Nutrition, Feeds and Feed Technology for Mariculture in India

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Mariculture of finfish on a commercial scale is non-existent in India. CMFRI, RGCA of MPEDA, CIBA are the Institutions promoting finfish mariculture with demonstrated seed production capabilities of Asian seabass (*Lates calcarifer*), cobia (*Rachycentron canadum*) and silver pompano (*Trachynotus blochii*). Seed production is not sufficient enough togo in for commercial scale investment. Requisite private investment has not flown into this segment of aquabusiness and Public Private Partnerships (PPP) are yet to take off. The scenario being this in the case of one (seed) of the two major inputs in this food production system, feeds and feeding, which is the other is the subject of elaboration here.

Quality marine fish like king seer, pomfrets and tuna retails at more than Rs.400/- per kg in domestic markets. In metro cities it Rs.1000/- per kg is not surprising. With this purchasing power in the domestic market, most of the farmed marine fish is sold to such a clientele which is ever increasing in India. Therefore, without any assurance of a sustainable supply of such fish from capture fisheries, there is no doubt that we have to farm quality marine fish. With as deficit in seed supply at present, let us examine nutrition, feeds and feed technology required for this farming system in India.

Farming sites, technologies of cage fabrication and launch, day-to-day management, social issues, policy, economics and health management, harvest and marketing, development of value chains, traceability and certification are all equally important and may or may not be dealt with in this training programme. We will focus here on nutrition, feeds and feed technology.

The species of fish suitable to be farmed in cages in sea are prioritized with a different set of parameters. In general, most marine fish have a prolific fecundity with survival rates in hatchery conditions is some species as low as 10 % and still cost effective because of the return on investment on seed cost, cost of fish of stockable size and farm gate prize of fish.

Broodstock nutrition

Now let us examine what is fed during the hatchery phase. Before that there is another area in fish nutrition know as brood stock nutrition which involves feeding of the fish being reared to spawn in captivity. A multitude of factors are involved here in which nutrition is only one. Sex reversal, temperature, light, water quality, stress, hormones and the list can be populated.........

In terms of nutrition, it is not protein and carbohydrate, no doubt, they should be available, it is more of functional nutrients like, fatty acid makeup of the phospholipids, carotenoids and several other unknown factors like the interplay of vitamins minerals and hormones.

So, what should we feed the brood fish? No single ingredient or formulated feed is sufficient. It should be a mix and match of several ingredients with inclusion of functional feeds and nutraceuticals. There are many artisanal practices to nourish aquaculture broostock. Raw seafood, commercial feeds and specialized feed additives or a combination of all the three are applied. It is appalling that scientific brood stock nutrition is not a part of the hatchery management. Science based brood stock nutrition is always rewarding.

Animals should be switched to a broodstock formulation for three to four months for maximum gonadal development. Batch spawners enter a starvation period after gonadal development and rely on bodily stores to supply immense amounts of energy and specific nutrients for final gonad and ovary maturation and ultimately spawning. Therefore, providing the specialized nutrition to allow the build-up of bodily stores greatly influences reproductive success. Continuous spawners which include several marine species should be also fed high quality broodstock diets which greatly influences the egg quality.

Development of a set of data enabling us to make reproductive success predictable should be the broodsotck nutrition management programme. Fecundity, fertilization and hatching rates are good indicators of spawning trend allow planning of broodstock replacemnts, fry production and future needs.

Nutrients identified to have a vital influence on broodstock are, 1-2% of n-3 highly unsaturated fatty acids from marine oils, vitamin E (250 ppm), carotenoids like astaxanthin (100 pm),vitamin C (200 ppm) and amino acids of marine origin (80% of the diet).

Even with limited species-specific information available on broodstock nutrition and limited availability of commercial broodstock feeds, scientific management of broodstock nutrition is important and possible.

Larval nutrition

There is no way we can mimic the micro and macro-environment of the open ocean or fresh water body inside a hatchery. Ensuring all critical inputs to achieve the output of maximum number of young fish is refined day by day through research and development.

