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RELATIONS BETWEEN VARIOUS PAIRS OF BODILY VARIABLES IN TWO SUMMER-OLD CULTURED CYPRINIDS

Gabriela Vasile, Elena Rada Misăilă, Elena Ciornea

Keywords: *bodily variable, bighead carp, silver carp, correlation, regression*

INTRODUCTION

As known, silver carp and bighead carp represent the most productive and economic fish species grown under controlled conditions, which may be explained by their higher growth rhythm - comparatively with the common carp (*Cyprinus carpio* L.) - as well as by the fact that - once they are able to filtrate particles from the phyto- and zooplanktonic mass - they do not require granulated food (OȚEL, 2007).

Generally, cyprinid meat is cheaper than that of other terrestrial animal species, as due to some morpho-physiological peculiarities assuring a reduced energetic consumption.

Consequently, the cyprinids do not need a strong skeleton, similar to that of mammals, the energy required for its formation and maintenance being utilized, instead, for a more powerful muscle mass.

As poikilothermal organisms, they consume no energy for maintaining a constant bodily temperature. As a result of the extremely large spectrum of trophic aquatic resources consumed by cyprinids, their growing in polyculture is quite cheap and sufficiently accessible (MANEA, 1985; STONE *et al*., 2000; GROZEA and BURA, 2002; BUD *et al*., 2004; VASILE and MISĂILĂ, 2005; VASILE *et al*., 2008).

MATERIAL AND METHOD

The experimental part of the present study involved the analysis of some external bodily variables, such as: total length, standard length, length of the head, maximum bodily height, circumference and weight, for two species of culture cyprinids, namely *Aristichthys nobilis* (bighead carp) and *Hypophthalmichthys molitrix* (silver carp), both occurring in their second summer of growth. Consequently, for biometric analysis, 100 individuals from each fish species have been .

RESULTS AND DISCUSSION

In two summer-old bighead carp representatives, higher values of the main statistical indices (variance, standard deviation, standard error of the mean) were recorded for total length, standard length and bodily weight. The highest variation coefficient (18.19%) was registered for the average bodily weight, while the mean bodily circumference showed the lowest variation coefficient (5.493%). The two summer-old bighead carp individuals show a maximum total length of 40 cm and a bodily mass of 750 g (Table 1).

On the basis of the average values and of standard deviation, the (upper and lower) limits of the confidence intervals for all analyzed bodily variable have been subsequently calculated as a function of a critical value *t (α, n-1)*, given by *α = 0.05* and *n-1* degree of freedom *t (0.05, 99) = 1.986* (VARVARA *et al*., 2001).

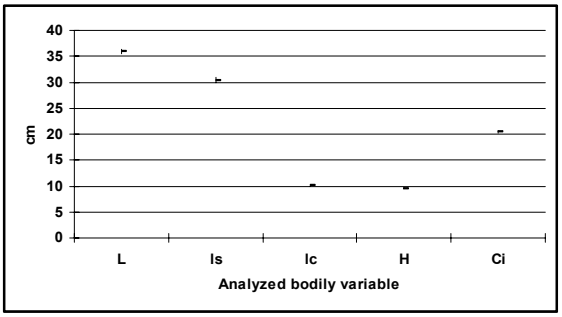

Fig.1. Confidence intervals of the external bodily variables in two summer-old *Aristichthys nobilis*

For α = 0.05, that is, with a probability of 95%, the two summer-old *Aristichthys nobilis* individuals have a total average length ranging between 35.473 and 36.386 cm, standard average length between 29.921 and 30.882 cm, head average length between 9.843 and 10.302 cm, height average between 9.387 and 9.612 cm, the average of circumference between 20.192 and 20.637 cm, and the average of weight between 542.168 and 582.771 g (Fig. 1).As shown by the graphical representation of the confidence intervals limits of the analyzed bodily variables, these are extremely reduced for all biometric parameters investigated (Fig. 1).

