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Review article

FOOD REQUIREMENTS AND DIETARY IN AQUARIUM FISH (Review)

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ABSTRACT: Nutrients essential to fish are the same as those required by most other animals. These include water, proteins (amino acids), lipids (fats, oils, fatty acids), carbohydrates (sugars, starch), vitamins, minerals and other supplementary additive such as probiotic and prebiotic. In their natural environment fish have developed a wide variety of feeding specializations (behavioral, morphological, and physiological) to acquire essential nutrients and utilize varied food sources. In past decade the nutritional requirements of various fish species have understood and technological advances in feed manufacturing have been obtained. This resulted in development and use of formulated and manufactured feeds to replace natural feeds in the aquaculture industry. The production and trade of ornamental fish is a profitable alternative in the aquaculture activity. In spite of economical importance of ornamental fishes, the nutritional information for these fishes is few or even no data is available. In this respect we had a review of some articles on nutritional requirements of ornamental fishes.
Keywords: nutrition- formulated feed- ornamental fish- aquaculture industry

INTRODUCTION

The feed of fish and their nutrient value is one of the most important factors in production cost and health of fish. Feeding habite of the fish is very difference in the form of Carnivorous, Herbivorous, Omnivorous and also there is a large diversity in their feeding patterns. Like farmed fish, some aquarium fish are surface feeders, some mid-water or bottom feeders Diets for aquatic animals can only be effective if they are formulated to contain the full array of necessary nutrients at appropriate concentrations relative to each other along with appropriate factors inducing rapid consumption on a consistent basis [1]. Some fish are tiedly depend on natural feed. We may give example of some sturgeon fish [2] and some grow by formulated artificial food. Obviously it is not possible supply their native food and the varieties that they need to survive and grow but by analyzing the requirement the food factories try to prepare the best food for aquarium fish. Aquarium fish feed is plant or animal material intended for consumption by pet fish kept in aquariums or ponds. Fish foods normally contain macro nutrients, trace elements and vitamins necessary to keep captive fish in good health [3]. In most cases, fish only need to be fed once a day, and only need to feed a small amount. Your fish should be able to get enough nutrients from the food they can consume in under two minutes, as long as the food provides for their nutritional needs [4]. Feeding ornamental fish is more serious and difficult compare to pond fish culture due to limitation of space and lack of natural food. In order to make the aquarium similar to their habit: adjusting the temperature, light, salinity, oxygen, pH and hardness and filling with plants, the fish may feel self-confident and take the food.

In ornamental fish, a correct formulation of the diet improve the nutrient digestibility, supply the metabolic needs and reducing the maintenance cost and at the same time the water pollution [5]. In natural conditions, fish can regulate and maintain their food intake and therefore their nutritional requirements, reducing the possibility of suffering nutritional deficiencies. Despite the economical importance of this sector, the nutritional information for ornamental fish is scarce and often few or even no data of the nutritional requirements is available [6].

The aim of this article is to review the information available in the nutrition of freshwater ornamental fish, its digestion and physiology and the need to carry out more research in this relevant area.

Feeding and digestion in fish

The first portion of digestive system in fish is mouth. The positioning of the mouth is important. Most carnivores fishes have terminal (Astronotus sp. or Oscar Cichlid) mouths. Suckers and other bottom-feeders have subterminal mouths (Catfishes). Surface-feeders have upturned, or supraterminal, mouths. Some species of fish have teeth. The teeth in fish are generally adapted for performing special functions. Predatory Catfish will for instance have small sharp pointed teeth [7]. Esophagus in bony fishes is short and expandable so that large objects can be swallowed. The esophagus walls are layered with muscle. The stomachs of fish are also generally adapted to the kind of food they eat. Gastric glands release substances that break down the food to prepare it for digestion. At the end of the stomach, bony fishes have pyloric caeca, it probably functions both in digestion and absorption of food [8]. Food that is partially digested moves from the stomach into the intestine. Here it is digested further and the nutrients are absorbed into the body. The herbivores have an elongated intestine and their systems are more complicated than the carnivores. Food that is not completely digested and absorbed leaves the body through the anal opening, together with other waste products produced by the metabolism [7].

