BITTERLING GROWTH BIOLOGY (*Rhodeus amarus* L.) IN THE BISTRIȚA RIVER

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Abstract. Growth biology for Rhodeus amarus population was estimated by means of several parameters, such as: length-weight correlation, size structure on age groups, mortality rate, productive potential (the turnover) and the physiological conditions of the bitterling population from the regulated catchment area of the River Bistrița.

Growth parameters for this particular species were influenced mainly by environmental conditions and nutrition. These parameters showed the highest growth in the first two years. Afterwards it decreased and the age groups recorded low numbers. The instantaneous mortality coefficient recorded a moderate value, indicating the lack of predation pressure. The turnover characteristic to the bitterling population in the sampling area indicated a medium to low renewal rate.

Key words: *bitterling, length and weight growth, mortality, productive potential*

INTRODUCTION

This paper presents data regarding growth biology of bitterling population (*Rhodeus amarus* L.) at the Gherăieşti (Bacău II) sampling site, located in the regulated stretch of the Bistrița River.

Growth parameters consisted of the following: length-weight correlation; length and weight growth, mortality rate, productive potential (turnover) and the physiological state of bitterling population in this river.

MATERIAL AND METHODS

Fish material was collected by means of electronarcosis. Sampling proceedings included fish counting, measurement (using some biometric indices), weighting, scale sampling for establishing age, determining sex and the gonad development level, lipid accumulation degree etc.

Length-weight correlation was estimated according to the following formula:

$W = a \cdot l^b$, where: W – fish weight (g)
l – standard length(cm)
b – the value of "l" exponent (a constant parameter)

This formula has the following logarithmic form: $\log W = \log a + b \ln l$, where „b" represents the regression coefficient (which equals with the angle of the curve with the ordinate) and „ln a" represents the intersection point with the abscissa.

Length and weight growth was estimated by means of the Bertalanffy formula:

$L_t = L_\infty \left[l - e^{-k(t-t_0)} \right]$, where: L_t – standard length of age groups; L - maximum physiological length that the fish might record in actual environmental conditions; k – the constant of the growth speed; L_0 – larva length at hatching; e – the base of natural logarithms; t_0 – the length of embryo incubation period until hutching; l-e^k (or b) – annual growth rate.

The mortality index can be assessed by means of:

- Z (total mortality) – estimated according to the formula: $Z = K \frac{L_\infty - \bar{L}}{\bar{L} - l'}$

where: k – the growth constant; L - maximum physiological length; $\bar{L}$ - the length where the capture is maximum; l' – the standard minimum length of the capture; t(l) – the age of fishes having size l'; t($\bar{L}$), the age of individuals having size $\bar{L}$.

- M (natural mortality) – calculated according to: $M = 0,8 \cdot e^{(-0,0152-0,271\ln L_\infty+0,6543\ln k+0,643\ln T)}$

where: T – mean annual temperature

- F (mortality due to fishing) – estimated according to the formula: F=Z-M

The productive potential was estimated on the basis of the following:

- recalculated biomass B: $\bar{B} = \frac{B_0\left[e^{(G-Z)}-1\right]}{G-Z}$, when G > Z

$$\bar{B} = \frac{B_0\left[l-e^{-(Z-G)}\right]}{Z-G}$$, when Z > G

where B_0 represents the weight of one age group (one cohort);

- instantaneous mortality index Z: $Z = -\frac{\ln N_2 - \ln N_1}{\Delta t}$, where N_1 and N_2 represent the initial and the final number of individuals from the same age group; t = t_2-t_1 – time period of the experiment;

- instantaneous growth index G: $G = \frac{\ln G_2 - \ln G_1}{\Delta t}$, where G_1 and G_2 represent the mean individual weight at the beginning and at the end of the test for the same age group;

- production – expressed by means of the formula: $P = G \times \bar{B}$

- turnover: $T = \frac{P}{\bar{B}} \cdot 100$, where T represents the rate of biomass (%) compared to the biomass recorded in the previous period.

Biometric indices

These indices were estimated in order to illustrate the physiological condition of bitterling population (*Rhodeus amarus* L.) from the regulated catchment area of the river Bistriţa. Thus, the following indices were considered: fattening coefficient (Fulton), profile index, thickness index and the circumference index (Kiselev).

