

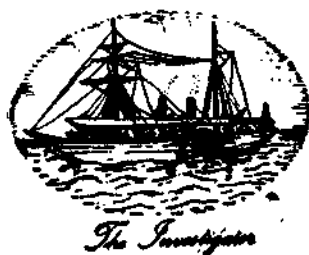
PROCEEDINGS OF THE SYMPOSIUM ON COASTAL AQUACULTURE

Held at Cochin

From January 12 to 18, 1980

PART 1: PRAWN CULTURE

(Issued on 25th February 1982)



MARINE BIOLOGICAL ASSOCIATION OF INDIA

POST BOX NO. 1244, COCHIN 682 011, INDIA

Price : Rs. 400.00

EDITORIAL BOARD

DR. E. G. SILAS
DR. P. V. RAO
DR. P. V. R. NAIR
DR. K. ALAGARSWAMI
MR. T. JACOB
DR. K. C. GEORGE
MR. K. RENGARAJAN
DR. P. P. PILLAI
MR. K. J. MATHEW
MR. V. K. PILLAI
DR. A. G. PONNIAH



MARINE BIOLOGICAL ASSOCIATION OF INDIA

COCHIN-682 011, INDIA

SYMPOSIUM SERIES 6

Abbreviation

Proc. Symp. Coastal Aquaculture, Pt. 1.

PRINTED IN INDIA BY K. G. JOHN AT THE DIOCESAN PRESS, MADRAS 7 AND PUBLISHED BY
E. G. SILAS ON BEHALF OF THE MARINE BIOLOGICAL ASSOCIATION OF INDIA, COCHIN-682 011.

RESEARCH PROGRESS IN THE CULTURE OF PENAEID PRAWNS ALONG THE COASTS OF INDIAN OCEAN AND INDO-PACIFIC

M. S. MUTHU, M. KATHIRVEL, P. VEDAVYASA RAO AND N. N. PILLAI

Central Marine Fisheries Research Institute, Cochin-682 018

ABSTRACT

A wealth of information on different aspects of culture of penaeid prawns is continuously being made available in recent years as a result of active R & D programmes taken up by several organisations. A compilation of these information covering the areas such as breeding, rearing, seed production, nutrition and diseases of important species of penaeid prawns being cultured along the coasts around the Indian Ocean and Indo-Pacific, is presented in this paper. This review would be useful to understand the present status of the culture of these prawns and to formulate future strategies.

INTRODUCTION

THE REGION covered in this review comprises of the tropical and sub-tropical belt extending from Long. 30°E to 150°W. Aquaculture, in countries such as Bangladesh, India, Indonesia, Thailand and Philippines located here, has been in vogue since time immemorial. Among the different systems of aquaculture being developed and practised in the region at present, penaeid prawn culture is the most dynamic field receiving the attention of scientists, administrators, planners, industrialists and farmers. This interest is motivated mainly by factors such as sustaining market demands for the commodity, availability of suitable species and water resources and increasing awareness of the importance and the role of the system in improving the economy and generating employment opportunities in the coastal rural areas.

Following the success achieved by Japan in controlled breeding and rearing of *Penaeus* (*Marsupenaeus*) *japonicus*, most of the countries in the region have turned their attention to developing prawn culture on sophisticated lines. Consequently during the last 50 years,

considerable progress has been achieved in the field and a wealth of information has been gathered on various aspects of penaeid prawn culture. The present paper attempts a review of the research and technological progress made particularly in the field of raising prawns in the grow-out systems, seed production, induced maturation and broodstock development, prawn nutrition and diseases.

SPECIES CULTIVATED

About 82 species, belonging to 8 genera of the family Penaeidae, which are either commercially exploited or possess potential economic value occur in the region. Of these, the species of penaeid prawns cultivated in the region belong mainly to the genera *Penaeus* and *Metapenaeus*. The important species and the countries where they are cultivated are given in Table 1. Among these prawns *P. (M.) japonicus* and *P. (Fenneropenaeus) chinensis* are sub-tropical species while the others are tropical. While all the species are found to be suitable for culture, the species belonging to *Penaeus* are preferred over those of *Metapenaeus* as they grow to larger size and have

greater market demand. Among the species of *Penaeus*, *P. (P.) monodon*, the tiger prawn, is the most important as candidate species in view of its wider distribution, largest size, faster rate of growth, greater fecundity and relative hardiness.

allowed to enter the culture fields during high tide and prevented from escaping during low tide by screens kept in the sluice gates. Harvesting is done during new moon and full moon phases with the help of sluice nets or traps. In this simple and inexpensive method

TABLE 1. Important species of penaeid prawns cultivated along the coasts of Indian Ocean and Indo-Pacific

