

Sustainable Shrimp Farming in India - Prospects and Challenges

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Abstract : Shrimp farming has grown into a multi-crore industry in India. It has vast potential for further expansion. However, this growing industry needs to develop appropriate indigenous technologies in specific areas to make it a sustainable and profitable venture. This paper looks into some important areas pertaining to Indian condition and highlights the need for developing and refining indigenous technologies.

Introduction

India is producing about 80,000 tonnes of shrimps annually employing different farming practices and has tremendous potential for future expansion. This bio-industry has attracted large capital investments and has grown into a multi-crore enterprise. However, the industry faced a major crisis in 1994 in the form of disease outbreak along the east coast. The disease outbreak occurred mainly due to nonscientific proliferation of shrimp farms and improper management strategies used. It is therefore imperative that eco-friendly measures are implemented and appropriate indigenous technologies developed in specific areas. This paper addresses some important problems faced by the Indian shrimp farming industry and also suggests viable solutions.

Site selection

Shrimp farming along the banks of estuaries and brackishwater creeks has resulted in wanton destruction of mangrove areas, particularly in southeast Asia (de la Cruz, 1984; Librero, 1984) which harbour a large variety of commercially important species and form

the natural nursery for several fin and shell fishes, including the penaeid shrimps (Macnae, 1974; Achuthankutty and Nair, 1983; Achuthankutty, 1990). In India, conversion of agricultural land and other productive areas into shrimp farms has been taking place. Besides, large areas along the banks of narrow brackishwater creeks are being developed and many farms which are located away from the mouth of the creeks do not get adequate water exchange, leading to water stagnation and waste accumulation thereby lowering water quality and introduction of pathogens and diseases. It is in this context that Achuthankutty and Parulekar (1995) recommended the preparation of master plans for all maritime states of India, delineating suitable shrimp farming sites, keeping in view the environmental aspects and develop common infrastructure facilities before leasing to entrepreneurs. This would greatly help in effective management of the farms.

It is high time that excessive stress exerted on brackishwater areas by shrimp farming activities should be reduced to minimise environmental and

socio-economic problems. Shrimp farming should be encouraged along sea fronts (as per CRZ) which has several advantages over brackishwater farming.

Species Selection

Indian shrimp farmers prefer tiger prawn (*P. monodon*) due to its larger size, faster growth and lucrative price. This may lead to indiscriminate exploitation of wild spawning stock and over a long period of time may also adversely affect the capture fishery resources. Moreover, the demand for spawners is increasing far beyond supply due to establishment of new hatcheries.

It is in this background that concept of rotation of species and use of native species gains strength. It should be made mandatory that hatcheries and farms should rotate species with local species which will help in reducing the stress exerted on the spawning stock of a single species. Adoption of such strategies can make shrimp farming a sustainable venture.

Shrimp hatcheries

More than 150 medium and large scale shrimp hatcheries have gone into production and a few more are in the pipeline. All these hatcheries depend on wild spawners. Due to inadequate supply of tiger prawn spawners, most of the hatcheries are unable to achieve the installed production targets, leading to shortage of seed (Achuthankutty et al. 1994) and causing concern and financial loss to shrimp farmers (Achuthankutty and Parulekar, 1995).

To achieve a moderate yield of 3 t/ha/crop with an average survival rate of 80% and a harvestable size of 30 g/shrimp in the semi-intensive system, the requirement of seed will be ~ 125,000. If

farming is extended to 100,000 ha, the annual seed requirement for 2 crops will be ~25 billion. With uncertainties over supply of spawners and seed, sustainable shrimp farming can never become a reality.

The most viable solution to tackle this problem is to produce seed from locally available fast growing species. The other alternative is to produce spawners under captivity. This is not an immediate possibility and requires support of excellent R&D.

Indigenous Feed Formulation

Nutrition and dietary regulation are integral part of sustainable shrimp culture. Scientifically managed shrimp culture activities where production targets are much higher require well balanced, growth efficient, environment friendly and cost effective formulated diets (Raj, 1994). Studies on shrimp nutrition was initiated in the early 1970s (New, 1976, 1980 for review). A number of shrimp feeds are now available in the market (see Jung and Co, 1988; Aliyama and Dominy, 1989; Raj, 1994 for details of feed formulation) and >50% of recurring expenditure goes in feed procurement.

Shrimp culture essentially requires two types of feeds. The larvae (hatchery) depend exclusively on a feeding regime composed of live organism such as phytoplankton and *Artemia* nauplii and grow-out stages (ponds) need artificially formulated diets.

Larval feeds

Use of live algae and *Artemia* nauplii as shrimp larval feed was introduced by Hudinaga (Liao et al., 1993). The success of this has led to development and refinement of algal and *Artemia* nauplii culture techniques (Smith et al.

