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CONDITION FACTOR AND LENGTH-WEIGHT RELATIONSHIP OF HUCHEN (*HUCHO HUCHO*) FINGERLINGS IN CULTIVATED CONDITIONS

SUMMARY

The experiment of determining the condition factors and length-weight relationship of cultivated huchen (*Hucho hucho*) fingerlings aged 8 (beginning) to 11 months (end), was conducted in the aquaculture laboratory of the Faculty of Agriculture, University of Banja Luka for 91 days. A total of 35 huchen fingerlings of average body weight (W) ($\pm$ SD) of 6.00 $\pm$ 1.74 g, total body length (TL) of 8.95 $\pm$ 0.98 cm, fork length (FL) 8.36 $\pm$ 0.90 cm and standard length (SL) 7.74 $\pm$ 0.85 cm were housed in three flow-through aquariums (65 l / aquarium). Body lengths and weights were measured once a month. The huchen fingerlings feeding was according to appetite, using commercial trout feed. The aim of this study was to determine the condition factor and the length - weight relationship of huchen (*Hucho hucho*) fingerlings in cultivated conditions. The growth of body length and weight of fingerlings was expressed by a highly positive correlation ($r^2 = 0.979$). Negative allometric growth (b < 3) was determined for the total observed period, with a tendency to intensify growth in the last observed period when positive allometric growth (b > 3) was recorded. The length-weight relationship of huchen fingerlings was calculated as $W = 0.011995L^{2.822}$. A highly positive correlation between body length (TL, FL and SL) and body weight was found. The condition factor (CF) huchen fingerlings for the whole observed period averaged 0.82.

Keywords: Condition, growth, cultivated huchen fingerlings

INTRODUCTION

Huchen (*Hucho hucho*) is a very important salmonid fish species for sport and recreational fishing. It is known as one of the largest salmonid fish species in the world (Holčik *et al*., 1988, Mikavica & Savić, 1999) and is one of the most endangered fish species inhabiting the Danube basin of Central Europe, and many populations are supported by artificial reproduction and restocking programs. Ihut et al., 2014). Huchen (*Hucho hucho*) is endemic to the Danube river basin district, where it inhabits streams and rivers with fast water flow, water temperature

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usually up to 15°C and sufficient amount of dissolved oxygen (8 − 9 mg L−1), although it can withstand adverse conditions (eg water temperature up to 22°C and up to 5 mg L−1 dissolved oxygen) (Simonović *et al*., 2011). During the warmest months of the year (July-August), the average water temperature of rivers in Austria inhabited by huchen ranges from 12 to 18°C (Ratschan, 2014). In huchen habitats, water temperatures range from 6 to 18°C (Baensch & Riehl, 1991), and spawn at a water temperature of 6 to 10°C (Kahrimanović *et al*., 2013). In the first year of life it reaches a total body length of about 25 cm and a body weight of about 150 g, and at the age of two it reaches a total body length of about 40 cm and a body weight of about 500 g (Pasarin, 2007).

Comparing the growth of huchen from the river and cultivated conditions, it is indicative that in the first year of life the growth is approximately the same and is classified as slow, while in the second year of life the growth of huchen in the river is faster (classified as average) compared to the cultivated conditions which is classified as slow growth (Andreji & Stráňai, 2013). This is primarily the result of differences in feed and space (Pavlík, 1998). The regression coefficient (b) provides information on fish growth (Sangun, 2007), and for most fish the expected range of the regression coefficient (b) is $2.5 < b < 3.5$ (Froese, 2006). Froese et al. (2014) state that the calculated value of $a = 0.01$ is a fish with a spindle-shaped elongated body. Simonović et al. (2011) state that the growth of huchen from the Drina River in the early stages of development was faster in length than the growth of the weight. After reaching the total length of 107.45 cm of the huchen, there is a faster growth of weight compared to the growth of body length, which can be seen from the b value of 2,187 in the younger stages, and in the older stages it increased to 3,910 (Simonović et al., 2011). This is confirmed by Andreji and Stráňai (2013) who state that the analysis of the growth of huchen, aged 5+ to 24+, caught from the river and from cultivated conditions shows positive allometric growth. Bajić et al. (2015) found a high positive correlation between body length and body weight ($R^2 = 0.8359$ and $R^2 = 0.9246$) of huchen fry from two examined groups in cultivated conditions, however, the b value is less than 3, ie negative allometric growth is present.