The feeds are a multitude of microscopic organisms'phyto and zooplankters among which, phytoplankton, rotifers, artemia and then microfeeds is the norm. Replacing live feeds with formulated feeds, enriching live feed with deficient nutrients have been the approach worldwide. Going into details of all the zootechniques is beyond the scope of this article, certain strong points are presented.

Problems in altricial (born undeveloped requiring care) fish are 1. Marine fish larvae grow more rapidly than juveniles. 2. Natural diets of marine fish larvae are rich in phospholipids rather than triacylgcerol and, 3. The ratio of 22:6(n-3): 20:5 (n-3) in phospholipids naturally consumed is ca. 2:1 whereas this ratio in triacylglycerols in fish oil is less than or equal to 1:1. Thus the marine larval fish feeds based on conventional fish oils with ratios of 22:6 (n-3): 20:5(n3) less than or equal to 1:1 are sub-optimal, either by not providing 22:6(n-3) or by providing an excess of 20:5(n-3). Over emphasis of (n-3) HUFA has resulted in the neglect of arachidonic acid (20:4n-6) as a dietary essential fatty acid for marine fish and the role of mono unsaturated fatty acids as major energy yielding nutrients in fish.

Metabolic interrelationships, conversions and competitions.

18:3 (n-3) ——————→ 20:5 (n-3)
Linolenate EPA

Either non-conversion, or very low conversion due to Ä-5 fatty acid desaturase activity.

20:5 (n-3) ——————→ 22:6 (n-3)
EPA DHA

Conversion at low rates not likely to meet the high demands of larval fish growth fully.

Problems: Visual impairment due to impaired rod function leading to decreased efficiency in capturing prey at low light intensities.

22:5 (n-3) ——————→ 22:6 (n-3) is not by direct Ä-4 desaturation but by a complex pathway where,

20:5 (n-3) is chain elongated to 22:5 (n-3) and then converted to 24:5 (n-3). 24:5 (n-3) is converted to 24:6 (n-3) by Ä-6 desaturase and 24:6 (n-3) is chain shortened through peroxisomal â-oxidation to 22:6 (n-3) or DHA.

Or

18:2 (n-3) ——————→ 18:4 (n-3)
by $\varepsilon\Delta$-6 desaturase

and interestingly, 18:4 (n-3) and 24:5 (n-3) are substrates for the same enzyme.

Thus, 18:3 (n-3) competitively depresses conversion of 20:5 (n-3) ——————→ 22:6 (n-3)

High concentration of 22:6(n-3) exists in the neural tissues. The acyslases and transacylases that esterify fatty acids into phospholipids do not have absolute specificities for particular fatty acids. Therefore, fatty acid compositions of tissues are partly determined by the levels of fatty acids available from the diet. This is true in the case of PUFA where an excess of one dietary PUFA e.g., 20:5n-3, can lead to an elevation of that PUFA in tissue phospholipids at the expense of another PUFA present in much lower concentrations in the diet e.g., 22:6n-3. This effect has been established for phospholipids of fish brain.

Artemia, rotifers and copepods contain substantial amounts of 18:3(n-3) linolenic acid and probably linolenic acid competitively inhibits 20:5(n-3) to 22:6(n-3) conversion, even if the fish has the capacity to carry out this conversion. *Artemia* nauplii supplemented with fish oils preferentially catabolize 22:6(n-3) relative to 22:5 (n-3). Thus final ratio of 22:6 (n-3): 20:5(n-3) is invariably substantially less than the starting feed. Oils with a high ratio of DHA: EPA should be used in live feed enrichment protocols. Relative excess of 20:5(n-3) over 22:6(n-3) can be harmful in larval feeds. 20:5(n-3) competitively inhibits production of eicosanoids from arachidonic acid 20:4(n-6). Arachidonic acid is the major precursor of eicosanoids in fish and higher vertebrates, despite the surfeit of 20:5(n-3) over 20:4(n-6) in fishes. Current emphasis is on a desirable ratio of 20:5(n-3):20:4(n-6) in larval fish feeds.

General understanding is that marine fish lack Ä-5 desaturase activity. Hence they cannot convert 18:2 (n-3) to 20:4(n-6). Therefore, 20:4(n-6) has been an essential function of producing eicosanoids making it an essential fatty acid (EFA) in marine fish, which has to be provided in larval feeds. Supplementation of marine fish larval feeds with (n-3) HUFA fish oils has obscured the potential importance of 20:4 (n-6) in larval nutrition.

