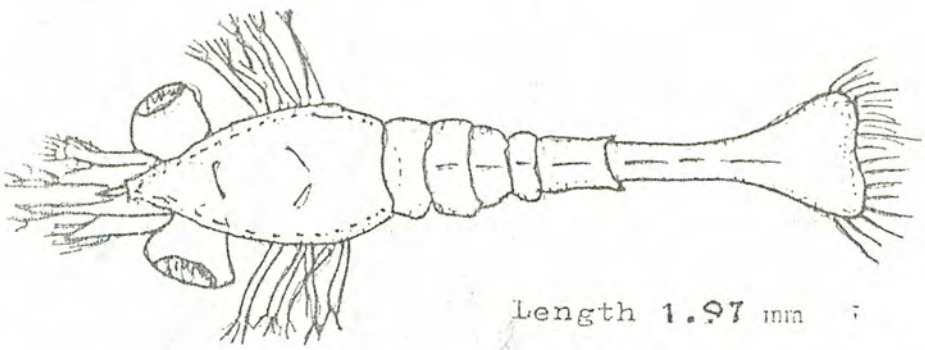


FIG 14 I larval stage



Length 1.97 mm

FIG 15 II larval stage

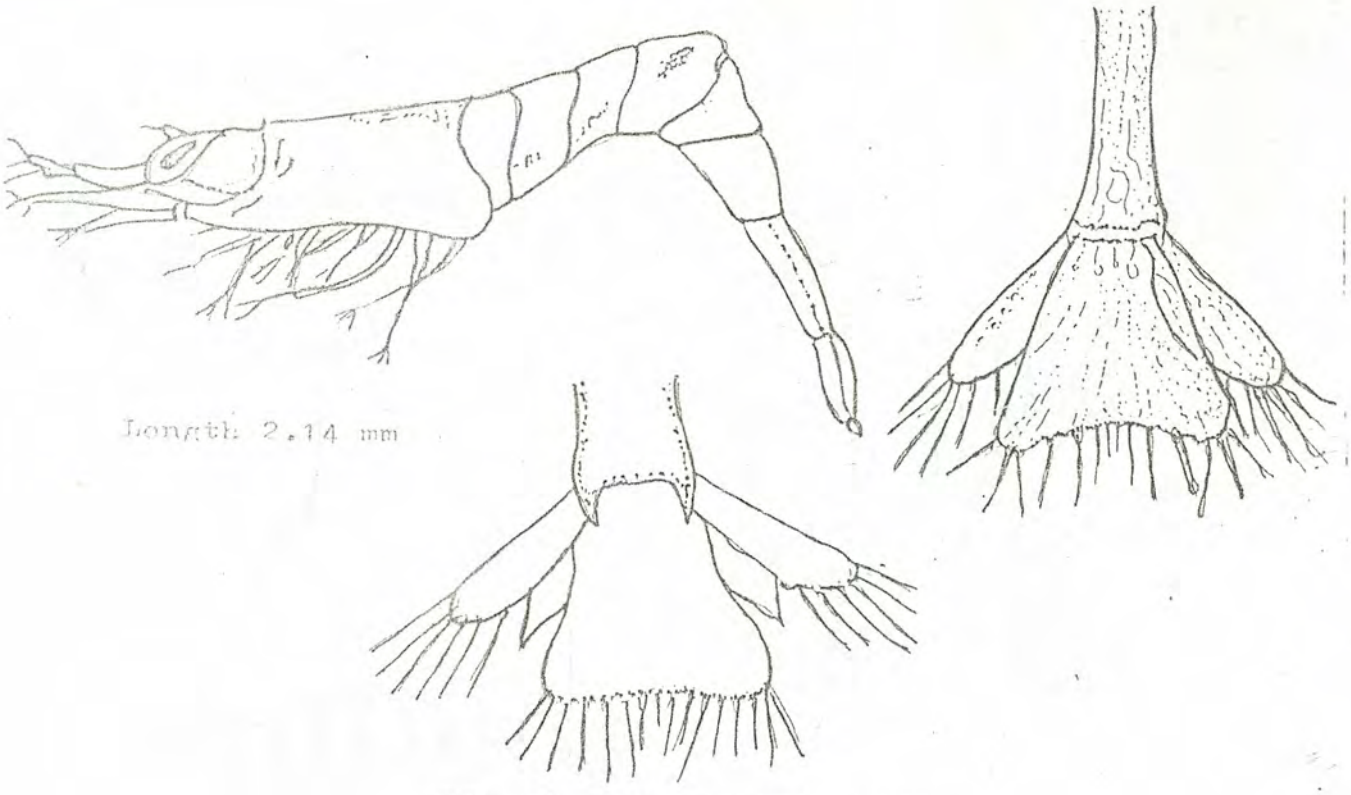


FIG 16 III larval stage

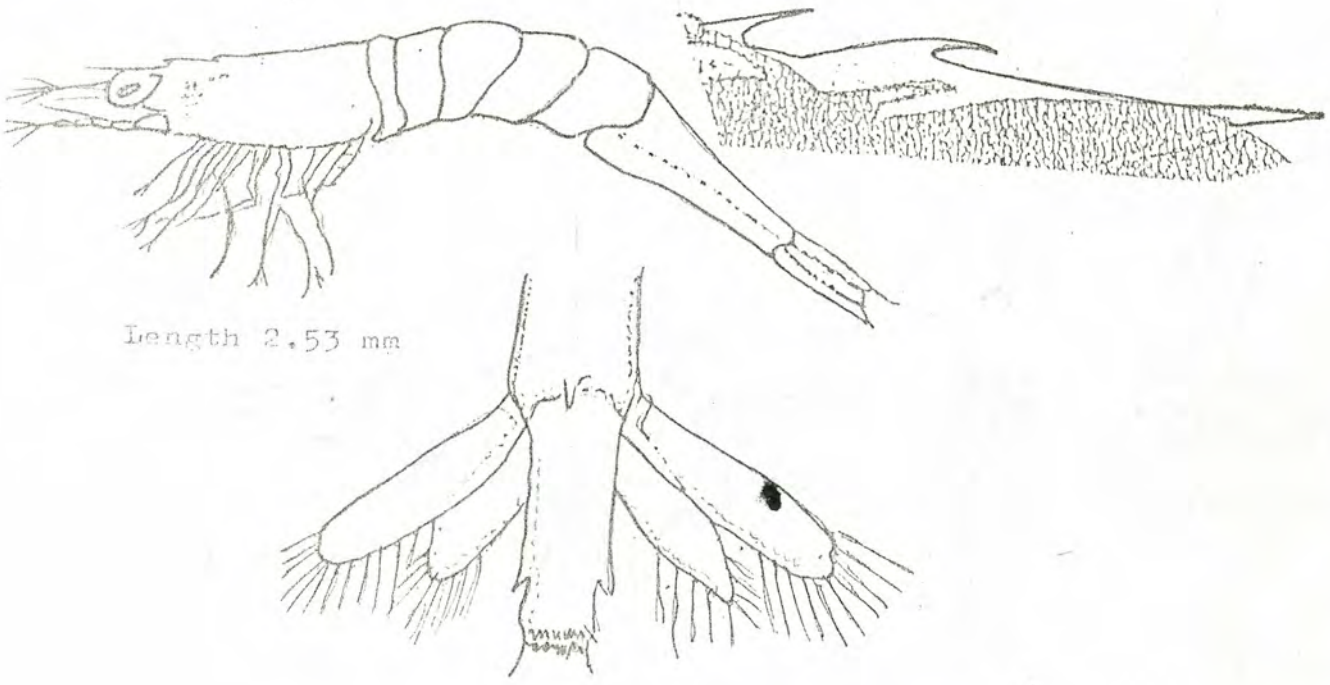


FIG 17 IV larval stage

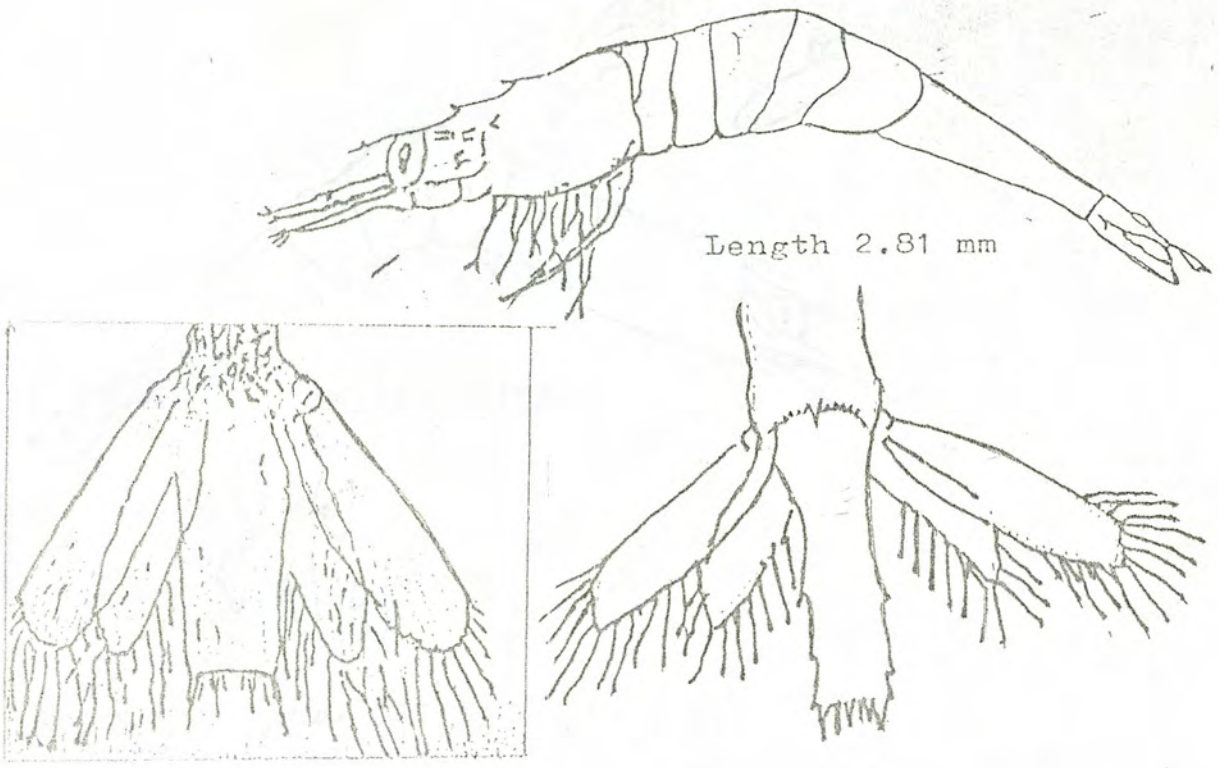


FIG 18 V larval stage

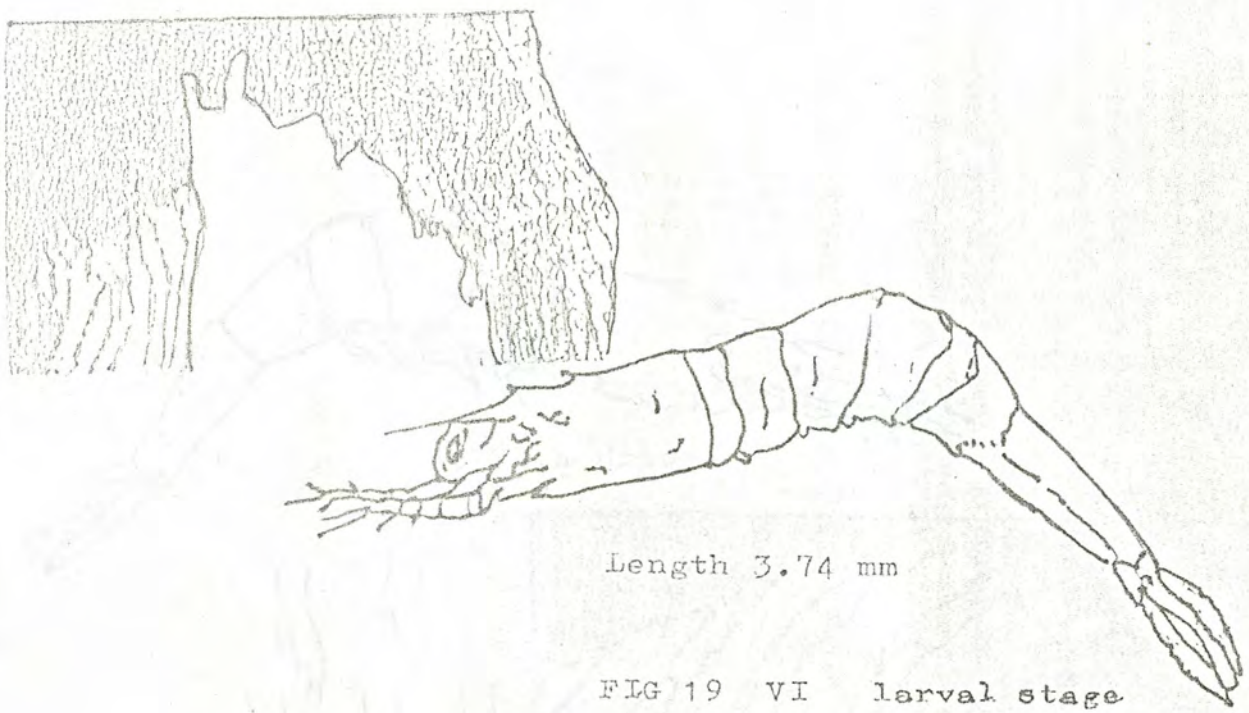


FIG 19 VI larval stage

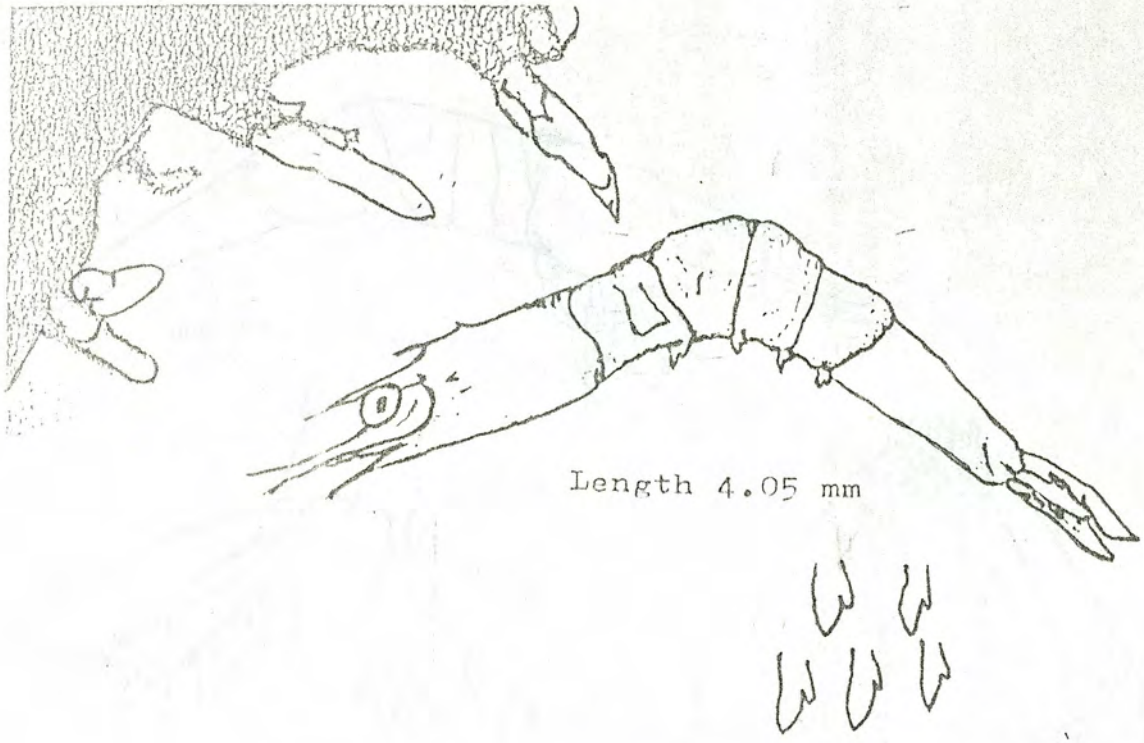


FIG 20 VII larval stage

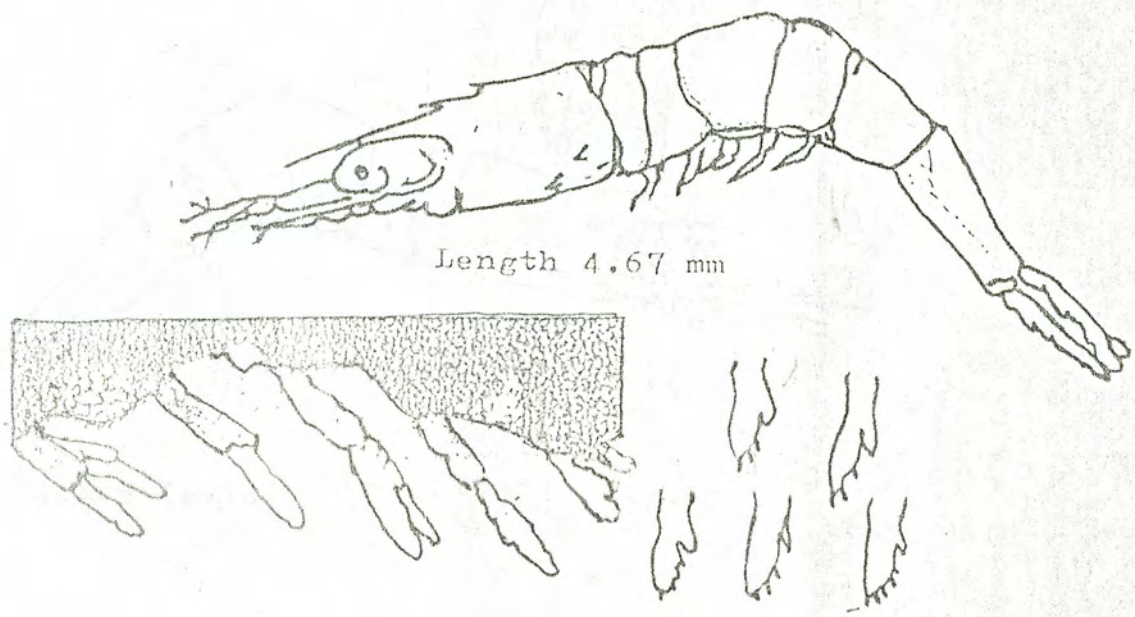


FIG 21 VIII larval stage

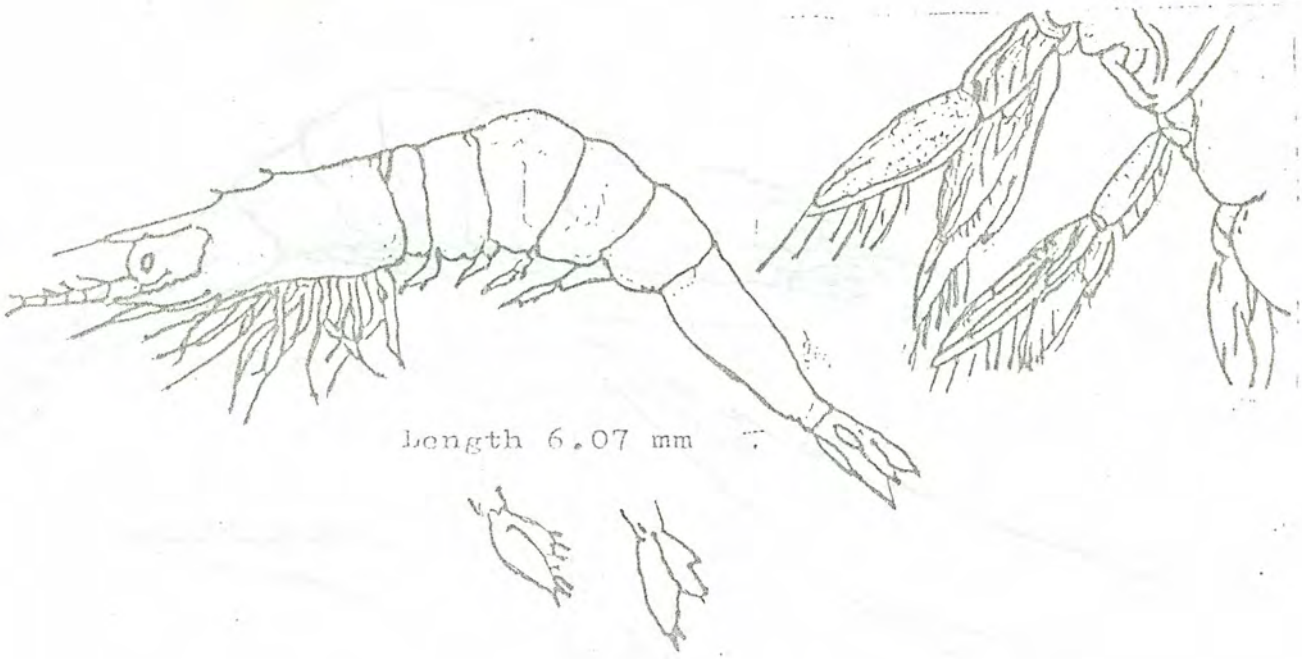


FIG 22 IX larval stage

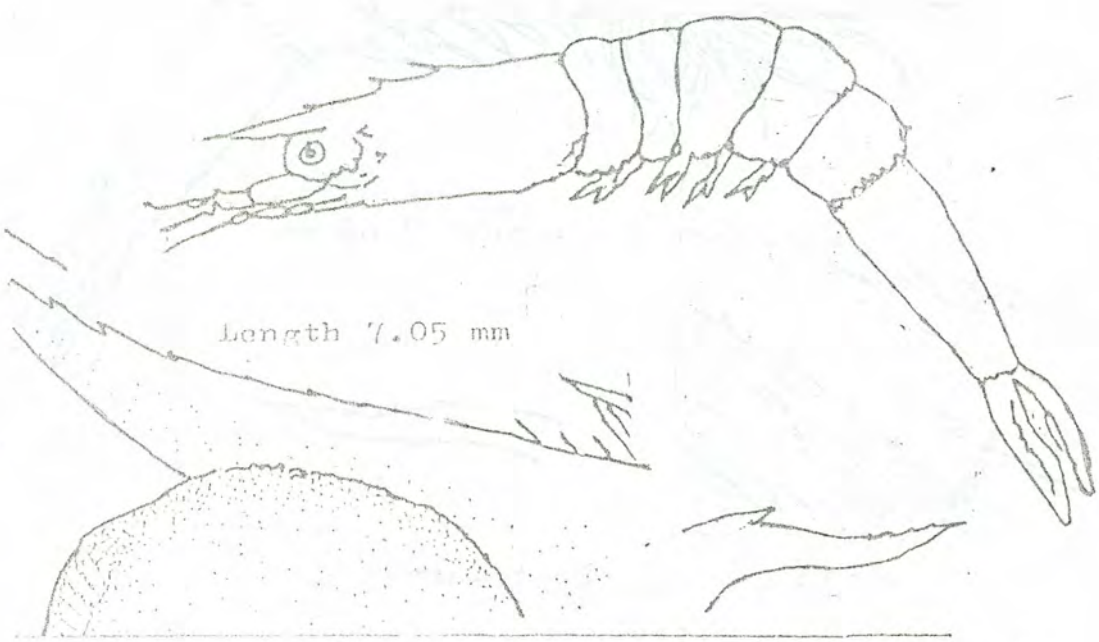


FIG 23 X larval stage

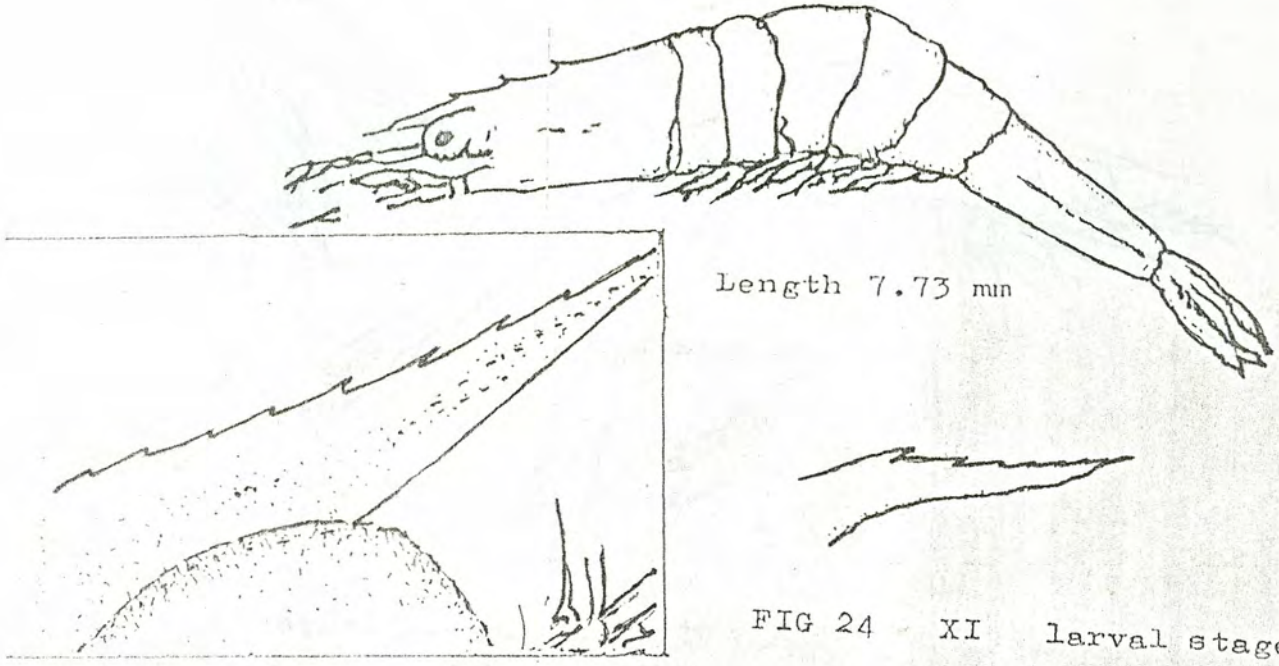


FIG 24 XI larval stage

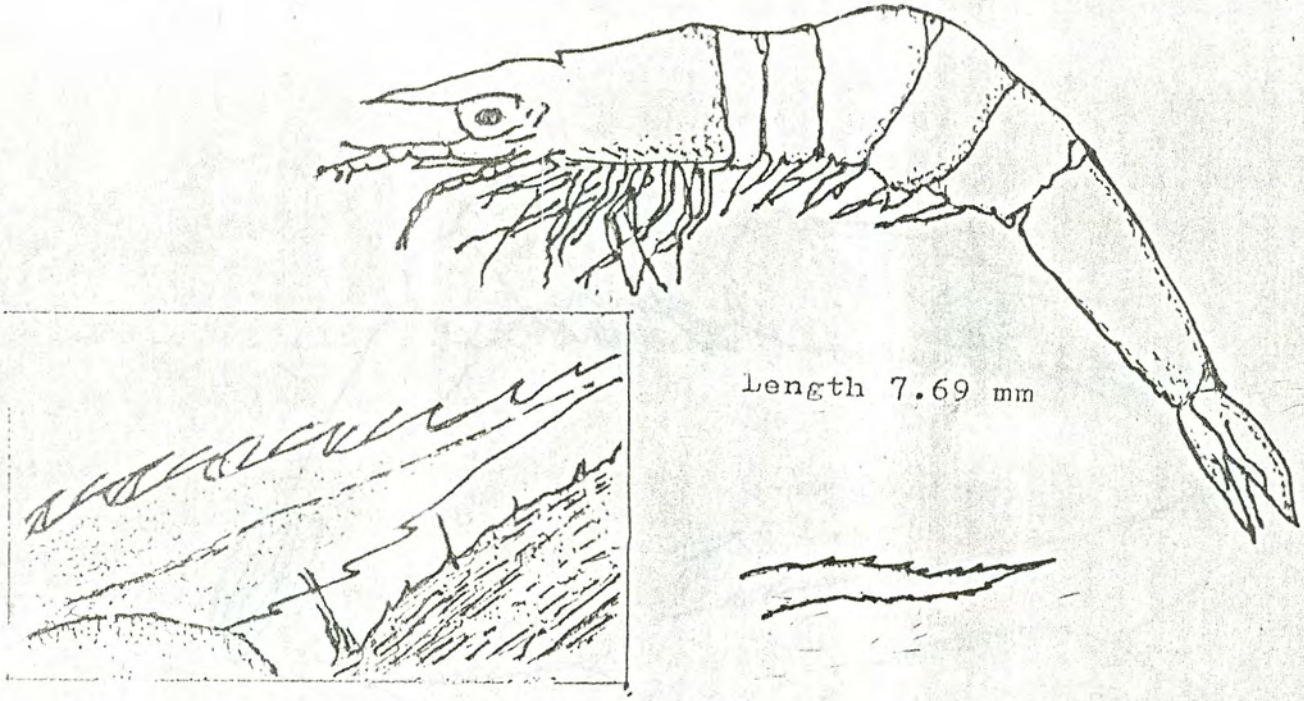


FIG 25 Post larva

Table 1. Larval stages of *M. rosenbergii*

Stage	Average body length (mm)	Age (in days)	Developmental changes
I *(Fig. 14)*	1.73	1-2	eyes sessile, fan like telson with 7 pairs of spines.
II *(Fig. 15)*	1.97	2-3	eyes stalked, telson with 8 pairs of spines.
III *(Fig. 16)*	2.14	3-5	uropods appear, Exopodites with 6 pairs of setae. Endopodites bear no setae.
IV *(Fig. 17)*	2.53	5-9	rostrum with two dorsal teeth. Setae on endopodites appear.
V *(Fig. 18)*	2.81	9-12	telson elongated and narrower, blue and yellow, colourlation of 2nd walking legs visible.
VI *(Fig. 19)*	3.74	12-18	buds of swimming legs (Pleopod) appear.
VII *(Fig. 20)*	4.05	15-20	pleopods (swimming legs) divided into endopodite and expodite but devoid of setae.
VIII *(Fig. 21)*	4.67	18-22	pleopods with setae.
IX *(Fig. 22)*	6.07	25-30	chelae on 1st and 2nd walking legs as well as appendices internae on endopods of pleopods appear.
X *(Fig. 23)*	7.05	27-34	3 to 4 teeth on dorsal edge of rostrum
XI *(Fig. 24)*	7.73	28-37	teeth on half of upper dorsal margin.
Post larva	7.69	36-48	teeth on dorsal and ventral margin of rostrum, change of swimming behaviour is also observed.

salinities (6-15 ppt) which is a characteristic of *M. rosenbergii*. In nature post larvae remain in brackishwater for few weeks. They grow rapidly and then slowly migrate upstream towards freshwater as juveniles.

IDENTIFYING CHARACTERS, MORPHOLOGY AND LIFE CYCLE OF COMMERCIALLY IMPORTANT SHRIMP, *PENAEUS MONODON*

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Barrackpore

INTRODUCTION

The penaeid prawn under the family penaeidae are very important. They are dollar earners fetching high prices in foreign countries. India produces about 350,000 tons of prawns from both capture and culture systems and more than 70,000 ha is under coastal aquaculture out of total estimated water areas of 12,00,000 ha. Penaeid prawns contribute to the major bulk of prawn fisheries. The important family penaeidae is represented by the genera *Penaeus*, *Metapenaeus* and *Parapenaeopsis*. *The genus* Penaeus comprising many commercially important species and about 30 species are cultivated in various countries of the world. In India, the important cultivable species under genus *Penaeus* are *P. monodon*, *P. indicus*, *P. semisulcatus*, *P. merguiensis* and *P. penicillatus*. Among them, *Penaeus monodon*, commonly known as tiger prawn (in Bengali *bagda*) is the most preferred species for cultivation because of its bulk availability, fast growth rate, tolerance of wide range of salinity and temperature as well as high market demand. In the present communication the identifying characters, morphology and life cycle of *P. monodon* have been delt with along with the key morphological characters of other four cultivable species mentioned above for their comparison.

Distribution of *P. monodon and allied species*

Species	Distribution	Habit and maximum size
I.		
P. monodon (Giant tiger prawn)	Indo-West Pacific; East Africa to Japan. Widely distributed throughout the tropical and sub-tropical zones such as, Madagascer, Mauritius Pakistan, east and west	Depth 0-160 m; muddy or sandy bottom; marine (adult) and estuarine (juvenile); Maximum total length 336 mm, 60-130 g. This is the largest Indian marine

	coast of India, Sri Lanka, Malaysia, Singapore, Philippines, South Japan, Taiwan and Northern Australia (Fig. 1). In India, more common on east- and west coasts especially Bengal and Orissa.	prawn. It is a euryhaline species with high tolerance to fluctuations in salinity.
II. *P. semisulcatus* (Green tiger prawn)	Widely distributed; Indo-West Pacific, Red Sea, East and south east Africa to Japan, Korea, Northern Australia; mostly in tropical countries, In India, it occurs on both the coasts but more common along the east coast.	Depth, 2-130 m; muddy or sandy bottom; Marine (adult) and estuarine (juvenile); Maximum total length male- 180 mm & female- 228:
III *P. indicus* (White prawn)	Indo-West Pacific, East and south east Africa to South China, and Northern Australia. In India, in all coastal waters of east and west.	Depth 2 to 90 m; Muddy or sandy bottom; marine (adult) and estuarine (juvenile); Maximum length male 184 mm and female 228 mm.
IV *P. merguiensis* (Banana prawn)	Indo-West Pacific, Persian Gulf to Thailand, Hong Kong, Philippines, Indonesia and Northern Australia. In India, middle regions along the east and west coasts.	Depth 10 to 45 m; Muddy bottom; Marine (adult) and estuarine (juvenile); Maximum total length- female 240 mm.
V *P. penicillatus* (Red tail prawn)	Indo-West Pacific; Pakistan to Taiwan and Indonesia. In India found commonly in Bombay and Orissa coastal waters.	Depth 2 to 90 m; Marine: Maximum total length male 163 mm and femele 212 mm.

Identifying characters of *P. monodon* and taxonomical classification, morphology and identifying characters upto genus *Penaeus* are dealt in a separate lecture script entitled "Identifying characters, morphology and life cycle of *Macrobrachium rosenbergii*. Therefore, only species characters of few commercially important members of genus *Penaeus* are discussed here.

I. *P. monodon* (Fig. 2)

i) Hepatic carina present and horizontally straight.

ii) 5th walking legs (periopods) without exopodite

iii) Rostral formula $\frac{\text{7-8 (dorsal)}}{\text{3 (ventral)}}$

iv) Adrostral crest and groove not extending beyond epigastric tooth (fig. 4a).

v) General colouration (in adult) dark blue to almost black with dark bands across carapace and abdomen; pleopods and uropods tipped blue.

COLOURATION OF JUVENILE (6-14 mm) *P. MONODON*

A red streak is present along the entire ventral side of the abdomen. Reddish brown chromatophores are visible on the endopodites of sixth abdominal segment (uropod) and also occasionally present on the innner side of the exopodites of uropod (Fig. 3). In larger specimens over 18 to 20 mm size. The reddish streak turns pink and then green.

II. *P. semisulcatus*

i) Hepatic carina present and not horizontally straight

ii) 5th walking legs with small exopodite

iii) Adrostral crest and groove extending well beyond epigastric tooth (Fig. 4b)

iv) Rostral formula $\frac{\text{6-7 (dorsal)}}{\text{2-3 (ventral)}}$

v) Body colour: green grey to brown, abdomen with dark brown to dark grey and pale yellow dorsal transverse bands.

III. *P. indicus* i) Hepatic carina absent

ii) Gastro-orbital crest reaching posteriorly as far as hepatic spine (Fig. 4 c).

iii) In adult male, dectyle of third maxilliped as long as propodus (Fig. 4 f)

iv) Rostral crest not triangutar in profile

v) Rostral formula $\frac{\text{7-9 (dorsal}}{\text{4-5 (ventral)}}$

vi) Body colour: whitish and translucent with scattered brownish chromatophores over the body. The terminal portion of the appendage is pinkish.

vii) Adrostral crest just reaching epigastic tooth (Fig. 4c)

IV. *P. merguiensis* i) Hepatic carina absent

ii) Adrostral crest not reaching as far as epigastric tooth (Fig. 4 d)

iii) Gastro-orbital carina not reaching hepatic spine (Fig 4 d)

iv) In male, dactyle of third maxilliped half the length of propodus (Fig. 4 g)

v) Triangular rostral crest

vi) Rostral formula $\frac{\text{8-10 (dorsal)}}{\text{2-3 (ventral)}}$

V. *P. penicillatus* i) Hepatic carina absent

ii) Adrostral crest just reaching epigastric tooth (Fig. 4 e).

iii) Gastro-orbitala carina situated between orbital margin and hepatic spine (fig. 4 e).

iv) Dectyle of third maxilliped much longer than propodus (Fig. 4 h).

LIFE CYCLE OF *P. MONODON* (BAGDA)

The species completes its life cycle in two environments, the marine and estuarine environments. The species breed in the deeper regions of the sea. The occurrence of the larvae is reported from many estuaries and lakes of east and west coasts of India. The adults occur in deeper waters of sea.

AGE AND GROWTH

Female grows faster than male. Based on culture experiments the growth of this species is as follows:-

In India

Stocking size	Size attained	at the end of
Post larva	160-170 mm/ ((30-35 g)	6 months
12-15 mm	40-45 mm	1 month
30 mm	150 mm/25 g	3 months
In Philippines		
15.3 mm	94.7 mm/6.88 g	3 months
Do	149.9 mm/22.3 g	6 months
Do	229.8 mm/95.1 g	12 months

Maximum size groups belonging to 254 to 279 mm and above 300 mm are exploited from inshore and offshore region respectively of our country. The age of the species is estimated as 'O' year class for inshore catch and "one" year class for offshore catch.

FOOD AND FEEDING HABITS

Adults feed on small crabs, molluscs, polychaetes, vegetable matter, blue green algae, diatoms, small fish and prawn and decaying organic matters. Adults show cannablastic habit. In different nauplii stages during larval development they do not feed because yolk supplies sufficient food. In zoea stages they feed well on diatoms of 3 to 20 micron size namely *Melosira, Thallasiothri, Nitzschia, Rhizosolenia, Skeletonema, castetum* etc.

In mysis stages they prefer predominantly zooplankton (200 micron size) diet.

MATURITY:

Penaeid prawns are heterosexual. The size at first sexual maturity of male and female *P. monodon* is found to be 37.0 to 38.5 mm carapace length/35 to 40 g body weight and 45 to 47.0 mm carapace length/63 to 68 g body weight respectively. In eye ablated conditon maturity may attain even after 5 months of age.

MALE AND FEMALE SEXUAL CHARACTERS.

Male: (Fig. 5)

i) The males are usually smaller in size than the females

ii) Endopodits of the first pair of swimming legs (pleopods) are provided with hooks to form a rod-like structure, the petasma.

iii) Appendix masculina a process is present on the endopodites of 2nd pair of pleopods.

iv) The genital ducts (pores) open at the base of 5th walking legs.

Female: (Fig. 5)

i) The females are usually larger than males

ii) The most striking character is the presence of a ventral thoracic structure (made of sternal plates *viz* anterior, posterior and two lateral plates) called thelycum. The thelycum is situated between the last three pairs (3rd, 4th & 5th) of walking legs.

iii) Genital ducts (pores) are situated on the base of the 3rd pair of walking legs.

Maturity stage in female (Fig. 6): In *P. monodon*, five maturity stages have been determined by the colour, size of the gonads, and the size and microscopic appearance of ova.

Stage I Immature:

Overy tape like, thin, transparent and not visible through the dorsal exoskeleton. They contain oocyte and small spherical ova.

Stage II Early maturing

Thin ovaries visible through the exoskeleton. The anterior lobes are developing. The dorsal surface is light yellow to yellowish green colour. Yellow granules are opaque.

Stage III Late maturing

Thick and solid ovaries visible through the exoskeleton. The anterior and middle lobes are fully developed. Maturing ova are opaque. Colour is light green.

Stage IV Mature

Diamond shaped ovaries appear dark olive green visible through the exoskeleton. Ova well developed and periphery of ova are transparent.

Stage V Spent:

Spent ovaries appear similar to stage I.

Breeding:

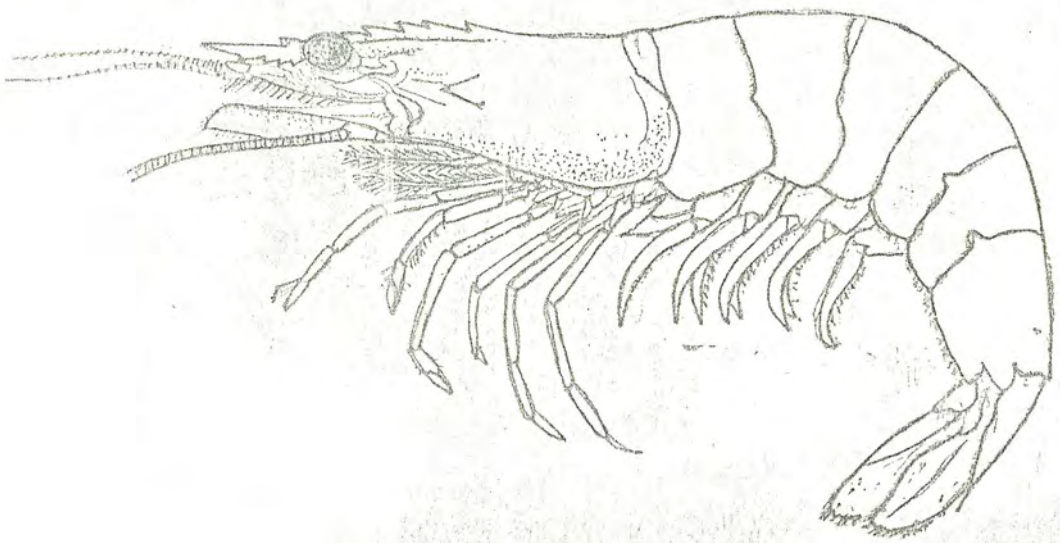
In wild condition, the sexual maturity is attained only in the sea. Breeding seems to take place almost round the year with a peak season between January and May.

Pre-copulatory behaviour in *P. monodon* begins with the attraction of more than one hard shelled males to a newly moulted female. One male manages to take position directly below the female and both male and female swim parallel to each other. Then after some time, the male turns ventral side up and finally shifts from parallel position to perpendicular to the female (Fig. 7 a & b). And finally the male curves his body in a 'U' shaped around the female (Fig. 8 a & b). The mating process may last from 30 minutes to 3 hours.

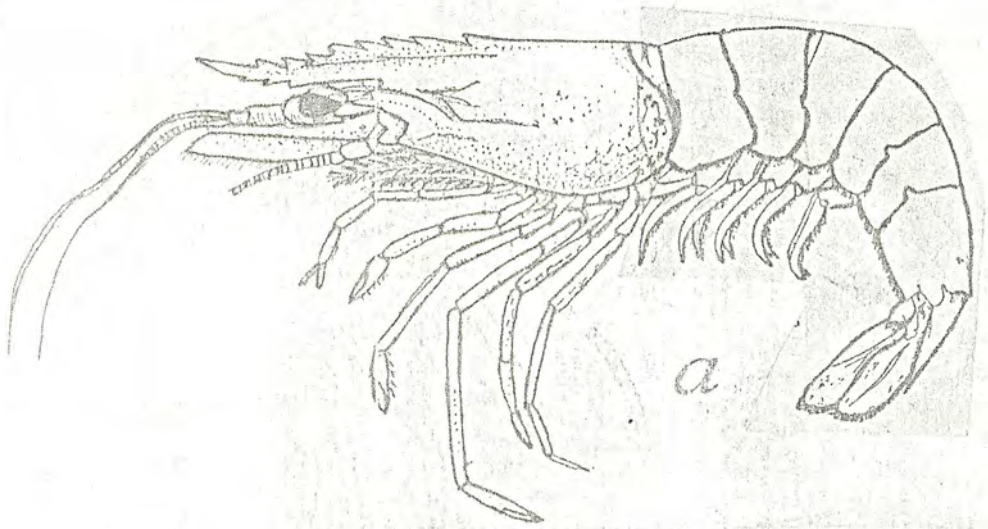
Spawning:

Spawning in *P. monodon* generally occurs between 22.00 and 02.00 hrs. Eggs are generally released through the gonopores over a period of 2 to 7 minutes.