Of the few groups of fishes known to derive their nutrition from the benthos, it is only the tilapias that have true stomachs and a gut structure and function that are remarkably similar to mammals, so that digestion and absorption generally correlates with diet [9].

Digestive processes differ in different fish species, but there are elements common to many fishes, and these could serve as a basis for estimating general parameters of digestion. A well-known and general relationship is the dependence of oxygen consumption rate on weight and temperature [10]. Therefore to have healthy fish in aquarium high oxygen supply should be managed. Another important factor regarding the digestion is the duration of digestion. The basic factors which determine the duration of digestion in fishes are: temperature, weight of food portion in the stomach, and fish weight [11]. In addition, duration of digestion may substantially depend on food composition and quality. Therefore, data obtained with natural food are of particular interest for ecologists [10].

Characteristics of fish foods

Most of fish have powerful sensory characters. If the flavor and odor of food is not good they reject of feeding. The characteristic of food is very important especially for bottom feeders. Flavor and taste, sound, smell, color and buoyancy of food are the main factor influence in feeding of ornamental fishes.

Flavor and taste: Smell can be detected by the specific anatomical receptors in fish, but flavor has to be dissolved in water for the fish to locate it. Some fish have receptors in their mouths, or on the head or lips. Some even have taste receptors on their skin. These receptors carry messages to the brain and tell the fish to swim towards the food [7]. The taste is generally caused by oxidation of the fat, however several factor increase oxidation. The long chain polyunsaturated fatty acids in fish oil and fish meal prevent the food oxidation. Storing meal will increase the chance for oxidation. Fish are an extremely diverse group, and meeting each species' nutritional requirements can be very different. A mixed diet or using different diet is the best way to ensure that all of your fish's nutritional needs are being available for fish. Fish are governed by olfactory senses and to certain extent taste buds. The food should be available and good flovor and good taste for fish, otherwise even it nutritionally would be superior but it is useless if it is far from the use of fish.

Sound: Through water, sound travels about four times faster than it does through air. So, a fish can actually "hear" sound through the vibrations that take place in water. By picking up these vibrations in water, the fish become aware of the feeding frenzies that cause many fish to conglomerate when the feeding begins. Also, there are fishes that are so used to a routine in their feeding that they start grouping when they hear sounds that normally precede feeding [7].

Smell: Fish meal manufacture is often associated with a characteristic of smell The smell comes over the meal and carries away vapours. The sense of smell is highly developed in fish. In nature, fish needs to be able to identify their food and also their mates through the sense of smell. So, many fish species have nostrils that help them to identify the various things they come across. These sensors thus help the fishes to zero-in on their food [7].

The chemicals in the effluent vapours from a fish meal are very much diluted, and are normally not harmful, but they are particularly smelly even when present in very low concentrations. Fresh raw material causes less trouble than stale, therefore rapid handling and processing has a beneficial effect. The smell of fishmeal should be fresh The fishy smell of high quality fishmeal is not very strong, the degree of fineness is even and state is fluffy, to be freshness, without dirt, big fish bones or ammonia smell.

Color and buoyancy of food: Fishmeal has a yellow brown, russet, off-white or dusty color and few are white. Fishmeal has slightly differences in appearances and smells according to its type. The moisture should be within 10% to ensure its storage and use safely. The buoyancy of fish meal depend on the fish in aquarium. Bottom feeder and most of tropical fish prefer to take the food when it sinked to the bottom.

Nutritional ingredients requirements in ornamental fish

Ornamental fish have basically the same nutritional requirements as other farmed fish. Prepared of complete artificial diets supply all the ingredients of protein, fats, carbohydrates, , vitamins, minerals and trace element, necessary for the optimal growth, reproduction and health of the fish. Most fish use complete diets, those containing all the required protein (15-50%), lipid (10-25%), carbohydrate (10-25%), ash (5-10%) and in addition about 5 percent other material such as trace element, vitamins, minerals, supplementary and complement (probiotic, prebiotic and enzymes). The nutritional value of a dietary ingredient is in part dependant on its ability to supply energy. Physiological fuel values are used to calculate and balance available energy values in prepared diets. They typically average 4, 4, and 9 kcal/g for protein, carbohydrate and lipid, respectively [12]. Feed acceptability, palatability and digestibility vary with the ingredients and feed quality. In feeding the Aquarium fish it should be pay careful attention in acceptance, calculate feed conversion ratios and feed efficiencies, and feeding activity of fish.

