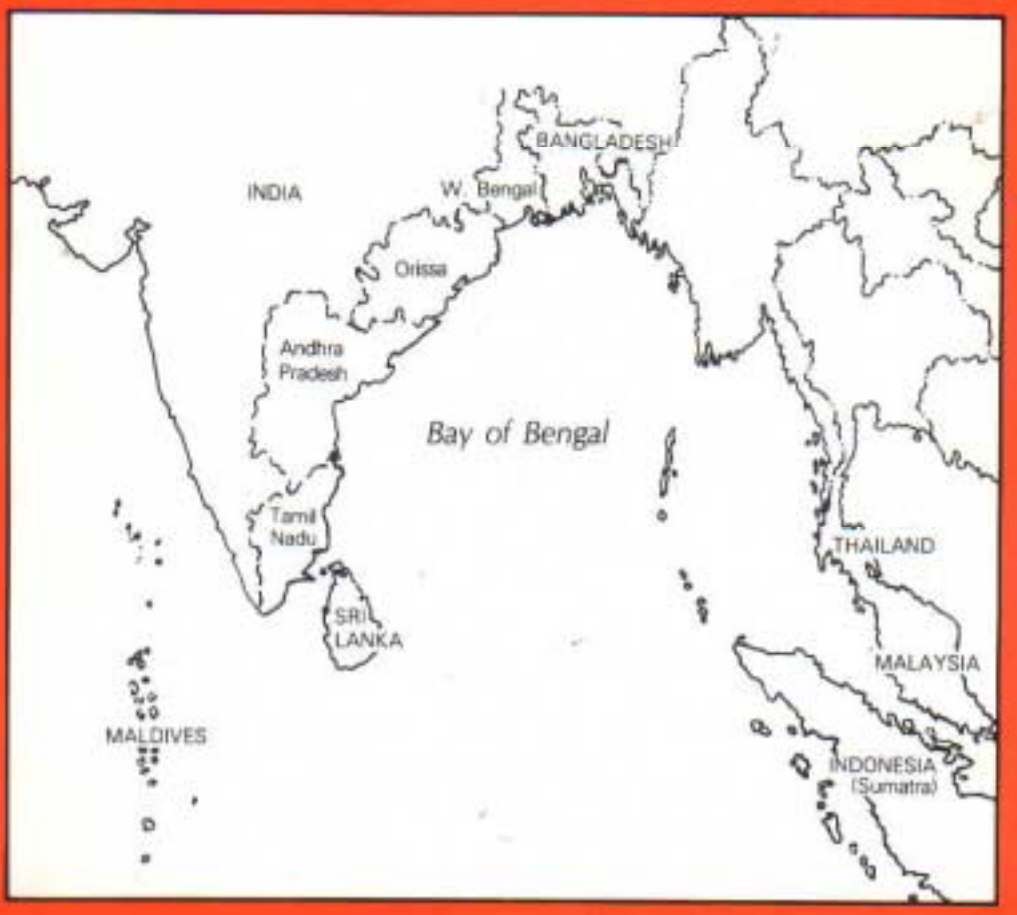
BOBP/REP/52

Feeds for artisanal shrimp culture in India — Their development and evaluation



BOBP For Fisheries Development
BAY OF BENGAL PROGRAMME

BAY OF BENGAL PROGRAMME **BOBP/REP/52**

Post-Harvest Fisheries Overseas Development Administration

Feeds for artisanal shrimp culture in India — Their development and evaluation

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In 1989, the Indian Council for Agricultural Research (ICAR) approached the UK Government-funded Post-Harvest Fisheries Project of the FAO's Bay of Bengal Programme (BOBP), based in Madras, for assistance in the formulation, manufacture and feeding trial evaluation of feeds for the artisanal culture of shrimp in India.

This report presents the findings of a collaborative programme conducted during 1989-91. It has been prepared in the hope that it will further stimulate the development of local shrimp feed manufacture and the artisanal shrimp culture industry in India. The case study is not, therefore, a reference text on the subject of shrimp feed production and evaluation, but a distillation of field experiences and results upon which new research and farm studies can be based.

The report describes the Indian shrimp culture industry, the principles and practices used within the project for the formulation of shrimp feeds, the principles and practices of pond environment assessment, feed manufacture and feed evaluation by feeding trial, a financial appraisal of the feeding trials and recommendations for further studies.

The Bay of Bengal Programme (BOBP) is a multi-agency regional fisheries programme which covers seven countries around the Bay of Bengal — Bangladesh, India, Indonesia, Malaysia, Maldives, Sri Lanka, Thailand. The Programme plays a catalytic and consultative role : it develops, demonstrates and promotes new techniques, technologies or ideas to help improve the conditions of small-scale fisherfolk communities in member-countries. The BOBP is sponsored by the governments of Denmark, Sweden and the United Kingdom, by member-governments in the Bay of Bengal region, and also by AGFUND (Arab Gulf Fund for United Nations Development Organizations) and UNDP (United Nations Development Programme). The main executing agency is the FAO (Food and Agriculture Organization of the United Nations).

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Abbreviations

ICAR : Indian Council for Agricultural Research, Delhi.

CIBA : Central Institute for Brackishwater Aquaculture, Madras.

MPEDA : Marine Products Export Development Authority, Cochin.

IAS : Institute of Aquaculture, University of Stirling, FK9 4LA, Scotland.