RESULTS AND DISCUSSIONS

Length-weight correlation

Analyses of the data concerning standard length (l) (cm) and weight (W) (g) of ten size groups (see table 1) led to the following relation:

W = 0.0568 $l^{2.2886}$

The exponent of the parameter "l", having the value 2.2886 (the "b" value) indicates a much faster growth in length than in weight. This value indicated the presence of a young population, where the ages 0+ - 1+ dominated, relative to the adult individuals percent.

Figure 1 presents the length-weight correlation curve, which revealed the following aspects:

- at hatching, individual length could be 0.4 cm, and after the summer (0+) the length reached 1.2 cm;
- the modulation point that appeared at the value 1.55 g (mean weight) and 4.4 cm (standard length) indicated the change from juvenile stage to adult stage. At that particular point the curve inclined to the right indicating an increased weight growth and a lower length growth;
- the sexual maturation took place at decreased fish sizes (1.5 g and about 4 cm) at the age of 1-2 years.

Length and weight growth

Age structure of fish population was estimated by means of the dimensional dispersion of the population (see figure 2). On the basis of this dispersion, five age groups were identified (0+, 1+, 2+, 3+, 4+, 5+), as shown in table 2.

Growth index values indicated a fast-growing species, having a life history of about 5-6 years. It reached maximum physiological sizes in 3-5 years.

Figure 3 depicts the length and weight growth characteristic to this particular species.

The speed of the bitterling population growth in length, as shown in figure 4, was maximum at 1+ (two summers), exceeding half of the total growth. Afterwards it decreased very fast to the adult age of 2+, 3+, 4+, when it reached the maximum physiological size (L_∞) (see table 2a).

Weight growth parameters indicated the same kind of growth, very fast to the point of sexual maturity (the second summer), and decreasing as fast afterwards (see table 2b).

Growth parameters	Maximum physiological sizes	b – the annual growth rate	k – the growth constant	t_0
Length	8.61 cm	0.6656	0.407	0.6989
Weight	8.63 g	0.3902	0.941	0.6577

Decreased physiological sizes (about 8 cm and 8 g) indicated a fish population having a very short life cycle.

Mortality index

Table 3 presents the way bitterling population mortality was assessed. The total mortality value (Z) was 0.94, a value considered to be normal for this particular species with fast growth.

On the graph representing the mortality logarithmic curve (fig. 5), the 90^0 angle indicated a drastic drawback of the number of individuals that reached sexual maturity or final ages (that did not exceed 3-4 years). These data are in accordance with the fast type of growth and short life cycle of this particular species.

On the other hand, high mortality values recorded at mature ages could be explained by worse physiological and trophic conditions (see the Fulton index).

$$\bar{L} = 50{,}44 \text{ cm};\ l' = 35{,}00 \text{ cm};\ L_\infty = 8{,}61;\ k = 0{,}407;\ t_0 = 0{,}6989;\ Z = 0{,}94$$

Productive potential

Because bitterling is a species without economic value, estimating the productive potential referred only to annual rates of biomass renewal, thus determining species sustainability on the long term.

Table 4 presents the proceedings of estimating the turnover. The value 57.8% indicated a medium-low renewal rate. Hence, the species sustainability in this habitat was low. Thus, possible future drawbacks of species percent in fish community might occur.

The physiological status of bitterling population

Tables 5 and 6 depict the value variations of main biometrical indices that characterize the general physiological condition of the bitterling population.

The Fulton coefficient values decreased, indicating worse general conditions. The first significant drawback occurred at the point of reaching sexual maturity (gonad maturation). The second major drawback took place at maximum ages, probably due to a worse trophic regime or to a point event like water pollution.

The thickness index followed the same variation, thus confirming the previous results.

The variation of the Kiselev index was somewhat similar, but it ranged within narrower limits.

The profile index usually increased reaching sexual maturity.

CONCLUSIONS

In the first two years the length growth was more intense, being linear. Afterwards, the growth decreased in intensity, developing a curve trajectory (asymptotic curve). The speed of length growth was a decreasing linear function.

Biometrical indices calculated for this particular population, together with the growth indices estimated by means of Bertalanffy formula recorded lower values, thus indicating a decreased general development. Moreover, the age groups were not numerous (4).

