Fish Nutrition[1]

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Introduction

For many years water quality has been the most important limitation to fish production. Advances in life support technology have been substantial in recent years, and nutrition is increasingly regarded a key limitation to increased production efficiency as well as the growth and propagation of “new” species.

Commercially prepared diets for channel catfish and salmonids have been developed using a great deal of research data on specific nutritional requirements of these species, their production systems and their life stages. Some nutritional studies have also been carried out for tilapia production. For all other species, including freshwater and marine ornamentals, nutritional management is based on a combination of application of knowledge generated for the species mentioned above and the experience of successful aquarists.

Most successfully reared ornamental fish are omnivores, and these are the species that have adapted best to captive conditions, including available nutrition. Successful maintenance of “difficult” species is often influenced by the aquarist's success in obtaining or rearing specialized food items. For example, members of the highly popular sygnathid family, sea horses and sea dragons, have long, tubular mouth parts. These animals are not physically capable of ingesting typical commercial fish foods. Instead, successful husbandry typically involves significant investment in the rearing of brine or mycid shrimp. The popularity of these animals has made the extra investment worthwhile for many commercial exhibits, but makes it unrealistic for the typical home aquarist.

Nutritional Composition of Fish Diets

Generally, fish diets tend to be very high in protein. Foods for fry and fingerlings frequently exceed 50% crude protein. As growth rate decreases and fish age, protein levels in diets are decreased accordingly. Protein levels on grow-out diets often approach or exceed 40% crude protein, while maintenance diets may contain as little as 25-35%. In addition to decreasing the protein content of the food as fish grow, the particle size must also be changed. Many fish require live food when they are hatched because their mouth parts are so small. Some fish, such as the channel catfish, are large enough to place on a fry diet immediately without having to bother with the expense and labor needed for live foods.

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Fish meal should be a major protein source in fish diets. There are essential amino and fatty acids that are present in fish meal but not present in tissue from terrestrial plants or animals. Low cost formulations in which fish meal has been eliminated and replaced by less expensive proteins from terrestrial sources (ie soybeans) are not recommended for fish. Fish meal and fishery by-products have high lipid content and therefore rancidity can be a problem if foods are not properly stored. Feed storage is discussed briefly below.

In addition to the concern for essential amino acids that may be present in fish meal, fish require long chain fatty acids (C_{20} and C_{22}) that are not found in tissue from terrestrial organisms. Fish meal, shrimp meal and various types of fishery by-products are the source for these essential fatty acids. In addition, crustacean by-products serve as a source of carotenoid pigments that are excellent for color enhancement. There is a high oil content associated with carotenoid pigments, so vitamin E supplementation is recommended when these are used.

Vitamin and mineral requirements of most fish species are not well understood. It is known that fish absorb minerals from the water. Calcium deficiency of channel catfish fry has been associated with calcium concentrations less than 10 mg/L in rearing systems. Calcium chloride has been used to raise the calcium concentration of water used for fry rearing. Conversely, too much calcium in the water has been associated with reproductive problems in some Amazon fish. Water hardness > 100 mg/L has been attributed to formation of hard shells for eggs of some tetra species, and fry were not able to hatch.

Most fish require dietary ascorbic acid (vitamin C). This becomes very important if fish are reared in a poorly lit area where algae cannot grow, or if they are so crowded that they cannot consume any natural food items that might be in the water. Ascorbic acid added to fish foods should be phoshorylated to stabilize the vitamin and increase storage time. In addition, vitamins A, D, E and B complex should be added to fish foods. The concentration of vitamin E is often inadequate, especially in diets that are high in fat. If fish are housed in natural systems with algae and phytoplankton, and stocking rates are not too great, then vitamin supplementation seems to be less important, presumably because of the availability of natural food items.

Feed Storage

Because fish feeds usually contain relatively high amounts of fish meal and/or fish oil, they are very susceptible to rancidity. In addition, ascorbic acid is highly volatile, but critical to normal growth and development of most species of fish. For these reasons, fish feeds should be purchased frequently, ideally at least once a month and more frequently if possible. Feeds should be stored in a cool, dry place and should never be kept on hand for more than three months. Refrigeration of dry feeds is not recommended because of the high moisture content of that environment. Freezing is an acceptable way of extending the shelf life, however.

Vitamin C is an essential vitamin for fish, and most species tested are not capable of synthesizing their own. Stabilized (phosphorylated) forms of ascorbic acid are available and are used in many, but not all, fish feeds. Feeds that do not contain stabilized ascorbic acid are not recommended for fish. If assays for ascorbic acid content are to be run it is imperative to know which form the vitamin is in before sending the feed sample to a laboratory.

