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The effect of feeding frequency on growth performance of rainbow trout fingerlings reared in recirculating system

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Abstract. Growth, feed consumption and conversion ratios of trout fingerlings (*Oncorhynchus mykiss*) subjected to daily feeding frequencies were evaluated. The trial performed using 295 fish with a mean weight of 5.53±0.25 g divided equally to four tanks. The two treatments (namely, daily feeding frequencies of two - F1 and four meals- F2) were each applied for two tanks. Mean live weights of the fish in trial groups reached 13.15 g and 13.61 g at the end of the trial in groups F1 and F2, respectively. Growth data indicated that, the final live weight and SGR values of group F2 were similar with those of the F1 group (4.22%/bw/day respectively 4.19%/bw/day). Condition factors (CF) showed similar values. It seems that, rainbow trout fed twice a day performed better than those fed four times a day, in terms of feed conversion ratio (FCR) and protein efficiency ratio (PER) (FCR was 0.55 in F1 and 0.63 in F2; PER was 4.33 in F1 and 3.8 in F2).

Key words: rainbowtrout, fingerlings, feeding frequency, growth, condition factor**.**

Rezumat. În studiul de faţă s-a cuantificat performanţa de creştere, consumul de furaj şi rata de conversie a hranei la puietul de păstrăv curcubeu (*Oncorhynchus mykiss*) în condiţiile testării a două frecvenţe de furajare. Studiul a fost intreprins utilizând un număr iniţial de 295 exemplare cu o greutate medie de 5,53 ± 0,25 g distribuite randomizat în patru unităţi de creştere. Cele două regimuri de furajare (numărul de mese administrate zilnic, notate cu F1 pentru 2 mese/zi şi F2 pentru 4 mese/zi) au fost testate utilizând pentru fiecare variantă experimentală o replică. Greutatea individuală medie la finalul studiului a fost de 13,15 g şi 13,61 g în grupurile F1 şi respectiv, F2. Rezultatele obţinute au indicat faptul că atât sporul de creştere (7,73 g/ex, respectiv 7,97g/ex.) cât şi valorile SGR (4,22%/BW/zi, respectiv 4,19%/BW/zi) pentru variantele F1 au fost similare cu cele obţinute pentru variantele F2. Se pare că, păstrăvul curcubeu furajat de două ori pe zi a performat mai bine decât cel furajat de patru ori pe zi, acest lucru fiind reflectat de valorile indicatorilor de conversie a hranei - FCR, respectiv de eficienta proteică- PER (FCR a fost 0,55 în F1 şi 0,63 în F2; PER a fost 4,33 în F1 şi 3,8 în F2).

Cuvinte cheie: păstrăv curcubeu, puiet, frecvenţă furajare, spor de creştere, factor de condiţie.

Introduction. The primary objective of intensive aquaculture is to minimize costs and maximize growth, understanding that feed is the largest cost in salmonid culture (De Silva & Anderson 1995; Başçınar et al 2007). Overfeeding mostly leads to feed spillage, decreasing feed efficiency and polluting the environment. Likewise, underfeeding results in reduced growth as well as decreased feed efficiency (Talbot & Hole 1994; Einen et al 1995). The feed conversion ratio (FCR) and specific growth rate (SGR) represents a primary determinant of profitability in aquaculture and combines feed ration (FR, the input) with growth (G, the output).

The amount of the daily feed ratio, frequency and timing of the feedings are the key factors of feed management strategies, influencing the growth and feed conversion (Jobling 1995; De Silva & Anderson 1995; Goddard 1996). Kaushik & Gomes (1988) observed that frequent feeding reduced excretory losses of nitrogen, optimizing the amount of nutrients

and energy available for growth. Optimal feeding frequency may vary depending on species, age, size, environmental factors, husbandry, and feed quality (Goddard 1996). The limited information available suggests that optimum feeding rates and frequencies should be determined for each species and different sizes of the same species cultured under various environmental and husbandry conditions.

Ruohonena at al (1998) found no effects of feeding frequency on energy retention efficiency in rainbow trout and a pattern of decreasing protein efficiency with more frequent feedings.

The present paper aims to emphasize the effects of feeding frequency on the technological performance of rainbow trout fingerling reared under intensive conditions in a closed recirculating aquaculture system.

Material and Methods. The experiment was carried out between 25th October and 16th November 2010 at the pilot recirculating system located in a laboratory of „Aquaculture, Environmental Science and Cadastre" Department, Lower Danube University, provided with 4 rearing units with total volume of 0.336 m^3 (0, 35×0, 80×0,120 m) each and water quality maintenance units represented by water filtration unit, water sterilization unit (represented by a UV lamp) and water oxygenation unit (represented by two compressors).

