STUDY OF SOME BODILY VARIABLES IN *HYPOPHTHALMICHTHYS MOLITRIX* SPECIES OF DIFFERENT AGES

Gabriela Dumitru, Elena Ciornea, C. Misăilă

Universitatea „Alexandru Ioan Cuza" Iaşi, Facultatea de Biologie,
Laboratorul Profesional de Biochimie şi Biologie Moleculară
e-mail: gabriela.dumitru@uaic.ro

Abstract

The present paper had the main aim to investigate some biometric corporal variables (total length and standard length of the body, the head's length, the maxim height and the circumference) and gravimetric (the body's weight) for Hypophthalmichthys molitrix individuals in different stages of development (three summer-old and, respectively, four summer-old), from Research and Development Station for Aquaculture and Aquatic Ecology of Iasi. The analysis of parameters taken into study was realized with the biometric and gravimetric classical methods, calculating in the same time the values of main statistical indices which characterize a number of data (average, median, standard error and deviation, variance, range, the variation coefficient and of average's precision, as well as the limits of confidence intervals in which each variable oscillates). To establish the correlation and regression relations we chose to calculate the Pearson correlation indices and the outline of regression equations, and on the base of determination coefficient (R^2) it was identified the number of cases in which the relation is available. On the basis of the obtained results we can mention, with a probability of 95%, the fact that at three summer-old Hypophthalmichthys molitrix representatives the total medium length of the body varies between 54.5-56.26 cm, and the weight between 1450.79-1607.21 g. In exchange, at four summer-old silver carp individuals present a total medium length between 64.59-66.54 cm and a medium weight between 2994.29-3109.71 g.

Key words: silver carp, age, Pearson correlation index

INTRODUCTION

Hypophthalmichthys molitrix, a species of East-Asian origin, has - together with the bighead carp, grass carp and common carp - a special economic and alimentary importance, which is mainly due to its nutritive and curative qualities, silver carp meat representing a high-quality animal protein source.

In controlled systems, the literature of the field makes mention of the following growing ratios: 1 kg in 55 days (Newton, 1980), 1 kg in 5 months [2], a 17 times increase in weight in 78 days in individuals with an average length of 7.6 cm [13], 2 - 2.5 kg in 2 years [8] and 18 - 23 kg at ages ranging between 4 and 5 years [6]. Growing of the silver carp is essentially influenced by the availability of the food and also by the populating density [5, 9].

In our country, at Nucet Station, district of Dâmbovița, in low-density basins (*i.e.*, 10 - 20 individuals/ha), the four year-old silver carp representatives attained an average weight of 5.5 kg, the maximum value of weight being of 7.2 kg, length varied between 65 and 72.5 cm [7], while the five year-old females recorded 8.5 kg and 10.5 kg, respectively, at an age of six summers [11]. According to Antalfi and Tolg (1972) cited by [4], in Romania, silver carp registers a bodily weight of 164 g at the age of one year, of 2030 g at two years and between 2500 and 4000 g, respectively, at three years. In their origin zones, silver carp may attain an average weight of 20 kg at ages between 12 and 15 years.

MATERIALS AND METHOD

The main external bodily variables taken into study were total length, standard length, length of the head, maximum height of the body, circumference and bodily weight at *Hypophthalmichthys molitrix* representatives (silver carp) with ages of three and, respectively, four summers, from the Research and Development Station for Aquaculture and Aquatic Ecology of Iași.

For assuring an as high as possible faithfulness extent of the experimental results, each development stage was investigated on 100 individuals, the results obtained being subsequently subjected to statistical analysis [1, 3, 5, 12]. Finally, the Pearson indices of parametric correlation were calculated for four pairs of variables (standard length - length of the head, standard length - bodily weight, height - bodily circumference, circumference - bodily weight), on the basis of the regression equations, the number of cases in which the relation is valid being percentually estimated [14, 16].

RESULTS AND DISCUSSION

A first objective of the present study was to analyze the bodily variables in a three summer-old silver carp population. Thus, with a probability of 95% (*i.e.*, $\alpha = 0.05$), the total average length of the individuals varies between 54.502 - 56.267 cm, average standard length - between 47.295 and 48.804 cm, average length of the head - between 11.717 and 12.212 cm, average height between 15.602 - 16.201 cm, average circumference between 32.244 and 33.365 cm, and weight, between 1450.79 - 1607.21 g.

