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ROLE OF NUTRITION IN BROODSTOCK MANAGEMENT - PRAWNS

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For successful hatchery production of prawn seed a steady supply of spawners of desired species of prawns at the proper time is a necessary prerequisite. The uncertainity of procuring spawners from the wild has stimulated worldwide interest in the efforts to induce prawns to mature under controlled conditions. A successful technology for inducing maturity and spawning of penaeid prawns has been developed at the Marine Prawn Hatchery Laboratory (MPHL) of Central Marine Fisheries Research Institute by employing the method of unilateral eyestalk ablation. Using this technique many commercially important species of penaeid prawns (Penaeus monodon, Penaeus indicus, Penaeus semisulcatus, Metapenaeus dobsoni, Metapenaeus monoceros and Parapenaeopsis stylifera) have been induced to mature and spawn in captivity (Muthu and Laxminarayana, 1977, 1979, 1982; Laxminarayana and Sasidharan, 1983). A system for sustained production and maintenance of hroodstock has been established.

One of the important factors in the development and management of broodstock is the availability of an appropriate feed. Dietary nutrition plays an important role in the maturation, spawning and the quality of eggs spawned. However, precise information on the nutritional requirements of broodstock prawns is scanty. Of late, considerable interest has been generated in the nutritional studies of prawns. The major dietary nutrients like proteins, lipids, carbohydrates and minor nutrients such as vitamins and minerals play a vital role in the maturation of prawns. Recent studies on the nutritional requirements of prawns have focussed on lipids which provide energy as well as essential nutrients such as fatty acids and steroids. Research work on the requirements of other nutrients for broodstock prawns is very much needed to establish the missing links. Based on the knowledge of the nutritional requirements, a comprehensive feed for broodstock has to be evolved. The information available on the nutritional studies of broodstock prawns is presented in this paper.

NUTRITIONAL REQUIREMENTS

Earlier studies have shown that penaeid prawns have a very high lipid content which is maintained by dietary intake. Of the lipid components, steroids and fatty acids are most important. Steroids are needed by shrimp as moulting hormones, sex hormones and membrane components, yet these animals are unable to biosynthesize the steroid nucleus. Fatty acids are also membrane components and fulfil a significant role in energy storage. A range of these components can be biosynthesized, but others ("essential fatty acids") are needed in the diet of prawns.

Middleditch et al. (1979) studied the fatty acid profiles of gonad, digestive gland and tail muscle samples of male and female penaeid shrimp (Penaeus setiferus, P. stylirostris and P. vannamei) obtained from the sea. The major fatty acids of the lipids from mature ovaries were C_{20} and C_{22} polyunsaturated fatty acids (PUFA). They obtained ovarian maturation and spawning in P. setiferus by feeding the prawns with an annelid (Glycera dibranchiata) which is rich in C_{20} and C_{22} polyunsaturated fatty acids. Based on their studies Middleditch et al. (1979) suggested that the reproduction of prawns is mediated by prostaglandins derived from these fatty acids.

In whild Penaeus japonicus, Teshima and Kanazawa (1983) observed an increase in the ovarian lipid concentration from slightly mature to yellow ovarian stages reaching constant levels in mature ovaries and declining after spawning. In contrast, lipid levels in the hepatopancreas declined in mature ovaries after reaching a maximum in the yellow ovaries, suggesting a possible movement of lipids from the hepatopancreas to ovaries during maturation. Ovarian lipid concentration in wild Penaeus aztecus showed an increase from early developing to ripe stages and a decline in spent stages (Chamberlain and Lawrence, 1983). There was also an increase in ovarian carbohydrate levels from nearly ripe to ripe stages but no changes in the protein concentration for all maturation stages. Ovarian lipid concentration in immature Penaeus monodon increased upon reaching full maturity from 5.8 to 17.0% in wild (unablated) females (Willamena et al., 1984) and from 7.5 to 21.9% in wild ablated females. The fatty acid profile showed 12.14 - 24.87% and 11.81 - 24.50% for total fatty acids in wild (unablated) and wild ablated females respectively, to consist of 20:4W6 (arachidonic acid) 20:5W3 (eicosapentaenoic acid) and 22:6W3 (docasahexaenoic acid). The same plyunsaturated fatty acids were reflected in spawned eggs, indicating their importance in the reproductive process.

FOOD AND FEEDING

Broodstock prawns have generally been fed on fresh or frozen mussel, clam, oyster or squid meat. Other food items used are fresh or frozen marine worms, mysids shrimp and fish and dried pellets. These various items may be given alone or in combination. The broodstock are fed *ad libitum* or according to a daily feeding rate of approximately 3-5% for dry feed (pellets) and 10-30% for wet (fresh or frozen) feed. Feed is given once upto 4 times a day and daily ration divided accordingly. Best results were obtained when the broodstock of prawns (*Penaeus indicus*, *P. monodon*, *P. semisulcatus*, *Metapenaeus dobsoni*, *M. monoceros* and *Parapenaeopsis stylifera*) were fed *ad libitum* on clam (*Sunneta scripta*) meat (Muthu and Laxminarayana, 1977, 1979, 1982; Laxminarayana and Sasidharan, 1983). The clam fed to broodstock prawns usually have mature gonads which may be supplying the essential fatty acids and carotenoids needed for the ovarian development of prawns. Middleditch *et al.* (1980 b) have found that bivalves are rich in C20:4, C20:5 and C22:6 fatty acids.

