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Effect of Initial Size on Growth Rate of Rainbow Trout, *Oncorhynchus mykiss,* Reared in Cages on the Turkish Black Sea Coast

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Abstract

A rearing trial was carried out to examine the effect of initial fish size on growth rate of rainbow trout, *Oncorhynchus mykiss*, reared in marine cages. The fish were introduced into the cages at the same stocking density (2.1 kg/m^3) and three different size groups (small: 52.1±10.8 g, n=2,250; medium: 77.6±11.7 g, n=1,500; large: 118.6±20.1 g, n=1,000) with two replicates. The fish were fed to satiation three times a day with commercial pelleted diet.

The growth, feed conversion, daily feeding and final biomass were found to be significantly affected by stocking size (P<0.05). The specific growth rate in small group (1.11%) was better than other two groups (1.02%). The highest daily feeding rate was in large (1.66%), and followed by medium (1.55%) and small size groups. The feed conversion values varied between 1.37 and 1.70. There was a negative relationship between the final biomass and initial stocking size of fish. Growth performance of rainbow trout appeared to be depressed at large size group.

Key Words: Rainbow trout, *Oncorhynchus mykiss*, size effect, growth, Black Sea, cage culture.

Introduction

Culturing of rainbow trout has become more popular because it is relatively easy in variety of aquaculture systems. Rainbow trout, *Oncorhynchus mykiss*, one of the most important fish species for freshwater aquaculture in Turkey and have been cultured in sea cages in the Black Sea since early 1990s. The main aim of aquaculture is to maximize production efficiency and this mainly depens on market value or the price of fish. The later is determined by the market demand and supply, which include size and optimising production from a system a number of factors such as the physico-chemical condition of the water, the production system, the type and size of the rearing tanks, the water exchange rate, the size of the fish an quality of the ration must be considered (Papoutsoglou *et al*., 1987). While a number of studies have examined biological characteristics, such as growth, survival and production of rainbow trout under different stocking densities around the world (Wedemeyer, 1976; Refstie, 1977; Hortle, 1981; Austreng *et al*., 1987; Papoutsoglou *et al*., 1987; Teskeredzic *et al*., 1989; Holm *et al*., 1990) and in Turkey (Çelikkale *et al*., 1996; Şahin *et al*., 1999) there is limited information on the relationship between biological characteristics and initial stocking size of fish from economic point of view.

The main objectives of the present study were to assess the effect of initial size on growth rate of rainbow trout, *Oncorhynchus mykiss*, cultured in cages and to asses the relationship between the initial stocking size and final biomass.

Material and Methods

The rainbow trout used in the study were obtained from a private trout farm. The experimental system consisted of six reserach cages moored in a fishing harbour east of Trabzon (40°57'30" N, 39°51'42" E). The water depth at the cage site was around 6 m. The cages were 4x4x3.5 m with nets of knotted nylon mesh of 15 and 18 mm. The fish were introduced into the cages in the same stocking density (2.1 kg/m^3) with two replicates. The initial body weights of the fish at three different size groups were 52.1±10.8 g (n=2,250; small), 77.6±11.7 (n=1,500; medium), and 118.6±20.1 g (n=1,000; large). The study lasted 202 days, from 4 November 1996 to 26 May 1997. During the study period the fish were fed three times a day to satiation by hand with a commercial pelleted feed containing 46% crude protein, 13% lipid, 13% ash, 3% fiber, 11% moisture, 2% calcium and 1.3% phosphate. Daily measurements of water quality parameters, namely temperature, dissolved oxygen, salinity and pH values were carried out. Apart from water quality parameters, food supply and mortality were also recorded daily.

At monthly intervals 30 fish in each cage was randomly taken as sample, anaesthetised with tricaine methane-sulphonate (MS-222) of 0.04 g/l concentration and weighed. Using the data collected during the study, specific growth rates (SGR), feed conversion ratios (FCR), condition factors (CF) and daily feeding rates (DFR) were determined (Ricker, 1975, Boyer *et al.,* 1994):

$$SGR=100[(\ln W_t-\ln W_0)/t];$$

$$DFR=\{(\sum f_k)/[t \times (W_t+W_0)/2]\}\times 100;$$

$$CF=(W/L^3)\times 100;$$

$FCR = (\sum f_k)/(W_t-W_0)$; where t: feeding days (day), W_0: initial live weight of fish (g), W_t: final live weight of fish (g), L: total length (cm), and f_k: weight of feed consumed by fish at each feeding (g).

For the statistical analysis, data from the replicates of each group were pooled for one-way ANOVA analysis and differences at the 5% level were considered significant.

