

CONDITION FACTOR AND ORGANOSOMATIC INDICES OF RAINBOW TROUT (*ONCHORHYNCHUS MYKISS*, WAL.) FROM DIFFERENT BROOD STOCK

Radoslav Dekić¹, Nebojša Savić², Maja Manojlović¹, Dragojla Golub¹, Jerko Pavličević³

¹Faculty of Natural Sciences and Mathematics, University of Banja Luka, Mladena Stojanovića 2, Banja Luka, Bosnia and Herzegovina

²Faculty of Agriculture, University of Banja Luka, Bulevar vojvode Petra Bojovića 1A, Banja Luka, Bosnia and Herzegovina

³Faculty for Agriculture and Food Technology, University of Mostar, Biskupa Čule bb, Bosnia and Herzegovina

Corresponding author: dragojlav@yahoo.com

Original scientific paper

Abstract: Condition factor and organosomatic indices of fish represent a way of monitoring environmental factor influence on fish. The rainbow trout (*Oncorhynchus mykiss*, Wal.) individuals that were used in the work originated from different brood stock and different fish farms. Spawning was carried out on five selected fish farms. After that, the breeding eggs were delivered in Klasnik hatchery where the same environmental conditions were provided during embryonic development and cultivation of all five groups of individuals. As a conditioning factor in this work Fulton's condition factor and coefficients of the heart, liver and spleen were analyzed. In all individuals we determined the total length, standard length and body mass. In total, fifty individuals, which were divided into five groups from five brood stock, were analyzed. The results show significantly different values for the condition factor and organosomatic indices between some of the analyzed groups.

Key words: rainbow trout, brood stock, organosomatic indices

Introduction

Condition factor and organosomatic indices are usually used in assessing the general health of the fish, on individual and population level (Hoque *et al.*, 1998). Since they include many levels of processes in the organism at various levels of organization, indices like Fulton's condition factor can indicate nutritional status of individuals and the general health status of fish (Adams *et al.*, 1992).

The condition factor presents a degree of individual's response to the influences coming from the environment such as the quantity and quality of nutrients, the presence of pathogens, pollutants and toxic substances, which can result in a change in the mass of individuals and organs compared to individuals from the unchanged environment. The value of condition factor is an expression of the physical condition of the fish and it is suitable for comparison of individuals of the same species and demonstrates differences in relation to sex, season and place of sampling (Dekić, 2010).

Organosomatic indices can be described as the ratios of organs to body weight when the measured organ in relation to body mass can be directly linked to some environmental changes (Ronald and Bruce, 1990). It is manifested through changes in size that are reflected through a reduction or increase, influenced by environmental factors. Size and weight of the liver, spleen, heart, gonads and other organs are related to the overall length and weight of fish and indicate the general status of health of the fish. The aim of this research was to determine the values of condition factor and organosomatic indices at five groups of rainbow trout from different brood stock and to estimate their shape and health status.

Materials and Methods

The rainbow trout (*Oncorhynchus mykiss*, Wal.) individuals that were used in the work originated from different brood stock and different fish farms. Spawning was carried out on five selected fish farms. After that, the breeding eggs were delivered in Klasnik hatchery where the same environmental conditions during embryonic development and cultivation of all five groups of individuals were provided. Spawning of rainbow trout from five investigated groups was conducted from November 21, 2011 to December 13, 2011. As a conditioning factor in this work Fulton's condition factor and coefficients of the heart, liver and spleen were analyzed. In all individuals total length, standard length and body mass were determined. In total, fifty individuals, which were divided into five groups from five brood stocks, were analyzed.

Fulton's condition factor (K) were calculated by using the formula:

$$K = W * 100 / L^3, \text{ where:}$$

W - weight of the fish (g),

L - standard length of the fish (cm) (Akombo et al., 2013).