Figure 1 shows that the three summer-old silver carp population under investigation is homogeneous, the limits of the confidence intervals of all biometrical parameters being extremely narrow.

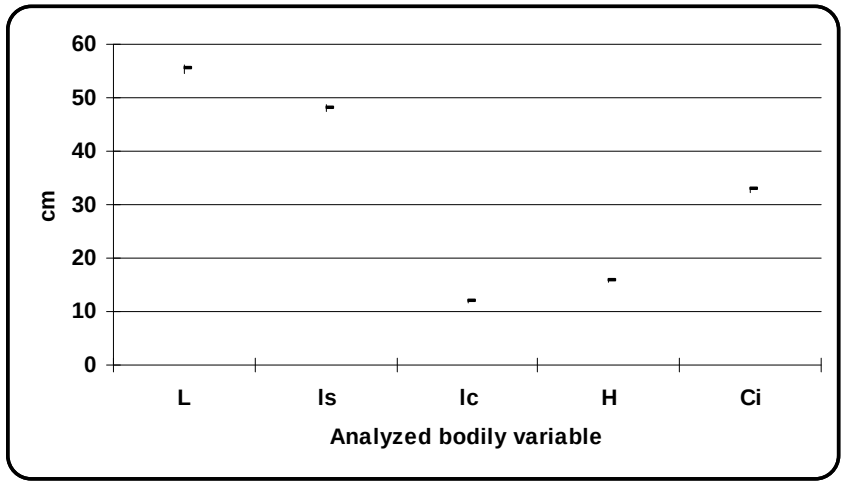

Fig.1. Confidence intervals of the external bodily variables in three summer-old *Hypophthalmichthys molitrix*

As to the variation coefficient of the mean value, in three summer-old *Hypophthalmichthys molitrix* representatives, the highest value was recorded for average bodily weight (25.778%), while the minimum threshold is registered for the mean standard length of the body (7.91%). In this development stage, silver carp attains a total maximum length of the body of 64 cm and a maximum bodily weight of 2500 g (Table I).

Table I. Values of the main statistical indices in three summer-old *Hypophthalmichthys molitrix*

Statistical indices	Bodily variables					
	L (cm)	ls (cm)	lc (cm)	H (cm)	Ci (cm)	G (g)
Average	55.385	48.05	11.965	15.902	32.805	1529
Standard error	0.444	0.38	0.124	0.151	0.282	39.416
Median	55	48	12	15.5	32	1450
Mode	55	52	12	15	40	1200
Standard deviation	4.447	3,8	1.245	1.51	2.825	394.16
Variance	19.777	14.446	1.551	2.281	7.984	155362.6
Range	16	13.5	4.5	6.5	11	1500
Minimum	48	41	10	12.5	28.5	1000
Maximum	64	54.5	14.5	19	39.5	2500
Confidence level (95%)	0.882	0.754	0.247	0.299	0.56	78.21
Upper limit	56.267	48.804	12.212	16.201	33.365	1607.21
Lower limit	54.502	47.295	11.717	15.602	32.244	1450.79
VC%	8.029	7.91	10.411	9.497	8.613	25.778
m%	0.802	0.791	1.041	0.949	0.861	2.557

L = bodily total length, ls = sandard length, lc = length of the head,
H = bodily maximum height, Ci = circumference, G = weight,
VC% = average variation coefficient, m% = average precision coefficient

The values of the Pearson coefficients of parametric correlation among various pairs of characters are listed in Table II, the observation being made that, in all cases, the value of *calculated t* is higher than that of *critical t*, which means rejection of the null hypothesis (no correlation present) and acceptance of the alternative hypothesis (presence of a correlation). Consequently, the assertion may be made that, for the three summer-old silver carp individuals under analysis, positive correlations do exist between all pairs of bodily variables taken into study.

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

Analyzed variable	Correlation coefficient (r)	*n - 2*	*Calculated t*	*Critical t* (α = 0.05, n - 2)
ls / lc	0.322	98	3.372	1.986
ls / G	0.501	98	5.735	1.986
H / Ci	0.903	98	20.904	1.986
Ci / G	0.649	98	8.456	1.986

ls = standard length, lc = length of the head,
H = bodily maximum height, Ci = circumference, G = weight

In this stage of development, the weakest correlation (statistically insignificant) occurs between the length of the head and standard bodily length (r = 0.322).