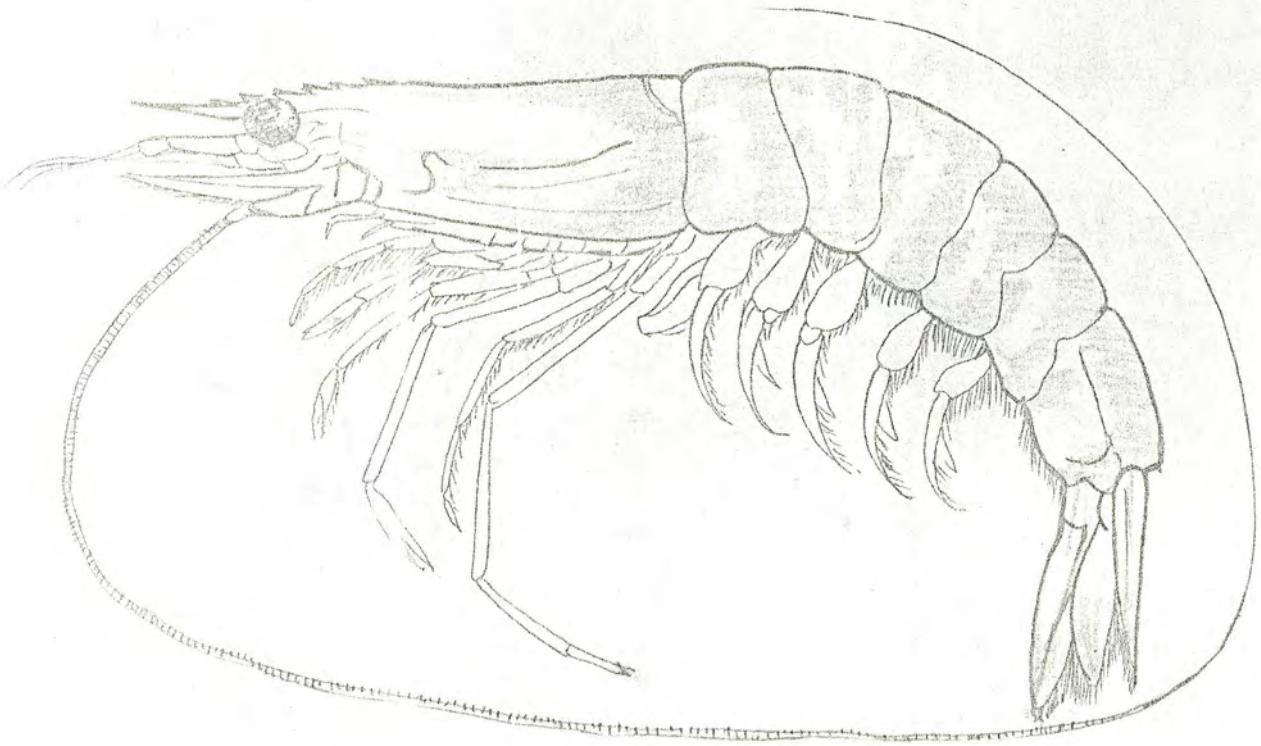
Fertilisation is external and the fertilised eggs are never carried by the female like *Macrobrachium* species. Hatching time varies between 12 and 16 hours at 27-29 0C temperature.



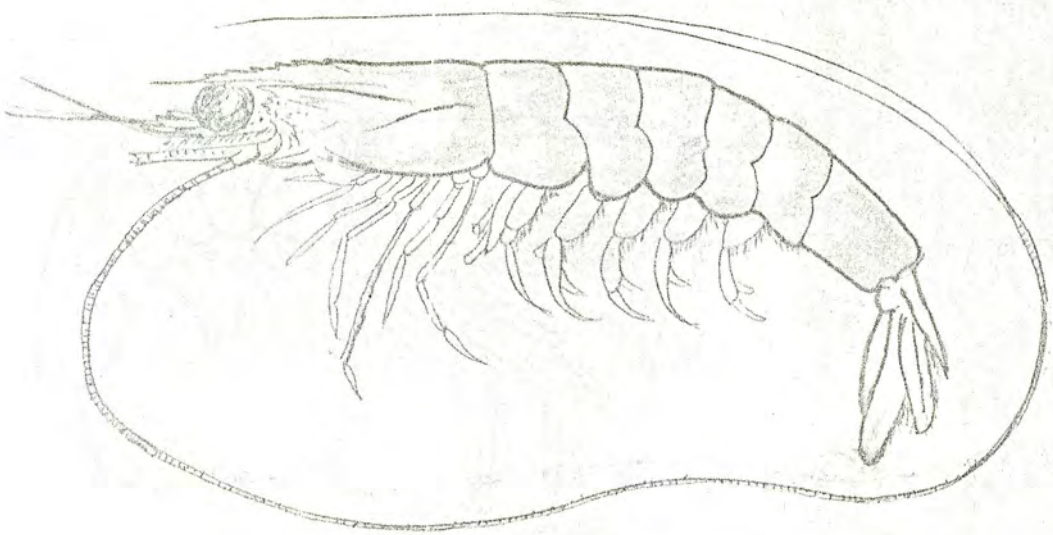
Penaeus indicus



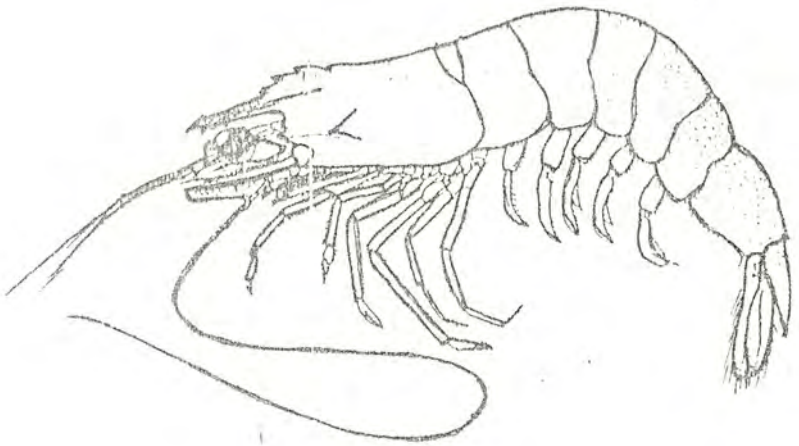
Penaeus semisulcatus



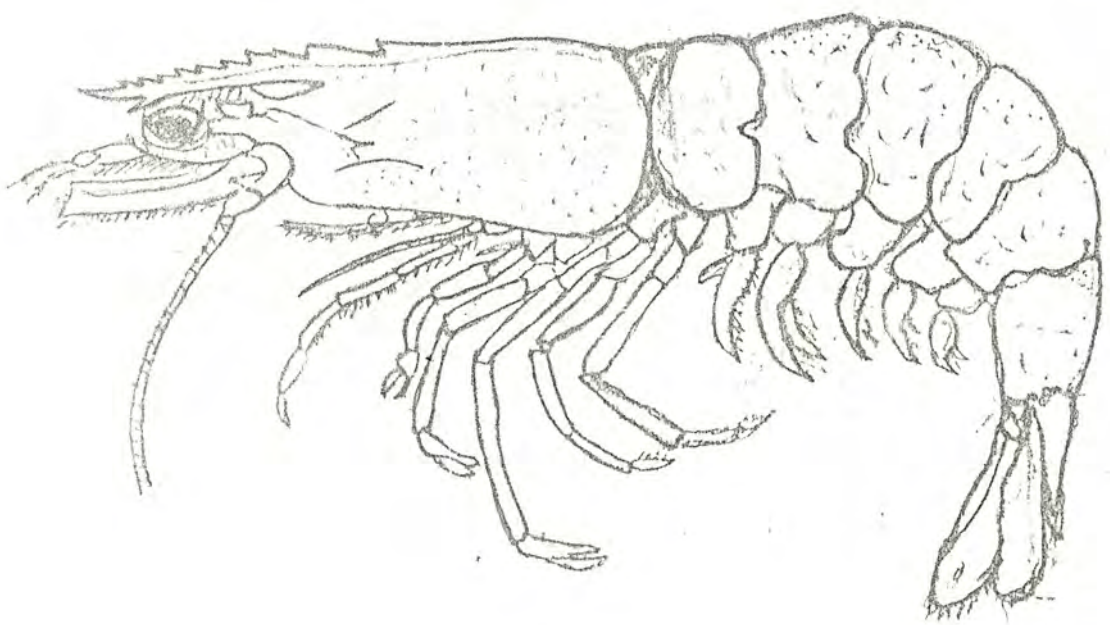
Metapenaeus affinis



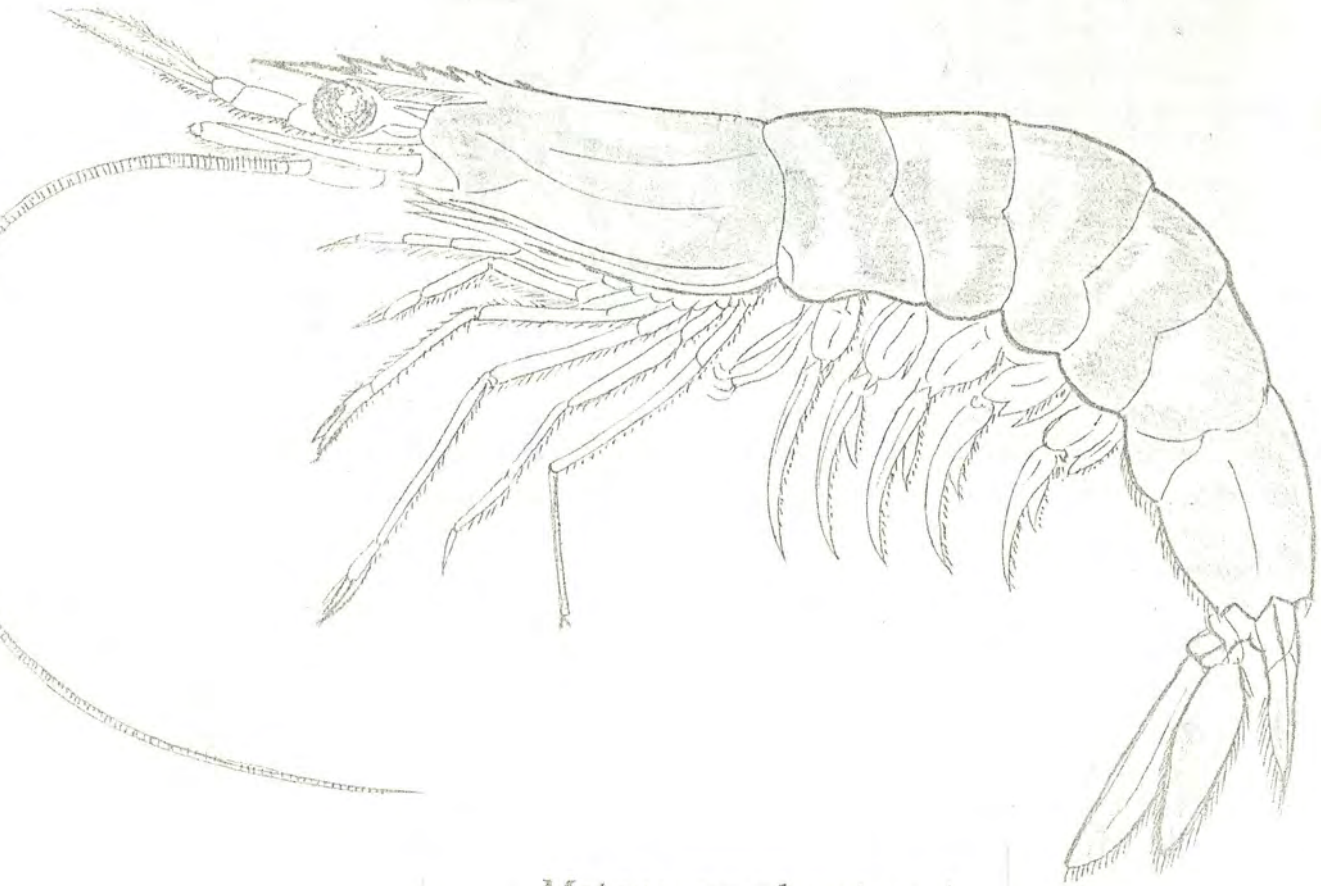
Metapenaeus dobsoni



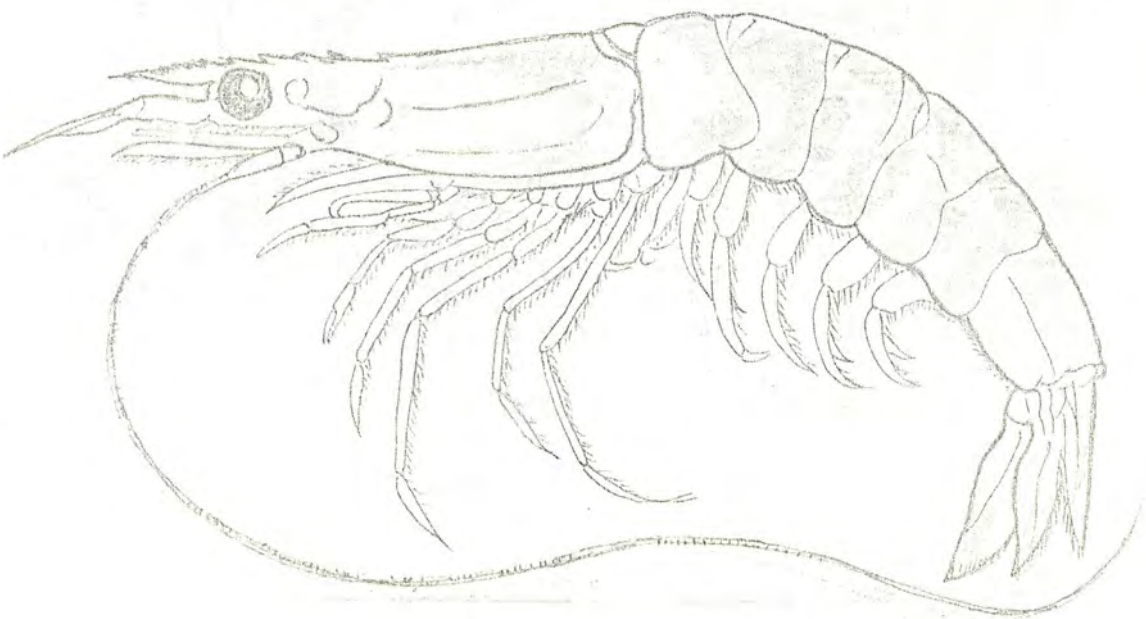
Penaeus merguiensis



Penaeus canaliculatus



Metapenaeus brevicornis



Metapenaeus monoceros

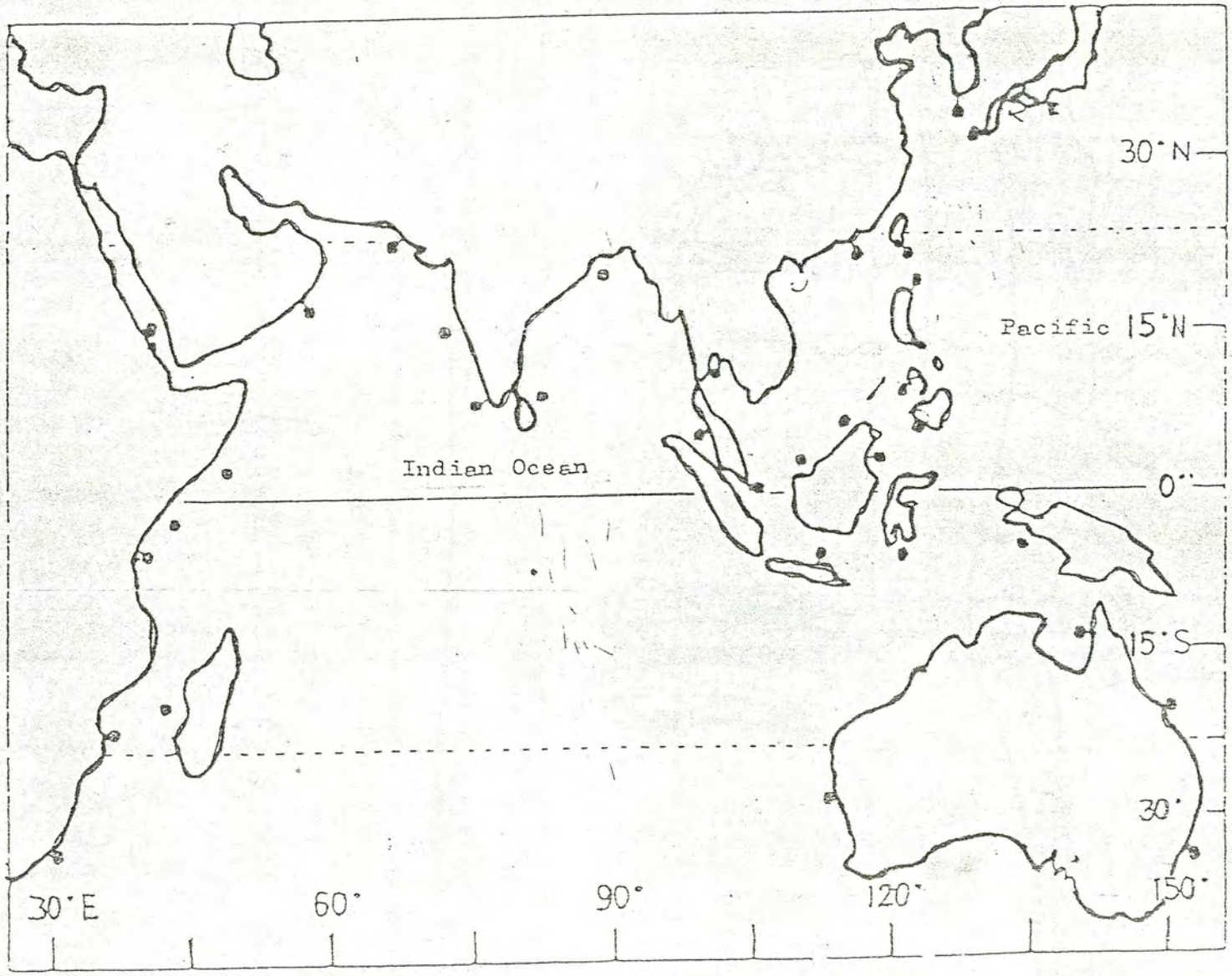


FIG.1. Distribution of Penaeus monodon.

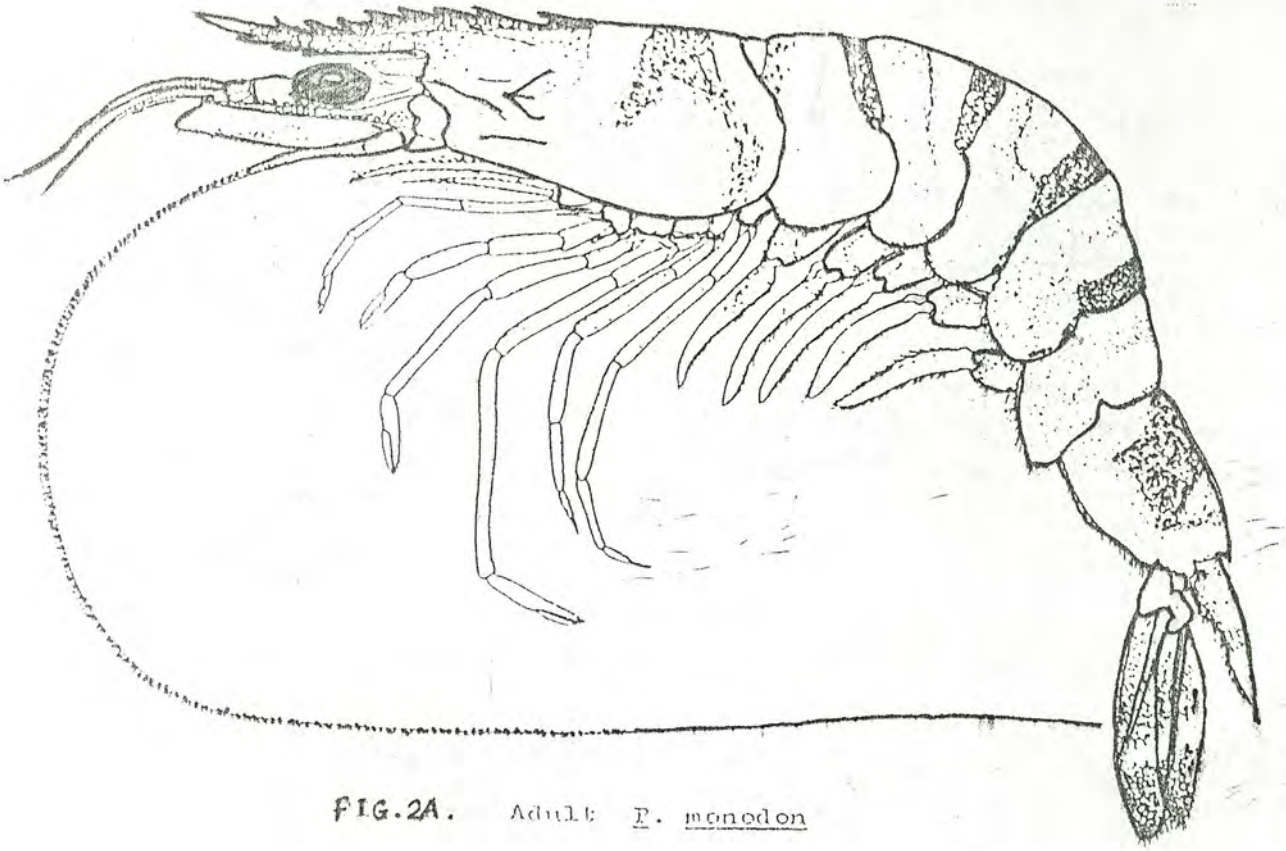


FIG.2A. Adult P. monodon

FIG.2B. Thelycum of female

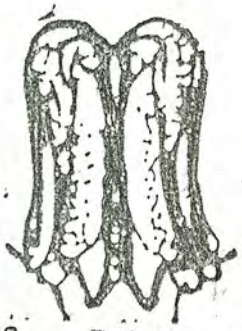


FIG.2C. Petasma of male

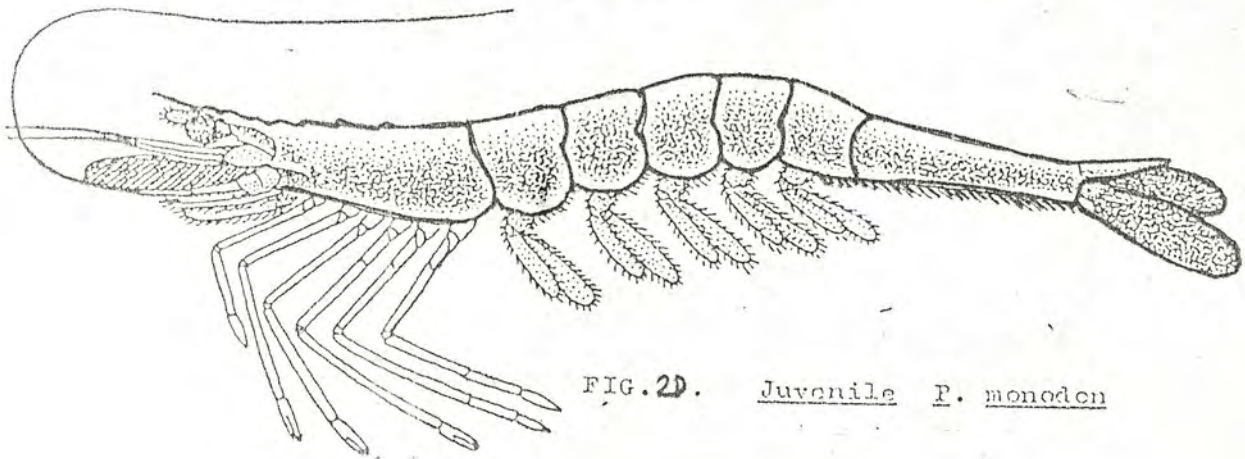


FIG.2D. Juvenile P. monodon

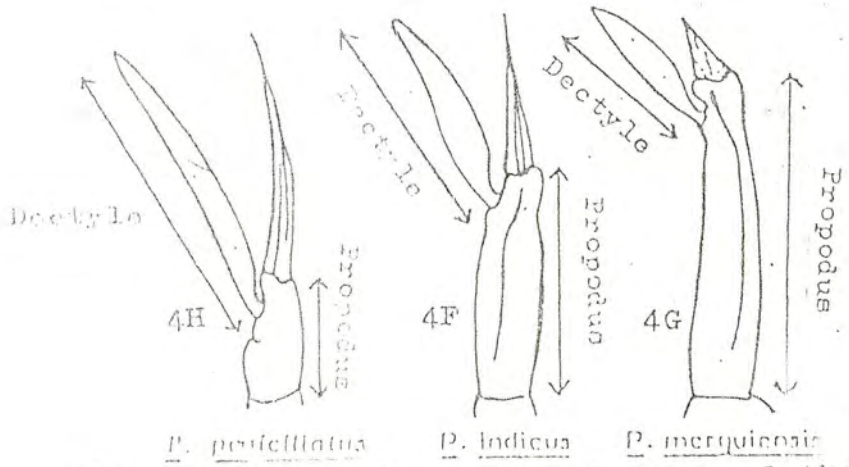
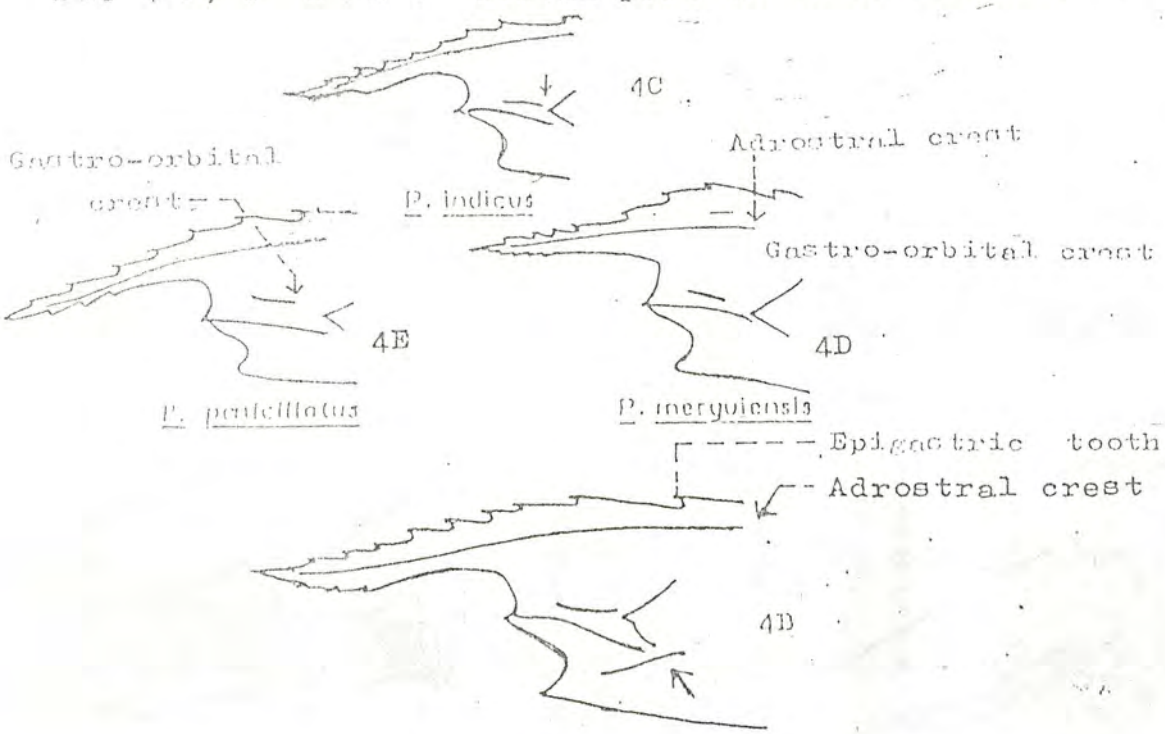
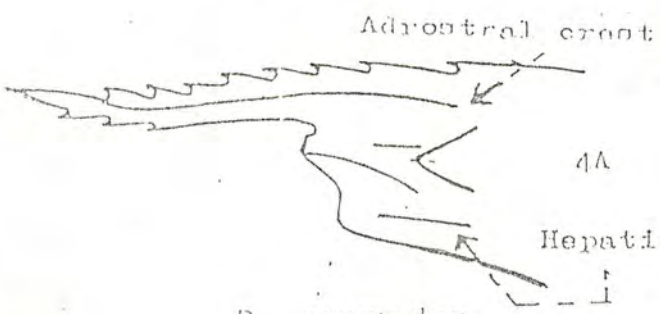


FIG 4 F, G & H : Distal part of third maxilliped



P. semisulcatus



P. mixrodon

FIG. 4A, B, C, D, and E : Anterior part of Carapace.

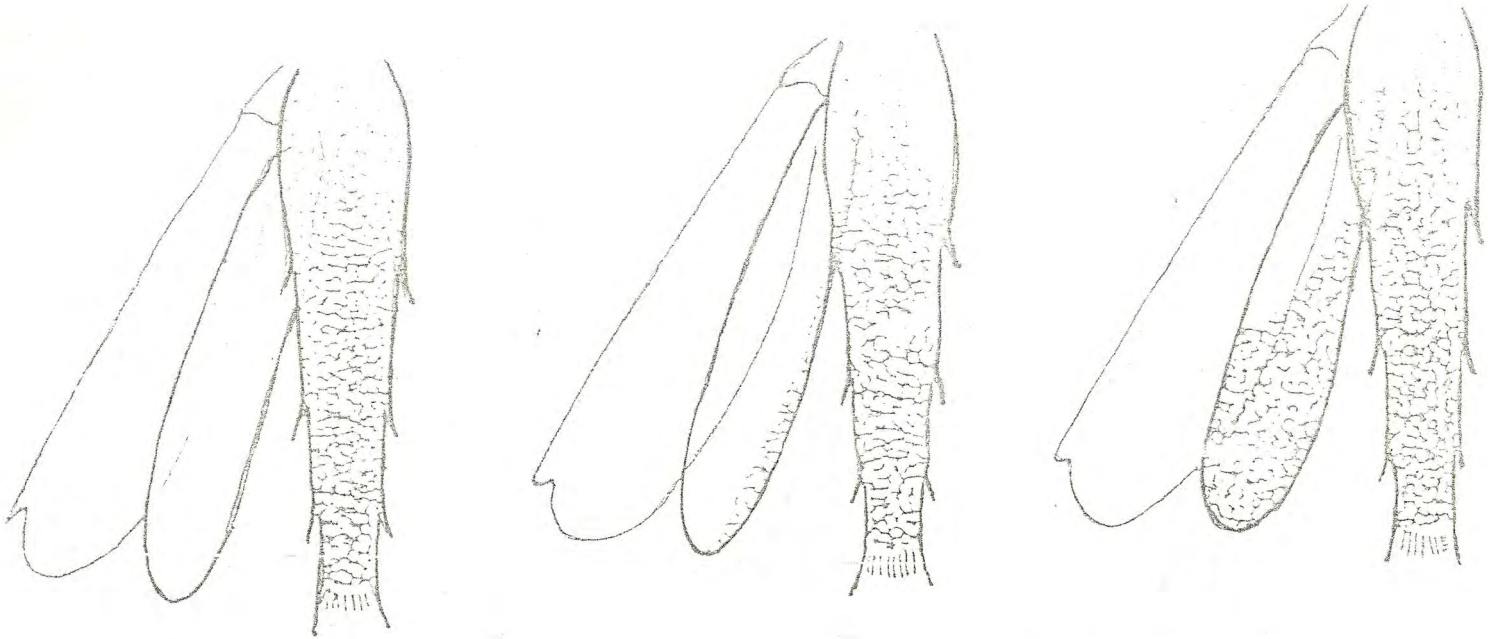
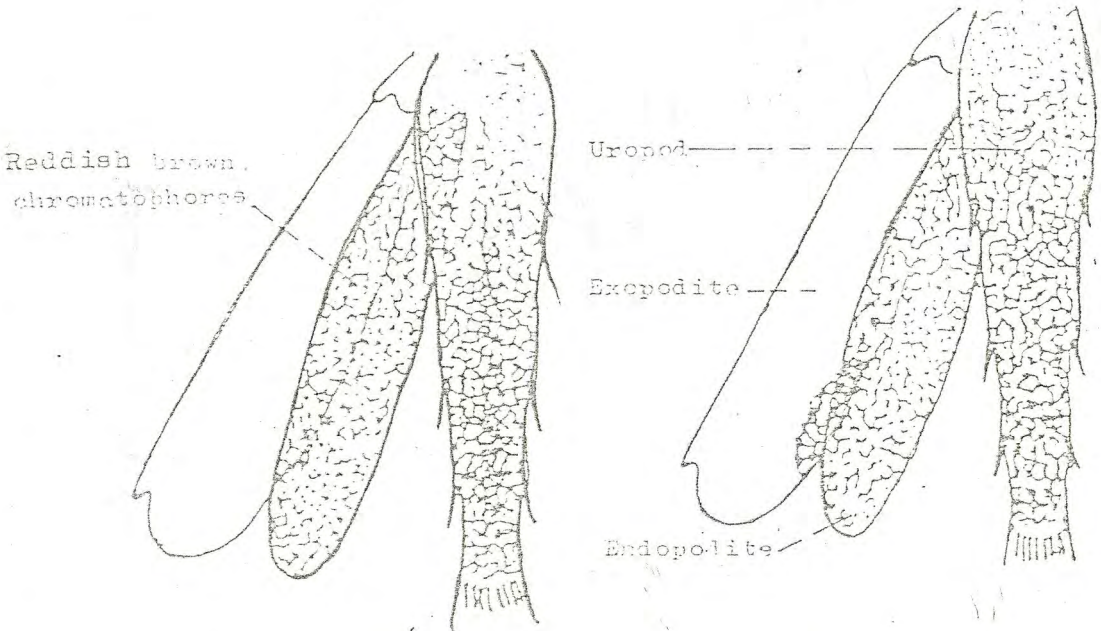


FIG.3 Chromatophores on endopod of sixth abdominal segment.



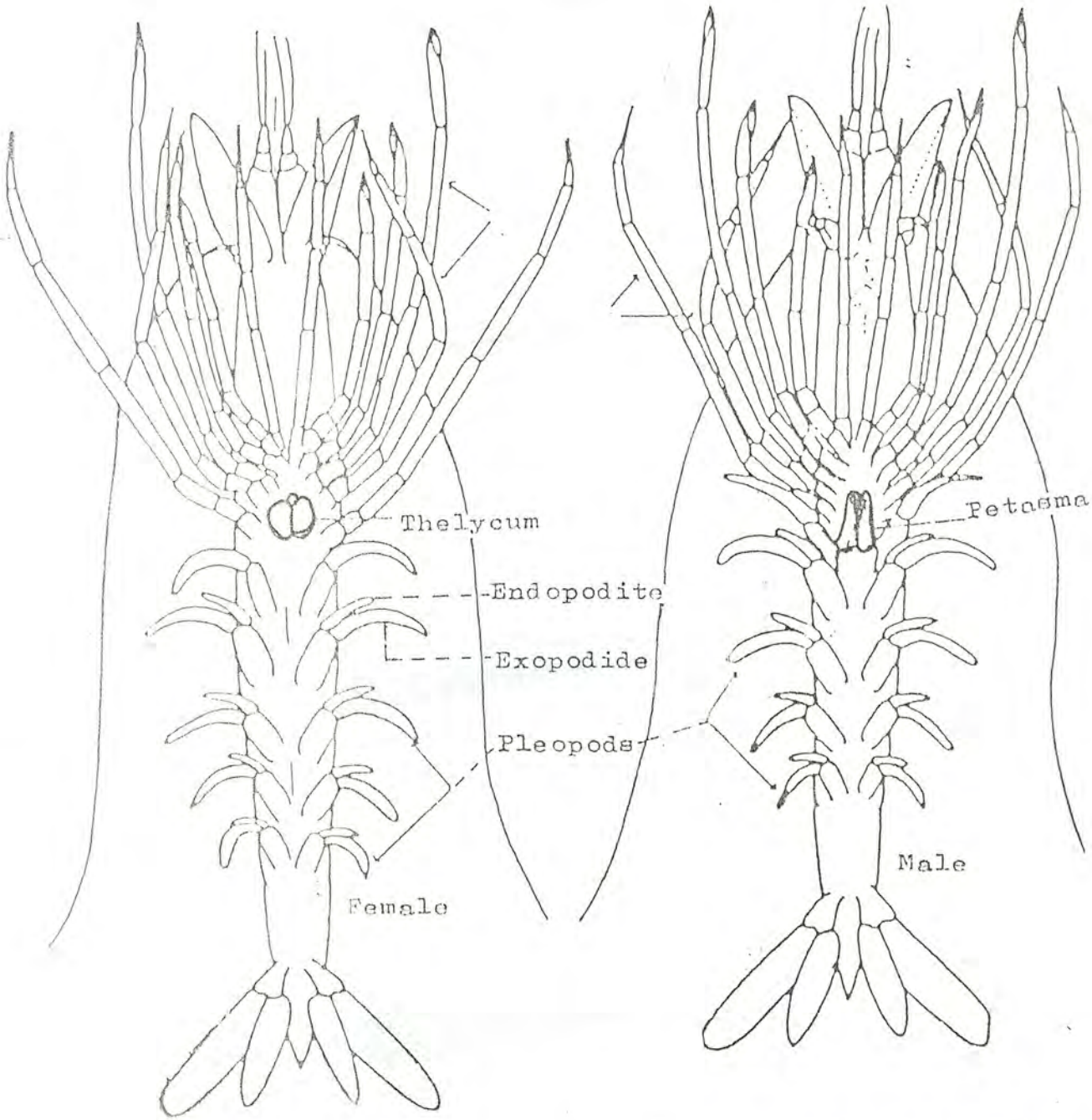


FIG 5 : Diagrametic figure of male and female P. Monodon (Venlral side)

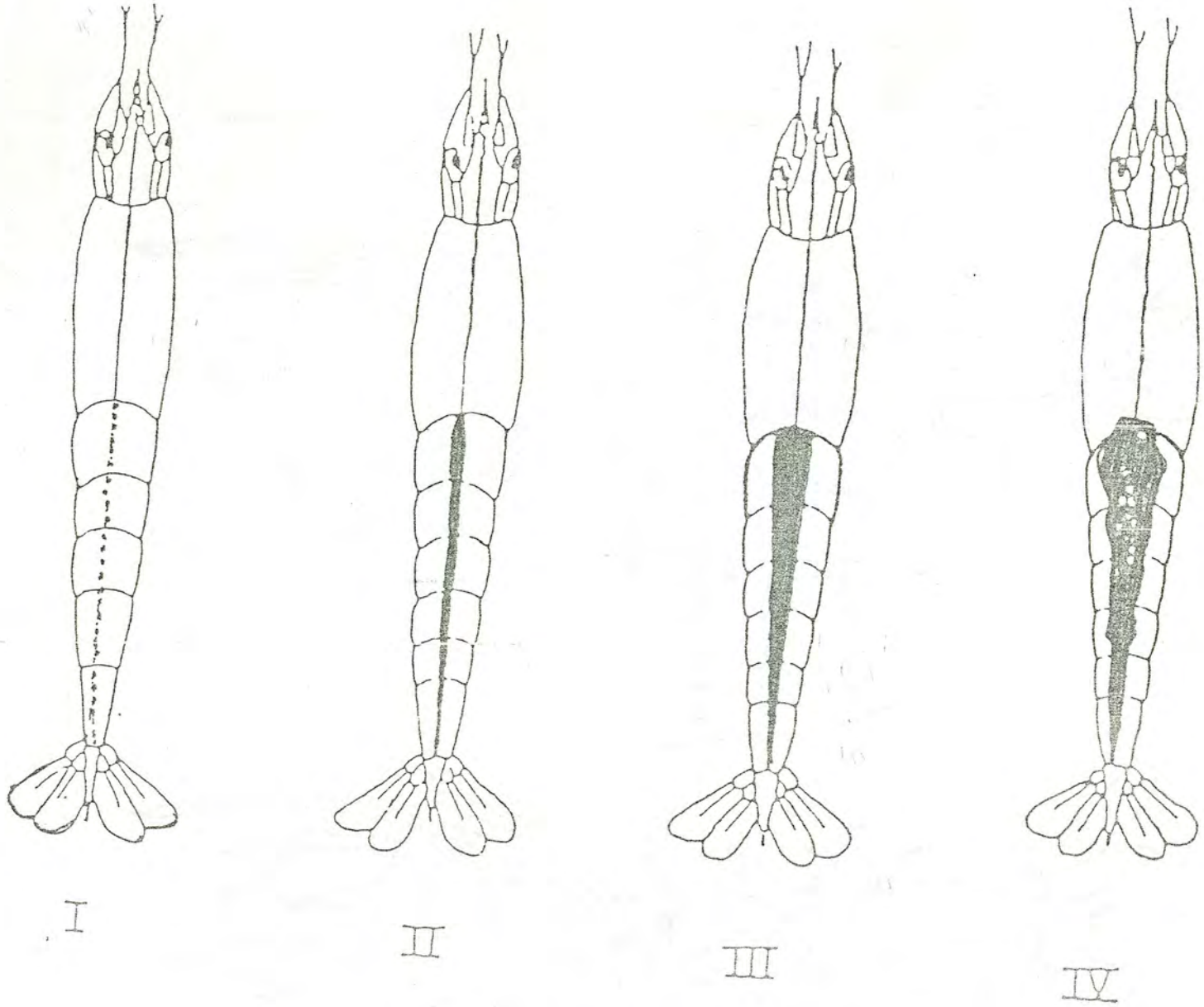
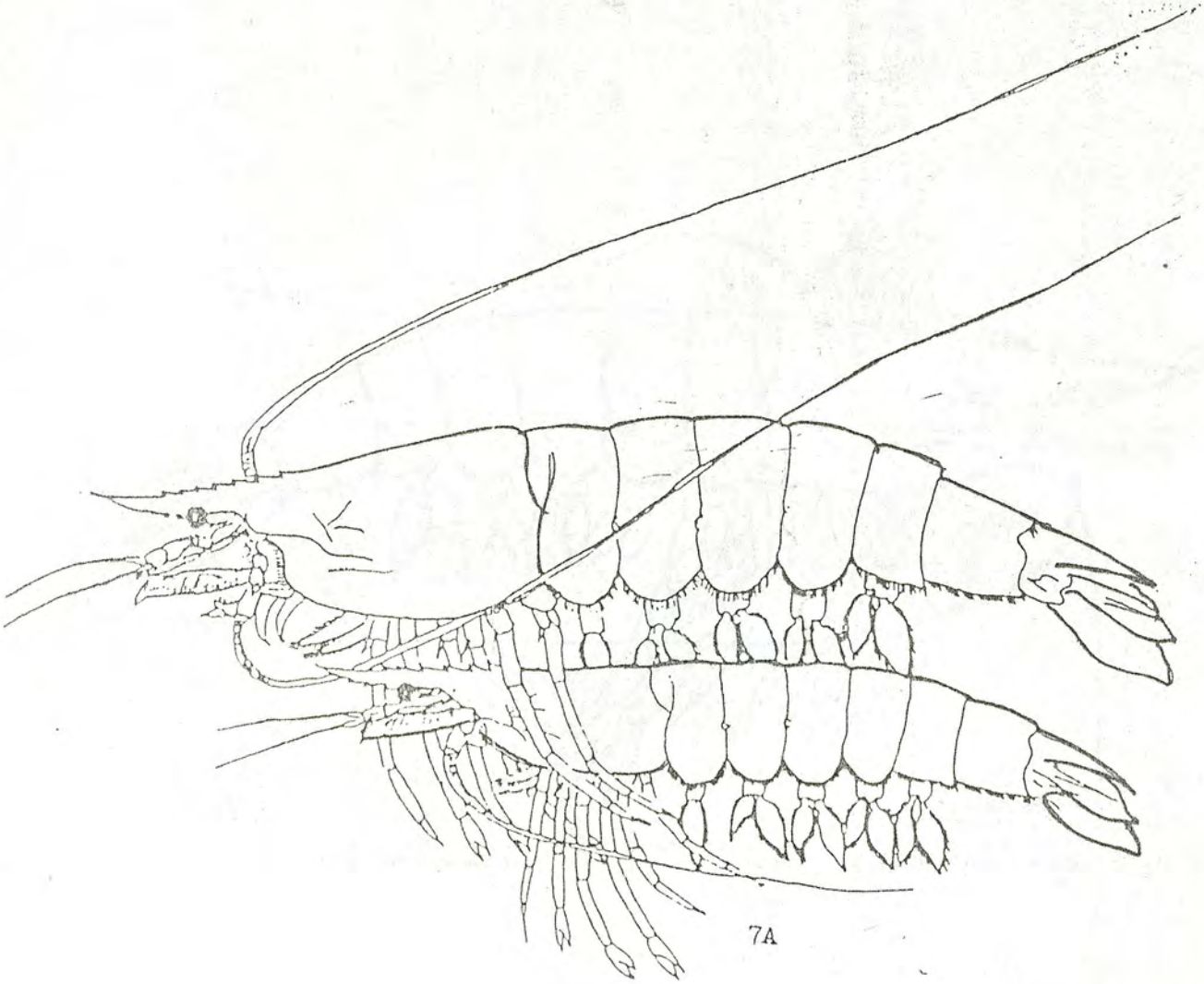
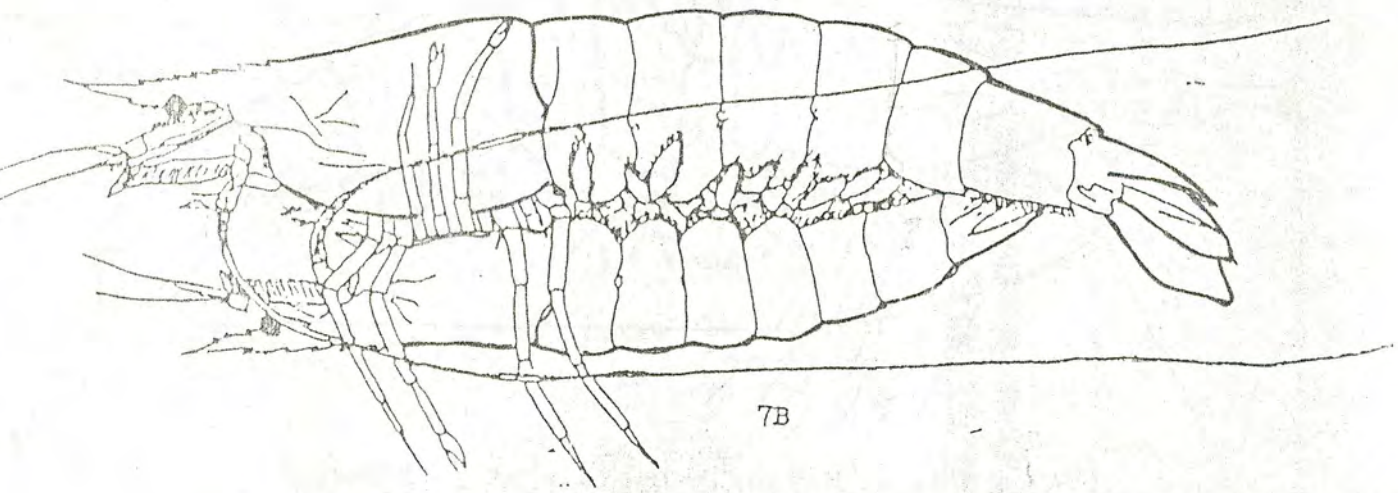