After that, the liver, spleen and heart were carefully removed and weighed. Organosomatic indices for liver (HSI), heart (CSI) and spleen (SSI) were calculated as follows:

$$\text{OSI} = [\text{weight of the organ (g)} / \text{weight of the fish (g)}] \times 100$$

Statistical analyses were obtained by using SPSS 15, and ANOVA and LSD test for data comparison ($p < 0.05$).

Results and Discussion

Comparing the average values for standard and total body length of rainbow trout from different fish farms, no significant differences were observed. Values for body mass showed significant difference between first and second group ($p=0.027$) and there were significant differences for Fulton's condition factor by comparing fifth with the first and the third group ($p = 0.030$; $p = 0.042$).

In regards with the coefficients of organs, we observed higher differences between groups. There were significant differences for CSI by comparing the fifth group with the second and the third groups ($p = 0.038$; $p = 0.019$), and for HSI, when we compared the first with the second ($p = 0.023$), third ($p = 0.026$), fourth ($p = 0.016$) and fifth groups ($p = 0.008$).

Spleen somatic index showed the highest differences compared in groups; significant differences were noticed between the first and fourth groups ($p = 0.034$), second and third ($p = 0.006$), third and fourth ($p = 0.003$) and between third and fifth group ($p = 0.010$).

Analysing the results of examined parameters, it can be said that the individuals in the first group had the highest values of total length, standard length, body mass, and Fulton's coefficient, whereby it is necessary to emphasize that the individuals of this experimental group were spawned a few days earlier than other groups. In contrast with the morphometric characteristics and condition factor, individuals from the third experimental group had the highest index values of organosomatic indices.

Values of examined parameters of rainbow trout are given in Table 1.

Table 1. Morphometric characteristics, condition factor and organosomatic indices of *Oncorhynchus mykiss* form different brood stocks

STATISTICAL PARAMETERS*		Total length (cm)	Standard length (cm)	Mass (g)	Fulton coefficient	Cardiosomatic index (%)	Hepatosomatic index (%)	Speleunosomatic index (%)
I	Mean	15.47	13.79	50.69	1.91	0.154	1.907	0.181
	SD	1.24	1.16	12.10	0.25	0.031	0.258	0.053
	MIN	13.80	12.20	28.63	1.58	0.119	1.609	0.119
	MAX	17.20	15.10	67.03	2.29	0.213	2.283	0.240
	CV	8.02	8.42	23.88	13.19	20.263	13.541	29.137
II	Mean	14.09	12.40	34.88	1.80	0.158	1.575	0.180
	SD	1.12	1.09	8.03	0.12	0.032	0.352	0.064
	MIN	12.00	10.50	21.23	1.61	0.099	1.052	0.107
	MAX	15.70	13.90	46.55	2.04	0.205	2.416	0.258
	CV	7.93	8.81	23.02	6.52	20.063	22.376	35.339
III	Mean	14.33	12.57	44.14	1.90	0.168	2.498	0.225
	SD	3.08	2.92	28.22	0.25	0.055	1.383	0.098
	MIN	9.90	8.40	10.40	1.44	0.120	1.344	0.133
	MAX	18.60	16.90	89.79	2.32	0.278	5.769	0.397
	CV	21.51	23.22	63.94	13.37	32.882	55.344	43.589
IV	Mean	14.83	13.25	42.36	1.82	0.138	1.555	0.124
	SD	0.95	0.90	7.18	0.18	0.020	0.283	0.025
	MIN	13.20	11.70	31.93	1.60	0.105	1.132	0.092
	MAX	16.30	14.50	52.12	2.10	0.174	2.151	0.174
	CV	6.44	6.77	16.94	9.76	14.236	18.168	20.247
V	Mean	14.49	12.99	38.68	1.72	0.124	1.515	0.138
	SD	1.30	1.20	11.41	0.10	0.021	0.198	0.042
	MIN	11.80	10.40	18.54	1.61	0.084	1.218	0.084
	MAX	16.80	15.20	63.23	1.87	0.151	1.940	0.236
	CV	8.98	9.23	29.50	6.02	17.248	13.066	30.557

Cardio somatic index (CSI) in the examined groups of rainbow trout originate from different brood stock and indicate the existence of significant differences when compared in groups, with the highest values among individuals from the third group. The values of the CSI can indicate various changes in the organism under the influence of abiotic and biotic factors.

