

Nutrition of Ornamental Fish: Water Soluble Vitamin Leaching and Growth of *Paracheiroidon innesi*¹

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EXPANDED ABSTRACT

Indexing Key Words:

- ornamental fish • neon tetra • *Paracheiroidon innesi* • vitamin leaching • feed frequency

Ornamental fish keeping has become an increasingly popular hobby, and there are now more than 330 million ornamental fish sold each year throughout the world (Riehl and Baensch 1989). Although the total number of fish species exceeds 30,000 (Priede 1987), only 4000 of these species classify as freshwater ornamental species (Riehl and Baensch 1989). Of these species a few hundred are popular and are generally available to the hobbyist. In contrast to the popularity and the scale of the ornamental fish hobby the knowledge of the nutritional requirements of popular ornamental fish species kept in captivity has received very little attention. The present knowledge of the nutritional requirements of fish are limited to a small number of species that are important in the aquaculture food-fish industry (NRC 1981, 1983).

Except for goldfish (*Carassius auratus*) and a small number of tropical freshwater carnivorous fish species (i.e., some *Cichlidae spp*), ornamental fish are rarely kept in a single species environment. In a multi species tank, representatives of herbivore, omnivore and carnivore fish species share a common environment in which they feed on a single diet. Nutritional strategies for ornamental fish highlight the need to strike an equilibrium in the dietary formulation between the requirements of herbivorous and carnivorous species when delivering diets for community fish species. More critical than the dry matter formulation is the distribution of food between individuals of one species and between different species kept in the same aquarium. The physical characteristics of the diet also plays an important role when species of various weights,

from 0.15 g (*Characidae*) to >20 g (*Cichlidae*), are fed on one diet. Diets need to be small enough for the smaller species but large enough to be identified and eaten by the larger species. Natural hierarchy between individuals within one specie and across species (Milinski 1993) is further exacerbated during feeding because not all ornamental species will consume food from the surface or the bottom of the tank. In their native habitat most species will forage for food during the day and are not adapted to rely on a single meal; they do not have a defined stomach and are therefore unable to temporarily store large quantities of food. The smallest species of ornamental fish (*Characidae*) have a high metabolic rate and require a frequent supply of food to sustain growth or maintenance.

Materials and methods. Study 1. The effect of feed frequency on growth of neon tetras (*Paracheiroidon innesi*) was carried out using 120 fish, with an average bodyweight of 0.1705 ± 0.004 g, which were purchased from a local dealer and quarantined for a period of 4 wk before the trial. The fish were fed experimental diet 1, which was a steam drum-dried, flaked product with 39.0% protein, 12.7% fat, 30.0% carbohydrate, 13.3% ash, 4.8% moisture and GE 19.66 MJ · kg⁻¹ and a particle size of 2 mm. Fifteen randomly chosen neon tetras were assigned to each of eight 50-l tanks maintained at 26°C. The eight tanks were part of a matured recirculation system with a flow rate of 150 l/h per tank. The fish were fed Monday to Friday but not during the weekends. Feeding was maintained

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at 2.5% of the total bodyweight per feeding-day throughout the 20 feeding days of the 28-day trial. Four separate feed frequencies were maintained in duplicate. Fish were either fed their whole portion at 0900, two half portions at 0900 and 1500, three one-third portions at 0900, 1200 and 1500 or four one-quarter portions at 0900, 1100, 1300 and 1500. The neon tetras were weighed individually on an analytical balance (Sartorius, AC 210P, Göttingen, Germany), while swimming in a container with 25 ml aquarium water, at the beginning of the trial, after 2 wk and at the end of the trial. The feeding portions were recalculated as 2.5% bodyweight after the first 2 wk to maintain a fixed bodyweight feeding level. Two days prior to weighing the fish were deprived of food. Growth was expressed as specific growth rate (SGR) (Table 1) and calculated as

$$\text{SGR (\% bodyweight growth/day)} = 100 \cdot (\ln W_2 - \ln W_1) \cdot 28^{-1}$$

in which $\ln(W_2)$ and $\ln(W_1)$ are the \log_e of the average bodyweights at the end (W_2) and beginning (W_1) of the trial.

Study 2. Leaching of pyridoxine, cyanocobalamin, pteroylmonoglutamic acid, choline, ascorbic acid and pantothenic acid was measured from an experimental flake diet 2. It was a steam drum-dried, flaked product with 35.5% protein, 8.3% fat, 40.7% carbohydrate, 11.0% ash and 4.5% moisture (GE: 18.95 MJ · kg⁻¹ and the average surface to volume ratio was 728 cm² · gram⁻¹ (See Table 2 for vitamin content). A 250-g sample of flake was placed into a nylon-mesh net that was submerged for 30 s in tap water inside a 1000-l tank, without fish, at a temperature of 26°C. After 30 s the flakes were removed from the water and immediately frozen to -20°C and were freeze dried. Percentage vitamin leaching was calculated as the decrease in vitamin concentration, on a dry matter basis, after submersion in water.