FIG 6 : Female maturity stages of *P. monodon*

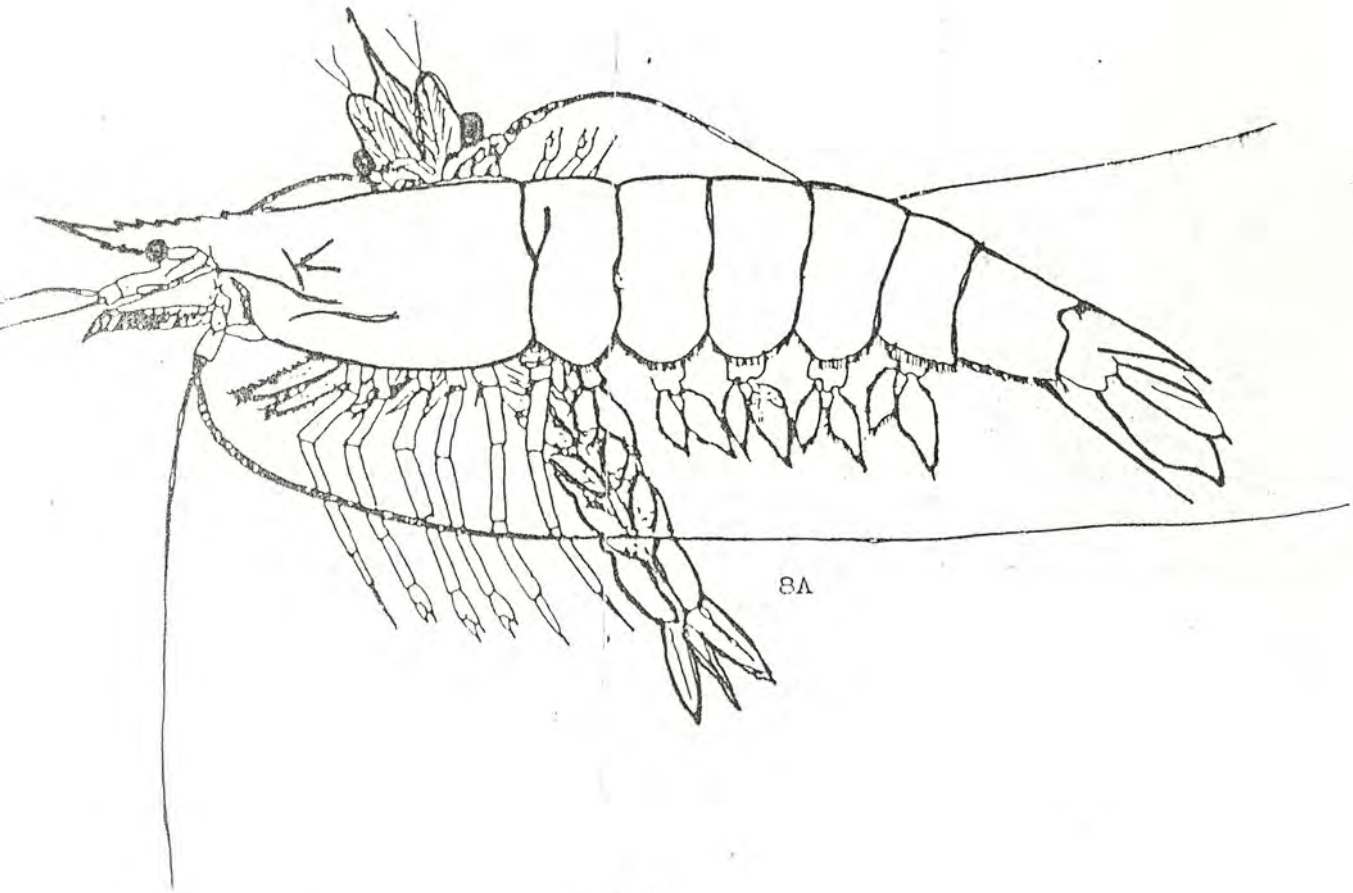


7A

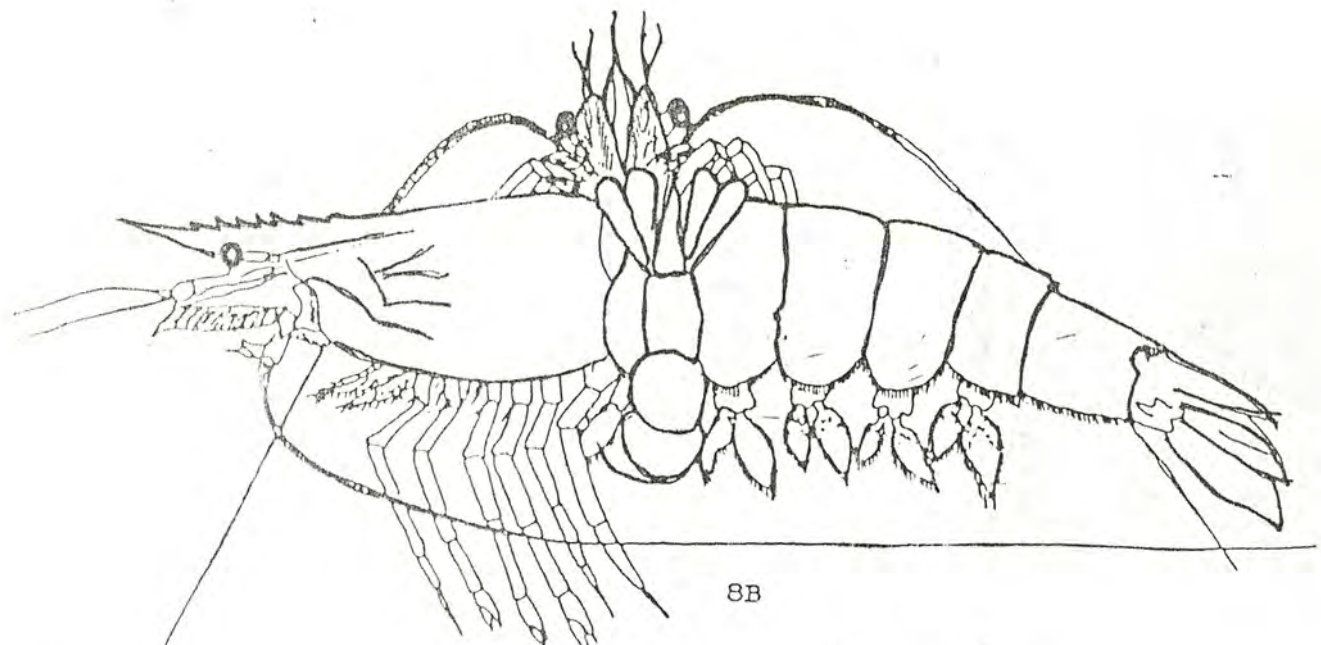


7B

7A & 7B : Pre-copulatory behaviour of P. monodon



8A



8B

8A & 8B : Mating behaviour of P. monodon

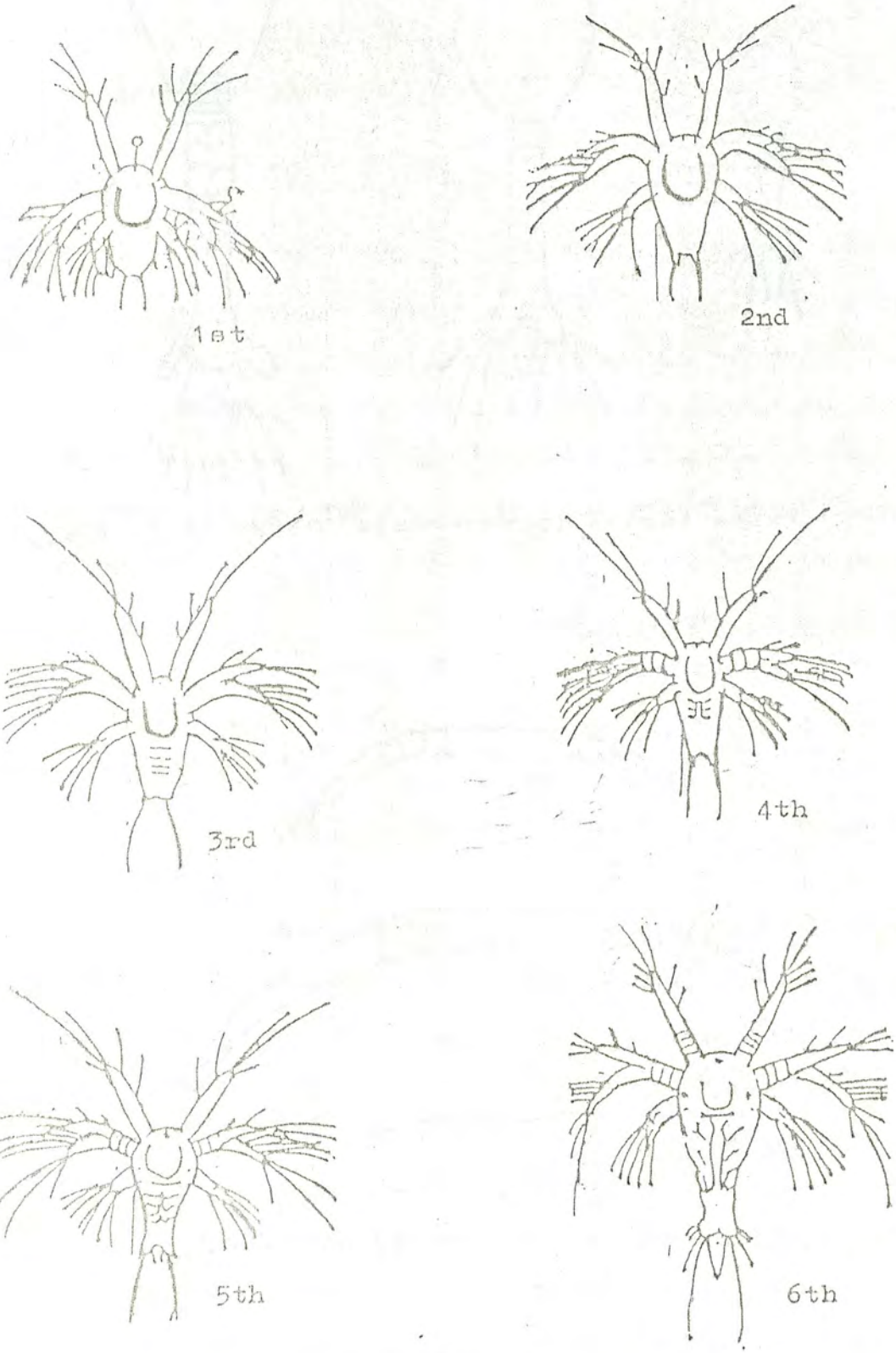


FIG 9 : Six larval (nauplii) stages of P. monodon

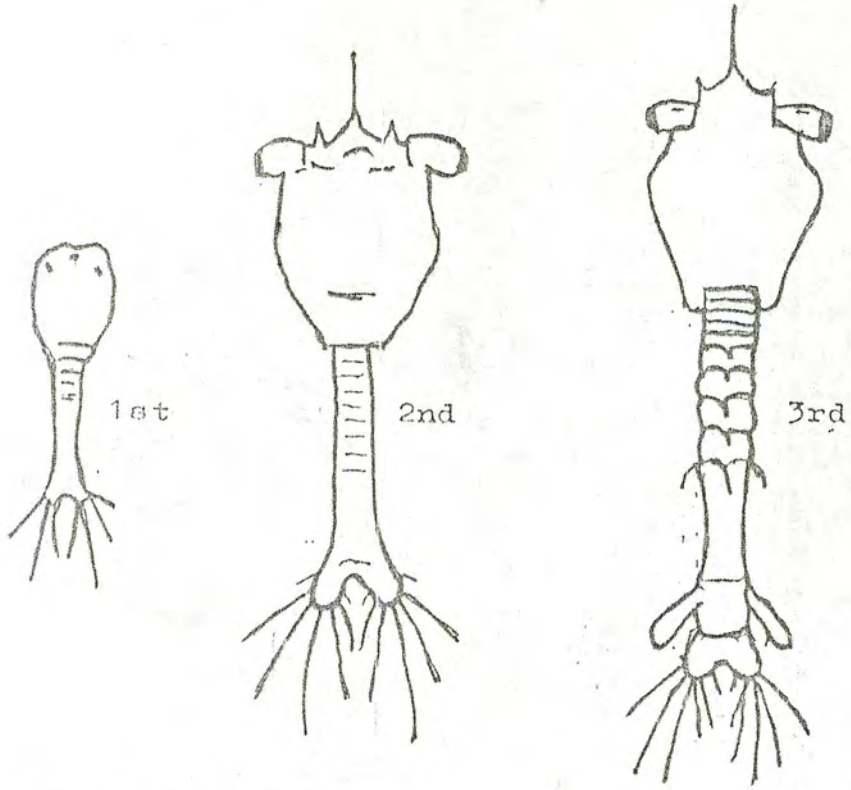


FIG 10 : Three larval (proto-zoeae) stage of P. monodon

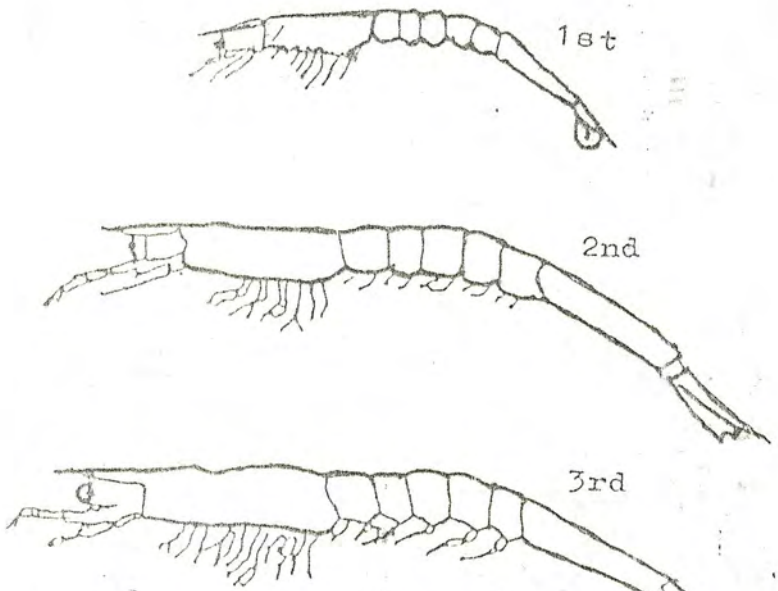
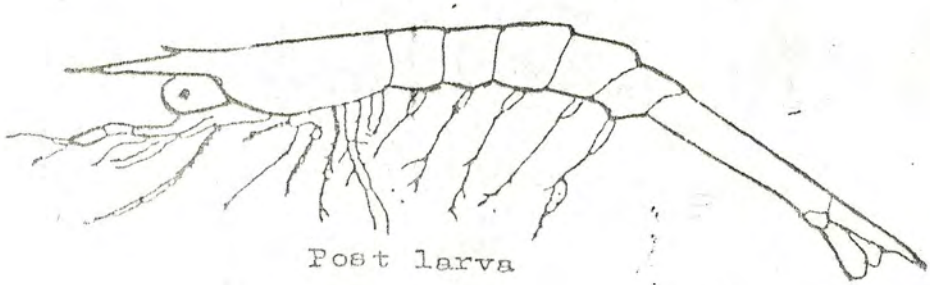


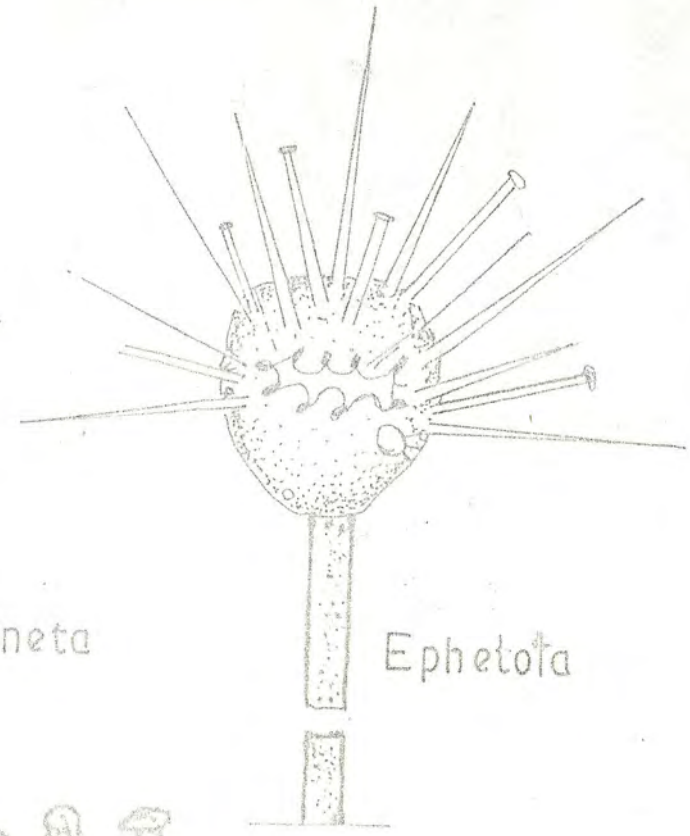
FIG 11 : Three larval (mysis) stage of P. monodon



Post larva

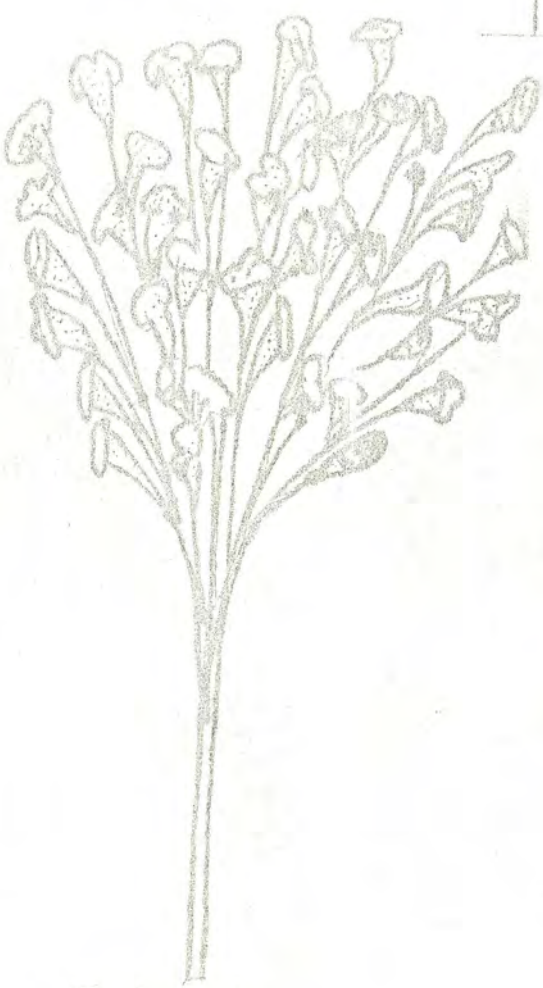
FIG 12 : Life cycle of P. monodon

Acineta



Ephetota

Vorticella



Epistylis

Zoothamnium

Fecundity:

Fecundity is estimated to range from 3,00,000 to 8,00,000 eggs. Eye stalk ablated females are reported to lay eggs from 60,000 to 6,00,000 numbers during spawning.

Larval development

The newly hatched larva passess through twelve distinct larval stages to attain post larva. The larval stages include 6 nauplii, 3 protozoeae and 3 mysis. The period of metamorphosis from newly hatched larva to post larva (14 mm stage) varies from 18 to 24 days (Table-1). The post-larvae, shrimp like in appearance invade inshore and brackishwaters and become bottom dwellers living in shallow littoral areas. In these rich nursery grounds they grow rapidly, develop into juvenile. As size increases they move gradually toward offshore and finally reach the spawning ground when they become adults. This life cycle is repeated (Fig. 12).

Table 1. Stages of larval development of *Penaeus monodon*

	Stage	Size (mm)	Day
1.	Nauplius (N_1)	0.32	6 nauplii stages take 1 and half to 2 days (Fig. 9. 1st to 6th)
2.	,, (N_2)	0.35	
3.	,, (N_3)	0.39	
4.	,, (N_4)	0.40	
5.	,, (N_5)	0.41	
6.	,, (N_6)	0.54	
7.	Protozoeae (Z_1)	1.02	3 protozoeae stages take 5 days (Fig. 10. 1st to 3rd)
8.	,, (Z_2)	0.90	
9.	,, (Z_3)	3.20	
10.	Mysis (M_1)	3.80	3 mysis stages take 4-5 days (Fig. 11. 1st to 3rd).
11.	,, (M_2)	4.30	
12.	,, (M_3)	4.50	

Post larvae or Megalopa larvae again undergo 3 to 4 stages which take 6-15 days and to attain 14 mm post-larval stage it requires 18-24 days.

PRAWN SEED RESOURCES, ITS COLLECTION TECHNIQUES, TRANSPORT AND MARKETING

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INTRODUCTION

In India a large variety of species of prawns is avaialble in open estuaries and coastal lagoons. The name of the important commercial species are; *Penaeus monodon, P. indicus, P. semisulcatus, Metapenaeus dobsoni, M. monoceros, M. affinis, Palaemon styliferus, Macrobrachium rosenbergii, M. malcolmsonii, M. lamarei, M. rude* etc. The seed resources of *P. monodon, P. indicus* and *M. rosenbergii* are dealt here since all these species are fetching a good return due to its high growth rate, demand and export value.

Seed resources :

The occurrence of these species is very wide. It breeds in sea and the development of larval stages takes place in sea where the salinity is quite high. Through the tidal waters the post larvae ranging from 12 to 20 mm in size migrate to the estuarine area. Almost throughout the year the post larvae are available in lower reaches of Hooghly-Matla estuary, estuarine creeks, in lagoons and in backwaters of Gopalpur in Mahanadi estuary and in the mouth of Chilka lake. The post larvae are available in Hooghly-Matla estuary throughout the year with peak in April to June. In Godavari estuary the post larvae are available during new moon fortnight in November to March. In Pulicat lake post larvae of the species are abundant during January to April and August to November. The larvae and Post larvae of this species are also available in back water of Madras.

The availability of shrimp seed in West Bengal at a glance :-

P. monodon

i) Entire stretches of River Hooghly in Diamond Harbour, Nurpur, Uluberia - maximum availability during April to June.

ii) Haldia, Sagar, Kulpi, Ghoramara, Lohachara, Kakdwip, Patharpratima, Godamathura - maximum available during April to July.

iii) Namkhana, Frezerganj, Bokkhali, Jambu Dwip, Mausumi - maximum available during March to June.

iv) Roydighi, Buraburirtat, Kankan Dighi - maximum available during May to June.

v) Taldi, Canning, Gosaba - maximum available during April to July.

vi) Itindaghat, Hasnabad, Kalinagar - maximum available during May to June.

vii) Entire stretches of shore area from Contai to Digha of which the following area are famous for *P. monodon* seed collection centre. Mandarbani Khal, Dubda basin khal, Patra Bar Khal - maximum seed are available during February to July.

P. indicus

Post larvae of *P. indicus* are generally available during full moon period, in Godavari estuary where maximum seed available during the end of the year i.e., November to December. In Pulicat lake maximum seed available during January to April. In the back waters of Cochin seed are available during February to April and November to December. The seed are available almost throughout the year in Chilka lake abundantly available during January to April.

Post larvae and juvenile are available in Hooghly-Matla estuary, Uluberia, Kolaghat, Nurpur, Chandipur - maximum available during February to March, Canning, Gosaba, maximum available during December to March; Kakdwip, Namkhana, Sagar, Patharpratima, Mausuni - maximum available during end of December to March.

M. rosenbergii

There are good number of freshwater prawn species available in the tropical and sub-tropical waters, out of which giant freshwater prawn *i.e., M. rosenbergii* is being cultured for its matchless fast growth, high demand in international market and nutritional value. The prawn breeding unit of CIFRI developed technology for artificial breeding and now a days some of the private entrepreneurs also breed the prawn and supply seed. The natural prawn seed resources in West Bengal is discussed below :

a) Midnapur District

i) Silabati river - in Ghatal, maximum seed are avialable during April and May.

ii) Keleghai river in Potashpur and Egra area - highest number of seed are available during July to October.

iii) Subarnarekha near Dantan area, Rasulpur, Khajuri and Kalinagar area, Pousi Khal - seed area maximum available during July to September.

b) North 24 Parganas District

In Ichamati river highest number of seed are available during June to October in the following places - Baduria, Swarupnagar, Gaighata and Itindaghat.

c) Hooghly District

Large quantities of seed are available during April to June in the river Rupnarayan, Mundeshwari and Darakeshwar. Seed are sold in Bandarghat, Tungirghat and Garer ghat area.

d) Nadia District

i) Sufficient seed are available in the month of April to June in the river Hooghly near Chakdah area.

ii) Seed are available during June to September in the river Churni at Benali Bazar, Harikhali, Balikamari, Mathabhanga near Krishnagar, Ranaghat and Simurali.

Seed collection techniques :

The process of seed collection is almost similar in all the cases. During the time of full moon and new moon period, the tidal influx lasts for 5-7 days. The occurrence of seed availability is also higher during this period. The following are the methods of collection of post larvae in West Bengal.

a) Shooting net

The post larvae of prawn seeds are generally collected with the help of shooting net. It is a funnel-shaped bag net usually made of monofilament nylon of 1/8" mesh size and is operated in shallow margin of a river or in the creeks with the mouth of the net facing the current. The size of the net varies from place to place according to the facility of the operational area. The mouth portion of net varies from 30-35 metre width. At the cod end of the net there is a detachable portion from where the larvae and post larvae are collected time to time. In nets of smaller size, separate tail pieces are not generally used. The net is fixed in such a way that its axis lies in line with the current direction. One big bamboo pole is used in the mouth portion to keep it stretches and two bamboo sticks about 3-4 metre are used to keep the mouth open in the direction of the current. At regular intervals, seeds are collected and stored in the container. In slightly deeper portion the shooting nets are operated with the help of boat.

b) Stick net

In some of the estuarine area where the slope is very steep and infested with sharks, the boats are used to collect the prawn seeds. For this reason the stick nets are used for the above seed collection. This net looks like a small funnel shaped net, the mouth portion is kept open with the support of a bamboo pole on either side. In the tail portion an empty container is tied. It functions in a double way, it acts as a container as well as a float. A person operate the net at shallow water level and collect the prawn seeds.

c) Square drag net/Scoop net

In the above two cases tidal current is highly essential otherwise the seed collection will be a problem and to avoid this problem fine meshed nylon nets are used to collect prawn seeds. A square sized net is prepared with the help of bamboo frame, the size of the bamboo frame varies from place to place *viz.*, 4 m x 4 m and 3 m x 3 m. One person drags the square type net through water from the shore and collect the seed at frequent intervals.

d) Leaf bush

It is the general nature of prawn post larvae adhere to and in floating bushes of shoots, leaves, paddy straw and other garbages in estuarine rivers and creeks. That is why the prawn seed collectors artificially keep this type of bushes in the flowing water and time to time collect the post larvae by jarking the buses in a container.

e) Pit collection

Previously this method was used for collection of brackishwater fish only, but as the demand of prawn seeds has become high, mostly the poor children of the villages of Sundarbans are using this technique for prawn seed collection too. A small hand net of size ranging from 1 to 2 metre in diameter and round, rectangular or triangular in shape is used for collection of prawn seed from inter tidal pits. During the off time when the water level is low, different sizes of pits are dug adjoining to the river banks. At time time of high tides during the full moon and new moon period the river banks are flooded and the prawn and fish seeds take shelter in the pits. During low tide the water recedes and only the water in the pits remains. A good number of prawn seed are accumulated in the pits. The local fisher folks scoop the pits through this nets and collect the prawn seeds.

Method of Prawn seed transport :

Prawn seeds are usually transported through Earthen/Aluminium hundi and as a result huge mortality occurs. It can be

controlled with the application of scientific technique. The following are the methods which can reduce the mortality :

i) It is better not to transport the seed immediately after collection from the river/creeks but acclimatize for 3-4 hours.

ii) Use 45 x 80 cm plastic bag.

iii) Fill 1/3 portion *i.e.*, 8 litres freshwater/river water in which the seeds are acclimatized, check the bag, if there is any leakage or any problem - discard the bag.

iv) Put 250-1000 prawn post larvae/litre of water, density depends upon the distance to be covered.

v) Add 2/3 fresh oxygen from the cylinder till the bag is fully inflated, then close the bag tightly.

vi) For protection from heat the plastic bag can be kept in a container and it is better to place a paper in between the bags and the container. In this process the seed can be transported up to a period of 36 hrs. with minimum mortality.

At the time of transport, mortality of the prawn seed takes place due to high density of seed, improper acclimatization, change of temperature, reduction in dissolved oxygen, accumulation of metabolites & faulty packing.

Marketing :

Marketing of Prawn seed is done in assembling centres or at the collection site itself to middle man. In assembling centres, the traders generally own individual small area (10' x 10') for their activities. They dug out small earthen pits of 4' x 3' x 2' with proper ramming of the sides and the bottom. After examining the seed and negotiating the price, it is purchased from the seed collector and stored temporarily in those dug out pits. The representatives of bheri owners purchase the seed from the assembling centres and transport it to the bheries at their own arrangements. Though price of seed is offered and negotiated per thousand seed basis but it is measured though predetermined cup. Current year (1995), the price of *P. monodon* seed varies between Rs. 700 and Rs. 3000/- per thousand and Juvenile of *M. rosenbergii* varies between Rs. 850/- to 2500/- per thousand.

At present thousands of collectors belonging to the fisher folk and agricultural communities are engaged in prawn seed collection and trade.

PRODUCTION OF LIVE FOOD FOR PRAWN

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Barrackpore

Introduction :

Aquaculture in general and the prawn farming in particular have registered phenomenal growth in recent years. It is almost an industry now and thus needs effective management at all level of exercise. One of the major problems in the prawn hatchery operation is the need for a continuous and adequate supply of the right kind of live food. More the expansion of prawn farming more the demand for acceptable single cell protien (SCP) and as a result triggered the all-out effort to conduct extensive feeding studies and screening of promising algal species. The early *Zoea* stages of prawn are exculsively dependent on the available single-celled protiens for growth and survival. It is imperative, therefore, that mass culture of such organisms is a must to amke the operation meaningful and economically viable.

Evidently blending of phycology and prawn farming is the necessity of the hour for getting higher yield. Besides, algal cells live food of animal origin like *Artemia* may also be given due consideration as the organism too has proved highly acceptable in prawn hatcheries.

1. Selection of live food :

The experience gained in different parts of the globe has indicated that all algal forms are not acceptable to prawn and thereby we have to have judicious in selecting live food for culture purposes. It is also true that the type of resource is a guiding factor in the selection of organism.

1.1 Brackishwater Algae :

Screening of algal spectrum from Brackishwater reveals that the memebrs of Bacillariophyceae dominate the system and therefore, a number of diatoms have been found highly acceptable to prawns, *Peaneus monodon* in particular. It has been observed that average diatom consumption per larva at the *Zoea* stages was as under :

Zoea I = 6,000 cells 1 day
Zoea II = 13,000 - 15,000 cells 1 day and
Zoea III = 15,000 - 20,000 cells 1 day.

Initially, attempts were made to grow natural and mixed diatoms species, in the hatchery pond itself. The diatoms found suitable for this type of activity were *Chaetoceros sp., skeletoma sp., Nitzschia spp.,Navicula spp* and *Thalossiosira sp. Chaetoceros calcitrans* in particular has shown comparatively better promise because of its small size (4 - 5 um in idiameter) fast growing capability and better adaptative quality under different environmental conditions. The other non diatoms species like Tetraselmis chuii, *Isochrysis galbana, dunaliella* etc. were also found suitable but with lesser degree of acceptability.

1.2 Freshwater Algae :

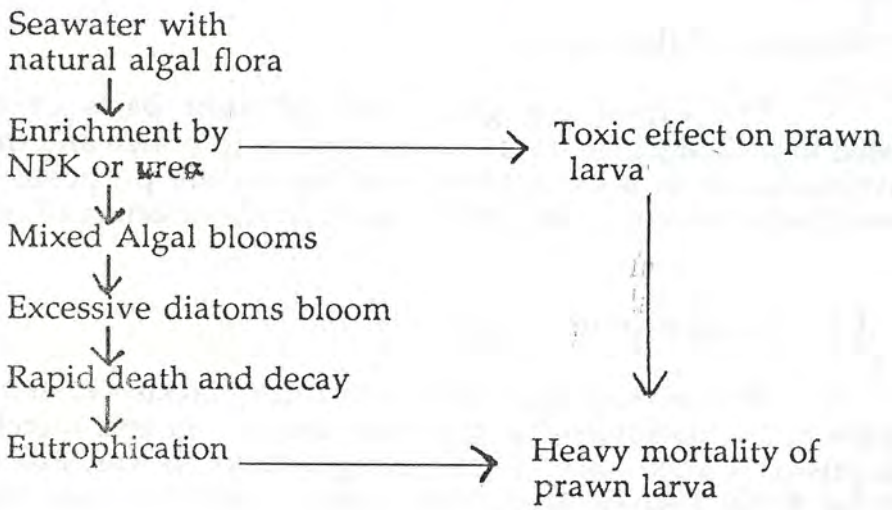
Many freshwater algae have been identified as fast growing, easy to isolate and easy to culture. And amongst them *Chlorella ellisoidea, C vulgaris, Chroococcus dispersus Slenastrum* sp., *Scenedsus* spp., *Ankistrodesmus falcatus, Navieula cuspidata, N cryptocephalla, Euglenaa Elongata* etc. were of significance.

1.1.3 Culture methods :

1.1.3.1 Brackishwater :

Mass culture of Brackishwater algal forms can be performed by two well established methods *viz., Batch culture* and *stock culture.*

Batch culture being the most conventional and convenient has been used to cultivate algal forms in the rearing tank itself. But this mode of algal cultivation generally ends with a negative impact on the water quaility, which may be summerised as under :



Inorder to minimise the rate of mortality and the reoccurrence of unhygenic condition, the Batch culture procedure need be modified by adding provision for sand filterations of the algal biomass and the concentrated diatoms population should be siphoned out in to some other reearing tank.

Stock culture is an improved mode of operation which is done in the laboratory and finally shifted to the field for having mass production. The selected algal species are being isolated from the nature and inoculated in a suitable medium containing 'macro' and 'micro' nutrients. *Chaetoeros calcitrans* is the most experimented algae in this regard as its isolation is very easy coupled with high multiplication rate in shortest possible time.

The culture medium for the mass culture of *Chaetoeros calcitrans* is presented in Table -1.

Table - I *Chaetoceros medium*

NaNo3	0.1g/l
K2HPO4	1.0g/l
FecL4	0.2g/l
Na2SiO3	0.1g/l
Vitamin (B1 + B1	1.0g/l
*Agrimin	1.0g/l
Seawater	500 ml
Freshwater	500 ml

* Agrimin 15%, Boron 5%, Iron 5%, Calcium 3%, Z inc 10%, Molybdenum 5 - 10%, Copper 5 - 10%, Pottasium 3%and Silicon 36%.

1.1.3.2 Freshwater :

Culture of freshwater algae both in laboratory and in the field, can be done using 'inorganic', 'organic' and semi-synthetic media. *Chlorella* spp. have been recognised as the most suitable algae for the mass-culture as they multiply very fast and have shown good stability under different environmental conditions. *Chroococcus dispersus* is the another organism which has shown high reproductive rate in shortest time. *Navicula Cuspidata* is the diatom which prefer organic media the most and grow very fast.

Some of the media are presented in table 2 for the culture of selected algal species.

Table - 2. Media for growing selected freshwwater algae

Inorganic medium	**g/l**
CaNo3	0.128
Mgcl2	0.0654
Mg So-1	0.0450
Kcl	0.0191
Nacl	0.0812
$NaHPo_4$	0.0229
Na NO_3	0.2573
$NaSiO_3$	0.1861
$Recl_4$	0.0003
Micronutrients	1ml/l

Organic Medium

Rice bran meal extract : Pulverise 500 gm rice bran, squezee through organdy cloth in 500 ml distilledwater; autoclave for 15 minutes.

Duck manure extract

Pulverise 500g duck manure; squezee through organdy cloth in 500 ml. distilled water; autoclave for 20 min.	10ml/l
	10ml/l
Agrimin	10g/100ml

Water	979ml/l

Semi-synthetic medium	*ml stock/l*
Inorganic medium (withour micronutrients)	800/l
Soil water extract	200/l
Agrimin	1g/l

1.2 Culrue of Artemia :

Indoor culture of Artemia , an important live food in the early stages of prawn farming, may be carried out by batch culture method.

1.2.1 Culture system :

The air-water lift operated raceway (AWL - raceway) has been recognised as an effective culture system for growing *Artemia* larval in batch culture from nauplii to adults. This system consists of a rectangular tank with a central partitioning where air-water lifts are attached.

Advantage of AWL are as under :

(a) Continuous aeration of the medium.

(b) Homogeneous circulation of the cultural medium.

(c) All particulate materials are kept in suspension.

(d) Feed added at one place is distributed all over the tank within minutes.

1.2.2 Supply of food for Artemiia :

Ricebran has been recognised as a good food for *Artemia* being the cheapest and easily available. The food should be distributed frequently, every 4 hours to attain fast growth.

1.2.3 Culture procedure :

Stocking : (a) Fill the AWL - raceway with natural seawater.

(b) Stock newly hatched Artemia nauplii in the late afternoon.

1.2.4 Management :

(a) Start food distribution before stocking.

(b) A plate separator be attached on the the rhirsl or fourth day of stocking. The mesh size of the filtre screen should variy according to the size of *Artemia*.

(c) Maintain the following conditions through out the culture period.

Salinity	30-50ppt
pH	7.5-8.5
Temparature	25-30°C
D.O.	More than 2 ppm
Ammonia Concentration	Below 80-90 ppm

Sampling and Harvest

A rough index of population density may be estimated every third day with 40ml bottles. Three samples may be taken from a fixed point in each receway culture, in bottles and individual counts may be made.

Growth need be checked by measurement of length of at least 25-30 individuals every third day.

A production of at least 3.0 - 8.0 kg net weight of Artemia per *c.* m is expected after two weeks culture time in a AWL - raceway at optimal condition.

1.3 Pond Culture of *Artemia* :

Artemia production has shown promising results in salt pens or salt ponds.

1.3.1 Selection of site :

Adequate care need be taken in the selection of proper site for the pond culture of Artemia. Costal Areas with low - rainfall and high evaporation is suitable for such operation.

1.3.2 Characteristics of suitable ponds :

A suitable pond for Artemia culture must have the following characteristics :

- High salinity, 90-100ppt
- facilities for replacement of fresh seawater.
- filling of th ponds may be done with mangrove waters for better results.

1.3.3 Depth of the ponds :

The ponds must be deep enough to retain at least 30 cm water.

1.3.4 Eliminations of predators :

Predator and other fauna must be eliminated before the ponds are stocked with *Artemia* Cysts. It is essential inview of food competition . This can be done by drying the pond and allow the same to remain dry till it cracks.

1.3.5 Growing natural food for Artemia *:*

Natural algae may be grown as the food of *Artemia,* by applying chicken mannure @ 2t/ha or inorganic fertilizers @ 50 kg/ha.

1.3.6 Artemia inoculation sstocking

- *Artemia* cysts may be be inoculated immediately after the development of naturlal food.
- Inoculation may be done at relatively low temparature *i.e.,* in the morning or in the evening.

  A stocking density of 50nos./l of pond water should be maintained.
- To determine the number grams of cysts needed for stocking, the formula given below may be followed.

Vol. of water in pond = Pond Area X water depth X 100

= L/cu m.