Species	Countries where cultivated
<i>Penaeus (Fenneropenaeus) chinensis</i> (Osbeck)	.. Korea, China
<i>P. (Fenneropenaeus) indicus</i> Milne Edwards	.. India, Singapore
<i>P. (Fenneropenaeus) merguensis</i> De Man	.. S.E. Asia
<i>P. (Fenneropenaeus) penicillatus</i> Alcock	.. Taiwan
<i>P. (Marsupenaeus) japonicus</i> Bate	.. Japan, Korea
<i>P. (Melicertus) latisulcatus</i> Kishinouye	.. Japan, Australia
<i>P. (Melicertus) marginatus</i> Randall	.. Taiwan, Hawaii
<i>P. (Penaeus) semisulcatus</i> De Haan	.. Taiwan, Thailand
<i>P. (Penaeus) monodon</i> Fabricius	.. Bahrain, Kuwait, S.E. Asia
<i>Metapenaeus dobsoni</i> (Miers)	.. India
<i>M. monoceros</i> (Fabricius)	.. India
<i>M. ensis</i> (De Haan)	.. S.E. Asia
<i>M. bennettiae</i> Racek & Dall	.. Australia
<i>M. brevicornis</i> (Milne Edwards)	.. India, Thailand
<i>M. joyneri</i> (Miers)	.. Korea, Japan
<i>M. stebbingi</i> Nobili	.. Bahrain, Kuwait
<i>M. macleayi</i> (Haswell)	.. Australia

CULTURE PRACTICES

The culture operations prevailing in the grow-out systems in the region could be conveniently grouped under three categories, namely, extensive culture, semi-intensive culture and intensive culture.

Extensive culture: Traditional methods of trapping and growing penaeid prawns along with fishes such as milkfish and mullets in brackishwater ponds and impoundments in the coastal areas is being practised in Bangladesh, India, Indonesia, Malaysia, Philippines, Singapore, Thailand and Vietnam. In this form of culture the prawn seed which abound in the brackishwater creeks and estuaries are

there is no control over the quality or quantity of seed stocked; no efforts are made to control the predators and no supplementary feed is given. Yields varying from 45-1000 kg/ha/year are obtained by this method.

In Thailand the tidal water is not taken in through the sluice gates but lifted into small enclosures along with the prawn seed by dragon wheels which prevent the large predatory fish from entering the ponds. After accumulating sufficient seed prawns in these nursery enclosures the water is treated with tea seed cake or derris root to selectively kill even the small fish which might have entered along with the prawn seed (Cook, 1976). Then the bunds of

the nursery enclosures are cut in places to allow the prawns to move into the surrounding large growing ponds.

The recent trends in improving the yield from this type of culture relate mainly to adoption of better pond management principles. These involve careful preparation of the ponds for stocking by eradication of unwanted organisms in the ponds by tea seed cake and mahua oil cake (both containing saponin) or derris root powder (containing rotenone); application of organic and inorganic fertilizers to enhance the fertility of the ponds; and supplemental stocking of the ponds with the seed of fast growing species such as *P. (P.) monodon*, *P. (F.) indicus* and *P. (F.) merguensis* collected from the wild to improve the quality of the yield.

Semi-intensive culture : In this method, the culture ponds are selectively stocked with fast growing species of *Penaeus* and are fed with artificial feeds. The water exchange through the sluice gates is only to maintain the water quality in the ponds and not for stocking purposes.

In Japan, Taiwan and Korea, *P. (M.) japonicus*, *P. (P.) monodon* and *P. (F.) chinensis* respectively are grown in monoculture in earthen ponds. Hatchery reared seeds are stocked in earthen ponds which may have concrete or brick walls, at stocking densities of 15-20 prawns/m². The ponds are well aerated either through perforated P.V.C. pipes laid on the bottom of the pond or through paddle wheels and other mechanical agitators. The prawns are also regularly fed with trash fish, clams or pelleted formula feeds. Yields varying from 2000-3000 kg/ha/year are obtained in commercial scale operation by this method. On an experimental basis, however, an yield as high as 4945 kg/ha was obtained in a culture operation extending over a period of 4½ months in Taiwan.

In India, Indonesia, Thailand, Philippines, Australia and Fiji selective stocking of *P.*

(P.) monodon, *P. (F.) merguensis* and *P. (F.) indicus* is being experimented in earthen ponds without aerating devices at stocking densities of 1-7 prawns/m² and encouraging results have been obtained. Yields of 1000-1185 kg/ha/year have been achieved in India and Indonesia. Polyculture of different species of prawns with milkfish and mullets has also been tried in India.

The results of experiments conducted on semi-intensive method of prawn culture in earthen ponds indicate that a stocking strategy with juveniles measuring 40-60 mm in size gives higher survival and production rate than stocking the field with post-larvae (10-15 mm size); short term culture operations of 2½-4 months duration has distinct advantage over the long term culture which often leads to poor survival and growth; prawns kept in growing ponds beyond 4 months are affected in many ways. The accumulation of metabolic wastes and unused food in the pond soil and the rapid growth of larval fishes that enter the pond along with the tidal waters leading to competition for food or predation, result in stunted growth and poor survival of the stocked prawns. Risk from diseases is also higher. Growth of prawns in the ponds is found to be inversely proportional to stocking density particularly when supplementary feeding is not resorted to in the culture operations. Since the market value of prawns is more for larger prawns it is better to stock a lesser number and obtain a greater size at harvest than to stock a larger number of prawns and get a slightly larger yield of small sized prawns which fetch lower price per unit weight. It is also found that without special aerating devices, the stocking density in natural ponds cannot be increased beyond 10 prawns per m².