Table 1. Values of the main statistical indices of bodily variables in two summer-old *Aristichthys nobilis*

Statistical indices	Bodily variables					
	L (cm)	ls (cm)	lc (cm)	H (cm)	Ci (cm)	G (g)
Mean	35.93	30.402	10.073	9.5	20.415	562.47
Standard error	0.23	0.242	0.115	0.056	0.112	10.231
Median	36.5	30.5	10	9.5	20.5	564
Mode	37	31	10	9	20.5	450
Standard deviation	2.302	2.423	1.156	0.568	1.121	102.314
Variance	5.303	5.847	1.337	0.323	1.257	10468.15
Range	10	12.5	4.5	2.5	4.5	420
Minimum	30	22.5	7.5	8	17.5	330
Maximum	40	35	12	10.5	22	750
Confidence level (95%)	0.456	0.480	0.229	0.112	0.222	20.301
Upper limit	36.386	30.882	10.302	9.612	20.637	582.771
Lower limit	35.473	29.921	9.843	9.387	20.192	542.168
CV%	6.409	7.972	11.483	5.984	5.493	18.19
m%	0.64	0.797	1.148	0.598	0.549	1.819

L = total length, ls = standard length, lc = head length, H = maximum bodily height,
Ci = circumference, G = weight, CV% = mean variation coefficient,
m% = mean precision coefficient

In a subsequent stage of the analysis of the variables here considered, the correlation and regression relations between a series of pair characters were established, namely:

- length of the head *versus* the standard length of the body;
- weight *versus* the standard length of the body;
- total length *versus* the standard length of the body;
- height *versus* the standard length of the body;
- circumference *versus* the standard length of the body;
- height *versus* the circumference of the body;
- circumference *versus* the weight of the body.

Thus, for each pair of variables, the Pearson index of parametric correlation was first calculated, after which its significance was tested. The calculated *t values* were compared with those of *critical t (α = 0.05, n-2) = 1.985*. The null (no correlation present) and the alternative (correlation present) hypotheses have been established and, on the basis of the *critical t- calculated t* comparison, one of the two hypotheses was accepted. There followed plotting of the regression straight line and of the regression equation of the straight line, after which the regression coefficient was determined - *i.e.*, the extent to which some variable may determine the increase of the other one, as well as the coefficient (factor) of determination (R^2), which expresses the percent ratio to which the values of a dependent variable are determined by the other independent variable, and vice-versa (SIMIONESCU, 1983).

In two summer-old bighead carp populations, application of the signification evaluation test of the Pearson correlation index for all pairs of analyzed variables led to the refusal of the null hypothesis and acceptance of the alternative one, as *calculated t* is higher than *critical t*. Related to positive correlations, one can assert that, when the dependent variable increases, an increment of the independent variable also occurs, the reciprocal being also valid.

Table 2. Coefficients of correlation between the tested variables and analysis of their significance in two summer-old *Aristichthys nobilis* individuals

Analyzed variable	Correlation coefficient (r)	*n - 2*	*Calculated t*	*Critical t* (α = 0.05, n - 2)
ls / lc	0.827	98	0.6847	1.986
ls / G	0.586	98	0.3443	1.986
ls / L	0.901	98	0.8126	1.986
ls / H	0.420	98	0.1764	1.986
ls / Ci	0.735	98	0.5403	1.986
H / Ci	0.712	98	0.5082	1.986
Ci / G	0.479	98	0.2295	1.986

L = total length, ls = standard length, lc = head length, H = maximum bodily height, Ci = circumference, G = weight

The Pearson correlation index between standard bodily length and the length of the head is of 0.827, the values evidenced by the two characters being reciprocally determined in 68.47% of cases (Fig. 2).

The regression coefficients calculated for the

- for an 1 cm increase of bodily standard length, the length of the head increases with 0.394 cm;
- for an 1 cm increase of head length, the standard length increases with 1.733 cm.

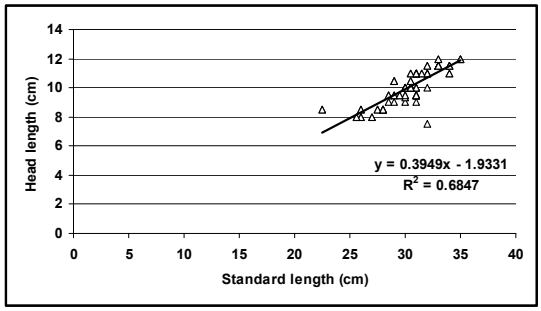

Fig.2. Graphical representation of the regression between standard bodily length and head length in two summer-old *Aristichthys nobilis*

As illustrated in Figure 3, the values of standard length are determined by bodily weight, the situation being reversed in only 34.43% of cases.