No. of nauplii for stocking = Vol. of water X 50 nauplii

Wt. of cysts to be hatched = Hatching efficiency X total Nos. of nauplii

(The hatching efficiency, 18 hours incubation vary between 4.8 to 18.0 according to the strain).

1.3.7 Artemia strain for inoculation :

There are number of Artemia strains available throughout the globe and amongst them Brazalian, San Pablo Bay, California, San Francisco Bay, Thailand and Australian strains have shown good results.

1.3.8 Pond Management :

- The salinity of the pond water must be maintained.
- A water depth of 30 cm must be maintained throughout the culture period.
- The available food for Artemia *viz.*, phytoplankton and suspend organic practices (fined rice bran) must be maintained
- The population density/profile must be monitored at regular intervals to augment the supply of food.
- Artemia cysts must be collected/harvested several time so that equal oppertunities are provided to all stages of development.

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PREPARATION AND UTILIZATION OF ARTIFICIAL SEAWATER FOR LARVAL REARING OF PRAWNS IN HATCHERIES

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INTRODUCTION

In the Indo-Pacific region prawn culture in coastal brackishwater ponds and impoundments has been practised for five centuries or more. The penaeid prawns belonging to the genera *Penaeus* and *Metapenaeus* spawn in the sea but the post larvae enter the estuaries and backwater areas and grow rapidly. This euryhaline nature of these prawns is exploited by man in the traditional culture operations where these naturally occuring post larvae and juveniles are trapped in tidal impoundments and allowed them to grow for short periods before they are caught. As time passed by fishery scientists made great strides in the field of aquaculture which lead to a more highly developed form of prawn culture called semi-intensive involving controlled stocking of seeds, fertilization of the ponds and supplementary feeding. In the most highly developed form of culture, all the stages from egg to the harvestable size are grown under controlled conditions. This form of culture is termed as intensive type. At present the prawn culture in India is restricted to the backwaters, lagoons and estuaries only, which cover an area of 2.6 million ha, out of which only 3 lakh ha can be utilized for culturing prawns. Presently only 65,000 ha is under culture with an average production of 0.5 t ha^{-1}. About 50,000 ha is under traditional farming system with average production of 250 kg ha^{-1} $crop^{-1}$ (NABARD). It is mainly due to the euryhaline nature of the prawn which requires saline water to complete its life history. Water management in prawn culture attains importance due to this physiological need of prawns.

WATER MANAGEMENT

Even in coastal areas nonavailability of good quality seawater/brackishwater is a major constraint in the mass scale production of prawn seeds. One of the major factors contributing to inconsistent post-larval production in hatcheries is water quality (Licop, 1988). Water quality parameters in prawn farming suggested

by the Marine Products Export Development Authority is given in Table 1. Salinity plays a crucial role in the production of prawn in intensive culture units. It is directly related to the life history of penaeid prawns where it influences many functional responses such as metabolism, growth, migration, osmotic behaviour, reproduction etc. In this context the preparation of artificial seawater becomes very important as a part of hatchery management.

PREPARATION OF ARTIFICIAL SEAWATER

The substances contained in seawater may be categorized into two types 1) dissolved substances including salts, organic compounds and dissolved gases and 2) substances present as a second phase such as gas bubbles and both organic and inorganic solids. The most obvious dissolved substances in seawater are the salts. A typical element of 1 kg seawater contains about 19 g of chlorine as chloride ion, 11 g of sodium ion, 1.3 g of magnesium and 0.9 g of sulfur mostly in the form of sulfate ion (Horne, 1969).

Dittmar (1884) made careful determinations of their compositions on 77 water samples representatives of all oceans which had been collected on the voyage around the world by H. M. S. Challenger. Dittmar's work showed that there were no significant regional differences in the relative composition of seawater. Preparation of an exact duplicate seawater with its complicated properties is impossible. Yet scientists worked on it since many decades. First work on this line is of McClendon *et al*, (1917). They were followed by Brujewicz (1931) and Lyman and Fleming (1940). Formulae for preparation of artificial seawater (Cl=19.00%) by these workers are given in Table 2.

ARTIFICIAL SEAWATER IN PRAWN FARMING

Studies were conducted by the Central Institute of Fisheries Education (CIFE), Central Institute of Brackishwater Aquaculture (CIBA), Central Institute of Freshwater Aquaculture (CIFA) and many other organisations to standardise formula for artificial seawater to suit the prawn culture experiments in India. Kanaujia and Pani (1994) in their work on the seed production of *Macrobrachium malcolmsonii* tried to grow this species in synthetic seawater. *M. malcolmsonii* needs brackishwater of 18-20 ppt salinity.

PREPARATION OF SYNTHETIC SEAWATER IN CIFA

A commmercial grade synthetic seawater was prepared with the following ingredients:-

Ingredients		*Quantiity* kg
Common salt	:	18.8
Magnesium chloride	:	3.8
Sodium sulphaste	:	3.12
Calcuim chloride	:	0.88
Potassium chloride	:	0.52
Sodum bicarbonate	:	1.16
Potassium bromide	:	0.08
Boric acid	:	0.02
Strontium chloride	:	0.002

These ingradients were dissolved in 1000 l of freshwater to obtain 18-20 ppt salinity. The prepared seawater was mixed thoroughly and kept for aging in sunlight for a week. This water is filtered through sand filter before use. The cost of this preparation was worked out as 40 paise per litre.

The larvae were reared in 300-500 l tanks adopting an air-lift recirculatory system with biofilter. There was no significant difference in the production of post larvae in synthetic and natural seawater (Kanaujia and Pani, *op. cit.*).

PREPARATION OF ARTIFICIAL SEAWATER IN CIFE

Sreekrishna *et al* (1994) standardised the preparation of artificial seawater in CIFE, Bombay. Artificial seawater of 15 ppt salinity was prepared by mixing six major salts, six minor salts and six trace salts. The quantities of major, minor and trace salts required to prepare 1000 l of 15 ppt seawater are given in Table 3. The preparation was made in three stages over a period of 3 days. All the six major salts are mixed at a time on the first day. Minor salts and trace salts are added on the 2nd and 3rd day respectively. Care must be taken to avoid precipitation of salts by stirring the mixture well.

The cost of artificial brackishwater (15 ppt) to produce 1000 post larvae is estimated at Rs. 40/- Here water exchange per day is 40%, rearing period is 45 days at a stocking rate of 40 larvae with survival rate of 40%. In this procedure 50% of water is recirculated through biofilter.

HATCHING AND LARVAL REARING OF *M. ROSENBERGII* IN ARTIFICIAL SEAWATER

In the CIFE experiment berried females with grey colour eggs were transferred into 400 l fibre glass spawning tanks with 4-5 ppt salinity artificial brackishwater. After hatching, stage-I larvae were removed to a rearing tank with 13 ppt salinity brackishwater. The salinity was gradually raised to 15 ppt and maintained until first post larvae were observed. Following this, the salinity was to reduce to 13 ppt. This salinity was maintained until all the larvae were metamorphosed into post larvae.

Preliminary experiments on rearing prawn larvae in artificial seawater have been undertaken in different agroclimatic conditions in Andhra Pradesh, Madhya Pradesh, Uttar Pradesh, Orissa, West Bengal and Kerala. It is hoped that many more hatcheries would come up where natural seawater is replaced successfully by artificial seawater.

Table 1. Water quality parameters in prawn farming

(suggested by MPEDA)

Parameters	Method of measurement	Suitable level
1. Salinity	Refractometer, Hydrometer	10-25 ppt
2. pH	pH meter, pH paper	6.8-8.7
3. DO	DO meter, Winkler titration	> 3.5 ppm
4. Temperature	DO meter, Thermometer	26-32 °C
5. Turbidity	Secchi disc	> 30 cm.
6. Total NH_3-N	Ammonia specific electrode	pH 7-8
	Calorimetric test using Nesslers RGT	< 1.1 ppm
7. Nitrite -N	Calorimetric test using sulfanilamide	< 0.1 ppm
8. Alkalinity	Two step titration of Std. 20 ppm Acid	> 20 ppm
9. H_2S	Colorimetric test using P-phenylene Diamine Hydrochloride	pH 6-7 <0.004 ppm pH 7-8 <0.007 ppm pH 8-9 <0.004 ppm

Table 2. Formulae for artificial sea water (Cl=19.00‰)

McClendon et al (1917)		*Brujewicz (Subow, 1931)*		*Lyman and Fleming (1940)*	
Salt	***g/kg***	***Salt***	***g/kg***	***Salt***	***g/kg***
NaCl	26.726	NaCl	26.518	NaCl	23.476
$MgCl_2$	2.260	$MgCl_2$	2.447	$MgCl_2$	4.981
$MgSO_4$	3.248	$MgSO_4$	3.305	Na_2SO_4	3.917
$CaCl_2$	1.153	$CaCl_2$	1.141	$CaCl_2$	1.102
KCL	0.721	KCL	0.725	KCL	0.664
$NaHCO_3$	0.198	$NaHCO_3$	0.202	$NaHCO_3$	0.192
NaBr	0.058	NaBr	0.083	KBr	0.096
H_3BO_3	0.058			H_3BO_3	0.026
Na_2SiO_3	0.0024			$SrCl_2$	0.024
$Na_2Si_4O_2$	0.0015			NaF	0.003
H_3PO_4	0.0002				
Al_2Cl_4	0.013				
NH_3	0.002				
$LiNO_3$	0.0013				
Total	34.4406		34.421		34.481
Water to 1,000.0000		***Water to 1, 000. 000***		***Water to 1,000.000***	

Table 3. Major, minor and trace salts required to prepare one ton of 15 ppt artificial brackishwater (after Spottes., 1979)

Salts	Chemical formula	Quantity
Major salts (kg)		
Sodium chloride	Nacl	11.824
Magnesium sulphate	$MgSO_4, 7H_2O$	2.953
Magnesium chloride	$MgCl_2, 6H_2O$	2.31
Calcium chloride	$Cacl_2, 2H_2O$	0.587
Potassium chloride	KCL	0.258
Sodium bicarbonate	$NaHCO_3$	0.0896
Minor Salts (g)		
Strontium chloride	$SrCl_2, 6H_2O$	8.5
Manganese sulphate	$MnSO_4, H_2O$	1.697
Sodium phosphate	$NaH_2PO_4, 7H_2O$	1.697
Lithium chloride	LiCl	0.425
Sodium molybdate	$Na_2MoO_4, 2H_2O$	0.425
Sodium thiosulphate	$Na_2S_2O_3, 5H_2O$	0.425
Trace salts (g)		
Potassium bromide	Kbr	11.52
Aluminium sulphate	$Al_2(SO_4)_3, 18H_2O$	0.368
Rubidium chloride	RbCl	0.063
Zinc sulphate	$ZnSO_4, 7H_2O$	0.041
Cobalt sulphate	$CoSo_4, 7H_2O$	0.038
Potassium iodide	KI	0.038
Cupric sulphate	$CuSO_4, 5H_2O$	0.038

Cost of production Rs. 40/1000 post larvae

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FRESHWATER PRAWN SEED PRODUCTION THROUGH HATCHERY MANAGEMENT

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INTRODUCTION

Recent boom in scampi culture has created high demand for freshwater prawn seed. But, the nature has its limitations to supply the same as needed. So, there is an urgent want for hatchery grown seed. Dr. S. W. Ling in 1962, established that *Macrobrachium rosenbergii* larvae require brackishwater for their rearing. By 1965, Dr. Fujimura developed 'green water' method of seed raising which has been subsequently replaced by the advanced technique of 'clean water' seed production system. *Macrobrachium* has 150 species of which 49 are commercial for Asian & Pacific countries. The fastest growing giant freshwater prawn, *M. rosenbergii* has three sub-species *viz.*, blue-clawed ones, orange-clawed ones and small spineless clawed ones. Blue-clawed scampi is the best from culture and growth point of view. The hatchery system comprises larval rearing tank, mixing and brine storage tank, *Artemia* incubator, biofilter for recirculation of water and other equipments.

Life history :

Scampi has four stages in its life *viz.*, eggs, larva, juvenile and adult. Number of molts and the duration of inter-molt in *M rosenbergii* is dependent on environment, food, etc. After molting, a female mates with a hard shelled male that transfers spermatophore into the brood chamber of the female that lays eggs after 3 weeks or so. Eggs are elliptical and 0.6 to 0.7 mm long. A 50 -100 g female can carry only 5000 -20,000 eggs. Larvae hatch at night, swim with head down and jump on contacting substrate. In wild, they feed on zooplankton, small insects and other invertebrate larvae.

In a hatchery, larval metamorphosis takes 26 days to become postlarva which feeds on aquatic insects and their larvae, phytoplanktons, seeds of cereals, fruit, samll mollusca, crustacea, fish flesh, slaughter-house waste and animal remains. They crawl and swim for movement. A larva passes through 11 stages of development to become a postlarva. The stages are ; sesile eyed, stalked eyed, uropoded, double dorsal epigastric toothed at the rostral base, narrow & elongated telsoned, pleopod buded, biramus & bare

pleopoded, setae covered pleoded, pleopodial appendix interna and endopodite stage, 3 - 4 dorsal toothed rostral stage and half covered dorsal marginal toothed rostral stage.

Hatchery site selection :

In selecting site for hatchery, the factors to be considered are : ground water quality; access to brine; availability of electricity, drainage system, semi-skilled labour; road communication facility; location within 16 hours' journey distance form the scampi farms and sufficiently elevated above sea-level in a flood and cyclone free area.

Hatchery shed :

The size of the shed has to depend on the capacity of hatchery. The shed has to contain hatching tanks, larvae rearing tanks, *Artemia* incubators, lab space, brood stock tanks, postlarvae storage tanks, brine storage and mixing tanks, water filtration and recirculatory systems, drainages and machine-cum-store room, etc. All these can be accomodated either together or seperately in sheds as per convenience. But the floor of the shed should be cemented and smooth for rapid cleaning. A foot bath at the entrance is required for health care.

Recirculatory system :

Sand filter tanks or barrels along with aeration system may be employed for removal of particulate material form the waste-water before recirculation.

Aeration system :

To keep the air oilfree, instead of piston-type compressors, twine lobe or vortex air blower are preferred. The blower is selected on the bais of water depth, frictional losses and airstones pressure drop *i.e.*, on effective total head which is calculated as follows :

Total head (cm) = Submergence depth (cm) + friction loss for pipe in cm + air stone pressure drop or diffuser in cm.

For a 5 million capacity hatchery 20 KVA power generators is required. Since the hatchery deals with brine, care should be taken against proper insulation of the electricity.

Tanks of the hatcheries

Tanks can be of fibre glass ferro cement, reinforced concrete plastered brick or plastic lined wooden/bamboo made usually 8 -10 m^2 tanks with in depth are used for maintining brood stock and and gravid females. Conical bottomed cement or fibre glass tanks with water changing provisions

are suitable for hatching. Otherwise a biofilter may be used, expecting for a shore hatchery. Round or coniclal bottomed tanks are superior for larval rearing as circulation and cleaning is easier. Such tank walls must be smooth and sloped for the outlet. A larval tank capacity should be within 3 to 10 t capacity for proper management and temperature stability.

Biofilter

The biofilter tank volume should be at least 6% of the rearing tank volume. It must be a multichambered one filled with gravels, shells or inert plastic bid for bacterial growth under the provision of aeration system. a 120 μ filter screen fitted siphon is attached to the last collecting chamber for maintenance of constnant level and for circulation of water @ 2 - 5 times the rearing tank volume a day. The waste water of the rearing tank is airlifted.

Artemia incubator

Translucent conical bottomed opaque cylindrical tank of 60 - 75 cm diameter 60 cm height and 150 - 250 l capacity is generally used for *Artemia* hatching. A 60 watt bulb is hung above the cylinder to stimulate hatching. The hatchlings are harvested through a small window at the tank bottom. In the night incubator should be covered to prevent insect entry.

Brine tank

Re-inforced concrete or plastic line brick and morter made tank can be used to store Brine. To make leak proof, the tank can have the inner coat of epoxy. Brine requirement volume is calculated as follows :

$$\text{Brine requirement volume} = \frac{\text{Salinity (12 ppt) X volume of rearing water (3 -10 t)}}{\text{Brine salinity (say 200 ppt)}}$$

= 180 - 600 l

Therefore, the freshwater requirement will be 2820 - 9400 l. Considering 210 days production season and 40 days' metamorphsis for each brood, four cycles per season is possible. So, as per requirement brine tank will be 180 - 600 l X 4 cycles *i.e.*, 720 - 2400 l.

To have two partial exchange *i.e.*, for 40% of the PL tank volume *i.e.*, 3 - 10 t x 0.4 = 1.2 - 4t, additional brine requirement during 4 cycles is ----

$$\frac{4 \text{ cycles} \times 12 \text{ ppt} \times 1.2 - 4t}{200 \text{ ppt}} = 72 - 240 \text{ l} \times 4$$

= 288 - 960 l.

So, total brine requirement for the PL tank is (720 - 2400 l) +(288 - 960 l) =1008 -3360 l. Now, say for 4 PL tanks of the hatchery, the brine requirement is to be multiplied accordingly.

Further, brine is required for *Artemia* cysts (eggs) stocked @ 2g/l in the incubator with 30 ppt saline water to feed prawn larvae @ 5/ml during day 1 to day 10 and @ 2.5/ml till day 40.

Thus, the estimated volume of *Artemia* incubation water is

$$\frac{(5 \text{ cysts/ml}) \times (3 - 10 \times 10^6 \text{ ml})}{2.50 \times 10^5 \text{ cysts/g} \times 0.8 \text{ hatching rate}} \div 2\text{g/l}.$$

$$= 37.5\ 125 \text{ l}.$$

So, four incubating tanks for one cycle will require 150 - 500 l/day of water for 10 days then for next 29 days the requirement will drop to 75 - 250 l/day totalling to (1500 -5000 l) + (2175 -7250 l) = 3675 - 12250 l. *i.e.*, equivalent to

$$\frac{30 \text{ ppt} \times (3675 - 12250 \text{ l}}{200 \text{ ppt}} = 551.25 - 1837.5 \text{ l brine}$$

Therefore, for 4 cycles, the need being 6327 - 20790 l and keeping some excess for emergencies, the total brine tank capacity should be of 6500 - 2100 l capacity.

The volume of mixing tanks for 12 ppt water should be double the volume of PL rearing tanks and for 30 ppt water should be double the volume of *Artemia* incubators.

Equipments required :

Submersible stainless steel pumps of 0.75 - 1.5 w are suitable for water circulation, etc. A refregerator is used to keep supplementary feed, *Artemia* nauplii and veterianary grade antibiotics. A stereo microscope for examination of larvae, a refractometer for salinity measurement, a simple beam balance for weighing *Artemia* cysts, feed ingredients, medicine, etc. then common laboratory glass wares pH papers (6 - 10 pH), an electrical pH meter, immersion heaters, aerators, etc. are also required.

Chemical requirement :

The requirement per season is 50 kg bleaching powder, 5.5 kg sodium thiosulphate and other chemicals @ 1kg each. The commonly used hatchery chemicals are : Calcium hypochlorite, sodium bicarbonate, calcium oxide, sodium thiosulphate, sodium carbonate, sodium salt of EDTA, sodium

hydroxide, etc., for water treatment; then chloramphenical, tetracycline, sulfaerazine, formalin, furnace, etc., for disease control; and then agar, corn starch, milk powder, vitamin mix, etc. for feed preperation.

Requirments of miscelleneous items:

Items like, nylon nets of varying meshes, plankton nets, 120 u *Artemia* screen, plastic hose, PVC pipe and gate valves of different sizes, saucepan, heater, pressure cooker, spoon, strainer, knife, feed washing screens, blender, etc. are also needed for a hatchery.

Water quality to be used :

Avoiding contaminated reservoir brine and toxic crystallizer brine, the condenser brine of 220 - 240 ppt is preferred. Underground freshwater is recommended for dilution. Tap water can be used, if aerated for 24-48 hours. The optimum standard for the hatchery water should be as follows : -

12-15 ppt salinity, 28°- 31°C temperature, 7.0-8.5 pH, 0.1 ppm nitrite nitrogen, 20 ppm nitrate nitrogen, chlorine free, hydrogen sulphide free, 100ppm hardness and 2 ppm iron. To maintain the standard, the water is either aerated, soda lime treated, filtered, pre-chlorinated, flocculated with alum at 150ppm level, sodium thiosulphate treated or bleaching powder treated as per requirement. Culture water is chlorinated with 10g of 70% calcium hypochlorite or with 0.1 litre of 5-6%sodium hypochlorite per tonne of water maintaining a static duration of 12 hours, after mixing thoroughly. Detoxification of water needs mixing of 12 ppm of sodium thiosulphate and aeration for 12-24 hours.

Brooder maintenance :

To produce quality egg, the brooder requires careful management. The tank bottom is to be provided with enough shelter. Daily in the morning and evening 50% water should be changed. The brooders are to be fed @ 5% of the body weight in the night with chopped fish and mussels, small shrimps, adult *Artemia*, dry pellets, etc. Before feeding, the tank is disinfected with 20ppm formalin and washed. Injured prawns, if any, is required to be removed. On availability, berried females are transferred to spawning tank. Brooders are collected from nature and transported in tubes with net closed ends submerged in water tub.

Hatching tank maintenance

Prawns are sotocked @ 4 nos./m^2 in water with 30-40 cm depth. Every day tank bottom is cleared and 50% water exchanged. Salinity is gradually increased to 12ppt level. Feeding is done at 5% level with bivalve meat, snail, worms, etc. Water is aerated continuously at a temperature of 28°-29°C before releasing the prawns into the hatching tank. Egg development in

the abdomen takes 19 days and egg changes from bright orange to greenish colour. If egg becomes dark grey, then the berried prawn is treated with 25 ppm formalin for 90 minutes under constant aeration. For every 100 g prawn, 500 l capacity hatching tank is required. The water (12 ppt) is pre-treated with 5-10ppm sodium salt of EDTA for better hatching. Berried prawns in the hatching unit are not to be fed. Hatching takes place in the early night or occassionally in the evening. The hatchling swims after 5 minutes of hatching with head down and they are made to gather at the corner of the tank for removal into the rearing tanks.

Rearing tank management :

Rearing tank also filled with 12 ppt water pre-treated with 10ppm EDTA. Stage-I larvae are stocked @ 100 nos./l and then after 10 days. the density is adjusted to 60-80 nos./l. In an average 15-20 PL/l are produced, but a properly managed hatchery can produce 30-40 PL/l while there are reports of producing 60-100 PL/l even. Water change is essential with the rise in turbidity, if any. Keeping in view the lethal limits for temperature to be 24°C and 33°C, it is better to control it at the range of 28° - 30°C with the help immersion heater. Fluctuation of 1°C temperature even produces stress for mortality.

Salinity is monitored at every 4-5 days interval and temperature is checked 5-6 times a day. Tank covering at night reduces diurnal fluctuations. A little illumination helps survival and growth while direct sunlight is harmful. Strong aeration prevents climbing tendency.

Biometabolites bring changes in the water quality, expecially increases ammonia, nitrite and nitrate levels, pH value, etc. Nitrite level of 1.8 ppm is lethal. So, it is better to maintain it below 1 ppm state and nitrate, 20 ppm level. A biofilter with oyster or clamshells during water exchange controls ammonia and acts at a buffer for pH to be maintained at 8.0-8.2.

Helth care and precautions :

Health care against *Zoothumnium, Epistylis,* hydroides, etc are essential. So, disinfectant must be used at every possible steps. The follwing precautions are also essential for larvae production.

1. Larvae should not be given excess feed.
2. Tank walls should be hygienically clean.
3. After first feed, aeration is to be stopped for solid waste and dead larval settlement at the bottom for cleaning by a siphon immediately.

4. Sea beach hatchery needs 50% water exchange whereas in recirculatory system, even a smaller proportion of exchange is possible. A 20% replacement on day 10 and day 20 is beneficial.

5. During deterioration of ambient water and weak larval movement, complete exchange of water is needed.

6. EDTA @ 5-10 ppm is to be added for improved production.

7. After completion of each cycle of seed raising, the tank walls must be bleached with strong and moist bleaching powder for 24 hours and then treated with 250 ppm of formalin before washing and cleaning in a repeated manner for a day.

8. Larval counting is difficult. So, average of several beaker (250 ml) collected samples may be considered for estimation.

9. Feed and feeding :

First stage of larva cannot search for food like, advanced stages. So, food item must be available readily and should be minute enough to swallow. Hence, *Artemia* nauplii is used as feed. The feed should attract the larva and should be of desired quality and fresh. Putting secondary importance to the cost, it should be hygienically prepared and stored in a refrigerator. During feeding, the feed should remain suspended in water. Feed particle size should match the girth of the mouth of each stage separately or in groups.

Popular brand of *Artemia* cysts contain 2,50,000 cysts/g and their hatching rate is 80%. So, for 2,50,000 nauplii, the requirement is ----

$$\frac{\text{2,50,000 nauplii}}{\text{250,000 cysts/g} \times \text{0.8 nauplii/cyst}} = \text{125g of cysts}$$

It is better to use decapsulated cyst to avoid contamination of disease and dead casing as waste product. The decapsulated cyst is a better food than the nauplii.

Cyst decapsulation process

About 200g of cyst is soaked in 3 l of water for one hour against vigorous aeration. Then the cysts are washed in running water keeping them in 120 μ screen. Side by side decapsulation solution is prepared by disolving 160g of bleaching powder and 120g of sodium carbonate in 4-5 l of water and allowing the mixture to settle for 30-45 minutes and then decanting the super natent liquid from the top. After adding cysts to such solution, aeration is done for 20-25 minutes, keeping the temperature always below 40°C by putting pounded ice. Cysts becoming orange indicate completion of the

decaptulation process. If cysts do not change into orage colour then the treatment with the solution has to be prolonged. After decapsulation, orange cysts are washed under a tap by keeping them in a 120 μ screen till chlorine odour vanishes. Decapsulated cysts are further washed with sodium thiosulphate solution by dissolving 10-20 g of $Na_2S_2O_3$ in 2 l water by aerating the whole thing for 5-10 minutes to neutralize the residual chlorine.

Again, they are rinsed throughly in tap water and kept in 2-3 l of freshwater. The decapsulated ones will sink and the undecapsulated ones will float to be removed by siphoning and stored in brine so that further decapsulation can be tried for them.

Before these, decapsulated cysts are either used for hatching or for storage @ 100 cysts/50ml.

Hatching of Artemia

Immediatedly after stocking decapsulated cysts @ 1-2 g (dry weitght) in the incubator, the hatching takes place. So, the volume of incubator is adjusted according to the daily need of *Artemia* cysts. The usual hatching time is 12-18 hours of stocking at 28-31ppt brine with 8-9pH. Addition of $NaHCO_3$ brings the pH to 8.5-9 before adding cysts.

Thirty minutes before collection of nauplii, 50 ml of 50 ppm formalin as disinfactant is added. Hatching tank must be covered with opaque cloth for sttlement of nauplii at the lighted bottom of the tank so that partial harvesting can be done between 18-36 hours of hatching. The hatchlings are required to be fed to the prawn larvae as early as possible. *Artemia* nauplii may be collected either by siphoning or by a plankton net of 250 μ mesh. The waste water after hatching of *Artemia* is thrown away.

Unhatched cysts are used in the larval rearing tank. Where they may either hatch or otherwise consumed as such by the prawn larvae. If shells are there form uncapsuslated cysts, then they are removed in floating condition after stopping the drainage of water temporarily.

Artemia nauplii are rinsed in clean 12 ppt saline water and then transferred into the larval rearing tank, by removing the same from plankton net to a bucket and then to the tank. Every day a new batch of nauplii has to be produced for larval feeding.

Artificial feed preperation :

Mixing milk powder 60g, corn flour 20g, egg (2 nos.) 70g, small fish/shrimp 80g, codliver oil 3.5 ml, vitamin mix 2g, agar powder 4g, and tetracycline 0.5g in a blender, steaming is done to get the custard which on cooling is grinded and seived through a screen to obtain the particles of desired size. This serves the protein requirement in the diet. The feeding behaviour is observed carefully to regulate the feeding.

During 2nd to 10th day, 1-day old *Artemia* nauplii @ 5 BSN/ml. is given to the larvae. Subsequently, 50% nauplii is recommended when artificial diet is also given. Quantity of *Artemia* nauplii to be used is dependent on the volume of rearing tank water and not on the larval number. So, for a 5t tank, 4.3 kg *Artemia* cysts for a 50 days rearing cycle is required. Quality and cleanliness of the feed is to be examined always. During feeding, aeration is to be seized. With the age, artificial feeding rate is increased. From day 10 onwards artificial feed @ 15-30g/tank and then 100g/tank is given, so that for a complete cycle 6-8 kg feed/tank of 5 t capacity is required.

Certain Important Features :

Inadequate cleaning, use of spoiled feed, over or under feeding, improper supervision, powercut, water circulation failure, aeration disruption, temperature fluctuation, etc, may lead to hazard. Larval jump has to be reduced to prevent their collision with the tank wall.

Larval movement at the water surface, instant taking of food, reddish brown look, non- cannibalistic behaviour, swimming with head down and jumping against contacting any substance are good signs for the healthy larvae.

On the other hand, bluish look, black spot on the body with irregularities, unwillingness to feed, tendency for bottom settling and swimming downward in a spiral path are bad signs for the larvae.

Disease :

Known diseases in prawn larvae can be caused by bacteria, protozoa and nutritional deficiency mainly. Mid-cycle larval disease (MCD), bacterial necrosis (BN), exuvia entrapment disease (EED), microscopic epibion disease (MED), etc. show symptoms of spiral swiming, turning bluish and stop feeding, failure to cast off the shell during ecdysis, and protozoan attack respectively.

The corresponding treatment for these diseases are : discarding the affected crop and disinfection of the system, use of bipenicillin-streptomycin @ 2ppm, furanace @ 0.1 ppm or erythromycin phosphate @ 0.65-1ppm, etc., diet improvement and use of antibiotics respectively.

Post-harvest activities :

After the harvest of PL, they are acclimatized gradually in freshwater by lowering the salinity from 12 ppt. PL at a density of 5000/m^2 may be kept for a week and then at a density of 2000/m^2 if they are held for a longer period.

During transport, travel-time and distnance are important. So 30,000 fry can be transported in 40 l water if travel time is less than an hour. 500 PL of 1 cm per litre of water can be transported for $1^{1}/2$ hour. If transport takes more than 16 hours, then oxygen packing will be required.

Conclusion :

Hatchery management is very delicate in nature. A little carelessness may lead to crop loss. But, the venture is a lucrative one from profit point of view and from the angle of its bright future.

PENAEID SHRIMP SEED PRODUCTION THROUGH HATCHERY MANAGEMENT

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INTRODUCTION

Nature is bountiful to provide India with vast potential area for brackishwater farming when there is ample demand for the aquacrop. Production of fish and shrimp from the ocean has its limitation. So, brackishwater farming system has to be popularised for future increase in the aquacrop. But, the yield rate of brackishwater fishes are restricted to 1-2 tonnes per hectare per year, whereas through production of more costlier penaeid shrimps, a crop of 2-4 tonnes per hectare in 4-6 months is possible to earn lot of foreign exchange for the country and use the system in a more rational way.

Present dependence on inadequate seed availability in the nature is the greatest hindrance for the expansion of penaeid prawn farming. Hence, there is an urgent need to produce penaeid seed through hatchery management.

Hudinaga (1942) succeded first in breeding and rearing penaeids. Since then, many development has taken place in the hatchery management practices and now, many commercial hatcheries have come up side by side with ones for research purpose. The success of a hatchery depends on appropriate application of scientific knowhow, managerial and technical skills, site selection, effective use of artificial diets, water and air circulation system, maintenance of clean hygienic condition and such other aspects.

Among penaeids, cuture of *P. monodon* and *P. indicus* are more viable than any other prawn in the country. So, immediate attention is required towards the development of hatcheries for these species of prawn in India.

SPAWNERS

Normally, a pond grown spawner produces less number of nauplii compared to wild one. So, for breeding purpose wild spawner from the sea are preferred.

After eye-stalk ablation, *P. indicus* matures in 3 to 5 days and produces 70,000 nauplii. *P. merguensis* also takes 3 to 5 days for its maturation. But, *P. monodon* takes 7 to 11 days. Eggs produced by a female *P. monodon* ranges from 1 to 6 lakhs with an average of 2 lakhs (for pond grown one) and 3 lakhs (for a wild stock). It has also been recorded that wild female on ablation of eye-stalk produces 2 to 10 lakh eggs with an average of 5 lakh.

SITE SELECTION

Hatchery for penaeids should be located on a sea shore away from human habitations to avoid any pollution of freshwater source and of sea water through drainage of domestic, industrial or agricultural waste, etc. The site must have good communication facilities, roads, electricity and so on. The climate of the area should be congenial for larval rearing, especially the temperature (about 28° - 31°C) and salinity of the sea water (32 ± 2 ppt) and should not be in a cyclone prone area. Over and above, spawners should be readily available in the region. There should be either prawn landing centres or brackishwater prawn farming centres in the vicinity.

ESSENTIAL REQUIREMENTS FOR THE HATCHERY

The following items should be readily available for a hatchery:

1) *Sea water (Temp. 24°-31°C) pH 7.5-8.5, DO>5 ppm, salinity 28-33 ppt, hardness medium, turbidity <50 FTU, NO_2-N<0.02 ppm, NH_3 0.1 ppm, BOD_5 <1 ppm, insecticide free, heavy metal < 0.01 ppm, Hg <0.01 ppm and iron & manganese in traces).*
2) *Freshwater (Temp. 28°-31°C, pH 7.0-8.5, DO > 5 ppm, salinity < 0.5 ppm, $CaCO_3$ 20 ppm, turbidity < 50 FTU, NO_2-N<0.02 ppm, NH_3 <0.1 ppm, BOD_5 < 1 ppm, and Mn < 0.2 ppm)*
3) *Matured brooders (at least 80-100 g female and 50-60 g male)*
4) *Brooder tank/Maturation tank*
5) *Prawn feed*
6) *Water and air circulation system*
7) *Spawning tanks*

8) *Water filter system*
9) *Larval rearing tanks*
10) *Properly equipped laboratory*
11) *Hatchery sheds*
12) *Egg washer*
13) *Pumps*
14) *Generator*
15) *Sea water & freshwater storage tanks*
16) *Water sumps*
17) *Overhead tank for potable water*
18) *Proper drainage system*
19) *Cemented floor*
20) *Stores*
21) *Electricity*
22) *Trained Hands*

BROODER STOCKING

Brooders are collected from either marine catches or from brackishwater farms or from mangrove areas, if available and stocked in a well disinfected pond/tank/pen in the nearby region to minimize the transportation. In an one tonne capacity tank, 400 brooders can be transported for one hour. But for a journey of 4-5 hours the concentration is reduced to 50%. Transportation is done either in the early hours of morning or in the late evening. On arrival brooders are acclimatised for 1-2 weeks in water of the same salinity and temperature of the transporting container and thereafter treated with a bath in 25-50 ppm formalin. Stocking is usually done @ 2-7 nos/m^2 only. Otherwise brooders are raised in the hatchery complex where juveniles are stocked at first @ 10-20 nos/m^2 and gradually this density is reduced to 1-2 nos/m^2 as they gorw for 9-12 months with supplementary feeding, mainly with molluscan meat, squid flesh, squilla meal, and polychaete worms. Polychaetes are especially recommended in the diet as they contain arachidonic acid and docosahexaenoic acid, the polyunsaturated fatty acids predominantly found in mature ovaries of penaeids, suggesting their role in reporduction.

Sexing is done by observing the ventrally located petasma in male and thelycum in female. The intact female brooder prawns are unilaterally eye-stalk ablated for maturation, keeping in view that the prawns are not less than 80-100 g in size. These females must have spermatophores in their thelycum through mating. Pinching method of ablation is preferred to other methods like, ligation, cautery, cutting, etc. Ablation is to be done during inter-molt period. If done during pre-molt stage then maturation will start only after the molt and will thus get delayed. Wild brooders mature quickly after ablation, showing peak spawning in 1-2 weeks time with termination within 4 weeks whereas prawns from brackish water areas show peak spawning

after 3-4 weeks of ablation with termination within 6-8 weeks. Moreover, mortality rate is high in wild brooders, but they produce higher number of spawn than those from the pond grown ones.

MATURATION TANK MANAGEMENT

Penaeid shrimps exhibit five stages of maturation *i.e.*, immature, early maturing, late maturing, mature or ripe and spent. During immature stage (I), slender thread like ovary is visible only on removal of the exoskeleton. At early maturing stage (II), a thin linear band of ovary is visible through the exoskeletion. Then the band thicken visibily at late maturing stage (III) and at mature stage (IV), a diamond shaped expansion of the ovary in the first abdominal segment is seen. The spent stage (V) is similar to stage (I).

In maturation tank, ablated females with normal adult male are kept in the ratio of 1 male : 1-2 or even 3 females (sometimes) @ 60 nos per tank of 12 m^3 capacity or @ 350 nos per pen of 16 x 16 x 4 m diamension.

The maturation tank is usually made up of cement, fibre glass, plastic or canvus lined alluminium walled one or of wood. To avoid stress on the prawns, the inside wall is painted with black epoxy resin and the tank covered with a black screen. Penaeid prawns prefer large water bodies for mating. But bigger than 20 m^3 tank is unmanageable while a depth of 80-100 cm is desirable for the purpose.

In maturation tanks, water exchange up to 200-400% in a day is recommended. In case of water crisis, same water can be recirculated after passing the same through a biofilter. Such water circulation can be done with a air-water lift. In such cases, 1/4 to 1/3 water is replenished every day and this appears to be sufficient. When the sand surface turns dark brown due to accumulation of dirt over a long period either in the maturing tank or in the biofilter, it is disinfected with 1 ppm muriatic acid for 24 hours, followed through rinsing. There are two opposing views that white sand is to be or not to be used at the bottom of the maturing tank for better result. But sand is useful in a sense that the damage of legs, tails, etc. are minimized within the container.

The temperature and salinity of the ambient water are to be maintained at 27° - 31°C and 30-33 ppt respectively. Moreover, direct sunlight for the maturation tank is to be avoided and rather the tank should be kept inside the hatchery shed with preferred green light for 14 hours a day or so (Hillier, 1984). Any female prawn grown earlier at 15 ppt salinity should be brought to 33 ppt gradually for release into the maturation tank.

MATING OF PENAEIDS

Mating of penaeids take place in the maturation tank where the adult female immediately after molting attracts males and starts swimming above a male which turns, puts its back downward and makes intimate contact of its ventral side with ventral side of the female. Then the male rotates at 90° angle with lengthwise direction of the female to grasp it through an U-bent of the body bringing its head and tail closer. In this fashion with the help of petasma, the male transfers its spermatophore into the thelycum of the female where sperms get lodged and wait for fertilizing the eggs laid by the female.

Among adult *P. monodon* molting occurs about every 3-5 weeks, it is synchronous and spread over a period of 5 days. Copulation generally takes place at night following molting which is a primarily nocturnal event (Primavera, 1985). In *P. monodon*, courtship and mating last for 30 minutes to 3 hours and in *P. japoniicus* only for 10 minutes (Hudinaga, 1942).

On the basis of thelycum structure and mating pattern panaeids are of two groups. Those with a close thelycum in which mating follows molting as in *P. merguensis*, *P. monodon*, etc. & those with open thelycum where in mating of hard shelled female immediately proceeds spawnings as in *P. stylirostris*, *P. vannamei*, etc. Gravid females of the first group will spawn, whether they have mated or not and if females of that group mate in an immature stage then they cast off the spermatophore of the thelycum at the time of molting. Courtship in *P. javanicus*, starts at premolting stage of the female, but actual mating takes place immediately after the molt. In *P. monodon* copulation starts when they are 4-5 molts old, but they spawn only after about 10 molts. Minimum recorded size for a female *P. monodon* spawner is 75 g and for the largest it is 300 g though 600 g females are caught from the ocean.

SPAWNING OF PENAEIDS

Female penaeids which are matured up to stage III or IV naturally or through eye-stalk ablation and have copulated with a male are called potential spawners. These spawners are released individually in one 250-300 litre cylindro-conical tank made of fibre glass or PVC. Larger spawning tank (400 l) is needed for a wild spawner as it lays more eggs (about a million).

A 250 l spawning tank is filled with 200 l of sea water having at least 30 ppt salinity. The most congenial salinity and temperatures are 33 ppt and 26° - 29 °C. Spawning tank is provided with a bottom drainage system, so that the water can be removed as per requirement. As an optional step, the spawners are given a bath of formalin or furanace for disinfection. Before releasing the spawners

into the tank, the water is chlorinated for removal of bacteria and germs, and then treated with EDTA for chelating under constant but mild aeration.

Spawners are generally released into the spawning tank in the evening and kept overnight. Initially the water surface remain covered with air bubbles, but with the release of eggs, a pink to orange scum is formed at the margins of the tank water surface. In the morning, all the females are removed from the spawning tank and kept in the maturing tank again even if they have not bred. In the next night, the spawners which did not breed earlier are tried again for the release of egg. In case the spawner fails to breed in three successive nights and remains at stage III or IV then that should be discarded for its microsporidian infection in the ovary. The ovary of such diseased female is whitish or milky. Usually 50% spawners in a spawning tank breed and among those which have bred, roughly 80% spawn completely and others partially. Partial spawners or non-spawning females will either spawn after 2-3 days or will resorb their ovaries. The nature of spawning can be detected by holding the spawner against a bright light such sampling are usually done by under water flashlight tied to a pole to be held close to the prawn, so that the light strikes perpendicular to the back of the prawn. *P. monodon* females probably have multiple spawning in a single season and undergo spawning for more than one season. *P. merguensis* female spawn once in every 2.6 months and *P. japonicus* spawn once every 2.8 months.

The egg and sperm are released by the spawner often forcefully while swimming and actively moving the pleopods. Spawning lasts from 2 to 7 minutes. Among ablated *P. monodon* females that spawned once, at least 50% will spawn a second time and 15% a third time. A subsequent spawning may take place as quickly as 3-5 days after the preceeding one. The rate of maturation and egg quality progressively deteriorate 6-8 weeks after initial ablation.

PROCESSING OF EGGS AND QUALITY CONTROL

Random samples of eggs are examined under microscope. Morphologically eggs have been divided under five types (A_1 A_2, B C & D) A_1, type eggss are fertilized, spherical with bilaterally symmetrical embryo inside, exhibiting 58% hatching rate of strong healthy hatchlings. A_2 type eggs are also fertilized, somewhat spherical with a little sub-normal embryo inside, exhibiting 32% hatching rate of weak and abnormal hatchlings. B type eggs have asymmetrical embryonic cytoplasmic mass and they do not hatch. C type eggs have undifferentiated cytoplasmic mass and D type eggs have very little remains of cytoplasm for bacterial attack. These morphological egg types have also been observed for *P. indicus* and *P. merguensis*

(Primavera & Posadas, 1981). So, these two types of eggs also do not hatch at all. Therefore, if the egg samples from the spawning tank show > 30% of good (A1 type) eggs then the eggs are retained otherwise discarded totally. Being sure that egg samples are satisfactory, the orange scum containing eggs are harvested with the help of a siphon. These eggs are washed with a series of 2 nets (one course with 0.35 mm mesh and the other fine with 0.25 mm mesh). Course net arrests larger particles by allowing passage of eggs through it and the fine net allows smaller particles to pass through by retaining the eggs. Eggs are always kept immersed in sea-water avoiding any mechanical injury. Through sample counting the total number of eggs produced are estimated.

LARVAL REARING TANK MANAGEMENT

Clean eggs are released into well aerated larval rearing tanks for hatching. These tanks are usually 1-10 m^3 in size. Hatching take place after 12-15 hours of egg release. In these tanks also 33 ppt salinity and 26°-29°C temperature of the ambient sea-water is preferred. Japanese type 10-20 m^3 larval tanks are difficult to be managed. So, Galveston type small larval rearing tanks are used. In any case, the density of egg should not exceed 3000 nos/litre of sea-water. After every 8-9 hours, nauplii (N_1) which hatched from the eggs molt and develop into nauplii (N_2, N_3, N_4, N_5 and N_6).

