Kuwait J. Sci. **44 (1)** pp. 106-113, 2017

Comparison of effects of two different feeding rations (high feed rates and limited) on growth of rainbow trout in rectangular concrete pools culture conditions of Suşehri in Turkey

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Abstract

This study is focused on comparison of effects of two different feeding rations on growth of rainbow trout in rectangular concrete pools culture conditions of Suşehri in Turkey. Also, the water used in the experiment was analyzed for 15 physicochemical parameters. During the experiment, food was given to the fish in the first group at 2% ratio of their live weight and to the second group, until satiation. At the end of the experiment, the live weights of groups were determined as 116.36±36.84 g, 147.53±24.82 g, respectively and the difference among both groups have been found to be significant ($P<0.05$). In the study, total length gain, relative total length gain, weight gain, relative weight gain, specific growth rate, survival ratio, condition factor and feed conversion ratio of groups were calculated. Feed conversion rates have been found to be 1.57 and 2.93, respectively. The best feed conversion rate was found with the first group (2%). At the end of the economic analysis, it was found that food cost is low with the first group and high with the second group.

Keywords: Effect; feeding ratio; growth; rainbow trout.

1. Introduction

Rainbow trout (*Oncorhynchus mykiss* W., 1792) is cultured in many countries all over the world. Rainbow trout is the most dominant fish species for aquaculture in Turkey. Commercial rainbow trout farming started in Turkey in 1971 and it has increased very much. In 1986, 990 tons of rainbow trout was produced in Turkey (TUIK, 1998; Yıldız *et al*., 2011). The production level reached 122873 tons, according to the data in 2013 (GDFA, 2015). Feeding is one of the most important factors in commercial fish farming, as feeding level has been proven to be the main differentiating factor in all growth, feed conversion and body composition parameters (Van Ham *et al*., 2003). Optimal feeding level is important not only for promoting best growth and minimizing feed conversion rate but also for economic and environmental reasons, preventing water quality deterioration as a result of overfeeding (Ng *et al*., 2000; Mihelakakis *et al*., 2002; Luo *et al*., 2006). This study is focused on comparison of effects of two different feeding rations on growth of rainbow trout in rectangular concrete pools culture conditions of Suşehri in central Anatolia of Turkey.

2. Materials and methods

2.1. Study area

Suşehri is located in central Anatolian region of Turkey and is situated in the east of Sivas about 140 km towards the city centre and located at an average altitude of 1163 m above sea level. The area of Suşehri is a district of Sivas in terms of administration and is about 985 square kilometers. The district has been named as Suşehri because of the bounty of water in the region (Dirican *et al*., 2009). Forty seven rainbow trout farms are present in the Sivas and their total production capacity was about 5544.00 tons in 2013. About 80% of this production occurs in the farms in Suşehri (Dirican, 2014).

2.2. Experimental practices

This study was performed in two concrete pools of the fish farm of Suşehri Vocational Training School of the Cumhuriyet University in Turkey. Water source of the present study was ground water pumped from 25 m depth. The water used in the experiment was analyzed during study period for 15 physicochemical parameters in the field. The water temperature, dissolved oxygen and oxygen saturation were measured with a Bante