NRI : Natural Resources Institute, Chatham Maritime, Kent ME4 4TB, England.

CIFT : Central Institute of Fisheries Technology, Kochi.

1. INTRODUCTION

With the Government of India seeking to expand shrimp culture as a means of providing new labour opportunities in rural coastal regions, the culture of shrimp in brackishwater ponds in India is steadily increasing. To encourage shrimp culture, the Indian and state Governments have commenced a programme of opening up saline coastal lands for low-cost leasing for artisanal shrimp culture. But yields/ha, in the farms of India, are relatively low. Typical yields are 400-600 kg/ha/annum from a single harvest, compared with up to 12,000 kg/ha/harvest from intensive culture in Taiwan.

Storage of juvenile shrimp for growing out to market size is one of the factors limiting shrimp culture development. Some progress is now being made to meet the increasing demand for juveniles through the establishment of private and Government funded shrimp hatcheries. There is, however, an urgent need to develop shrimp feed processing technology and formulations which are appropriate to India's needs and culture practices.

The study reported on here was directed towards the development of feeds for artisanal shrimp culture. This sector is attempting the transition from minimal input, extensive shrimp culture to that of low input, semi-intensive culture. However, since shrimp feeding is only one component of shrimp culture management, it was considered necessary to also examine the way in which the pond environment and its management had an impact on feed utilization by shrimp.

The initial hypothesis put forward in establishing these trials was that the provision of improved quality feeds, with a minimum change in pond management practices, should enable shrimp yields of 1000-1500 kg/ha to be obtained from a single harvest. The extent to which this hypothesis was confirmed is examined in this case study.

Details of the specific project objectives are presented in Appendix I.

To whom is this case study directed?

- **To policy makers** concerned with the development of artisanal shrimp culture in India – to assess the impact on feed resources, and the opportunities and problems of shrimp culture expansion.
- **To the feed industry** – by outlining problems of feed formulation and manufacture, and to present a clearer picture of the farming systems in which any manufactured feed must compete.
- **To researchers** – to add to the present literature on artisanal shrimp studies and to suggest possible new areas of study.
- **To extension workers and shrimp farmers** – to assist them in identifying the most limiting factors to making a profitable family business through artisanal shrimp culture in India.

1.1 Summary of findings

The consensus among many Indian researchers and shrimp farmers interested in the development of shrimp feeds for indigenous shrimp culture is that artisanal feeds prepared from trash fish, rice bran and oilcakes are poor sources of nutrients for shrimp, and that what farmers need is a feed of higher nutrient specification. Typical yields from artisanal culture after a 120-140 day growing season are 400-600 kg/ha/harvest, there being only one harvest each year. Typical stocking density is five animals/sq m. *(P monodon).*

An initial, small pond (18 ponds x O.O27ha/pond) feeding trial in West Bengal using experimentally pelleted feed of 35 per cent protein, and a stocking density of ten animals/sq m yielded the equivalent of 710 kg/ha in 80 days at a feed conversion ratio (FCR) of 2.9. The same feed formulation presented

in a powder-based doughball form yielded the equivalent of only 440 kg/ha at an FCR of 3.3. This trial indicated that the experimental doughball was performing similarly to artisanal feeds and the pelleted feed, when fed over a full growing season with shrimps stocked at twice the normal stocking density, had the potential to more than double shrimp yields from the pond. (Results are means from at least two ponds; FCRs were calculated on a dry feed basis.)

A second stage, large pond (0.75ha/pond) feeding trial in Andhra Pradesh was designed to evaluate the performance of the pelleted feed and powder-based doughball under management procedures adopted by local shrimp farmers. The performance of shrimp fed the experimental feeds was also compared with shrimp fed a trash fish and rice bran based feed, prepared and fed according to practices adopted by local farmers. Stocking density was ten animals/sq m.

A harvest of 1345 kg/ha equivalent was obtained within a 143-day growing period from shrimp fed the experimental pelleted feed. This compared well with the extrapolated yield from the small pond trial and was two to three times the average yield from ponds using supplementary feeding. The harvest from the powder-based, doughball was 950 kg/ha equivalent, again comparable to an extrapolated small pond trial result. FCRs were, however, poorer at 4.4 and 7.0 for the pellets and powder-based, doughball respectively.

The unexpected result from this trial was the yield of 1410 kg/ha equivalent from ponds fed the local, moist feed. This yield also surprised our collaborating scientists, since yields of this level had not previously been noted. The feeding regime for this local feed was similar to that of pellets and powder-based, doughballs. Since the composition of the local feed varied from day to day according to the availability of raw materials, an assessment of its typical composition could only be made at the end of the trial. The feed had an average crude protein content of 26 per cent, and the apparent FCR on a dry feed basis was 5.6.

Pond pollution in the large pond trial (as evidenced by the degree of blackness of the pond bottom mud) was most prominent in ponds using the powder-based, doughball and the local, moist feeds. The water-stable pellet appeared to produce little blackening of the mud, and thus, from a pollution prevention aspect, pelleting would appear to be highly desirable.

A financial analysis of the feeding trial results indicated that for the pelleted feed to be cost effective, its price would need to be reduced from 15 Rs/kg to 5.5 Rs/kg.

On the assumption that the nutrient requirements for shrimp can be provided in a feed of dry form, but of comparable composition to the local, moist feed, feed manufacturers may then be able to prepare feeds at a price which is competitive with the use of moist feeds. This requires experimental confirmation. Appropriate feeding strategies have been suggested.