The calculated values of the regression coefficients show that:

- for an 1 cm increase of standard length, bodily weight increases with 24.769 g;
- for an 1 g increase of weight, bodily standard length increases with 0.013 cm.

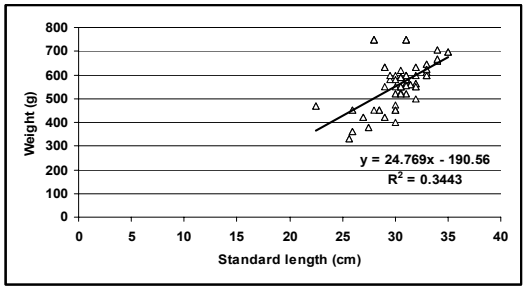

Fig.3. Graphical representation of the regression between standard length and bodily weight in two summer-old *Aristichthys nobilis*

In the case of the standard length - total bodily length correlation, the value of the correlation coefficient is close to the maximum one (r = 0.901), which is actually the - statistically - strongest significant correlation registered in two summer-old *Aristichthys nobilis* representatives.

The regression coefficients calculated for the two characters showed that:

- for an 1 cm increase of standard length, total bodily length increases with 0.856;
- for an 1 cm increase of total length, standard bodily length increases with 0.948 cm.

The determination coefficient (R^2) shows that, in 81.26% of cases, the values recorded by the dependent variable (total length) are determined by two characters showed that: the independent variable (standard length), and vice-versa (Fig. 4).

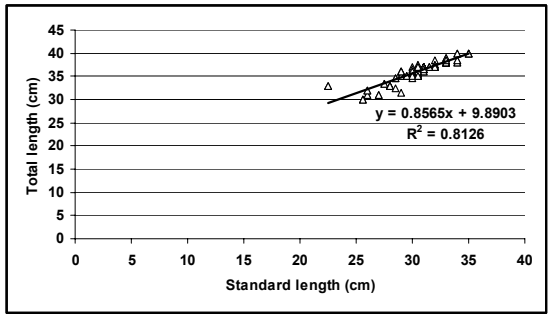

Fig.4. Graphical representation of the regression between standard length and total bodily length in two summer-old *Aristichthys nobilis*

Out of all pairs of variables taken into study, the weakest correlation was registered between standard length and bodily height (r = 0.420), a relation actually valid in only 17.64% of cases (Fig. 5).

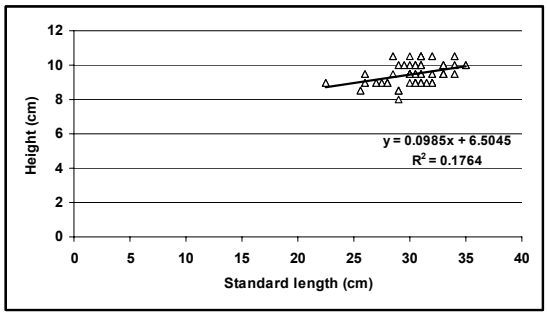

Fig.5. Graphical representation of the regression between standard length and bodily height in two summer-old *Aristichthys nobilis*

The values taken by the calculated regression coefficients showed that:

- for an 1 cm increase of standard length, bodily height increases with 0.098 cm;
- for an 1 cm increase of height, bodily standard length increases with 1.19 cm.Nevertheless, the correlation between standard length and bodily circumference is more intense then the previously described one, the value of the correlation coefficient being of 0.735.The regression coefficients obtained for the two characters evidenced that:
- for an 1 cm increase of standard length, bodily circumference increases with 0.34 cm;
- for an 1 cm increase of circumference, bodily standard length increases with 1.588 cm. As also evidenced by the graphical representation, the values attained by the two characters are reciprocally determined by one another in 54.03% of the cases under consideration (Fig. 6).

