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Effects of feed type and feeding frequency on growth performance, reproductive efficiency and skin coloration of auratus cichlids (*Melanochromis auratus*)

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Abstract

Feeding is an important factor for both cultured and ornamental fish species. This study was aimed to assess the effects of different feeds and feeding frequencies on growth, reproduction, coloration, ammonia excretion and profitability of auratus cichlids (*Melanochromis auratus*). The study was carried out in twelve fiberglass circular tanks (100 L) annexed to recirculating freshwater system. Ten fish (mean body weight 1.83±0.02 g and mean total length 4.08±0.02 cm) were placed in each tank with 1:4 (male:female) sex ratio. Feeding groups were determined with tropical granule (G) and trout pellet (P) and fish were fed with two feeding frequencies, including once daily (GF1, PF1) and thrice daily (GF3, PF3). The growth performance and reproduction parameters was influenced by feed type and feeding frequency in two-way ANOVA and PF3 group was the significantly highest among all these parameters ($P<0.05$). In contrast, skin coloration parameters of G groups were higher than P groups ($P<0.05$). In conclusion, the commercial pellet feeds are effective for growth performance but they caused to colour loss. These type of feeds can be used rotatory with tropical feeds and three times daily feeding is recommended for auratus cichlids.

Introduction

Aquarium is a hobby that affects the worldwide. Some people, mainly called aquarists, desire to collect the different kinds of aquatic organisms (fish, invertebrates, plants, etc.) in their personal home aquariums. Another group aim to breed these aquatic species. However, some group of people focus to sell only aquarium equipment, including filters, pumps, heaters, decorations, substrates, etc. All these people named as hobbyists, producers, wholesalers and retailers are keystones of aquarium sector and are integrated with each other. Coordinated works of these members caused to reach the total trade value of aquarium sector to 15-30 billion US$ (Çelik, Çelik, & Şahin, 2014). However, American Pet Products Association reported that the 10% of pet ownerships have freshwater and 2% of have saltwater aquariums in the USA (APPA, 2018).

Commercial production success in aquarium fish culture depends on reaching the market size in minimum time as in the other cultured edible fish species. One of the main factors affecting this situation is the structure and type of the feed given to fish. In some previous studies, the use of dry feeds instead of live feeds has been investigated (Gordon, Kaiser, Britz, & Hecht, 2000; James & Sampath, 2004; Bahadır-Koca, Diler, Dulluc, Yigit, & Bayrak, 2009). Although live feeds are more expensive than formulated feeds, they have positive effects on growth and coloration. With the inclusion of various raw materials and feed additives to commercial aquarium fish feeds, this problem was tried

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to be overcome and studies comparing different types of aquarium fish feeds were carried out (Harpaz, Slosman, & Segev, 2005; Karadal & Türkmen, 2014). Investigations aimed to use of commercial pellet feeds (such as aquafeeds of salmon, trout, etc.) in the aquarium fishes become important for reducing the feed costs more. (Tamaru & Ako, 1999; Royes, Murie, Francis-Floyd, & Terrell, 2004). However, commercial feeds such as trout, carp, etc., that are not designed for aquarium fish can cause loss of coloration, which is one of the most important criteria for the marketing of aquarium fish. Therefore, the coloration studies need to be carried on this subject.

The spread of the aquarium hobby has caused some problems. Especially misapplications are implemented about feeding. For example, some people feed their fish from time to time, others do not feed on most days (Türkmen & Karadal, 2017). This situation can be led many diseases, deformations and mortalities in fish (Damsgård Sørum, Ugelstad, Eliassen, & Mortensen, 2004). The proper feeding regime should be managed for healthy and lively fish in both aquaculture and aquarium systems (Noble, Kadri, Mitchell, & Huntingford, 2007; Riberio, Vasquez, Fernandes, & Sakomura, 2012). Feeding frequency is important because of the partially given feed is regulated the digestion and excretion in fish. Optimum feeding frequency is necessary for efficient growth parameters, survival rate and bright and vibrant coloration in ornamental fish (Hatefi & Sudagar, 2013; Karadal, Güroy, & Türkmen, 2017).