The environmental factor which appeared to limit shrimp growth during the latter stages of both the small pond and large pond trials was low dissolved oxygen (DO) levels in pond waters. This was due in part to low DO in the pond's incoming supply water, to oxygen demand for the decomposition of unconsumed feed, and to the higher-than-usual stocking density for shrimp. Occasional water aeration by pumping was necessary for the high yielding ponds during the final 2-3 weeks prior to harvest, when pond DO levels were below 3ppm.

The trials reported in this case study indicate that high nutrient-density diets, as used for intensive shrimp culture, appear to be inappropriate for artisanal shrimp culture in India. The use of lower nutrient specification diets could result in substantial reductions in the cost of production of pelleted shrimp feeds. Their development would improve the availability and distribution of feed raw materials to an expanding shrimp-farming market, enable shrimp farmers to feed a product of constant quality, considerably reduce the time required for feed preparation and reduce the risk of pond pollution.

2. A GENERAL OVERVIEW OF SHRIMP CULTURE

2.1 Worldwide shrimp culture

Shrimp has proved to be one of the great aquaculture cash crops of the 1980s and a source of prosperity in a number of developing countries. This has happened because supplies of wild, caught shrimp have stagnated, with catches around the world approaching, or even surpassing, their maximum sustainable yields. Since 1977, world landings have stabilized in the region of 1.6 million t/yr. (See Table 1 for production by the major shrimp suppliers to the world market.)

Table 1 : Shrimp production of major world suppliers

Country	Typical producrion 1985[2] (t/ha)	Aguaculture production 1986[2] (1000 t)	Marine landings 1986[2]/1000 t)
India'	0.4	17	201
Taiwan	7.7	65	55e
Thailand	0.4	16	117
China	0.7	70	230e
Indonesia	0.2	48	112
Ecuador	0.6	36	—
Philippines	0.2	9	76
Japan	6.0	1	59e

Ref. ¡ Csavas (1988); ' Liao (1988); ¦ MPEDA (1987); e = estimate

However, demand is income-elastic and shrimp consumption has continued to grow, spurred on by the generally increasing prosperity in the major industrialized markets. During the 1970s and 1980s, countries able to develop a shrimp culture industry found a seller's market as they plugged the gap between wild, caught supply and demand. World aquaculture production has soared, growing from 25,000 t in 1975 to 340,000 tin 1987, accounting for 16 per cent of the total harvest in the latter year. However, the early 1990s have seen alevellingin demand for shrimp and a fall in prices in the world market. This development may, therefore, limit the extent to which shrimp production in India through aquaculture can expand.

2.2 General classification of shrimp culture systems

Shrimp culture operations can, in general, be broadly classified into three categories: extensive, semi-intensive and intensive. The characteristics of the three systems are indicated in Table 2.

Table 2 : General classification of shrimp culture systems

	Extensie	Semi-intensive	Intensive
Stocking density (shrimp/sq m)	0.3-2	2.5-8	>10
Water management	Tidal + Pump	Pump	Pump t treatment
Aeration	No	Some	Yes
Fry source	Wild or hatchery	Wild or hatchery	Hatchery
Feed	Natural feed through fertilization	Fertilization with supplementary feed (fresh/formulated)	Formulated
Crops/year	1-3	2	2-2.5
Production t/ha/yr	0.3-0.8	1-3	8-12

(Kungvankij P and Kongeo H, 1988)

Intensive production is characterized by a high level of investment and technical expertise and takes place mainly in Taiwan and Japan. In the Philippines, Thailand, Indonesia, and Malaysia, there are increasing moves towards intensification. By way of contrast, many farms in Latin America and China have adopted semi-intensive methods.

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Kungvankij P and Kongeo H. (1988) Culture system selection, p. 123 in *Shrimp '88, (ibid.)*

MPEDA : Personal communication — data for 1987.

3. THE SHRIMP CULTURE INDUSTRY IN INDIA

3.1 Shrimp production

India is one of the world's larger shrimp exporters with an estimated annual production, in 1987/88, of 245,000 t. Approximately 215,000 t of this was sea-caught shrimp, the remaining 30,000 t coming from brackishwater culture in West Bengal, Andhra Pradesh, Kerala and Goa (Chong Kee-Chai 1991). But the sea-caught harvest, by far the primary source of foreign exchange for the shrimp industry, has remained constant over the last 5-10 years. Much interest is, therefore, being directed towards expanding shrimp production by culture, both in terms of the area of water under culture, and the yield/ha.

India's production of cultured shrimp has expanded rapidly during the last 13 years, with output rising from about 4,000 t in 1975 to 17,000 t in 1985 and at least 24,000 t in 1988. Notwithstanding this remarkable achievement, India's rate of growth in shrimp production has been slower than in a number of Asian countries which have moved faster to fill market requirements.

In 1975, India was Asia's (indeed the world's) second highest producer of cultured shrimp, but by 1985 her position had fallen to sixth in Asia and seventh in the world due, in part, to Ecuador's rapid expansion in prawn productivity (see Table 1).

Shrimp yields from pond culture in India are, however, low, averaging 500kg/ha/crop, although this is comparable with yields from extensive culture in other countries such as Indonesia or the Philippines.