Results. **Study 1.** Table 1 shows that as meal size decreased from 4.3 to 1.4 mg · fish⁻¹ · meal⁻¹ and meal

TABLE 1

Effect of feed frequency on specific growth rate (SGR) of neon tetras (Paracheirodon innesi)¹

Feeding frequency	Meal size	SGR ²
meals · d ⁻¹	mg · fish ⁻¹ · meal ⁻¹	% bodyweight · d ⁻¹
1×	4.26	0.32 ± 0.04
2×	2.13	0.42 ± 0.09
3×	1.42	0.52 ± 0.24
4×	1.07	0.27 ± 0.20

¹ Fifteen neon tetras were used per tank. Each frequency treatment was carried out in two tanks.

² Values are means ± SD.

TABLE 2

Effect of vitamin leaching from experimental diet 2 after a period of 30 s in water (n = 1)

Vitamin	Concentration before contact with water	Percentage vitamin loss in 30 s
mg · kg dry diet ⁻¹		
Pyridoxine	49	6.1
Pteroyl-monoglutamic acid	25	16.0
Choline	3700	27.0
Pantotenic acid	76	47.4
Ascorbic acid	470	66.0
Cyanocobalamin	0.6	90.0

frequency increased from 1 to 3 meals per day the specific growth rate (%BW growth · day⁻¹) increased from 0.32 to 0.52% · day⁻¹. A further increase in meal frequency to 4 meals per day resulted in a decrease in SGR to 0.27% · day⁻¹. As neon tetras are shoaling pelagic feeders and predominantly consume food as it falls through the water column, it is possible that fish fed either one or four meals per day wasted more food. When fish were fed their daily ration as one meal they were unable to consume all the food as the sinking rate of the diet exceeded the rate of consumption by the fish. The fish fed four small meals invariably had difficulty in finding their food before it reached the bottom of the tank. This may explain why the increased standard deviation of SGR increased from 13 to 74% of the mean, as meal frequency increased from one to four times per day.

Study 2. The results of the leaching experiment (Table 2) illustrate that leaching during the first 30 s in water varied between 6.1% for pyridoxine up to 90.0% for cyanocobalamin. These findings show that ornamental fish foods should not be formulated to provide nutrients as a percentage of the dry diet but with the consideration as to the actual amount consumed by each species. However over supplementation with the aim to overcoming vitamin degradation and leaching should be avoided to limit the risk of hypervitaminosis (NRC 1987), especially if these diets are fed to surface-feeding species. The vitamins that are leached into the water are not known to be taken up through the skin or gills by freshwater fish species which, in a hypo-osmotic environment, do not drink. Marine species do drink seawater; however, the drinking rate is lower than the tank volume so that only a small fraction is taken up through this route. Depending on the surface-to-volume ratio of the diet and the solubility of the nutrients the diet will show a rate-dependent loss of each individual nutrient. Bottom-feeding fish in a community aquarium not only receive a smaller share of the diet but are also most likely to encounter diets deficient in water soluble nu-

trients than other fish. Fish owners can in part overcome this disadvantage by increasing the total feed gift to the aquarium; however, the repercussion on pollution of the aquarium environment and its effect on pollution-induced stress make this option unpractical (Pannevis 1993). Although difficult to quantify the rapid turnover of ornamental fish can be partly explained by poorly formulated ornamental fish foods combined with overfeeding and a lack of aquarium maintenance, further research has to be focused on the study of the nutritional requirements of ornamental fish in relation to the interspecies dynamics and husbandry objectives. In order to determine the nutrient requirement of ornamental fish, further research has to be carried out by formulating palatable, microencapsulated or low-leaching diets that provide the necessary amounts of water soluble nutrients to ornamental fish.

LITERATURE CITED

- Milinski, M. (1993) Predation risk and feeding behaviour. In: *Behaviour of Teleost Fishes* (Pitcher, T. J., ed.), 2nd edition. p. 285–305. Chapman & Hall, London, UK.
- NRC (1981) Nutrient requirement of coldwater fishes. National Academy Press, Washington, DC.
- NRC (1983) Nutrient requirements of warmwater fishes and shellfishes. National Academy Press, Washington, DC.
- NRC (1987) Vitamin tolerance of animals. National Academy Press, Washington, DC.
- Pannevis, M. C. (1993) Nutrition of ornamental fish. In: *Waltham Book of Companion Animal Nutrition* (Burger, I. H., ed.), chap. 7, p. 85–96. Pergamonn Press, Oxford, UK.
- Priede, I. G. (1987) Introduction to fish. In: *The UFAW Handbook on Care & Management of Laboratory Animals* (Poole, T., ed.), 6th ed., chapter 54, p. 784–823. Longman Science & Technical, London, UK.
- Riehl, R., Baensch, H. A. (1989) *Aquarium Atlas*. Baensch, Melle, Germany.