A mussel-pellet and all-mussel feeding combination gave better maturation and hatching rates than a squid pellet or all-pellet feeding for ablated *Penaeus monodon* (Primavera *et al.*, 1979). The composition of the pellet used by Primavera *et al.* (1979) is given below.

Ingredients	% in diet
Fish meal	20
Shrimp head meal	20
Squid meal	25
Rice bran	10
Wheat flour	10

Agar	4
Sago palm starch (Landing)	4
Soybean oil	5
V22 (Vitamin mix)	1.9
Ascorbic acid	0.1

Aquacop (1979) found that among the different compounded pellets tested, the best ones were high protein diets (60%) containing squid meal. They also reported that if females are isolated and allowed to complete the ovarian development in separate tanks where a supplement of fresh troca (Trochus niloticus) flesh is given, the quality of eggs spawned is much better.

Chamberlain et al. (1981) fed four single diets (clams, shrimp, squid and worms) and one composite diet consisting of all four foods to the broodstock of Penaeus vannemei. They found that the composite diet was the best overall diet while squid was the best single-food diet, followed by shrimp, worms and clams. (Caillouet (1973) fed unablated Penaeus duorarum with diets to which additives such as beta carotene, phosphatidylcholine, cholesterol, DL alpha tocopherol, calciferol and 17 beta estradiol were added, but the prawns did not attain maturity.

Lawrence et al. (1980) fed the broodstock of Penaeus setiferus on oyster (Crassostrea sp.), squid (Loligo sp.), sandworm (Neries viridens) and a prepared dried feed. They have used three feeding times: 0800 hrs, oyster or prepared dried feed; 1130 hrs, squid; and 1500 hrs, sandworm. Maturation and repeated spawning and successful hatching was achieved when the above feed combination was used. The composition and percent protein, carbohydrate and lipid content of the prepared feed is given below:

Component of feed	Percent
Shrimp Meal (sun dried)	35.0
Squid meal	25.0
Manhaden meal	15.0
Rice bran	12.5
Vitamin mix (AIN 76)	2.0
Mineral mix (AIN 76)	1.0
Fish soluble	2.0
Menhaden oil	2.5
Cholesterol	0.5
Lecithin	1.0
Sodium Hexametaphosphate	1.0
Sodium Alginate	2.5

The percent protein, carbohydrate and lipid content of the above feed was 40.8, 28.2 and 12.4 respectively.

REMARKS

For feeding the broodstock prawns definite time schedules and feeding rates should be established so that the quantity of food would not be limiting. These schedules will also ensure that a variety of nutrients will be supplied during different time of day. Care should be taken to see that the excess food and faecal matter in the maturation pools and tanks are removed daily. If this is not done, the water quality will deteriorate rapidly as decay of these substances, will increase the biological oxygen demand of water. Under such circumstances the intake of food by the prawns declines markedly (Muthu and Laxminarayana, 1982).

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NUTRITION OF BROODSTOCK - FINFISH

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One of the requisites for development of finfish culture is an assured supply of the fish seed throughout the year. The production of healthy larvae, fry and fingerlings of finfish depend on the nutritional and physiological status of the broodstock. Though nutrition is known to have considerable effect upon gonadal growth and fecundity, precise information on the nutritional requirements for gonadal maturation in finfish broodstock is lacking.

Poynter (1976) clearly demonstrated that the fecundity of hatchery reared lake trout appears to be directly related to food availability. Fish fed at a daily rate of 0.75% of their body weight produced more and larger eggs with higher fertility than those fed at a rate of 0.5% of their body weight. Scott (1962) found that variations in egg number are related to the size of the fish, size of the eggs, and adequacy of the diet. Hester (1964), working with *Lebister reticulatus*, determined that reduced numbers of offspring and reduced large - middle - sized oocyte with reduced ration. Bagenal (1969) also observed that the number of eggs produced by the brown trout *Salmo trutta* was higher in the better fed fish. Dahlgren (1980), who studied the effect of three different protein levels on the fecundity of the guppy *Poecilia reticulata* reported that the average gonadosomatic index (GSI) was highest in groups fed the highest protein diet, but the fecundity of the fish was not affected by diet.

Watanabe et al. (1984 a, b, c) have carried out a series of nutritional experiments on broodstock of both rainbow trout and red sea bream.