Intensive culture : In Japan, high density culture of *P. (M.) japonicus* was started in large concrete raceways fitted with double bottom, air lift circulation and continuous flow of sea water along with intensive feeding with clams

and trash fish. However, the unused food and moults of prawns accumulating at the bottom posed problems and led to the development of 2000 to 13,000 tonnes concrete circular self-cleaning tanks by Shigueno (1975). These tanks are equipped with false bottom, central drain pipe and constant supply of fresh seawater which is sprayed into the tank in such a way that a circular motion is imparted to the water in the tank which drives the debris towards the middle of the tank from where they are evacuated through the central drain. *P. (M.) japonicus* is stocked in densities upto 125 prawns/m² and fed with pelleted formula feeds. Harvests of 2.1 to 2.6 kg/m² of tank surface have been achieved after 6 months in this system.

The construction of these specialised tanks and the logistics of providing such a large volume of running seawater and the complete dependence on pelletised feeds make this system highly capital investment and is found to be economical only in Japan where land and labour are costly and the live prawns command an unusually high market price as a luxury food. The high density culturing is also greatly vulnerable to diseases and large scale mortalities due to mechanical failures even for a short duration.

SEED PRODUCTION

One of the basic requirements for proper planning of the culture operations entails availability of quality prawn seed as and when required by the culturists. The distribution pattern and abundance of prawn seed in the coastal lagoons, estuaries and brackishwater areas exhibit wide fluctuation. In fact inadequate supply of prawn seed forms a major constraint in the development of prawn culture in the brackishwater ponds in Indonesia, Philippines, Thailand and India. To overcome this, hatchery propagation of penaeid prawns under controlled conditions has been perfected in Japan, Korea and Taiwan and is

being developed in other countries of the region such as Philippines, Indonesia, Australia, Thailand, Hawaii, Tahiti, Malaysia, India, Bahrain and Kuwait.

The larval rearing system which was developed by Fujinaga and his associates in Japan over a period of 30 years has undergone several changes (Fujinaga, 1969). During 1933-1964, the larvae were grown indoors in porcelain tiled tanks and fed with separately grown pure cultures of *Skeletonema costatum* in the protozoa stage and with *Artemia* nauplii in the mysis stage, and finely chopped clam meat in the postlarval stages. In 1964, Kittaka started fry production in large out door concrete tanks of 50-200 tons capacity. The basic principle of this 'Community culture' method is to rear the larvae along with food organisms in the same tank by proper management of nutrient concentration, vigorous aeration and control of light intensity. This system of larval rearing is now adopted in many hatcheries in Japan to produce several hundreds of millions of fry annually. The method although involves relatively less labour and operational cost, is dependent on a ready supply of large volumes of good seawater. Further, when the sun light is poor the diatom bloom may not develop or the diatoms which develop may not be suitable as feed for the larvae, and this often results in poor survival of the larvae. To compensate the poor growth of diatoms finely powdered Soy cake (Hirata *et al.*, 1975) or compounded feed is added @ 1.5 g per 10,000 larvae. However, the difficulties encountered in maintaining sustainable diatom blooms and good quality rearing water often hamper the hatchery operation. Hence in recent years (since 1974) there is a revival of interest in the earlier system of growing the larvae and the feed organisms separately under more rigorously controlled conditions. Besides Japan, several countries in the region have developed technologies for mass production of prawn seed (Table 2). While commercial scale hatcheries are opened

for only a few species such as *P. (M.) japonicus* and *P. (P.) monodon*, they are still in an experimental stage for several species as seen in the Table 2.

The recent trend in the mass production of penaeid prawn seed in the region is to develop

low-cost technologies for adoption at the village level by using smaller containers and substituting the expensive *Artemia* nauplii with other cheaper food organisms such as *Brachionus*, *Moina* and nematodes, for feeding the mysis stage larvae. The experiments using blended

TABLE 2. Countries in the Indian Ocean and Indo-Pacific region where mass production of penaeid prawn seed is developed

Country	Species	Production level	Source
Australia	<i>P. (M.) latisulcatus</i>	commercial	Pownall (1974)
China (Main land)	<i>P. (F.) chinensis</i>	experimental	Ryther (1979)
Hawaii	<i>P. (M.) marginatus</i>	experimental	Gopalakrishnan (1977)
India	<i>P. (P.) monodon</i> <i>P. (F.) indicus</i> <i>P. (F.) merguensis</i> <i>P. (P.) semisulcatus</i> <i>M. dobsoni</i> <i>M. monoceros</i> <i>M. affinis</i> <i>Parapenaeopsis stylifera</i>	experimental experimental experimental experimental experimental experimental experimental experimental	CMFRI
Indonesia	<i>P. (F.) merguensis</i>	experimental	Anon. (1976)
Japan	<i>P. (M.) japonicus</i>	commercial	Shigueno (1975)
Korea	<i>P. (F.) chinensis</i> <i>M. joyneri</i>	commercial experimental	Kim (1967) Lee & Lee (1969)
Malaysia	<i>P. (P.) monodon</i> <i>M. ensis</i>	experimental experimental	Anon. (1973)
Philippines	<i>P. (P.) monodon</i> <i>P. (F.) merguensis</i>	commercial experimental	Platon (1978)
Tahiti	<i>P. (P.) monodon</i> <i>P. (F.) merguensis</i>	commercial commercial	AQUACOP (1977)
Taiwan	<i>P. (P.) monodon</i> <i>P. (M.) japonicus</i> <i>P. (P.) semisulcatus</i> <i>M. ensis</i> <i>M. joyneri</i>	commercial experimental experimental experimental experimental	Liao (1977) Liao and Huang (1973)
Thailand	<i>P. (F.) merguensis</i> <i>P. (P.) semisulcatus</i> <i>P. (P.) monodon</i>	experimental experimental experimental	Ruangpanit (1971) Kungvankij <i>et al.</i> (1972) Kungvankij (1976)