The efficiency of nutrient use by ornamental fish can contribute to the formulation of appropriate diets, as well as helping to decrease the elimination of nitrogen and phosphorus in excreta, thereby favoring the maintenance of the water quality and reducing environmental pollution caused by effluence [13]

Energy: Dietary nutrients are a source of stored energy for fish digestion, absorption, growth, reproduction and other life processes of fish. The nutritional value of a dietary ingredient is in part dependant on its ability to supply energy. To create an optimum diet, the ratio of protein to energy must be determined separately for each fish species. Excess energy relative to protein content in the diet may result in high lipid deposition. The deposition of fat are first in liver and prevent the growth of fish. Similarly, a diet with inadequate energy content can result in reduced weight gain because the fish cannot eat enough feed to satisfy their energy requirements for growth. Properly formulated prepared feeds have a well balanced energy to protein ratio that is different in different fish. Small fish have a high energy demand and must be feedall the time with short interval. In fish, carbohydrates are stored as glycogen however in mammals they are major energy source, but are not used efficiently by fish.

Like all other animals, ornamental fish require their diet to provide them with a controlled, slow release source of energy that is able to fuel every metabolic process. The energy from any feed is influenced by a series of complex enzymes, each of which require the presence a range of vitamins or minerals to function properly[36]. The energy required for maintenance and protein synthesis in fish is less than in mammals[15]. Therefore, the protein: energy ratio in fish is higher mainly due to the low levels of energy requirements. The single most important factor that affects the energy requirement of a fish is water temperature. An increase in water temperature will increase the body temperature of the fish, which will, in turn, speed up the metabolic reactions and increase the energy requirements of the fish. Consequently, the amount of food required by a fish will increase as water temperature begins to rise and will decrease as water temperature starts to drop[14].Table 1 shows the energy requirements in some species of freshwater ornamental fish.

Proteins and amino acids: The protein is directly related to the amino acid content which essentially are for growth of fish. The protein of feed should be match with the amino acid requirements of each fish species reared. Fish are very adept at converting food to body tissues. That is why fish need lesser amounts of food than do most other animals. Carbohydrates are almost nonexistent in the food intake for many fish species, since energy is also derived from proteins. The quantity of protein required for the fish to be healthy depends on a number of variables like the species of fish, amount of natural food available, growth rate etc. As the fish grow larger, their dependency on protein reduces. The temperature of the water also affects protein requirements. Because protein is the most expensive part of fish feed, it is important to accurately determine the protein requirements.

Fish meal, soybean meal, fish hydrosylate, skim milk powder, legumes, and wheat gluten are excellent sources of protein[16]. An amino acid is any molecule that contains both amines and Carboxylic acids.

Amino acids are the basic components of proteins. Most animals including fish species require 10 essential amino acids namely arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan and valine[17]. Of these, lysine and methionine are often the first limiting amino acids. Fish feeds prepared with plant (soybean meal) protein typically are low in methionine. Restrictions on certain stocks may have implications for fishmeal nutritional performance. For instance, smaller fish (i.e. salmon <1 kg) need high levels of the amino acid histidine that is found in much higher levels in South American fishmeals – exclusion from these would necessitate much higher fishmeal inclusion levels of European meals and thus higher [18].

According to Elangovan and Shim,the comparison of protein requirements between fish species is complex since this can vary according to the size and life stage, diet formulation or farming condition[19,5]. The Protein and energy requirements of some freshwater ornamental fish species are shown in table 1.