It was found that the CSI values get lower in the individuals whose embryos were exposed to higher temperatures as compared to specimen whose embryos were exposed to lower temperatures. Temperature affects the myogenesis process, organelle structure, gene expression, size of distribution of muscle fibers, diameter of muscle fibers and heart development (Johnston, 2006). Stickland et al. (1988) are during experiments on *Salmo salar* and *Salmo trutta* embryos incubated on high temperatures notice significant reduction of muscle fibers than those, which were incubated at low temperatures. Heart abnormalities were observed in cultivated individuals compared to individuals that are sampled from natural habitats (Poppe and Seierstad, 2003).

In addition, values of CSI for *Oncorhynchus mykiss* infected with parasite *Ichthyophonus* were significantly higher. Because of the experiment, it was determined that heart mass and CSI of the infected fish were significantly higher than in individuals from the control group (for approximately 40 %). Increased mass of the heart can be explained with the parasite biomass, infiltration of immune cells and fibrous tissue surrounding the parasite and any of these events may compromise the heart's function, for example, reduction in cardiac capacity (Guyton, 1961).

Similar to the CSI, HSI showed significant differences in our research (between investigated groups), with the largest value in the third group. The liver coefficient (HSI) is a good indicator of the energy status and fish in poor habitat conditions have lower values of this index than fish species that inhabit the food rich habitats. Coefficient of the liver is considerably lower in fish exposed to toxic substances, such as cadmium, and zinc.

HSI of bony fish varied in the range from 1 to 2 %, and it was characteristic for the particular species, but within the same species it depended on the physiological and health status of fish, as well as their condition (Oguri, 1978). The values obtained by this research are in the range from 1 to 2%, with the exception of individuals from the third group, where average value was 2,498%. The liver is an energy reservoir and plays a significant role in the metabolism. The changes in its size and weight are directly related to the stressors that come from the environment. Considering all organosomatic indices, HSI is most often associated with exposure to contamination (Adams and McLean, 1985). HSI values vary with season (Sabrowski and Buchholz, 1996; Beamish et al., 1996), and on its relative size directly affects the quality and quantity of nutrients (Foster et al., 1993). HSI also varies depending on the gender and stage of gonads development (Fabacher and Baumann, 1985; Forlin and Haux, 1990).

Increased values of HSI and liver in general are noticed for *Oncorhynchus mykiss* (Oikari and Nakari, 1982) which were exposed contaminants from oil spills. Anderson et al. (1988) have suggested that the increased HSI is a result of increased production of the endoplasmic reticulum and increasing of protein synthesis under the influence of contaminants. This condition is associated with

hypertrophy of the hepatocytes and hyperplasia due to the presence of contaminants (*Elskus and Stegeman, 1989*). The HSI in our research showed significant differences of the respective groups, and the highest value of this ratio was in the third group.

Spleen has an important hematopoietic function in a vertebrate and because of that SSI is a good indicator of the state of activity of the immune system and the occurrence and intensity of infection and disease. Increased values of SSI indicate a bacterial or parasitic infection, while lower values indicate a complete absence or a mild infection and suggest a good general state of health of fish. The spleen somatic index is used as a reliable diagnostic tool because of its hematopoietic function (*Anderson, 1990*), and its dysfunction can lead to the changes in the level of the entire organism.

