HATCHERY PRODUCTION OF PRAWN SEED

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Introduction

The successful spawning of the Japanese prawn *P. japonicus* and the rearing of its larvae through various stages under controlled conditions achieved by Hudinaga (1935, 1942) have opened up series of developments all over the world leading to commercial cultivation of marine prawns. By adopting and adapting Hudinaga's methods several species of penaeid prawns have been successfully spawned and their larval forms reared to a stockable size under controlled conditions by various workers in different countries (Cook and Murphy, 1969; Huang *et al.*, 1969; Liao and Huang, 1973; Aquacop, 1977; Ewald, 1965; Muthu *et al.* 1977, 1978; Raje and Ranade, 1972; Devarajan *et al.* 1978; Silas and Muthu, 1977; Mohamed *et al.* 1978; Thomas *et al.* 1975, 76a, 76b, 77). The methods followed by these workers have undergone several changes resulting in development of more efficient techniques for production of seed prawns in large quantities for commercial prawn culture.

It is now widely accepted that increased production of prawns can be brought about through employing systematic culture of prawns in coastal marine impoundments. A number of marine penaeid prawns have been identified as suitable candidate species for culture in various parts of the world as a result of the extensive investigations undertaken by several workers. A detailed list of the species in which artificial propagation has been achieved is given in Appendix 1. Among the various culturable species of prawns available in India, the Indian White prawn, *Penaeus indicus* and the tiger prawn, *Penaeus monodon* are the most popular and it is on these two species much of the work in this country is in progress at present.

The culture systems developed during the years following Hudinaga's success with rearing of *P. japonicus* can be broadly classified as two types. 1) The mass culture system exemplified by the Japanese method of simultaneously spawning a number of spawners in large cement concrete tanks where the seawater is fertilized to develop food organisms and 2) A closed – cycle hatchery system developed by the scientists of the Galveston laboratory, USA, in which the spawning is conducted in small fibreglass tanks and the larvae are fed from external source of separate live feed cultures. This second system is considered as more sophisticated and has been adapted and used by several workers and agencies.

Spawners

Hatchery operations start with procurement of spawners. Availability of spawner prawns in ready-to-spawn condition of ovarian maturity is a factor dependant on season and infrastructural facilities for transport of the same to the hatchery. Although Initial work on prawn breeding has been carried out with the help of spawners obtained from the wild, the use of spawners induced to maturation from captive stock of the farms has also gained practice in recent years. The well known method of eyestalk ablation to induce maturation in crustaceans is now being practiced as a routine procedure at the Narakkal Prawn Culture Laboratory (NPCL) of the Central Marine Fisheries Research Institute for developing spawners of ***Penaeus indicus*** for their regular use. Since brood stock development and maintenance is the subject matter of another section of the symposium it is not necessary to go into the details here.

Hatchery systems

The well known Japanese system of hatchery for penaeid prawns consist of large cement concrete tanks of 60 to 200 tonne capacity, which are provided with the aeration systems and rotating agitators (Hudinaga and Kittaka, 1967; Hudinaga, 1969; Shigueno, 1975; Yang, 1975). The tanks are cleaned, dried and filled with fresh seawater to a height of 0.4 meter before spawners (@1 spawner per m^3 of tank capacity) are introduced in cage nets. After the spawning, the spawners are removed along with the cage net leaving the eggs and hatched-out larvae in the tank. Rearing of the resultant larvae takes place in the same tank into which more water is pumped in and regularly fertilised with nutrients to promote blooms of naturally occurring diatoms. Vigorous aeration is provided through airstones from a compressed air grid and the water is agitated by slowly rotating vanes attached to an electric motor. On the second day the diatoms bloom (attain 5,000 to 20,000 cells/ml concentration), providing ideal food for the protozoea. The zooplankton organisms also develop on the following days forming food for the mysis stage larvae. The feed environment created by these procedures is very closely similar to conditions obtaining in the sea and this is considered to be an advantage. From the first day of mysis to the 4th day of post-larvae fresh seawater is pumped into the tank every day until the water level of the tank is increased to 2m from its original level of 0.4m. Supplementary feed in the form of *Artemia* nauplii for mysis and crushed and washed clam meat or ground soy bean waste are also given for postlarval stages.