Table 1. Protein and energy requirements in some freshwater ornamental fish species [Cited: 5]

Scientific name	Common name	Weight (g)	Energy (kJ/g)	Protein requirements (%)	Reference
Arapaima gigas	Pirarucu	120.7 ± 3.5	23.63 GE (564.5 kcal/100 g)	48.6 (FM - S)	Ituassú et al [20]
Barbodes altus	Tin foil barb	0.812	20.38 GE	41. 7 (C)	Elangovan and Shim (19)
Carassius auratus	Goldfish	0.2 0.008	11.72 DE 20.3 GE	29 (FM - C) 53 (FM - C)	Lochmann and Phillips (21) Fiogbé and Kestemont (22)
Cichlasoma synspilum	Redhead cichlid	0.28	1.55 DE	40.81 (FM)	Olevera-Novoa et al (23)
Cichla sp.	Tucunaré	10 - 30	14.65 DE (3500 kcal/kg)	37 - 41 (FM - FE - S)	Sampaio et al (24)
Colisa lalia	Dwarf gourami	NR	NR	25	Shim et al (25)
Poecilia reticulata	Guppy	0.1	13.10 ME	30 - 40 (FM - C)	Shim and Chua (26)
Pterophyllum scalare	Angelfish	2.33 ± 0.26	12.97 DE (3100 kcal/kg)	26 (S - CM)	Zuanon et al (27)
Symphisodon aequifasciata	Discus	4.45 - 4.65	21.65 GE	44.9 - 50.1 (FM - C)	Chong et al (28)
Xiphophorus helleri	Swordtails 6 - 8 weeks	NR	NR	45% (FM - S)	Kruger et al (29)
	Females, 20 wk	1.1 -1.2	16.5 GE	30 (FM - C)	Chong et al (30)
	Females, 20 wk	0.8 - 0.9	20.9 GE	30 (FM - KM)	Ling et al (31)

The protein source is also an important factor to be consider in the diet formulation. Marine protein sources were more efficiently to induce the weight gain in neon tetra (*Paracheirodon innesi*) than diets based on vegetable proteins; however, fish fed with both protein sources diets containing 45% or 55% crude protein showed a better growth performance than 25% crude protein diets[32, 5]. The life stage also affects the protein requirements level, for example in juvenile goldfish the protein requirement is lower (29%) than larvae (53%) [22, 21, 5]. To avoid water pollution, the ornamental fish require an efficient utilization of the dietary protein to minimize the ammonia excretion. Therefore, new alternatives of fish meal replacement have been studied, with soybean meal being a good option due to its high protein level and satisfactory growth results [33].

Lipids and fatty acids:

Lipids are high-energy nutrients that can be utilized. Lipids mainly containing omega 3 and omega 6 based on whether it is the source of marine or freshwater organisms have high-energy nutrients that can give approximately twice the energy as proteins and carbohydrates. Lipid also has essential fatty acids and serves as transporters for fat-soluble vitamins. The amount of fat or lipid in fish meal is 5-10 %. Recently the fish culturist use higher levels of lipids in the diet in fish feeds in order to give more energy and fattening the fish. According with Sales and Janssens, the lipids are important sources of energy and fatty acids which are essential for normal growth and fish survival[33,5] Although increasing dietary lipids can help reduce the high costs of diets by partially sparing protein in the feed. However as excessive fat deposition in the liver can decrease the health and market quality of fish. In most cases, excess fat can be damaging to the general health of the fish. Some fish lose their reproductive capabilities if there is too much body fat. The connection between excessive lipids and fatty liver disease has been common knowledge in the aquaculture industry for many years. Simple lipids include fatty acids and triacylglycerols. Fish typically require fatty acids of the omega 3 and 6 (n-3 and n-6) families. Marine fish oils are naturally high (>30%) in omega 3 HUFA, and are excellent sources of lipids for the manufacture of fish diets. Freshwater fish do not require the long chain HUFA, but often require an 18 carbon n-3 fatty acid, linolenic acid (18:3-n-3), in quantities ranging from 0.5 to 1.5% of dry diet. This fatty acid cannot be produced by freshwater fish and must be supplied in the diet. Marine fish typically do not possess these elongation and desaturation enzyme systems, and require long chain n-3 HUFA in their diets. Other fish species, such as tilapia, require fatty acids of the n-6 family, while still others, such as carp or eels, require a combination of n-3 and n-6 fatty acids [12].

Fats are important for insulating body organs against shock, maintaining body temperature, and promoting healthy cell function. They also serve as energy stores for the body. Fats are broken down in the body to release glycerol and free fatty acids[34][online]. The lipids (fats) in fishes can be separated into liquid fish oils and solid fats. This is why fats/lipid for use in fish food are best obtained from aquatic sources such as Whole Fishmeal. Fish lipids are highly digestible by all species of fish (& animals) and are excellent sources of the essential polyunsaturated fatty acids (PUFA) [34] [online]. The composition of essential fatty acids in some of these alternative food is shown in the table 2.