Condition factor (CF) is one of the ways to monitoring the impact of environmental factors on fish (Dekić et al., 2016), and within the population it also depends on various internal (genetics, developmental stages) parameters (Treer et al., 2013). When managing huchen, it is important to know that CF depends not only on environmental conditions, but also very strongly on body length. This means that low CF at certain lengths does not necessarily reflect suboptimal habitat conditions, as the growth of huchen body length is much faster than the growth of body weight during the first years of life (Treer et al., 2013). Faster growth in body length than body weight may be due to the elongated body of the huchen, compared to other salmonids (Vuković & Ivanović, 1971). Mruk and Kucheruk (2019) state that the condition factor of the huchen broodstock, aged 6+ and 7+, was the same and amounted to 0.77.

The aim of this study was to determine the condition factor and the length - weight relationship of huchen (*Hucho hucho*) fingerlings in cultivated conditions.

MATERIAL AND METHODS

The experiment of determining the factors of condition and length-weight relationship of cultivated huchen (*Hucho hucho*) fingerlings aged 8 (beginning) to 11 months (end), was conducted in the aquaculture laboratory of the Faculty of Agriculture, University of Banja Luka for 91 days. The seven months old huchen fingerlings, were obtained from the hatchery of the Sports Fishing Association Banja Luka (SRD BL). The huchen fingerlings were transported at the end of November 2020. from the SRD BL hatchery to the aquaculture laboratory of the Faculty of Agriculture, University of Banja Luka. Huchen fingerlings was housed in flowing aquariums, where it stayed for a month until the beginning of the experiment in order to adapt to the new environmental conditions. There was a total of 35 fingerlings of average weight (± SD) 6.00 ± 1.74 g, total length (TL) 8.95 ± 0.98 cm, fork length (FL) 8.36 ± 0.90 cm and standard length (SL) 7.74 ± 0.85 cm.

The huchen fingerlings are uniform in size (body weight and length) and distributed in three flowing aquariums (11, 12 and 12 individuals) with a volume of 65 l / aquarium, in which the same conditions were present. The water supply and drainage was independent for each aquarium, and there were 25 changes water / aquarium in 24 hours. The water in the aquariums is additionally aerated using an air compressor. The photoperiod was 7 and 17 hours, light (from 8 am to 3 pm) and darkness (from 3 pm to 8 am). The light sources were four 60 W bulbs, placed 70 cm above the aquarium. TL (cm), FL (cm), SL (cm) and W (g) were measured at the beginning of the experiment and once a month during the experiment. Body length (cm) was measured with an ichthyometer (accuracy 0.1 cm) and individual body weight (g) with a Kern EMB 600-2 digital scale (load capacity: 600 g; accuracy: 0.01 g). For anesthesia of individuals, just before measuring body length and weight, the anesthetic 2-phenoxyethanol was used. The water temperature during the experiment was measured daily with a digital thermometer (HANA, Miniterm HI 8751), and the pH value was periodically measured with a digital pH meter (WTW, Germany). Aquariums were cleaned once a week.

The huchen fingerlings feeding was according to appetite, using commercial trout feed. The chemical composition of the commercial feed used (feed granulation 1.9 mm) was: crude protein 50%, crude fat and oil 20%, crude fiber 0.7%, crude ash 7.5%, phosphorus 1.3% and digestible energy 19.2 MJ / kg.

Condition factor was calculated using the formula according to Ricker (1975):

$$CF = (W/L^3)*100$$

W - body weight (g), L - total length (cm).