The status of knowledge being so, we have replacements for phytoplankton in the shrimp hatchery known as crustacean algal replacement (CAR). In fish hatcheries, green water is the hatching medium till mouth opens and even after the mouth opens, green water continues to be the medium till the larvae feeds upon rotifers or copepodites.

Copepodites have the phospholipid profile with the most appropriate fatty acid ratios. Culture of copepods is difficult and it is well known that if available that is the best live feed once the fish larvae are able to feed on zooplankters. Products like 'Cyclopeeze' is a case in point. Other than that, tuna orbital oil based products, *Schizochytrium* based products like Algamac and many others are available today. CMFRI has also developed a product with fish roe, crude sardine oil and additives which are very cost effective compared to imported products.

Micro feeds

Feeds below 1.5 mm size are called microfeeds. They are used in larval nutrition, nurseries where fish fry a grown to a stockable size, especially for stocking in cages. All particulate feeds, micro embedded diets (MEM) and micro encapsulated diets (MED) come under this category. Twin screw extrusion, followed by marumerization and spheronization are the technologies used for their production. It will not be out of place to mention here that ornamental fish feeds also belong this category.

Indigenous production of these feeds is still in its infancy because capital investment in this segment of aquafeed production is lacking because the market is catered to with imported products. Import and trade of these products increases the cost of seed production. In order to optimize the cost of seed production in our country, at some stage indigenization of this segment is imperative.

Growout feeds

Aquafeed production in India started with shrimp feed. According to American Soybean Association, from 1.25 lakh tonnes in 2005 shrimp feed production is reported to be 7.85 lakh tonnes annually in 2015. During the same period fish feed production from meager 3000 tonnes grew to 5.85 lakh tonnes.

The indications clearly are that fish feed production in India is growing with more and more farmers switching over to floating extruded feeds, especially in the freshwater fish culture.

State-of-the-art extruders have come in and the two types of extruded floating fish feeds are available for the fresh water fish culture sector. Carp feeds containing fishmeal and fish oil, and catfish feeds without fishmeal and fish oil. The feed containing marine ingredients is for carps and the one without them is for catfish.

This is produced by about 14 extruded feed mills and according the American Soybean Association for which there is an overcapacity now. The installed capacity is for 1.5 million tones and the current production is approximately 0.6 million tonnes. There is no commercial scale marine fish feed production because it requires a few add-on technologies.

Marine fish require high protein and fat diets. The requirement is shown below.

Nutrient requirements of marine carnivorous fish (in percent)

Size of fish	Moisture	Crude protein (CP)	Crude fat or Ether extract (EE)	Crude Fiber (CF)
Fingerling (1 inch – 20 g)	<12	>42	>5	<4
Juvenile (20-50 g)	<12	>40	>5	<4
Grower (50-300 g)	<12	>38	>5	<4
Marketable size (> 300 g)	<12	>35	>5	<4

With fat in these feeds exceeding 10% production of floating feeds require another technology known as post-pellet liquid application (PPLA) which is vacuum coating. The internal fat in feed formulation when exceeds 6% cannot be extruded with the floating property. Therefore, vacuum coating of fat is required to incorporate fat above 6% and still retain the floating property of the feed.

To conclude, it can be said that seed and feed which are the major recurring inputs in aquaculture are sufficiently available for fresh water aquaculture and shrimp culture. For marine fish culture, especially in cages in the sea, seed availability is a constraint. Hatchery and nursery feeds (micro feeds) are imported making the cost of seed production and nursery rearing costly. Indigenous micro feed production capability should be established. For grow out, there is an over capacity already installed for extruded feed production. As the volume of requirement for marine fish feeds grows with add on technologies like vacuum coating, self-sufficiency can be achieved in its production faster than micro feed production for which capital investment is yet to begin.

All feed production figures are from American Soybean Association, India represented by Dr. P. E. Vijay Anand, Deputy Regional Director, Asia subcontinent, USSEC, Mr. R. Umakanth

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For all related references please contact the author through email.