Results

Monthly mean sea water temperatures ranged from 7.9 to 15.3°C with a clear seasonal variation (Figure 1). Dissolved oxygen content also exhibited considerable variation ranging from 7.7 to 10.0 mg/l, whereas salinity and pH values did not show much variation and varied 16.6-18.0‰, and 8.0-8.3, respectively.

Survival rates were high (89.2-95.4%) for all groups and although fish size had no significant effect on mortality, losses were relatively higher in larger size groups.

The data on growth and feeding gathered during the trial were summarized in Table 1. Final mean weight values of small, medium and large size groups were 455.3±84.9, 547.6±124.8 and 740.7±174.7 g, respectively (Figure 2). Growth rates varied between

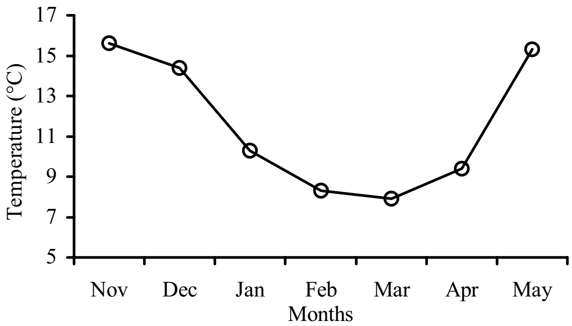

Figure 1. Monthly variations in mean seawater temperature

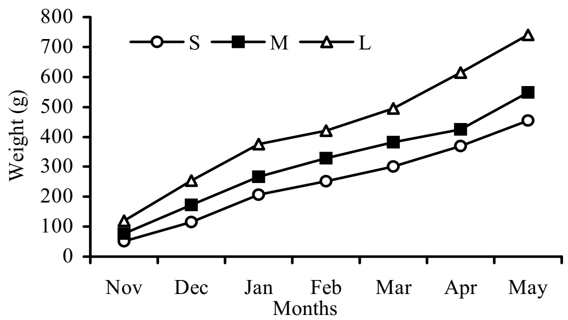

Figure 2. Changes in mean weight values of rainbow trout during study period.

Table 1. Mean (±SD)[1] weight, growth (SGR), feed provision (DFR), feed conversion ratio (FCR), condition factor (CF), survival rate and biomass of rainbow trout reared in marine cages.

No of fish per cage	Small size (n= 2,500)	Medium size (n=1,500)	Large size (n=1,000)	ANOVA
Initial weight (g)	52.1±10.8[a]	77.6±11.7[b]	118.6±20.1[c]	*
Final weight (g)	455.3±84.9[a]	547.6±124.8[b]	740.7±174.7[c]	*
SGR (% / day)	1.11±0.88[a]	1.02±0.99[b]	1.02±0.99[b]	*
DFR (% / of body weight)	1.35±0.64[a]	1.55±1.07[b]	1.66±0.77[c]	*
FCR	1.37±0.36[a]	1.70±0.38[b]	1.65±0.32[b]	*
CF	1.39±0.06	1.44±0.08	1.43±0.11	NS
Survival (% of initial stock)	95.4±0.3	92.6±0.4	89.2±0.1	NS
Initial biomass (kg/cage)	117.3±2.8	116.4±0.6	118.6±1.4	NS
Final biomass (kg/cage)	997.1±29.0[a]	780.0±15.6[b]	677.8±18.0[c]	*
Initial stocking density (kg/m³)	2.09±0.05	2.08±0.01	2.12±0.03	NS
Final stock (kg/m³)	17.8±0.52[a]	13.9±0.28[b]	12.1±0.32[b]	*

[1] Mean of two replicates (e.g. a, b and c)
*: significantly different at a level of $p<0.05$
NS: not significantly different

1.02 and 1.11% (Figure 3). The best growth was obtained at small size group, and differences were significant (P<0.05). There were clear declines in values with increasing body weight. As expected, maximum daily growth increments were observed at the beginning of trial when the fish were relatively small and mean sea water temperature was near optimum for the species, 15.6°C. Total biomass increased from 117.3, 116.4 and 118.6 kg to 997.1, 780.0 and 677.8 kg, respectively. Variations in biomasses during the study period are shown Figure 4. Final biomass was significantly affected by stocking size of fish (P<0.05).

The daily feeding rate increased with increasing fish size (P<0.05), i.e., the highest daily feeding rate was found in large size group (1.66%), and followed by medium group (1.55%) and small size groups (1.35%). Food consumption and feed conversion values were lowest in small group. The estimated feed conversion ratios varied between 1.37 and 1.70, and differences among groups were found significant (p<0.05) in favour of small size group.

Condition factors values of the groups calculated at the end of the study were very similar ranging 1.39 between 1.44, while they varied from 1.21 to 1.53 during the study.

