Proc. Indian natn. Sci. Acad. B 46 No. 1 pp 63-71 (1980)

Food and Feeding in Prawns in Hatchery and Intensive Rearing Systems

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The importance of feed requirements in different type of prawn culture systems is presented in this paper. The hatchery, in which larval rearing is undertaken, is described as an individual system where feed inputs, particularly its quality, plays a major role in high density rearing and survival. The developments in this direction in the Galveston Shrimp Culture Laboratory, U.S.A. observed by the author, are described. The extensive brackishwater farming system of India which depends on naturally occurring seed of estuaries, is described as an extensive though semi-controlled system. The importance of quality of feeds and therefore, the nutrition is presented from experimental results of Kakdwip Fish Farm of Central Inland Fisheries Research Institute. The directions in which hatchery system should develop in India, are suggested.

Key Words: Feeding, Hatchery, Galveston, System, Semi Controlled, Brackishwater Farms

Introduction

A knowledge of the feed preferences and nutrition of prawns is of prime concern especially since India is aiming for commercial production of these crustaceans in brackishwater farms. Development of a suitable diet would thus serve the dual purpose of serving the farmers and stimulating the interest of the industry.

Brakishwater prawn and fish farming under intensive, semi-controlled conditions has already stimulated the interest of private farmers, and a few industries in the coastal states of India. In the Kakdwip Research Centre of the Central Inland Fisheries Research Institute, Barrackpore, the annual harvest of the single, most sought-after species of prawn of India, *Penaeus monodon* has recently risen up to 1.2 tons/ha.

India is still, however, depending on the naturally occurring seed of prawn in the estuaries and creeks, for its extensive culture operations. Major percentage of seed of *Penaeus monodon* is now supplied by the Hooghly estuarine system in West Bengal followed by the Kakinada Bay-Godavari estuarine-creek complex in Andhra Pradesh. Once the potentialities of *P. monodon* culture and its high unit value are known the demand for supply of seed will escalate.

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For successfull and sustained growth of prawn culture in India, the major thrust of research should be in two directions:

(i) Development of a mechanically operated, fully controlled and intensive hatchery system,

(ii) Intensive though semi-controlled, manually operative large-scale production practices which are now at a take-off stage.

Natural food sources will be absent in the first one i.e. the fully controlled system. Therefore, all the requirements will have to be met either by laboratory mass-cultured products or through formulated rations. Since this approach is industrial, a formulated ration should meet essential requirements such as:

(i) indigenous products,

(ii) economic considerations,

(iii) nutritional needs, and

(iv) adaptability by operators i.e. the private entrepreneurs.

The same principles are applicable to the intensive rearing under semi-controlled conditions which we are currently practising in India, for instance in the Kakdwip Research Centre of the CIFRI. We now find that artificial fertilisation which stimulates natural growth of plankton, and supplemental feeding do play an important role in increasing the production per unit-area. Often, however, the results are highly variable since some of the environmental factors are outside our control.

Other factors involved in hatcheries are operational e.g. circulation of air; supply of filtered sea water directly into the hatchery tanks; water filtration techniques; water drainage and metabolite removal. These are all variables not connected with nutrition as such.

Hatchery operations observed by me in the Galveston Shrimp Culture Laboratory, USA particularly as to how the feed requirements for each stage of growth of larval prawns are fulfilled are discussed in this paper. The observations presented on the growth of *P. monodon* and the food and feeding are the results of research in brackishwater fish farm at Kakdwip.

A series of experiments are conducted in the laboratory with several feed formulae using *P. monodon* as the test animal. The initial studies are in glass jars—a closed system. Later these were carried over to semi-enclosed system in the field. The results of these experiments are also discussed.

Hatchery System

The larvae of penaeid prawns hatch out as nauplii in the sea water into which the fertilised eggs are directly released by the parent. These nauplii metamorphose through three distinct growth stages viz., protozoea, Mysis and post-larvae. The only stage free of food-dependence on outside sources is the nauplii. We can therefore, consider it to be the strongest since it is independent. Other stages are dependant on microscopic planktonic food. The difficult phase is the intermediary zoea phase. From Mysis stage onwards phytoplankton can be fed and hence rearing becomes easier. Post-larvae accept powdered artificial feed which settles down on the bottom.

Many effective feeds are being devised for zoea stage, diatoms leading the list. Animal feeds such as oyster eggs, nauplii of ***Artemia*** are supposed to yield better survival rates. Benthic algae, rotifers such as ***Brachionus*** were also used. However, the results obtained in glass jars or glass aquaria do not seem to be tenable for large hatchery tanks. This point proves that mass culture of a food species at the specific time of breeding of the prawn is the key for high density rearing and high survival.