Different endogenous and exogenous factors have impact on SSI; it can vary depending on the taxonomic status of the species (*Anderson et al., 1982; Ruklov, 1979*) and within the same population (*Ruklov, 1979*). The relative size of the spleen may vary depending on fish sex, age, size, stage of development of the gonads and the growth (*Ruklov, 1979*). Nonspecific stressors, e.g. hypoxia may affect changes in the morphology of the spleen. Hypoxia is very common in the aquatic environment, and impact of moderate and acute hypoxia was studied with the rainbow trout, *Oncorhynchus mykiss*, which results with the contracted spleen (*Yamamoto, 1987; Randall and Perry, 1992*). In addition, if hypoxia takes a long time, it leads to the increase in number of erythrocytes, which is explained, with increased concentration of erythropoietin. Changes in the size of the spleen may be a sign of dysfunction that affects the general health of the individual. Reduction of the size of the spleen can be in connection with acute nonspecific stressors, as well as with a number of chronic exposures to chemical contaminants, which are responsible for the necrosis and changes in cellular processes (*Yamamoto, 1987; Randall and Perry, 1992*).

Conclusion

All experimental groups of rainbow trout have the same environmental conditions during the embryonic development and growing. Values of total and standard body length did not show any significant differences for all experimental groups but other investigated parameters showed statistically significant differences. Considering that all individuals were under the same conditions and the same treatment, the observed differences can be explained with conditions on the fish farms and different brood stock.

Koeficijent kondicije i organosomatički indeksi dužičaste pastrmke (*Oncorhynchus mykiss*, Wal.) iz različitih matičnih jata

Radoslav Dekić, Nebojša Savić, Maja Manojlović, Dragojla Golub, Jerko Pavličević

Rezime

Koeficijent kondicije i organosomatski indeksi riba predstavljaju jedan od načina praćenja uticaja faktora spoljašnje sredine na ribe. Jedinke dužičaste pastrmke (*Oncorhynchus mykiss*, Wal.) koje su korišćene u radu poreklom su od različitih matičnih jata, sa različitih ribogojilišta. Mrest je obavljen na pet izabраниh ribogojilišta, nakon čega je oplodena ikra dopremljena u mrestilište Klašnik gde su obezbeđeni isti uslovi sredine tokom embrionalnog razvoja i gajenja za svih pet grupa jedinki. U radu je kao kondicioni faktor analiziran Fultonov koeficijent uhranjenosti, te koeficijenti srca, jetre i slezine. Kod svih jedinki određene su vrednosti totalne dužine, standardne dužine i mase tela. Ukupno je analizirano 50 jedinki iz pet grupa, odnosno matičnih jata. Rezultati pokazuju postojanje razlika u vrednostima praćenih koeficijenata između pojedinih analiziranih grupa.

References

- ADAMS S.M., MCLEAN R.B. (1985): Estimation of largemouth bass, *Micropterus salmoides* Lacepede, growth using the liver somatic index and physiological variables. *Journal of Fish Biology* 26, 111-126.
- ADAMS S.M., CRUMBY W.D., GREELEY Jr.M.S., RYON M.G., SCHILLING E.M. (1992): Relationships between physiological and fish population responses in a contaminated stream. *Environmental Toxicology and Chemistry*, 11, 1549-1557.
- AKOMBO P.M., ATILE J.I., ADIKWU I. A., ARAOYE P.A. (2013): Morphometric measurements and growth patterns of four species of the genus *Synodontis* (Cuvier, 1816) from Lower Benue River, Makurdi, Nigeria. *International Journal of Biological Research* Vol. 1 (4): 59-65.
- ANDERSON D.P., ROBERSON B.S., DIXON O.W. (1982): Immunosuppression induced by a corticosteroid or an alkylating agent in rainbow trout (*Salmo gairdneri*) administered a *Yersinia ruckeri* bacterin. *Developmental and Comparative Immunology* 6 (Suppl. 2), 197-204.
- ANDERSON T., FORLIN L., HARDIG J., LARSSON A. (1988): Physiological disturbances in fish living in coastal water polluted with bleached kraft mill effluents. *Canadian Journal of Fisheries and Aquatic Sciences* 45 (9), 1525-1536.