However, for five months of the year, the monsoon rains lower pond and estuarine water salinity to levels below which shrimp culture is practically not viable. India's shrimp farmers are, therefore, limited to only one major growing season a year. Despite this difficulty, an increasing number of shrimp farmers, in Andhra Pradesh In particular, are attempting to culture a second, low-input crop when the water salinity is low but the price of shrimp juveniles is also low.

3.2 Traditional shrimp culture practices

3.2.1 EXTENSIVE SHRIMP CULTURE IN WEST BENGAL

The culture of shrimp in West Bengal has, traditionally been associated with rice production, whereby rice was intercropped with naturally stocked fish and shrimp seed which had been washed over the ricefield perimeter bunds during high tides. This type of culture is termed bheri culture, after the local name for the large, flooded ricefields. Impoundments or bheris may range in size from 1 to 200 ha of water without subdivision, although IO ha could be considered to be a 'typical' farm size.

In traditional bheri culture, no feed supplementation is practised. Shrimp and fish growth are dependent upon natural pond fauna and flora as the sole feed sources. Some enterprising shrimp farmers in West Bengal are also supplementariIy stocking their tidal ponds with wild or hatchery-reared shrimp post-larvae at a stocking density of 55,000/ha (56/sq m).

3.3 Recent developments in shrimp culture

3.3.1 FEEDING PRACTICES

The most rapid developments in shrimp culture have occurred in Andhra Pradesh. Here there has been no history of rice-cum-fish/shrimp culture and the otherwise unproductive saline coastal lands have been converted to brackishwater ponds.

Farmers adopting supplementary feeding practices use mixtures of oil cakes, rice bran, locally available snail, clam or mussel meat, and buffalo meat. Some examples of feed mixtures are presented

in Table 3. Mollusc and buffalo meats are often pre-cooked and minced to a paste. A blend of these raw materials may then be mixed with cooked tapioca (cassava) as an adhesive binder. Moulded paste balls are placed in pottery bowls at marked feeding sites (approximately 30/ha), and feed consumption is examined at 2-3 hourly intervals.

Table 3 : Typical shrimp feed mixes

	Mix 1	Mix 2	Mix 3
Groundnut meal	10%		
Cooked buffalo meat		40%	
Rice bran	60%	60%	50%
Soyabean meal	20%		
Groundnut cake			20%
Tapioca (cooked)	10%		
Dried shrimp head waste			20%
Clam meat			10%

Towards the end of the shrimp growing period, a low percentage of locally available dried trash fish may be added in the feed mixtures in an attempt to boost shrimp growth.

Feed conversion ratios using these feeds are very variable even on the same shrimp farm. Some farmers indicated that feed conversion ratios of 10 kg moist feed/kg shrimp growth were commonplace, especially during periods of low water salinity.

3.3.2 RAW MATERIAL SHORTAGES

A particular problem with formulations based on molluscs is that they are not sustainable in the long term. They depend on scarce proteinaceous ingredients whose availability cannot sustain a major increase in demand.

Obtaining raw materials of animal and marine origin for shrimp feed preparation is becoming increasingly difficult as the number of operational shrimp ponds rises. Often there is considerable competition for the limited quantities of trash fish available, particularly when fishing boats are unable to go to sea because of bad weather. At these times, shrimp farmers may use sundried fish as an alternative to fresh trash fish. There would appear to be no long-term opportunities for large increases in fishmeal production within India. (The problem of competition for fishmeal by the poultry sector is discussed in section 3.7.)

Supplies of beef from buffalo or cattle are also erratic, as beef availability is dependent upon the variability in the demand for skins by the leather industry.

The method of feed preparation is very time-consuming. Common experience shows that approximately six man-hours daily are needed for the preparation of sufficient feed for a 1 ha pond. A further three man-hours may be required for the daily collection of trash fish and beef.

3.4 Problems of environmental concern

Although the artisanal and landowner shrimp farmers have demonstrated to their own satisfaction the short-term profitability of using moist feed mixtures, many farmers are concerned at the increasing problems of deterioration in pond water and sediment quality arising from feed disintegration and decomposition.

Of equal concern is the practice of discharging pond effluent into the channels which also serve as the source of incoming ‘clean’ water.

Since the tidal amplitude of many of the supply creeks is low, and sedimentation rates are high (due to both natural processes and anthropogenic effects), the potential for adequate water exchange is steadily decreasing. Without improved pond planning, this problem will be compounded as the number of shrimp farmers attempting to culture shrimp increases. This practice also becomes of major importance should shrimp disease outbreaks occur in a locality.

The problem is re-examined in paragraph 7.3 in the light of the results from the feeding trials.

3.5 Manufactured shrimp feed and its potential demand

In addition to the provision of land and seed, the Government of India has identified the need to provide feed for shrimp culture. This requirement has been recognized for some years, but, to date (1991), there is no established shrimp feed manufacturing industry in India.

There is a general conception by Indian shrimp farmers that local moist feeds do not produce the shrimp yields that they anticipate, and that manufactured feeds in pellet form of high nutrient quality and water stability would give improved yields comparable to those in other shrimp-producing areas of the world. Shrimp farmers are, however, unwilling to pay the price for imported feeds which meet this criteria, and locally manufactured pelleted feeds are considered to be of low water-stability, poor nutritional quality, untested and too expensive. There is, therefore, a need to determine the extent to which the Indian shrimp industry can benefit through the use of high-quality feeds. Since the Government of India foresees an important role for the artisanal shrimp farmer in shrimp culture expansion, it is important that the farmer is provided with appropriate technology for controlling pond inputs, including the possible preparation of feeds from local raw materials.