Freshwater aquarium fish divided some sub-groups including carps, livebearers, cichlids, labyrinths, catfish, killifish, etc. One of the most important among them, cichlids, is a large group of fish with 1700 scientifically described species (Vanhove *et al*., 2016). *Melanochromis* is a genus of haplochromine cichlids which are endemic to Lake Malawi, Africa and members of this genus are characteristically slim but muscular fish with lengthwise stripes of yellow, black and blue (Konnings & Stauffer, 2012). The auratus cichlid (*Melanochromis auratus*), also known as golden mbuna or Malawi golden cichlid, is endemic from Jalo Reef to Crocodile Rocks in Southern Lake Malawi (Snoeks, 2004; Konnings, 2007). Juveniles and females have three distinctive black stripes which are mainly covered by thin white stripes on the upper half of the body (two stripes) and dorsal fin (one stripe) along from anterior to posterior, and the other regions of the body are bright yellow. Males have black colour on the lower half of the body and light blue or brown stripes on the top of the body (Snoeks, 2004). Aquarium enthusiasts' desire the auratus cichlid for these coloration characteristics but aggressive behaviours are limited the caring of this species in aquariums. In aquarium conditions, auratus cichlids can be kept with peaceful cichlid species and the aquarium may decorate with large amount of rocks to reduce the aggressiveness (Sweeney, 1997). Also, it is thought that the proper feeding regime will suppress the harsh characteristics and positively affect the important parameters such as growth or coloration in auratus cichlids.

The aim of the current study was to evaluate the effects of commercial ornamental fish feeds and pellet freshwater fish aquafeeds with different feeding frequencies on the important marketing parameters such as, growth performance, survival, coloration, reproduction efficiency and profitability of auratus cichlids.

Material and Methods

Rearing systems and fish

Auratus cichlids (*Melanochromis auratus*) were obtained from a commercial importer in İstanbul, Turkey and transported to Ornamental Fish Unit of Armutlu Vocational School, Yalova University, Yalova, Turkey. Fish were transferred to 100-L tanks and fed a commercial tropical diet (42% protein, 5% lipid, 1.1% fiber, 7% ash; AHM Marin) for two weeks for acclimation, before the start of the feeding trials. Twelve (100-L) fiberglass circular tanks (diameter: 50 cm, height: 55 cm) within a 4000-L recirculation freshwater system annexed to a 650-L sand filter system and ultraviolet light unit were used in the study. A partial freshwater exchange (10% total system volume) was performed twice each week. The water flow rate was 5 L/min and water quality was monitored daily. Water temperature was maintained at 27.2±0.4 ºC and dissolved oxygen at 7.91±0.26 mg/L (Handy Polaris, Oxy-Guard International A/S, Birkerod, DK). Average pH at 7.58±0.12 (HI 9125 Hanna Instruments Inc., Woonsocket-RI, USA) and 0.08±0.02 mg/L NH_4-N (Hach Lange DR 2800, Hach Lange Loveland, Colorado, USA). The photoperiod was maintained at 12:12 h (light:dark). Auratus cichlids (mean body weight 1.83±0.02 g and mean total length 4.08±0.02 cm) were randomly distributed amongst 12 tanks at the density of 10 fish per tank with three replicates for each feed type and feeding frequency. Ten fish were placed in each tank with the 1:4 (male:female) sex ratio.

Experimental design and diets

The feeding trial was carried out with 2 x 2 experimental design as two feed types (tropical granule, G and trout pellet, P) and two feeding frequencies of one (F1) and three (F3) daily feeding. Feeds were given at 09:00 for F1, 09:00, 13:00 and 17:00 for F3 groups. Fish were hand-fed to near satiation for 16 weeks with commercial cichlid granule (AHM Marin Natural Cichlid Granulate) and trout pellet (Çamlı Trout Fry Feed). Chemical composition of the diets was shown in Table 1. Feed intake was assessed from the difference between feed given to the fish and the uneaten feed siphoned

Table 1. Chemical composition of the granule and pellet feed (%, dry matter)

	Granule (G)	Pellet (P)
Moisture (%)	7.0	10.0
Crude Protein (%)	42.0	50.0
Crude Lipid (%)	5.0	15.0
Crude Fibre (%)	1.1	1.5
Crude Ash (%)	7.0	11.0
Nitrogen Free Extract (NFE)	44.9	22.5

Nitrogen-free extracts (NFE) were calculated as NFE = 100 - (protein% + lipid% + fibre% + ash%).

from 20 min after the end of the feeding period. Fish were weighed in bulk biweekly after suspending feeding for 1 day. At the end of the feeding trial, fish were starved for 24 h, and the total number and individually fish weight in each tank were determined for calculation of growth performance.