By this procedure about 1 million prawn fry (P_{35}) are obtained from each 10 m x 10 m x 2 m tank. Modifications in the feeding pattern have been introduced into this practice by several workers. In Taiwan Liao and Huang (1973) used oyster larvae (produced by artificial fertilisation) whenever phytoplankton did not develop well. Bread yeast was used along with mixed diatoms to feed the protozoea and mysis in Philippines (Anon, 1976b). Separately cultured rotifer ***Brachionus*** was also used to feed mysis and early postlarval stages.

Facilities constructed elsewhere at high cost using this technology has not been so successful. Apart from

the cost, the chief disadvantage of the method is the uncertainity or lack of control over the production of desired species of phytoplankton at appropriate time and frequent development of blooms of undesirable species of plankton organisms such as dinoflagellates leading to mass mortality of larval stock. In order to exercise control over these factors several workers started developing and using separate live feed cultures to feed the larvae. In Japan and Philippines although large concrete tanks are still used for spawning and rearing of the larvae, large scale live feed cultures are also maintained and used as a regular practice.

Besides, it has become more and more clear that high initial strength of nauplii resulted in poor survival rate (Fuginaga, 1969; Shigueno, 1975; Liao and Huang, 1973; Anon, 1976a and b). The Philippine workers (Anon, 1976) suggest a very low concentration of larvae-not exceeding 6000 larvae/ton of seawater-and the use of only 6 spawners (of *P. monodon)* even in a 200 tonne concrete tank. The main reason for high mortality in crowded tanks appears to be the accumulation of metabolites produced by the larvae themselves and this problem is surmounted by the Japanese workers by increasing the tank size and by use of greater volumes of seawater to dilute the metabolites released by the larvae. The method is, however considered wasteful as a greater portion of the food added to the system will be unutilised and since it involves extra cost in pumping of seawater.

The closed-cycle system of hatchery for breeding of prawns and rearing of larvae developed by the scientists of the Galveston laboratory in USA (Cook and Murphy, 1976, 1969; Cook, 1969; Mock and Murphy, 1977; Mock and Neal, 1974; Salser and Mock; 1974) is based on an integrated system of several independant processes requiring higher technical inputs. The entire process is carried out in smaller containers and the chief operation of larval rearing is made independant of the live feed cultures thereby exercising greater control over management and quality of water.

Cook (1969) originally used a smaller fibreglass tank of 946 litre capacity for spawning and a small inverted 19 litre polyurethane carbuoy for rearing the larvae upto postlarval stage. He along with Murphy (1969) scaled up the operation using 1890 litre cylindrical polyethylene containers fitted with a small seawater recirculating system for both spawning and larval rearing. He used pure cultures of desirable species of diatoms and unicellular algae to feed the protozoeal stages; the concentration of phytoplankton in the system being maintained at a density of 10,000 to 15,000 cells/ml with the help of an automatic dispensing system. Freshly hatched brine shrimp nauplii were given at the rate of 3-5/ml of water for feeding the larvae from mysis stage onwards. This system has been further improved by Salser and Mock (1974) by introducing cylindro-conical fibreglass containers of $2m^3$ capacity for rearing larvae. The shape of this container facilitates easy cleaning and efficient dispersal of food. The aerating stones kept at the bottom of the cone ensured vigorous vertical move-

ment of water which kept the food particles in constant motion. Separate facilities for phytoplankton culture and large scale hatching and collection of brine shrimp nauplii are essential components of this system.