820 model oxygenmeter. The pH, ammonium, nitrite, nitrate, ortho-phosphate, chloride, carbonate hardness, acid binding capability and total hardnes were analysed immediately with test kits from Aquamerck, Darmstadt, Germany. The pH, ammonium, nitrite, nitrate and ortho-phosphate were measured by colorimetric method using test kits 1.08027.0001, 1.08024.0001, 1.08025.0001, 1.11170.0001 and 1.14661.0001 respectively. Chloride, carbonate hardness, acid binding capability and total hardness were measured by titrimetric method using test kits 1.11106.0001, 1.08048.0001 and 1.08039.0001 respectively. Calcium and magnesium values were calculated according to the formula of total hardness change (Dirican & Barlas, 2005). Classification of water quality was performed according to Turkish water pollution control regulation (TWPCR, 2008). The experimental system consisted of two experimental concrete pools. In the present study, which was carried out on two groups, a total of 2000 rainbow trouts were used (1000 in each group). The samples of fish were counted and divided equally into two separate groups and were placed in two rectangular pools of size of 10 x 4 x 1.2 m, manufactured from concrete. The experiment lasted for 90 days from 05 October 2012 to 04 January 2013. During the experiment, food was given to the fish in the first group at 2% ratio of their live weight and to the second group ad libitum. Fish were fed extruded trout feed along with a commercial trout feed. 1 mm feed contains nutrients in the ratio: 45% crude protein, 20% crude fat, 3% crude fiber, 15% crude ash, 1–2% calcium, 0.2–1% sodium, 1.5% total phosphorus, 12% humidity, metabolic energy 4250 kcal/kg and 3 mm in the ratio: 45% crude protein, 20% crude fat, 3.5% crude fiber, 10% crude ash, 1.1% calcium, 0.5% sodium, 1.5% total phosphorus, 10% humidity, metabolic energy 3959 kcal/kg. Fish were fed twice a day by hand. From each group, 10 fish were randomly sampled and their live weight and total length were measured during each 15 days interval. Each sample of fish were measured to the nearest ±1 mm in total length and weighed to the nearest ±0.1 g in live weight. During the experiment, dead fish were removed, weighed and recorded daily to correct the calculations.

2.3. Data calculations and statistical analyses

The data obtained was evaluated according to previos researches (Berg *et al*., 1990; Kim *et al*., 1996; Okumuş *et al*., 1999; Arıman & Aras 2003; Froese 2006; Kayım *et al*., 2007; Akgün 2008; Akbary *et al*., 2010) using following formulae:

Weight Gain = FBW – IBW
Relative Weight Gain (%) = WI / IW x 100
Where: FBW = Final Body Weight (g); IBW= Initial Body Weigth (g);
WI= Weight Increase (g); IW= Initial Weight (g).

Total Increase Length = FTL – ITL
Relative Total Length Gain (%) = TLI / ITL x100
Where: FTL= Final Total Length (cm); ITL= Initial Total Length (cm);
TLI= Total Length Increase (cm).

Condition Factor = W/L^3 x 100
Where: W= Wet Fish Weight (g); L= Total Length (cm).

Survival Percentage (%) = (FNF ×100) / INF
Where: FNF= Final Number of Fish; INF= Initial Number of Fish.

Specific Growth Rate (%) = [(lnW2 – lnW1) / (t2 – t1)] x 100
Where: W1= Initial Mean Live Weigth (g); W2= Final Mean Live Weigth (g);
t2 – t1= Period of Experiment (day); ln= Natural Logarithm.

Feed Conversion Ratio = FC / (A_2+D) - A1
Where: FC= Feed Consumption (g); A_1= Total Weight at the Beginning of the Period (g); A_2= Total Weight at the End of the Period (g); D= Weight of Dead Fish in Period (g).

Statistical analysis of data was performed with SPSS version 17.5 for Windows. Biostatistical analysis of this study, the mean of variables, standard deviation, minimum and, maximum frequency and percentage values were defined. Data was analyzed by repeated measures of ANOVA, chi-square and t test. The post-hoc LSD (least significant difference) test was employed for the comparison of means ($P<0.05$). $P<0.05$ was considered statistically significant. The statistical power for the study was observed at about 0.90 levels for sample size. This statistical power level shows that there is sufficient sample size for the study.