The instantaneous mortality coefficient (Z), estimated for the whole population, recorded a moderate value (0.94), due to the lack of predation pressure.

As regards the productive potential, the turnover recorded 57.8%, indicating a medium to low renewal rate.

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Table 1 Length-weight correlation for the bitterling population

Number of size groups	Standard length (l) (cm)	Weight (W) (g)	No. ind.	$\ln l(x_i)$	$\ln W(y_i)$	$x_{(i)^2}$	$x_{(i)} \cdot y_{(i)}$	Recalculated W (g)	Variance
1.	3.68	1.01	2	1.3029	0.0099	1.6975	0.0129	1.106	+9.50
2.	4.06	1.58	12	1.4012	0.4574	1.9634	0.6642	1.385	-12.3
3.	4.45	2.33	14	1.4929	0.8459	2.2287	1.2628	1.709	-26.64
4.		1.68	34	1.5748	0.5188	2.4799	0.8170	2.061	+22.73
5.	5.21	2.18	17	1.6506	0.7793	2.7245	1.2863	2.45	+12.48
6.	5.59	3.00	14	1.7209	1.0986	2.9615	1.8906	2.88	-3.98
7.	5.97	3.20	8	1.7867	1.1632	3.1923	2.0783	3.34	+4.38
8.	6.35	3.50	4	1.8484	1.2528	3.4166	2.3157	3.85	+10.18
9.	6.73	(4.00)	2	1.9066	1.3863	3.6351	2.6431	4.41	+10.25
10.	7.11	6.00	2	1.9615	1.7917	3.8475	3.5144	4.99	-16.75
n=10			109	$\sum X_{(i)} = 16.6467$ $\overline{X} = 1.6647$	$\sum Y_{(i)} = 9.3039$ $\vec{Y} = 0.9304$	$\sum X_{(i)}{}^2 = 28.1471$	$\sum X_{(i)} \cdot Y_{(i)} = 16.4853$	$\left[\sum X_{(i)}\right]^2 = 277.1126$ $\sum X(i) \cdot Y_{(i)} = 154.8792$	

Table 2a Estimating the parameters of length growth for the bitterling population at the Gherăieşti sampling site

Age	No. ind.	l(cm) recorded	$L_t \cdot L_{t+1}$	$L_t{}^2$	$L_\infty - L_t$	$\ln(L_\infty - L_t)$	L_t recalculated
0+	1	1.3		1.69	7.31	1.9892	0.99
1+	15	3.98	5.174	15.8404	4.63	1.5326	3.54
2+	78	5.02	19.9796	25.2004	3.59	1.2781	5.23
3+	14	6.2	31.124	38.44	2.41	0.8796	6.36
4+	2	7.3	45.26	--	--	--	7.11
n=5		A=16.5 B=22.5	C=101.5376	D=81.1708		E=5.6795	(7.61)5+ (7.94)6+

Table 2b Estimating the parameters of weight growth for the bitterling population at the Gherăiești site

Age	No. ind.	W_t recorded (g)	$\sqrt[3]{W_t} = Y_t$	$Y_t \cdot Y_{t+1}$	Y_t^2	$Y_\infty - Y_t$	$\ln(Y_\infty - Y_t)$	Y_t calculated	W recalculated (g)
0+	1	0.002	0.27		0.0729	1.78	0.5771	0.5	
1+	15	1.59	1.17	0.3159	1.3689	0.881	-0.1267	0.56	0.82
2+	78	2.08	1.28	1.4976	1.6384	0.771	-0.2601	1.4694	3.17
3+	14	3.00	1.44	1.8432	2.0736	0.611	-0.4926	1.8245	6.07
4+	2	3.50	1.52	2.1888	2.3104	0.531	-0.633	1.9628	7.56
5+	2	6.00	1.81	2.7572	--	--	--	2.0167	8.20
			A=5.68 B=7.22	C=8.5967	D=7.4642		E=-0.9353	(2.035)	(8.42)6+ (8.52)7+