Evaluation of growth performance

Feed intake (FI) was recorded to calculate feed conversion ratio. Growth performance was monitored biweekly by collectively weighing the fish from each tank. All fish were anesthetized with clove oil (0.001 mL/L). The feed conversion ratio (FCR), specific growth rate (SGR) and survival rate (SR) were calculated as follows: FCR = feed intake / weight gain, SGR = 100 x [(Ln final fish weight) - (Ln initial fish weight)] / experimental days, SR = 100 x (total fish - dead fish) / total fish.

Determination of reproduction efficiency

The reproductive efficiency of auratus cichlids fed with different feed types and frequencies was monitored over 16 weeks. Brooding females were checked for spawning activity daily. Whenever present, eggs were gently removed from the buccal cavity of brooding fish, and the spawning rate monitored over 14 days. After the collecting seeds from female, they divided to two types as eggs and larvae. Then, unfertilized eggs were counted and removed from other eggs. Absolute fecundity (AF), relative fecundity (RF), fertilization rate (FR), hatching rate (HR) and average seed production (ASP) were calculated according to Berenjestanaki Fereidouni, Ouraji, and Khalili (2014) as follows: AF = total seed number / female number, RF = total seed number / female weight, FR = 100 x (total eggs - unfertilized eggs) / total eggs, HR = 100 x (total fertilized eggs - non hatching eggs) / total fertilized eggs, ASP = total seed collected during the study per group / number of replicates.

Skin coloration measurement

Female fish were individually measured for skin colour using Minolta CR-300 Chroma Meter (Minolta Camera Co. Ltd., Asaka, Japan) before commencement of the feeding trial to establish baseline measurements (week 0) and then every 2 weeks for the 16 weeks period. The measurements were performed on left surface (10 mm) of body area and caudal region of each fish. Skin coloration of body and caudal areas were determined by the front and end of dorsal fin vertically, respectively. The Chroma Meter was set to take absolute measurements in the *L**, *a**, *b** measuring mode (CIE, 1976) using D65 illuminate. *L** is the lightness variable (where white: 100 *L** and black: 0 *L**), *a** is the red chromaticity coordinates where +*a** stands for red, and -*a** stands for green, and *b** is the yellow chromaticity coordinates where +*b** stands for yellow, and -*b** stands for blue.

Determination of total ammonia-nitrogen (TAN) excretion

After the feeding trial, fish were starved for a period of 3 days to ensure evacuation of food from the gut. On the morning of the fourth day, tanks were thoroughly cleaned and fish in all tanks were fed appropriate diet to apparent satiation. Thirty minutes postprandial, water flow to each tank was discounted, uneaten food was removed and a baseline TAN excretion level was analysed with the ammonia salicylate method using NH_3-N reagent kits from Hach Lange (LCK 304) and measured in a spectrophotometer (Hach Lange DR 2800). At 12 h postprandial, an additional sample was taken and analysed and the TAN levels were determined by subtracting the baseline value of each tank.

Economic analysis

The economic analysis in terms of economic conversion ratio (ECR) and economic profit index (EPI) were developed by Sánchez-Lozano *et al*. (2007) and determined using the following formulae: ECR (€/g) = feed conversion ratio x feed price, EPI (€/fish) = (final mean weight, g x fish sale price, €) - (economic conversion ratio x weight gain, g).

Feed prices were determined as 0.01 €/g (10 €/kg) for granule feed and 0.003 €/g (3 €/kg) for pellet feed according to Turkish market. Auratus cichlid price was calculated as 0.22 €/g (Average weight and price for total lengths of 3-5 cm is 2 g and 0.44 €).

Statistical analysis

The Shapiro-Wilk W test and Levene test were examined to verify normality and homogeneity of variance before further analysis was undertaken. All data were subjected to two-way analysis of variance (ANOVA), after proving the normality and homogeneity of the data. Duncan's multiple range test was used to rank groups when interaction between the factors was found different by using Statgraphics Centurion XVI (Statpoint Technologies Inc., The Plains, VA) statistical software (Zar, 1999). All data were presented as "mean±standard error" of the mean calculated from all replicates. In all tests, a significance level of P<0.05 was used.