- ANDERSON D.P. (1990): Immunological indicators: effects of environmental stress on Immune protection and disease outbreaks. American Fisheries Society Symposium, 8, 38-51.
- BEAMISH F.W.H., JEBBINK J.A., ROSSITER A., NOAKES D.L.G. (1996): Growth strategy of juvenile lake sturgeon (*Acipenser fulvescens*) in a northern river. Canadian Journal of Fisheries and Aquatic Sciences, 53 (3), 481-489.
- DEKIĆ R. (2010): Cirkanualna istraživanja hematološkog statusa *Barbus peloponnesius* u funkciji staništa. Doktorska disertacija. Prirodno-matematički fakultet. Univerzitet u Banjoj Luci.
- ELSKUS A.A., STEGEMAN J.J. (1989): Further consideration of phenobarbital effects on cytochrome P450 activity in the killifish, *Fundulus heteroclitus*. Comparative Biochemistry and Physiology, 92C: 223-230.
- FABACHER D.L., BAUMANN P.C. (1985): Enlarged livers and hepatic microsomal mixed-function oxidase components in tumor-bearing brown bullheads from a chemically contaminated river. Environmental Toxicology and Chemistry 4: 703-710
- FÖRLIN L., HAUX C. (1990): Sex differences in hepatic cytochrome P-450 monooxygenase activities in rainbow trout during an annual reproductive cycle. Journal of Endocrinology 124:207-213.
- FOSTER A.R., HOULIHAN D.F., HALL S.J. (199): Effects of nutritional regime on correlates of growth rate in juvenile Atlantic cod (*Gadhus morhua*): comparisons of morphological and biochemical measurements. Canadian Journal of Fisheries and Aquatic Sciences 50 (3): 502-512.
- GUYTON A.C. (1961): Cardiac failure. In: Textbook of Medical Physiology, 2nd edn (ed. by A.C. Guyton), pp. 466–480. W.B Saunders Co, Philadelphia.
- HOQUE M. T., YUSOFF F. M., LAW A. T. (1998): Effect of hydrogen sulphide on liver-somatic index and Fulton's condition factor in *Mystus nemurus*. Journal of Fish Biology 52, 23-30.
- JOHNSTON I.A. (2006): Environment and plasticity of myogenesis in teleost fish. Journal of Experimental Biology 209, 2249–2264.
- OGURI M. (1978): On the hepatosomatic index of holocephalian fish. Bulletin of the Japanese Society of Scientific Fisheries 44 (2): 131-134.
- OIKARI A., NAKARI T. (1982): Kraft pulp mill effluent components cause liver dysfunction in trout. Bulletin of Environmental Contamination and Toxicology, 28: 266–270.
- POPE T.T., SEIERSTAD S.J. (2003): First description of cardiomyo-pathy syndrome (CMS)-related lesions in wild Atlantic salmon *Salmo salar* in Norway. Diseases of aquatic organisms, 56: 87–88
- RANDALL D.J., PERRY S.F. (1992): Catecholamines. In Fish Physiology. Vol. XII B The Cardiovascular System (ed. W. S. Hoar and D. J. Randall), Orlando, Academic Press, pp. 255-300.

RONALD W.G., BRUCE A.B. (1990): Organosomatic indices and an autopsy based assessment as indicators of health condition of fish. *American Fisheries Society* 8:93-108.

RUKLOV F.N. (1979): A description of some morphophysiological characters of salmon of the genus *Oncorhynchus*. *Journal of Ichthyology* 19: 23-40.

SABOROWSKI R., BUCHHOLZ R. (1996): Annual changes in the nutritive state of North Sea dab. *Journal of Fish Biology* 49:173-194.

STICKLAND N.C., WHITE R.N., MESCALL P.E., CROOK A.R., THORPE J.H. (1988): The effect of temperature on myogenesis en embry- onic development of the Atlantic salmon (*Salmo salar*, L.). *Anatomy and embryology*, 178: 253–257.

YAMAMOTO K. (1987): Contraction of spleen in exercised cyprinid. *Comparative Biochemistry and Physiology* 87A: 1083–1087.

Received 12 April 2016; accepted for publication 25 May 2016