1993; Liao *et al.*, 1993; Dhont *et al.* 1993). A number of unicellular algae are being used as shrimp larval feed due to various properties exhibited by them. For instance, *Isochrysis* although small in size and low in highly unsaturated fatty acids (HUFA) content is still a preferred protozoal diet because of its fast proliferation potential and ability to tolerate high temperature (Helm and Laing, 1987) and is usually fed in combination with other algae (Kuban *et al.*, 1985). The diatom *Chaetoceros* finds favour due to its high HUFA, large size and fast growth (Tabias-Quinito and Villegas, 1982). *Thalassiosira* is nutritionally rich albeit slow growth (Emmerson, 1980).

However, live algal culture is also associated with several drawbacks such as the need for elaborate and labour intensive culture system, possibility of sudden collapse, introduction of pathogens and diseases, etc. To circumvent these problems, different types of artificial shrimp larval feeds have been formulated and tried with promising results. They include, microencapsulated diets (Jones *et al.*, 1987; Kurmaly *et al.*, 1989), spray-dried algae (Biedenback *et al.*, 1990), concentrated algal pastes (Laing and Verduga, 1991; Nell and O'Connor, 1991), etc. Smith *et al.* (1993) opined that among formulated diets, concentrated algal pastes and dried algae hold promise for the future.

A serious concern expressed in using some of these diets is the presence of antibiotics, corticosteroids, anabolic steroids and steroid hormones which may lead to production of weak and poor quality larvae (Liao *et al.*, 1993). Although total replacement of live feeds with microencapsulated diets may not be an immediate possibility, they may provide partial replacement (Kurmaly *et al.*, 1989). It is important that R&D efforts

in India should be directed to indigenously produce cheap and nutritionally rich larval feeds.

Grow-out feeds

Jung and Co (1988), Akiyama and Dominy (1989) and Raj (1994) have reviewed various aspects of shrimp feed formulation. The Indian shrimp culture industry depends almost exclusively on imported feeds at high costs. Non availability of good quality fishmeal in India is the major constraint in preparation of quality feeds. Due to improper processing, the amino acid configuration gets denatured and lipids become rancid (Raj, 1994). Its adequate supply can be ensured if the untapped potential resources of the mesopelagic myctophid fishes, which has an estimated annual production of 100 million tonnes in the Arabian Sea (Gjosaeter, 1984) are caught and scientifically processed. They are considered economically unimportant due to small size, but contain high quality protein (>65%) and essential amino acids (Nair *et al.* 1983) which are ideal for shrimp feed (Raj, 1994).

The Indian coastal waters have large, mostly unused resources of the epipelagic sergestid shrimp *Acetes* which can form a potential feed component, supplementing or even substituting shrimp meal. Squid meal contains certain polyunsaturated fatty acids (PUFA) which stimulates growth and maturation in penaeid shrimps (Kanazawa *et al.*, 1977; Bottino *et al.*, 1980; Chamberlain and Lawrence, 1981; Achuthankutty *et al.*, 1993) and is a good source of cholesterol which is required for synthesizing many sterols and other essential components such as moulting hormones, bile acids and vitamin D (Akiyama and Dominy, 1989).

Several marine organisms are good natural source of essential amino acids and fatty acids. *Artemia* has been rec-

ommended as a feed component (Nair *et al.*, 1995) because it contains good quality protein and amino acids (Leger *et al.*, 1986) and the biomass is available in large quantities in salt pans and salt lakes of India (Royan, 1980).

Crustaceans, including shrimps lack the capability of de novo synthesis of omega-3 linoleic, linolenic, eicosapentaenoic and docasahexaenoic acids and omega-6 arachidonic acid (Harrison, 1990). The latter three are very important for spawning females (Primavera, 1985) and their deficiency can cause serious health and survival problems to adults and larvae. Many marine microorganisms are potential sources of PUFAs (Findlay *et al.*, 1986). They have the advantage of rapid proliferation and mass production and can be harvested easily. Our research should be directed in identifying commercially unimportant marine organisms which can substitute/supplement some of the expensive and commercially important organisms in shrimp feeds.

Disease control and Management

Disease control and health management should receive utmost priority in India because the disease outbreak occurred in 1994 caught us unawares and caused heavy financial loss.

References

- Achuthankutty, C.T., 1990. Riches from mangroves. *Sci. Rep.*, 27:12-16.
- Achuthankutty, C.T. and Nair, S.R.S., 1983. Larval migration and growth of marine prawns in the estuarine habitat. *Mahasagar - Bull. Natn. Inst. Oceanogr.*, 16:243-250.
- Achuthankutty, C.T. and Parulekar, A.H., 1995. Shrimp farming - roof without a strong foundation. *Proc. Natn. Symp. Aquaculture for 2000 AD*, pp. 41-46.
- Achuthankutty, C.T., Nair S.R.S. and Parulekar, A.H., 1994. Development of indigenous technologies - need for shrimp farming. *Proc. Sem. Ocean and Industry - Realities and Expectations*, pp. 119-120.
- Akiyama, D.M. and Dominy, W.G., 1989. Penaeid shrimp nutrition for commercial feed industry. *Texas Shrimp Farming Manual*, Vol. I, 50 pp.
- Biedenback, J.M., Smith, L.L. and Lawrence, A.L., 1990. Use of a new spray-dried algal produce in penaeid larviculture. *Aquaculture*, 86:249-257.