wet tissues of *Acetes* and mysids (Hameed Ali, 1980), powdered Soy cake (Hirata *et al.*, 1975), fermented kitchen waste (Motoh, 1978) and powdered and micro-encapsulated clam meat (Jones *et al.*, 1979) for feeding the protozoa stages are aimed at replacing the diatoms and algae with more easily prepared feeds. To overcome the difficulties encountered in synchronising the production of diatoms with the development of the larval stages, attempts are being made to concentrate the cultured phytoplankton by centrifuging or flocculation and preserve them either by deep freezing with 10% glycerol as cryoprotectant or simply by sundrying. Experiments in the SEAFDEC, Philippines have proved that the protozoal stages can be grown on frozen and sundried *Tetraselmis* and *Chaetoceros* (Anon, 1977).

MATURATION OF PRAWNS IN CAPTIVITY

Maturation under controlled conditions

Steady supply of spawners is an essential prerequisite for effective planning of the hatchery operations. In Japan, procuring spawners poses no problems as there is a well organised system for capturing and transporting *P. (M.) japonicus* alive to the market in ship-board tanks with running seawater. But in all other countries of the region getting spawners for the hatchery is very expensive and uncertain. To overcome this problem intensive studies are being conducted in Japan, Philippines, Indonesia, Tahiti and India to induce prawns to attain full maturity in captivity and to maintain a broodstock. *P. (M.) japonicus* is reported to have been maintained in captivity for many generations in Japan. In Taiwan, tank reared *P. (P.) monodon* (Liao, 1977) and *P. (F.) penicillatus* (Liao, 1973) are reported to have attained maturity and spawned successfully without any special treatment. At the SEAFDEC in Philippines, *P. (P.) monodon* reared in 120 ton tanks with flow through system and fed with mussel meat have attained

maturity and spawned (Primavera *et al.*, 1978). In China, Ryther (1979) reports that *P. (F.) chinensis* matures routinely in captivity while in Tahiti AQUACOP (1975, 1979) has developed mature captive broodstocks of *P. (F.) merguensis*, *P. (M.) japonicus*, *P. (Litopenaeus) vannamei*, *P. (L.) stylirostris* and *M. ensis* in 4 m diameter tanks fed with running seawater through perforated concentric P.V.C. pipes embedded in gravel and coral sand at the bottom and drained through a central drain pipe. The prawns were fed with compounded diets. In Fiji, natural reproduction of *P. (F.) merguensis* in 0.2 ha seawater ponds stocked with adults led to the production of 50,000 postlarvae (Lichatowich *et al.*, 1978).

Induced maturation

Eyestalk ablation technique which interferes with the endocrine control of maturation process of the ovary, has been developed to induce prawns to mature in captivity. Induced maturation and subsequent spawning of *P. (F.) merguensis* through bilateral eyestalk ablation has been reported by Alikunhi *et al.* (1976) from Indonesia. However, in recent years, unilateral eyestalk ablation has been successfully used to induce *P. (P.) monodon* to mature in captivity at Tahiti (AQUACOP, 1977) and in Philippines where the experiments were conducted in the net lined bamboo enclosures erected in protected bays (Wear and Santiago, 1976; Santiago, 1977; Rodriguez, 1978), in concrete 120 ton indoor tanks with flowthrough system (Primavera *et al.*, 1978) and in circular 12 ton ferrocement tanks constructed on the AQUACOP model (Primavera, 1978; Tolosa, 1978); the prawns were fed with fresh or salted flesh of the brown mussel (*Modiolus metacalfi*). In the Prawn Culture Laboratory of the Central Marine Fisheries Research Institute (CMFRI) at Narakkal, *P. (F.) indicus*, *P. (P.) monodon*, *M. dobsoni* and *Parapenaeopsis stylifera* have been induced through unilateral eyestalk ablation to mature and remature in 10 ton capacity circular

plastic lined tanks, fitted with submerged biological filters operated by air lifts (Muthu and Laxminarayana, 1979). Detailed studies on the neurosecretion and endocrine control of gonadial maturation of penaeid prawns are being carried out in Japan and India (Nakamura, 1974; Kulkarni and Naga-bhushanam, 1980).

RECENT ADVANCES IN NUTRITIONAL RESEARCH

Food is normally the largest single item in the running expenditure of a prawn farm employing semi-intensive or intensive culture methods. Appropriately enough the major studies on prawn nutrition have been done in Japan on *P. (M.) japonicus*. These investigations mainly related to the relative merits of the paste and pelleted diet (Kitabayashi *et al.*, 1971) and determination of protein level and aminoacid composition required for optimum growth (Deshimaru and Shigueno, 1972). Contrary to the high protein levels (50-65%) required by *P. (M.) japonicus*, Colvin (1976) found that in *P. (P.) monodon* and *P. (F.) indicus* the optimum dietary protein level was 45.8% and 43% respectively and that any increase in protein levels above these values does not result in proportionate increase in growth rate.