Table 3 Mortality for the bitterling population

No. age class	No. individuals	l mean / group	$C\left(\frac{l_1+l_2}{2}\right)$	Age (years)
1.	2	36.85	73.7	1.75
2.	12	40.65	487.8	2.27
3.	14	44.45	622.3	2.48
4.	34	48.25	1640.5	2.72
5.	17	52.05	884.85	2.98
6.	14	55.85	781.9	3.27
7.	8	59.65	477.2	3.60
8.	4	63.45	253.8	3.97
9.	2	67.25	134.5	4.44
10.	2	71.05	142.1	4.99
	n=10		$\sum C \cdot \left(\frac{l_1+l_2}{2}\right) = 5498.65$	

Table 4 The productive potential for the bitterling population

Age	No. ind.	Individual weight (g)	Biomass / age group B_0 (g)	Z	G	Z – G (a) G - Z (b)	Biomass (g)	Production (g)	Turnover (%)
0+	(2)	(0.02)	0.04	2.0149	3.7135	1.6986 (b)	0.1052	0.3906	371.26
1+	15	0.82	12.3	1.6486	1.3522	0.2964 (a)	10.6446	14.3937	135.22
2+	78	3.17	247.26	- 1.7176	0.6496	2.3672 (b)	1009.79	655.96	64.96
3+	14	6.07	84.98	- 1.2528	0.2195	1.4723 b 22.83	193.89	42.56	21.95
4+	4	7.56	15.12	- 0.6931	0.0813	0.7744 (b)	22.83	1.86	8.1
5+	2	8.2	16.4	--	--	--	--	--	--
	109						1237.26	715.16	57.80

Table 5 Values of biometrical indices depending on size groups

No. class	Size groups		Biometric indices			
	Variance	Mean	Fulton coefficient	Profile index	Thickness index	Kiselev Index
1.	3.50-3.87	3.69	2.33	3.29	8.65	2,11
2.	3.88-4.25	4.07	2.41	3.53	9.48	1,63
3.	4.26-4.63	4.45	2.51	3.48	7.96	1,46
4.	4.64-5.01	4.83	1.38	2.98	7.11	1,64
5.	5.02-5.39	5.21	1.60	3.09	7.19	1,42
6.	5.40-5.77	5.59	1.84	3.62	6.79	1,23
7.	5.78-6.15	5.97	1.41	4.81	6.32	1,19
8.	6.16-6.13	6.35	1.33	4.19	6.41	1,45
9.	6.54-6.91	6.73	(0.63)	3.68	5.91	1,41
10.	6.92-7.29	7.11	1.54	4.79	6.89	1,21
Mean value for the population			1.698	3.405	7.832	1.340