Cook (1969) has been able to produce 2000 postlarvae in 15 litres of seawater in the Carbuoy i. e. 133 postlarvae/litre as against the yield of 5-10 post larvae/litre by the Japanese method. Although this system is brought out as a small scale operation unit, it enables exercise of strict controls over the essential parameters responsible for successful rearing of the larvae.

This method has been further modified and used in Tahiti (Aquacop, 1975; 1977), in Philippines (Platon, 1978) and in the United Kingdom (Beard *et al.*, 1977) to produce postlarvae of penaeid prawns. The changes brought about in the process of this development include increase in initial stocking density of 50-100 nauplii/l, use of higher concentration of phytoplankton bloom (30,000 to 100,000 cells/ml) for feeding protozoea, feeding rotifer (5-10/ml) to the mysis stage and *Artemia* nauplii (5/ml) for postlarvae $P_1 - P_5$.

In India, attempts for breeding of prawns under controlled conditions can be said to have started with the commencement of the *Ad hoc* scheme on 'Prawn Culture and Propagation' sanctioned by the ICAR in 1975. The scientists of Narakkal Prawn Culture Laboratory (NPCL) established under the scheme by the Central Marine Fisheries Research Institute, after having completed the preliminary work of larval rearing of the cultivable Indian species of marine prawns, (see appendix) took up the work on mass production of prawn seeds. Silas and Muthu (1977) reared larvae of *Metapenaeus dobsoni* and *M. affinis* in 50 l. plastic bins using phytoplankton film collected from the brackishwater ponds. Since then the NPCL has developed methods of mass rearing of *Penaeus indicus* larvae using modified Galveston system. Appropriate live feed cultures have also been developed. I would like to use this occassion to give a brief account of these efforts.

Following a modified Galveston type hatchery system, mass production of *P. indicus* seeds commenced at the NPCL in 1980. The spawning is carried out in small indoor plastic pools of 500 l. capacity and newly hatched nauplii are transferred to 2000 l. capacity plastic line pools (@ 50/l) where the rearing is carried out. In simultaneous operations separate batch cultures of mixed phytoplankton predominated by the diatom *Chaetoceros* sp. and continuous cultures of the rotifer *Brachionus plicatilis* and the cladoceran *Moina* sp. are maintained in the laboratory. The seawater (Salinity 32 ± 2 ppt.) is previously pumped into large containers where it is allowed to settle for 2 days after which it is filtered through a 60 micron mesh nylonbolt cloth before use in the culture operations. From last nauplius stage onwards (2nd day after spawning) 200 l of mixed phytoplankton culture predominated by *Chaetoceros* (200,000 cells/ml) is pumped into the culture tank after reducing equal quantity of water from it every day. The protozoea stage onwards

the larvae begin to feed on diatoms. When the larvae transform into mysis, in addition to this feed, frozen *Brachionus plicatilis* is also provided as food at the rate of 100 rotifer per larvae per day. Feeding of diatom is discontinued when the larvae metamorphose into postlarvae. At this stage frozen cladoceran *Moina* sp. is provided as food at the rate of 20 per postlarva per day. Five days after they become postlarva they are harvested and counted before stocking in a nursery.

Vigorous aeration of water is provided throughout the rearing period and constant check is made on the quality of seawater used. From nauplius to postlarvae an average survival rate of 70% is achieved through this process. The number of batches and the amount of *P. indicus* seeds (PL20) produced at the NPCL is given in table-1.

Table - 1.

P. indicus seeds produced at Narakkal Prawn Culture Laboratory

Year	No. of batches	Seed produced PL 20 ($\times 10^4$)	Seeds distributed to farmers ($\times 10^6$)
1980-81	27	1.6	0.5
1981-82	41	1.2	0.28

From late 1981 onwards the mariculture facility of the CMFRI at Kovalam, Madras has started producing seeds of *P. monodon* by following this system using plastic lined pools of 10,000 l. capacity.

The advantage of this system is that it has used the culture of the diatom *Chaetoceros* which is easy to develop under local conditions and attains high concentration in short time. Besides, it has completely obviated the use of brine shrimp nauplii to feed the mysis stage upwards by substituting with easily culturable *Brachionus* and *Moina*.