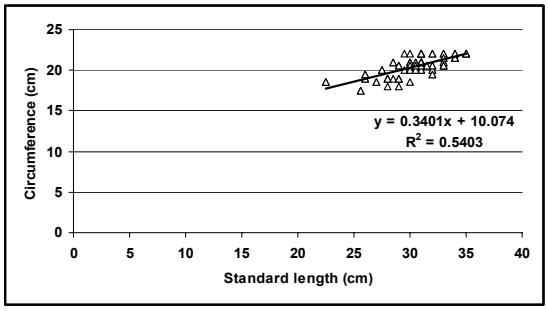

Fig.6. Graphical representation of the regression between standard length and bodily circumference in two summer-old *Aristichthys nobilis*

A positive correlation was also observed in the relation between height and bodily circumference (r = 0.712), this type of link being valid in only 50.82% of cases (Fig. 7).

Calculation of the regression coefficients shows that:

- for an 1 cm increase of height, bodily circumference increases with 1.406 cm;
- for an 1 cm increase of circumference, bodily height increases with 0.361 cm.

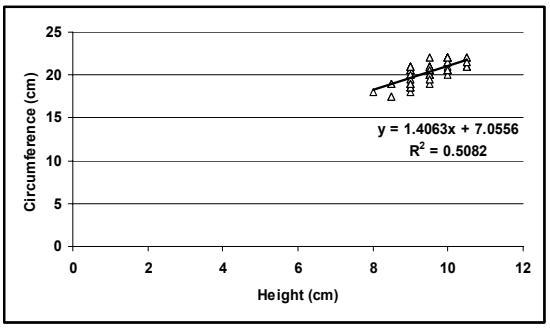

Fig.7. Graphical representation of the regression between height and bodily circumference in two summer-old *Aristichthys nobilis*

The correlation between the bodily circumference and weight (r = 0.479) may be explained in 22.95% of cases (Fig. 8).The calculated values of the regression coefficients showed that:

- for an 1 cm increase of circumference, bodily weight increases with 43.705 g;
- for an 1 cm increase of weight, bodily circumference increases with 0.005 cm.

In the case of two summer-*old Hypophthalmichthys molitrix* representatives, higher values of variance and of standard deviation are to be recorded, similarly with the *Aristichthys nobilis* individuals of the same age, for total length, standard length and bodily weight. Nevertheless, the lowest variation coefficient was evidenced for total average bodily length (7.418%) while, in the bighead carp of the same age, the average circumference occupied the last position, while the average bodily weight takes the highest value in the representatives of both genera (20.79%). The maximum weight recorded is of 770 g, while the maximum total bodily length is of 42 cm (Table 3).

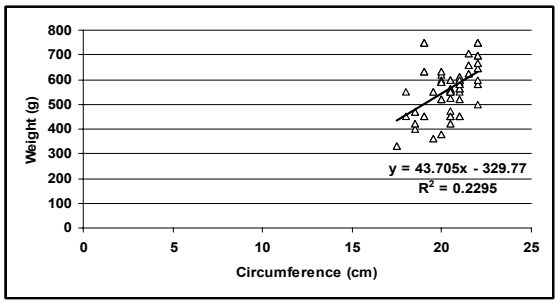

Fig.8. Graphical representation of the regression between circumference and bodily weight in two summer-old *Aristichthys nobilis*

Analysis of the correlations established among all pairs of bodily variables under investigation led to the acceptance of the alternative hypothesis, this time, too, the value of *calculated t* being higher than that of *critical t* (Table 4).Unlike the two summer-old *Aristichthys nobilis* representatives, in which an intensely positive correlation (0.827) is established between bodily standard length and the length of the head, in the individuals of the *Hypophthalmichthys* genus the weakest link is evidenced between the above - mentioned two variables, the Pearson correlation index attaining a value of 0.436.

The regression coefficients thus calculated established that:

- for an 1 cm increase of bodily standard length, length of the head increases with 0.147 cm;
- for an 1 cm increase of length of the head, bodily standard length increases with 1.287 cm.

The determination factor shows that the length values attained by the two characters are reciprocally determined by one other in only 19.04% of cases (Fig. 10).

In exchange, in the case of silver carp, the standard length-bodily weight correlation (r = 0.722) is more intense than the one evidenced in the bighead carp of the same age (r = 0.586).

Analysis of the regression coefficients showed that:

- for an 1 cm increase of standard length, bodily weight increases with 34.690 g;
- for an 1 g increase of weight, standard bodily length increases with 0.015 cm.