Results

Growth performance of auratus cichlid fed with different feeds and frequencies during the 16 weeks was detailed in Table 2. The highest final mean weight (FMW) was found in PF3 (P<0.05) and two feed types (P=0.0255) and feeding frequencies (P=0.0200) were affected to FMW. The lowest and highest final mean total length (FMTL) were observed in GF1 and PF3 groups, respectively (P<0.05). FMTL was influenced by feed type (P=0.0000) and feeding frequency (P=0.0000) and there is an interaction between them (P=0.0049). Feed intake (FI) of PF3 was significantly different from GF1 and PF1 (P<0.05) and type of feed and frequency difference were impacted to FI (P=0.0220, P=0.0154). Specific growth rate (SGR) and protein efficiency ratio (PER) of GF1 was significantly lower than PF3 (P values of SGR and PER for feed type were 0.0403 and 0.0004, for feeding frequency were 0.0406 and 0.0002). There is no significantly difference in feed conversion ratio (FCR) and condition factors (CF) among all groups (P>0.05). Survival rate (SR) of GF1 was significantly higher than PF3 (P<0.05) and feeding frequency was affected to SR (P=0.0391).

Reproduction efficiency and seed production of auratus cichlids in feeding trial during 16 weeks were presented in Table 3. No statistical difference was found in absolute fecundity (AF) and relative fecundity (RF) among the groups (P>0.05). Fertilization rates (FR) of GF3 and PF3 were significantly higher than PF1 group (P<0.05). Hatching rate (HR) of GF1 was significantly lower than GF3 and PF3 groups (P<0.05). Both of these two parameters were influenced by feeding frequency (P value for FR=0.0091 and P value for HR=0.0126). Although there is no statistically differences in average seed production (ASP) among the groups (P>0.05), there is an alignment as PF3 > GF3 > PF1 > GF1 from more to less.

Skin coloration outputs in body and caudal regions of auratus cichlids were shown in Table 4. Final body L^* and final caudal b^* of GF1 and GF3 groups were significantly higher than PF1 and PF3 (P<0.05) and contrast situation was observed in final body a^* value. Both L^* and a^* values were affected by feed type (P=0.0000). Final body b^* of PF1 was significantly lower than GF3 (P<0.01) and there is an impact of feed type (P=0001) and have an interaction (P=0.0380). Final caudal L^* was significantly decreasing from GF1 to PF3 groups (P<0.05). Feed type (P=0.0000) and feeding frequency (P=0.0356) were affected to final caudal L^* and there is an interaction among the groups (P=0.0131). No significant difference was found in final caudal a^* of the groups (P>0.05).

The total ammonia-nitrogen (TAN) excretion of auratus cichlid fed with granule feeds reduced compared to fish fed pellet feeds, irrespective of feeding frequencies (Figure 1).

Economic analysis of rusty cichlids fed with different feeds and frequencies were given in Table 5. Economic conversion ratios (ECR) of GF1 and GF3 groups

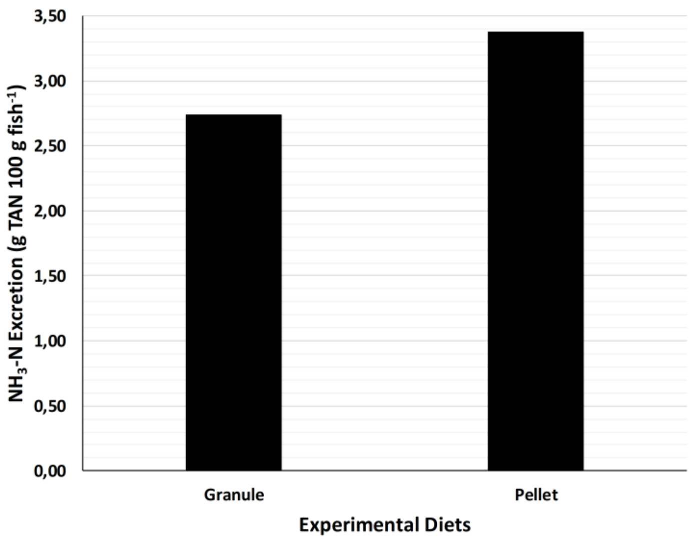

Figure 1. Total ammonia-nitrogen excretion of auratus cichlids after 12 h of feeding on experimental diets