Discussion

In the present study, approximately 10 months old rainbow trout grew from around 52.1-118.6 g to 455.3-740.7 g mean weight in 202 days. These values are higher than those of fish cultured in traditional freshwater farm where fingerlings of around 30-50 g can hardly reach portion size (200-250 g) even in experimental tanks at sea level in 6-7 months time (Çelikkale *et al.,* 1997). When the results of the present trial are compared to those of similar studies on rainbow trout (Hortle, 1981 in Tasmania; Austreng *et al*., 1987 in Norway; Teskeredzic *et al*., 1989 on the Adriatic coast of former Yugoslavia; Şahin *et al*., 1999 in the Black Sea), the growth of the trout observed in this study, appears to be lower. It is well known that growth is not constant and numerous environmental factors (temperature, fish size, stocking density, access to acceptable quality of food, water exchange and salinity) may influence food consumption and growth rate (Jobling, 1993). Stocking density can stimulate schooling and up to a particular level, positively affect food consumption, food conversion, and growth performance (Wedemeyer, 1976; Schreck *et al.,* 1985). When the fish are held at low densities (e.g. <20 kg/m^3 for Arctic charr and brook trout) they tend to congregate in a losse group close to bottom, rather than forming distinct schools in the water column (Jørgensen *et al.,* 1993; Okumuş *et al.,* 1998). Slow growth rate at low stocking density can be due to increased energy-demanding activity levels related to social interactions (Okumuş *et al.,* 1998). Optimum stocking density for the growth of rainbow trout in marine cages has been estimated as 4-5 kg/m^3 at the beginning or 20-25 kg/m^3 at harvest (Şahin *et al.,* 1999). Slow growth rate in the present study may be explained by stocking density was around half of optimal level.

In intensive rainbow trout culture systems optimum feed conversion ratio is between 1 and 2, for commercial dry feed. The values of feed conversion ratio for all groups in the present study were within the ranges reported for commercial feed by other investigators (Papoutsoglou *et al*., 1987; Çelikkale *et al.,* 1996; Yıldırım *et al.,* 1998; Şahin *et al.,* 1999). It was observed that feed conversion ratio increased with increasing fish weight, and it was the best at small size group. As it has been observed in small size group, rainbow trout are able to utilize their feed very efficiently (Storebakken and Austreng, 1987).

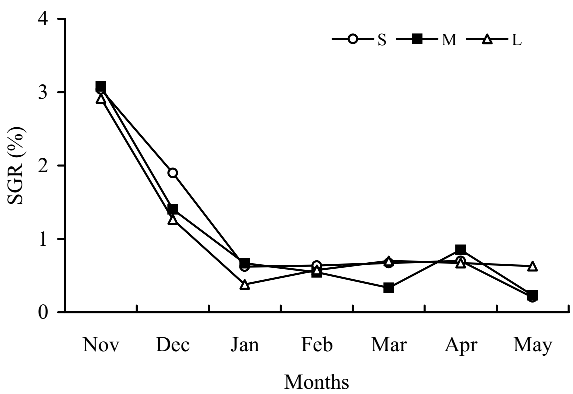

Figure 3. Variations in SGR values during the study period.

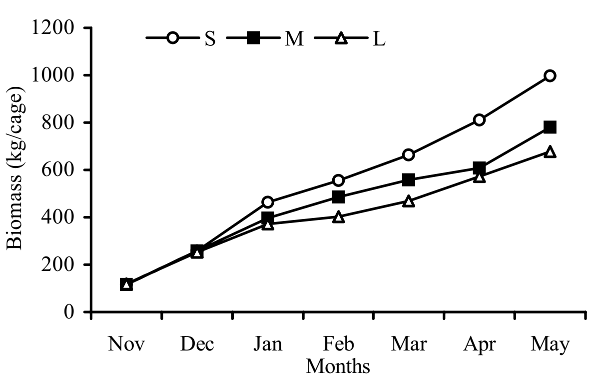

Figure 4. Changes in mean biomass values of rainbow trout during study period.

Although absolute weight gains at large size group is higher than the other groups, specific growth rates decreased with increasing body size. The specific growth rate is observed to vary depending on the size of fish; smaller fish grow faster than larger ones (Sumpter, 1992). Growth rate is considered a trait of great economic importance for all species used in aquaculture. Rapid growth speeds up the turnover of production (Gjerde, 1986).

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.

Growth performance of rainbow trout appears to be depressed at large size group. It would also appear from these data that final biomass can be maximized at optimal stocking densities for smaller/younger fish than for larger/older fish. From an economic point of view the most significant criterion is increasing of biomass, production by area, which affects the revenue.

In conclusion, based on the findings of the present study, initial stocking size of fish is negatively correlated to final biomass and in order to increase biomass per unit volume, small size fish should be stocked into floating cages at the beginning of rearing season.

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