The determination factor (R^2) evidences that this type of relation is valid in 52.13% of cases (Fig. 11).

According to the Pearson correlation index (0.958), an intensely positive correlation has been established between standard length and total bodily length. Mention should be made of the fact that a similar situation was also observed for bighead carp individuals of the same age.

The values of the regression coefficients established that:

- for an 1 cm increase of standard length, total bodily length increases with 1.076 cm;
- for an 1 cm increase of total length, standard bodily length increases with 0.854 cm.

The determination coefficient expresses the fact that, in 91.94% of cases, the values taken by the dependent variable (total length) are determined by the values of the independent variable (standard length), and *vice-versa* (Fig. 12).

Table 3. Values of the main statistical indices of bodily variables in two summer-old *Hypophthalmichthys molitrix*

Statistical indices	Bodily variable					
	L (cm)	ls (cm)	lc (cm)	H (cm)	Ci (cm)	G (g)
Mean	37.51	31.915	8.845	11.11	22.74	572.7
Standard error	0.278	0.247	0.083	0.103	0.205	11.906
Median	38	32.75	8.5	11	23	580
Mode	38	33	8.5	12	23	700
Standard deviation	2.782	2.478	0.839	1.036	2.051	119.069
Variance	7.742	6.141	0.705	1.073	4.209	14177.48
Range	12	9	4	5	10	440
Minimum	30	26	8	8	16,5	330
Maximum	42	35	12	13	26.5	770
Confidence level (95%)	0.552	0.491	0.166	0.205	0.407	23.625
Upper limit	38.062	32.406	9.011	11.315	23.147	596.325
Lower limit	36.957	31.423	8.678	10.904	22.332	549.074
CV%	7.418	7.765	9.496	9.326	9.022	20.79
m%	0.741	0.776	0.949	0.932	0.902	2.079

L = total length, ls = standard length, lc = head length, H = maximum bodily height, Ci = circumference, G = weight, CV% = mean variation coefficient, m% = mean precision coefficient

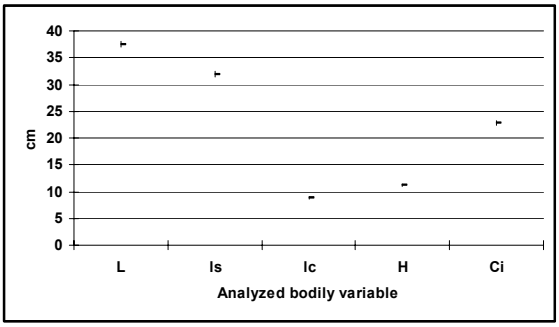

Fig.9. Confidence intervals of the external bodily variables in two summer-old *Hypophthalmichthys molitrix*

Table 4. Coefficients of correlation between the tested variables and analysis of their significance in two summer-old *Hypophthalmichthys molitrix*

Analyzed variable	Correlation coefficient (r)	*n – 2*	*Calculated t*	*Critical t* ($\alpha = 0.05$, n - 2)
ls / lc	0.436	98	4.801	1.986
ls / G	0.722	98	10.331	1.986
ls / L	0.958	98	33.433	1.986
ls / H	0.924	98	23.946	1.986
ls / Ci	0.931	98	25.308	1.986
H / Ci	0.96	98	34.079	1.986
Ci / G	0.672	98	8.995	1.986

L = total length, ls = standard length, lc = head length,
H =maximum bodily height,
Ci = circumference, G = weight

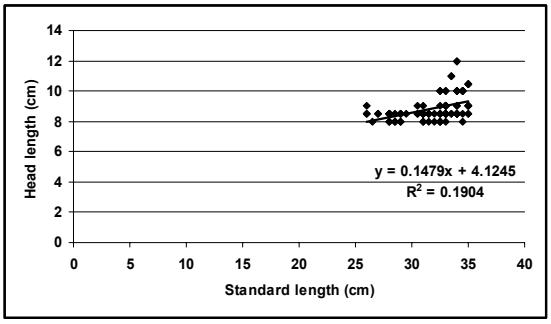

Fig.10. Graphical representation of the regression between standard bodily length and head length in two summer-old *Hypophthalmichthys molitrix*