The calculated regression coefficients showed that:

- at an 1 cm increase of bodily standard length, the length of the head increases with 0.105 cm;
- at an 1 cm increase of the length of the head, standard length increases with 0.948 cm.

According to the determination factor, this relation is valid in only 10.4% of the cases (Fig. 2).

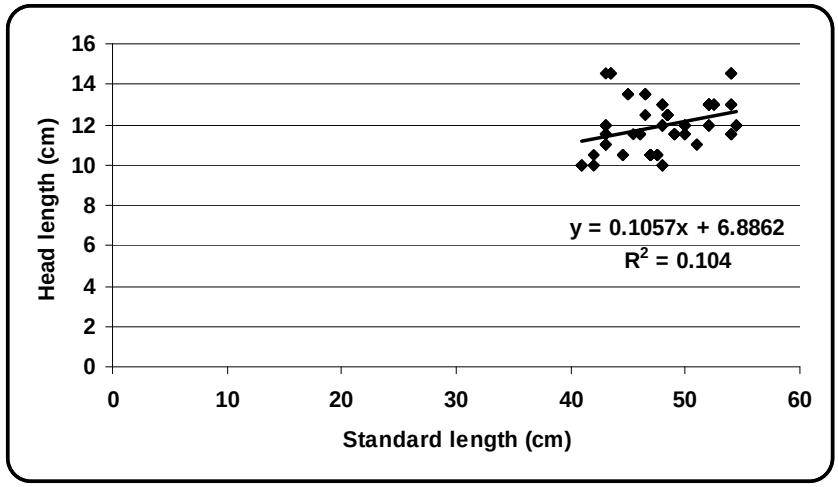

Fig.2. Graphical representation of the regression between standard bodily length and head length in three summer-old *Hypophthalmichthys molitrix*

The value of the Pearson correlation index established between standard length and bodily weight was of 0.501.

The values of the regression coefficient permit the following assertions:

- at an 1 cm increase of standard length, bodily weight increases with 51.987 g;
- at an 1 g increase of weight, bodily standard length increases with 0.004 cm.

The determination coefficient (R^2) shows that the two variables are reciprocally influenced one by another in only 25.13% of the cases (Fig.3).

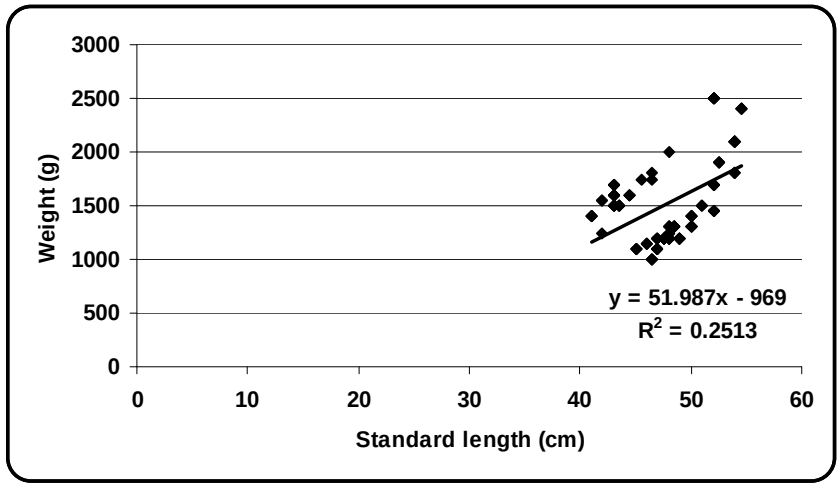

Fig.3. Graphical representation of the regression between standard length and bodily weight in three summer-old *Hypophthalmichthys molitrix*

In three summer-old silver carp representatives, the strongest correlation is found between height and circumference of the body, the Pearson correlation index taking a value quite close to the maximum one (0.903).

The regression coefficients calculated for the two characters showed that:

- at an 1 cm increase in height, bodily circumference increases with 1.69 cm;
- at an 1 cm increase in circumference, bodily height increases with 0.483 cm.