Attention has, therefore, to be directed to mass production under laboratory conditions of the most preferred species. Japanese workers found *Skeletonema costatum* fulfilling these requirements although trials still continue for suitable food to replace the cumbersome process involved in the single-species cultures of diatoms or algae. In the Galveston Laboratory, USA, another species, a flagellate *Tetraselmis chui* was found recently to fulfil this need. Philippine workers are experimenting with another diatom, *Chaetoceros* as larval food.

Artemia salina was found by almost all workers in this field, to be the most suitable food for successful survival and growth of penaeid shrimp larval stages. Its drawback in major use is its absence in the natural prawn farms. For use, in India, it would be inordinately expensive to import it. However, apparently no artificial food can replace this species in its effectiveness.

Culture of Tetraselmis chui in the Galveston Laboratory, USA

The process involved in isolating and maintaining stock cultures of diatoms or algae is well known. Similar techniques have been used in isolating this flagellate. A stock solution called NH medium with special additives is maintained with a salinity of 28‰ temp. 24°C. Cultures are maintained at constant illumination. Mass cultures are made with synthetic sea water made up with special additives (Griffith et al. 1973). This species is found to be an adaptable culture organism thriving well in outside tanks in natural light or under laboratory conditions with artificial light sources.

The most interesting part of this work is the harvest of the mass cultures by centrifuging with a milk separator. Known quantities of cells are either used directly immediately or can be preserved for further use by freezing or freeze drying. Forty–sixty million cells/ml could be concentrated with a recovery of 70% or more. *Skeletonema*, the chain-forming diatom, could be concentrated to 500–600 million cells/ml with a recovery of 80% or more of the cells in culture (Salser & Mock 1974). The technique ensures readily available and acceptable food at the time when breeders are brought in and spawning takes place. Further point in favour is that this food can be taken out and used whenever required. It can be kept frozen for longer periods.

Other mass production techniques tried in Japan and USA include fertilisation of water in rearing tanks to stimulate growth of diatoms, use of waste water as a fertilizer, etc.

This food, i.e. diatoms or algae or flagellates, supplies adequate nutrition through the zoea to Mysis stage and if necessary to post-larval stage as well. However, at Mysis stage high density, high survival could be achieved by supply of (live) animal protein feed. The brine shrimp *Artemia salina* nauplii is reported to fulfil this requirement.

Artemia salina: Concentrating the dispersed nauplii of this species is itself a valuable technique. In the Galveston Laboratory a simple technique is used. The equipment used is the standard hatchery tank used for rearing the shrimp larvae. The water is aerated with suspended air stones along the wall and centre. Water is drained out from the bottom. Intensified lighting is used to increase hatching. The eggs are placed in water 16 hr prior to the time when Mysis stage of prawn is expected to evolve in the prawn rearing tanks. The *Artemia* larvae hatch out in 14–16 hr. These are concentrated by the use of a single bulb at one corner of the tank at the bottom (figure 1). A screen bag made of 0.16 mm mesh nylon or

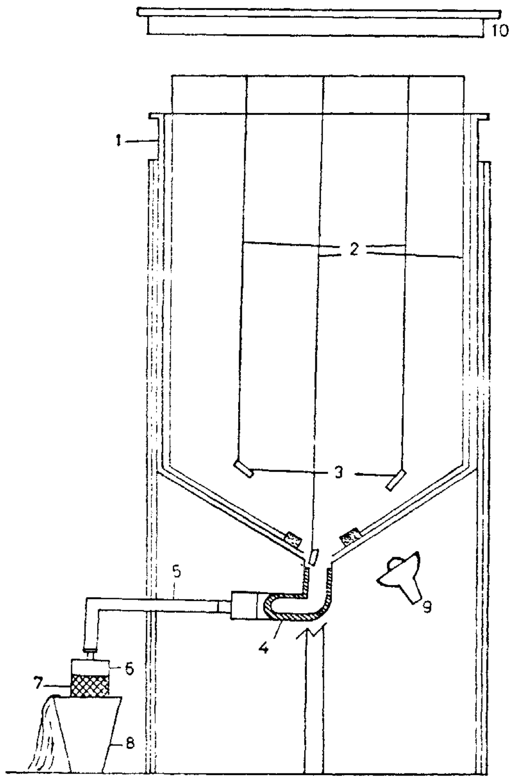

Figure 1 A standard hatchery for hatching Artemia (Galveston Lab. U.S.A.). (from Salser & Mock) 1, Tank; 2, Air line; 3, Airstone; 4, valve assembly; 5, Drain hose; 6, Harvesting screen; 7, Screen support; 8, Plastic bucket; 9, Harvesting Light; 10, Flourescent hatching lights