The research results indicated that the amino-acid composition of the best protein source (clam meat and squid meat) for *P. (M.) japonicus* closely resembled the aminoacid profile of the prawn meat (Deshimaru and Shigueno, 1972). Feeds containing a greater proportion of basic aminoacids like lysine and histidine were better than feeds containing a higher proportion of acidic aminoacids. However, soya bean is said to be good source of protein for penaeids (Kanazawa *et al.*, 1970) although it is low in basic aminoacids and poor in methionine (Deshimaru and Shigueno, 1972). Diets containing pure aminoacids and peptides were

found to be inferior to those with intact protein (Deshimaru and Kuroki, 1974; 1975 a, b). A basal diet supplemented with methionine (0.53%) and arginine (0.83%) gave better growth rates; at higher concentrations, however, the growth was inhibited (Kitabayashi *et al.*, 1971 c, d). Free aminoacids also play a role in the palatability of fresh diets; a tactile response is induced in the walking legs of *P. (M.) japonicus* by glutornic acid (Takei and Ai, 1971).

Recent studies on prawn nutrition have brought to light the importance of lipids (Deshimaru and Kuroki, 1974 a; Guary *et al.*, 1974, 1975) phosphorus, calcium, vitamins (Kitabayashi, 1971 a, d) and sterols in the diets (Teshima and Kanazawa, 1971; Deshimaru and Kuroki, 1974).

It is seen that most of the Japanese works are based on purified diets with an accent on discovering the dietary needs of prawns for various carbohydrates, proteins, aminoacids, fattyacids, sterols, vitamins and minerals and are fundamental to an understanding of prawn nutrition. Compounded pelleted feeds suitable for semi-intensive culture in ponds and intensive high density culture in large concrete tanks are produced by commercial firms in Japan, Taiwan, Korea and Philippines. Although the main ingredients are known, the proportion and method of processing are trade secrets. Squid meal, fish protein concentrates, wheat gluten, tuna testis meal, activated sludge, vitamin mix and mineral mix are some of the ingredients used in Japan in the diets. Shrimp meal as a protein source is said to increase the efficiency of the diets; in fact even 25% to 35% protein levels have given good results with *P. (M.) japonicus* when shrimp meal is used (Balazs *et al.*, 1973). The high protein level of 50-65% said to be necessary for *P. (M.) japonicus* by Japanese workers may be due to the fact that casein was generally used as the main protein source by them; casein may not be a suitable

protein as its aminoacid composition is different from that of prawn meat. It is likely that by balancing the aminoacid composition of the diet by suitable inclusion of different protein sources such as shrimp meal, Soy bean meal and groundnut cake, an efficient diet with low protein levels around 30% could be formulated. In India inclusion of powdered squilla meal (Ali, 1980) or slaughter house waste (Verghese and Singh, 1979) in compounded diets have yielded good results.

STUDIES ON DISEASES OF CULTURED PENAEID PRAWNS

Very little work on penaeid prawn diseases has been done in this region. With the introduction of high density culture of *P. (M.) japonicus* in concrete tanks in Japan, mortalities due to bacterial and fungal diseases came to light. Egusa and Ueda (1972) and Fukuyo and Egusa (1974) identified the fungus *Fusarium soloni* as the causative agent for the blackgill disease in pond reared *P. (M.) japonicus*. Severely infected gills collapse and shrink and the prawns die within two weeks. Four different types of pathogenic bacteria identified as *Vibrio* spp. were isolated from the blood and liver of *P. (M.) japonicus* which died in the circular intensive culture tanks (Shigueno, 1975); the basal part of the antenna, oviduct and seminal duct, the hepatic carina and the posterior border and lateral edges of the abdominal shells become blackened or whitened in the diseased individuals. Feeding the prawn with compounded feed mixed with sulfisozole, nifurstyreic acid and chloremphenicol cured the diseased prawns. In high density cultures another infectious gill disease caused by an unidentified bacterium has been discovered; in the initial stages the colour of the gills is dull orange-yellow or light brown and turns black as the disease progresses (Shigueno, 1975). Immersion in 2-3 ppm furazolidone is recommended for treating the affected prawns.

Two types of bacterial diseases decimated the larval population in the hatcheries at Kagoshima (Shigueno, 1975). In one, the mysis and postlarvae lost their appendages and died. In the other known as the 'white turbid liver disease' the midgut gland of the postlarvae become white and they floated inactively on the surface of the water.

At the CMFRI three types of bacterial diseases of pond grown penaeids have been encountered. The most frequent disease is caused by *Vibrio anguillarum* and leads to emaciation and softening of the muscles and thinning of the cuticle. Reddening of the rostrum or telson leading to destruction of these organs and black cuticular lesions are caused by different pathogenic bacteria. In the course of larval rearing mass mortalities due to a bacterial infection was also encountered; the uropods, antennal scales and other appendages become eroded progressively resulting in the death of the larvae.