The length-weight rrelationship of huchen fingerlings was determined on the basis of the total length (cm) and body weight (g) of individuals, according to the exponential function (Tesch, 1968):

$$W = aL^b$$

Transformed into logarithmic form:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

W - weight of fish (g); a = regression constant; b = regression coefficient; L = total length (cm).

Statistical analysis included descriptive statistics, regression and correlation, and calculations were done through the statistical programs SPSS17 and MS Excel.

RESULTS AND DISCUSSION

Table 1 shows the average water temperatures, with minimum and maximum values, coefficient of variation and standard deviation for the three control periods. The average pH value of water during the experiment was 7.123.

Table 1. Water temperature during the experiment

Days	Water temperature ^{o}C				
	Average	SD	CV	Min	Max
0-32	12.5	0.92	7.3	10.5	14.3
33-64	12.3	1.13	9.2	9.7	13.9
65-91	12.3	0.57	4.7	11.1	13.4

Water temperatures during the experiment were similar and averaged 12.5°C and 12.3°C, respectively. Water temperatures were within the range of 6 - 18°C reported by Baensch and Riehl (1991), but were lower than optimal (16 - 18°C) in terms of growth and mortality of fry and fingerlings huchen reported by Jungwirth *et al.* (1989).

The largest variations were found in average body weight, with a trend of increasing variation from the beginning to the end of the experiment. In contrast to body weight, body length variations were significantly lower, indicating a more even increase in individual body length. The body of the huchen is very elongated, which can be seen from the research of Nikcevic *et al.* (1998) which stating that the catch of a four-month-old huchen fry, which was released into the river after swimming in a hatchery, determined an average total body length of 58.95 ± 2.33 mm and an average body weight of 2.07 ± 0.14 g.

The condition factor was the highest at the beginning, after which there was a tendency to fall slightly (Table 2). Limits of variation (minimum and maximum values, CV) of body length (cm), body weight (g) and CF of fingerlings during the experiment are shown in Table 2.

The results shown in Table 3 show that there are highly positive correlations between body lengths (TL, FL and SL) and body weight (W). The increase in body length was more intense and uniform to each other.

Table 2. Variations in body length (cm) and weight (g), and condition factor (CF) of huchen fingerlings during the experiment

Parameter	Days	0	32	64	91
	Age (months)	8	9	10	11
	Number of fish (n)	(n=35)	(n=34)	(n=33)	(n=32)
TL (cm)	Average	8.95	10.18	11.72	12.67
	SD	0.98	1.24	1.42	1.69
	CV	10.98	12.17	12.14	13.36
	Min	6.80	7.70	8.50	9.60
	Max	11.30	13.30	15.0	16.90
FL (cm)	Average	8.36	9.65	11.04	11.94
	SD	0.90	1.17	1.38	1.62
	CV	10.72	12.17	12.52	13.56
	Min	6.40	7.30	7.70	9.00
	Max	10.30	12.70	14.20	16.10
SL (cm)	Average	7.74	8.76	10.08	11.01
	SD	0.85	1.03	1.30	1.54
	CV	10.93	11.74	12.87	13.99
	Min	5.80	6.60	6.90	8.20
	Max	9.60	11.40	13.00	15.20
W (g)	Average	6.00	8.79	12.88	16.35
	SD	1.74	2.86	1.42	6.98
	CV	29.04	32.52	33.77	42.67
	Min	2.80	4.00	4.20	6.60
	Max	10.40	16.60	24.50	35.40
CF	Average	0.835	0.832	0.799	0.798
	SD	0.006	0.008	0.007	0.028
	CV	0.69	0.98	0.94	3.57
	Min	0.831	0.827	0.792	0.783
	Max	0.842	0.841	0.807	0.831

TL – total length (cm), FL – fork length (cm), SL – standard length (cm), W – body weight (g); CF – Condition factor.