It is well known that the key factor of the successful hatchery operation for production of prawn seeds is the availability of appropriate feed for the larval prawns and it is this factor that makes it a complicated operation. Developing and maintaining phytoplankton and zooplankton cultures require technical expertise with the result these practices have not come to the level of the common man. For a long time, attempts made to rear prawn larvae using compounded feeds have not been very successful. The recent works of Hameed Ali (1980), Hameed Ali and Dwivedi (1977) and Alikunhi *et al.*, (1980) has shown that successful rearing of prawn larvae in large quantities can be achieved through the use of prepared feed made out of finely ground tissue of crustaceans held in suspension in the culture medium.

Hameed Ali (1980) successfully reared larvae of *P. merguiensis*, *Penaeus* sp. and *Metapenaeus monoceros* in plastic pools using a tissue suspension made out of freshly ground *Acetes* species. This method, no doubt, is an improvement over the others as it obviates the need of elaborate set up of phytoplankton cultures and the *Artemia* nauplii. In the experiments conducted at Jepara, Indonesia he prepared this diet from frozen and stored blocks of *Acetes* sp. by a process of

blending the same with saltwater, boiling, decanting and sieving through different mesh nylon netting. He used 50 to 160 micron size particles of this material for zoea and 250 to 400 micron size for mysis and early postlarvae. This feed held in suspension is broadcast over the hatchery pool at 5 hourly intervals at the rate of 2 to 3 times the weight of the larvae initially and increasing the feed by 50 to 70% subsequently. In these experiments which are mostly carried out in 1.78 tonne capacity plastic pools, slow exchange of 15 to 25% of water was made after the larvae reached the mysis stage and also when too much of provided food remained unconsumed in the medium. By this method he produced 475,732 post-larvae of *P. merguiensis* (survival 48.4%), 21,374 post-larvae of *Penaeus* sp. (survival 97.16%) and 76,583 post-larvae of *Metapenaeus monoceros*. This method of rearing is particularly noteworthy as relatively high production rate, as much as 58,390 postlarvae per m^3 of seawater, is attained in the experiment conducted in a pool of 6 m^3.

This method of rearing has been further extended by Alikunhi *et al.*, (1980) who used ground tissue (in suspension) of juvenile penaeids and the stomatopod *Oratosquilla nepa* in the regular commercial hatchery operation at the Regional Shrimp Hatchery at Azhicode, Kerala for rearing *P. indicus, P. monodon, P. semisulcatus, M. monoceros, M. dobsoni and Parapenaeopsis stylifera*. The feed preparation and feeding has been further refined. The artificial feeding started as soon as the nauplii moulted into the first zoea stage when particle size of feed given was 50 to 150 microns. This was increased to 200-300 microns for I and II stage mysis and to 400 micron for III stage mysis and early postlarva. The Regional Shrimp Hatchery produced over 3 million postlarvae of *P. indicus* in 1979 and 1980 in addition to smaller quantities of other species. The survival rate attained by the hatchery in the case of *P. indicus* was 20% in 1979 and 20% in 1980.

As indicated earlier the successful use of a prepared wet feed stuff that could be used from off-the-shelf in rearing prawn larvae is certainly a step forward towards development of prawn culture even if the preparation of the same involves technical skill. Let us hope that the researches being carried out in the various laboratories and the trials in the hatcheries will soon develop a suitable and efficient dry feed stuff that could be dispensed from shakers for rearing prawn larvae in mass quantities. Such a development only can bring the prawn culture operation to the level of common farmer.

Factors considered important for successful larval rearing

Technology for mass production of prawn seed is now available and I am sure, whether one method or the other is used, this technology will get refined and improved in efficiency during the course of practice. Now let us identify and consider various factors responsible for successful hatchery operations for large scale seed production.

