INVESTIGATION UPON CORRELATION BETWEEN WEIGHT, WATER, PROTEINS AND LIPIDS OF CARP FISH *(Cyprinidae)*

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KORELATIVNI ODNOSI IZMEĐU TEŽINE, VODE, PROTEINA I LIPIDA KOD ŠARANSKIH VRSTA

Abstrakt

Cilj istraživanja je bio da ispita korelacije između mase, vlage, proteina i lipida kod šaranskih riba (Cyprinidae): šarana (*Cyprinus carpio* L.), sivog tolstolobika (*Aristichthys nobilis* Rich.) i belog amura (*Ctenopharyngodon idella* Val.). Ustanovljeno je da su najjače i izvorne korelacije, sa suprotnim predznakom, između mase i nivoa vode (r = -0.40; r = -0.791), proteina (r = -0.69) i lipida (r = -0.783); vode i lipida (max r = -0.926) i proteina i lipida, u telu riba. Dostupnost korelacija između mase i biohemijskih indikatora koji su praćeni ukazuje na mogućnost da se oni koriste kao dodatni kriterijumi u oceni kvaliteta gajenih riba u toku prve godine, kako bi se mogla proceniti hranljiva vrednost riba u ishrani.

Ključne reči*: šaranske ribe, vlaga, protein, lipidi, korelacije*

INTRODUCTION

The weight is a summary indication, which reflects fish growth, while the chemical composition allows for nutritive value assessment. On the basis of the already established interrelations and correlations between proteins and fish weight, 68 investigations have been made using 68 species of fish and hybrids. R a m s e y e r (2002) has developed a model for prognosticating nitrogen and proteins (N x 6.25), depending on their weight. According to some authors (L o v e, 1970; T u d o r, 1984) the variations in fish chemical composition can also be related to fish length and weight. The investigations made by G e r i et al., (-1993[a], -1993[b]), G e r i et al. (1995) have been connected with investigations upon the effect of weight, age, season, growing medium (the water

temperature effect) upon the chemical composition of muscles and fatty acid composition of muscle lipids of the carp. A correlation between fish weight (39 ÷ 2776 g) and morphological elements of different parts of the body upon fish value as food has been established. W e a t h e r l e y et al. (1983) has determined the proteins, lipids, water and energy of trout body depending on fish size at different growing conditions. It has been established that energy increase (calculated on the basis of fish body chemical composition) has been on the account of lipids percent increase.

An investigation upon the eventual correlations between weight and indications describing fish chemical composition can be utilized as objective information in assessing species specificity and nutritive value. Concerning this, the purpose of this study is to investigate the correlations between weight, water, proteins and lipids of carp fish *(*Cyprinidae*)*.

MATERIALS AND METHODS

Fish. When studying the correlations between weight, water, proteins and lipids, we have been included fish from already carried out research experiments with the species of carp (*Cyprinus carpio* L.), big-head carp (*Aristichthys nobilis* Rich.) and grass carp (*Ctenopharyngodon idella* Val.). Weight variation of the fish investigated has been, as follows: Carp (*Cyprinus carpio* L.): I group: from one-summer old to two-summer old carp K (I) with weight of 10.0 to 1060 g; II group: from one-summer old to two-summer old carp K (II) with weight of 10.0 to 1300 g; III group: two-summer old carp (K_{1+}) with weight of 300 to 1150 g; big-head carp (*Aristichthys nobilis* Rich.) two-summer old (T_{1+}) with weight of 350 to 1100 g; grass carp (*Ctenopharyngodon idella* Val.) two-summer old (A_{1+}) with weight of 385 to 1446 g. In order to investigate the correlations between water, proteins and lipids, we have also included: one-summer old carp (K_{0+}) with weight of 10.26 to 100 g; one-summer old (T_{0+}) and one-year old (T_1) big-head carp with weight of 30-50 g; grass carp one-summer old (A_{0+}) and one-year old (A_1) with weight of 30-50 g.

Analysis and processing of data. For the analysis we have used at an average 3-10 fish, two-summer old, and one-summer old and one-year old fish by 10-20 fish each, selected at random. From the fish body (the whole body without the head and insides and autoclaved) and from fish musculature (the lateral muscle) by separating the skin and the hypodermic fats, subjected to grinding and homogenization samples have been prepared, which have been analyzed for defining the content of water (105^{o}C, 24 h), protein (Kijeldahl and Parnas-Wagner distillation of nitrogen N x 6.25) and lipids (Soxhlet). Fish weight has been measured by weighing on an electronic balance, with accuracy of 0.01 g.

Correlations have been determined and correlation coefficients between weight and biochemical parameters of the investigated fish were indicated. The correlation coefficient (**r**) and the significance rate (p) were determined by Excel computer program of a statistical package Statistica 6.0 (Manov, 2001). Upon comparison of two samples the significant differences were analyzed upon application of t-test according to Student, the probability rate being $p < 0.05$*; $p < 0.01$**; $p < 0.001$***.

