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Effect of feeding guppy fish fry (*Poecilia reticulata*) diets in the form of powder versus flakes

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Abstract

The effects of feeding guppy (*Poecilia reticulata*) fry a diet offered as either powder or flakes on their growth and survival were tested over a period of 8 weeks. The results show that the growth of both male and female fish was considerably enhanced when the diet was presented in the form of a finely ground powder compared with a flake form. Final average weights of fish given a diet containing the exact same ingredients (44.9% protein and 6.1% fat), from the same batch of raw materials in the powdered form were 280.0 ± 12.1 mg compared with 114.6 ± 19.9 mg for the diet given in the form of flakes. In a diet that had a higher fat level (45.1% protein and 10.6% fat), the difference in final weight attained was even more dramatic: 303.9 ± 16.7 mg for the powder-fed fish compared with 92.6 ± 12.5 mg for the flake-fed fish. The coefficient of variance in the fish fed a flake diet was significantly higher than that exhibited in the treatments fed the powder feed. The ability of the fish to consume the food in a rapid manner, preventing leaching of vital nutrients from the feed before being engulfed by the fish probably led to the better growth results exhibited by the fish given the powdered food.

Keywords: guppy, *Poecilea reticulata*, feed preparation, growth

Introduction

The commercial production of ornamental tropical fish is gaining momentum in many regions of the world. The live bearer guppy fish (*Poecilia reticulata*) are the most popular among hobbyists because of their vibrant colours and the fact that they are easy to breed and keep. Guppy fish have served as a subject for numerous behavioural studies related to predator avoidance mechanisms and evolution-related studies (Seghers 1974a, b; Reznick 1982; Reznick, Bryga & Endler 1990; Magurran & Seghers 1991; Godin & Briggs 1996; Reznick, Butler & Rodd 2001); genetic models (Reznick 1982; Breden, Scott & Michel 1987; Shikano, Chiyokubo, Nakadate & Fujio 2000); and different factors affecting their reproductive behaviour and reproductive performance (Liley 1968; Endler 1980; Dzikowski, Hulata, Karplus & Harpaz 2001). In contrast to the vast number of studies on these subjects, research aimed at better understanding the nutritional needs of these fish is scarce. The guppy *P. reticulata* is considered omnivorous and requires around 40% dietary protein (Dahlgren 1980). The required protein level in the guppy diet was evaluated by Shim and Chua (1986), and their results show that fish receiving 30% and 40% dietary protein showed the lowest feed conversion ratio and highest gonad development. Similar results were found in another poecilid fish (*Xiphophorus helleri*), (Chong, Ishak, Osman & Hashim 2004). For the most, the sources of information on different diets and feeding regimes for guppy fish are hobbyist magazines, websites and discussion forums of guppy hobbyists (e.g. GuppyLog.com; Guppies.com; vetofish.com). Although data presented are very helpful to hobbyists, they are usually anecdotal and lack proper scientific evaluation methodology and documentation. In addition, the feed preparation techniques have not been studied. The purpose of the present study was to elucidate differences between two methods of feed preparation for ornamental guppy fish fry i.e. the preparation, from the same batch of raw materials, of powdered extruded feed or drum dried in the form of flakes.

Materials and methods

The experiment was conducted in an indoor monitored set-up: a total of 48 glass 15 L aquariums, partitioned from each other with an opaque plastic sheet, equipped with an air stone through which pressurized air was bubbled to supply sufficient oxygen to the fish. All aquariums were connected to a central bio-filter and settling unit of 300 L, through which heated water was circulated with the aid of a submersible pump, at a rate equivalent to total water replacement every $1\frac{1}{2}$h. The temperature level was kept at 27 ± 1 °C and the photoperiod was set at 12D:12N throughout the experiment. This temperature level was based on the findings of Dzikowski and colleagues (2001).

Water quality parameters were monitored regularly three times a week and did not deviate from conditions considered favourable for these fish i.e. an oxygen level of 90–100% saturation; ammonia (measured as NH_4^+) did not exceed 0.25 ppm and the nitrite level did not exceed 0.5 ppm. Each morning, excess leftover food was carefully siphoned out. Once in a fortnight, during weighing, a more thorough cleaning of the aquaria and the settling tank was carried out. The amount of water that needed to be replaced during this activity was approximately 25%.

Guppy fish from the same strain (red cobra) were obtained from a commercial farm. After initial nursing with newly hatched *Artemia salina* as supplementary live food, they were weaned to an artificial diet made of a mixture of flakes and powder (not used in the subsequent experimental set up) over a period of ten days. A total of 1440 fish were used in the experiment and they were randomly assigned to the experimental aquaria. A total of 30 fish at an average initial weight of 20 ± 1.8 mg were stocked in each of the 48 experimental aquaria with a density corresponding to two fish per litre.