Water quality:

The quality of the seawater to be

used for spawning and larval rearing is the most important among these factors. Clean unpolluted seawater with no suspended impurities is essential for the operations and this should be the foremost consideration in the selection of site for hatchery. In almost all the hatcheries the seawater is taken in for use only after filtration which may be effected through various means such as elaborate fast or slow sand filters or simpler system of settling and filtering through suitable mesh cloth filters or even by introducing simple mechanical filters in the water inlet system of the pumps. The actual type of filter system to be used can only be determined after the water quality is assessed but it should aim at removal of all suspended matter and such planktonic elements which are likely to develop, multiply or bloom subsequently.

Hudinaga and Kittaka (1975) found that hatching and survival rates of the larvae were affected by biological differences between the seawater from different regions. Significant differences in the survival of the larvae of pink shrimp cultured in bay waters and oceanic waters was observed by Ewald (1965). He found that oceanic waters always gave better results. At the NPCL we observed that seawater containing large numbers of ctenophore, *Pleurobrachia* sp. is unsuitable for larval rearing even when they are removed by filtration.

Several workers have used EDTA (Ethylene diamine tetra Acetic Acid) to enhance the quality of seawater used for spawning of prawns and for larval rearing. Cook and Murphy (1969) added 1 gm. of sodium salt of EDTA to every 100 litres of the rearing medium to avoid catastrophic mortalities. Cook (1970) found that the larvae of *P. aztecus* survived well in 24 ppt salinity with EDTA but suffered complete mortality without it. Philippine workers (Anon 1976a & b) also added EDTA at the rate of 0.5 gm/1000 litres/day in the large outdoor concrete tanks of large scale production of prawn fry. Seawater used for larval cultures by Beard and Wickins (1980) was treated with EDTA (at the rate of 0.1 gm/100 litres) and vigorously aerated 24 hours before use. EDTA is a metal chelator and has been used successfully in phyto cultures also. The beneficial effects of this addition of EDTA is still not well explained.

The temperature of the water is another parameter which has definite influence on successful spawning and rearing of the larvae. 28° C $\pm$ 2 is considered as suitable water temperature for hatchery operations by many workers. That lower temperatures retard the development of the eggs and larval stages and conversely the higher temperatures accelerate such processes is well known. Lee and Lee (1968) found that at a given temperature the eggs of most of the penaeid prawns take approximately same time to hatch out. Muthu *et al.*, (1978) observed that this is due to similarity in the quantity of yolk stored in the eggs of different species and that the variations in the size of eggs of different species is due to the difference in the size of perivitelline space. In the nauplius stage of the larvae the development is mainly controlled by the

temperature of the medium. The effect of temperature on development becomes reduced when the larvae start feeding i. e. from protozoea onwards.

Temperatures ranging from 24° C to 32° C have been found to be suitable for the development of penaeid larvae (Hudinaga, 1942; Cook and Murphy, 1969). In the experiments conducted at NPCL temperatures below 24° C have created low survival and sometimes even total loss of stock particularly when the larvae are in the lower stages of development.

The salinity of the water exercise profound influence in the development of prawn larvae. Hudinaga (1942) found that salinities ranging from 27 to 34 ppt was suitable for development of penaeid larva. Survival of the larvae of *P. aztecus* was best at 28 to 30 ppt and at 34 ppt the survival was relatively poor (Cook, 1970). Beard *et al.* (1977) found that gradual reduction of salinity to 25 ppt by the time postlarval stage is attained was beneficial in rearing the larvae of *P. merguiensis*.