Table 3. Correlative relationships of body length and mass (*Pearson Correlation*)

	TL (cm)	W (g)	FL (cm)	SL (cm)
TL (cm)	1	0.964[**]	0.998[**]	0.994[**]
W (g)		1	0.963[**]	0.966[**]
FL (cm)			1	0.993[**]
SL (cm)				1

TL – total length (cm); FL – fork length (cm); SL – standard length (cm); W – body weight (g).
**. Correlation is significant at the 0.01 level.

The total condition factor (CF ± SD) was quite stable and averaged 0.82 ± 0.02 (min 0.80; max 0.84), with minor variations (CV = 2.47) during the experiment. Bajić *et al.* (2015) state that by breeding huchen fry during the early juvenile phase CF was 0.688 (huchen fry of average weight 3 g) and 0.581 (huchen fry of average weight 1.1 g), and this is the result of using different feed during the initial diet of huchen (artemia salinae + factory feed for trout and

gamarus sp. + fish meat). It is noticeable that in this experiment CF is higher compared to the results of Bajić *et al.* (2015), which indicates that in favorable environmental conditions, with increasing age, there is a uniform increase in the length and body weight of the huchen, as a result of which the condition factor increases. Accordingly, Treer *et al.* (2013) state that low CF of young shoots at certain body lengths does not necessarily reflect suboptimal habitat conditions, due to faster growth of fingerling body length in relation to body weight in the first years of life.

Survival of huchen fingerlings was high during the experiment (91.43%). Mortality was 8.57% (a total of 32 survived huchen and 3 died).

From the beginning to 64 days into the experiment, there was a negative allometric growth (b < 3) of huchen fingerlings with a positive correlation coefficient (r) of total length and body weight and coefficient of determination (r^2), according to Bajić *et al.* (2015). As the total length and body weight increased, the regression parameter b also increased (Table 4).

Table 4. Logarithmic values of total length and body weight, regression parameters, correlation and determination coefficient of huchen fingerlings by observed periods

Age (months)	Days exp.	No. fish (n)	Log TL			Log W			Regression parameter		R	r^2
			Min	Max	Average±SD	Min	Max	Average±SD	a	b		
8	0	35	0.83	1.05	0.949±0.049	0.45	1.02	0.759±0.133	-1.780	2.674	0.979	0.959
9	32	34	0.89	1.12	1.004±0.054	0.60	1.22	0.920±0.151	-1.870	2.778	0.992	0.985
10	64	33	0.93	1.18	1.065±0.054	0.62	1.39	1.083±0.162	-2.047	2.938	0.988	0.976
11	91	32	0.98	1.23	1.099±0.058	0.82	1.55	1.176±0.185	-2.200	3.072	0.967	0.935

Observed by days, the calculated regression coefficients (b) ranged within the limits stated by Froese (2006), that in most fish the expected range of the regression coefficient (b) was 2.5 < b < 3.5. Analysis of logarithmic values of total length and body weight from 64 to 91 days revealed positive allometric growth (b > 3), with a correlation coefficient (r) of length and body weight of 0.967 and a coefficient of determination (r^2) of 0.935 (Table 4).

Taking into account all measured values (from the beginning to the end of the experiment), the analysis of logarithmic values of the total length and body weight of the huchen fingerlings showed a negative allometric growth (b < 3). The correlation coefficient (r) of total length and body weight was 0.98967, and the coefficient of determination (r^2) was 0.979 (Table 5).

Table 5. Logarithmic values of total length and body weight, regression parameters, correlation and determination coefficient of huchen fingerlings during the experiment

Log TL			Log W			Regression parameters		R	r^2
Min	Max	Average±SD	Min	Max	Average±SD	a	b		
0.83	1.23	1.028±0.08	0.45	1.55	0.979±0.22	-1.921	2.822	0.98967	0.979

In relation to the results of this research, Bajić *et al.* (2015) report a lower correlation of huchen fry of $R^2 = 0.9246$ and $R^2 = 0.8359$, which is related to a lower condition factor.