The determination factor showed that the values attained by bodily height are determined - in 81.68% of the cases - by bodily circumference, and reciprocally (Fig.4).

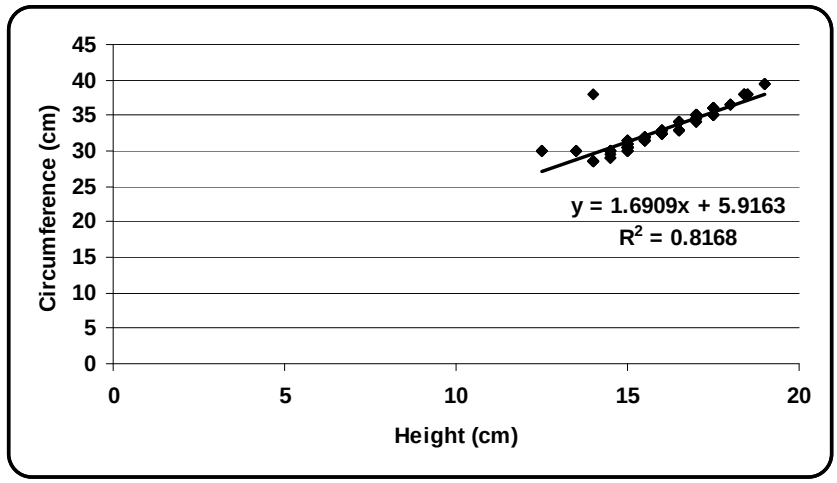

Fig.4. Graphical representation of the regression between height and bodily circumference in three summer-old *Hypophthalmichthys molitrix*

A positive correlation has been also established for bodily circumference and weight, the value of the correlation index being of 0.649.

The regression coefficients showed that:
- at an 1 cm increase of circumference, bodily weight increases with 90.601 g;
- at an 1 g increase of weight, bodily circumference increases with a 0.004 cm.

According to the value recorded for the determination factor, this type of relation is valid in only 42.19% of the cases (Fig.5).

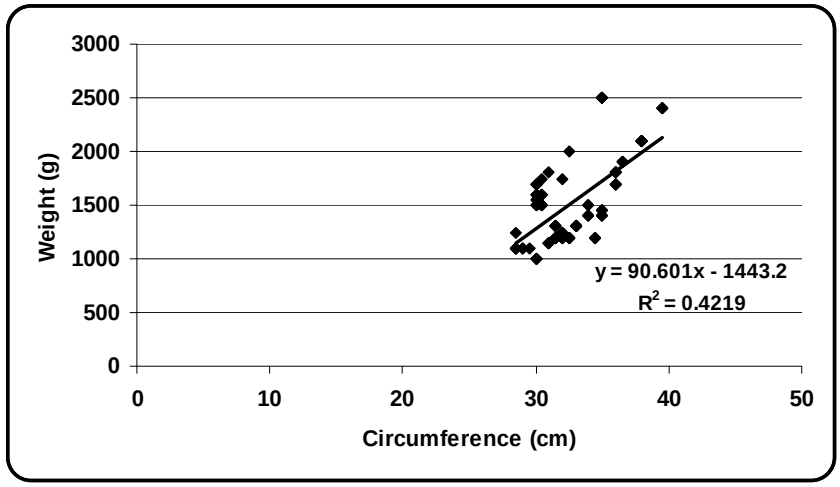

Fig.5. Graphical representation of the regression between circumference and bodily weight in three summer-old *Hypophthalmichthys molitrix*

Another objective of the present research was to estimate the correlations established between the various pairs of external bodily characters in the four summer-old *Hypophthalmichthys molitrix* species, the values of the main statistical indices being listed in Table III. The data show that higher values of the main statistical indices (variance, standard deviation, standard error) have been observed for total bodily length, standard length, circumference and bodily weight, while the length of the head and bodily height show a very low variability. The highest variation coefficient was registered for the average length of the head and average height of the body (12.326% and, 12.306%, respectively), the lowest coefficient appearing for the total average length of the body (7.472%). The four summer-old silver carp population under investigation has a total maximum length of 74 cm and a weight of 3900 g.