In the SEAFDEC hatchery in Philippines, mass mortality of larvae due to a fungal disease caused by *Lagenidium* occurs frequently and furnace is being tried to control the larval infections. The AQUACOP team in Tahiti uses the antibiotic Gallymycein and the fungicide 'Treflan' to control infections during larval rearing.

GENERAL REMARKS

A perusal of the fisheries development programmes of different countries in the region would reveal that the development of penaeid prawn culture is a field to which most of the countries have attached great importance. However, prawn culture is least developed on the east coast of Africa and the Persian Gulf region. A few studies on the nutrition of *P. (F.) indicus* in S. Africa and the experimental rearing of penaeid prawns in Bahrain and Kuwait mark the beginning of interest in penaeid prawn culture in this area.

In India and the S.E. Asian region a great deal of interest is shown in expanding and improving the traditional extensive methods of pond culture. The yield of prawns in commercial culture operations in this system is found varying from 0.3 tonnes to over 2 tonnes/ha/year although achievement of a production rate of 35 tonnes/ha/year in experimental farming is on the records of literature. This indicates that the technology needs further perfection and the production system needs further improvements.

While the development of hatchery system for prawn seed production, formulation of efficient compounded diets, monitoring of the stocked prawns in the field, control of diseases in the hatcheries and grow-out ponds and perfection of pond management principles are some of the fields in which active researches are being pursued in the region, there are several areas which need intensive studies and experimentation. One of the information often elicited relates to the minimum size of an economically viable ponds. The relationship between growth, survival, incidence of diseases, feeding efficiency, production rate of prawns and the size of the pond has not been clearly elucidated. In the context of development of prawn culture in small holdings with minimum inputs, investigations on this aspect has become an urgent necessity. Similarly, it is essential that a scientific basis for determination of stocking rate on a set of parameters of the conditions prevailing in the pond is evolved. At present, the stocking density rate ranges from 20,000/ha in simple culture operations carried out without using supplementary feeding to several hundred thousands per ha in intensive and controlled systems with supplementary feeding. But the basis on which such stocking rates are arrived at is seldom indicated.

Several interactive variable factors prevailing in the rearing medium in hatcheries and in the pond may affect the growth, survival, quality

and production of prawns. While there is fairly good knowledge of the requirements of abiotic factors such as temperature, salinity and dissolved oxygen for the growth and survival of the important cultivable species of prawns, very little information is available on the role of various dissolved substances such as Ammonia, Nitrate, Nitrite, Carbon, Sulphur, Phosphorus, Calcium, Magnesium, Sodium, Chloride, Floride and Silicate in the rearing media of larvae and in the pond soil and their fluctuations on the well-being of prawns. Another aspect which needs further investigation is the rational application of supplementary feed in the fields when water exchange is through tidal currents and self-generating natural food is available to some extent to the stocked prawns. It is also essential that researches are intensified to develop low-cost feeds utilising plant proteins and vegetable wastes.

Documented studies on economics of prawn culture operations are scarce. Although, the culture operation is linked with and dependent on several factors such as the site, seed, feed, labour, the infrastructure facilities available and the socio-economic conditions of the place, it is imperative that reliable information on this aspect is made available to evaluate and propagate the system.

In an attempt to extend and establish prawn culture, efforts are made to introduce suitable species and to develop a stock for further propagation. Thus, exotic species of penaeid prawns are introduced into the Polynesian Islands where native cultivable species of prawns are not found. In recent years, Japan is endeavouring to develop 'Ocean ranching' by releasing large number of hatchery grown post-larvae (7-9 mm long) of *P. (M.) japonicus* on specially constructed artificial tide-lands from where they migrate to the sea and grow to commercial size to be caught by the fishing vessels.

The foregoing account outlines the trend of progress of research in penaeid prawn culture in the region during the past few years. It also indicates that the field is beset with many pro-

blems which call for intensive studies and concerted developmental, training and extension inputs to reap the maximum benefits.