Types of Feeds

Commercially milled fish foods are usually sold as dry or semi-moist pellets or as flakes. Pellets are typically the most complete diets. They are cooked, and, if marketed as a complete ration, the nutrition in each particle should be uniform. Disadvantages include the potential for rapid sinking unless the pellet is extruded. In addition, the pellet size is very important. It may be impossible to manufacture a particle small enough for some fish, especially juveniles of many species. For larger animals, a very small pellet may be unacceptable. Semi-moist diets are soft and compact. Many of these are expensive, but they tend to be high quality diets and may be an excellent choice for some species.

Flakes have been used extensively in the ornamental fish industry for many years and have the advantage of being soft enough for very small fish to consume. They also sink very slowly. Unfortunately, the volume required to meet the nutritional needs of the animals may be deceptively high. The author recommends weighing the diet to approximate the amount required and avoid accidental underfeeding.

Technology associated with rearing of live foods is improving rapidly. This is having a positive impact on larval rearing, a frequent bottleneck for commercialization of “new” species. Rotifers are the smallest live food that is routinely used for larval rearing. Newly hatched brine shrimp are larger, but still quite small, and are commonly used in fish hatcheries. Cultured live foods can provide a source of high quality nutrition, but care must be taken to avoid perpetuation of infectious disease. Use of wild caught food items is also risky because of the potential for disease introduction.

Feeding Practices

Fish should be fed based on a percentage of body weight. For maintenance, 0.5-1.0% body weight per day is adequate. Fish should probably be fed at least 5 days per week. The most common mistake made by pet owners is over-feeding their fish, often with resulting degradation of water quality. Occasionally however, owners dramatically underfeed their fish. This is alluded to above. One feeding per day is plenty for most pet animals. Rearing of young stock does require small meals fed more frequently. This is often accomplished using automatic feeders on commercial farms.

Nutritional Diseases

Nutritional disease is often a diagnosis of exclusion. Other explanations for the problem are ruled out and then the feeding program is critically evaluated. Several examples of nutritional disease merit mention. These include starvation, scoliosis, nutritional anemia, and gill disease. Each is discussed briefly below.

Starvation is usually the result of poor husbandry and, in many cases, is a sequelae to environmental problems. A poorly designed or maintained system is likely to develop water quality problems with related morbidity or mortality among the fish. In an effort to correct the water quality problems aquarists may cut back on feed to the point where the animals are in a negative caloric balance and begin to lose weight, If the problem becomes chronic, starvation can result.

The classical cause of scoliosis, or “broken back disease” in fish is ascorbic acid deficiency. Improvements in feed manufacture, including phosphorylation of vitamin C, and feed storage, have decreased the incidence of nutritionally derived scoliosis. Still, ascorbic acid deficiency must be considered as a possible cause of scoliosis and a thorough review of feeding practices is warranted when evaluating such cases.

Nutritional anemia is caused by folic acid deficiency and has been reported in channel catfish. The diagnosis is often based initially on history, with multiple units developing similar signs at the same time. When suspected, a sample of feed should be frozen for later analysis, but all affected ponds should have the feed changed immediately to a fresh lot. The problem is caused by bacterial contamination of feed, so it is not related to particular brands or formulations.

Nutritional gill disease has been described in channel catfish and is caused by pantothenic acid deficiency. The primary lamellae at the tips of affected gills are fused, resulting in a very characteristic histologic lesion. Clinically the condition is rare, probably because of improvements in feed formulations.

Advances in the diagnosis and correction of nutritional disease should be significant over the next few years as there seems to be a great deal of research activity in this area. In the interim, practitioners are encouraged to include questions about diet and feeding practices in their histories and to keep the potential for a nutritional etiology in mind when working through perplexing cases.

Recommended Reading

1. Lovell, T. 1988. *Nutrition and Feeding of Fish*. Van Nostrand Reinhold, New York, NY 260 pp.

2. Roberts, R.J. 1989. Nutritional pathology of teleosts, In: *Fish Pathology*, R.J. Roberts (Ed).,. Balliere-Tindall, London Pp. 337-362.

3. Winfree, R.A. 1992. Nutrition and feeding of tropical fish, IN*: Aquariology: The Science of Fish Health Management*. J.B. Gratzek (ED). Tetra Press, Morris Plains, NJ Pp. 197-206.