The desire to develop water stable feeds of proven, consistent quality, but at the right price, remains, therefore, a prime objective of the Government of India.

3.5.1 POTENTIAL FUTURE DEMAND FOR SHRIMP FEED IN INDIA

Forecasting the demand for shrimp feed is difficult, but if Indian manufacturers were to supply a feed of proven quality and at a reasonable price, it might, at the present rate of shrimp farm development, be adopted by 1993 for regular use in 8000 ha. This area is about 15 per cent of the total area currently under culture, or about half the area belonging to farmers registered with MPEDA in 1990. The potential feed demand can be estimated if a number of assumptions are made. For example, assuming that

- the annual yields/ha were to commence at 800 kg, and rise at five per cent/annum throughout the 1990's;
- the apparent feed conversion ratio was 2.5 : 1;
- the total area under culture was increasing by five per cent/annum, and
- the proportion of farmers using supplementary feed was rising by 10 per cent/annum (i.e. there is a 20 per cent compound annual growth in demand and the area using supplementary feed would be increased to 28,000 ha in ten years),

THEN, the annual feed demand would rise to about 82,500 t over that period.

Given the number of imponderables, there is a considerable margin of error in such estimates. However, it should be noted that even if demand for shrimp feed were to increase to 80,000 t it would still be only 2.5 per cent of the 1990 demand for poultry feed.

The implication of these findings is that shrimp culture is unlikely to greatly affect supply and demand for many of the feed ingredients which are used in large quantities for poultry and other livestock feeds. However, an expanding poultry feed market faced with raw material shortages could well deprive a developing shrimp feed industry of some of its key raw materials.

3.6 Current proposals and developments

Experience in other Asian countries suggests that India will progressively move from extensive to semi-intensive culture using supplementary feeds, and that the Taiwanese model of intensive culture will be adopted by only a few farms with sufficient capital and expertise. Moreover, under the conditions of depressed prices which are likely to pertain in the 1990s due to over-supply in the shrimp market, there may be sound economic reasons for preferring extensive/semi-intensive as opposed to intensive production systems.

Although some Indian shrimp culturists have looked enviously at the high yields of shrimp obtained by intensive culture in countries such as Taiwan (at up to 12 t ha/harvest and 2-3 harvests/year), the Government of India has taken a more realistic approach in seeking to find appropriate means of increasing yields from a typical 500 kg/ha, to 1000 to 1500 kg/ha on a low input, sustainable basis. Simultaneously, the Government of India is opening up new lands for the construction of shrimp ponds for use primarily by financially weaker groups. Under the Government of India guidelines, new lands must be apportioned in the following way :

- 60 per cent to financially weaker groups, including fisherfolk, scheduled caste groups and those of any caste with an income of less than Rs 6000/annum;
- 20 per cent self-employed technocrats; and
- 20 per cent larger entrepreneurs.

Expansion of shrimp culture has occurred most rapidly in Andhra Pradesh. By 1990, approximately 6,000 ha of land were under shrimp culture, although 23,000 ha have been identified for potential pond development. Expansion is planned for, and being implemented, in other coastal states.

In seeking to establish new ponds, the Government of India is taking precautions against the destruction of the coastal mangroves, which are the natural breeding grounds of marine shrimp, by siting new ponds away from such areas.

Shortages of shrimp seed are being addressed through the construction of shrimp hatcheries in both the private and Government sectors, e.g. MPEDA hatcheries at Gopalpur, Orissa, and Mangamaripet, Andhra Pradesh, which use French and American hatchery technology respectively.

3.7 Shrimp feed ingredients

The nutritional requirements of aquatic organisms vary greatly from those of terrestrial animals, interms of both the balance and structure of macro- and micro-nutrients.

However, some of the major ingredients which have been recommended in the technical literature for the manufacture of shrimp and fish feeds are the same as for farm animals, particularly poultry. However, because of certain specific nutrient requirements of shrimp – for example, to enable good exoskeleton moulting and regeneration – and the desirability to make feeds attractive to the slow-feeding shrimp, some less common materials have also been recommended for inclusion in feeds.

Since it is generally accepted that shrimp feeds fed under intensive or semi-intensive shrimp culture should be water stable for a minimum of two hours, raw materials and manufacturing processes must also be selected in terms of their ability to induce water stability.

In terms of raw material requirements for shrimp grown under semi-intensive/intensive culture, the most critical are the marine proteins and oils, the major sources in India being fish meal, shrimp heads, small non-penaeid shrimp, meat from bivalve molluscs and snails, squid processing waste and squilla (stomatopods). Unfortunately these materials are available only in limited quantities. This is particularly the case with fish meal, because it is an essential source of protein in alternative animal feeds. In contrast, oilseed meals and cereals are in abundant supply, though there will be competition between the poultry and the expanding shrimp industry for those materials of high protein quality which are least available (i.e. soya and sesame meals as plant sources of lysine and methionine/cystine, respectively).

Ingredients for low inclusion level, but which are essential for most diets – such as fish oils, phospholipids and sterols for good skeletal moulting, vitamin and mineral mixtures and polymer binders – may need to be imported.

However, in presenting this list of recommended ingredients, it must be emphasized that the nutrient requirements of shrimp grown under differing culture systems is not fully known. (This aspect is considered in more detail in sections 4.1 and 4.2 concerning feed formulation. Recommended nutrient levels for intensive shrimp culture are listed in Table 9.)