Table 2. Growth performance of auratus cichlids after 16 weeks

	Granule (G)		Pellet (P)		Two-way ANOVA		
	GF1	GF3	PF1	PF3	Feed Type	Feeding Frequency	Interaction
Initial mean weight (g)	1.83±0.02	1.82±0.01	1.84±0.02	1.84±0.01	0.3204	0.7597	0.9712
Final mean weight (g)	7.86±1.60^{a}	11.49±1.55^{a}	11.21±1.05^{a}	16.95±0.12^{b}	0.0255	0.0200	0.5039
Initial mean total lenght (cm)	4.07±0.01	4.08±0.01	4.09±0.02	4.08±0.04	0.7008	0.9657	0.8302
Final mean total lenght (cm)	7.37±0.03^{a}	9.12±0.07^{b}	8.87±0.18^{b}	11.37±0.08^{c}	0.0000	0.0000	0.0049
Feed intake (g)	6.66±1.34^{a}	10.96±1.69^{ab}	10.55±1.03^{a}	15.91±0.03^{b}	0.0220	0.0154	0.7257
Feed conversion ratio	1.19±0.06	1.16±0.05	1.38±0.24	1.12±0.01	0.4943	0.2181	0.3160
Specific growth rate (%/day)	1.27±0.18^{a}	1.63±0.11^{ab}	1.61±0.09^{ab}	1.98±0.01^{b}	0.0403	0.0406	0.9574
Protein efficiency ratio	2.52±0.30^{a}	5.75±0.67^{b}	5.39±0.32^{b}	10.74±0.71^{c}	0.0004	0.0002	0.0997
Condition factor (%)	1.53±0.08	2.07±0.73	1.60±0.06	1.15±0.02	0.4093	0.9248	0.3374
Survival rate (%)	93.33±6.67^{b}	73.33±8.82^{ab}	85.00±5.00^{ab}	65.00±5.00^{a}	0.3153	0.0391	1.0000

In the same line, values with different superscript letters are significantly different (P<0.05).

Table 3. Reproductive efficiency of auratus cichlids after 16 weeks

	Granule (G)		Pellet (P)		Two-way ANOVA		
	GF1	GF3	PF1	PF3	Feed Type	Feeding Frequency	Interaction
Absolute fecundity (number)	6.58±1.91	13.42±1.99	9.96±2.03	14.63±3.73	0.3920	0.0529	0.6801
Relative fecundity (number/g)	0.98±0.36	1.22±0.24	0.87±0.13	0.86±0.22	0.3895	0.6650	0.6371
Fertilization rate (%)	83.85±2.71^{ab}	89.12±1.26^{b}	81.74±2.80^{a}	90.49±0.10^{b}	0.8608	0.0091	0.4203
Hatching rate (%)	74.74±7.02^{a}	93.90±1.46^{b}	85.46±3.39^{ab}	93.04±2.64^{b}	0.2715	0.0126	0.2032
Average seed production (number)	52.67±15.30	107.33±15.96	79.67±16.22	117.00±29.84	0.3920	0.0529	0.6801

In the same line, values with different superscript letters are significantly different (P<0.05).

Table 4. Colour parameters in body and caudal regions of auratus cichlids after 16 weeks