Table III. Values of the main statistical indices in four summer-old *Hypophthalmichthys molitrix*

Statistical indices	**Bodily variables**					
	L (cm)	ls (cm)	lc (cm)	H (cm)	Ci (cm)	G (g)
Average	65.57	56.635	15.48	18.355	39.12	3052
Standard error	0.489	0.524	0.19	0.225	0.349	29.084
Median	65	55	14.25	18.75	38.5	3000
Mode	63	54	14	16	39.5	2900
Standard deviation	4.899	5.243	1.908	2.258	3.497	290.846
Variance	24.005	27.489	3.641	5.102	12.232	84591.92
Range	18.5	21	6.5	8	14	1400
Minimum	55.5	45	13.5	15	33.5	2500
Maximum	74	66	20	23	47.5	3900
Confidence level (95%)	0.972	1.04	0.378	0.448	0.693	57.71
Upper limit	66.542	57.675	15.858	18.803	39.813	3109.71
Lower limit	64.597	55.594	15.101	17.906	38.426	2994.29
VC%	7.472	9.257	12.326	12.306	8.94	9.529
m%	0.747	0.925	1.232	1.23	0.894	0.952

L = bodily total length, ls = standard length, lc = length of the head,
H = bodily maximum height, Ci = circumference, G = weight,
VC% = average variation coefficient, m% = average precision coefficient

The limits of the confidence intervals in which the real mean of the population for the bodily characteristics under study were calculated from the mean values and from standard deviation. Thus, with a 95% probability, the four summer-old *Hypophthalmichthys molitrix* population shows a total mean length ranging between 64.597 - 66.542 cm, standard mean length - between 55.594 and 57.675 cm, mean length of the head - between 15.101 and 15.858 cm, mean height - between 17.906 and 18.803 cm, mean circumference - between 38.426 - 39.813 cm and medium weight - between 2994.29 and 3109.71 g.

Similarly with the three summer-old silver carp population, the limits of the confidence intervals of the biometrical parameters under investigation are extremely narrow (Fig. 6).

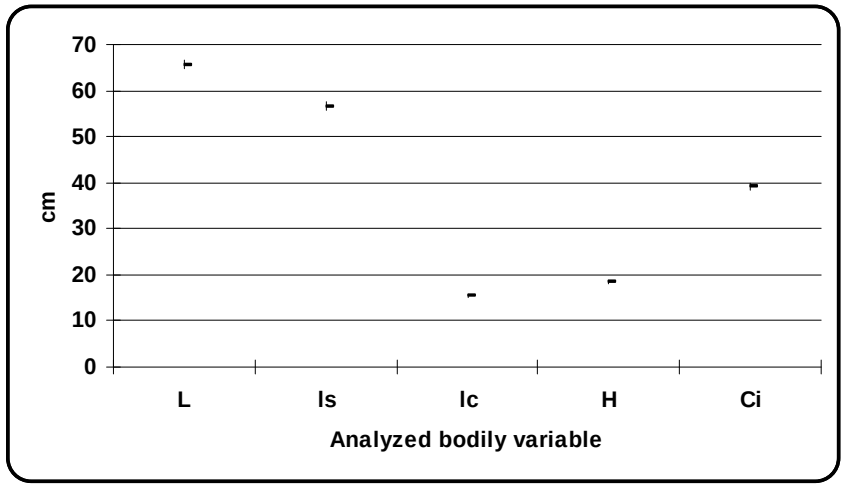

Fig.6. Confidence intervals of the external bodily variables in four summer-old *Hypophthalmichthys molitrix*

Application of the statistical test evidencing the significance of the correlation coefficient in four summer-old *Hypophthalmichthys molitrix* representatives, for all pairs of bodily variables analyzed led, once again, to the rejection of the null hypothesis and acceptance of the alternative one (assuming the existence of a correlation), once the value of *calculated t* was, each time, higher than that of *critical t* (Table IV).

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

Analyzed variable	**Correlation coefficient (r)**	***n - 2***	***Calculated t***	***Critical t* (α = 0.05, n - 2)**
ls / lc	0.847	98	15.814	1.986
ls / G	0.73	98	10.582	1.986
H / Ci	0.914	98	22.321	1.986
Ci / G	0.573	98	6.933	1.986

ls = standard length, lc = length of the head,
H = bodily maximum height, Ci = circumference, G = weight

To better put into evidence the type of relation between the bodily variables under study, the equations of the regression straight lines - permitting to estimate the value of a character, once known the value of another one - were established.