Potential sources of shrimp nutrients within India are given in Table 4 and Fig 1. Raw material availability and competitive users are quantified in Table 5. (See facing page.)

3.7.1 FISHMEAL

Composition of fishmeal

Fishmeal is made almost exclusively from small demersal fish and shellfish brought in as by-catch – and not used for direct human consumption – as well as with some processing waste and some

Fig. 1 **Possible raw materials for the manufacture of shrimp feed** in India

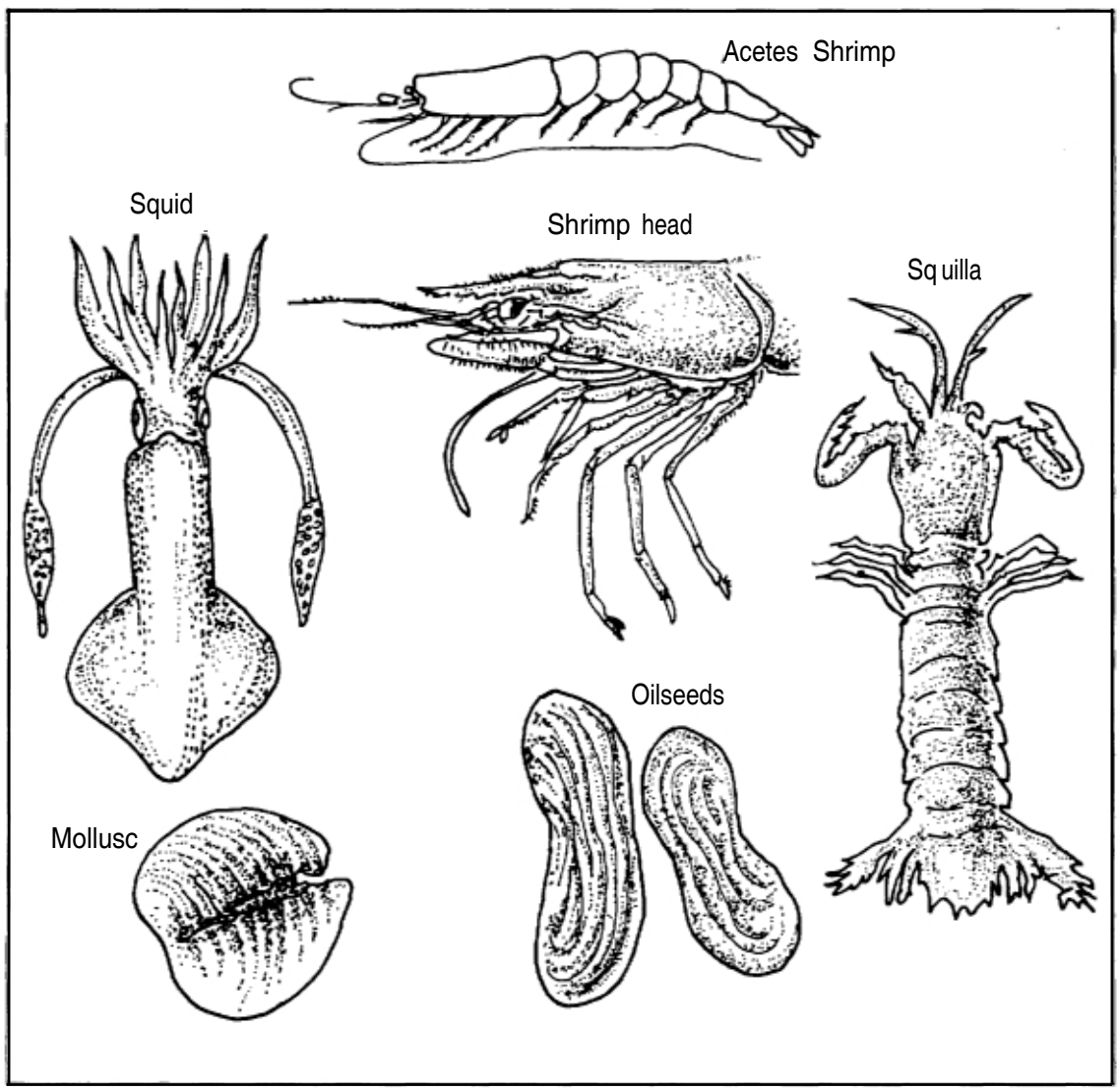

Table 4 : Sources of major nutrients for prawn feeds in India

Type	Typical inclusion level (%)	Sources	Major Nutrients Supplied					Attractant properties	Waler stability properties
			Protein	Corbohydrafe	Essential fatty acids	Phospho-lipids	Sterols		
Marine Proteins	30-50	Fishmeal	X		X	X	X	X	
		Shrimp meal	X		X	X	X	X	
		Shrimp head meal	X		X	X	X	X	
		Squid meal	X		X	X	X	X	
		Clam meat	X		X	X	X	X	
		Mussel meat	X		X	X	X	X	
		Snail meat	X		X	X	X	X	
		Squilla meal	X		X				
Non-marine Animal Proteins	1-5	Meat meal	X						
		Blood meal	X						
Vegetable Proteins	15-30	Groundnut cake	X		X				
		Soyabean cake	X		X				
		Sesameseed cake	X		X				
		Copra cake	X						
		Dried yeast	X						
Cereals	15-30	Wheat flour	X	X	X				
		Wheat gluten	X	X					X
		Wheat bran	X	X					X
		Rice bran	X	X					
Starches	1-20	Tapioca (precooked)		X					X
Phospholipids	0.5-2	Lecithin			X	X			
oiis	I-5	Fish Oil			X				
Polymer binders	0.5-4	Guar/gum							X
		Celluloses							X
		Alginates							X
		Synthetics							X