A persual of the literature in shrimp diseases (Johnson, 1990, Lightner, 1993; Lipton, 1994) reveals that cultured shrimps are susceptible to various types of infectious and noninfectious diseases. A number of viral, rickettsial, bacterial and fungal diseases besides parasites and epicomensal pests have been reported (Lightner, 1993). Dietary deficiencies, toxins, mineral imbalances and chemical and physical stressess also occur in culture environment (Johnson, 1990; Lightner, 1993; Flegel and Sriurairatana, 1993). However, the diagnostic methods presently available are expensive, cumbersome and time consuming. By the time the cause and its prophylaxis are identified it spreads so quickly to nearby areas that prevention and control become almost impossible. Therefore, techniques should be developed to rapidly detect diseases so that necessary prevention and control measures can be effectively taken before it assumes epidemic proportion. Hence, there is an urgent need to develop reliable, simple and cheap diagnostic kits and molecular probes and biochemical kits may be the answer. This needs the backing of strong R&D.

- Bottino, N., Gennity, M.L., Simmons, E. and Finne, G., 1980. Seasonal and nutritional effects of the fatty acids of three species of shrimps, *Penaeus setiferus*, *P. aztecus* and *P. duorarum*. *Aquaculture*, 19:139-148.
- Chamberlain, G.W. and Lawrence, A.L., 1981. Maturation, reproduction and growth of *P. vennamei* and *P. stylirostris* fed natural diet. *J. world Maricult. Soc.*, 12:209-224.
- Chin, T.S. and Chen, J.C., 1987. Acute toxicity of ammonia to larvae of tiger prawn *Penaeus monodon*. *Aquaculture*, 60:247-253.
- de la Cruz, A.A., 1984. A realistic approach to the use and management of mangrove areas in southeast Asia. In: H.J. Teas (Editor), *Physiology and Management of Mangroves*, Dr. W. Junk Publishers, The Hague, pp. 65-68.
- Dhont, J., Levens, P. and Sorgeloos, P., 1993. Preparation and use of *Artemia* as food for shrimp and prawn larvae. In: J.P. McVey (Editor), *Handbook of Mariculture*, Vol.1, 2nd Edition, *Crustacean Aquaculture*, CRC Press, Boca Raton, pp. 61-93.
- Emmerson, W.D., 1980. Ingestion, growth and development of *Penaeus indicus* larvae as function of *Thalassiosira weissflogii* cell concentration. *Mar. Biol.*, 58:65-73.
- Findlay, R.H., Fell, J.W., Coleman, N.K. and Vestal, J.R., 1986. Biochemical indicators of the role of fungi and thraustochytrids in mangrove detrital systems. In: S.T. Moss (Editor), *The Biology of Marine Fungi*, Cambridge University Press Cambridge, pp. 91-103.
- Flegel, T.W. and Sriurairatana, S., 1993. Shrimp health and management : an environmental approach. In: R.P. Subasinghe and M. Shariff (Editors), *Diseases in Aquaculture: The Current Issues*, Malaysian Fisheries Society, Malaysia, pp. 1-48.
- Gjosaeter, J., 1984. Mesopelagic fish, a large potential resource in the Arabian Sea. *Deep-Sea Res.*, 31:1019-1035.
- Harrison, K.E., 1990. The role of nutrition in maturation, reproduction and embryonic development of decapod crustaceans: a review. *J. Shellfish. Res.*, 9:1-28.
- Helm, M.M. and Laing, L., 1987. Preliminary observations on the nutritional value of 'Tahiti *Isochrysis*' to bivalve larvae. *Aquaculture*, 62: 281-288.
- Johnson, S.K., 1990. *Handbook of Shrimp Diseases*. TAMU-SG-90-601, Texas A&M University, Sea Grant College Program, College Station, Texas, 25 pp.
- Jones, D.A., Kurmaly, K. and Arshad, A., 1987. Penaeid shrimp hatchery trials using microencapsulated diets. *Aquaculture*, 64:133-146.
- Jung, C.K. and Co, G. William., 1988. *Prawn Culture : Scientific And Practical Approach*, Cushon Printing Press, Calasiao, Angasinan, 323 pp.
- Kanazawa, A., Teshima, S. and Tokiwa, S., 1977. Nutritional requirements of prawns. VII. Effects of dietary lipids on growth. *Bull. Jpn. Soc. Sci. Fish.*, 43:849-856.
- Kuban, F.D., Lawrence, A.L. and Wilkenfeld, J.S., 1985. Survival, metamorphosis and growth of larvae from four penaeid species fed six food combinations. *Aquaculture*, 47: 151-162.
- Kurmaly, K., Jones, D.A., Yule, A.B. and East J., 1989. Comparative analysis of the growth and survival of *Penaeus monodon* (Fabricius) larvae, from protozoa 1 to postlarvae 1, on live feeds, artificial diets and on combination of both. *Aquaculture*, 81:27-45.
- Laing, I. and Verdugo, C.G., 1991. Nutritional value of spraydried *Tetraselmis suecica* for juvenile bivalves. *Aquaculture*, 92:207-218.
- Leger, P., Bengston, D.A., Simpson, K.I. and Sorgeloos, P., 1986. The use and nutritional value of *Artemia* as food source. *Oceanogr. Mar. Biol. Ann. Rev.*, 24:521-623.
- Liao, I-Chin, Su, Huei-Mees Lin, Jaw-Hwa., 1993. Larval foods for penaeid prawns. In: J.P. McVey (Editor), *Handbook of Mariculture*, Vol.1, 2nd Edition, *Crustacean Aquaculture*, CRC Press, Boca Raton, pp. 29-59.
- Librero, A.R., 1984. Mangrove management in the Philippines. In : H.J. Teas (Editor), *Physiology and management of Mangroves*, Dr. W. Junk Publishers, The Hague, pp. 79-87.