RESULTS AND DISCUSSION

Investigating the Correlation Between Fish Weight and Water, Proteins and Lipids

The average values obtained on fish weight (g) and water, proteins and lipids (%) in the body and muscle tissue of fish investigated are shown on Table 1. The correlations between proteins and lipids of carp, big-head carp and grass carp, one-summer and one-year old, have been investigated by reporting the fat that these are the main plastic and energetic substances and that they have a predominant significance in quality assessment of the stocking material and its readiness for hibernation.

The similarity in body composition of the various fish weighing groups and species has outlined the tendency for preserving the relative proportion ratios (the relative share, %) of the chemical composition within the limits of 17.97 ÷ 22.25% dry matter content, 72.17 ÷ 82.65% proteins and 10.46 ÷ 23.32 % lipids, depending on live weight. Similar conclusions have been made in Weatherley` et al. (1983) studies, according to which the body composition might be dependent approximately on their live weight.

Table 1. Average values of weight (g) and biochemical indices (% in fresh sample) of carp fish.

Fish species, age	n	Parameters							
		weight, g		water,%		protein,%		lipids,%	
		x	Sx	x	Sx	x	Sx	x	Sx
K (I)	18	396.2	93.26	78.45	0.192	17.41	0.177	3.07	0.23
K (II)	25	537.5	85.7	77.79	0.263	16.03	0.285	5.18	0.413
K_{1+}	64	526.56	16.53	82.03	0.086	14.27	0.149	2.53	0.065
T_{1+}	10	720.63	41.39	77.45	1.946	16.36	0.20	3.75	0.261
A_{1+}	27	891.0	68.20	80.40	0.216	16.20	0.318	2.05	0.204
K_{o+}	9	50.19	10.23	78.64	0.414	17.61	0.308	2.78	0.179
T_{o+}	10	46.64	7.25	79.40	0.456	15.94	0.261	3.12	0.166
T_1	10	36.64	6.14	80.29	0.342	16.01	0.142	2.67	0.089
A_{o+}	10	51.25	12.21	77.75	0.413	17.08	0.263	3.59	0.086
A_1	10	48.15	10.17	80.75	0.651	14.88	0.189	2.64	0.166

K(I)- Carp I group; K(I)- Carp II group; K_{1+}- two-summer old carp; T_{1+}- two-summer old bighead carp; A_{1+}- two-summer old grass carp; K_{o+}- one-summer old carp; T_{o+}- one-summer old bighead carp; A_{o+}- one-summer old grass carp; T_1- one-year old bighead carp; A_1- one-year old grass carp;

Table 2 depicts the results obtained for correlation coefficients values concerning the couple of indices investigated: weight (g) and water (%) for the species of carp, bighead carp and grass carp.

A considerable negative and significant correlation ($P<0.05^*$; $P<0.01^{**}$; $P<0.001^{***}$) has been established between weight and water of the fish species investigated. A similar correlation has been reported in W e a t h e r l e y` et al. (1983) investigations in various trout groups. By increasing the weight, the water level decreases, respectively the dry matter content in fish body and muscle tissue increases. From the correlations studied fish weight has determined a relative variation share (%) of water from R^2 = 0.27 – 0.39 in carp to R^2 = 0.625 in silver carp.

Table 2. Correlations between weight (g) and water (%) in body and muscle tissue of carp, bighead carp and grass carp.

Para-meters	weight, g				
	water, %				
	carp, K $_{(I)}$	carp, K$_{(II)}$	carp, K $_{1+}$	bighead carp, T $_{1+}$	grass carp, A $_{1+}$
r	-0.631	-0.525	-0.40	-0.451	-0.791
P	0.005**	0.007**	0.0010***	0.0265*	0.0110**
n	18	25	64	10	27

Table 3 reflects the results obtained for the correlation coefficients values of the couples investigated indices: weight (g) and proteins (%), and weight (g) and lipids (%) for carp.

The relation between weight and protein level in fish has been considerable, reverse and with a high degree of significance (P<0.001) in II group carp. The data for correlation coefficients between weight and lipids have been analogical, as well, and the correlation of II group carp has been authentic, big and positive. The differences in correlation between the indices traced might be due to the fish excerpts, because the correlations have been demonstrated in the group having n=25. From the correlations studied, fish weight has determined a higher variation percent of proteins ($R^2 = 0.476$) and of lipids ($R^2 = 0.613$) in the II group carp.

Table 3. Correlations between weight (g), proteins and lipids (%) in carp.

Parameters	weight, g			
	proteins, %		lipids, %	
	carp, K $_{(I)}$	carp, K$_{(II)}$	carp , K $_{(I)}$	carp, K$_{(II)}$
r	0.274	-0.690	0.347	0.783
P	0.271	0.00013***	0.158	0.000004***
n	18	25	18	25

Investigating the Correlations between Water, Proteins and Lipids in Fish

The results obtained for correlation coefficients value for each couple of indices investigated have been given in Table 4, Table 5 and Table 6.

An exceptionally big, negative and significant correlation (P<0.01**; P<0.001***) has been established between water and proteins level in one-summer old carp. The relation between water and lipids of fish has been predominantly big, reverse and significant (P<0.05; P<0.01; P<0.001).

Table 4. Correlations between water and proteins (%) in carp body and muscle tissue.