Once every 2 weeks, the fish in each aquarium were batch weighed and counted. This was done in order to monitor survival and to update the feeding ration, according to each individual tank's growth rate following the bi-weekly weighing. At the end of the experiment, all the fish in all the tanks were separated into males and females and individually weighed. This was done to compare the effects of the treatments on growth and survival as well as the coefficient of variance (CV) in the fish growth for both sexes. In some of the treatments, it was extremely difficult to determine the sex of the fish accurately because of their small size and in these cases, the fish were included in the total weight gain of the aquarium but their sex was not determined.

The diets tested were commercial and experimental diets currently used by guppy fish producers. Our main target was to compare the feed preparation method (i.e flakes versus powder) and therefore we did not (and could not) adjust the protein and fat levels of the diets. The comparison among the feeds included a flake diet with a high protein level considered to be a diet that supports excellent growth; an experimental powdered diet with a much lower protein level; and two diets containing the same ingredients prepared using two different methods: drum dried or extruded and sieved to the appropriate size.

The six diets tested were as follows:

A. Flake feed, Tetramin, manufactured by Tetra Company (Melle, Germany).
48.4% protein; 10.1% fat; 8.7% ash

B. Flake feed, experimental diet 1 manufactured by Maabarot Company (Kibbutz Maabarot, Israel).
45.2% protein; 5.9% fat; 6.4% ash

C. Flake feed, experimental diet 2 manufactured by Maabarot Company.
44.9% protein; 10.4% fat; 7.4% ash

D. Powder feed (exact same ingredients as in B) manufactured by Maabarot Company.
44.9% protein; 6.1% fat; 6.8% ash

E. Powder feed (exact same ingredients as in C) manufactured by Maabarot Company.
45.1% protein; 10.6% fat; 7.5% ash

F. Powder feed – experimental feed produced by IOLR (Eilat, Israel).
38.5% protein; 8.6% fat; 8.2% ash

Two sets of the feeds (B&D and C&E) had the same ingredients from the same batch split into the two preparation methods. However, our proximate analysis of these feeds performed on the prepared diets showed very slight differences between them. This most probably reflects the measurement range and not an actual difference between them. Each of the above treatments was tested in eight replicates.

The proximate analyses of feed content (protein, fat and ash) were conducted at our laboratory. The level of protein was determined according to the Kjeldahl procedure and the 2000 Digestion System (Tekator, Stockholm, Sweden). Fat was determined using a Soxhelt extractor with 95% ethanol. Ash levels were determined using a BIFATherm C-36 oven (BIFA, Ramat Gan, Israel) at 600 °C.

Fish were hand fed twice a day, 7 days a week with a ration equivalent to 20% of their body weight per day during the initial 2 weeks, and thereafter, 10% of their body weight per day. During the feeding time, the aeration was stopped in order to prevent excessive agitation of the water surface. Food was administered in the form of fine powder (0.1–0.3 mm in diameter) or in the form of thin flakes (roughly 0.5–1.5 cm^2). Halfway through the experimental period, the fish feed was switched to larger powder or flake particles, as appropriate for the change in the fish size. The transition was carried out over a period of a few days during which a mixture of the small- and larger-sized particles was given.

Observations on feed consumption rate and floatation of feed particles were conducted once a week during the morning feeding session.

Statistical analysis was carried out using JMP statistical package. One- and two-way ANOVA followed by a Tukey–Kramer HSD test, set at $P<0.01$, were conducted.

Results

Food floatation and consumption rate

The observations carried out on the position of the feed in the water column showed that the powdered feed would evenly spread out on the top layer of the water, slowly sinking only after an average of 5 min, or when the water surface was strongly agitated. The flakes were also found to float on the top layer on the water; they would remain intact and only after a relatively long period (>20 min) would slowly sink to the bottom. The rate at which feed was consumed by the fish was much faster in the case of the powdered feed compared with the flakes (two to three times faster).

Growth and survival

The fish growth results are presented in Table 1. The growth of the fish given all the powdered form feeds was significantly better ($P<0.01$) than that obtained with the flake feed. The growth of the fish given feeds D and E (in a powdered form) was by far better ($P<0.001$) than that of the same ingredients given in the flake form (feeds B and C). Among the feeds presented in a flake form, the Tetra feed showed the best results, while among the powdered feeds the experimental diet containing a relatively lower protein level yielded, as expected, a lower growth rate. Yet, the growth obtained was comparable with that of the Tetra feed. The final average weights of fish given a diet containing the exact same ingredients (44.9% protein and 6.1% fat) in the powdered form were 280.0 ± 12.1 mg compared with 114.6 ± 19.9 mg for the diet given in the form of flakes. In a diet that had a higher (almost double) fat level (45.1% protein and 10.6% fat), the difference in final weight attained was even more dramatic: 303.9 ± 16.7 mg for the powder-fed fish compared with 92.6 ± 12.5 mg for the flake-fed fish.