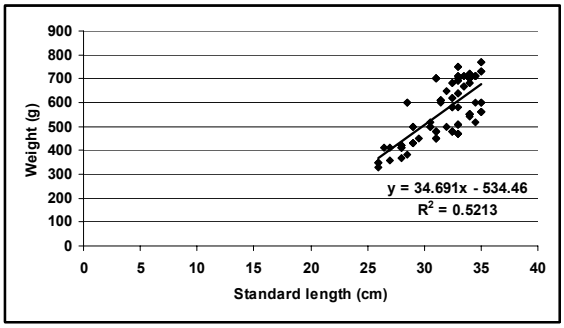

Fig.11. Graphical representation of the regression between standard length and bodily weight in two summer-old *Hypophthalmichthys molitrix*

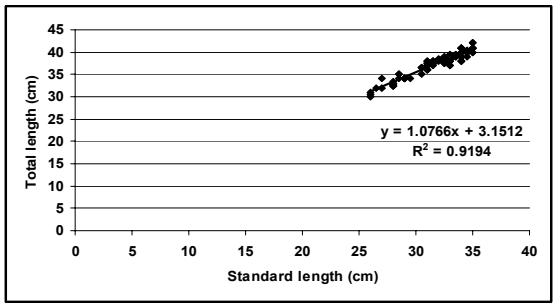

Fig.12. Graphical representation of the regression between standard length and total bodily length in two summer-old *Hypophthalmichthys molitrix*

If, in two summer-old bighead carp representatives, the Pearson correlation index between standard length and bodily height takes a value of 0.42, in the silver carp an intensely positive (that is, statistically significant) correlation has been established between these two bodily variables (r = 0.924).

According to the regression coefficients calculated for the two external bodily variables, there results that:

- for an 1 cm increase of standard length, bodily height increases with 0.386 cm;
- for an 1 cm increase of height, standard bodily length increases with 2.21 cm.

The determination factor (R^2), graphically plotted in Figure 13, expresses the reciprocal influence of the two characters, in 85.4% of cases.

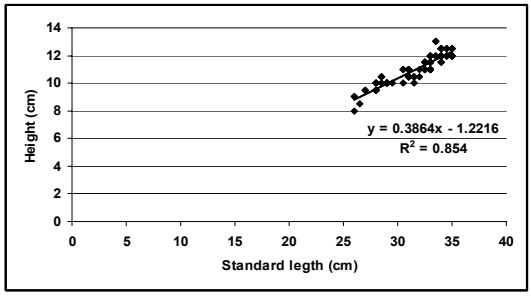

Fig.13. Graphical representation of the regression between standard length and bodily height in two summer-old *Hypophthalmichthys molitrix*

An intensely positive correlation has been also established between standard length and bodily circumference, the value of the Pearson correlation index being of 0.931.

The calculated regression coefficients estimated that:

- for an 1 cm increase of standard length, bodily circumference increases with 0.771 cm;
- for an 1 cm increase of circumference, standard bodily length increases with 1.124 cm.

The determination coefficient states that, in 86.73% of the cases under investigation, the values registered by bodily circumference (the dependent variable) are determined by standard length (the independent variable) and *vice-versa* (Fig. 14).

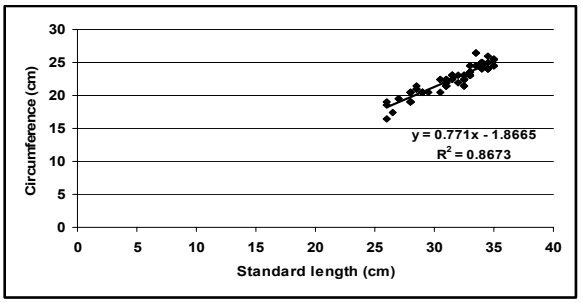

Fig.14. Graphical representation of the regression between standard length and bodily circumference in two summer-old *Hypophthalmichthys molitrix*

In this development stage of the representatives *Hypophthalmichthys molitrix* genera, the closest connection is established between height and bodily circumference, the Pearson correlation index being close to its maximum value (0.96).

The values of the calculated regression coefficients established that:

- for an 1 cm increase of height, bodily circumference increases with 1.901 cm;
- for an 1 cm increase of circumference, bodily height increases with 0.484 cm.