As to the relation between bodily standard length and length of the head, mention should be made of a strong correlation established between them, the value of the calculated index being of 0.847.

According to the regression coefficients estimated for the two variables, the following observations were made:

- at an 1 cm increase of standard bodily length, the length of the head increases with 0.308 cm;
- at an 1 cm increase of the length of the head, standard bodily length increases with 2.329 cm.

The determination coefficient expresses the fact that, in 71.85% of the cases, the values attained by the dependent variable (length of the head) are determined by the values of the independent one (standard bodily length), and *vice-versa* (Fig.7).

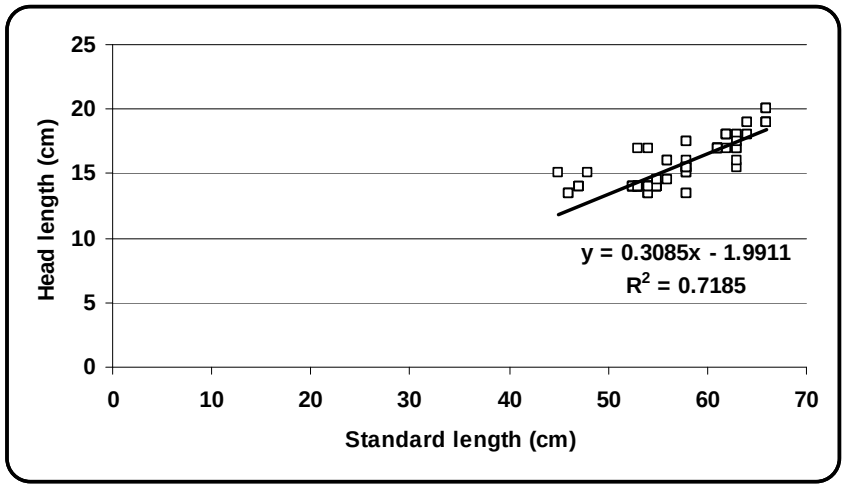

Fig.7. Graphical representation of the regression between standard bodily length and head length in four summer-old *Hypophthalmichthys molitrix*

The value of the correlation coefficient between standard length and bodily weight is of 0.73, while the calculated regression coefficients showed that:

- at an 1 cm increase of standard length, bodily weight increases with 40.511 g;
- at an 1 g increase of weight, bodily standard length increases with 0.013 cm.

The determination factor (R^2) evidences a reciprocal influence between the two variables in 53.33% of the cases (Fig.8).

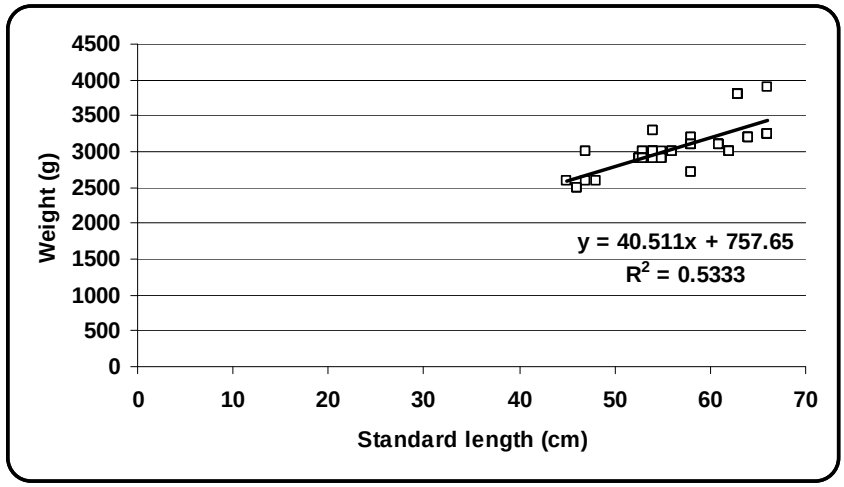

Fig.8. Graphical representation of the regression between standard length and bodily weight in four summer-old *Hypophthalmichthys molitrix*

A high correlation degree may be also noticed, similarly with the case of three summer-old individuals, between height and bodily circumference, the correlation index taking the highest value - *i.e.*, of 0.914. Analysis of the regression coefficients shows that:

- at an 1 cm increase in height, bodily circumference increases with 1.415 cm;
- at an 1 cm increase in circumference, bodily height increases with 0.59 cm.