	Granule (G)		Pellet (P)		Two-way ANOVA		
	GF1	GF3	PF1	PF3	Feed Type	Feeding Frequency	Interaction
Initial body L*	64.45±0.27	64.93±0.25	64.39±0.39	64.34±0.01	0.2170	0.6162	0.2889
Final body L*	74.61±0.45^{b}	74.84±0.49^{b}	67.86±0.30^{a}	68.18±0.38^{a}	0.0000	0.5466	0.9183
Initial body a*	-2.33±0.01	-2.31±0.01	-2.34±0.02	-2.32±0.02	0.5353	0.1702	0.9781
Final body a*	-3.23±0.03^{a}	-3.17±0.03^{a}	-3.07±0.04^{b}	-3.04±0.03^{b}	0.0000	0.1893	0.6800
Initial body b*	17.87±0.11	18.02±0.11	18.07±0.11	18.21±0.12	0.0947	0.2118	0.9564
Final body b*	22.34±0.38^{bc}	23.44±0.41^{c}	21.53±0.39^{ab}	20.90±0.41^{a}	0.0001	0.5719	0.0380
Initial caudal L*	60.21±0.36	60.73±0.47	60.98±0.39	60.38±0.40	0.5997	0.9181	0.1735
Final caudal L*	63.84±0.25^{c}	64.00±0.45^{c}	62.11±0.34^{b}	60.23±0.50^{a}	0.0000	0.0356	0.0131
Initial caudal a*	-2.11±0.03	-2.07±0.03	-2.12±0.02	-2.09±0.03	0.6388	0.1698	0.6745
Final caudal a*	-2.15±0.33	-2.48±0.03	-2.32±0.03	-2.26±0.02	0.8792	0.4228	0.2442
Initial caudal b*	9.95±0.01	9.91±0.01	9.95±0.02	9.95±0.01	0.2783	0.1648	0.1235
Final caudal b*	14.93±0.07^{b}	14.90±0.06^{b}	14.35±0.05^{a}	14.25±0.06^{a}	0.0000	0.2961	0.5179

In the same line, values with different superscript letters are significantly different (P<0.05).

Table 5. Economic analysis of auratus cichlids after 16 weeks

	Granule (G)		Pellet (P)		Two-way ANOVA		
	GF1	GF3	PF1	PF3	Feed Type	Feeding Frequency	Interaction
Economic conversion ratio(€/g)	0.012±0.001^{b}	0.012±0.001^{b}	0.004±0.001^{a}	0.003±0.001^{a}	0.0000	0.4022	0.6999
Economic profit index (€/fish)	0.33±0.02^{ab}	0.29±0.01^{a}	0.37±0.01^{b}	0.35±0.01^{b}	0.0116	0.0900	0.3472

In the same line, values with different superscript letters are significantly different (P<0.05).

were significantly higher than PF1 and PF3 (P<0.05). Economic profit index (EPI) of GF3 was significantly lower than PF1 and PF3 groups (P<0.05). Both of these two parameters were influenced by type of feed (P value for ECR=0.0000 and P value for EPI=0.0116).

Discussion

The present study shows that the type of feed and regular feeding affected to growth performance, survival rate, reproduction efficiency, skin coloration, ammonia-nitrogen excretion and profitability of auratus cichlids. Feeding frequency impacted positively on final mean weights (FMW) and final mean total lengths (FMTL) for both granule and pellet feed types. In contrast, the survival rates (SR) decreased with further feeding frequencies. Fish fed with pellet feed three times daily consumed the highest amount of feed and growth parameters such as specific growth rate (SGR) and feed conversion ratio (FCR) of this group offered the best results among the other groups. Also, three times daily feeding improved the fertilization and hatching rates (FR and HR). The highest amount of offspring was taken from the cichlids fed with pellet feed three times daily. On the other hand, commercial ornamental fish granules enhanced the skin yellowness (*b**) and lightness (*L**) and reduced the excretion of total ammonia-nitrogen. But despite that, the profitable group was found as pellet feed.

Effects of feeding frequency are mainly studied on American cichlids, especially angelfish (*Pterophyllum scalare*). The results of the previous studies carried on angelfish showed that one daily feeding cause negative impacts on growth performance. Kasiri, Farahi, and Sudagar (2011) and Fujimoto *et al*. (2016) tested one time, two times and four times daily feeding on 0.9-2.4 g angelfish and they suggested that the growth rates of two and four daily feeding frequency groups were higher than one daily feeding. Ribeiro *et al*. (2012) investigated both feeding level (30, 60 and 90 g/kg BW/day) and feeding frequency (one and two meal/day) on 1.2 g angelfish and they stated that the growth rates improved with further feeding levels and frequencies. Montajami *et al*. (2012) carried out a study with another American cichlid species, Texas cichlid (*Herichthys cyanoguttatus*), with one, two, three and four times daily feeding frequencies. FMW and SGR of four times daily feeding group was the significantly highest among the other groups. SR of three and four times daily feeding frequencies were higher than one and two daily feeding groups. Texas cichlid specialized as their territorial and semi-aggressive behaviours any they can grow to be over 33 cm length (Goldstein, 2000). As in this previous study, optimum feeding frequency is increased for fish that are active and grow to a higher body sizes. Although auratus cichlids are belong to African Malawi mbuna group, they show the similar feeding behaviours in the aquariums as Texas cichlids. So, it can be expected that growth rates of auratus cichlids enhance with from the higher feeding frequencies to the limit of the optimum feeding frequency. In a previous study carried with another mbuna cichlid species, kenyi (*Maylandia lombardoi*), attained higher growth rates at higher feeding frequencies (Karadal *et al*., 2017) as in this present study.