3. Results and discussion

The mean physicochemical parameters were measured at following water temperature 13.0±2.98 ^{0}C, dissolved oxygen 7.1±2.12 mg/l, oxygen saturation 78.6±19.59%, biological oxygen demand (BOD_5) 0.6±0.28 mg/l, pH 8.0±0.00, clorid 25.0±1.41 mg/l, total hardness 19.2±0.14 ^{0}dH, carbonate hardness 13.5±0.21 ^{0}dH, acid binding capability 4.9±0.14 mmol/l, calcium 137.1±1.01 mg/l and magnesium 82.2±0.61 mg/l in the water used in the experiment. Ammonium, nitrate, nitrite and ortho-phosphate were not found during the study period. All the mean physicochemical parameters were within the acceptable ranges for rainbow trout culture (TWPCR, 2008). According to TWPCR (2008), classical continental inland water sources of the Turkish water pollution control regulation, the mean physicochemical datas of the water used in the experiment could be categorized as class-I or high water quality standard.

A comparison of mean total length of rainbow trouts according to periods are presented in Table 1. At the end of the experiment, the mean total length of trouts in group-I varied between 10.60±1.49 and 20.42±2.34 cm, and that in group-II varied between 10.66±1.29 and 22.97±1.02 g. The length of the trouts between group-I and group-II did not show any difference until 75th day, but showed significant difference on the 90th day ($P<0.05$). These results indicate a better growth of trouts in the second group. There are no statistical differences, among groups in comparison to mean total length of rainbow trouts according to 15th, 30th, 45th, 60th and 75th days ($P>0.05$).

Table 1. Comparison of mean total length of rainbow trouts according to periods.

Periods	Group I		Group II		t	P
	N	Mean±SD	N	Mean±SD		
0 th Day	10	10.60±1.49	10	10.66±1.29	-0.10	0.924
15 th Day	10	12.58±1.38	10	12.33±2.11	0.31	0.761
30 th Day	10	13.70±1.31	10	14.55±2.11	-1.08	0.294
45 th Day	10	13.90±1.77	10	14.56±1.91	-0.80	0.433
60 th Day	10	17.22±2.12	10	17.56±1.89	-0.38	0.710
75 th Day	10	19.81±2.81	10	18.93±1.42	0.88	0.389
90 th Day	10	20.42±2.34	10	22.97±1.02	-3.16	**0.005*****
	P= 0.018 periods; 0 th Day < 15 th Day = 30 th Day = 45 th Day < 60 th Day < 75 th Day = 90 th Day		P= 0.000 periods; 0 th Day < 15 th Day < 30 th Day = 45 th Day < 60 th Day < 75 th Day < 90 th Day			

SD: standard deviation, the asteriks (: P<0.05; **: P<0.001; ***: P<0.001) show the significance level of the comparisons. The significance of the period between the 0 th day and 90 th day was tested by repeated measures of ANOVA. It determined that in fiction meaningful comparison of the difference, the bilateral relations of the period, depending on the number of days in the period are presented in the premises after the P value in the bottom of the table.*

A comparison of mean live weight of rainbow trouts according to periods are presented in Table 2. At the end of the experiment, the mean live weight of trouts in group-I varied between 15.91±5.07 and 116.36±36.84 g, and that in group-II varied between 17.28±4.63 and 147.53±24.82 g. The live weight of trouts between group-I and group-II did not show any difference until 15th day, but showed significant difference on the 30th day and the 90th day ($P<0.05$).

Table 2. Comparison of mean live weight of rainbow trouts according to periods.

Periods	Group I		Group II		t	P
	N	Mean±SD	N	Mean±SD		
0 th Day	10	15.91±5.07	10	17.28±4.63	-0.63	0.535
15 th Day	10	23.27±5.83	10	24.75±13.74	-0.31	0.757
30 th Day	10	26.09±8.26	10	37.64±15.05	-2.13	0.047*
45 th Day	10	34.30±15.32	10	39.17±17.59	-0.66	0.517
60 th Day	10	64.46±22.17	10	70.14±24.88	-0.54	0.597
75 th Day	10	101.72±32.13	10	90.72±21.75	0.90	0.382
90 th Day	10	116.36±36.84	10	147.53±24.82	-2.22	0.040*
	P= 0.011 periods; 0 th Day < 15 th Day = 30 th Day = 45 th Day < 60 th Day < 75 th Day = 90 th Day		P= 0.001 periods; 0 th Day = 15 th Day < 30 th Day < 45 th Day < 60 th Day < 75 th Day < 90 th Day			