During the observed period, the increase in body length was more pronounced, in relation to the increase in body weight of huchen fingerlings, which was reflected in negative allometric growth (b < 3), according to Simonović *et al.* (2011) and Bajić *et al.* (2015). Treer *et al.* (2013) state that negative allometric growth is present in younger age categories of huchen, due to faster growth of body length in relation to body weight.
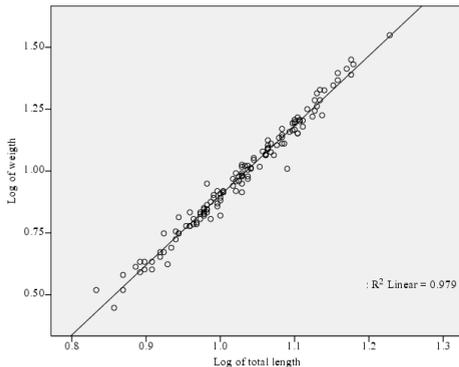
Graph 1. Logarithmic values of total length and weigth of huchen fingerlings
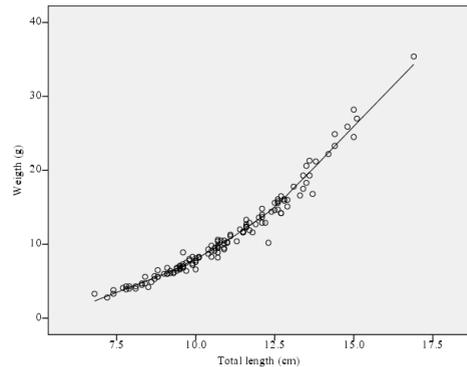
Graph 2. Length - weigth relationship of huchen fingerling

The equation of length-weight relationship of the analyzed huchen fingerlings is $W = 0.011995L^{2.822}$, and the logarithmic form LogW = -1.921 + 2.822LogL. A highly positive correlation (Graph 1) was found between the logarithmic values of the length and body weight of the huchen fingerlings in cultivated conditions ($r^2 = 0.979$).

CONCLUSIONS

The growth of body length and body weight of huchen fingerlings was expressed by a highly positive correlation ($r^2 = 0.979$). The length- weight relationship of huchen fingerlings was calculated as $W = 0.011995L^{2.822}$.

Negative allometric growth (b < 3) was determined for the total observed period, with a tendency to intensify growth in the last observed period when positive allometric growth (b > 3) was recorded.

A highly positive correlation was found between body length (TL, FL and SL) and body weight (W). The condition factor (CF) of the huchen fingerlings during the experiment averaged 0.82.

REFERENCES

Andreji, J. & Stráňai, I. (2013). Growth parameters of huchen *Hucho hucho* (L.) in the wild and under culture conditions – *Archives of Polis Fisheries* 21: pp. 179-188.

Bajić, A., Sipos, S., Pejčić, Lj., Demény, F., Sokoray-Varga, S., Müller, T. & Miljanović, B. (2015). Rearing Danube salmon, *Hucho hucho* (L. 1758), in controlled environment during early juvenile stage. *Pisces Hungarici* 9 (2015), pp. 81–88.

Baensch, H.A. & Riehl, R. (1991). Aquarien atlas. Bd. 3. Melle: Mergus, Verlag für Natur-und Heimtierkunde, Germany.

Dekić, R., Savić, N., Manojlović, M., Golub, D. & Pavličević, J. (2016). Condition factor and organosomatic indices of rainbow trout (*Oncorhynchus mykiss*, Wal.) from different broodstock. *Biotechnology in Animal Husbandry* 32 (2), Belgrade, Faculty of Agriculture, pp. 229-237, DOI:10.2298/BAH1602229D.

Froese, R. (2006): Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. *Journal of Applied Ichthyology*, 22, pp. 241–253.