The effects on the growth and survival rates of different forms of feed used in aquariums have been investigated on many aquarium fish. Harpaz *et al*. (2005) used different forms of powder and flake feed in the feeding of guppy (*Poecilia reticulata*) fry and the results of this study indicated that fish fed with powder feed show more efficient growth than flake feed group. Siccardi *et al*. (2009) reported that the best results in a study conducted with zebrafish (*Danio renio*) were in the order of pellet, flake and stick feed groups. Beside the commercial ornamental fish feeds, Bahadır-Koca *et al*. (2009) used a commercial extruder pellet feed in 0.73 g angelfish (*P. scalare*) and they reported that the FMW and SGR of fish fed with pellet feed were higher than ornamental fish feed group as shown in this present study conducted with auratus cichlids. Tamaru and Ako (1999) carried out a study with the same species, angelfish (2.8 g), fed with flake and salmon fry pellet feeds and they pointed that the FMW of pellet feed group were significantly higher than fish fed with flake feeds. The same outputs were reported by Royes *et al*. (2004) in two mbuna species, including powder blue (*Pseudotropheus socolofi*) and electric blue hap (*Sciaenochromis ahli*). The main result of this situation is the differences between the protein and lipid levels of the feeds. Siccardi *et al*. (2009) interpreted that the growth rates do not directly affect to health of fish, but they need optimum levels of dietary nutrients in their meal for regular growth. In this study, auratus cichlids fed with 50% protein (trout pellets) grown up better than fish fed with commercial cichlid granules (42% protein).

Feeding may affect some physiological characteristics, such as neurological, immunological, or reproductive aspects (Siccardi *et al*., 2009). Fish were met their optimum feeding requirements show more efficient fertility. Townshend and Wootton (1984) underlined that the fecundity of the convict cichlid (*Cichlasoma nigrofasciatum*) on the low and medium food supplies declined. Similar results were reported by Karadal *et al*. (2017) in a study carried on kenyi cichlids (*M. lombardoi*) fed with one and three times daily. The authors declared that ASP of kenyi cichlids fed with three times daily was higher than one daily feeding group. This present study offered the similar results as in these previous studies. Hatefi and Sudagar (2013) studied the effect of feeding frequency (one to five times daily) on fecundity of angelfish. The outputs of this previous study showed that the highest fecundity was found in fish fed three times daily. The similar results were presented by Lawrence, Best, James, and Maloney (2012) on zebrafish fed with one, three and five times daily. It can be said that the feeding frequency is limited to the optimum level for fecundity. In contrast, James and Sampath (2003) tested five feeding frequencies including every two days, every other day, every day, twice daily and thrice daily in red swordtail (*Xiphophorus helleri*) and they stated that the gonadosomatic index, gonad weight and number of offspring increased with higher feeding frequencies. Same authors also studied the effects of different feed types (*Artemia*, earthworms, liver, pellet feed and mixture) on fertility of the same species (red swordtail) in a different experiment (James & Sampath, 2004). The authors revealed that the fry production of fish fed with 45.5% protein containing pellet feed was lower than mixed diet (41.8% protein) and *Artemia* (56.5% protein). The mixed diet and *Artemia* contain the essential amino acids, balanced composition of NFE and high level of protein. This situation can be explained that these optimum dietary nutrients affected gonad development and enhanced fertility. However, Güroy, Şahin, Mantoğlu, and Kayalı (2012) declared that the reproductive success in cichlids influenced by not only protein and lipid composition of feed but also other nutritional compounds.