SD: standard deviation, the asteriks (: P<0.05; **: P<0.001; ***: P<0.001) show the significance level of the comparisons. The significance of the period between the 0 th day and 90 th day was tested by repeated measures of ANOVA. It determined that in fiction meaningful comparison of the difference, the bilateral relations of the period, depending on the number of days in the period are presented in the premises after the P value in the bottom of the table.*

A comparison of mean condition factor of rainbow trouts according to periods are presented in Table 3. At the end of the experiment, the mean condition factor of group-I varied between 0.98±0.10 and 1.34±0.13, and that of group-II varied between 1.18±0.18 and 1.41±0.18. At the start of the experiment, mean values of condition factor ranged between 1.32±0.16 (group-I) and 1.41±0.18 (group-II), with no significant differences. The condition factor of trouts between group-I and group-II did not show any difference until 15th day, but showed significant difference on 30th day and 90th day (P<0.05). These results may indicate that the fish grow faster in length than in weight. Condition factor, one of the most important feeding and growth criteria, is expected to be higher than 1.0 for rainbow trout, and it was within the normal ranges during the study, except till 15th day for group-I. The condition factor obtained from the present study was found to be similar to the condition factor of Okumuş & Mazlum (2002) (between 1.23 and 1.25); but was higher than that of Ağırağaç & Büyükhatipoğlu (1998) (between 1.20 and 1.17) and was lower than that of Aral *et al*. (1996) (between 1.47 and 1.37). It is thought that this difference might have been caused by the different environmental conditions, the initial total lengths and the initial body weights of trouts in these studies.

Table 3. Comparison of mean condition factor of rainbow trouts according to periods.

Periods	Group I		Group II		t	P
	N	Mean±SD	N	Mean±SD		
0 th Day	10	1.32±0.16	10	1.41±0.18	-1.26	0.222
15 th Day	10	1.16±0.17	10	1.19±0.15	-0.36	0.720
30 th Day	10	0.98±0.10	10	1.18±0.18	-3.22	**0.005*****
45 th Day	10	1.20±0.26	10	1.19±0.12	0.09	0.930
60 th Day	10	1.22±0.06	10	1.24±0.14	-0.48	0.640
75 th Day	10	1.28±0.18	10	1.32±0.14	-0.47	0.642
90 th Day	10	1.34±0.13	10	1.21±0.14	2.07	0.053*

SD: standard deviation, the asteriks (: P<0.05; **: P<0.001; ***: P<0.001) show the significance level of the comparisons.*

Initial mean body weight, final mean body weight, mean body weight gain, relative weight gain and specific growth rate in groups are summarized in Table 4. Initial mean live weight for first group was 15.91±5.07 g and for second group was 17.28±4.63 g, while final mean live weights found that end of experiment for first group was 116.36±36.84 g and second group 147.53±24.82 g. The significance level of initial mean body weight and final mean body weight were compared with t test. There was a significant difference between initial mean body weight and final mean body weight (P<0.001) as shown in Table 4. Optimal feeding varies with species, age, size, environmental factors, husbandry and feed quality. These results indicate that rainbow trouts could partially compensate the differences in body weight by 90th day, when the differences in initial body weight are not drastic. Mean weight gained in first group 100.45 g and in second group 130.25 g were obtained. Relative weight gain was found to be 631.36% in first group and 753.76% in second group. As shown in Table 4, the highest average body weight gain (130.25 g) was recorded in group-II which was fed at ad libittum. Specific growth rate was found to be 1.12% in first group and 1.45% in second group. The result of this study is in line with the findings of Öz (2004), as specific growth rates were found to be 1.21 and 1.46%.