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- Lightner, D.V., 1993. Diseases of cultured penaeid shrimp. In: J.P. M. Vey (Editor), Handbook of Mariculture, Vol. 1, 2nd Edition, *Crustacean Aquaculture*, CRC Press, Boca Raton, pp. 383-486.
- Lipton, A.P., 1994. Shrimp diseases and control. In: Manual of Workshop on Shrimp Farming Techniques, Problems and Solutions, Madurai Kamaraj University, Madurai, pp. 34-45.
- Macnae, W., 1974. Mangrove Forests and Fisheries, FAO/IOFC/DEV/74/34, FAO, Rome, 35 pp.
- Nair, A.L., James, M.A., Mathew, P.T. and Gopakumar, K., 1983. Studies on lantern fish (*Benthoosema pterotum*) II. Nutritional evaluation. *Fish Technol.*, 20:20-23.
- Nair, S.R.S., Achuthankutty, C.T. and Royan, J.P., 1995. comparison of live adult *Artemia* and squid meat on the growth of penaeid shrimp *Metapenaeus dobsoni* (Miers). *Proc. Ind. natn. Sci. Acad.*, B61 : 419-422.
- Nell, J.A. and O'Connor, W.A., 1991. The evaluation of fresh algae and stored algae concentrates as a food sources for Sydney rock oyster, *Saccostrea commercialis* (Iredale & Roughley), larvae. *Aquaculture*, 99:277-284.
- New, M.B., 1976. A review of dietary studies with shrimps and prawns. *Aquaculture*, 9:101-144.
- New, M.B., 1980. A bibliography of shrimp and prawn nutrition. *Aquaculture*, 21: 101-128.
- Primavera, J.H., 1985. A review of maturation and reproduction in closed thelycum penaeids. In : Y. Taki, J.H. Primavera and J.A. Llobrero (Editors). *Proc. 1st Intn. Conf. Culture of Prawns/Shrimps*, Aquaculture Department, Southeast Asian Fisheries Development Centre, Philippines, pp. 47-63.
- Raj, S.P., 1994. Shrimp feed formulation. In: Manual of Workshop on Shrimp Farming Techniques, Problems and solutions, Madurai Kamaraj University, Madurai, pp. 25-33.
- Royan, J.P., 1980. Laboratory and field studies on an Indian strain of the brine shrimp *Artemia*. In: G. Persoone, P. Sorgeloos, O. Roels and E. Jaspers (Editors), *The Brine Shrimp Artemia : Ecology, Culturing, Use in Aquaculture*, Wetterln, Universa Press, Vol. 3, pp. 223-230.
- Smith, L.L., Fox, J.M. and Treece, G.D., 1993. Intensive algae culture techniques. In: J.P. McVey (Editor), Handbook of Mariculture, Vol. 1, 2nd Edition, *Crustacean Aquaculture*, CRC Press, Boca Raton, pp. 3-13
- Tobias-Quinto, E. and Villegas, C.T., 1982. Growth, survival and macronutrient composition of *Penaeus monodon* (Fabricius) larvae fed with *Chaetoceros calcitrans* and *Tetraselmis chuii*. *Aquaculture*, 29: 253-260.