PVC material, 16 cm in diam and 46 cm deep, supported by plastic netting, is placed in a plastic bucket. As the drainage valve is opened the *Artemia* larvae flow out from the valve through the screen and are retained while the superfluous water flows out. *Artemia* can then be stored up to 72 hrs at densities of 5000–6000/ml.

Artemia cultures can also be maintained in outdoor tanks in continuous cultures without any particular care. The only draw-back in this system would be availability of sufficient quantities of larvae at the time the Mysis of prawns are ready to feed.

Other operational techniques

In their simplest form the operational techniques involve a standard circulating sea-water system in which eggs can be reared to post-larval stages. Several water filtration techniques are being used to have clean water for rearing purposes. Aeration system comprises compressors, air-lines, air stones and air lift-pumps. A biological monitoring system is essential to keep a careful check on nitrates, nitrites and ammonia, the metabolites, the dissolved oxygen, *p*H, alkalinity, salinity and suspended matter. Monitoring of leaching of toxic substances into the water from the material used for construction of tanks, or pipes etc. which are likely to cause large scale mortality, is also needed.

A standard hatchery being used is shown in figure 2. Material that is used for construction is of primary importance. In Galveston Laboratory fibre glass is being used, coated with epoxy resin on its inner walls. This material is expensive initially. However, once constructed it meets with the standard requirements of a hatchery, and is easy for handling and manipulation. In the Philippines collapsible tanks made of marine plywood are used for construction of rearing tanks.

Waste removal

Next to the feeding, waste removal is the key factor in the hatchery. Despite constant water circulation and aeration, if waste is allowed to accumulate or biological decomposition is permitted to take place, high density rearing of shrimp larvae would be a failure. Daily replacement or alternate day replacement of atleast half the water in the hatchery, is necessary.

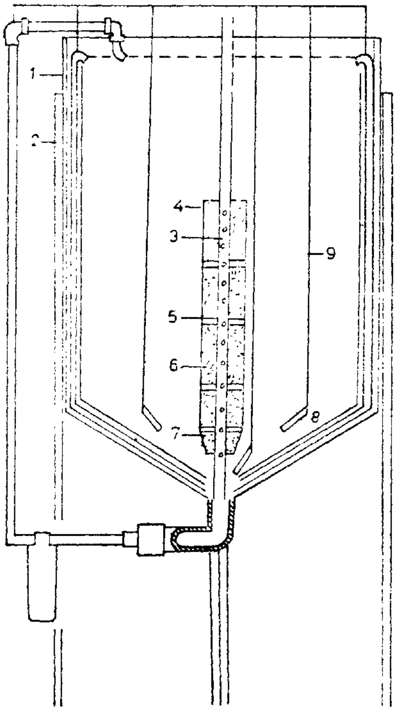

Figure 2 A standard hatchery tank constructed of fibre glass (Galveston Lab. U.S.A.) (taken from Salser & Mock) capacity 1,900 litres, depth 165cm & diameter 137cm. Bottom cone 43cm days inclination 32° angle. 1, Rearing tank; 2, Tank supports; 3, PVC pipe perforated; 4, Plywood Disc; 5, Plastic collar Nylon screen (0. 16mm mesh); 7, Plywood disc; 8, Air-stone; 9, Air-line

The importance of waste removal is pertinent also to the high-density rearing of juveniles of prawns. It must be noted that in India, the first step in intensive culture operations would be the direct semi-controlled system where the percentage survival is still extremely low. If the juvenile phase is also taken care ot under totally controlled conditions, most of the mortality could be controlled. A possible commercial application is thus envisaged at this stage of culture. Nutritional needs of juveniles could be similar to those of adults since at this stage prawns become bottom feeders. Pelletized feed could be used. Choice of ingredients are discussed later in this paper.

The other aspects of juvenile rearing are once again operational. These are the removal of accumulated metabolites from time to time and constant biological and chemical monitoring. As in the hatchery phase, the material used in construction of juvenile-rearing tanks or raceways is extremely important for high-density/high survival.