Table 5 : Availability of major raw materials for prawn feeds in India

Row materials	Estimated potential availability per annum (tonnes)	Estimated off take by other users (tonnes)	Of her users
Fishmeal	110,000	110,000	Poultry feed
Shrimp head mea)	2,200	100	Export, resource IO be developed
Acetes shrimp	15,000	15,000	Human food — export
Squilla meal	10,000	10,000	Poultry feed/fishmeal, fertilizer
Clam meal	500+	500	Export — Taiwan
Mussel meat	N.A.	N.A.	Used wet in local prawn feeds, Human food
Rice bran'	2.2 million	N.A.	Poultry and cattle feed
Groundnut cake[2]	I .4 million	300,000	Export-animal feed
Sesame cake'	270,000	1.1. million	Animal feed
Soyabean cake'	560,000	560,004	Animal feed
Tapioca	5.6 million	N.A.	Human food, Starch, Aanimal feed

Notes : ı 55.5 million t. paddy per annum x 4% rice bran fraction.

2 6.7 million t. shell on nuts per annum x 50% crushed x 43% cake.

ı 0.5 million ı. seed per annum x 90% crushed x 60% as cake.

4 0.7 million t. seed per annum x 80% as cake.

N.A = not applicable

small pelagic fish caught in periods of glut. The small demersal fish and shellfish used are almost entirely shrimp trawler by-catch or, rather, that part of the catch which remains after the larger and more valuable species have been separated out for human consumption.

Annual production

Sources within the Indian fishmeal industry estimate the annual national production to be around 110,000 t. This figure agrees with estimates of by-catch from shrimp landings, and is probably the best estimate of fishmeal production levels. Expansion of fishmeal production, at least in the short term, does not seem feasible since unpublished data from the Government fisheries institutes indicate that overall fish landings have fallen greatly in 1987-88, and it is feared that this is the beginning of a long-term trend resulting from over-fishing and/or ecological phenomena. In 1988, the fall in landings due to reduced catch size resulted in an estimated 45 per cent decrease in fishmeal production from the normal (110,000 t) to about 60,000 t. It should be added that shortage of marine fish is a problem affecting many parts of the world, but the Indian subcontinent in particular.

Production technology

Most of the fishmeal plants using reduction technology (rather than sun drying and grinding) were established in India during the 1960s and 1970s. Many are now out of business, though plants in Karnataka operate during the peak anchovy/sardine season. At the same time, the proportion of sea-caught shrimp by-catch which is landed and is available for conversion to fishmeal is slowly decreasing, as more and more of it is marketed fresh, or dried, for human consumption. Feed compounders seem unwilling to pay the price for trash fish which is now used for human food, for conversion to fishmeal.

Most Indian fishmeal is made by sun-drying on the beach and grinding. The fishmeal is of low quality because of poor handling and processing. Material with a protein content of 45 per cent or more is now considered the best quality, compared with 65 per cent or more in the international markets. Most Indian fishmeals also have high microbiological counts and contain rancid oils and considerable impurities, including salt and sand. These are major headaches for feed manufacturers, affecting the quality of their formulations, feed palatability and the useful life of their processing equipment.

Possible sources of material

However, since large quantities of shrimp by-catch are discarded at sea, there is the possibility of increasing fishmeal production if the collection of by-catch and its conversion to fishmeal can be made economically viable. Up to 690,000 t of by-catch are estimated as being discarded at sea per annum from shrimp trawling operations. This is equivalent to approximately 172,000 t of fishmeal. However, the economic viability of returning such material to shore remains doubtful.

Fishmeal consumers

The primary consumer of fishmeal is the poultry industry. An average inclusion rate of 5-7 per cent in poultry feed, as typically recommended, equates to an annual requirement by the poultry industry of about 210,000 t. This is twice the estimated availability of fishmeal in normal years and almost four times the availability in 1988. As a result of this scarcity, the price of fishmeal during 1988 increased by about 60 per cent over the previous level.

With the poultry feed industry growing by 10-12 per cent/annum, and fishmeal supplies probably declining in the long term, there is a prospect of increasing scarcity and rising real prices. If shrimp feed manufacturers are obliged to buy domestically produced fishmeal, which is of poor quality and in chronically short supply, then the rate of development of shrimp culture in India may be severely hampered. There is, therefore, a case for permitting the import of quality fishmeal into India at non-prohibitive rates of duty for the manufacture of shrimp feeds.

3.7.2 SQUID WASTE

Where not discarded overboard, most squid waste is dried for use as fishmeal. For this reason, it cannot be regarded as a separate resource in addition to those already discussed. Small quantities of squid waste are dried for export to Taiwan. However, logistical problems of waste collection and the export of squid in whole form prevent larger quantities from being collected.