At the NPCL successful spawning and rearing of the larvae of most of the species of penaeids have been carried out in seawater of salinities varying from 27 to 34 ppt. But the best result have been obtained in salinity range of 28 to 34 ppt. Even partial exchange of water with another batch of water with variation of salinity of 2 ppt. was injurious to larvae in early stages. Light intensities below 1000 lux inhibited normal development of protozoea of *P. kerathurus* and prevented their metamorphosis to mysis stage (Lumare *et al.*, 1971). But Cook and Murphy (1966) found that the larvae can also be reared in the dark and that light is not essential for their development. According to Kurata and Shigueno (1979) adequate light intensity is necessary for successful rearing and that the postlarvae reared outdoors was healthier in appearance. Hameed Ali (1980) and Alikunhi *et al.*, (1980) carried out their experiments outdoors but covered the culture tanks with tarpaulin to reduce excess sunlight. My own experience at NPCL is that better growth and survival of larvae was obtained in the rearing pools kept in the glass house exposed to bright sunlight. Production of diatoms in the pools is enhanced due to exposure to sunlight.

Higher values of pH in the culture medium (8.5) was reported to be inimical to protozoea of *P. japonicus* (Furukawa, 1969) and caused large scale mortality and abnormalities in development. In the open community method of larval rearing heavy mortality was reported due to increase of pH upto 9.0 following blooms of phytoplankton. This malady was often experienced during the experiments at the NPCL and care was taken to see that the pH never exceeded 8.2 in the culture tanks.

Accumulation of ammonia and nitrites in the culture medium is toxic to the animals. Here again, precise level of toxicity of these metabolites to penaeid larvae is not clearly known. Cathedral *et al.*, (1977) found that tolerance of *P. monodon* larvae to these metabolites increased as they grow older. Collection of information on the long term and short term effects of these metabolites on prawn larvae is urgently needed particularly since we are planning to put up

large number of hatcheries throughout the country for production of prawn seeds.

Larval rearing and feed

Prawn larva starts feeding from the protozoea stage onwards. The breakthrough in culture of prawn larvae happened in 1942 when Hudinaga successfully used pure cultures of the diatom *Skeletonema costatum* to feed protozoea. *S. costatum* remained as the classical food of prawn larva for a long time. Later Hudinaga and Kittaka (1967) and Fujinaga (1969) showed that prawn larvae can survive equally well by feeding on mixed cultures developed in concerte tanks by fertilizing with inorganic fertlizers. Cook and Murphy (1969) used pure culture of *Skeletonema costatum, Thalassiosira* sp., *Cyclotella* sp., *Phaeodactylum tricornutum, Dunaliella, Exuviella, Gymnodinium spendens* and *Isocrysis galbana* and found that only *Isocrysis galbana* was unsuitable for the purpose. Several other species of diatoms like *Chaetoceros gracilis, Coscinodiscus granii, C. centralis* and *Cylindrotheca* were also used by different workers either as pure cultures or as mixed cultures to feed prawn larvae in their early stages. (Anon, 1977; Kurata and Shigueno, 1979; Beard *et al.*, 1977; Aquacop, 1975, 1977; Salser and Mock, 1974).

Several prepared feeds have been tried and among these the bread yeast used by the Philippine workers, finely powdered soyabean cake by Hirata *et al.*, (1975), a formula feed of Kurata and Shigueno (1979), powdered fat free rice bran used by Ishida (1967), activated sludge used by Imamura and Sugita (1972), marine yeast used by Furukawa, (1973) washings of filamentous algae and juice of Sargassum (Anon, 1976a) and fermented extract of vegetable refuse from kitchen and egg yolk (Anon 1977) have given fair amount of success. The latest among the prepared feeds used are the microencapsulated feeds used by Jones *et al.*, (1979), tissue suspension of *Acetes* and *Mesodopsis* used by Hameed Ali (1977) and Hameed-Ali and Dwivedi (1980) and similar suspension of juvenile prawn and squilla meat used by Alikunhi *et al.* (1980). Different sized particles of this feed have been used for the different stages of development.