Tablo 4. Initial mean body weight, final mean body weight, maen body weight gain, relative weight gain and specific growth rate in groups.

Groups	Initial Mean Body Weight ±SD (g)	Final Mean Body Weight ±SD (g)	Mean Body Weight Gain (g)	Relative Weight Gain (%)	Specific Growth Rate (%)	P
I	15.91±5.07	116.36±36.84	100.45	631.36	1.12	**P<0.001**
II	17.28±4.63	147.53±24.82	130.25	753.76	1.45	**P<0.001**

SD: standard deviation, initial mean body weight *and final mean body weight were compared with t test and it was observed that advanced significantly different (P<0.001).*

Initial mean total length, final mean total length, total length gain and relative total length gain in groups are summarized in Table 5. Initial mean total length of trouts in first and second groups was found to be 10.60±1.49 cm and 10.66±1.29 cm respectively, while final mean total length for first and second groups was found to be 20.42±2.34 cm and 22.97±1.02 cm respectively. The significance level of initial mean total length and final mean total length were compared with t test. There was a significant difference between initial mean total length and final mean total length (P<0.001). Total length gained in first group was 9.82 cm and in second group was 12.31 cm. Relative total length gained in first and second groups was found to be 92.64% and 115.48% respectively. As shown in Table 5, the highest average total length gain (12.31 cm) was recorded in group-II which was fed at ad libittum.

Tablo 5. Initial mean total length, final mean total length, mean total length gain and relative total length gain in groups.

Groups	Initial Mean Total Length ±SD (cm)	Final Mean Total Length ±SD (cm)	Mean Total Length Gain (cm)	Relative Total Length Gain (%)	P
I	10.60±1.49	20.42±2.34	9.82	92.64	**P<0.001**
II	10.66±1.29	22.97±1.02	12.31	115.48	**P<0.001**

SD: standard deviation, initial mean total length and final mean total length were compared with t test and it was observed that advanced significantly different (P<0.001).

Table 6. Final number of fish, final number of dead fish, survival ratio, weight of dead fish in period, feed consumption and feed conversion ratio in groups.

Groups	Final Number of Fish	Final Number of Dead Fish	Survival Ratio (%)	Weight of Dead Fish in Period (g)	Feed Consumption (g)	Feed Conversion Ratio (%)	Chi-square Test Results
I	421	579	42.10	32471.76	51225	1.57	X^2= 152.2 **P<0.001**
II	695	305	69.50	20849.65	61470	2.93	

SD: standard deviation, at the end of experiment between the group-I and group-II, final number of fish and final number of dead fish were compared with chi-square test and it was observed that advanced significantly different (P<0.001).