Froese, R., Thorson, J. & Reyes, Jr. B.R. (2014). A Bayesian approach for estimating length-weight relationships in fishes. *Journal of Applied Ichthyology* 30(1): pp. 78-85.

Holčik, J., Hensel, K., Nieslanik, J. & Skácel, S. (1988). The Eurasian Huchen, *Hucho hucho*. Largest salmon of the world – Dr. W. Junk Publishers, Dotrecht, Boston and Lancaster, p. 242.

Ihut, A., Zitek, A., Weiss, S., Ratschan, C., Holzer, G., Kaufmann, T., Cocan, D., Constantinescu, R. & Miresan, V. (2014). Danube salmon (*Hucho hucho*) in Central and South Eastern Europe: A review for the development of an international program for the rehabilitation and conservation of Danube salmon populations. Bulletin UASVM Animal Science and Biotechnologie, 71: pp. 86-101.

Jungwirth, M., Kossmann, H. & Schmutz, S. (1989). Rearing of Danube salmon *(Hucho hucho* L.) fry at different temperatures, with particular emphasis on freeze-dried zooplankton as dry feed additive. *Aquaculture,* 77: pp. 363-371.

Kahrimanović, A., Omanović, H., Halimović, S. & Kahrimanović, D. (2013). Salmonidae. Univerzitet u Sarajevu, Poljoprivredno-prehrambeni fakultet, Sarajevo.

Mikavica, D. & Savić, N. (1999). Ribe rijeke Drine [Fish of River Drina]. Univerzitet u Banjoj Luci, Poljoprivredni Fakultet, Banja Luka, p. 84.

Mruk, A. & Kucheruk, A. (2019). Fish-biological characteristics of danube salmon (*Hucho hucho* L.) breeders. International Scientific and Practical Conference; Modern technologies of propagation and restocking of native fish species, Mukachevo, Ukraine, pp. 41-42.

Nikcevic, M., Mickovic, B., Hegediš, A. & Andjus, K.R. (1998). Feeding habits of huchen *Hucho hucho* (Salmonidae) fry in the River Tresnjica, Yugoslavia, *Italian Journal of Zoology*, 65:S1, 231-233, DOI:10.1080/11250009809386821

Pavlík, L. (1998). A note to huchen stocking – *Rybarstvo*, 3: pp. 8-9.

Pasarin, B. (2007). Salmonicultură practică. Ed. Alfa pp. 69–71 Iaşi.

Ratschan, C. (2014). Aspekte zur Gefährdung und zum Schutz des Huchens in Österreich. Den 33.

Ricker, W.E. (1975). Computation and interpretation of biological statistics of fish populations. *Fisheries Research Board of Canada Bulletin* 191: pp. 1–382.

Sangun, L., Akamca, E. & Akar, M. (2007). Weight-Length Relationships for 39 Fish Species from the North-Eastern Mediterranean Coast of Turkey. *Turkish Journal of Fisheries and Aquatic Sciences* 7: pp. 37-40.

Simonović, P., Nikolić, V., Tošić, A. & Marić, S. (2011). "Length-weight relationship in adult huchen Hucho hucho (L., 1758) from Drina River, Serbia" *Biologia*, vol. 66, no. 1, 2011, pp. 156-159. https://doi.org/10.2478/s11756-010-0135-2

Tesch, F.W. (1968). Age and growth. p. 93−120. In: Ricker, W. (Ed.): *Methods for Assesment of Fish Production in Fresh Waters.* Oxford and Edinburgh.

Treer, T., Šprem, N. & Piria, M. (2013). Condition of huchen (*Hucho hucho* Linnaeus, 1758) from the Croatian-Slovenian Kupa River. Blackwell Verlag GmbH, *Journal of Applied Ichthyology*, pp. 1–3.

Vuković, T. & Ivanović, B. (1971). Slatkovodne ribe Jugoslavije/Freshwater fishes from Jugoslavia. Zemaljski muzej BiH, Sarajevo, p. 268.