Due to positive phototaxis, the nauplii can be siphoned out from the water surface after stopping the aerators. If nauplii are harvested in the night of the day of hatching then they will be at N_1 and N_2, stages, otherwise if harvested in the next morning they will be of N_3 and N_4 stages. These can be packed at a density of 20,000/l in a 20 litre plastic container and transported for 4-5 hours. For longer transport duration, the density must be reduced to 25% only *i.e.*, 5,000/l. While transporting care should be taken that they do not become protozoea on the way.

In the larval rearing tanks, these nauplii are also grown to different postlarval stages and juvenile stage taking care about their feed, aeration and hygienic and congenial conditions.

QUALITY CONTROL OF FRY

Before distribution quality control of fry is essential. Shrimp fry with light grey, brown to dark brown and black colour are good for growth and survival. Postlarvae with red to pink colouration in the body show stressed condition while those with light to dark blue colour are infected with virus. Postlarvae should not move spirally or abnormally. Good quality postlarvae have noticeably open tail; A PL_{20} must be 16-19 mm long. Any bodily abnormality is undesirable for the fry. In any case, shell should be clean, gut should be full and reduce

the sixth abdominal segment should be muscle packed. Grainy tail muscle indicates stressed condition of the fry. *Vibreo* infection causes red and reddish yellow spots on the larvae. Bacterial infection shows thick filamentous mat on the larval body. Bacterial necrosis causes carapacial erosion and brownish red to black colouration. Appearance of pyramidal or tetrahedral bright bluish red stains on the larval body after 5 minutes , bath in 1 ppm malachite green or methyl green pyronin solutions is the indicative of viral infection (Narayanasamy & Sampath, 1995). Larvae showing liquid filled boils, blackening or erosion on the tip or edge of the uropod with opaque white spots on the abdominal segments have attack of muscle necrosis. So, it is very difficult to get 100% disease free larvae from a hatchery. Hence, the hatchery producing 85% healthy larvae or fry is a standard one.

EFFECTIVE WATER SUPPLY

Good quality sea water are generally obtained from a sub-sand filter system. A 250 mm diameter PVC pipe, perforated on its surface and to a length of 2 m is provided with end caps at both the ends. The perforated surface of the filter is covered with two layers of 1000 µ mesh plankton cloth and a layer of coconut coir mat. A 90 mm perforated PVC outlet pipe is inserted into the filter by making hole on 250 mm end cap and pipe protrudes one metre outside. A non-return flap type check valve is fixed in line with the 90 mm PVC pipe. The position of the valve can be either inside or outside the filter and connected to the suction line of the pump. The filter is installed 3-4 m deep into the sand bed and about 100 m inside the sea from the high tide level. It is advisible that the filter is installed at a place where atleast 1 m high seawater will always be available above the sand bed. The pre-fabricated filter is installed vertically by using high pressure water jet created by a 5 HP submersible/mono-block pump. Installation of a filter is easier during low tide. Pumping has to be done immediately after installation otherwise fine sand grains will penetrate and choke the filter. Pumping has to be done at least 2 hours a day even if water is not required so much. Filter has to be removed, cleaned and reinstalled atleast once in every 2 months. Filter is to be protected from direct wave action.

The water drawn through the sand filter unit is pumped into a sump where settling of sediments, if any, is done. Then the water is passed through 10 µ and 5 µ filters and then through a biofilter. Next the water is exposed to UV radiation or treated with antibiotic and antifungal medicines. Treatment with 2 ppm EDTA has proved to be beneficial. During larval development the sea water is treated with Erythromycin @ 0.5-1.0 ppm on every 3rd day. Beside these, furnace, tetracyclin, etc. are also used. Towards the end of seed production chloramphenicol @ 2-6 ppm for prophylactic purpose and @ 2-10 ppm for curative measures are applied otherwise maracyn I,

maracyn II and terramycin are used. Treflan and Trifluerine @ 0.1-0.2 ppm are required from nauplii stage to control fungal attack.

Before water exchange when water volume is reduced these medicines are applied. Malachite green @ 0.1 ppm and 10% formalin @ 5 ppm controls the attack of *Lagenidium* fungus and protozoan like *Zoothamnium* sp.

A seed hatchery also needs freshwater supply from a tube-well to clean the hatchery tank and for dilution of sea water, if required. But, this freshwater is reuired to be made almost free from Fe, Mn, hardness etc. So, the water is properly treated before use. EDTA is always added for the purpose.

AERATION SYSTEM

Instead of air compressors, air blowers may be used to aerate the tanks with oil free air. Two 5 HP air blower (Rootes type twinelobe) is enough for a standard hatchery with 20 m^3 sea water requirement. When one will be in operation the other one will be given rest. Portable aerator can be used in a small hatchery.

HATCHERY SHED

A 32 x 13 m shed serves the purpose of a standard hatchery where spawning tanks, larval tanks, algae culture tanks are kept on slightly raised platforms leaving passage for movement.

In separate sheds (11 x 6 m & 6 x 2m), maturation tanks and generators respectively are kept. PL rearing tanks do not require any shed.

FOOD AND FEEDING

Whenever possible broodstock should be fed with variety of live and fresh food items, especially with polychaetes. Repeated feeding encourages faster growth and maturation as well as feeding efficiency. Generally recommended feeding rates range from about 20% of the biomass at PL_{30} to PL_{35} to 4% at 2 g size. About 12% has been observed to be the optimum ration size for the postlarvae while for juveniles and adults it is 8% and 4.5% respectively. Indiscriminately these ration sizes need not be adhered to but should be tested under field condition about the utilization rate and wasteges, if any. Accordingly the feeding rates may be modified (Nair & Sridhar, 1994). Of course, while selling prawn feeds, different, commercial firms recommend different feeds for different stages of life and the ration size along with the feeding frequencies. Usual feeding frequencies are 4-5 times a day.

Always live-feed items may not be available. So, they can be stored in a freezer at -8 °C or lower. Feed pellets required for the brood stock must contain 40% protein and that can be achieved by mixing 20% fish meal, 20% shrimp head meal, 25% squid meal, 10% rice bran, 10% wheat flour, 4% agar, 4% sagopalm starch, 5% soyabean oil, 1.9% vitamin mix and 0.1% ascorbic acid. In pens, salted molluscan meat @ 20% (wet weight) a day of the prawn biomass is given. In pond/tanks such feed @ 5% (wet weight) a day and 2% (dry weight) of the prawn biomass is given in the morning and evening hours respectively.

To meet the requirement of protozoea, unicellular algae or yeast is cultured. During metamorphosis from protozoea to mysis, rotifer is cultured. Then for 10th to 14th day of rearing of mysis III and PL_1 to PL_5, formalin disinfected *Artemia* nauplii are produced in *Artemia* incubator, 60-75 cm diameter and 60 cm high cylindro-conical tank which can hold 150-250 l of 30 ppt brine. From 1 g of cysts (dry eggs), 25 millions of *Artemia* nauplii can be produced while considering 80% hatching from decapsulated orange cysts produced through hydration, washing with 120 µ mesh cloth, 10 minutes bath in a mixture of 160 g bleaching powder and 120 g Na_2CO_3 in 4-5 litre of water, vigorous aeration, treatment with 10-20 g $Na_2S_2O_3$ in 2 litres of water for 5-10 minutes, then rinsing under tap water, etc. Quantity of *Artemia* nauplii is to be given for feeding is dependent on the volume of water in the tank. So, a 10 t larval rearing tank will require 172 g of cyst to produce *Artemia* nauplii for a day. For the growth beyond PL_5, diatoms *viz.*, *Chaetoceros* sp. *Skeletonema* sp. *Tetraselmis* sp. etc. are produced. In lieu of these algae, frozen algae is also used. Moreover, a supplementary diet is also prepared with egg-yolk, soyabean card & meal, yeast, etc. Besides *Artemia*, finely minced fish flesh enriched with essential amino acids are also given to the larvae of prawns. Rationing of artificial diets per 1, 00, 000 larvae are: 8-9 g at zoea III stage and 10-12 g at PL_1 to PL_5 stage given in five splitted doses during the course of the day. About 120-250 µ particulate feed and about 250-350 µ particulate feeds are given to zoea III and PL1 to PL_5.

HEALTH CARE

Before and after operation of a set, all the containers, filters, pipes, tanks, etc. of the hatchery complex are required to be disinfected. So, 12% NaClO at 200 ppm is used for 24 hours. Dilute HCl is applied to rub the bottom and side walls of the tank or detergent powder, chlorox, etc. are employed for cleaning purposes. Provision of hot freshwater ensures better cleaning. Beside these, just before using the hatchery, the tanks are treated with formalin at 50 ppm and Furanace at 3 ppm for 10-15 minutes and washed cleanly

with treated sea-water. Likewise, brooders are also given a bath in Treflan (0.5-1 ppm) $KMnO_4$ (3 ppm) and formalin (25 ppm) mixed solution.

DISEASE BREAKOUT

Inspite of all such cares, sometimes diseases breakout in a hatchery. These diseases are:

1. ***Soft shell disease:*** Due to attack of chitinolytic bacteria, *Vibrio* and *Aeromonas.*

2. ***Necrosis:*** Due to attack of *Vibrio* or *Pseudomonas.*

3. ***Filamentous covering:*** Due to *Leucothrix mucor.*

4. ***Luminous bacterial disease:*** Due to *Vibrio harveyi,* mostly attacking prawn postlarvae.

5. ***Fungal disease:*** Due to *Lagenidium* sp., *Sirolpidium* sp. and *Fusarium sp.*

6. ***Protozoan disease:*** Due to ectocommensals like, *Zoothamnium* sp., *Epistylis* sp. and *Vorticella sp., ectoparasites like Ephelota sp. and Acineta sp,* and endoparasites like *Gregarines* and *Microsporidian.*

7. ***Viral diseases:*** Due to *Monodon Baculovirus (MBV),* infectous hypodermal & hematopoietic necrosis virus (IHHNV) and hepatopancreatic *Parvo* like virus (HPV)

8. ***Helminth infection:*** Due to aquatic cestodes, trematodes and nematodes

9. ***Colour change & bending:*** Due to malnutrition, DO depletion, heat, etc.

CONCLUSION

Hatchery management is a very delicate affair. At every step special care should be taken to keep away the diseases. Regular monitoring for hatchery hygiene, water quality, feed quality, aeration system, etc. are required. A little negligence at any stage may lead to mass mortality or production of poor quality seed. To keep the hatchery engaged round the year, breeding of other important penaeids also can be taken up besides producing only *P. monodon* seed. Moreover, to avoid any mass mortality, the hatchery should be well equipped with the medicines so that the service can go a long way for boosting shrimp culture in India.

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FARM DESIGN, CONSTRUCTION, WATER MANAGEMENT AND AERATION DEVICES IN PRAWN PRODUCTION SYSTEM

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INTRODUCTION

With an increasing demand of prawn in the national and international markets there is a growing trend of converting tidal mud flats, char lands, tidal marshes into productive fish farms for raising prawns and mullets.

Planning and construction of prawn farm depends on the site condition, design of farm and the system of farming. The common engineering investigations and data collection required for setting proper prawn farm, include typographic survey, hydrographic survey, surveys on physical properties of soils, tidal range and tidal influx, flood frequency, source and quantity of freshwater supply and collection of meteorological data.

2. FARM PLANNING

2.1 Elevation of site and tidal phenomena

The tidal innundation at the site is the major source of water supply to prawn ponds. One of the main determining factor for site selection is thorough knowledge about the depths and extent of submergence of the farming during various phases of the tidal rise

The spring tides of high tidal range occur when the sun, the moon and the earth are in a straight line, as during the new moon and full moon. During the first and third quarters of the moon, when the sun and moon are at right angles in relation to the earth, neap tides of low range occur.

If at a location + 0.50 m above MSL, the mean higher high water reaches + 1.50 m, the prawn pond gets a tidal flooding to a depth of 1.0 m. But on the other hand if the tidal amplitude is less or land elevation is higher, in such a situation pumps would be necessary to fill the ponds.

2.2 Properties of soil

The saline soils in the coastal areas generally belong to the following categories, *viz.*, (i) clayey soil (ii) loamy soil (iii) sandy loam and iv) silty or silty clay.

The high chloride content in saline soils affect soil consistency at different degrees of moisture contents, and the coefficient of soil permeability. Furthermore low bulk density and high liquid limit of such soils pose difficulties in using the soil for building strong and stable farm embankments.

Becuase of poor bearing capacity, the dike should necessarily be so designed that sub-soil salinity is not lost in any way.

2.3 Water supply

Adequate water supply is necessary both for water replenishment and maintaining required water quality and salinity in the range between 15 and 25 ppt.

Coastal prawn farm ponds since usually have high salinity, dilution is done with freshwater to bring down the water salinity to optimum level.

2.4 Culture system

Prawn culture system may be either extensive, semi-extensive or intensive.

In the extensive culture system, the stocking rate is low, there is less scope of supplementary feeding and water exchange depends on tides. While in the semi-intensive system, the stocking density is moderately high, it requires adequate water exchange and proper water management.

The intensive culture system requires high stocking, artificial feeding, efficient water management and aeration.

2.5 Lay out and design

A well laid out prawn farm consists of the following essential components :

(i) Ponds of various types such as nursery pond, growing pond and stocking pond, inlet canal etc.

(ii) Peripheral dike and partition dikes.

(iii) Water regulatory gates - main and secondary gates.

(iv) Aeration devices.

(v) Farm infrastructures.

The layout is dependent on topographical characteristics and tidal fluctuations at the site (Fig. 1) . Most of the deltaic lands formed through the process of alluvial deposit generally have central areas at higher elevation than the rest part which gradually slopes down to the estuary. The lower areas may be suitably utilised for locating larger ponds for copious supply of water and draining out conveniently as and when required. A clear margin of 50 m mangrove forest should be left between the tidal creek and the main dike for safety of the farm against tidal thrusts.

The layout of the farm may be based either on the principle of straight line system or modular system.

Square ponds are economical in construction and provides facilities for management. The square shape enhances water circulation and extend, adequate scope for aeration beside facilitating easy drainage.

However, the bigger ponds should as far as possible be made rectangular with longer sides located in the line with the prevailing wind direction.

2.5.1 Farm channel

The prawn farms have generally two types of channels : (i) the main inlet or supply channel, and (ii) the secondary channel or distribution channel.

The main channel receives the tidal flow through the main sluice directly while the distribution channels convey the supply to individual ponds.

The cross-sectional area of main channel should be sufficient to convey required tidal discharge to fill the farm ponds to optimum level. The velocity of flow should invariably be non-silting or non-scouring.

The mean velocity of flow may be determined from the following equations -

$$V = 1/n \cdot R^{2/3} \cdot s^{1/2} \text{ m/sec}$$

where R = hydraulic mean depth

s = channel bed slope or fall/length
n = Mannings roughness coefficient

3. DIKES

3.1 Earthen dikes

The prawn farms have two types of dikes *viz.*, the peripheral dike, and the partition dikes.

Peripheral or main dike forms the boundaries of the farm which must be sufficiently strong to withstand tidal onslaughts, wave forces and erosion due to rains and wind. The partition dikes divide the pond system into compartments of different shape and measurements.

For stability of soil mass in dike, it is essential that the shear resistance of the soil must be more than the shear stress induced in the soil due external loading.

3.2 Dike height

The safe height of dike is determined by taking into consideration the tidal rise and giving allowances for free board, flood rise, wave height and shrinkage allowance of dike soil. Therefore the safe height of dike is

H = (ht + hf + hw + hs + hfl) meter

where, ht = Tidal rise due to HHWL
hf = Allowance for free board, for main dike free\board height may be 0.30 m.
hw = Wave height, which depends on wind velocity and fetch length, usual allowance considered is 0.30 m.

hs = Shrinkage allowance. A freshly deposited soil in the dike keeps setting for sometime till it assumes a stable profile. Allowance for shrinkage is between 20 - 25%.

hfl = Allowance for flood due to excessive rain in the catchment.

The dike surface exposed to the action of tidal thrusts should preferably be strenthened by brick or stone pitching which otherwise also helps in preventing percolation and erosion.

3.2.1 Crest width

As per Engineering standards reccommendations the top width should not be less than 2.40m for dikes or 3 m. height. When used as a roadway, the top width should necessarily be at least 2.70 m.

4. WATER CONTROL DEVICE

Water flow is regulated by main intake gate which is usually constructed as a R. C. C. or masonary structure and draws water for supply to the whole farm. Often the main sluice serves both as an intake during flood tides and outlet during the ebb tides. The sluice sill level is fixed a little above the L. L. W. L.

Tidal ingress to individual ponds is accomplished through secondary sluices which are either close conduits with gate valve arrangements or conventional wooden box type sluice with wooden control gates at both ends of the sluice.

5 CONSTRUCTION

Before commencement of pond construction, the site should first be cleared of all vegetation. The roots and tree stumps are throughly removed. The corners are correctly marked on the ground with help of levelling instrument.

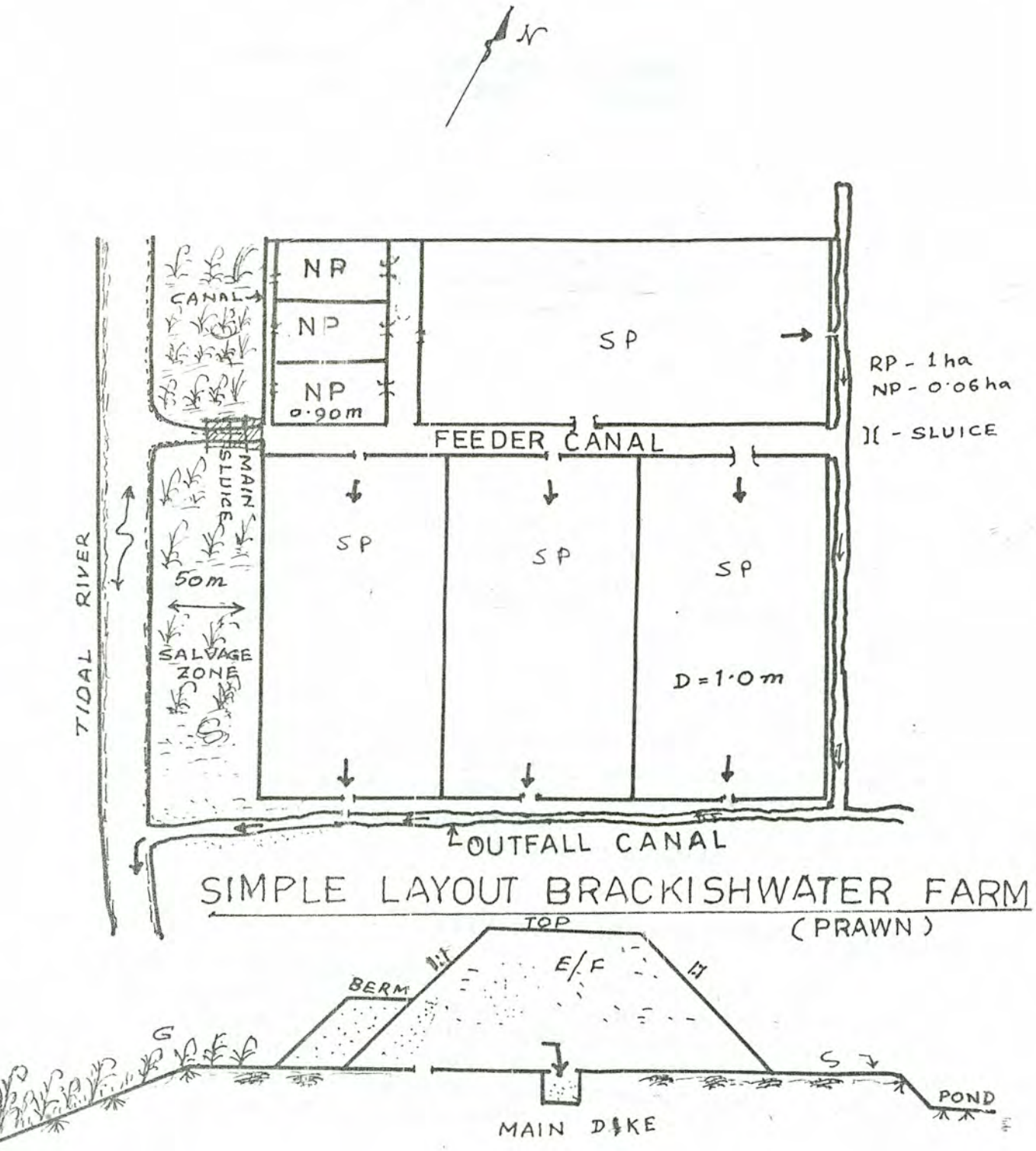
The lean months have to be chosen for construction when the tidal fluctuations are appreciably low and labour and constructional materials are cheaply available.

Soils used in constructing dikes must be adequately compacted to improve the strength and resistance to weathering. Each layer of soil laid in dikes should be rolled well until all clods are flattened. Side slopes should be perfectly stabilized against slipping. Stability of slopes can be increased by perfect compaction of material. Sheet piling into the ground near the toe line of the slope increases the factor of safety against slipping.

6 AERATION

Higher rates of stocking in ponds demand for artificial aeration with a view to maintaining adequate dissolved oxygen level.

Various types of aerations such as paddlewheel, air blower, air diffusers are commonly used, the selection is primarily based on oxygen transfer efficiency. It is found that 4 one-hp aerators per ha of pond area is sufficient to meet the oxygen requirement in semi-intensive culture system.


N
NP
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][- SLUICE
FEEDER CANAL
MAIN SLUICE
SP
SP
SP
50m
SALVAGE ZONE
D = 1·0 m
TIDAL RIVER
OUTFALL CANAL
SIMPLE LAYOUT BRACKISHWATER FARM
(PRAWN)
TOP
E/F
BERM
G
S
POND
MAIN DIKE

Fig – 1

OPTIMUM REQUIREMENT OF SOIL AND WATER CONDITIONS OF A FRESHWATER PRAWN FARM

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INTRODUCTION

The giant prawn *(Macrobrachium rosenbergii)* is the largest freshwater prawn known in the world and has been identified as one of the priority organisms for aquaculture research and development. The assets in its favour are rapid growth rate, high nutritional value and high export market value. The commercial culture of this prawn is well established in several developed and developing nations.

Though fish culture in India is an age old practice, but prawn culture has come in prominence for the last two decades, and the prawn yields per unit area are generally low as no attention has been paid to the soil & water chemistry of the ponds. The detailed study for water and soil quality of the fish ponds where prawn culture practises are done should be taken up thoroughly for estimating the pond fertility.

POND SOIL AND POND PRODUCTIVITY

The bottom substratum of the pond appears to be determining factor in the production of prawns. Pond productivity is generally dependent on the availability of major nutrients such as nitrogen, phosphorus, organic matter, calcium, magnesium and potassium from the soil. Some micronutrients also contributes to pond productivity. The availability of the essential nutrients, is however, dependent on soil pH and texture.

pH

The pH of the pond soil should normally be neutral to slightly alkaline. Growth and survival of fish and prawn are generally very poor in ponds having acidic soil reaction (pH<5.0). Fish can not survive in ponds having soil pH less than 4.0. Acidic ponds may require lime treatment at a

heavy dose depending on soil acidity. Reclamation of acidic ponds involves liming or flushing and draining over a long period which is time consuming and expensive. So, it is always safer to avoid acid ponds for prawn culture.

Very alkaline soil is also not suitable for prawn culture. Pond soils with a very high soil reaction (pH>9.0) may be modified through ageing or by adding organic manures. Such ponds should be filled with water and manured with cattle dung. Within a few months, the biological cycles should reduce the pH to a desired level and make them fit for culture (Subrahmanyam, 1987). In general, the soil reaction of a good fish cum prawn culture pond should range between 7.0-8.0, highly acidic or highly alkaline pond soil is unproductive.

Soil texture

Sandy substratum may be an ideal habitat for the freshwater prawn. However, water retention may be a problem in ponds having sandy bottom soil. Ponds with a muddy substratum retain water and such substrata with a silt fraction are also suitable for prawn culture. Thus, Subrahmanyam (1987) observed high prawn production with sandy loam substratum (654-715 kg/ha) and silty clay loam texture (709 kg/ha), but he recorded poor production in pond having silty clay soil texture (124 kg/ha).

Phosphorus

Phosphorus is considered as the most critical single element for pond productivity. The availability of phosphorus from soil depends on soil reaction. In acidic soils, the phosphorus remained fixed as iron, aluminium or magnesium phosphate and phosphorus deficiency is reflected in pond water. However, in strongly alkaline soils, the phosphorus get fixed as calcium and magnesium phosphate.

Phosphate fixation is at its minimum in near neutral soil reaction (pH around 7.0). If the available phosphorus is less than 3 mg/100 gm soil the pond may be unproductive, average when 3-6 mg/100 gm and productive between 6-12 mg/100 gm of soil (Banerjee, 1967).

Nitrogen

Nitrogen is also important in fish ponds because it is a key constituent of protoplasm. Moreover, it is involved in several important biochemical transformations mediated by microorganisms. Nitrogen is brought down to pond soil during rains and also fixed there by bacteria and blue green algae. In soils it is present mostly in organic forms but all of it is not available for utilization. It is only the fraction which is easily utilised by plants (phytoplankton, algae etc.) which is termed as available nitrogen. It has been found that fish production is poor when available nitrogen is below 25 mg/100 gm, average when 25-50 mg/100 gm and high when 50-75 mg/100 gm soil (Banerjee, 1967).

Organic matter

The prawns are detritivorous in habit and feed on variety of feeds that come across them while scavenging on the margins of the ponds. Organic matter present in bottom soil are very useful due to their high carbohydrate content which is consumed by prawns and other organisms (both micro and macro). In pond soil, the bacterial activity depends not only on the carbon content but also on C:N ratio. Bacterial activity is low when C/N ratio falls below 10 and high when the ratio is more than 15. For high productivity, the organic carbon of pond soil should range between 1.0-2.5% (Nath, 1986). Similarly, C/N ration below 5 is indicative of poor production, 5-10 of average production and 10-15 of high production.

Calcium and magnesium

These two elements are very important in aquaculture to remove the pond acidity. Calcium is present in the pond as calcium carbonate and bicarbonate. Presence of calcium carbonate in soil is responsible for its alkaline reaction and reduced solubility of iron, manganese and aluminium. These elements are very toxic under acidic soil reaction. The availability of phosphate, molybdate exchangeable calcium and magnesium are greater in near neutral to slightly alkaline soils. Presence of lime stimulate the general purpose heterotrophic soil organisms thereby increasing the activity of the organic matter and nitrogen in the pond soil. The non-symbiotic bacteria and the nodule bacteria that fix nitrogen from the atmosphere are also stimulated in the presence of lime. On the other hand, disease producing parasites and micro-organisms are controlled by proper lime treatment.

POND WATER AND AQUATIC PRODUCTIVITY

The more important physical and chemical qualities of water influencing aquatic productivity are temperature, pH, dissolved oxygen, total alkalinity, salinity, nitrate, phosphate, calcium and total dissolved solids.

Temperature

Fish and prawn production in a pond depends greatly on the temperature regime of the growing season which may vary from year to year. Prawns grow faster at higher temperature, 28°-32°C, although in general the temperature may range between 24°-34°C (Subrahmanyam, 1987). Such temperature regimes are common in tropical areas and is a major factor to be taken into consideration for pond construction. Regulation of temperature is a very difficult process in larger water bodies. Hence, the prawn culture period should as far as possible synchronise with warm temperature. If necessary, stocking practices may be modified to match with the favourable growing season. According to Natividad (1982), *M. rosenbergii* prefer temperature ranging from 23.5°-25.5°C.

Dissolved oxygen

Dissolved oxygen in water is absolutely essential for the respiration of all aquatic animals. Pond water gets its oxygen from air by diffusion, mechanical agitation, wave action and from photosynthesis by the microscopic plants present in water. Oxygen acts both as a regulator of metabolic processes of plant and animal community and also as an indicator of water conditions. D.O. has an important role in maintaining the oxidative decay of the bottom organic matter. Soil bacteria and soil organisms take sufficient oxygen to mineralise the organic matter on the pond bottom. If the oxygen supply is plenty and pH favourable, mineralisation of the organic matter makes the pond nutrient rich and productive. Heavy organic load, water scarcity and plankton blooms often deplete D.O. in the pond. This is particularly noted before sunrise. Under such conditions, the prawns become lethergic and found to crawl out of the ponds margins and remain immobile till sunrise. This crawling along the edges exposes them to predators and human being. After sunrise with the gradual rise in D.O., many of them retreat and disappear under water. This happens in summer months. A quick remedy is to pump or release oxygen-rich water into the pond. In case of water scarcity, the water surface should be stirred or the pond should be aerated by an aerator to introduce more oxygen into water from atmosphere. These techniques to increase oxygen content in water during the late night hours are very important at times of greatest oxygen demand. Dissolved oxygen content above 5 ppm is indicative of a clean environment and is required for high prawn production. Natividad (1982) found dissolved oxygen content 5.8-8.0 mg/l conducive for *Macrobrachium rosenbergii*.

pH

Most natural waters have pH values of 6.5-9.0 but there may be some exceptions. The acid and alkaline death points for fish are about pH 4.0 and 11.0 respectively. However, if waters are more acidic than pH 6.5 or more alkaline than pH 9.0-9.5 for long periods, production and growth of fish will diminish (Swingle, 1961). Nath (1986) observed slightly alkaline water reaction (pH 7.2-8.2) was optimum for fish production, while Banerjee (1967) found slightly acidic to slightly alkaline (pH 6.5-7.5) pond water was most productive. The same may be applicable to freshwater prawn also. However, according to Natividad (1982), *Macrobrachium rosenbergii* preferred thriving at pH ranging between 4.0-8.5 at Phillipine rivers.

Alkalinity

Natural water normally contain more bicarbonate than that results from the ionisation of carbonic acid in waters saturated with carbon dioxide. Carbon dioxide in natural waters reacts with bases in rocks and soils to form bicarbonate as follows :

$$CaCO_3 + CO_2 + H_2O = Ca^{++} + 2HCO_3^-$$

The bicarbonate, carbonate and CO_2 in water acts as a buffer which helps in keeping the pH of water nearly constant. When there is an excess of CO_2 in water some carbonate gets converted to bicarbonate and the pH is maintained at a constant level. When however, due to photosynthesis, CO_2 is exhausted, the photosynthesis is continued by the decomposition of bicarbonate releasing the required carbon-di-oxide. Generally calcareous water with medium alkalinity (80-150 ppm) are most productive, while ponds with very low alkalinity (below 20 ppm) are not productive (Nath, 1986). But if the alkalinity is very high (above 200 ppm) with a high content of calcium as also the pH, the pond may be medium productive due to non-availability of phosphates and micronutrients.

Free carbon-di-oxide

Carbon-di-oxide in water is required by plants for photosynthesis. Free carbon-di-oxide is not appreciably toxic to fish/prawn; most species will survive for several days in water containing up to 60 ppm of CO_2, provided D.O. is plenty (Boyd, 1982). When D.O. content is low, the presence of appreciable CO_2 hinders oxygen uptake by fish or prawn. Normally, CO_2 content is high when D.O. content is low in a fish pond. Because of the relationship of CO_2 to respiration and photosynthesis, CO_2 content usually increases during the night and decreases during the day. Particularly high concentrations of CO_2 occur in ponds after phytoplankton die-offs, after loss of thermal stratification and during cloudy weather. Free CO_2 content ranging between 5 and 10 ppm may be considered favourable for fish production (Nath, 1986). However, if the free CO_2 exceeds 30 ppm, this may lead to oxygen depletion and fish mortality may take place.

Salinity

The freshwater prawn, *Macrobrachium rosenbergii* grows well under low saline freshwater conditions. However, it can also grow satisfactorily at salinities ranging between 0.25-0.75 ppt (Subrahmanyam, 1987). Adult prawn can tolerate salinity upto 25 ppt.

Phosphorus

In natural freshwater ponds, phosphorus concentration is usually very low. Phosphorus occurs in two forms i.e., inorganic and organic, but the soluble inorganic form is most important due to its active nature. Dissolved phosphorus below 0.05 ppm may be considered insufficient while 0.10-0.2 ppm and above 0.2 ppm may be indicative of medium to high and highly productive fish ponds (Nath, 1986). Phosphate content above 0.2 ppm may, therefore, be considered as favourable for fish production.

Nitrogen

Nitrogen, phosphorus and potassium are termed the primary nutrients in fertilizers, since they stimulate phytoplankton production, thereby favouring greater abundance of fish food organisms and greater yields of fish. Soluble nitrogen compounds occur in water in different forms. Organic nitrogen compounds may be converted to inorganic nitrogen compounds as nitrate, nitrite, NH_3 and ammonium salts. Ammonium and nitrate forms are readily absorbed by plants but green algae can use all the forms of nitrogen. Nitrogen and phosphorus in ponds are generally far below the concentration for the optimal growth of plankton. In semi-intensive culture, nitrogen content ranging from 1.0-2.6 ppm is optimum for fish production (Nath, 1986). However, for monoculture of giant freshwater prawn, the nitrate content should be less than 1 ppm, since at higher concentration there may be algal bloom in pond.

Calcium and magnesium

Calcium and magnesium play a great role in fish culture. They are added to the fish pond as lime which neutralize the soil and water acidity, fix CO_2 as their carbonate and bicarbonate for future use by aquatic plant organisms. Presence of calcium carbonate and bicarbonate in pond is responsible for its slightly alkaline reaction and reduced solubility of iron, manganese and aluminium. These ions are very toxic in acidic medium. In semi-intensive culture, Ca and Mg contents range from 14-42 ppm and 3-20 ppm respectively for optimum fish production (Nath, 1986). However, the hardness of pond water should not be very high, since excess calcium may precipitate phosphates and micronutrients which may reduce pond productivity. Thus, Subramanyam (1987) observed that calcium content of pond water should be less than 100 ppm for freshwater prawn culture.

Liming and fertilization

Subrahmanyam (1987) discussed the process of liming and fertilization of ponds for freshwater prawn culture. For newly constructed ponds 5-10 ton/ha cattleshed manure and 250-500 kg/ha lime are added depending on the soil and water quality and kept for about 15 days. An organic base on the bottom and slopes increases the fertility of the pond. Generally, smaller and older ponds gives higher production. However, such ponds required periodic liming for improvement of water and soil quality. Dried cattle shed manure mixed with lime is added in instalments during the culture period. Liming alone is sufficient in organically rich ponds to maintain desirable pH and pond hygine.

Freshwater prawns also grow in water bodies around the paddy fields. Experiment conducted by the Central Inland Fisheries Research Institute proved beyond doubt that prawns grow well in such water bodies fertilized by sewage water.

Aeration and water exchange

Pond productivity is greatly improved if a slow flow of water current is maintained during the growing season. If enough water is not available, the flow may be maintained during the late night hours to overcome D.O. stress. In stagnant pond with no facility to maintain water current, partial or total water exchange is necessary when the water quality deteriorates. Pond water should be free from pesticide and heavy metal concentration. During summer, there may be algal bloom in the pond which consume oxygen during night resulting in oxygen depletion. Emergency aeration should be adopted under such condition. If water scarcity during summer is a regular feature, then the culture period should be restricted to the period of water availability only.

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ROLE OF PHYSICO-CHEMICAL FACTORS IN BOOSTING PRAWN PRODUCTION FROM ESTUARINE WETLANDS

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INTRODUCTION

Production of fish and prawn from estuarine wetlands commonly known as Bheri, Nonabheri in West Bengal or Pokkali in Kerala is an age old practice. However, in traditional practices, the fish and prawn productions are variable and poor. Improper stocking, presence of predator and weed fishes, scarcity of fish food organ isms and adverse environment may be attributed to poor production in the system. Now a days, Tiger shrimp (*Penaeus monodon)* is cultured in brackishwater ponds and estuarine wetlands either alone (monoculture) or along with some compatible fishes and prawns (polyculture). High market value, faster growth rate and easy availability of seed are reasons for its large scale adoption for farming in estuarine wetlands. Commercial prawn farms, in general, are getting production of tiger shrimp @ 1-2.5 ton/ha/yr. Ghosh *et al.*, (1987) obtained a production 1193.3 kg/ha/3 months at the experimental farm at Kakdwip. One of the private entrepreneurs achieved a production of 9.3 ton/ha/year (2 crops) in West Bengal adopting modern practices of high density stocking (15-20/m^2), good water quality management and balanced pelleted feed (Algaraswami, 1990).

For successful prawn farming, regular monitoring of soil and water quality of the estuarine wetlands are very essential, otherwise large scale mortality may occur due to development of adverse environmental conditions.

Dissolved oxygen

For respiration of fish and other aquatic and soil organisms, adequate dissolved oxygen must be present in estuarine wetlands. In brackishwater fish ponds its content may vary between 5 and 8 mg/l. A pond gets oxygen through diffusion, wave action, mechanical agitation and by photosynthesis. Solubility of oxygen in water is dependent on temperature and salinity. At higher temperature the solubility is less. Similarily as salinity increases in a pond, the oxygen content shows decreasing trend. During summer season, oxygen content in the pond tend to decrease due to higher environmental temperature, high salinity and high metabolic requirements by fish, plankton and bottom biota. Oxygen content is higher

during day-time due to photosynthesis but during night animals and other organisms in pond consume oxygen for their respiration, gradually decreasing its content in water, ultimately resulting in oxygen deficiency during late night to early morning hours. Acute oxygen deficiency may lead to fish mortality in ponds. To avert fish kill, DO should be monitored regularly during afternoon (maximum DO) and during early morning (minimum value). If the afternoon value is very high it indicates algal bloom in the pond. Excessive algal bloom in culture ponds are not desirable since it consume large quantity of oxygen during night leading to oxygen deficiency during late night hours. For getting higher prawn production, a minimum of 5 mg/l of DO should be maintained in the pond.

pH

The water reaction of estuarine wetlands is usually slightly alkaline (pH 7.8-8.6) which is, in general, conducive for aquatic habitat. However, there may be some wetlands in the Sunderbans and other coastal areas which have very strong soil and water acidity (pH 3.5-4.0). These wetlands are not suitable for fish and prawn culture unless they are modified by liming. A large dose of lime (3-4 ton/ha) may be necessary for their rectification. Highly alkaline (pH>9.5) or acidic (pH<5.0) waters are not suitable for culture of *P. monodon*.

Salinity

Salinity in estuarine wetlands may vary considerably during the year. During summer, salinity is generally maximum and it may rise up to 40 g/l due to concentration of salts. But during rainy season, the salinity may drop appreciably to 4-5 g/l or even less. Sudden drop of salinity during monsoon after heavy rain may cause appreciable strain on prawns leading to its mortality. Salinity during this period may be enhanced by incorporation of ground water or coastal river or sea water, which have higher salinity content. For culture of *P. monodon*, salinity ranging between 20-25 g/l is generally considered to be optimum. However, the author observed that *P. monodon* grows very well at salinities ranging between 15 and 20 g/l at Kakdwip Research Centre ponds. Schuster (1952) found that benthic algae grow well at 15-45 g/l of salinity, but Bose (1960) reported 5-17 g/l salinity as optimum for growth and reproduction of blue green algae, *Oscillatoria splendida*.

Depth

The estuarine wetlands should not be very deep or very shallow. The optimum depth is around one meter. Water is introduced into the wetlands through sluice gate to maintain optimum depth. In deeper ponds, the bottom region do not receive sufficient light for growth of benthic algal complex called Lab Lab on which the young prawn feed and flourish well.

Turbidity

Phytoplankton and algae, present in water and bottom sediment, produce carbohydrate by photosynthesis during day time. Thus, the water of the pond should not be very turbid, since penetration of light as well as heat energy is poor in turbid water. Higher turbidity, particularly due to silt and clay particles, is detrimental since that will reduce the pond productivity by limiting light energy to penetrate into deeper zones. In estuarine wetlands, the turbidity is minimum during winter and summer, while higher turbidity is found during monsoon months. At higher salinity, the concentration of positively charged sodium, calcium, magnesium etc. combine with negatively charged soil colloid as follows :-

Colloid + cation = Colloid cation

Neutralization of the charge reduces the strength of repulsion between colloids and they agglemerate. The process of coming together of colloidal particles is termed flocculation and when a floc of particles is heavy enough, it precipitates. Calcium ion is 30 times as effective in coagulating colloids as sodium ion and aluminium and ferric ions are 1000 times as effective as sodium ion (Boyd, 1982). During rainy season, the concentration of all cations decreases appreciably in water, which fails to precipitate the soil colloids, resulting in higher turbidity.

Free carbon-di-oxide

Free CO_2 content of water of estuarine wetlands is not high, since at high pH (pH 8.3) the free CO_2 is fixed as bicarbonate. The author found it absent in surface water during most of the culture period of *P. monodon* at Kakdwip Research Centre ponds. However, free CO_2 may accumulate at pond bottom during late hours of the night, if the overlying water had poor oxygen content. CO_2 is not appreciably toxic to fish, provided DO is plentiful. When DO contents are low, the presence of appreciable CO_2 hinders oxygen uptake by fish. Decomposition of organic matter may produce appreciable CO_2 in pond bed and if the water exchange is poor, the CO_2 content may exceed 15 ppm which may be harmful to prawns.

Temperature

Temperature of pond water has important bearing on pond production. During summer, having higher temperature (28°C-34°C) the growth and production of *P. monodon* was maximum. On the contrary, during winter, the growth was very poor at North eastern part of India under temperature ranging between 15° and 18°C from November to February. The best growing period is summer for monoculture of P. monodon to take advantage of its fast growth. In monoculture practices, probably a vast ecological niche is left unutilized in *P. monodon* ponds, but the price of the reared prawn offsets this loss. In other season, polyculture practices can be

adopted. In polyculture, *P. monodon* has been grown with mullets, or milkfish or with other penaeid prawns and palamons groups (Rajyalakshmi, 1980).

Phosphorus

Although a relatively minor constituent, phosphorus is the most important nutrient relative to productivity in fish ponds. Phosphorus fertilizers are widely used in fish culture and phosphorus originating from metabolic wastes is an important factor in ponds that receive application of feed. Concentration of orthophosphate increase almost immediately after ponds are fertilized but decline rapidly to near pre-treatment levels, since it is absorbed by bacteria, phytoplankton and macrophytes. Studies using radioactive phosphorus showed that phytoplankton can absorb orthophosphate very quickly with a large percentage of the total uptake occuring within a few minutes. Phosphorus absorption by macrophytes is apparently slower than for phytoplankton (Hayes and Phillips, 1958). However, phosphorus that is not absorbed by phytoplankton and macrophytes is rapidly absorbed by muds. In general, muds that are strongly acidic or strongly alkaline absorb phosphorus more rapidly than neutral muds. In estuarine wetlands the phosphorus content in water is not high since the added phosphate reacts with calcium and magnesium and precipitates from pond water. In acid soil, the phosphate reacts with iron and aluminium phospate. Phosphorus content in water above 0.2 mg/l may be considered optimum for fish and prawn growth.

Nitrogen

The nitrogen cycle is a biochemical cycle in which most transformations involved biochemical reactions and most of the nitrogen in a pond is bound in living organisms and decaying organic matter. Forms of nitrogen in water are nitrogen gas, nitrate, nitrite, ammonium, ammonia and various forms of organic nitrogen. Organic nitrogen may be simple dissolved compounds, i.e., aminoacids or it may be complex particulate organic matter. Nitrogen occurs in the soil in the same forms that exist in water. Ammonia that reaches water from fertilizers, animal excrements or decay of organic matter exist in a pH dependent equilibrium with ammonium ion :

$$NH_3 + H_2O = NH_4^+ + OH^-$$

As pH increases the amount of ammonia increases and that of ammonium decreases. Thus in estuarine wetlands, having higher pH, considerable ammonia may be lost to the atmosphere by volatilization. Optimum utilization of nitrogen occurs at salinity ranging between 10-20 g/l. Nitrate nitrogen above 0.2 mg/l may be considered conducive for prawn growth in estuarine wetlands.

SOIL QUALITY OF *P. MONODON* CULTURE PONDS

Soil type, its texture and properties is very important for *P. monodon* culture in estuarine wetlands. The type of soil present in the wetland forms the basis for its characterisation. Too porous a soil permits water logging creating conditions of oozing. Fish cultured in such an wetland would find no shelter at the bottom.