Table 2. Essential fatty acids contained in alternative food used in freshwater ornamental fish. Values are expressed in mg/100 mg dry weight. (From Tamaru et al., 1997)(35).

Fatty acids	Bovine heart diet*	Bovine liver	Black tubifex	Red tubifex	Moina	Earthworms	Mosquito larvae
18:2n-6	1.71	1.56	1.68	1.43	0.11	0.11	0.48
20:4n-6	0.51	0.22	0.90	0.64	0.16	0.22	0.33
18:3n-3	0.2	0.0	0.51	0.19	0.04	0.10	0.31
20:5n-3	0.11	0.0	0.61	0.33	0.07	0.09	0.23
22:6n-3	0.33	0.0	0.0	0.0	0.0	0.0	0.0
Total FA	4.86	0.0	6.22	4.68	4.22	0.81	8.27

*Bovine heart contains 0.33 mg/100 mg dry weight of 22:6n-3. This essential fatty acid was absent in the other kind of food (0).

Vitamins

Vitamins are necessary in the diet for normal fish growth and health. These are organic substances that act as catalysts for many of the biochemical reactions within the fish. They often are not synthesized by fish, and must be supplied in the diet. Deficiencies in vitamins can cause undersized growth, loss of appetite, cloudy eyes, weakness in fish. For this reason it is suggested to give the fish vitamin supplements and adding to the feed frozen or fresh vegetables and live food. Water-soluble vitamins include: the B vitamins, choline, inositol, folic acid, pantothenic acid , biotin and ascorbic acid (vitamin C). Of these, vitamin C probably is the most important because it is a powerful antioxidant and helps the immune system in fish. The fat-soluble vitamins include A vitamins, retinols (responsible for vision); the D vitamins, cholecaciferols (bone integrity); E vitamins, the tocopherols (antioxidants); and K vitamins such as menadione (blood clotting, skin integrity). Of these, vitamin E receives the most attention for its important role as an antioxidant. Deficiency of each vitamin has certain specific symptoms, but reduced growth is the most common symptom of any vitamin deficiency. Scoliosis and dark coloration may result from deficiencies of ascorbic acid and folic acid vitamins, respectively [12]. Vitamins play a part in processes which are related to stress responses and the immune system, as they act as cofactors of enzymes, as antioxidants and as structural components of phospholipids[13]. Based on Lovell, most fish species require vitamin supplementation which vary according to species, fish size, food rates, environmental factors, nutrient interrelationships or health condition. Essential vitamins in some metabolic and corporal enzymatic reactions are commonly supplemented in the diet[15,5]. Some important function of vitamin [36]is listed as Thiamin is essential for a good appetite, normal digestion, growth, and fertility, Riboflavin function as enzymes of tissue respiration, Pyridoxine(B6) plays a vital role in enzyme systems and protein metabolism, panthotenic acid(B5) is essential for the development of the central nervous system, adrenal functioning, cholersterol production, Niacin(B3) is involved in lipid metabolism, amino acid and protein metabolism, and photosynthesis, Biotin is required in several specific carboxylation and decarboxylation reactions, Folic acid is required for normal blood cell formation and is involved as a coenzyme in one-carbon transfer mechanisms, blood glucose regulation, fish metabolism and improves cell membrane function and hatchability of eggs, Choline is essential for growth and good food conversion in fish, Inositol is a structural component in living tissues, Vitamin A is essential in maintaining epithelial cells, Vitamin E act as inter- and intracellular antioxidants to maintain homeostasis of labile metabolites in the cell and tissue plasma, Vitamin D functions as a precursor which stimulates the absorption of calcium from the intestine [36].

Minerals

Minerals are also necessary for thefish. Bones, teeth and scale tissues require lots of minerals. The minerals also carry out many supportive functions. Actually in most case the fish suffer from a lack of Calcium and Phosphorous and supplement mineral will help to compensate the deficiency but excess of some minerals also can be poisonous. Therefore, mineral supplements should not be used without any information and just by random.