REFERENCES

- ALI, S. A. 1980. Relative efficiencies of pelletised feeds compounded with different animal proteins and the effect of protein level on the growth of *Penaeus indicus*. *Symp. Coastal Aquaculture*, Mar. Biol. Ass. India, Abstract No. 235.
- ALIKUNHI, K. H., A. POERNOMO, S. ADISUKRESNO, M. BUDIONA AND S. BUSMAN 1975. Preliminary observations on induction of maturity and spawning in *Penaeus monodon* Fabricius and *Penaeus merguensis* de Man by eyestalk extirpation. *Bull. Shrimp Cult. Res. Cent.*, 1: 1-11.
- ANONYMOUS 1973. Review of the status of coastal aquaculture in Malaysia. In: T. V. R. Pillay [Ed.] *Coastal Aquaculture in the Indo-Pacific Region*. Fishing News (Books) Ltd., London, pp. 52-59.
- 1976. Shrimp culture research centre, Jepara. *Directorate General of Fisheries, Ministry of Agriculture, Jakarta*, pp. 1-24.
- 1977. Annual Report — Aquaculture Dept. *Southeast Asian Fisheries Development Centre, Tigbauan, Philippines*, pp. 1-25.
- AQUACOP 1975. Maturation and spawning in captivity of penaeid shrimp: *Penaeus merguensis* de Man, *Penaeus japonicus* Bate, *Penaeus aztecus* Ives, *Metapenaeus ensis* de Haan and *Penaeus semisulcatus* de Haan. *Proc. Sixth Ann. Workshop World Maricult. Soc., Seattle, Washington*, 6: 123-132.
- 1977. Reproduction in captivity and growth of *Penaeus monodon* Fabricius in Polynesia. *Proc. Eighth Ann. Workshop World Maricult. Soc.*, 9-13 Jan. 1977, *San Jose, Costa Rica*, 8: 20 (Mimeo).
- BALAZS, G. H., E. ROSS AND C. C. BROOKS 1973. Preliminary studies on the propagation and feeding of crustacean diets. *Aquaculture*, 2: 369-377.
- COLVIN, P. M. 1976. Nutritional studies on penaeid prawn. Protein requirements in compounded diets for juvenile *Penaeus indicus*. *Ibid.*, 7: 315-326.
- COOK, H. L. 1976. Problems in shrimp culture in the South China Sea region. *SCS/76/S.P/40*.
- DESHIMARU, O. AND K. KUROKI 1974. Studies on a purified diet for prawn—III: A feeding experiment with aminoacid test diets. *Bull. Jap. Soc. Sci. Fish.*, 40: 1127-1131.
- AND ——— 1975 a. Studies on a purified diet for prawn—IV: Evaluation of proteins, free aminoacids and their mixtures as nitrogen source. *Ibid.*, 41: 101-103.
- AND ——— 1975 b. Studies on a purified diet for prawn—V: Evaluation of casein hydrolysates as a nitrogen source. *Ibid.*, 41: 301-304.
- AND K. SHIGUENO 1972. Introduction to the artificial diet for prawn, *Penaeus japonicus*. *Aquaculture*, 1: 115-133.
- EGUSA, S. AND T. UEDA 1972. A *Fusarium* sp. associated with black gill disease of the Kuruma prawn, *Penaeus japonicus* Bate. *Bull. Jap. Soc. Sci. Fish.*, 38: 1253-1260.
- FUJINAGA, M. 1969. Kuruma shrimp (*Penaeus japonicus*) cultivation in Japan. *FAO Fish. Rep.*, 57(3): 811-832.
- FUKUYO, Y. AND S. EGUSA 1974. Study of *Fusarium* affecting black-gill disease on shrimp: Identification of BG—*Fusarium*. *Abst. Ann. Meet. Jap. Soc. Sci.* (in Japanese).
- GOPALAKRISHNAN, K. 1976. Larval rearing of red shrimp *Penaeus marginatus* (Crustacea). *Aquaculture*, 9: 145-154.
- GUARY, J. C., M. KAYAMA AND Y. MURAKAMI 1974. Lipid class distribution and fattyacid composition of prawn, *Penaeus japonicus* Bate. *Bull. Jap. Soc. Sci. Fish.*, 40: 1027-1032.
- , M. KOYAMA, Y. MURAKAMI AND H. J. CECCADDI 1976. The effect of a fat free diet and compounded diet supplemented with various oils on moults, growth and fattyacid composition of prawn, *Penaeus japonicus*. *Aquaculture*, 7: 245-254.
- HAMEED ALI, K. 1980. A new system for mass rearing of penaeid shrimp larvae. *Proc. First National Symposium on Shrimp Farming*, pp. 254-262.
- HIRATA, H., Y. MORI AND M. WATANABE 1975. Rearing of prawn larvae *Penaeus japonicus* fed soy cake particles and diatoms. *Mar. Biol.*, 29: 9-13.
- JONES, D. A., A. KANAZAWA AND K. ONO 1979. Studies on the nutritional requirements of the larval stages of *Penaeus japonicus* using microencapsulated diets. *Ibid.*, 54: 261-267.
- KANAZAWA, A., M. SHIMAYA, M. KAWASAKI AND K. KASHIKAWA 1970. Nutritional requirements of prawns. I. Feeding on artificial diets. *Bull. Jap. Soc. Sci. Fish.*, 36: 949-954.