Intensive Semi-Controlled System

The semi-controlled system is the brackish-water farm in India in which post-larvae collected from nature are reared through a nursery phase to production phase.

By closing or regulating the path of entry of tidal waters for short-term production periods, entry of natural feed is also restricted in order to avoid entry of predators and to maintain semi-controlled conditions. Therefore, artificial fertilization of ponds and supplemental feeding are resorted to. We find that these techniques are improving the production or yield patterns from the ponds.

Maintenance of water quality, particularly of chemical parameters, such as temperature, *p*H, salinity, total alkalinity, is conducted by the most direct way viz., by taking in fresh tidal water whenever necessary.

Supplemental feeding

Supplemental feeding under semi-controlled system does seem to improve the growth. Some interesting results have come out which raise the question of whether the supplemental feeds are directly utilized by the prawn or does the feed add to the natural fertilization of the pond and the shrimp benefit by grazing on the resulting benthic matter. It appears that both fertilisation and feeding might take place.

In the Kakdwip Research Centre, *Penaeus monodon* is being grown under different culture systems with varying species combinations; with mullets, *Muqil parsia, M. tade;* with other prawns, *P. indicus, Metapenaeus monoceros, M. brevicornis* and *Palaemon styliferus;* with *Chanos chanos* and also in monoculture.

Traditional practice of feeding is with rice bran in combinations of oil cake, wheat powder, etc., broadcast in a powder form, dispersed widely over the pond. This seems to help the mullets which come up to feed on the surface of the water. This also apparently acts as a fertilizer. For *P. monodon* in monoculture, on the other hand, pelletized-feed put in trays, is given. It is apparent, however that although prawns do feed on the pelletized feed, they are also mainly bottom feeders. Therefore, fertilization of ponds with organic and inorganic manuring is also undertaken.

In order to raise the protein percentage in the feeds, trash fish, slaughter-house waste, miscellaneous prawn powder are being tried in the feed formulae. Wheat powder is now replaced by maize powder. The growth rates, in terms of weight increment, under different feed combinations and species-combinations is given in table 1. It shows that the growth is quite fast in short-term rearing. The growth, however, is not feed-related only but temperature related too. Summer growth being relatively faster than that in monsoon and the slowest growth is in winter (table 2). Species-combinations do seem to play an important role although statistical significance cannot be tested under this semi-controlled system.

Survival in this system is generally around 25–40% despite management practices. This cannot be explained as due to lack of proper feed because intensive feeding

Table 1 *Growth rates (initial and final weights) of* P. monodon *in semi-controlled intensive system at Kakdwip Centre**

Species combinations	Stocking rate/ha.	Initial wt. (g) (Avg.)	Final wt. (g) (Avg.)	No. of days reared	Feed used
Liza parsia/P. monodon	50,000	0.01	27.5	200	Rice bran+Maize powder (1 : 1)
Liza tade/P. monodon	7450 (combined)	10.7	39.5	270	- do -
Chanos chanos/P. monodon	3000/150	12–15	60.0	120	Maize powder+wheat powder
Mixed culture of prawns	2 lakhs (combined)	6 mg–0.1 g	12–27	75	Maize powder+Rice bran
,, ,,	4 lakhs (combined)	0.01–2	20–30	270	- do -
Indian & exotic carps, Mullets & *P. monodon*	8000 (combined)	4.11	74.6	1 year	Mustard oil cake+ Maize powder
P. monodon monoculture *P. monodon/M. parsia*	3–4 lakhs for the first 4 weeks of nursery rearing and then reduced to 20,000	6 mg	30.0	120	Goat offal+Algal powder+yeast+shell powder etc.

*Data obtained from the on-going project programmes of the Kakdwip Research Centre

Table 2 *Weight increment (in grammes) in* P. monodon *in different seasons*

Initial size/ weight	Days of rearing/Final weight attained				
Season:	Summer			Winter & summer	Monsoon & winter
Days :	75	100	120	200	270
15–30 mm/ 6mg–0.1g	20	30	45	27.5	39.5

practices are being applied, as has been shown earlier. Some part of the mortality could be due to cannibalism.

Laboratory Experimental Work on Feeds

Using post-larvae of 12–15 mm (6 mg average weight) collected from nature, a series of glass-jar experiments were conducted.

