GROWTH PERFORMANCES AND HEMATOLOGICAL CHARACTERISATION OF RAINBOW TROUT (*Oncorhynchus mykiss* Walbaum, 1792)

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ABSTRACT
In present study correlations between hematologic characteristics and growth performances of rainbow trout were investigated. Fish were provided from a raceway trout farm located in the valley of the river Jerka near the city of Novi Pazar (N:43°13’67’’; E:20°43’96’’). The farm consists of 8 concrete lined production ponds (22 x 3 m x 1,2 m each) in which water is exchanged 75 times per day. After stocking fish from production ponds are being monthly classified into two groups depending on their body mass and body length and larger fish are transferred in separate ponds. For this study one year old fish were sampled. 25 from slower and 25 from faster growing group. Analyses were performed in 4 consecutive days in accordance with animal welfare regulations (Official Gazette of the Republic of Serbia 41/2009). Fish growth performances were estimated from body mass, total and standard body length and Fulton condition factor. Hematological characterization of rainbow was established on the basis of Red Blood Cell (RBC) and White Blood Cell (WBC) count, hemoglobin concentration, Packed Cell Volume (PCV), Mean Corpuscular Volume of erythrocytes (MCV), Mean Corpuscular Hemoglobin in individual erythrocyte (MCH) and Mean Corpuscular Hemoglobin Concentration (MCHC) in a liter of erythrocytes. The results obtained were statistically analyzed by SPSS. It was found out that there exist significant correlation between hematological and growth characteristics. High linear regression coefficients can explain mass and length gain by hematological parameters.

Key words: Hematology, growth performance, *Oncorhynchus mykiss,* aquaculture

INTRODUCTION

Numerous studies have shown that fish individuals of the same age raised in aquacultures under same conditions have different growth performances. It may be partly explained by individual differences in food consumption (JOBLING ET AL., 1989) resulting from the hierarchy that develops when the animals are fed in a group and dominant individuals gain a higher share of the feed than subordinate animals (MCCARTHY ET AL., 1992). Food consumption stimulates the synthesis of new proteins and also to a lesser extent, protein degradation as a result of protein turnover (HOULIHAN ET AL., 1988). However, fish with similar feed consumption and similar protein synthesis rates, may exhibit different efficiencies with which they deposit synthesized protein as growth (CARTER ET AL., 1993; DOBLY ET AL.2003).Growth is directly related to the quality and quantity of feed available for fish (WEATHERLEY 1976) and the rate at which a fish grows is a function of the amount of energy consumed as food, energy losses due to excretion, digestion, respiration, and the efficiency at which feed is converted to biomass (BAKER ET AL. 1993).
Of the same importance for fish physiology and growth are physical and chemical water parameters (WEDEMEYER, 1996) with water temperature and dissolved oxygen often having the greatest measurable effect (IVANC ET AL., 2008, 2008*a*).
There is a reasonable amount of information available on environmental factors, including nutrition, but there is limited understanding of the endogenous control of growth and the multitude of interactions between the various environmental, genetic and endogenous

factors (IVANC ET AL, 2005). Based on studies of PRASAD and MUKTHIRAJ (2011) growth performances are clearly affected by hematological status of the fish organism so that fish which exhibited optimum hematological features also have optimum growth performances. Thus ALEGBELEYE,(2005) found out that the low hematologic parameters had a negative effect on the productive performance index, thereby reducing the growth and weight gain of the fish and causing low productivity. Generally hematological characteristics provide reliable information about the physiology of fish organism and belong to the major indicators of its state over a prolonged period of time (REHULKA, 2004; IVANC ET AL., 2005).

Having this in mind the objective of the present study was to investigate more detailed correlations between hematologic characteristics and growth performances of farmed rainbow trout .

MATERIALS AND METHODS

Rainbow trout (*Oncorhynchus mykiss* Walbaum, 1792) for this study were provided form a raceway trout farm located in the valley of river Jerka near the city of Novi Pazar (N:43°13’67’’; E:20°43’96’’). The farm is situated at 538 m above sea level and 6 km away from the spring of the river Raška, from where the raceway culture gets its water supply. The farm consists of 8 concrete lined production ponds (22 x 3 m x 1,2 m each) in which water is exchanged 75 times per day. Ponds are stocked with fingerlings and than are being monthly classified into two groups depending on their body mass and body length and larger fish are transferred in separate ponds. For this study one year old fish were sampled. 25 from slower and 25 from faster growing group.