The determination factor, plotted in the graphic, shows that such a correlation is explained in 83.56% of the cases (Fig.9).

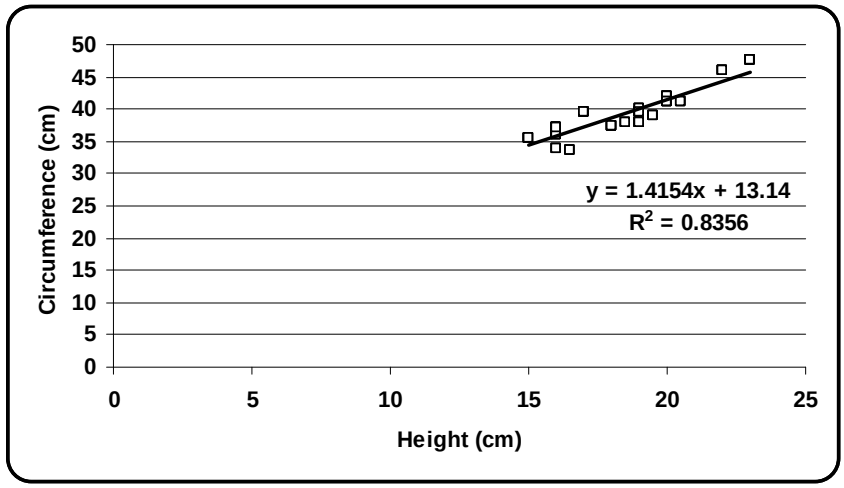

Fig.9. Graphical representation of the regression between height and bodily circumference in four summer-old *Hypophthalmichthys molitrix*

In the four summer-old silver carp population, the weakest correlation is established between circumference and bodily weight (r = 0.573).

The values attained by the regression coefficients showed that:

- at an 1 cm increase in circumference, bodily weight increases with 47.706 g;
- at an 1 g increase in weight, bodily circumference increases with 0.006 cm.

The determination coefficient shows that the values attained by the two parameters are determined one by another in only 32.91% of the cases (Fig.10).

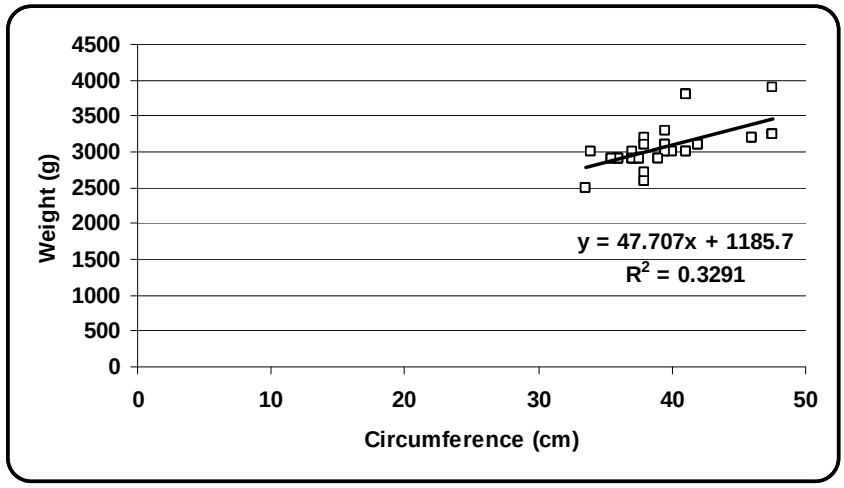

Fig.10. Graphical representation of the regression between circumference and bodily weight in four summer-old *Hypophthalmichthys molitrix*

CONCLUSIONS

Analysis of the biometric and gravimetric results led to the following general conclusions:

- At an age of three summers, silver carp attains a total maximum bodily length of 64 cm and a maximum bodily mass of 2500 g while, in four summer-old individuals, total mean length is of 74 cm, and a mean weight of 3900 g.

- Analysis of the Pearson indices evidenced the existence of some positive correlations between all pairs of bodily variables taken into study, the strongest relation occurring both in the third (r = 0.903) and in the fourth, respectively, summer of growth, between circumference and bodily weight.

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