- KIM, K. D. 1967. Studies on the artificial culture of *Penaeus orientalis* Kishinouye. *Proc. Indo-Pacif. Fish. Council.*, 12(2) : 253-257.
- KITABAYASHI, K., H. KURATA, H. SHUDO, K. NAKAMURA AND S. ISHIKAWA 1971 a. Studies on formula feed for Kuruma prawn—I: On the relationship among glucosamine, phosphorus and calcium. *Bull. Tokai Reg. Fish. Res. Lab.*, 65 : 91-107.
- , K. SHUDO, K. NAKAMURA AND S. ISHIKAWA 1971 b. Studies on formula feed for Kuruma prawn—II: On the utilization values of glucose. *Ibid.*, 65 : 109-118.
- , —————, —————, ————— 1971 c. Studies on formula feed for Kuruma prawn—III: On the growth promoting effects of both arginine and methionine. *Ibid.*, 65 : 119-127.
- , —————, —————, ————— 1971 d. Studies on formula feed for Kuruma prawn—V: On the growth promoting effects of protein level in a diet and re-examination of ingredients used. *Ibid.*, 65 : 139-147.
- KULKARNI, G. K. AND R. NAGABHUSHANAM 1980. Role of ovary inhibiting hormone from eyestalk of marine penaeid prawn (*Parapenaeopsis hardwickii*) during ovarian developmental cycle. *Aquaculture*, 19 : 13-19.
- KUNGVANKIJ, P., R. NIEWS, D. SINTHI AND C. CHAREON 1972. An experiment on artificial propagation of *Penaeus semisulcatus* de Hann. *Phuket Mar. Fish. Sta., Thailand*, 2 : 1-18.
- 1976. Breeding of *Penaeus monodon*. *Ibid.*, 6 : 1-11.
- LEE, B. D. AND T. Y. LEE 1969. Studies on the larval development of *Metapenaeus joyneri* (Miers)—Metamorphosis and growth. *Publ. Mar. Lab. Pusan Fish. Coll.*, 2 : 19-28.
- LIAO, I. C. 1973. Note on the cultured spawner of the red-tailed prawn *Penaeus penicillatus* Alcock. *Jt. Comm. Rural Reconstr. Fish. Sec.*, 15 : 59-65.
- 1977. A culture study on grass prawn *Penaeus monodon* in Taiwan—the patterns, the problems and the prospects. *J. Fish. Soc. Taiwan*, 5(2) : 11-29.
- AND T. L. HUANG 1973. Experiments on the propagation and culture of prawns in Taiwan. In: T. V. R. PILLAY [Ed.] *Coastal Aquaculture in the Indo-Pacific Region*. Fishing News (Books) Ltd., London, pp. 328-354.
- LICHATOWITCH, T., T. SMALLEY AND F. D. MATE 1978. The natural reproduction of *Penaeus merguensis* de Man, 1888 in an earthen pond in Fiji. *Aquaculture*, 15 : 377-378.
- MOTOH, H. 1978. Experiment on larval rearing of *Penaeus monodon* fed on the cultured diatom *Chaetoceros calcitrans* and fermented vegetable trash. *Quarterly Research Report, Aquaculture Dept. SEAFDEC*, 2(3) : 33-34.
- MUTHU, M. S. AND A. LAXMINARAYANA 1979. Induced breeding of the Indian white prawn *Penaeus indicus*. *Mar. Fish. Infor. Serv. T & E. Ser. CMFRI.*, 9 : 6.
- NAKAMURA, K. 1974. Studies on the neurosecretion of the prawn *Penaeus japonicus*. *Mem. Fac. Fish. Kagashima Univ.*, 23 : 173-207.
- PLATON, R. R. 1978. Design, operation and economics of a small-scale hatchery for the larval rearing of sugpo, *Penaeus monodon* Fab. *Aquaculture Extension Manual, SEAFDEC, Philippines*, 1.
- POWNAL, P. C. 1974. Port Broughton prawn farm well under way. *Australian Fisheries*, 33 : 11-13.
- PRIMAVERA, J. H. 1978. Induced maturation and spawning in five month old *Penaeus monodon* Fabricius by eyestalk ablation. *Aquaculture*, 13 : 355-359.
- , E. BORLONGAN AND R. A. POSUDOS 1978. Mass production in concrete tanks of sugpo, *Penaeus monodon* Fabricius spawners by eyestalk ablation. *Fish. Res. J. Philippines*, 3 : 1-12.
- RODRIGUEZ, L. M. 1979. A guide to the mass scale production of *Penaeus monodon* spawners. *SEAFDEC Aquaculture Dept. Tigbauan, Philippines*, 10 pp. (Mimeo).
- RUANGPANIT, N. 1971. Preliminary study on the artificial propagation of *Penaeus merguensis* de Man. *Songkhla Mar. Fish. Sta. Thailand* (Mimeo).
- RYTHER, J. 1979. Aquaculture in China. *Oceans*, 22(1) : 21.
- SANTIAGO, A. C. JR. 1977. Successful spawning of cultured *Penaeus monodon* Fabricius after eyestalk ablation. *Aquaculture*, 11 : 188-196.
- SHIGUENO, K. 1975. Shrimp culture in Japan. *Association for International Technical Promotion, Tokyo, Japan*, pp. 153.
- TAKEI, M. AND N. AI 1971. Studies on fishes favourable food. VI: Response of walking legs to substances in Kuruma prawn. *Bull. Tokai Reg. Fish. Res. Lab.*, 68 : 61-69.
- TESHIMA, S. AND A. KANAZAWA 1971. Biosynthesis of sterols in the lobster, *Panulirus japonicus*, the prawn, *Penaeus japonicus* and the crab, *Portunus trituberculatus*. *Comp. Biochem. Physiol.*, 38 B : 597-602.
- TOLOSA, R. 1978. Notes on the construction of a 12 cu. m. ferrocement maturation tank for prawn brood stock. *J. Ferrocement*, 8 : 93-103.
- VERGHESE, P. U. AND H. SINGH 1979. Utilisation of slaughter-house offal in compounding prawn feed. *Symp. Inland Aquaculture, CIFRI, Barrackpore, Abstract No. 172*.
- WEAR, R. G. AND A. C. SANTIAGO, JR. 1976. Induction of maturity and spawning in *Penaeus monodon* Fabricius 1788 by unilateral eyestalk ablation. *Crustaceana*, 31 : 218-220.