Analyses were performed in 4 consecutive days. After taking the fish from the pool it was put in a container with a volume at least ten times larger than the body mass of the fish. For catching of individual fish a piece of soft and thick thread net was used so treated fish can be kept securely without being injured. Study was performed in accordance with animal welfare regulations (OFFICIAL GAZETTE OF THE REPUBLIC OF SERBIA 41/2009).

On the spot, right after fish catching blood samples for hematological analyses were taken. Blood was taken by heart puncture with a sharp wide needle (1.0 to 1.2 mm) applying the rules of sterile work and collected into glass watch lined with paraffin wax.

Native blood without addition of anticoagulants was used for all analyses. Blood analysis were performed in the same period of the day, because the hematological condition, as the all other physiological processes have well expressed circadian rhythm. Red Blood Cell Count (RBC) and White Blood Cell Count (WBC) were determined in Neubauer hemocytometer by method of KEKIĆ and IVANC (1982). Hemoglobin concentration was estimated by Drabkins hemiglobin cyanide method (BLAXHALL AND DAISLY, 1973) and Packed Cell Volume (PCV) was defined in heparinized glass capillaries by means of microhematocrit centrifuge. Erythrocytes indices were calculated from the values of PCV, erythrocyte count and hemoglobin concentration.

Mean Corpuscular Volume of erythrocytes (MCV) was calculated according to

$MCV = \frac{PCV}{RBC/l}$ and volume was expressed in *fl* (μm^3).

Mean Corpuscular Hemoglobin in individual erythrocyte (MCH) was calculated by equation $MCH = \frac{Hb/l}{RBC}$ and the result expressed in *pg*

Mean Corpuscular Hemoglobin Concentration (MCHC) was calculated using equation $MCHC = \frac{Hb/l}{PCV}$ and the result is expressed in grams of hemoglobin per liter of erythrocytes.
Fish growth performances were estimated from body mass and total and standard body length. Body mass was determined by means of precise balance (0,01 g), and body length by ichthyometer with millimeter scale.
Fulton condition factor was calculated from body mass (g) and standard length as
$F = Bm \times l^{-3} \times 100$.
Sex of fish was estimated after dissection.
Descriptive and analytical statistics were performed using Microsoft Excel and SPSS for WINDOWS, release 16.0.

RESULTS

It is evident that two groups of rainbow trout have significantly different growth performances resulting in different body mass and body length.
Growth of rainbow trout under the raceway farm conditions were explained by hematological parameters of fish. According to Pearson correlation and linear regression analyses these differences may be explained by hematological characteristics of two groups. Linear correlation is defined separately for rainbow trout groups having different growth performances and also for the whole sample of studied rainbow trout.

Pearson linear correlation

Trout with lower growth performances

Linear correlation of variables of fish with lower growth performances has shown that the body mass is significantly positively correlated with hemoglobin concentration (p = 0,001), MCHC (p = 0,005), MCH (p = 0,000) and MCV (p = 0,030).
The same is true for total body length which is in significant positive correlation with Hb concentration, MCHC and MCH (p = 0,009, 0,017, 0,001 and 0,031, respectively).
However, total body length is in a negative correlation with RBC (p = 0,026).
Positive significant correlation is also estimated between standard body length and Hb concentration, MCHC and MCH (p = 0,025, 0,028 and 0,013 respectively).

Trout with higher growth performances

Using the Pearson linear correlation analysis in individuals with higher growth rate performances it was estimated that in this group of fish the correlations between body mass, total and standard body length and Fulton condition factor were not significantly correlated with any hematological characteristic.

Whole sample

By calculation of Pearson linear correlation of all analyzed fish, both having low and high growth performances it was estimated that Hb concentration has significant positive correlation with body mass, total and standard body length and Fulton condition coefficient (p = 0,004, 0,007, 0,011 and 0,011 respectively).
Also, PCV was found to be in significant positive correlation with body mass, total and standard body (p = 0,021, 0,008 and 0,009 respectively).
MCH is as well significantly positive correlated with body mass (p = 0,049), total body length (p = 0,050) and Fulton condition coefficient (p = 0,010).

It should be emphasized that MCV is positively correlated only with total body length (p = 0,050).