The survival rate was high (averages ranging from 86% to 93%) with no significant differences among treatments.

The CV within each aquarium was very high in the flake diets (averages per treatment ranging from 40.5 to 49.7), while the powdered diet values were significantly lower, ranging from 24.2 to 37.8 per treatment.

Discussion

Both the flakes and the powder were kept afloat at the top layer of the water by the water surface tension. It is presumed that the rapid consumption of the feed by the fish offered in the powdered diet led to better feed utilization for growth. Since the flakes are too large for the mouth orifice of the fish, they have to resort to nibbling on the floating flakes. This process required a significant amount of time (two to three times longer than with the powdered feed), during

Table 1 Final weight, survival and coefficient of variance ± SD attained by guppy fish fed flake versus powder feeds

Feed-type proximate analysis (P, protein; F, fat)	Final weight (in mg)	Survival (%)	Coefficient of variance (CV)
Flake			
A ($P=48.4\%$; $F=10.1\%$)	142.6 ± 19.0^{a}	91.0 ± 7.0	49.7 ± 2.3^{a}
B ($P=45.2\%$; $F=5.9\%$)	114.6 ± 19.9^{b}	87.5 ± 8.7	40.5 ± 6.6^{a}
C ($P=44.9\%$; $F=10.4\%$)	92.6 ± 12.5^{b}	86.0 ± 9.6	46.2 ± 6.1^{a}
Powder			
D (same ingredients as B)	280.0 ± 12.1^{a}	91.5 ± 8.7	27.0 ± 3.9^{b}
E (same ingredients as C)	303.9 ± 16.7^{a}	91.0 ± 5.9	24.2 ± 3.4^{b}
F ($P=38.5\%$; $F=8.6\%$)	185.9 ± 25.8^{b}	92.0 ± 7.4	37.8 ± 9.2^{ab}

For each feed type, values in the same column followed by different letters are significantly different at the $P<0.01$ level.

which, vital nutrients leached out of the food in a rapid manner. Goldblatt, Conklin and Brown (1979) demonstrated that pelleted feeds exhibit a remarkable loss of vital nutrients, such as water-soluble vitamins and amino acids, even after a short period of exposure to water. Their results show that only 35–65% of the vital, water-soluble vitamin C remains in the pellets after 20 min of exposure to water, while with choline only 15–35% remained in the pellets after the same period. Another way to reduce leaching would be to utilize de-capsulated *Artemia* cysts or live feed organisms as 'living capsules', as this method has been shown to be beneficial for the growth and survival of a number of ornamental fish including guppies (Lim, Dhert & Sorgeloos 2003). The method used for preparing the diets, drum drying as opposed to pellet extrusion, most probably also had an effect on the better food utilization exhibited by the fish that received the extruded powdered diet.

Kruger, Britz and Sales (2001) reared juvenile swordtails (*Xiphophorus helleri*), which were also poecilid fish, on three protein levels (30%, 38% and 45%) at three different dietary lipid concentrations (6%, 8% and 12%). Their results show that a diet of at least 45% protein at a 6% lipid concentration is required for the best specific growth rate and feed conversion ratio at this juvenile stage. The results of our study with guppy fish also showed similar growth when the fat level was increased from 6.1% to 10.6% in a diet containing 45% protein (Table 1, diets D and E). The CV in the fish fed a flake diet was significantly higher ($P < 0.01$) than that exhibited in the treatments fed the powder feed (Table 1). This higher level of variability in the size of the fish is probably because of the fact that the surface area covered by the flakes is rather small, enabling the dominant fish within the population to prevent the subordinate fish from accessing the food, thus increasing the size differences in the population. This hierarchy buildup in guppy populations has been described in detail by Warren (1973), who also showed that the level of aggressiveness in the fish population varied with density and compartment conditions (transparent or opaque aquarium walls). The experiment was terminated after 8 weeks since some of the fish in the treatments that attained the best growth rates had reached full sexual maturity. It was feared that energy directed towards reproductive activity at this stage would hamper the growth rate and mask the effects of the treatment.

The better growth obtained with the same diet presented in a powdered form compared with the flake form (Table 1, feed B compared with D; and feed C compared with E) can, in addition to better food utilization, have an impact on marketing capabilities. The overall growth can be misleading since the females grow faster and to a larger size. When separating and individually weighing the males and females, it was found that a higher percentage of males (which are more sought after in the market) reached a larger (marketable size) in the powdered feed treatment.

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