3.7.3 SHRIMP HEADS

Present availability

The main unutilised source of marine protein and oils is the heads of shrimp from the shrimp packing and processing industry. Heads are usually removed in peeling sheds near the landings or at packing plants. Shrimp landed by the large trawlers operating from Vishakhapatnam are, however, deheaded at sea.

India's total annual availability of heads, based on the quantity of shrimp exported, is estimated to be 30,000 t (where average export of tails is 55,000 t/annum and the weight ratio of heads:tails is 35 : 65). However, since this figure does not include catches of metapenaeid shrimp which increase the estimated total marine landings of shrimp to 210,000 t, a more realistic estimate of the quantity of shrimp head waste available for upgrading is 73,000 t *(i.e. 35* per cent of 210,000 t). Most of this quantity is currently discarded as waste, but small amounts are hot air dried for export to Taiwan, where it is believed to be used in the manufacture of shrimp feed. Since shrimp are deheaded at many small landing sites, there are logistical difficulties in collecting much of this material.

If shrimp head meal of high quality is to be obtained, the wet heads must be dried quickly after deheading in order to avoid deterioration due to enzyme activity. Hot water blanching, to denature enzymes before sun-drying, or rapid hot air drying are recommended methods of treatment.

Head meat extraction

A further possible development which merits investigation is the extraction of head meat by use of a meat bone separator before drying. The protein content of the whole shrimp head meal produced by hot air drying is believed to be about 30 per cent, but by extracting the head meat, an ingredient with a higher nutrient density and upwards of 60 per cent protein can be made. It might also be possible to produce chitin and chitosan as useful by-products of the process. However, in many of the small landing sites, the quantity of product available on a daily basis would not justify the investment in machinery for shrimp head processing.

The potential for shrimp heads extraction to yield a quality protein product also raises the question of the use of the extracted head meat for human consumption. Although such an alternative use is recognized, in the short term the development of technology for upgrading shrimp heads as a feed ingredient would enable a more rapid utilization of this waste product to be made.

3.7.4 ACETES SHRIMP

Landings of acetes shrimp *(Acetes indicus),* caught mainly in Maharashtra, averaged in excess of 70,000 t (approximately 15,000 t dried product) in 1985 and 1986. The potential of this small shrimp in animal feeds is limited, since it is mainly used for human consumption in India as well as being exported to Japan (for human consumption). Small quantities are also exported to Spain and Portugal as bird feed. In view of this trend, acetes should not be relied upon as a source of protein for shrimp feeding.

3.7.5 BIVALVE MOLLUSCS AND SNAILS

Meat from cooked mussels and snails is being used for shrimp feeding in localities where these animals can be easily collected. However, the supply based on known and accessible resources is limited, and will not sustain a major increase in offtake. For example, in Andhra Pradesh,the cost of clam meat to the farmer is 4.50 Rs/kg. On a dry weight basis, this is three to four times the wholesale price for fishmeal, and prices were reported to have doubled in the preceding two years. Similar constraints were reported with the use of snails in the Chilika Lake area of Orissa.

One company produced dried grey clam *(Vilforita cyprinoides)* and mussel meat for export to Taiwan, where they are presumably used as attractants in the manufacture of shrimp feeds. At a price of around 1500 and 2000 US $/t respectively, they cannot be considered as major sources of marine protein for Indian shrimp feeds, though they may find similar uses in India to those in Taiwan.

3.7.6 SQUILLA

Landings of stomatopods, consisting mainly of squilla *(Ovallosquilla nepa)* were estimated to be 40,000 t in 1985 and 1986. Landings are largely concentrated on the Karnataka coast. This resource is dried for use as a fertilizer and low-grade fishmeal. The main point of interest is that squilla could possibly be processed by the meat-bone separator as suggested for shrimp heads. The techno-economic feasibility of this proposition should be included in any studies on upgrading of shrimp heads by meat extraction.

3.7.7 OILSEED MEALS

India is a major producer of oilseed meals which could be utilized in shrimp feeds. Soya, sesame and groundnut are the most important oilseed cakes, though the latter should be screened for aflatoxin contamination.

3.7.8 CEREALS AND BY-PRODUCTS

There is a plentiful supply of cereals and their brans within the feed market for use in shrimp feeds. However, the development of water stability in shrimp feeds may require inputs of food grade wheat flour, so it is desirable to keep such inputs to a minimum.

3.7.9 MISCELLANEOUS INGREDIENTS

Minor essential ingredients

As indicated earlier, many of the minor but essential ingredients may need to be imported, the cost of which, including any duty, must inevitably be passed on to the feed purchaser. A list of possible ingredients is given in Table 6. An increased demand for these materials may encourage the emergence of local manufacturers, but in the short term, import would appear to be necessary.

Table 6 : Minor raw matehals for use in shrimp feeds

Ingredient	*Function*
Cholesterol Lecithin	Carapace development, moulting, and nutrient metabolism
Ethoxyquin Butylated hydroxy toluene Butylated hydroxy anisole	Oil anti-oxidants
Carboxy methyl cellulose Sodium alginate Guar gum Synthetic polymers	Polymer binders

3.7.10 SUMMARY OF RAW MATERIAL AVAILABILITY

From the above examination of raw material availability within India, it is clear that there is a major deficiency in marine protein and oils for shrimp feed manufacture. This problem will, of course, increase in relation to the rate of expansion of semi-intensive shrimp culture. Since deficiencies in marine proteins will limit feed production, the establishment of mechanisms to improve the supply of quality fishmeal to the industry requires attention.

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