Parameters	water, %		
	proteins, %		
	carp, $K_{(I)}$	carp, $K_{(II)}$	carp,K_{o+}
r	-0.347	0.186	-0.90
P	0.158	0.374	0.0009
n	18	25	10

Table 5. Correlations between water (%) and lipids in body and muscle tissue of carp and bighead carp.

Parameters	water, %				
	lipids,%				
	carp, $K_{(I)}$	carp, $K_{(II)}$	carp, K_{o+}	carp, K_{1+}	bighead carp, T_{1+}
r	-0.60	-0.745	-0.733	-0.43	-0.28
P	0.0085	0.00002	0.024	0.046	0.043
n	18	25	9	14	10

Table 6. Correlations between proteins and lipids (%) in the body of carp, bighead carp and grass carp.

Parameters	Protein,%					
	Lipids,%					
	carp,$K_{(I)}$	carp,$K_{(II)}$	bighead carp,T_{o+}	bighead carp,T_{1}	grass carp,A_{o+}	grass carp,A_{1}
r	-0.485	-0.789	0.774	-0.695	0.107	-0.619
P	0.041	0.000003	0.0007	0.006	0.703	0.050
n	18	25	10	10	10	10

The data for correlation coefficients between proteins and lipids have been analogical, as well, the correlation being significant, predominantly big and positive in one-summer old bighead carp (r = 0.774; r = 0.90) and negative (r = -0.485; r = -0.789) in the fish species investigated (with the exception of one-summer old grass carp data).

From the correlations studied water has determined a relative share of variation (%) of proteins within the limits of $R^2 = 0.81$ and of lipids within the limits of $R^2 = 0.555$ in one-summer old carp and in II group carp, while concerning the summary group I of carp, the relative share of variation has been low ($R^2 < 0.3$). The proteins have determined a higher relative share of variation (%) of lipids within the limits of $R^2 = 0.5997$ - $R^2 = 0.623$ in one-summer old bighead carp and in carp. Concerning one-year old bighead carp and grass carp, the relative share of variation of lipids has been within the limits of $R^2 = 0.24$ - $R^2 = 0.48$. The analysis of the results has indicated that the water percent has been in a big and reverse correlation with the lipids percent and with the protein percent. From the correlations deduced it follows that lipids and proteins level

has decreased together with water percent increase in fish body. A similar correlation has been proved in T u d o r` (1984) investigations, as well.

The correlation between proteins and lipids, which has been multi-directional concerning the various fish groups investigated, has been an index for the real effect of other factors of their growing medium, upon the quantity and the correlations between these two indices for the given species, age and conditions of inhabitance.

S z y p y l a` (2002) investigations have confirmed this statement, as well, for they have established the correlation between the coefficient of condition, fish weight, water temperature, feeding and other factors.

The chemical composition of fish within the period of active feeding has been different from that established within the hibernation or starvation period, and according to some authors (T u d o r, 1984) has influenced upon chemical indices relation.

The investigation data have illustrated that concerning fish groups, whose chemical composition has been investigated at the end of the vegetation period after an active feeding (one-summer old bighead carp and grass carp) the correlation has been positive and in fish after wintering the correlation has been reverse (one-year old bighead carp, grass carp and I and II group carp). The logical explanation of these facts is that as a result of the active feeding fish has increased its weight, more plastic and energetic substances have accumulated, on the account of water content decrease in tissues and body, i.e., proteins and lipids relative share increase has been observed in the dry matter.

During the period of wintering and passing to endogenous feeding mainly, as well as first, exhaustion of lipids, their relative share decreases and watering of the organism has been observed, while proteins relative share has been more stable, because of their more frugal exhaustion for energetic purposes during hibernation period. In transitional investigations it has been proved (H a d j i n i k o l o v a, 2007) that lipids consumption has been within the limits of 31.5% (bighead carp) – 61.5% (carp), while that of proteins has been within much narrower limits, from 8.7% (bighead carp) to 14.9% (grass carp).

From the summary of the results, a conclusion can be drawn, that the correlating effect of the live weight upon water level has been clearly expressed, authentic and reverse. Water content decreases by fish weight increase. Concerning the relation between weight and proteins and lipids level, a tendency for increasing their level by increasing fish weight has been reported.

Lipids and proteins have increased together with decreasing water percent, and the correlations between them concerning some of the investigated fish species and groups have been exceptionally big, negative and significant. The correlations between proteins and lipids in the fish species and ages investigated have been big, significant and positive in the one-summer old fish and reverse in one-year old fish.

CONCLUSIONS

The correlations between weight, water, proteins and lipids in carp fish (*Cyprinidae*): carp, bighead carp and grass carp have been investigated.

It has been established that the most powerful and significant, having a different sign have been the correlations between:

- fish weight and water level (r = -0.40; r = -0.791), proteins (r = -0.69) and lipids (r = -0.783);
- water and lipids (max r = -0.926) and proteins and lipids, in fish body;

The availability of correlation between the weight and the biochemical indices traced have outlined the possibility for their utilization as an additional criterion for stock fish quality assessment till reaching the age of one-year and for prognostication of nutritive value of fish for consumption.

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