Experimental design. 295 Trout fingerlings (with mean initial weight ± SEM, 5.53 ± 0.25g) brought from fish farm Cislau, Buzau were stocked in different densities in the aquarium at almost equal biomass (Table 1). The fish were distributed in such a manner to create homogenous groups with similar class frequencies and exemplar number. Statistical testes confirmed normal distribution of the cohorts. The two treatments (namely, daily feeding frequencies of two meals - F1 and four meals - F2) were each applied for two tanks. For the first six days of the experiment fish were fed with a ratio of 3%/BW/day and then was increased up to 5% on the eighth day; after that the ratio remained constant till the end of the trial. The fish were fed with extruded pellets with 50 % protein content (feed composition is presented in Table 2).

Table 1

Initial biometric and statistical data of the experimented fish groups

Biometric data	B_1	B_2	B_3	B_4
	F1	F1	F2	F2
Total biomass (g)	410	402	404	413
Number of exemplars	76	74	75	70
Mean individual weight (g)	5.39	5.43	5.39	5.90
Std. Deviation	1.47	1.33	1.60	1.71

Table 2

Biochemical composition of the NUTRA PRO MP-T pellets

Parameters	*Quantity*	*Parameters*	*Quantity*
Crude protein	50%	Phosphorus	1.20%
Crude fats and oils	20%	Calcium	1%
Crude fiber	1%	Sodium	0.40%
Crude ash	8%	Vit. A/E	6000 UI/kg
		Vit. D3	1200 UI/kg

Calculations. After three experimental weeks the fish were weighed and the growth performance of the fish were calculated:

Weight Gain (W) = Final Weight (Wt) - Initial Weight (W0) (g)

Food Conversion Ratio (FCR) = Total feed (F) / Total weight gain (W) (g/g)

Specific Growth Rate (SGR) = 100 x (ln Wt - ln W0) / t (% BW/d)
Relative Growth Rate (RGR) = (Wt -W0)/ t /BW) (g/ kg/·d)
Protein efficiency ratio (*PER*) = Total weight gain (W) / amount of protein fed (g)
Relative Weight Gain (RWG%) = (Wt – W0) x 100 / Wt
Statistical data processing. Statistical analysis was performed using the SPSS 15.0 for Windows. Distribution normality was verified using Kolmogorov-Smirnov test Z. Statistical differences between variables were tested using t test (α = 0.05). The coefficient of variation (CV) was calculated as the ratio of the standard deviation to the mean in order to have a measure of dispersion.

Results and Discussion. In our recirculating system the water quality parameters (Mean±SD) including water temperature (21.9±4.8^{0}C), dissolved oxygen (6.5±1.43 mg L^{-1}), pH (6.9±1.02), ammonium (1.24±0.30 mg L^{-1}), nitrate (38.52±11.8 mg L^{-1}) and nitrite (0.006±0.004 mg L^{-1}) were fairly constant during the period of experiments and not significantly affected by stocking density (ANOVA, P > 0.05). Regarding the dynamics of water quality parameters we didn't observed major modification or peaks during the day or after feeding.

The initial mean weight of the fingerlings used were not significantly different (p>0.05) for each group. There were relatively low mortality rates (1.33%-3.75%) throughout the trial, which proved that environmental and dietary conditions were at optimal limits. Mean live weights gain of the fingerlings in groups B1, B 2, B 3 and B 4 reached 6.56, 8.29, 7.78 and 8.17 g at the end of the trial. This translates into an average daily growth rate of between 0.36 and 0.39 g for each specimen. The data on growth and technological performance during the trial were summarized in Table 3.

Table 3

Biometric parameters and technological indices of the fish sampled at the end of the trial

Final biomass FB(g)	956.00	947.00	974.00	957.00
Mean final weight -MFW (g/piece)	12.92	13.72	13.16	14.07
Individual weight gain - IWG (g/piece)	7.52	8.29	7.78	8.17
Total weight gain - TWG(g)	546.00	545.00	570.00	544.00
Relative feeding rate-RFR (g/kg/day)	2.70	2.55	3.01	2.82
Specific growth rate -SGR (% BW/day)	4.16	4.41	4.25	4.14
Daily growth rate – DGR (g/kg/day)	0.36	0.39	0.37	0.39
Food conversion ratio - FCR (g/g)	0.55	0.55	0.61	0.64
Total protein (g)	126.00	126.00	145.74	145.74
Protein efficiency ratio - PER	4.33	4.33	3.91	3.73

The SGR values of group F2 were similar with those of the F1 group (4.22%/bw/day respectively 4.19%/bw/day). The FCR values showed slightly higher eficiency in the groups fed twice daily (0.55) comparing with the groups fed four times per day (0.61 for B3 and 0.64 for B4).