A clayey soil provides a hard bottom. An admixture of sand and organic detritus keeps it porous enough to enable shrimp to hide by burrowing. Too soft and porous bottom materials are to be avoided since that causes constant erosion.

Soil having 70-80% sand content will not have stability despite its good bearing capacity. The soil texture suitable is sandy clay, since it is useful for constructing compact dyke. Suitable types of algal growth occurs on which the young prawn feed and the animals find such soil easy to burrow and take shelter; clay loam is also good as a second choice.

In Japan, prawn culture ponds mostly have sandy bottoms, since Kuruma shrimp spend half of their life buried in sand (Shigeno, 1969).

Several aspects of chemistry of brackishwater soils of Sunderban area in West Bengal have been studied in relation to their productivity (Mondal, 1980; Chattopadhyay & Mondal, 1980; Chakraborty *et al.*, 1986). Most of the pond soils belong to silty clay loam or silty clay group. Organic carbon was poor 0.24-0.59%, which indicated necessity of manuring of such ponds.

Soil pH ranged from 7.9 to 8.4 . Electrical conductivity (3.0-11.4 millimhos/cm) indicated moderately high salt content in the soil. Total water soluble cation contents ranged from 7.0-30.8 me/100 gm soil. Among the cations, magnesium was most abundant, followed by calcium, sodium, and potassium respectively. Among the anions, chloride was most dominant. Chattopadhyay and Mandal (1980) found available nitrogen (50.4-110.6 ppm), total nitrogen (220-420 ppm) and available phosphate (42-84 ppm) in brackishwater fish pond soils of West Bengal were moderately low for good fish production. They also observed that rate of mineralisation of organic nitrogen in pond soils decreased with increase in salinity. The present author, during his study of Kakdwip fish farm ponds, which was under semi-intensive culture of *P. monodon* during 1986, observed moderately higher nutrient status (av. nitrogen 308-316 ppm, total nitrogen 980-1176 ppm available phosphorus 80-100 ppm, pH 8.1, electrical conductivity 9.2-11.4 millimhos/cm). Thus, by proper manuring and fertilization programme, the fertility of estuarine wetlands may be improved considerably as observed in Kakdwip fish farm ponds.

Rajyalakshmi *et al.*, (1988) studied the soil and water qualities of some confined brackishwater ponds of Chilka lake fringe area. In the pond soils the pH ranges from 7.43 to 7.72, organic carbon 0.297-0.405%, available nitrogen 12.89-20.02 mg/100 g and available phosphorus 2.47-4.05 mg/100 g indicating nutrient limitations. Since the ponds had no water exchange facility or aeration device and had poor nutrient turnover, the prawn production was generally poor (monsoon crop 135.4-203.4 kg/ha and winter crop 81-190 kg/ha).

Hickling (1971) emphasized the importance of bottom soil in maintaining the fertility of brackishwater fish ponds, since the benthic algae grow in the pond soil base. Mondal (1980) observed that the soils of highly saline fish ponds were characterised texturally by high clay contents, chemically by high percentage of exchangeable sodium and alkaline reaction and physically by extremely low permeability. In general, the soils of most of the estuarine wetlands of West Bengal have silty clay loam texture, alkaline soil reaction, low organic matter, low nitrogen and low available phosphate contents so that inorganic fertilizers and organic manures are necessary for enhancing their productivity.

Fertilization of estuarine wetlands for prawn culture

Since most of the esturine wetlands have poor nutrient status (low organic carbon, poor nitrogen and phosphorus in soil), fertilization is necessary to improve their productivity . Before culture,the pond bed should be dried for 2 to 6 weeks, lime may be applied @ 200-250 kg/ha to absorb excess CO2 and supply calcium required for the molting shrimp. Then poultry manure (1000-2000 kg/ha) or cowdung (2-5 ton/ha), urea (200-500 kg/ha/yr) and superphosphate (200-500 kg/ha/yr) are applied and water is let in to a level of 20-30 cm. This permits the growth of rich benthic algal complex called Lab Lab on which the young prawn feed and flourish well. In about a month, the pond is ready for stocking.

Water exchange in *P. monodon* ponds

Tiger shrimp generally remains at pond bottom for food and shelter. They often burrow the soil and take shelter. As the culture of prawn proceeds, organic substances gradually accumulate on the bottom of the pond and the decomposition intensifies the reduction condition. The pores in the sand bottom lose their oxygen content and during the process of decomposition sulphides, NO_2-N and other harmful substances collect instead. The pond bottom gradually turns dark in colour and emits a foul smell. The DO value is very low or trace at the bottom sediment compared to the pond water; the water in the bottom soil may contain 100 times more sulphur as sulphide. If the bottom layer is polluted as stated above, it

becomes detrimental to the growth and survival of shrimps, a fact well established by experiments (Shigene, 1969). Thus, in old ponds productivity may be low and growth is poor.

To avert the pollution of pond bottom, the estuarine wetlands for *P. monodon* culture should have adequate arrangement for water exchange. Dynamic changes take place in the environment of estuarine wetlands being fed from the estuary by the tidal water. Normally the spring tide are used in the flow in and flow out systems. Spring tides are those which occur at the time of full moon or new moon. The flow system acts to flush out accumulated metabolites in the closed environment with a high standing stock. It brings in freshwater with high DO and changed salinity, pH and temperature. Considerable plankton biomass is brought in the pond which acts as food for the standing crop. One difficulty is the introduction of larvae of unwanted species, specially predators. Regular water exchange reduce the pollutional load of wetlands and helps to improve survival and production of prawn. The flow system is also a must when unusual fish kill occurs in pond. At the first sight of a dead fish in pond, flushing should be done to eradicate any adverse effect caused by low DO, fall in temperature or salinity, change in pH and pollution due to unutilised feeds etc.

Almost all the prawn species thrive well when some low current prevails in the pond. The current keeps the gills washed, food moving and maintained a healthy environment to the bottom where these prawns commonly rest (Rajyalakshmi, 1980).

During rainy season, the salinity of estuarine wetlands may fall sharply which may lead to prawn mortality. So, water exchange is necessary to maintain the salinity. If required, highly saline ground water may be pumped into the system to raise salinity.

Aeration

Dissolved oxygen is probably the most important single variable regulating fish production in intensive culture (Boyd, 1982). The dynamics of DO is strongly influenced by phytoplankton density which in turn is regulated by the rate fish are fed. Aeration may be used to mechanically increase concentration of DO in ponds. Emergency aeration is employed to prevent fish from dying during period of oxygen depletion. Aeration is also employed to prevent thermal and oxygen stratification in ponds in an effort to reduce the risk of oxygen deficiency.

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SOME IMPORTANT STRESS FACTORS IN PRAWN FARMING

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INTRODUCTION

Growth of an animal is mostly dependent upon three important factors, namely,

1) *hereditary characteristics,*
2) *nutrition*
3) *Congenial environment*

Uptill now we have very little control over hereditary characteristics but the supply of nutritious diet and maintenance of congenial environment for the growing prawns either in freshwater or in brackishwater, are not out our reach.

Prawns, as we know have grazing nature and their locomotion is mostly confined closed to the soil-water-interface, Thus, the ecological condition of the subsurface water is most crucial for prawn health. Any physico-chemical stress at this region, will definitely cause distress to prawns and may prove to be fatal, depending upon its severity

STRESS FACTORS

pH

First of all, let us discuss about water pH. All living beings, including prawns, are capable of thriving well, only over a very limited range of acidity or alkalinity. pH below 6, is not conducive for growth of aquatic animal. pH below 5, opposes breeding mechanisms. pH below 4, directly affects prawn health. Similarly pH above 8.5 is not very conducive for the growth of prawns. pH above 10, directly causes stress on prawn health. Therefore, before releasing prawn seeds into a culture pond, its pH at the soil-water-interface must he tested and if required to be modified to the optimum range of 7.0 to 8.5. Again it has been found that the yield of prawn in the range of pH 7.5 to 8.5 is

more than around neutral range. So, the desired pH for prawn culture would be 7.5 to 8.5 at the bottom water, the ideal range is 8.0 to 8.2 (BOBP 1993)

Like most of the physico-chemical parameters, pH of a waterbody (fresh or saline) does not remain standstill at a point round the clock. With the advance of the day, along with increasing photosynthesis and luxurious consumption of carbondioxide, pH of water also increases and reaches its maximum in the afternoon and then begins to decrease due to release of carbondioxide through respiration with growing darkness, and reaches a minimum in the early morning. In case of existing heavy planktonic bloom, particularly, in sewage-fed freshwater and saline water wetlands, frequently the pH of the bottom water exceeds the optimum range in both the directions and cause distress to prawns. This is to be monitored through diurnal study and necessary action should be taken to avoid such stress factors if they last for a prolong period. Sometimes, the microbial spoilage of the easy oxidisable organic matter accumulated on the floor may release a large valume of carbondioxide and thereby, may reduce the pH of the bottom beyond the optimum range.

Remedial measure against this organic load would be to use i) Calculated amount of artificial feed so that the left over residue is minimum. Secondly, part of this organic load may be removed through water exchange. Thirdly, the assurance of optimum oxygen through artificial aeration. This will neutralise the hydrogen ion accumulation and keep the pH at the correct state.

DISSOLVED OXYGEN (DO)

Optimum level of dissolved oxygen (DO) is around 5.0 to 7.0 mg/litre. Dissolved oxygen concentration should not be less than 5.0 mg/l, over period of 16 h of any 24-h period (McKee and wolf, 1964) and it should never be less than 3.0 mg/l. Like pH, DO of a water body does not remain fixed at a point throughout the day. A variation of 3.0 mg/l to 10.0 mg/l, round the clock is quite good for a prawn culture pond. Almost similar to the fluctuation of pH, DO also increases with photosynthesis and becomes maximum in the afternoon and reduces to minimum in the early morning due to respiration of aquatic life, with night fall. If its value goes below 3 mg/l, the prawn will not die out immediately, but this will certainly act as an environmental stress factor upon prawn health and will retards its growth. This will also act as a precusor to bacterial infection as has been stated by Snieszko, 1973. Plumb et al., 1976 etc. Under culture condition it has been seen that the concentration of CO_2 and ammonia (NH_3) are often high when DO is low. Walter and Plumb, 1980, showed that the triad of environmental stresses to be more effective than low DO alone.

And most often the cause of failure of prawn culture has been attributed to the depletion of DO on the floor of the waterbody. Prolong exposure to poor DO, may force the prawns to come up near the shore by crawling and this may ultimately lead to mass mortality at the bottom which will not be known to the farmer at once as the prawns live on the floor of the pond. Daily monitoring of DO at the bottom, particularly, at night and artificial correction of the same is a must, in a prawn culture farm. Planktonic bloom, due to excessive, nutrients availability, may also raise the DO to super saturation in the afternoon and may cause gas buleble disease when its value exceeds 20 mg/l. (Boyd, 1982).

FREE AMMONIA (OR UNIONISED AMMONIA)

Protein is the main constituent of animal and plant body and nitrogen is the essential constituent of protein. But prawns do not take elemental nitrogen. They receive the same in the form of protein from planktons, benthic organisms or from artificial feed, given to them. Now the microbial spoilage of the dead plankton or residual artificial protein rich diet, release ammonia in water. Concentration of unionised ammonia, which is almost lethal to prawn increases in water directly with rise of temperature and pH as has been shown in the table by Boyd, 1982.

As the ammonia level increases in water, ammonia excretion by prawn decreases and levels of ammonia in blood and tissue increase (Colt and Armstrong, 1979) consequently, blood pH is elevated and this adversely affects enzyme - catalyzed reaction and membrane stability. High concentrations of unionised ammonia in water also reduce internal ion concentrations. Ammonia also increases oxygen consumption by tissues, damages gills, and reduces the ability of blood to transport oxygen. Histological changes occur in Kidneys, spleen, thyroid tissues and blood. Exposure to ammonia probably increases susceptibility to diseases. Ammonia is more toxic when DO is low (Merkens and Downing, 1957). Poor growth is often attributed to the accumulation of ammonia (Smith and Piper, 1975). Colt and Tchobanoglous (1978) concluded that any measurable concentration of ammonia would adversely affect growth. Thus, we see, that unionised ammonia is a major stress factor in prawn culture. Therefore, it is advised to monitor free ammonia in the bottom water, fortnightly, round the clock and correction of the same whenever present in measurable quantity.

HYDROGEN SULPHIDE

Hydrogen sulphide, which is mostly formed due to protein spoilage under low oxygen concentration and also by sulphate reduction by certain heterprophic bacteria (Boyd, 1982), is highly toxic to prawn health at all concentrations. Accumulation of this gas at the bottom layers can act as a serious stress factor and may cause prawn kill before we could detect the reason.

Adelman and Smith (1970) showed that egg survival and fry development were limited even by 0.006 mg/l of H_2S. The proportion of unionised H_2S decreases with increasing pH. Chronic exposure to 0.002 mg/l of H_2S may not cause any mortality but acts against the deposition of egg. Exposure to 0.003 mg/l, also adversely affect growth of prawn. Smith et al., 1976, stated that any detectable concentration of hydrogen sulphide should be considered as detrimental to prawn production.

OVERCROWDING

Overcrowding is a primary stressor in shrimp farming. This acts as a stress and cause injuries to prawns and spoils the water quality and favours the pathogen to thrive well. High population lead to greater spoilage of feed, discharge of increased excretory products. This makes the management more difficult. Water quality deteriorates due to formation of free ammonia, accumulation of H_2S and nitrite, at the bottom, under nearly, anoxic condition and pathogens become active at the same time (AQUA International, Feb, 1994). Acceptability of feed by shrimp is reduced and growth becomes poor which is extremely detrimental to the industry itself. (Fishing Chimes, April, 1995, Fifth Anniversary Bumper Issue).

TURBIDITY AND TRANSPARENCY

The turbidity due to clay particles, also act as a stress factor when its value rises above 175000 mg/l (Wallen, 1951). Clay suspension restricts light penetration and affects productivity. The particles will settle at the bottom, smother egg and destroy benthic communities (Boyd, 1982). The turbidity of water may also be caused by planktonic bloom. This gives a direct relationship with secchi disc transparency measurement. A secchi disc transparency of 15 to 40 cm. is ideal (Boyd, 1982), 40 to 100 cm is farely good and below 15 cm. acts as a stress factor and may cause mortality below 10 cm.

SALINITY

Ideal salinity for growth of *P. monodon* is around 10.0 to 25.0 ppt., though, prawn can tolerate still lower salinity to that of the sea water. Salinity itself does not póse to be a serious problem during

P. monodon rearing but its abrupt change as a result of heavy shower may cause immediate mortality. This should be guarded through exchange of brackish water, whenever there is an abrupt rise or fall by 3.0 ppt or more.

TEMPERATURE

Ideal temperature for rearing *P. monodon* is around 28-30 °C. Temperature below 24 oC and above 33 °C are lethal to P. monodon larvae. Sudden fluctuation of temperature by more than 1 °C may act as stress factor and cause mortality of *P. monodon* larvae (BOBP, Madras, 1973). Wide fluctuations of temperature in P. monodon farm by heavy shower or anything else is dangerous. Temperature should be monitoried five or six times a day (BOBP, Madras, 1993). Use of thermostat in prawn farming may be the answer.

ALKALINITY

Natural waters that contain 40 mg/l. or more total alkalinity, are considered more productive than waters of lower alkalinity (Moyle, 1945, Mais, 1966). Still lower alkalinity is not favourable for primary production and have low buffering capacity. This also acts as a predisposisng factor for the manifestation of fish diseases.

HARDNESS

Hardness below 20 mg/l, may also act as a stress factor in prawn farming. Hardness around 100 mg/l, may be ideal. Water should not contain calcium and magnesium concentrations below 5 mg/l and 2 mg/l, respectively.

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NUTRITIONAL REQUIREMENTS AND FORMULATION OF PRAWN FEED

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INTRODUCTION

In describing the concept of prawn nutrition and development of formulated feed for culture, it is first of all needed to categorize different aspects of prawn nutrition that must be considered if successful feeds are to be developed. The list appears long and somewhat descriptive but it is emphasized that information on all aspects are not needed at one time before attempts could be made to compound commercial rations for prawn. It may however be kept in mind that inspite of the progresses made in the field of aquaculture nutrition, there still remain sufficient gaps in our knowledge that make ration formulation for prawns an empirical science.

Whereas the terrestrial animal nutrition is based on adequate scientific principles, the same ramains lacking for aquatic animals. Many variables seem to operate. Sometimes, it appears difficult to keep the other variables constant while unravelling the mystery of one phenomenon.

The knowledge about nutritional needs of prawn is essential, as first of all, about 50-60% of the operational cost in an intensive or semi-intensive aquaculture goes to feeds. It appears thus relevant, on part of an aquaculturist, to manipulate the feed composition in an obvious attempt to maximise the output without any hindrance in its quality. Secondly, in studies of prawn nutrition and in the whole range of prawn cultivation, innumerable number of different prawns are used which not only varied from place to place but also from one country to another. A few mention of these prawns can be made as follows : *P. setiferus, P. japonicus, P. monodon, P. orientalis, P. stylirostris, P. vannamei etc.* The list is long and there is a danger, especially in nutritional sciences, of assuming that prawns are basically a homogenous group. The results which have been obtained for one species may not automatically apply to the other. This may probably be so in a few cases but not in all and this has to be continuously kept in mind while investigating the nutritional needs for prawns.

It is known that like other animals of terrestrial and aquatic origin, prawns in general require proteins for growth and body buildup, lipids (fats) not only for growth but also for energy and specific hormone production and the carbohydrates mainly for supplying the energy. When lipids and carbohydrates, are supplied in the diet in insufficient quantities, sparing action of proteins for carbohydrates and lipids and the vice-versa are seen to occur for adjustment of protein/energy ratios (P/E), although in many cases with uneconomical consequences.

In addition to the macro-nutrients (proteins, lipids, carbohydrates) that are needed in the diet in bulk quantities, there are obvious needs for the micro-nutrients which are to be supplied in the diet in lesser quantities. These are the vitamins and minerals. The vitamins and minerals act precisely to carry out essential physiological processes. A number of B-vitamins and metal ions like Ca^{++}, Mg^{++} etc. act as coenzymes and cofactors respectively for a large number of enzymes that perform biochemical reaction processes in prawn and other crustaceans.

Besides this, there are requirements for specific growth factors like the dietary sterols, phospholipids, polyunsaturated fatty acids (PUFA) etc., some of which work excellently in prawn cultivation system exhibiting rapid growth performances.

Finally, in considering the nutritional requirements of prawn, possible variations related to the moulting cycle must be considered. Prawn moults more or less at frequent and regular intervals and the shell and carapace exhibit a high but fluctuating demand of calcium and possibly phosphorus too, in addition to the specific requirements of dietary chitin.

Although many laboratories are working worldwide on specific nutritional requirements for prawn and feed formulations, how much of these different nutrients are exactly required in the diet by different species have not been fully elucidated. This readily explains why one could see a wide range of feed formulations, even for a single species of prawn, like the *penaeus monodon* (Fab.).

Table 1. Categorical aspects of nutritional requirement and feed formulation for prawn

a)	Nutritional Requirements	i)	Amino acids and protein
		ii)	Lipid (Fat)
		iii)	Carbohydrate
		iv)	Protein/energy ratio (P/E)
		v)	Crude fibre
		vi)	Vitamins
		vii)	Minerals
		viii)	Specific growth promotors
		ix)	Moulting requirements
b)	Feed Formulation	i)	Raw material selection, procurement and transportation
		ii)	Proximate composition of ingredients.
		iii)	Formulation programme
		iv)	Degree of milling and mixing
		v)	Form of final product
		vi)	Ease of handling and storage
		vii)	Water stability and nutrient leaching.

Besides the different aspects mentioned in the above table, there are a number of other aspects which must be taken care of simultaneously, if a successful ration has to be developed. These are the food intake and feeding level, growth and conversion ratio, other dietary evaluations like the specific growth rate etc., net protein utilization (NPU), protein efficiency ratio (PER), digestibility of nutrients, texture and palatability of diet, environmental conditions etc., the discussions of which are beyond the scope of present topic.

NUTRITIONAL REQUIREMENTS

Amino acids, Protein and Protein/Energy (P/E) Ratios

In so far as the amino acid requirements are concerned, C^{14}-tracer technique employing labelled amino acids has demonstrated the qualitative requirements in prawns and these, not surprisingly, have shown that the same amino acids are likely to be essential for prawns as for other groups of animals including fish (Cowey and Forster, 1971 ; Shewbart, Mies and Ludwig, 1973). These amino acids are methionine, arginine, tryptophan, threonine, valine, isoleucine, leucine, phenylalanine, histidine and lysine. In short, they could be termed as 'MATTVILPHLY'. However, the radioactive technique does not provide information on the quantitative requirements of these essential amino acids. How much quantities of these ten essential

amino acids are required to be present in the diet for maximum growth still remain to be worked out. Nevertheless, attempts have been made to correlate the amino acid profile of the diet with the growth performance in prawn. It has been observed that formulations deficient in phenylalanine, histidine, arginine and lysine have registered poor growth performance in prawn (Deshimaru and Shigeno, 1972). Fish meal, which is conventionally regarded as a high quality protein source for many a farm-animals, is no exception owing possibly to the lower content of these four amino acids. It has been reported that diets which gave the best growth performance in *P. japonicus*, most closely matched the body amino acid composition of the prawn. This interesting finding has prompted the analysis of many a species of prawn for their proximate composition and evolved a short-cut process of feed formulation by relating the composition of feedstuffs to those of the prawns under cultivation. It has been observed that good natural foods, such as short-necked clam, has an amino acid composition similar to those of squid meal and mysid shrimp meal which are most satisfactory components of formulated rations. The amount of squid meal in a diet could be reduced if 0.8% arginine or 0.5% methionine is substituted (Kitabayashi et. al. 1971). This revealed the growth promoting effect of the amino acids. A survey of literature indicates that requirements of various essential amino acids for different species of prawns have not been determined. This area thus warrants urgent attention. That the different species of prawn have different amino acid profiles is now known (Deshimaru and Shigeno, 1972). Therefore, till the time the individual amino acid requirements are determined for different prawns, it will be justified to incorporate amino acids in prawn diets matching with their body compositions, particularly in case of synthetic diets.

In so far as the protein requirements of prawns are concerned, a wide range varying between 27.5 - 70% has been suggested. A dietary protein requirement of 28 - 32% for *P. setiferus* (Andrew, Sick and Baptist, 1972), 40%, 54% and 70% for *P. japonicus* (Balazs, Ross and Brooks, 1973 ; Deshimaru and Kuroki, 1974a ; Deshimaru, 1975), 46% for *P. monodon* (Lee, 1971), 40% for *P. serratus* (Forster and Beard, 1973), 22.5 - 35% for *P. aztecus* (Shewbart, Mies and Ludwig, 1973) and 43% for *P. indicus* (Colvin, 1976) have been reported. The differences in optimal protein requirement are due to the species differences and the source of feedstuffs chosen for the culture.

Some of the best results in terms of overall growth have been obtained with very high protein levels, *i.e.*, around 60% of the diet. In contrast, other workers have reported much lower levels as being optimum and reported inhibition of live-weight gain as the dietary protein level is increased.

It can thus be inferred that good growth results with high protein diets have been obtained with *P. japonicus*, while the lower dietary protein values have generally been obtained with other prawns. Feeding habit too indicates that *P. japonicus* is predominantly carnivorous in the wild; and *P. setiferus* as well as *P. ajtecus* are mainly detritus feeders.

In *P. monodon*, it has been observed that not only the protein digestion and absorption from a high protein diet were better compared to a low protein diet (Lee, 1971), both the vegetative and the animal sources are well absorbed in the body. Increasing the protein content in diet from 18 -45% rendered steady growth increments in *P. monodon*. However, further increase upto 60% of protein resulted in depression of growth.

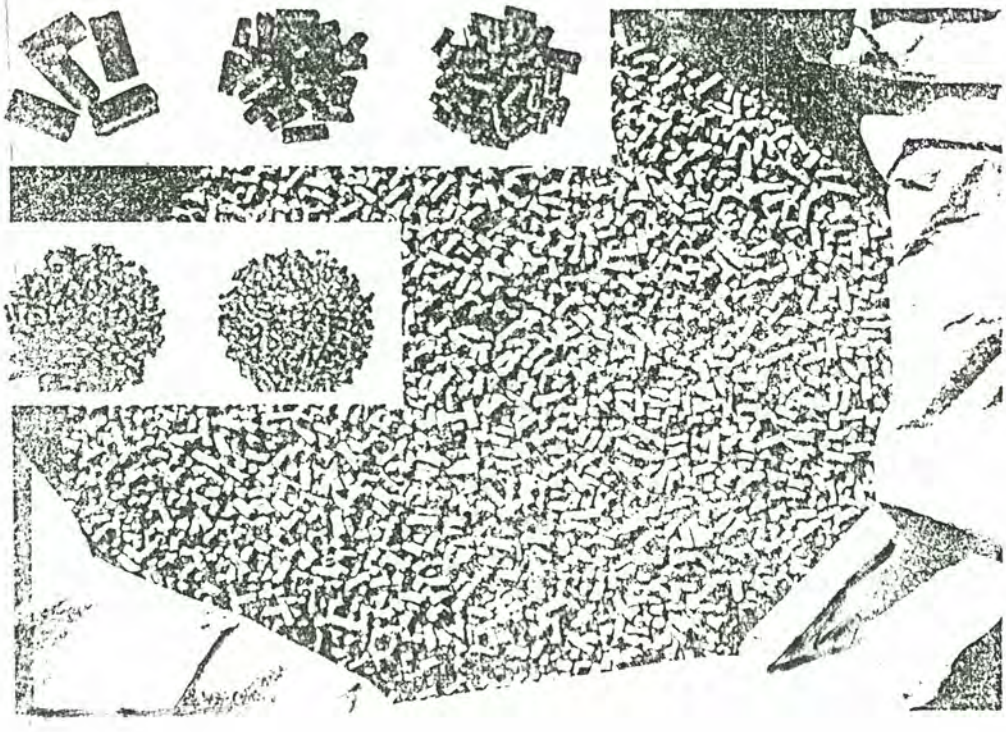
In *P. setiferus*, increasing the dietary protein level beyond 28% recorded reduction in growth, unless the dietary carbohydrate and lipid levels are increased (Andrew et. al., 1972). It is pointed out that the dietary optimum protein requirement of *P. setiferus* is around 30%. Against the penaeid prawns, the freshwater prawn, *Macrobrachium* is reported to require lesser dietary optimum protein content of abour 25% with the range varying between 15 - 35% (Balazs, 1973).

In *P. aztecus*, it has been observed that both the dietary low protein/high energy and high protein/low energy contents exhibit better growth performance than either the low protein/low energy or high protein/high energy levels (Hysmith et. al., 1972). This indicates the importance of adjusting the protein/energy (P/E) ratio of the diets. Whereas it is reported that the optimum protein requirement of *P. monodon* is 40% in which the total dietary energy content was 285 Kcal/100g, i.e., the P/E ratio is seen to be 140.3 mg protein/Kcal (Lovell, 1985), a much lower P/E ratio of 112.2 mg protein/Kcal has been reported to be optimum for growth of *P monodon* (Hajra et. al.,1985) when the protein requirement synchronises with its optimum level of 46% (Lee, 1971). It thus appears that both the dietary protein and total dietary energy play important roles in exhibiting optimum growth. The availability of protien-calorie from feedstuffs and the importance of the same for growth have also been indicated in finfishes (Hajra, 1987).

Effect of source

Earlier, dietary formulations for penaeid prawns utilized mainly the animal sources, like the fish meal, shrimp meal etc. Gradually, vegetable proteins found their access in the arena of formulations. Using soybean meal along with other ingredients, 72% growth in *P. japonicus* has been reported against a natural food item of short-necked clam (Kitabayashi, 1970). Thus, besides the quantity of dietary protien, the source also plays pronounced growth influence. This naturally refers to quality or the amino-acid make-up of it. Soybean protein exhibited better growth in *P. duorarum* compared to manhaden fish meal, shrimp meal, milk casein or maize gluten (Cherian et. al., 1991). Soybean has been demonstrated to be a good source of feed item for penaeids (Kanazawa, 1970). It contrast, the same is stated to support poorer growth as the source is low in arginine, lysine and histidine and hence requires to be supplemented with them (Deshimaru and Shigeno, 1972). The level of maximum incorporation of soybean powder has been determined. It is observed that upto 60% incorporation of soybean could be done in a 30% protein diet made from various sources without any growth diminution in *P. vannamei* (Lovell, 1988). Among the sources of animal origin, squid meal,

AQUACULTURE FEED.



mysid shrimp meal, clam, oyster and mussel meat etc. are considered excellent sources of protein. Squid meal at 6% incorporation level is demonstrated to exhibit pronounced growth enhancements in *P. japonicus* (Kanazawa, 1970).

To sum up about the principal controlling factor, the protein, it can be inferred that prawns are not nutritionally a homogenous group with respect to their protein requirements and that a level ranging between 30 - 45% may work well for a large number of the prawns.

LIPIDS

From a discussion of dietary protein and energy contents, let it now be moved on to a discussion of dietary lipids (fats) for prawn. Crustaceans, in general, do not require high levels of dietary fat. Unnecessary higher levels may exert adverse effects and if not, the feed cost may seem prohibitive. In one formulation, a level of 8.8% crude fat is seen to exhibit best results (Deshimaru and Shigeno, 1972). In yet another experiment, the addition of 4% squid liver oil to a standard ration improved growth in *P. japonicus* (Shudo *et. al*, 1971). However, inhibitions of growth at levels of 10% and 15% respectively have also been demonstrated (Andrews, Sick and Baptist, 1972 ; Forster and Beard, 1973). Using purified synthetic rations, it has been observed that 10% lipid gave better growth than no incorporation level (Sick and Andrews, 1973) and that a level of 6% dietary fat rendered better growth than either no incorporation or 12% incorporation level (Deshimaru and Kuroki, 1974). It appears relevant that prawns do not require higher levels of dietary lipid and that the optimum level lies somewhere between 5 - 10% of the feedstuff on a dry basis.

CARBOHYDRATES

The interest for carbohydrates in prawn possibly originated from the activities of many enzymes like amylase, maltase, saccharase, chitinase etc. in crustaceans (Kooiman, 1964). The carbohydrates are seen to play important role in energy production (TCA cycle), storage of carbohydrates as glycogen, synthesis of chitin, formation of fatty acids etc. (New, 1976). Initial indications were that the prawns are able to utilize quite high levels of carbohydrate and that starch rather than glucose or dextrin exhibits better results with respect to growth. Higher growth performance in *P. duoram* is reported on a diet containing 40% corn starch than diets containing 10% starch, 40% glucose or 10% glucose (Sick and Andrews, 1973). A standard laboratory diet to which 15% wheat starch had been added showed better growth performance (138% live-weight gain in 28 days) in *P. serratus* than the same diet to which glucose, oyster glycogen, dextrin or no carbohydrate supplements have been added. From various observations, it seems probable that prawns can digest and assimilate a variety of carbohydrates like wheat starch, corn starch, dextrin, oyster glycogen etc. Potato starch, however, is less well digested (Forster and Gabott, 1971). Wheat starch is seen to be less digested in *P. platyceros* (New, 1976). Glucose assimilation (3.75% supplement

in diet) is reported to occur in somewhat better way when added along with vitamin C (Kitabayashi, 1971). Cellulosic materials are, however, difficultly digested.

CRUDE FIBRE

Information on the role of dietary crude fibre in prawn and other crustaceans is limited. The source of crude fibre in feed owes its genesis to the presence of a number of vegetative ingredients employed in the formulations. In mammals, the presence of a definite amount of fibre in food materials helps in proper movement of bowl in the intestine. In domestic land animals, the presence of fibre in the herbivorous diet increases gastro-intestinal movement of the ingested material. Owing to the shorter length of G.I. tract in prawns, a lesser time is needed for digestion and assimilation because of a rapid rate of passage of ingested materials through the gut. As such, very limited investigations have been carried out on the possible impact of fibre in prawn feed. Additionally, crude fibre or the cellulosic and pectinaceous materials are difficultly digested (10 - 20%). The rest is obviously voided. The beneficial role of crude fibre in phytophagous finfish has been well documented (Hajra, 1987). Increased growth rate, survival and conversion efficiency have been reported in *P. aztecus* when fibre is included in the diet from turnip green upto 5% incorporation level (Venkataramaiah *et. al.*, 1985). A fibre level of 8.75% in the pelleted diet has supported excellent growth in *P. monodon* (Ghosh et. al., 1987). However, more detailed investigation on the possible impact of dietary fibre in shrimp feed is needed, because a vast majority of the formulations usually contain a number of raw materials of vegetative origin, all of which contain substantial amounts of crude fibre in them.

VITAMINS

It has been early reported that the members of B-group vitamins are needed in crustacean diet alongwith vitamins C and E (Fisher, 1960). That the prawns grow well in the presence of vitamins have been documented by others, the reported beneficial effects being more when used alongwith minerals (Sedgwick, 1980). The importance of vitamin C (L-ascorbic acid) in the diet of prawn has been indicated by many workers (Kitabayashi, 1971 ; New, 1976). The role of beta-carotene (provitamin A) as a precursor of vitamin A and in the pigment formation for prawn has been demonstrated (New, 1976). Vitamin C deficiency is reported to exhibit black death in prawn.An amount of about 0.3% vitamin C is generally needed in prawn diet that can check the occurrence of such death (Deshimaru and Kuroki, 1976). However, the quantitative requirements have not been fully elucidated for each of the vitamins (Lovell, 1985). Thus, pending such determinations, the use of vitamins in shrimp feed is likely to be guided by the requirement pattern of smaller terrestrial species. However, without proper knowledge about the requirements, the additions of excessive vitamins in feedmix are not only unadvisable for probable hypervitaminosis possibilities of A, D, E, and K but also a wasteful process, costwise. Till the

availability of comprehensive information, it would be better to follow the specifications laid down under the 'nutritional requirements of warm water fishes' (NRC, 1977).

MINERALS

The knowledge about the adverse effects of mineral deficiency and the ill-effects of the presence of excessive minerals have brought the attention of feed formulators to include such items in feed. For long, the use of calcined crustacean shells in the diet for fishes and prawns, like those of domestic animals, was known, without any scientific basis, however. The roles of Ca and P have been known from the good growth results in *P. japonicus* with 1.2% Ca and 1.04% P in the diet (Kitabayashi *et. al.*, 1975). In contrast, it was pointed out that the requirements of chloride, sodium, calcium and potassium are met through the osmotic regulation in *P. aztecus* (Shewbart et. al., 1973). The need for P has been stressed in shrimp diet (New, 1976). The role of phytate phosphorus in penaeids, too, was indicated (Lovell, 1985). However, besides the information about Ca and P, precise requirements of other minerals in prawn feeds are not readily available, owing to the paucity of reported data. Thus, in the case of minerals also, the additions in feed may follow the pattern of domestic animals or the specifications of the 'nutritional requirements of warmwater fishes' (NRC, 1977).

MOULTING REQUIREMENTS

In considering the nutritional requirements, possible variations relating to the moulting cycle of prawns must be borne in mind. Although there are considerable needs for the synthesis of chitin, it is not known whether these needs are cyclic, synchronizing with the moulting phenomenon or a constant one. Glucosamine is the precursor of chitin and various workers have added glucosamine to their formulations, but hardly any beneficial effects could be seen. Some effects are only reported when glucosamine is included at 0.5% level to a standard diet (Kitabayashi, 1971). It was demonstrated that when *P. serratus* is injected with C-14 labelled acetate (precursor of glucosamine), a large portion of the substrate radioactivity is rapidly incorporated in glucosamine, which could be recovered from chitin residue (Cowey and Forster, 1971). Thus, it seems probable that provided with the necessary substrates through ingredients in the diet, prawns could synthesize glucosamine and hence the chitin very efficiently and therefore dietary supplementation with glucosamine may be an unnecessary complication. No nutritional care with respect to this requirement, is therefore needed.

SPECIFIC GROWTH PROMOTORS

Lastly, for harvesting an increased amount of prawn within the shortest possible time, little discussion about the uses of specific growth promotors does automatically arise. The beneficial growth effects of polyunsaturated fatty acids (PUFA) particularly those of the linolenic series

(w_3) in prawns have been reported (Curzon, 1976). *P. serratus* is demonstrated to grow faster on diets with a long chain of polyunsaturated fatty acids (C_{22}) (Marlin 1980). Excellent growth performance of *P. aztecus* fed with diet containing 1-2% linolenic acid was reported (Shewbart and Mies, 1973) and high growth rate is observed in *P. californiensis* fed with rations comprising 1% linolenic acid (Brond and Colvin, 1977). A high w_3/w_6 ratio (linolenic/linoleic acids) is seen to exhibit better growth rates. Marine fish oil, in general, is richer in w_3 series than the w_6 series of fatty acids that are found in large amounts in vegetable oils. This easily explains why marine fish oil could be better utilized for obtaining increased growth compared to vegetable oils. High amounts of w6 fatty acids caused high incidences of mortality in shrimps (Sick and Andrews, 1973). Corn oil, a vegetable oil, has been used in the formulations that contained high amounts of w6 fatty acids, possibly contributing to the mortality. Diets composed of squid meal, brine shrimp and mysid shrimp showed excellent growth results because of the presence of desired fatty acids (w_3) in them. In lobster ((*Homarus americans*) too, the essential fatty acid (EFA) needs and higher growth rates are achieved with w3 fatty acids and not with w6 acids or with saturated fatty acids.

The special requirement of cholesterol in crustacean diet has drawn considerable attention of researchers. Since penaeid prawns are unable to synthesize sterols form its precursor acetate, as can be seen by the failure to incorporate radioactivity of labelled acetate into sterol, the dietary requirement of cholesterol is indicated not only for higher growth but also for normal reproductive functions (Teshrina and Kanazawa, 1971). 1-2% cholesterol incorporation in diet has shown very high growth rates in *Artemenia longinaris* and *P. kerathurus*, an argentine and a mediterranean prawn respectively (Kanazawa, 1970). The dietary requirement of cholesterol is 0.5% of dry diet for the post-larvae of *P. vannamei* (Kanazawa, 1970). Cholesterol is important for the synthesis of various reproductive steroids ; additionally the moulting hormones are beneficially affected which can elaborate new subcellular membranes connected to higher moulting efficiency and rapid growth. It seems that about 0.2 - .5% cholesterol would exert its rapid growth promoting effects, if incorporated in diet.

Dietary requirement of another faster growth-promoting compound, lecithin (a phospholipid) has been indicated. *P. monodon* exhibits very fast growth, survival and feed conversion at its 2% incorporation level (Kanazawa, 1970). It is reported that the presence of lecithin in shrimp feed could bring down the cholesterol requirement to 0.1 - 0.25% (Lovell. 1988).

The growth promoting effects of choline chloride (0.9%) and cholesterol (0.4%) together has also been demonstrated in the culture of *P. monodon* (Ghosh *et. al.*, 1987).

FORMULATION OF PRAWN FEED

The foremost duty in prawn feed formulation is the selection, procurement and transportation of raw materials needed for the purpose. A variety of feed ingredients can be selected, a few mention of which are : non-commercial shrimp meal, mysid shrimp meal, shrimp head-waste, squid meal, clam meat, oyster meat, mussel meat, fish meal, soybean meal, corn starch, potato starch, wheat starch, cod liver oil, shark liver oil, whale oil, marine fish oil etc. The 'best-buy' technique could be followed for the selection of ingredient, particularly for the high protein containing feedstuff, as this is the costliest part in any diet in farming system (Hardy, 1980). The technique works on the principle of computation of price per gram of protein, their comparision and selection.

Once this has been achieved, the ingredients are required to be carried out to the site, employing any cheaper method of transportation. Easily available cheaper ingredients at one place may not be used at an other place far away, if transportation cost appears prohibitive, limiting their uses. As far as practicable, therefore, locally available ingredients be selected, barring a few specific items that are required to be transported from far off places.

The second step in feed formulation is the chemical analysis of feed stuffs for determination of their quality (A.O.A.C., 1975).

Based on the analysed data of ingredients, formulations may be effected. From experience, many a formulations can be done by way of various combinations, but it is best to follow the 'balancing formula' method for adjusting either the protein or energy levels of the final diet (Hardy, 1980). The weighed quantities of ingredients may be pulverized well and starchy ingredients be boiled in water, to which other ingredients may be added for obtaining a dough of desired consistency. After moderate cooling, the vitamin mixture may be added at last, as many of them are extremely heat labile and therefore required to be treated with care below 60^{o} - 65^{o} C. The formed mash (dough) can then be used in whatever manner it should be presented.

The final form of presentation of shrimp feed itself could be an important aspect in dietary operations. The form of feed depends on the size of prawn under cultivation and the culture methods. Various forms may be used like the gels, flakes, steamed pellets, extruded dry pellets (spaghetti like mash), capsules etc. A number of binders could be used depending upon the desired stability of the diet under water. Chemical binders may be used like the Na-alginate etc. Autobinding could also be effected in which one of the sticky ingredients be processed by boiling in water like the potatoes, wheat powder etc. Yet, the third method could be used which could make paste or jelly-based diets.

EXPLANATIONS

1. BEST- BUY TECHNIQUE

This technique works on the principle of computing the cost per gram of protein of the ingredients, followed by procurement of the best-buy. Before purchase of the ingredients, aliquots (samples) of ingredients are required to be analysed for the determination of thier protein contents. Say, the market cost of some ingredients are as follows :-

Ingredients	Cost per kg.	Protein content	Cost per gram protein
Soybean meal	Rs.6.00/-	40%	1.50 paisa.
Groundnut oilcake	Rs.5.00/-	36%	1.39 "
Sesame oilcake	Rs.5.00/-	32%	1.56 "
Mustard oilcake	Rs.4.00/-	25%	1.60 "

Thus, on 'cost per gram of protein' basis, groundnut oilcake will be the best-buy (least cost), followed by soybean meal which will be a better-buy stuff. The mustard oilcake will be the worse-buy, at the prevailing rate of the market.

2. BALANCING FORMULA FOR PROTEIN LEVEL IN DIET

The 'Square Method'

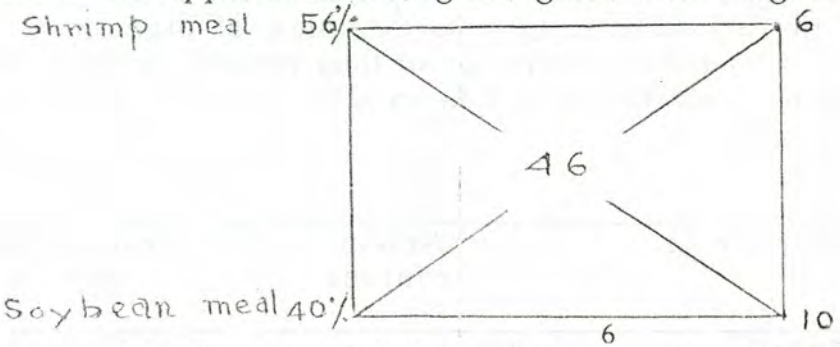
In majority of the diets, proteins are the costliest part and hence it is the first nutrient that is computed in feed formulation programmes. The 'square method' is used to determine the required proportions of high-protein ingredients and low-protein ingredients that are to be mixed to prepare a final prawn feed, which will meet the nutrient requirements of the species under culture. For this purpose, ingredients are first divided into high

protein stuff (protein more than the requirement, and low-protein stuff (protien less than the requirement). When mixed in suitable proportions, that are determined by the 'square method', the low-protein containing ingredients dilute the high-protein containing ingredients to form the final prawn feed with the required protien percentage.

Example : 1

Suppose, shrimp meal and soybean powder are the only two good feedstuffs that are available in the market to prepare a prawn feed with 46% protein content (say, the nutritional requirement =46% of protein).