Final number of fish, final number of dead fish, survival ratio, weight of dead fish during the period, feed consumption and feed conversion ratio in groups are summarized in Table 6. Survival ratio was found to be 42.10% and 69.50% in first and second group respectively. Survival ratio was much lower in first group than compared to second group. As shown in Table 6, the highest final number of fish was recorded at the end of the experiment in group-II. At the end of the experiment, the significance level of final number of fish and final number of dead fish were compared with chi-square test. There was a significant difference between final number of fish and final number of dead fish (P<0.001). Feed conversion was recorded to be 1.57% and 2.93% in first and second group respectively. The best feed conversion ratio was found in group-I, which was fed at 2% ratio of live weight, when compared to other group. In intensive rainbow trout culture systems, optimum feed conversion ratio is between 1 and 2, for commercial dry feed. In the present study, the values of feed conversion ratio for first group were within the ranges reported for commercial feed by other investigators (Okumuş & Başçınar, 2001; Zhu *et al*., 2001; Akbulut *et al*., 2002; Kayım *et al*., 2007; Kızak *et al*., 2010). Similarly, in the present study, the values of feed conversion ratio for second group were within the ranges reported for commercial feed by other investigators (Aral *et al*., 1996; Arıman & Aras, 2003). It is thought that the feed conversion ratio value is affected by some factors such as environment, feed quality, stock intensity and fish size. Okumuş & Mazlum (2002) reported a positive relationship between feed conversion ratio and temperature, but up to 15-18 °C after that the growth rate was found to decline. Water temperature certainly has major influence on food consumption and growth. Optimum growth temperature for rainbow trout has been accepted as 15–17 ºC (Okumuş & Mazlum, 2002). Water temperature values ranged from 10.5 to 18.2 °C in the present study. Besides, the present study was conducted from October to January, when water temperature was on the decrease. Therefore, it may be preferable to compare the growth performance among different aquaculture systems with rather different environment conditions. Feed conversion ratio is one of the criteria affecting the production cost and the profitability of rainbow trout rearing (Kayım *et al*., 2007). The cost of gaining 1 kg of live fish weight was calculated as to be 5.78 TL (2.83 USD) in group-I and 10.78 TL (5.28 USD) in group-II. At the end of the bio-economic analysis, the cost of gaining weight was found to be low in the first group, which was fed on 2% of ratio of live weight, but dead fish ratio was higher. Instead of high feeding rates, feeding was done in ratio according to needs of fish. Feeding rates, growth and feed conversion are major variables for commercial aquaculture enterprises. Feeding rates must be chosen to improve efficiency in aquaculture. Less feed would be required for maintenance of body size. Thus, cost per fish could be effectively reduced. In this study, more suitable feeding rates were observed in group-I.

4. Conclusion

In conclusion, the findings can provide helpful references for nutritional status and feeding levels of rainbow trout in Suşehri aquaculture conditions. Thus, cost per fish could be effectively reduced. This practice of environmental friendly aquaculture will ultimately lead to sustainable rainbow trout farming with less negative effects on the environment of the sector and allow passage of aquaculture quality to the quality of the environment. Furthermore, using this practice will provid significant contributions to the economy and will protect the environment.

5. Acknowledgment

This study was supported by the scientific research project fund of Cumhuriyet University under the project number STKMYO-002.

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Submitted **:** 03/07/2015
Revised **:** 20/04/2016
Accepted **:** 20/05/2016

مقارنة بين آثار اثنين من حصص التغذية المختلفة (معدل تغذية مرتفع ومحدود) على نمو أسماك السالمون الملونة في أحواض أسمنتية مستطيلة في منطقة سوشهري في تركيا

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خلاصة

تركز هذه الدراسة على المقارنة بين الآثار المترتبة على اثنين من حصص التغذية المختلفة على نمو أسماك السالمون الملون (rainbow trout) في أحواض اسمنتية مستطيلة في منطقة سوشهري في تركيا. أيضا، تم تحليل المياه المستخدمة في التجربة لعدد 15 من العوامل الفيزيويكيميائية. خلال التجربة، قدم طعاما للأسماك في المجموعة الأولى بنسبة 2% من وزنها، وإلى المجموعة الثانية حتى الشبع. في نهاية التجربة، تم تحديد الأوزان الحية للمجموعات وتبين أنها 116.36 ± 36.84 غرام، 147.53 ± 24.82 غرام على التوالي والفرق بين المجموعتين كان إعتباريا .($P < 0.05$) في الدراسة، تم احتساب مجموع الطول المكتسب، و نسبة إجمالي الزيادة في الطول، وزيادة الوزن، وزيادة الوزن النسبي، ومعدل النمو المعين، ونسبة البقاء على قيد الحياة، ونسبة التحويل الغذائي للمجموعات. وجد أن معدلات التحويل الغذائي كانت 1.57 و2.93 على التوالي. كان أفضل معدل للتحويل الغذائي في المجموعة الأولى (2%). في نهاية التحليل الاقتصادي، وجد أن تكلفة المواد الغذائية منخفضة مع المجموعة الأولى وعالية مع المجموعة الثانية.

كلمات البحث: تأثير؛ نسبة تغذية؛ نمو؛ السالمون الملون