The growth data clearly indicated that the final live weight, relative growth rate and SGR values of fish fed two times were not significantly different from those fed four times in both groups.

The lack of evident difference in feed conversion rate among the treatments in the fingerlings group was consistent with the argument that the effect of feeding frequency on feed conversion is usually small. This indicated that fish which were fed more frequently utilized that food as efficiently as the fish that were fed less frequently and that food consumption and not food conversion efficiency was the growth-limiting factor. The ability of an organism to utilize nutrients especially protein will positively influence its growth rate (Aderolu et al 2010). This is justified by the highest PER and low FCR in the treatments fed

twice daily. This suggested that fish must have efficiently converted feed consumed to growth.

Mean body weight of the fish in trial groups reached 13.15 g and 13.61 g at the end of the experiment in groups F1 and F2, respectively (Figure 1).

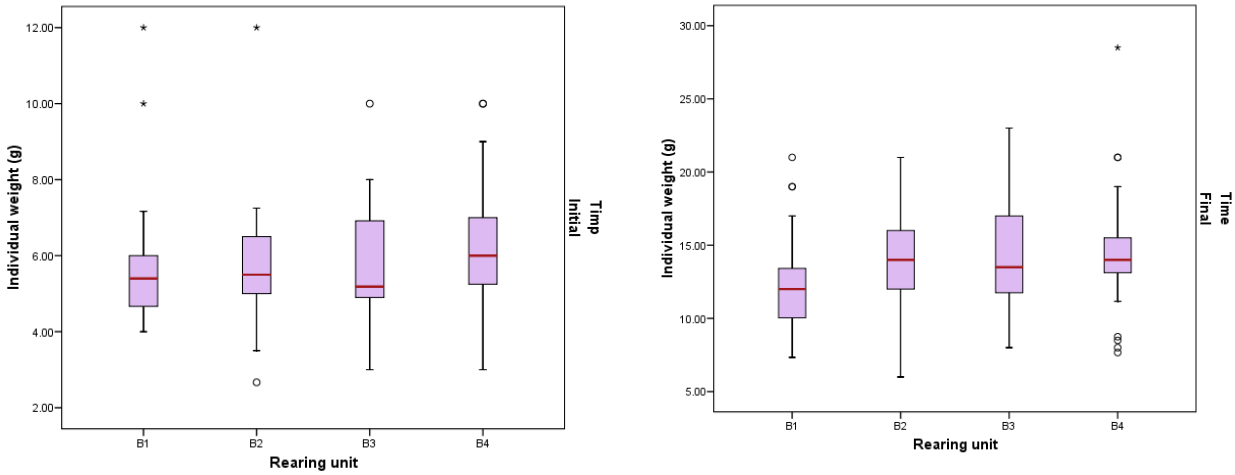

Figure 1. Individual initial and final weight of rainbou trout fingerlings.

Although there were no differences in the mean weights between treatments, there appeared to be greater size variation in the F2 (4 meals/day) treatment at the end of the experiment. Increased size heterogeneity (often expressed as the coefficient of variation, CV) has been suggested as an indicator of the social environment within fish populations, where an increase over time may indicate inter-individual competition within the fish group. Size variation suggest that inter-individual competition increased possibly as a result of the formation of dominance hierarchies, where a hierarchy can be defined as comprising of a group of dominant individuals at the top of the hierarchy, followed by a number of subdominants and, thereafter, a number of subordinates with low rank positions.

Table 4

Coeficient of variation (%) for the experimental groups in the beginning and in the end of the trial

Experimental variant	Rearing units	Coeficient of variation (%)	
		Initial	Final
F1 (2 meals/day)	B1	27.27	21.85
	B2	25.33	22.87
F2 (4 meals/day)	B3	29.68	26.68
	B4	28.98	27.53

Conclusions. In the presents experiment rainbow trout fed twice a day performed better than those fed four times a day, in terms of FCR and PER (FCR was 0.55 in F1 and 0.63 in F2; PER was 4.33 in F1 and 3.8 in F2.). The feeding frequency show no evident effect on other biotechnological indicators such us SGR and DGR. Although the weight gain was similar for all rearing units, the structure of fish population within the units was different. The main conclusion of the trial is represented by the fact that, on the long term, higher

feeding frequency could lead to more heterogeneous groups and less efficient technological results.

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