Although fish can absorb some minerals from the water through their gills, receiving a supply of minerals in their diet is essential because of their involvement in skeleton formation, the regulation of the acid-base balance and osmotic and ionic regulation[13]. Relatively little is known about the uptake, function, and biological availability of many trace elements. The concentration of minerals in the body of an fish depends on the food source, environment, species, stage of development, and physiological status of the fish[36]. Generally Ca, Mg, Na, K, Fe, Zn, Cu, and Se are derived from the water to satisfy some of the nutritional requirements of fish, however, chlorides, phosphates, and sulfates are more effectively obtained from food sources [37]. The addition of mineral supplements to these diets improved growth and survival [36].

Carbohydrates

Carbohydrates make up 20-30% of the common commercial foods. While they are alternate sources of energy, they are not very necessary for fish growth. Fish do not use carbohydrates very efficiently, and in quality feeds their use is primarily as a binding agent during the manufacturing process. Grains do have their place in fish foods, serving as binders and to help synthesize lipids and protein. Cooking starch during the extrusion process makes it more biologically available to fish

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In ornamental fish the information about carbohydrate metabolism and its function remain unknown. Although in ornamental fish the information about carbohydrate metabolism is limited, some physiological and biochemical function has been found in other fish species. The CHOn are involved in the secretion and activity of insulin and glucagon and in less proportion in the growth hormones [5].

Carotenoids

Carotinoids is a non-enzyme low molecules that such as pyruvate, flavonoids and ascorbate microorganisms use them for oxidative damage. Using antioxidant enzymes such as superoxide dismutases and a system based on repair enzymes which remove or repair oxidatively damaged macroulcules is also the sterategies for oxidative damage [38]. Fish, like other animals do not synthesize carotenoid and depend on dietary carotenoid content for the colouration. Hence, a direct relationship between dietary carotenoids and pigmentation exists in them [39].

Prebiotic and probiotic

It has been documented in a number of food animals that gastrointestinal bacteria play important roles in affecting the nutrition and health of the host organism. Thus, various means of altering the intestinal bacteria to achieve favorable effects such as better resistance to pathogens, enhancing growth and immune stimulation of the host organism have been investigated in various fish and shrimp. In this respect, probiotics and prebiotics are used for aquaculture, and the probiotic approach has been extensively used and advocate and in case of prebiotics supplements on fish some positive effects have been published [40].

Feed of live food

In most aquarium fish and some fame fish like sturgeon newly hatched fish and very young fish prefer to have eat from live feed due to their mouth size and the immaturity of the digestive system, otherwise they do not take the food will have starvation [2]. The choice to feed ornamental stock with live food, instead of dry manufactured feed, is mainly determined by the growth stage of the fish. Newly hatched fish desires food of a very small size during the early stages of life. Live foods, such as brine shrimp and mosquito larvae, that are readily absorbent, meet these requirements and provide the high-protein needs of larvae. However, do not rush to serve live food as the first meal. Generally, after a fish hatches or a fish gives birth they have what is called a yolk sac, which will be absorbed in approximately 2 – 3 days. After this time, live food can be given[41]. Live foods are highly nutritious sources of micro and macro nutrients, vitamins, fats, proteins and carbohydrates and contribute significantly to increased growth rates. The use of live foods simulates the natural eating environment for captive aquatic life, making the stock more vibrant and colourful. Furthermore, live food is an excellent conditioning agent for brood stock. Its high nutrient concentration encourages spawning activities; hence increasing your breeding success rates. The most important livefoods include: artemia, rotifer, daphnia, copepods, tubifex, bloodworms, infusoria, mosquito larvae and phytoplankton such as diatoma etc. Lim et al [42] proposed the use of decapsulated cysts as a substitute for Artemia nauplii or Moina in freshwater ornamental fish, showing a better growth performance, survival and stress resistance as well as a low cost and better hygienic procedure.

CONCLUSION

In feeding ornamental fish more care and attention should be paid, because these delicate fish in close, small and stagnant water are in under normal condition, Therefore, the improvement of feed mill based on the nutritional requirements of ornamental fish facilitate an increase in activity, growth, reproduction and quantity and quality of the fish produced. In this respect a balance food considering exact requirement of fish with using live feed and supplementary of probiotic , prebiotic, enzymes and other new product will guarantee the successful ornamental fish culturing.

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