For the mysis and early postlarval stages the classsical brine shrimp nauplii has been the accepted food for a long time. Shigueno (1975) made trials with replacing this with easily cultured *Brachionus,* chopped and washed mussel and clam meat and formula feeds. Frozen *Brachionus* has been found suitable for feeding mysis by Platon (1978) and by the Scientists of the NPCL. Similarly frozen cladoceran *Moina* has been successfully used at the NPCL for feeding postlarval stages. The free living nematode *Pangrellus* has been used to feed the mysis stages of *P. semisulcatus* and *M. stebbingii* in Israel by Samocha and Leweinsohn (1977).

Postlarval rearing

The general practice in hatcheries is to harvest the larvae at the stage of PL-4-5 as they are found to become overcrowded in the containers and acquire cannibalistic tendencies. In nature this is the stage in which they seek the protection of the coastal water and make their entry to estuaries. Postlarvae at

this stage are quite hardy and can be transported to farmers' nurseries without difficulty. The closed system of raceway described by Mock *et al.* (1973) is quite efficient in rearing them at high densities of 2300/m² (22mm) and 26000/m² (6mm) with over 90% survival. In a recent experiment at the NPCL 16000 PL–5 stocked in a 6m² cement tank fitted with an external biological filter resulted in 96.5% survival when harvested at 18 mm size (PL–20). Only formula feed was used for feeding.

Diseases

Data on the diseases affecting the larval forms of Penaeids in the hatcheries is scanty. Fungal infection caused by a species of *Lagenidium* is reported by Lightner and Fontaine (1973). This malady is often noticed during the experiments at the NPCL where the stock was abandoned and facilities disinfected when such occurrences happen. "White turbidliver" disease has been reported to have caused heavy mortalify in *P. japonicus* larvae (Momoyema, 1974). This disease is attributed to the bacteria *Vibrio* sp., and so also another disease reported by Shigueno (1975) causing loss of parts of appendages of larvae. In the initial stages of this disease the nervous system of the larvae develop yellowish vermillion and red colours. Frequent attack of the fungus *Langenidium* has been reported at the SEAFDEC hatchery in Philippines (Anon, 1977) where 1 ppm formalin has been used to treat the affected larvae. This treatment has not given good results at the NPCL.

Conclusion

Considerable progress has been achieved in rearing prawn larvae under controlled conditions in India and abroad. Based on these results commercial production of prawn seeds have commenced in hatcheries in different parts of the world. Recognising the need for large quantities of prawn seeds for developing aquaculture in coastal regions of India various agencies concerned are planning to establish prawn hatcheries. While the technology developed in this regard is suitable to run commercial hatcheries, it should be the endeavour of the research organisations to carry out planned research on different aspects of prawn breeding and larval rearing in order to find new and more efficient systems. Special attention may be given to simplify the procedures involved to develop small scale units using locally available material so that the farmers themselves could manage a hatchery for their own requirement of prawn seeds.

There are many aspects of this technology which call for immediate attention of the scientists both from the standpoint of basic and applied research. It is well known that the development of appropriate larval feed is the key factor in mass rearing of the prawn larvae. The live feeds, the prepared feeds and the formula feeds are, no doubt, successfulin varying degrees but they have all been developed on the basis of experience gained in rearing other species by research workers from materials of different kinds. It is possible that a detailed study of the feeding and food habits of the larvae in its natural environment will give us a better understanding of the problem. It is also

necessary to study the details of the feeding mechanism of the larvae in relation to the development of mouth parts and appendages.

Major part of the activities concerning prawn seed production in India is centred around Kerala where the prevailing monsoon makes it impossible to have year round production in hatcheries. The coastal sea water gets diluted and polluted with all the materials poured into it by the rivers in spate during monsoon. This situation can be met only by holding large quantities of sea water in storage in good season and having it used and reused with the help of appropriate water treatment measures. Such facilities are in existance elsewhere and it should be possible to develop and use such facilities here with advantage. Similarly use of automated feed dispensing arrangements as is used in developed countries can help minimise human errors and save labour.

Diseases affecting larval stock and measures to control them are fields in which very little information is available at present. It is desirable to give more attention to this aspect by the researchers and hatchery operators.