The skin coloration of aquarium fish depends on various nutritional characteristics, including dietary protein, lipid, vitamins, ingredients or additives (Kelsh, 2004; Güroy *et al*., 2012; Sefc, Brown, & Clotfelter, 2014; Karadal *et al*., 2017). Carotenoids are the main source of pigmentation in the skin of fish, but they cannot synthesize carotenoids. For this reason, the loss of pigments can be overcome by the addition of the carotenoids to the aquafeeds (Gupta, Jha, Pal, & Venkateshwarlu, 2007). Dietary carotenoids play an important role in the regulation of skin and muscle pigment in fish (Ezhil, Jeyanthi, & Narayanan, 2008). Carotenoids are therefore used to provide the colour associated with the consumer product, such as the bright vivid colours of ornamental fish (Mukherjee, Mandal, & Banerjee, 2010). Ornamental fish feed used in this study contains some natural pigment sources, such as krill meal, marine algae and *Spirulina*. Although krill meal found in the pellet trout feed, it does not indicate whether there is any micro or macro algae addition to the feed on the label. Algae in the aquafeeds, especially *Spirulina*, directly impact to the skin coloration of fish due to their rich contents of natural pigments (Güroy *et al*., 2012; Karadal *et al*., 2017). Enhancing colour parameters in auratus cichlids can be explained by gathering the natural pigments from ornamental fish granules in this study.

Ammonia is the basic end product of amino acid catabolism in freshwater fish (Fang *et al*., 2017) and TAN is a factor that restricts fish production in culture systems because of its toxicity (Cruz *et al*., 2013). Therefore, it can be used well-organized nutritional strategies to reduce TAN levels in fish systems without decreasing growth and reproductive performance or cost-effectiveness (Hardy & Gatlin, 2002). Previous studies have clearly stated that the dietary feed additives, especially plant-based, degraded TAN level. For example, Mojave yucca (*Yucca schidigera*) and soapbark (*Quillaja saponaria*) plants caused to decrease TAN levels in striped catfish (*Pangasianodon hypophthalmus*) juveniles (Güroy, Mantoğlu, Kayalı, & Şahin, 2014; Güroy, Mantoğlu, Merrifield, & Güroy, 2016). However, *Spirulina* has similar effects on yellow tail (*Pseudotropheus acei*) and kenyi (*M. lombardoi*) cichlids (Güroy *et al*., 2012; Karadal *et al*., 2017). Also, dietary nutrient levels affect the TAN. Gan *et al*. (2012) declared that lower levels of protein led to decrease the level of TAN in grass carp (*Ctenopharyngodon idella*). In this present study, two different commercial diets which have different protein ratios (42% and 50%) were used. High level of TAN in fish fed pellet feed can be related to protein and lipid level of the feed.

Some studies have been conducted to investigate the cost analysis in aquarium fish. Fujimoto *et al*. (2016) fed angelfish (*P. scalare*) five days a week and every day of the week. The results of the cost analysis revealed that they were more profitable depending on the growth parameters of the feed per day per week. Türkmen and Karadal (2017) presented the similar results in guppy (*Poecilia reticulata*) fed with every two days, every other day and one feeding daily frequencies. Silva *et al*. (2007) investigated the effects of growth and cost on the feeding cycle of pacu (*Colossoma macropomum*). After feeding fish with two and three meals daily at 5% and 10% of body weight, the best growth was found in three meals daily fed with 10% BW group. However, they reported that this group was more costly than two meals daily. However, by evaluating both the growth performance and the cost analysis parameters, the two meals came to the conclusion that nutrition is more appropriate. In the present study, although the pellet feed seems to be more profitable, the granule feed cycle needs to be accounted for in terms of marketing quality.

In conclusion, three times daily feeding was found more effective for growth, reproduction and coloration of auratus cichlids. Also, fish was fed with two types of commercial aquafeeds, including ornamental fish granules and trout fry pellets in this study. Although growth performance and reproductive efficiency of auratus cichlids enhance with the pellet feed, loss of coloration and increasing total ammonia-nitrogen levels were determined in fish fed with this feed. But, commercial granules improved the coloration and decreased the ammonia level while it does not profitable. This situation can be solved by rotatory feeding. As a suggestion of this study, cycled feeding regimes can be applied with ornamental fish feeds and other freshwater fish pellets. Further studies on the feeding schedule of different type of feeds can be improved this suggestion.

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