According to the value taken by the determination coefficient, this type of relation is valid in 92.22% of cases (Fig. 15).

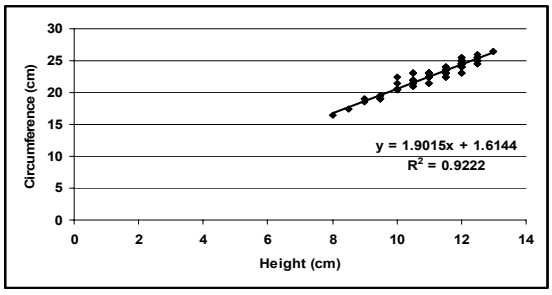

Fig.15. Graphical representation of the regression between height and bodily circumference in two summer-old *Hypophthalmichthys molitrix*

The value of the correlation coefficient between circumference (the independent variable) and bodily weight (the dependent variable) is of 0.672.

From the regression coefficients, there results that:

- for an 1 cm increase of circumference, bodily weight increases with 39.029 g;
- for an 1 cm increase of weight, bodily circumference increases with 0.011 cm.

The estimated determination factor shows that, in only 45.23% of cases, the values attained by the two variables depend on each other (Fig. 16).

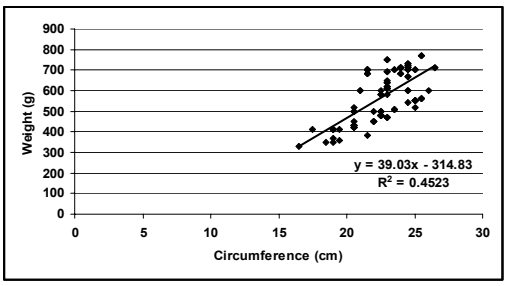

Fig.16. Graphical representation of the regression between circumference and bodily weight in two summer-old *Hypophthalmichthys molitrix*

ABSTRACT

The researches focused toward the study of relationships that exists between diverse pairs of corporal variables (total length, standard length, head length, height, and circumference and body weight) at two species of crap that belongs to the Chinese complex. Thus, we worked on a number of 100 exemplars for each analyzed specie (*Aristichthys nobilis* and *Hypophthalmichthys molitrix*). The analysis of the obtained results showed that at the two summer individuals belonging to *Hypophthalmichthys molitrix* specie, the variance and standard deviation values are higher. The same situation is registered in case of *Aristichthys nobilis* that had the same age regarding the total length, standard length and the body weight. Though the smallest coefficient of variation was observed for the average total weight of body (7.418%), while at marble crap with the same age, the body medium circumference was occupying the first place and the average body weight hold the highest values at the individuals belonging to the two genus (20,79%). The applying of the evaluation test for the significance of correlation coefficient Pearson for all the pairs of variables investigated, lead to the rejection of the null hypothesis and the acceptance of alternative hypothesis due the fact that the *t calculated* is higher than the *critical t*, so we can state that there are positive correlations. If there are positive correlations we can affirm that when the dependent variable increases, the independent variable increases too and vice versa.

CONCLUSIONS

1. For all bodily variables under analysis, the main statistical indices take values extremely close to the mean value, which indicates some uniformity among the representatives of one and the same species.
2. For both bighead carp and silver carp, analysis of the relations established between a series pair of morphological characters (standard length *versus* length of head, bodily weight, total length, height and bodily circumference, as well as height, *versus* bodily circumference, respectively, circumference *versus* bodily weight) evidences the existence of positive correlations between all bodily variables investigated.

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AUTHORS' ADDRESS

VASILE GABRIELA - "Alexandru Ioan Cuza" University of Iaşi, Carol I Bvd., 20 A, Faculty of Biology, Laboratory of Biochemistry and Molecular Biology, Romania, e-mail: gabriela.vasile@uaic.ro

MISĂILĂ ELENA RADA - Research and Development Station for Aquaculture and Aquatic Ecology, CP 847, OP 3, 700508 Iaşi, Romania, e-mail: rada2007misaila@yahoo.com

CIORNEA ELENA - "Alexandru Ioan Cuza" University of Iaşi, Carol I Bvd., 20 A, Faculty of Biology, Laboratory of Biochemistry and Molecular Biology, Romania, e-mail: ciornea@uaic.ro