A square is first made and the two feedstuffs are put on the two left corners along with the protein content for each. The desired protein content of the final feed, is subtracted from that of the feedstuffs, placing the, values in the opposite corner, ignoring the '+'or '-' signs.



$$\text{Therefore, amount of shrimp meal} = \frac{6}{10+6} \times 100\% = 38\% \text{ (approx)}$$

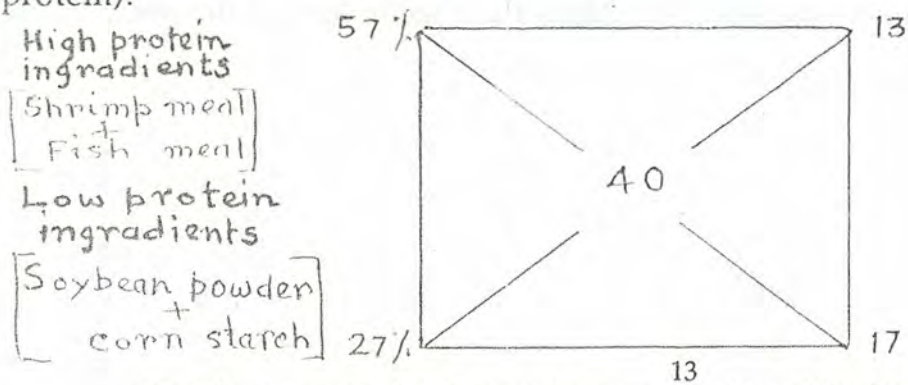
$$\text{and the amount of soybean meal} = \frac{10}{10+6} \times 100\% = 62\% \text{ (approx)}$$

Therefore, to prepare 1 kg of final prawn feed, mix 380g of shrimp meal with 620g of soybean powder and compound the diet. This will give 46% protein in the compounded stuff.

Example : 2

Again, suppose, four ingredients were procured from the market to prepare a prawn feed with 40% protein content (say, the nutritional requirement = 40% of protein).

First, group the high-protein ingredients as well as the low-protein ingredients, averaged for protein percent within each group and fit to the square method. Say, the ingredients are shrimp meal (52% protein), fish meal (62% protein), soybean powder (42% protein) and corn starch (12% protein).



$$\text{Therefore, amount of H.P. ingredients} = \frac{13}{17+13} \times 100\% = 43.3\% \text{ (approx)}$$

$$\text{and the amount of L.P. ingredients} = \frac{17}{17+13} \times 100\% = 56.7\% \text{ (approx)}$$

Therefore, to prepare 1 kg. of final prawn feed, mix 216.5g of shrimp meal, 216.5g of fish meal, 283.5g of soybean powder and 283.5g of corn starch together and compound the diet. This will give exactly 40% protein in the compounded stuff.

Note : Since, added vitamin mixture, mineral mixture and the added fats/oils do not contribute any protein to the final feedstuff, one must leave room for additions of these materials and adjust the protein level in the diet accordingly.

For example, say, calculated amounts of ingredients together contribute 5% oil and the nutritional requirement for lipids (fats/oils) is 8%. Then 3% exogenous oils are required to be added. Say, vitamin mixture and mineral mixture are to be added at the rate of 1% each. Then 100% -5% (3% oil +1% vit. mix. + 1% min mix.) =95%. Now, according to the formula,

amount 1 x strength 1 = amount 2 x strength 2

say, the final prawn feed should contain 40% protein

then, 95 x strength1 = 100 x 40

$$\text{then, strength 1} = \frac{100 \times 40}{95} = 42.1\% \text{ protein}$$

Thus, this apparent value of protein level (42.1%) should be placed in the centre of the square be and amounts of the ingredients be determined and mixed. This will give 42.1% protein in the diet. Finally, when 30g oil, 10g vit. mix. and 10g min. mix. per kg will be added and mixed, the grand final protein content will be diluted to exactly 40% in the prawn feed.

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SCAMPI CULTURE AND ITS FUTURE SCOPE IN INDIA

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INTRODUCTION

Till recent past prawns drew little attention being bottom level contributor to the quantum of total fish production of the country. The sense of economic importance of prawn as exchange earner has triggered thrust in prawn production from natural resources as well as artificial culture operations in confined water bodies . India is gifted with diverse freshwater resources in the form of flood plain wetlands, exbow lakes, pools and natural depressions etc. and in adddition innumerable tanks of different sizes. Most of these water resources, natural or man made have high productivity potentialities. Obviously the technologies so far developed for prawn culture if put into practices would not only enchance prawn production from the cultural waters but also help in generation of employment opportunities and strengthen economic condition of the country.

CULTURE OF SCAMPI IN CONFINED WATERS

In the light of environmental and ecological problems in intensive culture of brackish water prawn, culture of scampi has immense scope to flurish because the technology for culture of scampi in large scale is not determental to the ecology and environment of the culturable waters. The advantage of short term culture period for scampi has popularised cultivation of the species throughout the country.

INDIAN SCAMPI

Scampi in India means the giant freshwater prawn *Macrobrachium rosenbergii*. However, there are few other species under the genus *Macrobrachium* which can also be cultured in freshwater but with the limitations of low growth rate and restricted distribution in the Indian rivers.

SEED RESOURCE

Most of the major river systems in the country have natural population of *Macrobrachium* species. River Ganga with its tributaries is the prime resource of freshwater prawns in particular of the macrobrachium group. While Narmada in west coast and Mahanadi and Bramhaputra an east are also important prawn habitats but with less diversity and low population abundance.

CULTURE SYSTEM

Unlike teleosts, the crustaceans in particular the decapod prawns are highly delicate and pass through complecated physiological process of growth and reproduction. Obviously they need special care under culture environment. In early stage of metamorphosis these animals are highly susceptable to ecological changes and specific in food and feeding behaviour. Keeping in view the short period required for culture operation of prawns the culture system can be divided into two phases:

a) *Raising of stocking materials*
b) *Growing of table size prawns.*

In intensive or semi-intensive culture programmes emphasis need be laid upon development of infrastructural facilities for year round supply of stocking materials which involves artificial breeding of the culturable prawns in hatchery and thereafter rearing of the post larvae under complete controlled conditons. The second phase i. e. growing of table size prawns is also equally complecated procedure implying stocking manipulation, artificial feeding and finally maintenance of environmental hygiene for faster growth and maximum survival of the prawns.

HATCHERY MANAGEMENT

The inadequacy and uncertainity in scampi seed supply are being gradually over come with development of artificial means of breeding. A large number of freshwater prawn hatcheries have come up in the service of seed production and supply bulk of stocking materials for cuiture operations. In brief a prawn hatchery comprises prawn breeding tanks and a series of hatching units with continuous supply of brackish waster (0-12 ppt salinity). The temperature range in hatching tanks is maintained within 28 ^{0}C to 30 ^{0}C and the larvae are fed with artemia. In breeding tanks mature prawns in the ratio of 3-4 females: 1-2 males are released and after the breeding takes place the females with fertilised ova are removed to the hatching tanks. The spent females are taken out of the hatching tanks and the

ova are allowed to develop to pre and post larvae under running brackish water flow and supply of natural planktonic food organisms or artificial feed. The details of prawn hatchery management have been delt elsewhere.

NURSERY REARING

The post larvae either procured from the natural resources or produced in hatchery are grown to juveniles (2.0-3.0 cm) in shallow specially constructed nursery ponds. In this hype of small ponds the slopes are always gradient in the ratio of 2.5-3.0: 1 and the size ranges between 50 sqm and 200 sqm. Concrete cisterns and plastic pools of 50 sqm area and 75 cm depth are also suitable for nursing of prawn post larvae.

For a prawn farm of 10 hectare area, 12 nurseries of 200 sqm area each are required. These nurseries are provided with an organic base on the bottom and side slopes to increase natural fertility of the ponds. Application of cattle shed manure @ 5.0-10.0 tonnes/hectare and 250-300 kg/hectare of lime is recommended depending on the water quality of the pond. After 7 to 10 days of fertilisation the nursery is stocked with post larvae (1.0 cm) @ of 100 to 200 nos/m^2. The post larvae in addition to the natural food are fed with balanced nutritious artificial feed @ 8-10% of the body weight during morning (40% of the total feed) and evening (60% of the total feed) hours of the day. Regular monitoring of water qualities (DO, pH, temperature, depth, transparancy) and rectification of the adverse environment gives very high rate of prawn survavality in the nursery pond.

STOCKING POND MANAGEMENT

Improvised conventional, semi-intensive or intensive culture are simple manipulations of stocking density, feeding intensity and water quality management aiming achievement of estimated gole of turn over from the culture ponds. However, of these inputs water quality management plays vital role in prawn production in particular under high stocking density and intense feeding schedule.

POND FERTILISATION

The culture ponds which are by and large shallow and seasonal with dewatering facilities need little care about clearing of macrophytes and weed fishes. However, any pond having the problems of weed infestation and unwanted fishes may be cleared prior to

fertilisation. As has already been mentioned the prawn culture ponds must be shallow with high gradient slopes and moderate in size and easy managible as regards water quality manipulation and monitoring of prawn stock population as and when necessary. The stocking ponds are also fertilised in the same manner as practised in nursery ponds.

STOCKING

Prawn production is directly related to stocking density. But with increasing stocking density the average size of prawn at harvest is much smaller. In intensive farming as high as 2,50,000 of prawn juveniles (2.0-3.0 cm) can be stocked in one hectare water area, while 80,000 to 1, 00, 000 juveniles/hectare is the optimum density for semi-intensive prawn culture ponds. The stocking density can be further reduced to 20,000 to 30,000/hectare in improvised conventional culture ponds.

FEEDING OF PRAWNS

Fertilisation and liming maintain water quality and provide nutrition for the primary producers. The food items produced through natural biological process like periphyton, benthic flora and fauna are consumed by the prawns. But these natural food are not sufficient to sustain higher density of prawn population in stocking pond. To over come the deficiency of natural food in culture ponds it is necessary to supply artificial feed in required quantity at suitable time and interval.

The prawns are bottom dwellers and nimbling in feeding habit. They hold on the food with chelate legs and browse upon. Considering these feeding habits the pelletised artificial feed are best and can be supplied at the rate of 10% of the body weight in initial stage and thereafter reduced to 4% with the increase in weight of the prawns. Minced cockle meat which is tested to be a good food item may be provided as supplementary feed to the prawns and slaughter house wests can also be applied depending on their availability. However, the most effective supplementary feed would be highly nutritious (40-42% protein) pellets with more than 24 hours melting period. The pellets or minced food materials when kept in trays and placed on the pond bottom reduce misuse of food materials and also prevent environmental perturbation. The number of such trays will vary with the density of prawn population and one tray would hold the feed for 150 to 500 prawns depending on their average size.

HARVESTING

All prawns do not grow at the same rate even if the seeds of the same size are stocked. A very wide disparity in size appears at the harvest time. Hence for final harvesting the optimum size will have

to be checked from time to time. Once the average size of prawns reaches to desired weight, irrespective of sex and size difference they should be harvested.

Prawn harvesting is a labour intensive and slow operation. However, the high price of the commodity permits any mode of harvesting provided that is effective. Three methods of harvesting are being adopted according to the suitability of operation, The first method is use of drag nets and the same is practiced through out the country. Trapping in another method of prawn harvesting but this method has limitation in large scale and complete harvesting. The third method is dewatering of the pond either through the outlet or by pumping out the pond water. Though costly the last method is most effective for complete harvesting of the prawn population.

CULTURE MANAGEMENT

Management of culture system involves care of the animals, maintenance of the environment and precautionary measures to counter unforeseen threats and natural calamities. Prawn culture has the advantage of short operational period. Thus intensive care can be taken for achieving best output from the culture operation. The three important aspects to be looked into in prawn culture are control of pond environment, protection of the prawn health and encouragement for the prawn growth performance.

ENVIRONMENTAL CARE

Pond productivity improves if a feeble flow of water is maintained during the culture period. The flow of water if maintained nutralises the oxygen defficiency and also remove most of the organic waste load generated from metabolic activities and also unutilised food materials. Daily replacement of 25% of the pond water keeps the environment congenial for the prawn growth and survival. In intensive and semi-intensive culture ponds continous flow of water increases production return.

WATER DEPTH

Maintenance of water depth between 1.0 m and 1.50 m has been proved to productive for the prawn culture ponds. However, water depth below 1.0 m in summer rises water temperature and creats thermal impact on the prawns. To avoid such situation at least an average depth of 1.0 m need be maintained during the culture period.

DISSOLVED OXYGEN

Oxygen being the key factor in metabolism and respiratory activity of living organisms, must be regularly monitored and the concentration below 5.0 ppm must not be allowed in prawn culture pond for longer duration. In the event of sudden lowering of oxygen concentration immediate measures like aeration or water exchange are very much helpful. As such in intensive or semi-intensive prawn culture ponds a regular supply of atmospheric oxygen through aerators or wind mills must be arranged. High organic deposition, water scarcity and planktonic blooms often deplete oxygen level in prawn culture ponds. Such situation can be avoided by maintaining feeble flow of water

WATER TEMPERATURE

Prawns grow faster at slightly higher temperature range of 28 °C to 32 °C. In comparatively lower temperature the growth of prawn would be affected and rate of production also be low. At higher temperature beyond 32 °C the ecological conditons might not be congenial for very high rate of production. However, the sudden increase in water temperature can be controlled by introducing fresh cold water from the reservoir or by stirring the water mechanically or manually. Arrangement for artificial shed would also help in countering the temperature stress in prawns.

FUTURE SCOPE OF SCAMPI CULTURE

India being rich in freshwater resources and with conducive agro-climatic conditions for prawns has immense scope for large scale scampi culture. The three basic needs *i.e.* seed, feed and breed are gradually being fulfilled and at the present hundreds of hatcheries are in operation to cater to the needs of stocking materials. Different formulae of artificial feed have been developed and economically viable technologies are available for prawn culture industry. If the water areas like shallow weed infested oxbow lakes, shallow margines of reservoirs and natural depressions through out the country beside the farm ponds are judiciously exploited for scampi culture this would not only boost the prawn production but help in generation of employment opportunities for the rurals and earn foreign exchange for the country.

MANAGEMENT OF SCAMPI PRODUCTION IN MONO AND POLYCULTURE FROM DIFFERENT WATER BODIES

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INTRODUCTION

Culture of scampi has very recently been popularised in India. Such delay in introduction of the species in culture system might be attributable to scarcity in stocking materials and also lack of sound culture technology. With the development of artificial propagation technique and simultaneously economically viable culture technologies culture of freshwater prawn in particular the *Macrobrachium rosenbergii* has gained a momentum. Though monoculture of prawns is more profitable they can also be grown along with suitable species of indegenous or exotic carps, milk fish and mullets in polyculture system.

Monoculture system

Monoculture of prawn is being practised in prawn farms, pens installed in large water bodies and also in cages. These different culture methods require suitable management procedures depending on the habitats.

Prawn culture in farm ponds

Modern prawn culture farms are well planned and equiped with infrastructures necessary to maintain environmental hygiene. However, the indigenous ponds if suitable for prawn culture may also be brought under prawn culture programmes.

Management of prawn culture ponds

Management as we know is a combined effort in supply of adequate inputs and maintenance of congenial environment and health hygiene of the cultured population. In pond system the prawns are reared at varying densities and with different rates of feeding. These two inputs for better utilisation need environmental sovereignity and maintenence of prawn health hygiene.

a) Water quality maintenance

The water quality in a prawn culture pond must be monitored regularly and maintained hygeinic for best production. Most important out of several parameters are dissolved oxygen, temperature, alkalinity and macronutrients. For oxygen balance, natural productivity must be maintained at an optimum level by introducing organic fertiliser @ 5-10 tons/ha into the system. However, care must be taken to prevent algal bloom by controlling the level of available nutrients like nitrate and phosphate within the limit of 1.0 ppm. In case of sudden depletion of oxygen stirring or injection of atmospheric air come to the rescue of the prawn mortality. In intensive or semi-intensive culture, continuous flow of water must be provided which beside maintaining oxygen level removes the waste materials from the pond environment.

Temperature is also equally important as far as the growth and production of prawn is concerned. The optimum temperature range for scampi is between 28°C and 32°C. Obviously any fluctuation below or beyond this range will not only affect the growth but may lead to complete loss of the stocks in extreme high or low temperature conditions.

The nutrients control natural productivity of aquatic ecosystem. In prawn culture ponds their levels must not be maintained very high so that the planktonic blooms come up and interfere the production processes. Alkalinity is also an important parameter to be monitored. At higher concentration beyond 150 ppm alkalinity interferes the moulting and growth performance of prawns. Dilution is very effective in reducing the alkalinity of prawn culture ponds.

b) Prawn health protection

Rate of survival and finally production is always better if the prawns are healthy. The health condition of prawns depends on the quality and intensity of feeding and environmental hygiene of the habitat. Thus the feeding must be done with best quality feed at optimum dose in appropriate time of the day. Supplymentary feeding at the rate of 4 to 10% of body weight depending on size range with artificial pelletised feed containing 35-40% protein gives high rate of growth and survivality in prawn. The feeding is most effective if done during evening and early morning hours. Beside feeding the prawns are also to be kept away from the disease infestation. Remedial or preventive measures suggested for various prawn diseases are to be adopted well in time for the protection of the stock population.

Prawn production in polyculture system

The technique of polyculture with prawns and fishes is generally adopted in indigenous ponds having high depth of water column. The very purpose of polyculture is to utilise the ecological niches by introducing

suitable species with faster growth and high compatibility. Prawns are also introduced in polyculture ponds along with carps or with milk fish and mullets. However, for obtaining good production of prawn from polyculture ponds the following measures are useful.

Maintenance of water quality

In polyculture ponds the depth is generally high between 8 and 15 ft. The bottom layer is expected to contain comperatively low concentration of oxygen and some unwanted gases. The environmental condition thus remains uncongenial for the prawns. To cope up with this type of inconveniency arrangements must be made for aeration of the pond bottom by injecting oxygen into the system. Use of lime and potassium permanganet @ 250 kg to 500 kg/ha and 1 to 2 ppm respectively are also effective measures.

Prawn stock management

Unlike monoculture ponds feeding of prawns in polyculture system is difficult task. At the time of selecting species combination the competing species for prawns like *Cirrhinus mrigala, Labeo calbasu, Cyprinus carpio* etc. must be avoided. Such precausion would not only help in controlling food competetion but eleminate the problem of habitat disturbance for the prawns. Following selective species combination and optimum stocking density the prawn can be produced @ 300-500 kg/ha along 1000-1500 kg fish from polyculture ponds. The stocking size and density of prawns in a polyculture pond must be judiciously decided and in no case prawn juveniles less than 4-5 gm average weight should be released in 2:1 to 3:1 proportion of the fishes. The feeding programme must be followed as in case of monoculture but only during evening hours in required number of trays (one tray/150-500 prawns). The carp feeding may be done as usual with artificial feed during day hours.

Prawn culture in pens

Pens *i.e.*, artificially made enclosures are often used for culture of fishes and prawns in large water bodies like beels, jheels, reservoirs, bheries etc. In this type of culture the cost of production is comparatively less than farm ponds. The main advantage is of water management which is not required in pen but essential in case of prawn culture ponds.

Monoculture of prawns

In pens better profit can be expected by culturing prawns alone. Compared to farm ponds the growth of prawns is more in pens might be because of natural ecological conditions in the pen area. In penculture the stocking density must not be more than 40,000 juveniles/ha and preferably of the size range between 4 and 5 gm.

Water quality management in pen

Since prawn culture can be continued year round in pens in two to three consecutive batches there must be strict and effective water quality monitoring system. The prime condition to be monitored in pen is depth of water which must never go down below 90 cm. Water depth between 1.0 to1.5 mt is most ideal in pen. In summer the water crisis creates stress condition for prawns and at that period arrangement of sheds in patches in side the pen provide shelter and save the prawns from high temperature and other hazards. More over the submerged hydrophytes also help in maintenance of water temperature and oxygen concentration to a desired level. Production from summer crop is always poor in comparison to the monsoon but better than winter season.

Management of the prawn stock

In pen the prawns get natural food and at the same time provided with artificial feed. This advantage of natural and artificial feed in combination helps in faster growth of the prawns. However, entry of unwanted fishes and other biota creates problem in artificial feeding of prawns because they take away significant percentage of the food materials. Considering this loss of food materials regular netting is recommended in pens which beside controlling weed fishes helps in raking of the bottom soil.

Harvesting

Prawn harvesting is troublesome in particular from pens. However, the most effective method of prawn harvesting is nothing more than by dewatering of the pond. Complete harvesting is possible by this method. The other methods are use of drag or cast nets and trapping. The latter methods are not so effective but have no alternative for harvesting prawns from the pens. Nearly 10% of the prawns may be left out from these type of harvesting in pens which needs hand picking at the end.

PEN CULTURE OF FRESH WATER PRAWN IN LARGE WATER BODIES

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INTRODUCTION

Spreading over the flood plains of three contiguous eastern Indian States, West Bengal, Bihar and Assam, there are hundreds of large natural water bodies locally known as beels, boars, mauns, etc. During monsoon they get maximum precipitation and flood water from adjoining rivers and catchment areas and turn into vast sheets of water bodies. These water bodies are usually shallow and rich in soil and nutrient status. They serve as natural recycling centres for waste material and thus greatly help in maintaining equilibrium in our nature. They also support a rich growth of flora and fauna, many of which are intimately connected with our rural economy. Conservation of these wetlands for posterity through proper management, therefore, assumed greater importance these days.

Till recently capture fishery in these wetlands has been the main vocation of a large number of local poor. Though the potentiality of these water bodies for development of fishery has now been recognised, yet there has been numerous inherent problems which come on the way of over all development of fishery there. Important among these are greater number and conflicting uses of these water bodies, their leasing pattern, subsistence level of economy of the local fisherman community, and above all the forbidding cost of reclamation. To over come these problems CICFRI therefore has developed a package of pen culture technology and now maximum culturable area can be effectively utilised without disturbing the interest of other users.

All these years these water bodies have been primarily used for carp culture of late it has been found some of these water bodies are suitable for pen culture of fresh water prawn also. In fact a few experimental ventures of CICFRI in Akaipur beel gave very promising and spectacular results. Backed by these success CICFRI now advocates pen culture of fresh-water prawn in these water bodies. This way not only the gross productivity of this highly priced

commodity can be substantially increased, the country can as well earn an additional good amount of foreign currency also.

PEN OR ENCLOSURE

Pen is an artificial enclosure erected to prevent any undesirable entry to and exit from the farming zone. The success of pen culture depends largely on the suitability of the site selected for culture and proper fabrication and installation of the pen. As far as practicable pen should be made from locally available raw materials to make it cost effective.

1. ENVIRONMENTAL REQUIREMENTS FOR PEN CULTURE

Pen or enclosure is usually built along the margin of large water bodies. In selecting the site for erecting pen a good number of points need to be carefully considered so as to provide an ideal environment favourable for culture and growth of the species.

i) Nature of substratum

The texture of bottom soil of the water body plays an important role in determining the growth and production of prawn. Though sandy substratum is an ideal habitat for freshwater prawn, it can be successfully cultured in places having sandy-loam, sandy-clay loam or loamy soil. Muddy and clayey soils are not suitable for prawn culture.

ii) Water depth

The depth of water in the pen is of vital importance for prawn culture, the ideal depth of water should be between 3-5 feet 0.90-1.5 m,) and under no circumstance it should be less than 2 feet (0.60 m). Pen is generally installed from the shore line to gently sloping deeper zones where fluctuation of level is not very high. In case, the bottom gradient of the water body is gentle and almost uniform, providing supplimentary feed as well as harvesting operation in the pen become easier.

iii) Water quality

Water should be clean and devoid of suspended particles so that sunlight can easily penetrate and illuminate the bottom. This not only helps to produce more benthos, the natural food for prawn but also helps to keep the bottom environment clean. Turbid water is unsuitable for prawn culture.

iv) Aquatic vegetation

Because of shallow nature, rich soil and nutrient status these water bodies often support a dense growth of vegetation. The common ones are free floating *Eichhornia* and *pistia*; rooted submerged *Ceratophyllum, Hydrilla* and *Vallisnaria*; rooted floating *Nelumbo, Nymphaea, Nymphoides, Ludwigia, Limnophila*, etc. Over growth of these plants in the pen is detrimental for prawn culture. At night in absence of sunlight when photosynthesis cases these plants release large quantities of carbondioxide in the medium and exert a net respiratory oxygen demand on the dissolved oxygen content of water. This simultaneous increase and depletion of dissolved CO_2 and O_2 contents respectively not only adversely affect the growth of cultured prawn but may even cause their death. Accumulation of organic debris of these plants also make the bottom soil unhygienic.

v) Surrounding envirnment

Pen or enclosure should not be constructed in a place where there are large number of trees over hanging the shoreline. These trees obstract sunlight and shed leaves in the water body. These accumulate at the bottom and decompose, and thus pollute the bottom. Like all other plants they also release CO_2 at night and part of which when get dissolved in water also pollute the aquatic environment.

vii) Agricultural activity

Available land around large water bodies are usually put into intensive agriculture. Water being easily available are also freely used for irrigation. For cultivating high yielding varities of crops agricultural inputs like chemical fertilizers and pesticides are now a days used in large quantities. These chemicals leach out or wash down to water body and pollute the environment. At places the water body is also used for jute retting, making the water unsuitable for culture.

SELECTION OF PEN MATERIALS

Pen screen or mat as it may be called is usually made of split bamboo strips. For this good quality of bamboo are required. The bamboo strips are then closely woven to make the screen or mats of convenient size. While weaving the screen the strip should not be placed more than quarter of an inch or 6 mm apart if the space between the two strips exceeds this limit the prawn seed may easily escape from the enclosure and the predator and other undesirable elements from out side may also enter the farming zone. The height of the bamboo screen depends on the depth of water. As abnormally high bamboo screen do not last long, where necessary two such bamboo screens may be used one obove the other to achieve the required

height. CICFRI scientist are also actively probing the possible use of other cheaper indigenous raw materials like reeds *(Phragmites, Arundo* and sedges (*Cyperas*) for making pen screen.

CONSTRUCTION OF PEN

Pen is made by enclosing the farming zone with the pen screen. There is no fixed size or shape for the pen and all these depend on the actual nature and surrounding of the water body. The area of a ideal pen however should be between 0.2-0.5 hectare. Its main alignment should always be in the wind direction for that helps effective aeration in the enclosure. Its supporting structure also should be sufficiently strong to enable it to withstand thrusts of wind and waves. If the pen is constructed inside the water body away from the shoreline then the desired water space has to be completely encircled with the pen screen. If however, it is near the shoreline then all the sides other than those facing the shoreline have to be enclosed. Where ever possible pen should be constructed in such a way that atleast one of the sides faces the shoreline. This makes the management of cultured stock as well as harvesting operation much easier.

To stop completely the entry of predators and other undesirable aquatic organism and escape of costly prawn seeds to and from the culture area a nylon net may be installed on the innerside of the pen screen as a second protective curtain. This net may be removed after about a month because by then the prawns attain such a size that they no longer can escape from the pen and at the same time can defend themselves from these enemies.

During spells of draught water level usually receeds considerably reducing the culturable area substantially. The situation is often aggravated further by excessive intake of water for irrigational purpose. Therefore, there should always be contingent provision for extension of the pen in the deeper zone.

PEN PREPARATION

To make the pen ready for aquaculture it should be made free of aquatic weeds and undesired animals. Aquatic weeds can be removed manually. By repeated use of dragnets gastropods, insects, predatory and weedy fishes can also be eradicated from the pen. If requdired Mahua Oil Cake @ 200-300 kg/ha may also be used. Since the pen is the part of a large water body herbicides or pesticides should not be used in the pen.

APPLICATION OF LIME AND FERTILIZER

Lime @ of 200-300 kg/ha are to be applied in the pen to prevent undesirable growth of plankton and to maintain desirable pH level in the bottom soil. In prawn culture, application of balanced supplimentary feed is more economical than trying to increase production of natural food in the pen by application of organic fertilizer. However, organic fertilizer @ 1000-2000 kg/ha may be applied once in the begining. This increases the natural food for prawn, arthropod and annelid population in the bottom fauna.

Only after a week of application of lime and fertilizer, the prawn seeds can be stocked in the pen.

STOCKING OF SEED

Prawn seed can be stocked @ of 20,000-40,000/ha. The length and weight of the seeds should be between 5-7.5 cm and 4-5 gm respectively. Seeds should be acclimatised before stocking by keeping them inside hapa. Prawn seeds are stocked preferably in the morning hours.

FEED AND FEEDING

Since in the pen seeds are reared at higher stocking densities, the natural food available there can meet only a small fragment of the requirement. To ensure faster growth prawns therefore are to be given good quality balanced feed like specially prepared 'Pellated feed', chopped prawn and small fishes, minced cockled meat and slaughter house refuse, etc.

Prawns are more active during night. Hence evening is the ideal time for giving them supplementary feed. Feed however are best given twice daily in devided quantities 60% of the total feed in the evening and 40% in the morning. These should be given in a number of containers set up at different points, otherwise the feed will not be fully utilized. The supplimentary feed may be given at the following rate:

Post larvae 10% of the body wt., when attained a size of 10 gm 8% of the body wt., 30 gm 6% of the body wt, 50 gm 4% of the body wt. The quantum of feed offered is increased or decreased on the basis of routine examination of left over feed. Feed given in excess are not only wasted but pollute the pen environment also.

PEN MANAGEMENT

For success in pen culture pen environment should always be kept at optimum level, eg. water temperature of 24 °C-34 °C, dissolved oxygen more than 4 ppm, pH 6.5-10, and calcium less than 100 ppm. If the water temperature rises shades and shelter may be formed in some places in the pen with coconut or palm leaves etc. Artificial aeration is provided by spraying or pumping the water from out side in the pen at the time of oxygen depletion. The lime may be used in case of release of any obnoxious gas in the pen or appearance of algalbloom.

HARVESTING

In about 4 months time prawns attain a marketable size of 50 gm on an average. It is at this stage these are harvested. Both cast and drag nets are used for the purpose but the use of later are more effective and economical.

Prawn may be cultured singly or in combination with other fishes. Mono culture of prawn is no doubt more profitable but when required it can also be profitably cultured with all other carps except the bottom of feeder.

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INTENSIVE FARMING OF PENEID SHRIMP AND ITS PRESENT STATUS

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INTRODUCTION

India is recognised as one of the world leaders in shrimp production and export. At present about 70,000 ha of brackishwater area is under farming in 9 coastal States and Union Territories which produces 40-42 thousand tonnes of shrimp. It could be possible to increase this level of production by 2.68 lakh tonnes by employing additional 28,000 ha area under modified farming system.

Types of Prawn Farming

The process of growing shrimps upto marketable size in an enclosed water body can be termed as shrimp farming. At present prawn farming has become a commercially viable industry in India. According to the nature of management and inputs supply, the farming can broadly be classified as traditional, extensive, semi-intensive and intensive.

i) *Traditional* - In this system of culture the tide borne fish and shrimp seed are trapped in the tidal fed shallow and marshy water bodies during high tide and periodically harvested after interval of growth phase. Owing to indiscriminate stocking of both desirable and undesirable varieties of fish and shrimp the production obtained is very low (0.5 t/ha/yr or less).

ii) *Extensive* - This is an improved method of traditional one, involving construction/repairing of ponds of smaller dimension (1-5 ha) after selection of site. Selective stocking with fast growing shrimp varieties at lower densities (40,000-1,00,000 nos/ha) and with irregular addition of supplementary feed. Exchange of tidal water during spring tide period in every fortnight (kotal period) through natural phenomenon or by pumping from adjacent canal is adopted. The average production is ranging from 1-2 t/ha/yr.

iii) *Semi-intensive* - This type of farming involves scientific management from the beginning. Proper site is selected before construction of ponds. The ponds are generally smaller (0.2-0.5 ha) in area, selective

stocking is made with fast growing seed at a density of 1-3 lakh/ha and the water quality is maintained by exchange of saline water daily @ 10-20%. In addition, arrangement for aeration is provided at the pond and regular feed is employed. The average production is ranged from 4-5 t/ha/crop in 4-5 months period.

iv) *Intensive* - The intensive shrimp farming involves construction of cemented pond (0.03-0.5 ha), selective stocking with quality shrimp seed at high density (5-10 lakh/ha), maintaining high quality of water by exchanging 30% atleast daily, providing more oxygen to pond water through mechanised aerators and feeding with nutritionally well balanced high energy feed. The production generally expected from such system ranges from 10-20 t/ha/crop or more.

v) *Satellite Farming* - In order to gear up the process of development, a principal farmer plays a major role to provide necessary infrastructure and input supply for their own needs and also to cater to the needs of many small farmers living around them. A *nucleus* is thus set up to provide quality seed from own hatchery, balanced feed from own Feed Mill, R & D Unit, processing plant etc. This automatically takes care of everything essentially required by the small farmers at their door step which also includes technology, extension and marketing of the produce. The advantage of this system is the availability of finance. The Banks provide funds to small farmers as per their needs without hesitation.

INTENSIVE PRAWN FARMING

Shrimps are aquatic organisms inhabiting the sea, estuaries and backwaters. Generally, sea is the home of penaeid shrimps where they grow to adulthood and breed. The post larvae start their life by drifting into the estuaries and such other available backwaters for feeding. The ability of penaeid shrimps to adjust themselves to different levels of salinity at the sea and estuaries as well, make them candidate species for culture. Due to high profitability and export demand at attractive prices within a short culture period, about 32 aquaculture companies have been set up to grow shrimp, specially *P. monodon*, from coastal districts of the country.

There are more than 50 varieties of penaeid shrimps living around Indian coasts but six of them are identified for coastal aquaculture. In India the best species chosen for culture are *P. monodon, P. indicus, P. merguiensis, P. semisulcatus, Metapenaeus monoceros and M. brevicornis.*

How to start shrimp farming

Brackish/sea water is the major requirement for this type of farming. Therefore, the land should be suitably located adjacent to the sea or estuaries. Selection of a good site for a farm with proper resource would solve half of the problems faced by a farmer.

a) Site selection

The land must be flat, one metre above the highest tide mark and behind the mangrove areas. Too high or too low sites within the mangrove forest and acid sulphate soils should be avoided.

b) Pond preparation

Preparation of pond is one of the most critical activities in attaining desired growth rates of prawn. The pond size may be 0.3-0.5 ha area. They may be round or square and cemented. Separate inlet and outlet are required with drainage canal linking various ponds. A settling tank has to be provided before letting out of pond water.

c) Sundrying

After drawing all the water the pond bottom is exposed to sunlight for atleast 15 days or till the bottom cracks and the surface turns whitish. Better result can be obtained if the bottom ooze is scraped and removed.

d) Ploughing and Liming

After exposure, the pond bottom is ploughed and the wet soil is again dried. Lime (slaked) @ 200-300 kg/ha is applied, in instalments, at the pond bottom to obtain desired pH (7.0-7.5) at soil phase. After three days, a second ploughing will help to mix the lime with soil. Application of lime for the 2nd time may help to eliminate the hiding predators.

Doses of lime

pH	Amount of lime (kg/ha)
4.0	900
4.5	750
5.0	600
5.5	450
6.0	300

e) Water filling

Particular care is needed to check the dyke for water leaks before filling. The sluice gates are repaired and painted. The water is allowed to enter into the pond continuously till one metre depth is reached. The water salinity is preferably to match as that of hatchery from where the post larvae are taken.

Favourable water parameters for penaeid prawns

Temperature	-	26-32°C
Salinity	-	15-30 ppt
Transparency	-	25-30 cm
Dissolved oxygen	-	5-8 ppm
pH	-	7.0-8.5
Total ammonia	-	less than 1 ppm
Free ammonia	-	less than 0.25 ppm
Nitrite	-	less than 0.25 ppm

f) Aerator facilities

For a culture period of 4 months, 4-6 aerators (paddle wheelers) per hectare are installed in such a way to create necessary water movement in one direction only. It may be parallel or oblique to the farm dyke.

g) Stocking time and post larvae (PL) acclimatization

Good quality healthy seed must be reared for a profitable venture. PL 19-22 seed with tail noticeably opened during swimming and active movement at the container are good type. Transparent body with slight greyish or dark spots are chosen for stocking. The reddish colouration is a sign of poor quality seed.

About a week after filling, the pond is ready to receive the seed. Stocking of PL can be delayed for another week in case of non-availability of seed. Early morning period (6.30-8.30 hr) or late afternoon (16.30-18.30 hr) is preferred to minimise temperature stress. The stocking should be avoided during heavy rain.

Acclimatization of the PL in the same salinity, is a must before releasing them in the pond. Atleast for 30 minutes the PL container is kept afloat and then gradually the pond water is allowed to enter the container. Wait for sometime and allow the PL to swim out on their own against the feeble current.

h) Feeding management

Modern penaeid shrimp culture depends largely on commercially formulated feeds. The feeding requirement is initially calculated and checked against feeding schedule. The required amount of feed is weighed in a container to broadcast along the pond side and the corresponding amount is placed in feeding trays kept in the pond after stocking. Normally one tray is provided for 0.75 m^2 area. Initially eight numbers of feeding trays are provided per hectare water area later on which

may be increased to 14 nos/ha or as per requirement. The optimum food requirement is determined after hourly inspection of the trays. Initially 1% of the total quantity is placed in each tray for adjusting proper utilization of feed.

A feed inspection chart is essential to determine feed adjustment and to estimate survival rate of the stocked prawn. Feeding has to be manipulated after water exchange or other activities in the pond or even feeding may be cancelled if abnormal changes are observed in the pond environment.

Feeding guide

Days of culture	Type of feed	Survival rate	Daily feeding	% of feed distribution
1-15	Starter (post larvae)	95	Twice 0700 1700	50 50
16-30	Starter (upto 3.0 g)	90	Twice 0700 1700	50 50
31-45	Grower (3.5-6.5 g)	85	Thrice 0700 1700 2200	30 40 30
46-60	Grower (upto 11 g)	80	Four 0700 times 1100 1700 2200	20 20 35 25
60-upto harvest	Finisher (above 11 g)	80	Five 0700 times 1100 1400 1800 2200	15 15 15 30 25

i) Sampling

Sampling is generally done in every 15 days to determine the survival, growth and feed requirement. Preferably it is carried out during morning or late afternoon period using the feed tray and cast net. Samples are taken from different parts and collectively weighed.

Moulting cycle of penaeid prawn

Body Weight (g)	Moulting interval (hrs)
2-5	7-8
6-9	8-9
10-15	9-12
16-22	12-13
23-40	14-16
50-70 (female)	18-21
50-70 (male)	23-30

j) Water management

The most vital part in penaeid prawn farming. A regular monitoring of the following parameters are essential :

i) *Salinity* - The ideal salinity of *P. monodon* culture is 15-25 ppt. The readings are to be taken before and after water change.

ii) *Dissolved oxygen* - The ideal dissolved oxygen level is 4-8.5 ppm. Use of aerators is of immense help to maintain oxygen level in time of need.

iii) *Transparency and colour of water* - Secchi's disc is the instrument used to measure the transparency of water which is usually 30-40 cm as good. If it goes below 30 cm level, immediate water exchange is needed.

Once algal appearance in more quantity is detected, immediate water exchange is essential and mostly 50% of the water in the pond is exchanged.

iv) *Temperature* - In our climatic condition, normally temperature do not fluctuate much except in summer. Feed adjustment are normally done with the change of water temperature.

v) *Water exchange* - The water depth of the stock pond is generally kept upto 1 m initially (upto 60 days) during growing period and threafter it is raised upto 1.2 m till

harvest. The operation of water exchange initially starts with 10 hrs/day depending on requirement. The water change is usually indicated when :

a) the prawns are becoming sluggish in movement, loosing appetite and also poor converter of feed.
b) presence of extraneous deposits are noticed on shell/body parts.
c) the water colour turns cloudy, greenish or brownish or turbid.
d) oxygen depletion takes place in the pond water.

vi) *Aerator* - Most cheaper and popular type of aerator is the puddle wheel type aerators with 1-HP electric motor.

Predator control

The use of filters in water intake do not prevent all the potential predators. Tiny fish or eggs may pass through the filters or canals. Predators are detected by their presence on the feeding trays or along the pond side during inspection time. The use of hand net or application of tea-seed powder @ 20-30 ppm are the cheapest or even best methods for their elimination by taking advantage of water exchange.

Harvest

Harvesting usually starts during early morning hours. The time of occurence of high or low tides are also considered. Draining is usually started during ebb tide period. After draining 50% of pond water the sluice gate is fully opened and the prawns are allowed to flow along with water current. To minimise physical stress traps/bag nets are employed to catch the prawns. The catch is taken in instalments in fresh condition. After fully draining out the pond, the remaining prawns are hand picked and taken to the weighing area.

Suggestion

i) Sheer greediness to produce more and more would prove to be counter productive.

ii) Not to over do things which might effect the environment.

iii) Purification of the discharged water from the pond is a must for better environmental condition.

iv) Do not challenge the nature for temporary gain.

v) Prevention is better than cure.

Status of world farmed shrimp production in 1993

Country	Area under production(ha)	Total production (mt)	Production (kg/ha)
Bangladesh	1,10,000	30,000	273
China	1,40,000	50,000	357
Columbia	27,000	9,000	3,333
Ecuador	90,000	90,000	1,000
Hondurus	8,000	9,000	1,125
India	80,000	60,000	750
Indonesia	2,00,000	80,000	400
Mexico	8,000	9,000	1,125
Philippines	40,000	25,000	625
Taiwan	7,000	25,000	3,571*
Thailand	60,000	1,55,000	2,583
U.S.A	900	3,000	3,333
Vietnam	2,00,000	40,000	200
Others	16,000	24,000	1,500
Total	9,62,600	6,09,000	633

* highest (source : Fishing Chimes, July '94)

The world farmed shrimp production in 1993 was estimated as 6,09,000 mt. from a total culture area of 6.63 mt/ha and 80% of the global shrimp production came from Asian Countries. Presently, Thailand is the largest producer, 1.55 lakh mt followed by Ecuador, 0.9 lakh mt. Presently India is in 4th position with 0.6 lakh mt production. In 1990, China produced 2.0 lakh mt and the largest producer, the dominent species cultured was *P. chinensis*, other species were *P. penicillatus* and *P. merguiensis*. In Ecuador, over 1.0 lakh ha area was under culture with more than 90 hatcheries. *P. vannamie* is the species cultured mainly followed by *P. stylirostris*.

The global shrimp production was slumped by 16% due to drop in production in China. But Thailand and India could register an increase in production. The steep reduction in China was due to some unknown suspected bacteria or virus. Sloppy feeding practices, dirty pond bottoms, deteriorating water quality in ponds, poor management and high concentration of farms were stated to be related to the Chinese debacle, which is paralleled in the short history of commercial shrimp farming only by that of Taiwanese in 1988.

Status of shrimp farming in India

India is endowed with rich natural resources in the coastal zone in the form of brackishwater-estuaries for taking up penaeid prawn culture. An estimated area of 1.2 million hectare of which only about 65,100 ha are now shrimp farming. The technical improvements are made in penaeid prawn farming in many parts of the world paved the way to increase our

shrimp production through aquaculture by adopting extensive and semi-intensive systems of farming in the areas where environmental conditions are congenial. The traditional system of prawn farming is being carried out in the States of W.B., Kerala, Karnataka, Goa and Maharashtra in about 50,000 ha area. Paddy-cum-fish/prawn culture during rainy season and one crop of shrimp culture in January-June are carried out regularly in some field. Since the fields are auto-stocked there is no control over the quantity and quality of seed stocked in ponds, the stocked fish and prawns are allowed to grow to marketable size and the productions ranged from 200-500 kg/ha/season. Recently, some developments have taken place in A.P., Orissa, Tamil Nadu, Kerala, West Bengal etc. where a productivity level ranging from 500-2,000 kg/ha/crop has been achieved by following the scientific method of farming. The highest production of more than 10,000 kg/ha/crop has also been claimed by some private progressive entrepreneurs in Tamil Nadu, 6,000 kg/ha/crop by some Industrial entrepreneurs of Orissa, A.P. and West Bengal by adopting intensive method. New areas are being added every year as more and more entrepreneurs are entering the field. The respective State Governments are taking necessary steps to make land available to a few parties who are trying to set up 100% export oriented units in the coastal areas on lease or purchase for shrimp farming development. The following table gives a clear picture of the status and potential of shrimp culture in India.