Rainbow trout:

Studies with rainbow trout have shown that there was no significant difference in the egg production (3000 egg diameter (5.2 mm), the proportion of eggs reaching the eyed egg stage (90%), and the proportion of hatching (87%) between treatments fed with low-protein high energy diets (33-35% crude protein and 390 Kcal/100 g) or a high protein diet (43-47% crude protein). However a diet lacking supplementary minerals produced relatively less number of eggs (2000 eggs/female), less number of eggs reaching the eyed state (3.7%) and hatching (0.4%). These results demonstrate that diets with low protein and high energy can be successfully used for broodstock. But, a trace metal supplement was indispensable for the reproduction of rainbow trout. Subsequent trace metals analyses revealed that manganese concentration was significantly low (4.1 ± 0.7 µg/g) in eggs of females given the diet with minerals, when compared to diet lacking in trace metal supplement (1.6 ± 0.1 µg/g).

In a subsequent experiment, it was confirmed that broodstock diets with 36% crude protein and 18% lipid performed as well as those given a diet with 46% crude protein and 15% lipid. Besides, beef tallow when used at a level of 7% as on energy source had no adverse effect on the reproduction of rainbow trout. However diets deficient in essential fatty acids provided the lowest egg numbers, eyed eggs and total hatchlings. One salient finding is that addition of linoleic acid, 18:2W6 to the EFA deficient broodstock diet led to marked improvement in percentage fertilization, percentage of eyed eggs, and total hatch compared with broodstock given diets lacking essential fatty acids.

This is a very interesting finding since linolenic acid (18:3W3) is found to be the EFA for rainbow trout fingerlings. Subsequent research has shown that the eggs produced by rainbow trout contain 20:4W6 (arachidonic acid and a possible dietary importance of W6 fatty acids in rainbow trout has been suggested.

Red Sea bream

In red sea bream, when krill, *Mysis*, shrimp and crab wastes are fed to broodstock, pigmentation of the eggs has been noticed within a matter of hours, suggesting that the nutritional value of the diet given to broodstock shortly before spawning may affect the results of spawning. It is suggested that the quality of eggs may be improved by feeding the broodstock with some fat-soluble nutrients such as essential fatty acids and vitamins. Subsequent studies by Watanabe *et al*. (1984 a, b, c) showed that supplementation of diets with -carotene and canthaxanthin or krill oil extract led to a slight decrease in the total number of eggs produced. But the percentage of buoyant eggs increased from 49.1% to 56.4% and 69.6% respectively in the above diets with pigments. Frozen raw krill led to marked improvements in both the total number of eggs produced and percentage of buoyant eggs. In eggs from broodstock fed the diet containing corn oil, abnormalities in the number of oil globules increased to 94%. The number of normal larvae obtained were highest for the krill diet (91.2%) but lowest (24%) for the corn oil (10%) based diet. These results suggest the important of proper nutrition for fish broodstock.

Leptobarbus hoevenii:

Studies carried out on this species (Pathmasothy 1985) showed that relatively high protein levels (32 and 40%)

are required for optimum performance compared to a low protein diet (24% crude protein). The GSI values and fecundity were also significantly higher with the 32 and 40% diets than with the 24% diet. However, there were no significant differences in the individual egg weight.

Common carp:

Vitamin E has been shown to be important in the reproductive physiology of fishes. Adult female common carp (100 g) fed a vitamin E deficient diet for 17 months displayed reduced weight gain, lower gonadosomatic index, apparent muscular dystrophy, higher muscle water content, lower muscle protein content, lower concentrations of yolk granule in oocytes compared with individuals fed 700 mg -tocopherol/kg dry diet (Watanabe and Takashimo, 1977).

Assessment of nutritional status of broodstock based upon the biochemical composition of fully mature ova and fertilized eggs.

One of the best clues about the nutrient requirements of a fish broodstock can be gained from the biochemical composition of the ova as well as fertilized eggs. However, thus for work on this aspect has been very limited and incomplete. By determining the protein, lipids, carbohydrate, amino acids pattern, fatty acids profile, composition of minerals and vitamins, hormones, prostaglandins etc., guidelines can be evolved in providing nutritionally adequate diets. An important area of research requiring greater emphasis is the nutritional bioenergetics of the brood fish, to provide information as to how the nutrients are partitioned in maturing fish. Information on somatic growth would provide additional clues about the requirement.

Ackman (1964) concluded that the fatty acid composition of fish egg lipids is distinctive for each species and did not necessarily related to the diet or depot fat of the adult. Ackman (1964) found that cod roe contained increased levels of 16:0, 20:4W6, 20:5W3 and 22:6W3 compared with the liver lipids of the same female fish.

Shimma *et al*. (1977) found that the hatchability of eggs from carp fed several different formulated feeds was greatly reduced when the 22:6w3 of the egg lipid was less than 10%. They also observed that the muscle, plasma, and erythrocyte fatty acid compositions were more affected by dietary lipid than that of the eggs.

Lasker and Theilacker (1962) found elevated levels of 16:0, 20:5w3 and 22:6w3 and reduced 18:1 in the ovary compared to mesenteric fact of Pacific sardines fed a natural copepod diet. Ovary of sardines retained high levels of 20:5w3 and 22:6w3.

Thus, there is an urgent need to study the biochemical changes occurring in the gonad and muscle during maturation with reference to nutrients intake for evolving practical feeds for broodstock.