In the context of developing prawn culture in coastal areas, for which national priority is given, greater thrust is needed for transfer of technology programmes. The regular training programmes conducted by the Farm Science Centre (KVK) at Narakkal, the *ad hoc* training programmes conducted by various agencies and the Summer Institutes are no doubt helpful in transferring the tecenology to the farmers. More inputs in this direction will accelerate the process of development of prawn culture in the country.

Acknowledgement

I wish to record my thanks to Dr. E. G. Silas, Director, CMFR Institute for the guidance and encouragement given during the preparation of this paper and to my colleagues at the NPCL who have helped me in this work.

Appendix 1. List of species of penaeid prawns in which spawning has been carried out under controlled conditions.

Species	Country	Authors
Penaeus japonicus	Taiwan	Huang *et al.*, (1969)
P. teraoi	Japan	Liao and Huang (1973)
	Taiwan	Hudinaga (1942)
P. latisulcatus	Japan	Shokita (1970)
	Australia	Pownall (1974)
P. aztecus	U. S. A.	Cook and Murphy (1969); Cook (1969)
	Tahiti	Aquacop (1977)
P. duorarum	U. S. A.	Ewald (1965); Cook and Murphy (1969); Tabb *et al.*, (1972); Krantz and Norris (1976).
P. kerathurus	Italy	Lumare *et al.* (1971)
	Spain	Rodriguez (1975)
P. marginatus	Hawaii	Gopolakrishnan (1977)
P. stylirostris	Tahiti	Aquacop (1977)
P. schmiti	Venezuela	Pinto and Ewald (1974);
	Cuba	Perez and Saurez (1979)
P. vannamei	Tahiti	(Aquacop 1977)
P. orientalis	Japan	Oka (1967 a and d)
	Korea	Kim (1967)
P. indicus	Philippines	Anon (1976b)
	India	Muthu *et al* (1977, 1978 a)
P. merguiensis	India	Raje and Ranade (1972a)
	Thailand	Ruangpanit *et al.*, 1971)
	Tahiti	Aquacop (1975, 1977)
	U. K.	Beard *et al.*, (1977)
	Indonesia	Hameed Ali (1980)
	Philippines	Platon (1978), Motoh & Buri (1979)

Species	Country	Authors
P. monodon	Taiwan	Liao *et al.*, (1969a)
	Tahiti	Aquacop (1975, 1977)
	Philippines	Villaluz *et al.*, (1969); Anon (1976a); Platon (1978); Motoh (1979)
	Thailand	Kungvankij (1976)
	India	Silas *et al.*, (1978)
P. semisulcatus	Taiwan	Liao and Huang (1973)
	Israel	Samocha and Leweinsohn (1977)
	Thailand	Kungvankij (1972)
	India	Devarajan *et al.*, (1978)
P. esculentus	Australia	Fielder *et al.*, (1975)
Metapenaeus dobsoni	India	Thomas *et al.*, (1976b); Silas and Muthu (1977); Muthu *et al.* (1978b)
	Kuwait	Enomoto (1971)
M. affinis	India	Thomas *et al.* (1976a); Silas and Muthu (1977); Muthu *et al.* (1978c)
M. monoceros	India	Raje and Ranade (1972b); Silas and Muthu (1977); Mohammed *et al.* (1978)
M. ensis	Japan	Funada (1966)
	Taiwan	Liao *et al.* (1969b)
M. joyneri	Korea	Lee and Lee (1968)
	Taiwan	Liao and Huang (1973)
M. burkenroadi	Japan	Kurata and Pusadee (1974)
M. stebbingi	Israel	Samocha and Leweinsohn (1977)
Parapenaeopsis stylifera	India	Thomas *et al.* (1975); Silas and Muthu (1977); Muthu *et al.* (1978b)
Artemesis longinaris	Argentina	Boschi and Scelzo (1974)
Hymenpenaeus mulleri	Argentina	Scelzo and Boschi (1975)

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