Present status of shrimp farming in India

State	Estimated brackishwater area (ha)	Area under culture(ha)	Estimated production (tonnes)
West Bengal	4,05,000	34,050	16,300
Orissa	31,600	7,760	4,300
Andhra Pradesh	1,50,000	9,500	12,800
Tamil Nadu	56,000	530	1,100
Pondicherry	800	10	5
Kerala	65,000	13,400	9,750
Karnataka	8,000	2,570	1,150
Goa	18,500	550	350
Maharashtra	80,000	1,980	1,050
Gujarat	3,76,000	360	200
Total	11,90,900	70,710	47,005

Source : Fishing Chimes, Oct.'94)

PEN CULTURE OF BRACKISHWATER PRAWNS IN ESTUARINE WETLAND

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INTRODUCTION

The agricultural land is limited, means of production which can not be increased at will nor it can be replaced by another one. Due to various developmental activities the land resources are declining fast. So, we have to turn our activities for food production where water resources are the most important choice. Aquaculture embraces a wide range of activities from extensive "Sea ranching" to varied management activities in large and small water bodies. Recently, a number of technical advances have been made in the field of aquaculture which inludes the improvement of existing cultural practices and modernisation of the old practices. Pen and cage culture are the outstanding examples of these types. The principle in these systems, is the culture of fin fish and shell fish at 'enclosures' in open water bodies.

Pen and cage culture are generally practised in the natural habitat of the species, where sufficient water and natural food are available. It is possible to have a high density culture system in controlled condition with the addition of supplementary feed of high quality for increasing production.

Pen and cage culture are reported from many countries like Democratic Republic of Germany, Netherland, Japan, USA, USSR, Phillippines etc.

Site selection

The criteria for selection of a good site is essential for this type of culture.

i) Maximum and minimum water flow rates.

ii) The quality of water *eg.* salinity, temperature, dissolved oxygen, pH, current movement etc.

iii) Depth of water

iv) Direction of wind and tidal current

v) Substratum or pond bottom

The suitable pockets of rivers or impoundments should be congenial. The place must be situated in a place where ingress and egress of water are not in extreme condition. The site should not be very shallow. There should be limited wave and wind action. The water should be slightly alkaline (pH 7.5-8.0) and free from any pollution. The bottom soil should be loamy clay and sandy clay with less deposition of silt and organic decomposition.

Cage

A moveable enclosure with all sides (including top & bottom) closed and floating with surface above water or submerged.

Pen

This can be defined as a fixed enclosure in which bottom is the bed of the water body and certain area is cordoned off.

There is no particular design of a cage or pen suiting to all conditions. They are constructed according to prevailing conditions. As for example, in Asian countries bamboo mats or nylon stick mats while in USA varieties of galvanized welded wires and nylon nets are used.

Feeding

In traditional extensive trapping/growing method, no feeding is done at all. Later, when stocking densities were increased to semi-intensive levels, application of supplementary feed became highly essential. Thus, formulation of more efficient and less expensive feed was in need. The feeding in cages and pens in majority cases are done with locally available feed (rice, ricebran, maize, brewary wastes, fish/trash fish etc.) or nutritious protein rich (30-45%) feed. Supplementary feeds are used in different proportions. For commercial productions balanced and processed pellets are used in USA and other developed countries.

Material used for pen constructions

i) Bamboos, canes etc.
ii) Plastic rods
iii) Plastic/nylon twine with frame (synthetic material : Polymide, polyester,polythelene. polyvinyle, polyvinyl alcohol etc.)

Criteria for selections of shell fish

i) Price and market demand

ii) Hardiness (ability to withstand high density culture)

iii) Ready supply of fish seed (juveniles)

iv) Fast growth

v) Good response for supplementary feed.

Daily ration and conversion rate

3-6% supplementary feed are used in general case. It may vary according to feed intake of the species and its conversion rate (1.2 to 1.7 kg pellets for 1 kg fish/prawn).

The conversion rate of additional diet is dependent on the species size and density, quality of food its ration and distribution, and the physico-chemical parameters of the environment (Temp., DO, water quality etc.).

Shape and size

Shape of a pen may be of any type *i.e.*, circular, spherical or rectangular with cheap and locally available material. Generally patta (mat) is made from split bamboo, woven side by side, with the help of coconut coir rope. Nylon rope can also be used. The gap is maintained 10-20 cm. wide in between the slivers. 'Janos' in Chilka lake, 'pattas' at the bheries of Sunderbans can be cited for it.

The height of the pen is kept 1-$1^{1}/_{2}$ m or above the highest of high tide. The foot part of the pen is fixed at the bottom soil inserting 4-10 cm or more as per situation. The gap is variable depending on the size of the stocking material. In Chilka lake smaller pens 50-200 m^2 are used for culturing prawn.

Maintenance

A regular vigil of the pen is highly. Algal deposition may choke the gap if it is not cleaned and which may result obstruction of free exchange of water.

Pen culture experiments in bheries of West Bengal :

In the experiments conducted at CIFRI the young ones of *Penaeus monodon* (size 12.2-31.8 mm and weight 0.003-0.16 g) were stocked at the bamboo pens of 100 m2 in three saline zones *viz.*, low, medium & high. The stocking rate was followed @ 50,000 nos./ha. Free exchange of water was allowed in the pen and supplementary feed (wheat flour, fish meal and prawn meal at the ratio of 4:3:1) @ 10% of body weight initially were applied. Better survival (60-65%) were observed from high saline zone but good growth (av. 30 g/4 months) was observed in the pens of low saline area.

ASSESSMENT OF STOCK AND GROWTH OF PRAWNS IN VARIOUS WATERBODIES

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In aquaculture management it is essential to assess the number as well as biomass at different stages of growth to see how the prawns and the fishes are growing. In intensive culture of prawns it is needed to apply balanced feed for faster growth of prawns in certain percentage of the body weight of prawns *i.e.*, total biomass present in the system. But in most cases feed is applied without assessing the requirement of feed and cost of culture goes up making the culture an uneconomical one.

It is evident that there will be mortality due to natural processes such as predation, diseases etc. during the culture period. The number of prawns will decrease automatically. So, assessment of number as well as growth is a basic need for monitoring culture process and to take care of their health.

There are different ways of working out the population size and total weight of prawns in a waterbody. A few are discussed for application under certain conditions.

(1) Assessment of stock with the help of successive catch numbers (catch on two occasions).

The basic assumption under this procedure is that the chance of catching a prawn remains same for each individual.

Suppose a drag net is operated once. Let C1 is the number of prawns in the operation of net. Keep them in a hapa/cage.

Now, the net is operated second time. Let C2 is the catch in number in the second operation of net.

Then total number of prawns in the waterbody is estimated as

$$N = C1^2/(C1-C2)$$

For example,

Let the no. of prawns caught in the first haul, C1 =100 and no. of prawns caught in the second haul C2 = 80. So, total no. of prawns, $N = 100^2/(100-80)=500$.

(2) Assessment of stock by single marking method

In this method prawns are marked and released back in pond. Here, it is assumed that the chances of catching a marked prawn and that of an unmarked prawn are same.

Let in a waterbody there are 'N' number of prawns and 'm' of them are marked.

Let 'n' prawns are caught from the waterbody and 'c' prawns are found to be marked. Then, m/N = c/n.

or, N = mn/c = (no. of prawns marked x no. of prawns caught)/No. of marked prawns recovered.

For example,

Let 50 prawns have been released after marking
Let 300 prawns have been caught and
10 prawns have been found marked.

Then, total no. of prawns in the waterbody

N= (50 x 300)/10 = 1500.

Following steps may be followed in assessing the biomass present in the system.

We take a sample of prawns (say, k)
Let W gm is the weight of the prawns.
Then, average weight of prawns 'w' = W/k gm
If the total number of prawns in the waterbody is N, the total biomass is N x w.

For example,

Let the weight of 25 prawns = 300 gms.
Average weight of a prawn = 300/25 = 12 gms.
Let the total no. of prawns = 1500
Total biomass = 1500 x 12 gm = 18000 gms.

In judging economic viability of prawn culture, it is also necessary to see the cost of culture and return from the produce. If biomass is assessed we can immediately get the price of the produce and compare it with the cost incurred so far in raising the crop.

Sometimes it is also necessary to work out the production during a period. The following steps may be taken to evaluate the production.

Let N1 is the number of prawns at the beginning of the period.
Let N2 is the number of prawns at the end of the period.
Let W1 is the average weight of a prawn at the beginning of the period.
Let W2 is the average weight at the end of period.

Then, average gain in weight G = W2-W1.
Average number of prawns during the period N = (N1+N2)/2
The production during that period = N X G.

The assessment of production is necessary in identifying different important factors affecting the growth of prawns and will provide a guideline for present culture and future culture process.

For example,

Suppose the sampling is done weekly and we want to work out the gain in biomass during a week.

Let the no. of prawns at the beginning of the week is 2000. and the no. of prawns at the end of week is 1600.

Let the average weight of a prawn at the beginning is 10 gms and average weight at the end of the week is 15 gm.

Then, gain in weight = 15-10=5 gms.
The average no. of prawns = (2000+1600)/2 = 1800
The gain in biomass = 1800 x 5 = 9000 gms.

ENVIRONMENTAL HAZARDS IN PRAWN FARMING

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INTRODUCTION

The functioning of ecosystems, including man's survival and hapiness depends on the availability, conservation and recycling of natural resources such as minerals, water, land and energy sources. any perturbations in the broad frame work of the inter-relationships between living organisms and their environment may influence the availability of resources to human societies. Rapid population growth has placed enormous stress on life support of land, water, flora, fauna and the atmosphere. There is gradual diversion of forest and mangrove lands for a variety of other uses, thereby resulting in the loss of habitats rich in biological diversity. Therefore, sustainable development implies economic development where local environment and biosphere are protected. The decline in environmental quality has however, underlined the need for harmonishing the needs of economics with those of ecology.

Fishery resources

The inland fishery sector has tremendous potential in India, as the country is blessed with a vivid spectrum of inland waterbodies. The rivers and their floodplains, lakes, reservoirs, tanks, ponds, estuaries, mangroves, estuarine impoundments constitute the major resources having the potential to meet the 4.5 million tonnes of inland fish requirement by 2000 A.D. But fisheries development in our openwaters is becoming difficult due to environmental constraints posed by the anthropogenic stress on one hand and increased aquaculture on the other.

Problem

Commercial brackishwater prawn cultivation in the fragile ecosystem of the Sunderbans in West Bengal and other coastal states Tamil Nadu, Andhra Pradesh has been expanding rapidly for the last two decades. This shift to prawn farming has been primarily due to over-heated international market in this sector commodity. It is felt that while the sweeping 'blue revolution' in our coastal states has ushered in economic

prosparity to shrimp farm promoters in general and a few corporate giants in particular, it has brought an ecological disaster, with the desertification of fertile lands in villages abutting the shrimp farms. This poses a danger to the very livelihood of farm labour and fishermen in coastal districts of Tamil Nadu, Andhra Pradesh and Sunderbans in West Bengal.

Development of prawn farming

The Sunderbans is a net work of tidal rivers, creeks and inland stretching from the Southeastern tip of Midnapur district, through North and South 24-Parganas and into Howrah district of West Bengal. The dominant vegetation is the mangrove, and has been declared a fragile ecosystem under the man and biosphere programme. Nearly 50% of this brackishwater system is suitable for prawn and fish culture. The late 1970's through the 1980's saw a rocketing of world price of prawns, particularly of the species *Penaeus* and *Metapenaeus*. It is estimated that production in this region increased by 40% between last 50 years, and the number of prawn farms (bheries) generally operated by big merchants increased by 25% during the same period from 150-200. It has been reported that there was noted increase in the number of small farms from the mid 1980's. This latter development has been through the expansion of traditional farming system to include prawn farming i.e., fish-cum-paddy culture from August to December and brackishwater prawn cultivation from January to July. Though some economic benefits have been derived from this development, it is at the expense of rapid cutting down of mangrove forests. Further, the farms of all sizes are poorly managed under conditions of inadequate scientific knowledge creating low production of farming units. In these states, despite a ban on the setting up of shrimp farms in cultivable lands thousands of acres of fertile land is being taken over by shrimp farm promoters and big companies by offering small and marginal farmers money nearly twenty to thirty times of the land cost.

Ecological dimensions

Prawn farming can impinge on the environment in several ways; destruction of mangroves, collection of juveniles and by pollution. One that causes most concern is the destruction of the mangroves resulting in two ecological effects.

i) Loss of habitat

The destruction of mangroves means destruction of habitat for fauna and flora in the region. Secondly, it reduces the areas available for forest based activities (wild honey collection, match-making, wood collection and grazing) on what was common resource.

ii) Loss of detritus :

The mangrove forests provide the detritus which to a large extent determine the productivity and energy flow for organisms in the food chain in the mangrove ecosystem. Research in Thailand and Malaysia indicate a direct relationship between prawn catch and extent of land under mangrove. it has been reported that in Kerala though the total offshore catch has not declined, mangrove dependent species have declined.

The growth of commercial prawn culture has increased the trade in prawn juveniles most of which still comes from selective collection despite the growth of hatcheries. This is a wasteful process as it has been estimated that for every 1 g of prawn fry 10 kg of fin fish fry and larvae of non-commercial prawn species are destroyed and/or discarded on the banks, a further 20-25% of selected larvae is destroyed during handling and transportation.

With regard to water quality the ecological impacts have been observed with regard to changes in salinity, pH and reduced oxygen levels. These changes in many cases have resulted in fall in production.

Hazards

In the coastal belt of Tamil Nadu the fishermen find their traditional access to the sea cut-off as the shrimp farms have laid huge inlet pipes to bring in sea water to fill the ponds. It has also been reported that manyh drinking water sources in adjacent villages have turned saline due to the indiscriminate pumping of groundwater by shrimp farms. Further, some key water quality parameters in some villages have been reported to be alarmingly in excess of the prescribed tolerance limits for drinking water. According to some reports the intrusion of sea water coupled with the seepage of effluents has caused health hazards like cholera, malaria, jaundice and eye ailments in the vicinity.

Intensive farming harmful

The harmful effects of the effluents discharged by the hatcheries and ponds depend on the quality and quantity of the discharge, culture stage and the type of farming adopted. The impact is not much if the hatchery is being operated on a small scale.

But the discharges from large scale, extensive, semi-intensive and intensive hatcheries are likely to cause problems like hypernutrification and eutrophication. The intensive farming also increases the waste load in the pond water. The major pollutants from shrimp discharges include organic matter derived from uneaten feed and excreta and inorganic nutrients like nitrogen and phosphorus derived from the oxidation of organic matter in the ponds and from inorganic fertilizers.

International lessons

A survey conducted by Chittagong University, Bangladesh, showed that while exports of prawn made a lot of businessmen in that country millionaires, they ruined thousands of poor farmers living along the southern coastal belt, where shrimp hatcheries were set up on 100,000 hectares of land. The survey also cited other 'side effects' of the shrimp farms like scarcity of fodder, withering of coconut and other fruit bearing trees, death of cattle, shortage of milk and poultry and thousands of families were rendered landless in the coastal areas of Bangladesh due to the setting up of these hatcheries.

CONCLUSION

Environmentalists remain unconvinced about claims that aquaculture especially prawn farming can be made sustainable without endangering the environment. Developed countries like the U.S. and Japan can go in for large scale aquaculture instead they import shrimps from Asian countries. Only around 3000 tonnes of shrimp are harvested through aquaculture in the U.S. though its coastaline is several times longer than that of India. There is serious concern about the effect of prophylactics, including antibiotics, sulpha drugs, steroids etc. that are used in hatcheries on the environment and on people living in areas in their vicinity. It is felt that in the name of earning foreign exchange and promoting exports we may be damaging our coastal resources. The thrust should be harmonising the needs of economics with those of environment.

COMMON DISEASES IN PRAWN AND THEIR REMEDIAL MEASURES

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INTRODUCTION

The culture of prawn *viz. Penaeus monodon* in brackishwater and *Macrobrachium rosenbergii* in freshwater has recently attracted the attention of aquaculturists in India. This is because of the fact that the potential of developing the culture of these organisms into an economically successful industry has been recognised. However, along with its development one of the most important problem limiting its production in India is diseases. Since systematic culture of prawns in India is a recent development, work on their diseases is also in its infancy. However, from the experience of different workers engaged in prawn farming in India and abroad several diseases have been identified and certain remedial measures developed.

DISEASE AND THE ENVIRONMENT

Outbreak of disease in prawns is usually significantly related to poor environmental condition.

There are various ways in which the prawn the environment and the pathogenic organisms can interact.

i) Poor environmental condition can directly cause disease eg. Low dissolved oxygen below 4 ppm.

ii) Poor environmental condition can stress prawn and then it can be infected by an opportunist pathogen example deteriorating pond bottom condition may lead to vibriosis.

iii) Prawns may harbour some pathogenic organisms which will cause damage to it only when the host is stressed by poor environmental condition eg. Monodon baculovirus in hepatopancreas of prawn.

The presence of a pathogen in the tissue does not mean that it is the main cause of the problem. In majority of the cases the orginal cause of the problem is environmental. This must be taken into account when considering prevention or control of disease. For the farmer the most important aspect of disease diagnosis is the ability to detect the earliest stages of poor health or abnormalities in the prawn.

SYMPTOMS OF PRAWN DISEASE IN THE FARM

Outward observation: While observing from the pond dyke a healthy prawn should not be visible during culture. When the prawns are stressed by poor environmental conditions or suffering from some other disease they often come to the surface of the water or edge of the pond because of high dissolved oxygen. In some cases they may also be avoiding high levels of toxic substances at the bottom of the pond. It is important to check the ponds during night and in the early morning, since sick prawn will come to the surface and edge in large numbers at this time. At the first sign of prawn surfacing at the edge of the pond the bottom should be checked for dead prawn in areas, where waste accumulates.

Observation during sampling: During sampling close observations will reveal various predictive symptoms of disease outbreak. As such the factors to be looked into are:

i) Color of prawn- The color of normal prawn is related to their environmental conditions. For example in shallower ponds or in clear water the prawn will tend to be darker, than those in deeper or less transparent water. Change in color can also be an indication of poor health. Stressed prawn will often develop a blue coloration as opposed to the normal green color. Most injuries in prawns turn black or brown after a short period of time. This is due to the production of the pigment melanin which is toxic to microorganisms and can protect the prawns from infections. For example appendages that have been nibbled by other prawns will turn black at the end and areas of shell that have been infected with bacteria will also turn black.

ii) Soft shell- Very often the external shell is soft. Normally the shell hardens within 24 hours of moulting. If it fails to harden it may be wrinked and torn and more susceptible to superficial infections.

iii) Change in gill colour- Healthy prawns keep their gills clean, but lethargic or diseased prawns clean their gills less frequently allowing fouling organisms and debris to accumulate. This material gives the gills a brown colour. If gills are damaged they develop brown or black colour due to deposition of melanin.

*iv) External fouling-*Very prominent symptom of unhealthy prawn. Organisms grow on the surface and simultaneously they collect inanimate debris lending green or muddy color to the prawn. Healthy prawn clean themselves regularly and any persistent fouling is removed during moulting. Unhealthy prawn tend to clean themselves less often and moult less frequently.

v) Changes in gut- An empty or partially empty gut indicates that the prawn has not been eating. This may either be due to lack of food, adverse environment or poor health. The colour of the hepatopancreas can change, most significantly to a yellow colour in the so called yellow head disease. In case of septic hepatopancreatic necrosis the hepatopancreas will be small as well as discoloured.

vi) Change in the muscle- In many cases the abdominal muscle do not fill the carapace. This is observed either immediately after moulting or in cases of chronic starvation or where prawn appetite is reduced due to chronic disease. The muscle may become opaque for a number of reasons example due to chronic stress, microsporidean infection (cotton shrimp) on as in cramped muscle syndrome. The muscle may also develop brown or black lesion as in black splinter disease.

DISEASES ENCOUNTERED DURING CULTURE

Studies conducted by several workers in India and abroad reveal a large number of pathogenic organisms afflicting *Penaeus monodon* and *Macrobrachium rosenbergii*. However, in this communication for the sake of clarity the different organism producing similar type of disease manifestation have been grouped into smaller number of disease syndromes.

A. Non invasive external fouling

Symptoms: Fuzzy mat on shell and gills. The appearance of prawns with external fouling depends not only on the type of organisms involved but also on any additional debris which become attached. Fouling on the gill frequently causes a dark coloration and can even result in the gills appearing black.

Impact on host: The main effect of fouling is to interfere with movement and respiration. Affected prawns are often attracted to the water at the side of the pond with higher level of dissolved oxygen.

Causative organisms: Protozoans *viz. Epistylis* sp. *Zoothamnium* sp. *Vorticella* sp., *Suctoria* sp., bacteria *viz. Leucothrix* sp., fungi, macro invertebrates viz. barnacles and algae.

Host species: P. monodon & *M. rosenbergii.*

Method of control: Any form of treatment for fouling has to address the initial problem as well as the presence of organism. This usually involves improving the water quality to encourage the prawn to be more active and to moult regularly. Chemical treatments is done for cases of external fouling persisting even after improved water quality.

The most commonly used chemical is formalin (37 to 40% formaldehyde) @ 25 to 30 ppm. The prepared solution in water should be distributed uniformly in the water area and dissolved oxygen levels should be maintained.

B. Externally invasive disease

There are a number of infections which start on the outside of the shrimp and invade through the carapace.

Symptoms: Black spot or black or brown areas in different organs or portions of prawn.

Impact on host: Primarily the invasive organisms cause lesions, erosions or depressions in shell and when such invasions affect an inflammatory reaction in the internal tissue either gill or muscle in any portion, it leads to melanization.

Causative organisms: The invasive organisms are, *Vibrio* sp., *Pseudomonas* sp. *Aeromonas* sp. Fungi-*Fusarium* sp.

There are however a large number of other conditions which can result in significant melanization of the gill or the condition knowns as "black gill'. Some of the potential causes are;

i) localised bacterial infection *viz. Vibrio* sp.
ii) fungal infection, *Fusarium* sp.
iii) Protozoans
iv) acid waters, soils etc.

Area of the carapace other than the gill can be affected by localized damage. Appendages may be damaged by other shrimp or they can be affected by localised infection due to poor pond bottom condition. In ponds where the prawns cannot avoid the accumulated waste, swollen tail may be seen.

Host species: P. monodon, M. rosenbergii

Methods of control: The treatment of all these external invasive conditions depends on the original cause. If the causes of the irritation is removed the melanized tissue especially in the gills may be discarded at or before the next moult, returning the gills to normal appearance.

Better pond management in many cases eliminates the disease condition.

C. Vibriosis

The term vibriosis is used to refer to all types of infections caused by species of the genus *Vibrio* including bacterial shell disease and black gill.

Systemic infections appear to be the most common form of vibriosis either associated with poor water quality or with other diseases. In acute form the symptoms though non specific are:

a) abnormal behaviour eg. Prawns at the side or surface of the pond
b) lethargy
c) inappetite
d) discoloration either red or blue.

If prawns are severely stressed or the bacteria are highly pathogenic, a large number of prawns may die within a short period of time. Chronic infections often result in formation of black nodules in many tissues.

Some forms of disease outbreak due to *Vibrio* sp. have been given specific names as under

i) ***One month mortality syndrome:*** In culture ponds if benthic algae are allowed to grow on the pond bottom during early stages of culture the algae may subsequently decompose. The prawns come in close contact with this decomposing material after moulting and are exposed to stressful environment and large number of bacteria. This result in the prawns developing shell lesions and systemic bacterial infections.

Host: P. monodon, M. rosenbergii

ii) ***Black splinter disease*** It is a condition in prawn where a chronic melanised lesion develop in the muscle of the abdomen.

Host: P. monodon

iii) ***Luminescent bacterial syndrome*** It is very common in hatcheries and growout ponds. It is caused by some species of *Vibrio* which are luminescent. When present in large numbers they may cause the affected animals to glow in the dark.

Host: P. monodon

iv) ***Septic hepatopancreatic necrosis*** Here large areas of hepatopancreas is destroyed and the area turns dark. This condition is brought about by *Vibrio* infection. However, there are reports that similar condition is also associated with toxins (aflatoxin) in food or presence of other types of bacteria.

Causative species:- Vibrio parahaemolyticus V. Alginolyticus, V. Anguillarium, V. vulnificus V. fluvials. Certain other gram negative rods, including *Pseudomonas* sp. and *Aeromonas* sp. may occasionally incriminate the bacterial disease syndrome in prawns.

Methods of control: Vibriosis is very often associated with other problems in the culture ponds. Any mortality of prawn will have some *Vibrio* sp.

Treatment of vibriosis must always involve improving the environment. Maintain adequate water quality with low bacterial biomass, a stable phytoplankton bloom and proper feeding programme. Sterlise or filter recirculated water. Routinely monitor prawn and pond for early diagnosis of a problem. Avoid temperature extremes, handling, overcrowding and other stressors. Antibiotic therapy.

There are certains norms to be followed before we go for antibiotic therapy i) it is essential to improve pond environment ii) use antibiotics only for bacterial infections but not for viruses, fungi or protozoa iii) use an antibiotic to which the bacteria are sensitive. Antibiotics either oxytetracycline or Erythromycin etc., should be treated for 5 days. Prawns harvested after atleast 14 days.

D Viral infection in Hepatopancreas:

The hepatopancreas of prawn is affected by the following viruses:

i) Monodon baculovirus (MBV)
ii) Baculovirus penaei (PB)
iii) Type C. baculovirus
iv) Hepatopancreatic parva like virus (HPV).

These viruses damage the cells of the hepatopancreas and make shrimp more susceptible to stress or other diseases. The severity of their effect and the age at which infected shrimp are most sensitive vary with different viruses. It has proved to be difficult to demonstrate conclusively the effect of these viruses on the health of shrimp populations.

The viruses are detected by their effect within the cells of the hepatopancreas. With the exception of the type C Baculoviruses, they cause inclusion bodies in the nuclei of the affected cells. All these viruses are thought to be spread by excretion in faeces and subsequent ingestion by other shrimp. The infection may spread between the brood stock and the larvae by this route

Host: P. monodon

Methods of control: The pond disinfectants are widely used for reducing the load of bacteria in viral disease. The disinfectants used are buffered iodophores (CHI_3) and calcium hypochlorite. Lime can also be considered to be a pond disinfectant. Chlorine is also used as disinfectant.

Yellow head disease

Symptoms: The disease is characterised by pale body colour with yellowish gills and hepatopancreas. It is commonly seen in 50 to 70 days post stocking.

Impact on host: In this disease abnormalities should be observed, in the haemocytes including shrinking of nuclei, breakdown of nuclei and cytoplasmic inclusions.

Host: P. monodon

Causative agent: Yellow head baculovirus

Method of control: It is important to differentiate yellow head disease from other causes of mortalities. With yellow head disease the best course of action in most cases is to conduct an emergency harvest, regardless of the stage of production.

White spot disease

Symptoms: White spots appear on the carapace and extend to other parts.

Impact on host: Marked hypertrophy and intra muscular inflammation.

Host: P. monodon

Causative agent: A virus described as SEMBV (Systemic Ectodermal and Mesodermal Baculovirus) no treatment available. Prevention is the best method of control.

Method of control: The methods used for containing this disease is mainly preventive as discussed

i) Every pond should have a reservoir pond and inlet water should be kept 4-5 days prior to use. This water can be sedimented, disinfected (say @ 30 mgl^{-1} chlorine) and aerated prior to use in culture.

ii) Entry of wild prawn and crabs is prevented.

iii) Used trash fish, crabs and other crustaceans which can serve as potential carrier of SEMBV should be avoided in culture ponds.

iv) Carefully select post larvae

v) Maintain optimum water quality to avoid stress in prawn.

E. Microsporideans

Symptoms: Prawns appear cooked although alive. The infected muscle of the abdomen turns opaque and white. The appearance of the muscle has led to the condition being called cotton shrimp or milk shrimp.

Causative agent: The muscles of affected shrimp contains areas that are replaced by a large number of microsporidean cells. Each cell undergoes internal division to produce a small group of spores. The causative organism is *Agmasoma* sp.

Methods of control: There is no suitable treatment and control involves removing affected individual. This is possible because affected shrimp will often swim on the surface of the pond at night.

F. Soft shell syndrome

Symptom: The body muscle is soft and not tight.

Causative agent- It may be associated with exposure to a variety of insecticide as well as a number of different environmental condition viz.

i) poor quality feed
ii) overstocking or underfeeding
iii) low soil pH
iv) low water phosphate

Methods of control- Treatment involves improving the environment wherever possible, avoiding agricultural run off or other sources of pesticides and ensuring high quality feed with 1:1 ratio of calcium to phosphorus.

G. Cramped tail condition

Symptoms: Is described as a condition of prawns having a dorsal flexure of the abdomen which cannot be straightened.

Causative agent- This condition occurs during summer months especially with the handling of shrimp in the air where it is warmer than the culture system. The exact cause is unknown, other stress factor may be the cause of this condition, as reported.

HEALTH MONITORING OF PRAWN LARVAE

1. External fouling with protozoa, bacteria on fungus is thought to indicate poor quality larvae. If a large proportion of the post larvae have external fouling it may indicate poor water quality and or that post larvae are not moulting regularly.

2. The appendages and rostrum of the post-larvae should be of normal shape and without erosions or black discoloration. The abdominal muscle should be clear and it has been suggested the muscle to gut ratio in the sixt abdominal segment should be around 4:1. The gut should also be full of food.

3. There are certain aspects of behaviour of the post larvae (*P. monodon*) that are thought to indicate good health. Healthy post larvae swim with straight bodies, respond quickly to external stimuli and actively swim against the current when water is stirred. When the current subsides they tend to cling to the sides rather than being swept into the centre of the container. Unhealthy post larvae may be lethargic, unresponsive and may swim with arched bodies.

4. The health condition of post larvae can be further evaluated by the following tests

   Salinity test- The larvae are exposed suddenly to a salinity of 15-20 ppt.. If no mortality occurs over two hours of exposure and they recover and resume feeding within 24 hrs they can be considered healthy.

   Formalin test- Larvae are subjected to 100 mgl^{-1} formalin for 2 hours. If they survive and recover they are considered healthy.

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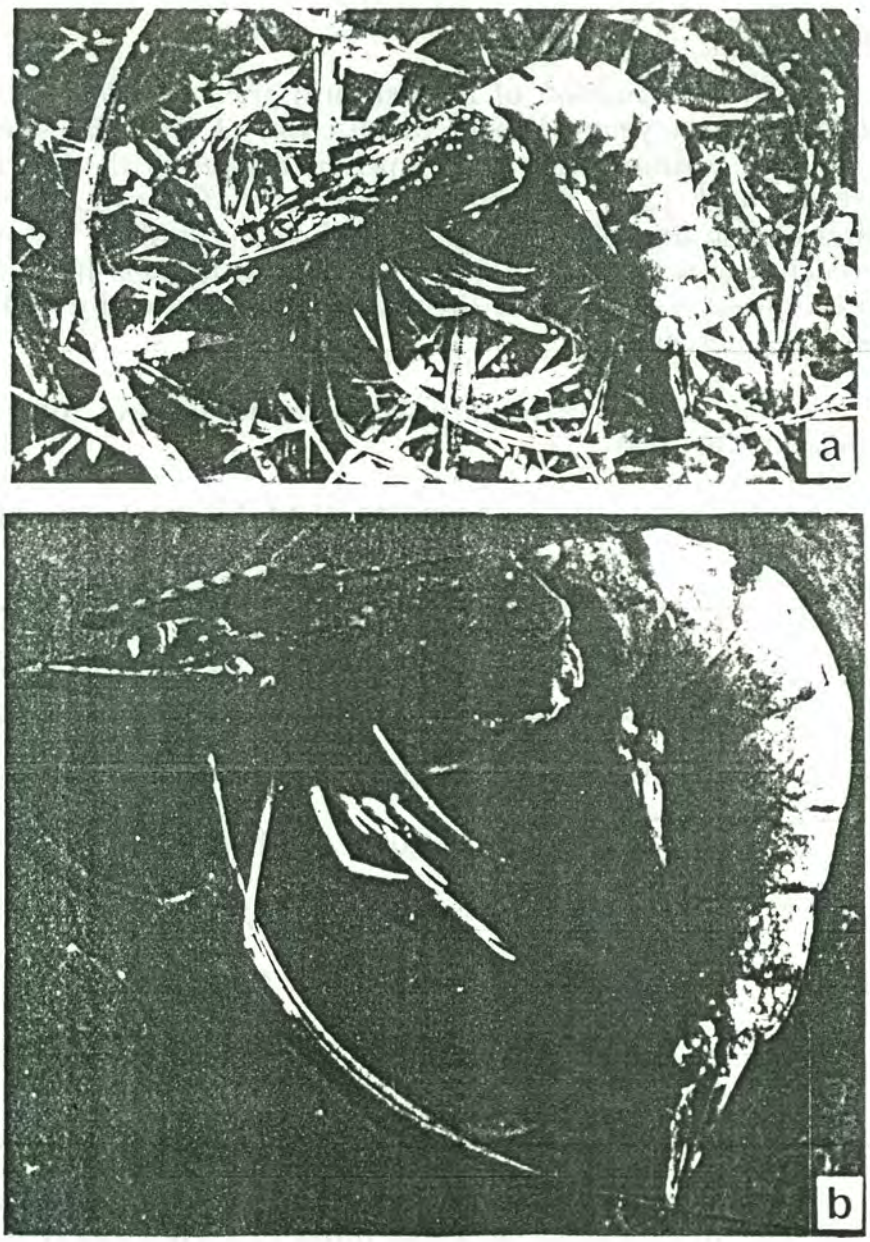

a. *Penaeus monodon* afflicted with white spot disease.

b. *Penaeus monodon* with white spots visible in carapace and tail region.

ECONOMICS OF PRODUCTION AND FOREIGN TRADE IN PRAWNS - CERTAIN POLICY ISSUES

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The production of fin fish and shell fish has shown an overall increase in the past years. World production of fish and shell fish from all sources in 1991 ammounted to 97 million tonnes with 84.3 million coming from fishing and 12.68 million tonnes from farming. Thus world farm production of fish and shell fish increased by 0.6 million tonnes form 1990 to 1991 to reach a new record total of 12.7 million tonnes. In 1984, aquacculture contributed about 8 percent to the world production. By 1991 its share had increased to 15 percent.

The following table gives a broad linking into world cultured shrimp production 1990 - 92.

Cultured Shrimp production : 1990 - 92 of Major producers-Head on production (Metric Ton)

Country	*1990*	*1991*	*1992*	*% change 92/91*
Thailand	1,10,000	1,53,000	1,63,000	+ 6
China	1,50,000	1,45,000	1,40,000	- 3
Indonesia	1,20,000	1,40,000	1,30,000	- 7
Ecquador	73,000	1,00,000	95,000	- 5
India	32,000	35,000	45,000	+ 29
Taiwan	30,000	30,000	25,000	- 17

India in recent years has emerged as a significant exporter of frozen shrimps. In quantitative terms India exported 76151 tonnes valued at Rupees 97912 lakhs during 1991-92 as against 62395 tonnes valued at Rupees 63333 lakhs in the corresponding period of 1990-91.

The export boom witnessed in the last decade has been mainly sustained by production of brackishwater prawn from capture sources. Recently, there has been a spurt in the production of freshwater prawn mainly due to favourable output price.

The following paras deal breifly with certain issues involved in the production as also foreign trade in shrimps.

ECONOMICS OF PRODUCTION

Every aquatic production venture has to depend on sound input supply sub-system in respect of seed and feed. So far culture of production of brackishwater prawn has been mainly dependent on natural collection of prawn seed from estuarine and brackishwater areas.

Till today there are no documented reports regardding availability trends in prawn seed of stockable size. Unlike carp seed production the production of hatchery reared seed has not made much headway. Several firms are being attracted towards this activity. Unless hatchery development is carried forward on scientific basis the production units may be threatened with closure. Further high density culture may also lead to occurence of disease. Further mush rooming of prawn ventures has posed a threat to the environment.

CAPITAL INTENSIVE NATURE OF INVESTMENT

Lumpiness in investment calls for reaping the internal economies of scale of otherwise average cost of production may go up. The dependance on natural supply of prawn seed should be reduced so as to put enterprizes on sound footing. The strength of the enterprise should not be solely based on overheated domestic and overseas market. The objective should be cost-effectiveness.

INTERNATIONAL TRADE

International trade is a trade among different countries or trade accross political frontiers. International trade is the result of geographical specialisation. Different countries are endowed with different kinds of resources and skills, climate, soil, and other factors. International trade exists due to comparative cost difference not due to absolute cost differences. Although, individuals by their own action may have no perceptible influence on overseas prices of shrimps, the combined decision of several prawn producers /exporters may bring about sizeable price changes. What is important in export trade in shrimp is the knowledge about the comparative cost of production of competitors otherwise our exportables may be outpriced due to comparative cost advantage. Further, strict quality control is another factor that influences the choice of importing countries say Japan or U.S.A. The regularity of supplies is also a factor to be considered in foreign trade. Further, consumers preferences of overseas buyers may also be kept in mind. For proper export planning overseas demand may be projected after analysing the trends in export trade.

EXTENSION STRATEGY FOR DEVELOPMENT OF PRAWN FARMING

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INTRODUCTION

Recent breakthrough in prawn production triggered off by the new scientific innovations and their use in commercial scale particularly adoption of the modern technologies and strategy has imparted new dynamism to the development of prawn farming and has given new hopes and confidence to millions of fish farmers. Prawn farming of India has heaved itself out of the rutts of traditional farming based on customs and traditions and is increasingly assimilating the modern and most scientific techniques for stepping up the prawn production.

As a result of breakthrough in research on prawn farming and available large number of findings, several programmes in the development of prawn farming have been initiated. The demands made upon transfer of technologies for accelerating prawn production from inland waters, are enormous and formidable. Therefore, integrated functioning of research, the education and extension has been the cardinal principles of prawn farming explosion. It is important to involve all groups of people including administrators, scientists, and fish farmers in the process of formulating and implementing management measures towards the development of prawn farming. The fish farmers are more likely to participate with management measures for larger benefit.

Characteristics of new technology

The modern technologies of prawn farming are sophisticated in nature and high input intensive. These are interdependent on so many inter-related practices, each one of which has to be applied rationally in time and in the manner recommended by the scientists. For example to get best result from prawn farming, it is not only the selection of right type of waterbody but application of accompanying package of practices such as weed clearance, control of predatory and unwanted fishes, liming, fertilisation, stocking ratio and density, supplementary feeding, sampling, harvesting etc. all of which contribute towards yield maximisation. Failure of any of these may upset the achievement of the desired yield level. A communicator of prawn farming technology, therefore, has to understand its characteristics in order to select

appropriate extension methods, techniques and media for increasing production with existing resources and for increasing the income of the prawn producers and lowering the price of produce for consumers.

There are three main aspects to this job for getting information to people :

(a) Getting the new knowledge from a source

(b) Interpreting the knowledge so that people understand it, and

(c) Transmitting the interpreted information to the people who will use it.

Problem of communicating information

The management practices of prawn farming are being communicated to the prawn producers by different communicators through various channels but effects of such communication are not always well pronounced as evidenced by prawn producers' inadequate knowledge, understanding, skill and sometimes negative attitude gained, leads to either delayed or no action by them. But whenever the technology has been profitable, feasible and communicated through appropriate extension methods and techniques, the prawn producers response has been spectacular. Communication is not a one unit act but a process having continuity and consisting of distinct eliments such as Communicator (source-inventors, scientists, extension workers, opinion leaders etc.). Message (Innovation, New idea), channel and Recipient (Fish farmers, members of social system) - all directed towards eliciting specific intended response form the recipient. In order to make sure that the process is complete and brings the intended response (desired behavioural change), it is crucial that these elements are well balanced, one fitting into another. The fault in one, may lead to breakdown of the entire process.

Extension strategy for effective communication :

The present prawn production strategy in the country calls for rapid dissemination of information on prawn farming and technical knowledge to the clientle in mass scale in the direction and bringing gap between research system and target groups in the field. The strategy for transfer of tecchnologies on prawn farming for the members of the resource poor target group is to be treated henceforth as one of the essential inputs to overall activity in the development programmes of prawn production.

Types of information :

i) Information on resource and potentiality of prawn production.

ii) Information on the biology of important prawns specially breeding habits.

iii) Information about seed availability.

iv) Information on infrastructure required for culture and hatchery management of prawn.

v) Information on nutritious feed and live feed.

vi) Information on diseases on prawn.

vii) Information on post-harvest technology.

viii) Information on marketing.

ix) Information on credit facilities.

It is felt negligible effort so far have been made in the country to provide information to the target groups towards prawn farming. Thus, a large gap has been created between awareness and adoption of prawn farming technology.

Dimension of communication :

There are five dimensions which can be adopted for communicatiung informaion in the programmes of prawn farming.

i) Communication from top-to-down e.g. communication form State headquarters to ordinary people or Fisheries Institutees to prawn producers.

ii) The second dimension of communication is from down-to-top or upward e.g., communication from prawn producers to extension personnel and then to research experts. This type of communication is needed to help the concerned people to adopt, modify or change the programmes, activities as even technology to suit local needs, aspiration etc. Without the feed back or upwward communication the downward communication may still be off the mark or even provoke resistance rather than concurrence.

iii) The third dimension is the communication among the clientle themselves where the poor prawn producers stimulate each other through example and experience in their efforts.

iv) The fourth dimension, intimately interlinked with the three discussed above, is the communication as one of the human resource development. The task has to be taken care of largely by communication media, both working in coordination with Institutes imparting training and acting as independent channel to bridge the gap between available knowledge and their application on a mass scale.

v) The fifth dimension of communication is in the context pf rural development and transformation of cultural life and values.

A communication system can perform well only if the performance of the people who run it, is well.

Communication planning for mass awareness

The prime objectives of the prawn farming programmes could not be achieved unless communication is taken as an important component and ingradient of development efforts. The constructive application of communication for prawn farming calls for proper planning that takes equal note of the national priorities & needs, preferences of individual and of social priorities. A essential ingredient of such communication planning is an understanding of the specific assets and limitation of each of different media. It may be appropriate to have an idea of the impact of each these on the society.

Face to face oral strategy

Extension personnel through personal contacts will establish rapport with the receiver and will communicate well tested messages to improve their skills, attitudes and knowledge.

Case studies

The case studies may come from all the areas of extension activities of prawn farming programmes. The case studies may be on achievements/activities of individual worker and experience of prawn producers. The information can be compiled to give upto-date data.

Circulation

Infformation on prawn farming technology could be widely circulated in the form of circular letter, hand out, leaftlet, pamphlet, mimeograph etc.

Joint field visit

Joint field vistis of researchers and extension personnel will enable them to understand about success of prawn production programme and to identify the constraints.

Group approach

Instead of the individual approach in communiccation, the group approach should be in the field.

Involvement of village motivators

The village motivators play a key role in establishing good participation of the members of the target group in the activities of prawn farming. They have a major responsibility in explaining prawn production programmes and in setting up good systems of dialogue so that members of the target group not only get full opportunity to express their opinions but also what they feel, can do so freely. There is no doubt that the village motivators have been helping this process enormously because they have been able to gain confidence of the members of the target group as they live in same village and thus, they have succeeded to establish that prawn farming programmes in the country has genuine reason to be helped.

Major issues

The diffusion of prawn farming technology could not be taken place due to lack of planning and monitoring of the programmes, financial indiscipline and inadequatee communication. Proper planning need be done to tackle the situation so that faith in the people could be restored about the government and the systems.

1) The rural poor prawn producers are affilicted by psychological poverty and lack of initiative adversely affecting the process of development. The extension agencies should take initiative to create a critical awareness among the prawn producers, so that they become effective participants in prawn farming.

3) Communication researchers have indicated potential of communication to enrich members of the target group and mobilise them. But there is need to conduct many more studies to generate more information in this area. Hence, enough scientific and financial support need be available for conducting communication research. The priority areas of research in communication towards prawn farming performances, could help in formulating new strategies.

4) To handle the programmes on prawn farming efficiently training facilities are required to be extended to the fisheries extension personnel.