Table 1. Hematological and morphometric parameters of rainbow trout *Oncorhynchus mykiss* with different growth performances

Statistics	Body mass g	Total body length cm	Standard body length cm	Fulton factor	RBC $x10^{12}/l$	Hb g/l.	PCV l/l	MCV fl	MCH pg	MCHC g Hb/l eryt.	WBC $x10^9/l$
Rainbow trout with lower growth performances											
Mean	130,00	22,74	20,48	1,509	1,010	68,03	0,368	375,60	70,00	186,32	39,800
Standard deviation	17,38	1,14	0,96	0,109	0,166	15,33	0,048	82,84	21,66	40,27	17,000
Count	25	25	25	25	25	25	25	25	25	25	19*
Coefficient of variation %	13,37	5,00	4,68	7,205	16,547	22,53	13,100	22,06	30,94	21,62	42,723
Rainbow trout with higher growth performances*											
Mean	304,80	29,14	26,68	1,605	1,020	78,49	0,415	428,18	82,34	182,66	29,100
Standard deviation	43,62	1,48	1,48	0,161	0,180	16,96	0,069	110,90	24,28	41,23	13,400
Count	25	25	25	25	24	20*	22*	21	16	17	20*
Coefficient of variation %	14,31	5,07	5,54	10,032	17,590	21,60	16,673	25,90	29,48	22,57	45,960

**Few hematological data had to be rejected resulting from an instrument reading error and are marked by * .*

Significance of differences between means is estimated by Students t – test (*Table 2*).

Table 2. Significance of differences between means of morphological and hematological values of rainbow trout, *Oncorhynchus mykiss*, with different growth performances

N	Body mass g	Total body length cm	Standard body length cm	Fulton	RBC $x10^{12}/l$	Hb g/l.	PCV l/l	MCV fl	MCH pg	MCHC g Hb/l eryt.	WBC $x10^9/l$
Rainbow trout with lower growth performances											
25	130,00	22,74	23,30	1,509	1,010	68,03	0,368	375,60	70,00	186,32	39,800
Rainbow trout with higher growth performances											
25	304,80	29,14	26,68	1,605	1,020	78,49	0,415	428,18	82,34	182,66	29,10
p =	0,0000	0,0000	0,0002	0,018	0,7147	0,0382	0,0108	0,0814	0,1088	0,7772	0,0357

Linear regression

Trout with lower growth performances

Linear regression has been done to see which of the hematological parameters can best explain body mass, total and standard body length and Fulton condition coefficient. In consideration have been taken only statistically significant coefficient of regression ($p \leq 0,05$).

Body mass is explained by hemoglobin concentration (r = 0,632) which was significantly lower in smaller fish (*Table 2*). Body mass is also explained by other hemoglobin parameters of erythrocytes MCHC (r = 0,540) and MCH (r = 0,679). It corresponds with results McCarthy et al. (1992) who found out that rainbow trout with different growth efficiencies had similar protein synthesis rates and hence protein degradation was suggested as being the major controlling factor in growth efficiency. Likewise body mass is explained by MCV (r = 0,435) which is always larger in mature red cells which also have greater Hb concentration - MCH.

By linear regression is also estimated that total body length is explained by RBC (r = 0,444), Hb concentration (r = 0,514) and with other Hb parameters of erythrocytes, MCHC (r = 0,472) and MCH (r = 0,642). Likewise total body length is explained by MCV with coefficient r = 0,431.

Using the same method standard body length is explained by hemoglobin concentration (r = 0,446), MCHC (r = 0,440) and MCH (r= 0,489).

Trout with higher growth performances

Using the linear regression analysis in individuals with higher growth rate performances it was estimated that in this group of fish the body mass, total and standard body length and Fulton condition factor could not be explained by any hematological characteristic.

Whole sample

By calculation of linear regression analysis of all analyzed fish, both having low and high growth performances it was estimated that body mass is explained by Hb concentration (r = 0,422), PCV (r = 0,336) and MCH (r = 0,309).

Total body length is explained by Hb concentration (r = 0,394), MCH (r = 0,309), PCV (r = 0,385) and MCV (r = 0,291).

Linear regression estimated that standard body length is explained by Hb concentration (r = 0,375) and PCV (r = 0,376).

Fulton condition factor is explained by Hb concentration (r = 0,376) and by MCH (r = 0,400).

CONCLUSIONS

In the present study growth performances of farmed rainbow trout were investigated in connection with their hematologic characteristics.

In fish of smaller size Pearson correlations between body mass, body length and hematologic characteristics were estimated as significant.

Linear regression analysis showed that in fish with low growth performances smaller body mass and body length can be explained by the values of hemoglobin concentration, MCH and MCV.

In fish group consisting of individuals showing both low and high growth performances (whole sample) it was estimated that body mass, total and standard body length were significantly correlated with hematological parameters.

Also, linear regression analysis has shown that body mass, total and standard body length can be explained by Hb concentration, PCV, MCH and MCV. It should be emphasized that Fulton condition factor can also explained by Hb concentration and by MCH.

Using the linear regression analysis in individuals with higher growth rate performances it was estimated that in this group of fish the body mass, total and standard body length and Fulton condition factor could not be explained by any hematological characteristic.

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