Powdered feed was used for post-larvae up to 30–40 days. Pelletized feed was used crumpled to small sizes to suit the size of the animal as it grows. The test feeds included soyabean powder, brewer's yeast, squid meal, fish meal, waste shrimp meal, vitamin mix, mineral salt mix to meet the nutritional requirements, particularly of protein. Sodium alginate is used as a binder. The experimental results are presented in table 3. This offered a study under controlled conditions when we could statistically test the growth rates and calculate the significance of the test results. In these feeds economic criteria have not yet been applied. It is expected that any significant result could be utilized by an industrial approach to feed formulation as was done in the case of poultry feeds and cattle feeds.

One major finding of interest in glass jar experiments was the wastage that could result by overestimates of feed intake by the prawns. Starting with 25% of body

Table 3 *Growth rates (initial and final weights) of the post larvae & juveniles of* P. monodon *in Laboratory experimental studies using different feeds*

Feed ration	Main ingredients in feed	Initial wt. of stock (mg)	Final wt. of stock (mg)	Conversion Ratio	Daily increment (mg)
Post-larvae					
1	Soyabean meal+maize powder+yeast	10.0	20.35	2 : 1	0.345
2	Fish meal+Ground nut oil cake	10.0	15.49	3 : 1	0.183
3	Squid meal+Rice bran	9.0	21.60	2 : 1	0.42
4	Offal+yeast	9.0	14.35	3 : 1	0.178
Juveniles					
1	Soyabean meal+Maize powder+yeast	130.0	348.5	2 : 1	5.4625
2	Fish meal+Ground nut oil cake	130.8	210.0	3 : 1	1.98
3	Rice bran+shrimp meal	131.2	268.5	3 : 1	3.4325
4 (control)	Offal+yeast	131.0	252.0	3 : 1	3.025

weight the feed was reduced to 10% when it appeared that the feed ration was going waste. 30 days after the start of experiments the feed was further reduced to 4–5%.

Discussion and Conclusions

The feeds formulated so far, in India have yet to fulfil a need of 40–60% crude protein that is found to be absolutely essential in artificially prepared feeds by other workers elsewhere in the world. It is still a far off step to meet the premise that the essential amino acid composition similar to that of the test animal fulfils the feed efficiency requirement. This premise was first suggested by Phillips and Broackway (1956) and later supported by Ogino (1963) Deshimaru and Shigeno (1972), among others.

Soyabean meal used in our experimental studies has given the best performance. "It is interesting to note that soyabean meal, a vegetable product, has a pattern of amino-acid distribution more similar to the prawn than the brine shrimp, even though it is also a crustacean like the prawn"(Deshimaru & Shigeno 1972) Unfortunately, soyabean is an imported product and we should find some other cheaper substitute to replace it. Another food found equally suitable is the squid/cuttle fish meal. It also supplies a specific protein source. However, squid meat is exported by India and as a prawn feed ingredient it may prove highly expensive and hence uneconomic.

However, under semi-controlled conditions, satisfactory growth rates are evident in composite cultures of prawn and fish with the current combinations of feeds. The percentage survival, however, is far from satisfactory. Survival and growth were also observed to be inversely proportional. The situation does not improve just by reducing the stocking densities. Timely removal of decomposing materials from the bottom and the metabolites might rectify this factor. This, however, is an operational technique not directly related to nutritional requirements.

A medium cost, high-protein combination of feed could be cuttle fish or squid meal + yeast to take care of protein requirement, vitamin mix, mineral salts, any low-cost oil cake to meet the crude fat requirement and high-glutein wheat powder or sodium alginate as binders. One low-cost material yet to be tested in field is the active sludge which would act as a fertilizer facilitating production of natural food in the pond itself.

In the hatchery system, under fully controlled conditions, we are yet to develop a species similar to *Skeletonema costatum* or *Tetraselmis chui*. This however, may not prove to be restrictive factor since the techniques of isolation cultures are well known. The diatoms, *Skeletonema* and *Chaetoceros* are prevalent in certain seasons in the off-shore plankton of India. However, a species most adoptable to mass culture in outdoor as well as controlled conditions would suit the hatchery needs. Development of a mass culture of such a species is a prerequisite to setting up of a hatchery. The isolated reports on culture of *Brachionus*, *Chlorella* and other species have not been tested as feeds for the high density and high survival rearing of zoael or Mysis stages of *P. monodon* or *P. indicus* resulting in high survival. Attempts at breeding of prawns and studies on mass cultures of suitable feeds for each larval stage as shown in this paper ought to go on as a parallel study.

Acknowledgements

The author's grateful thanks are extended to

Dr V G Jhingran, Director, C.I.F.R.I. for granting permission to use some of the scientific data of the project programmes of the Kakdwip Research Centre of C.I.F.R.I.

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