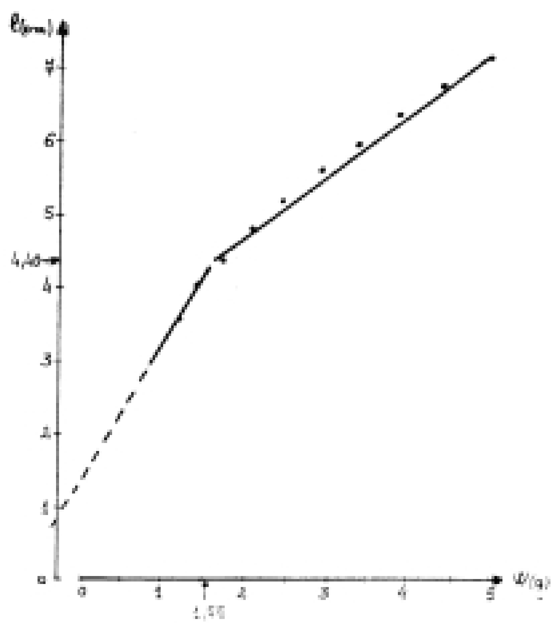

Fig. 1 Length-weight correlation curve for the bitterling population

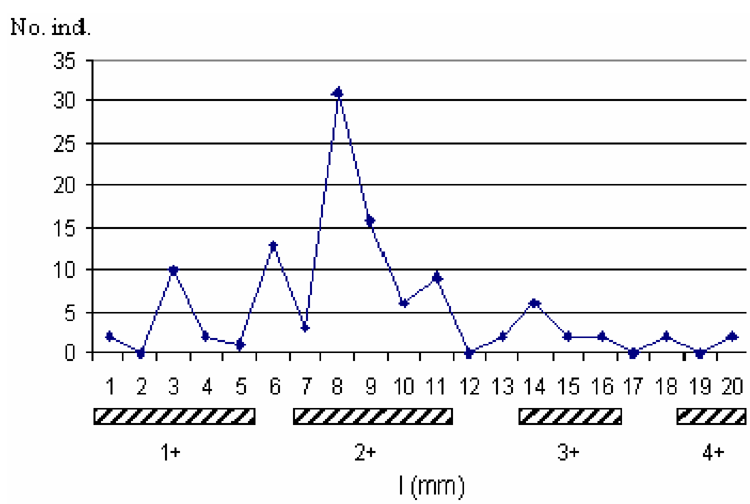

Fig. 2 Size dispersion and age groups for the bitterling population

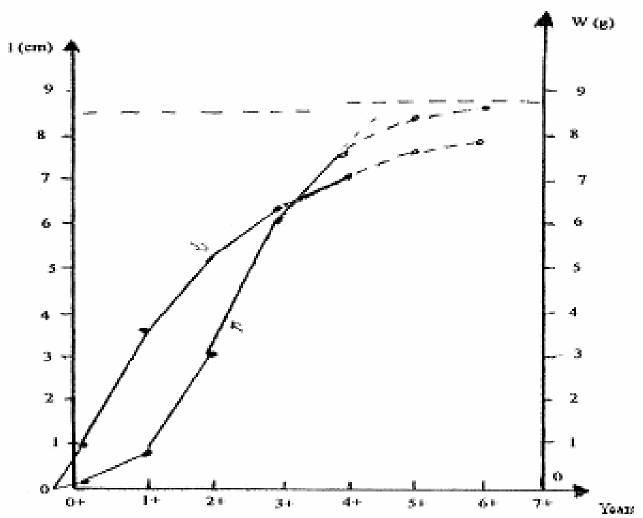

Fig. 3 Length and weight growth for the bitterling population

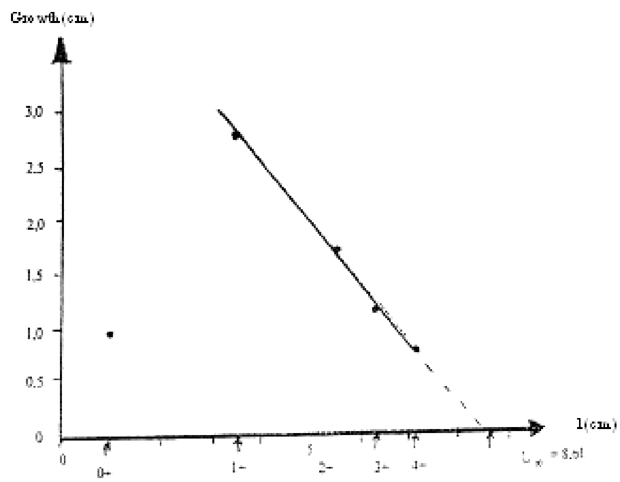

Fig. 4 The speed of length growth for the bitterling population

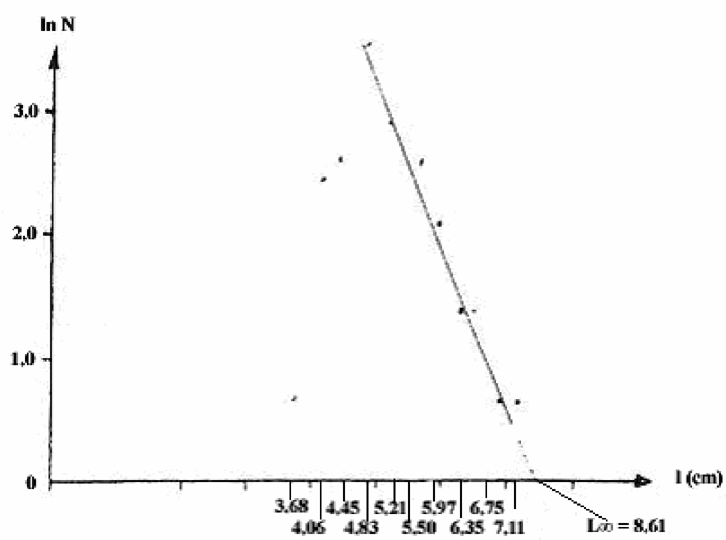

Fig. 5 The mortality graph for the bitterling population

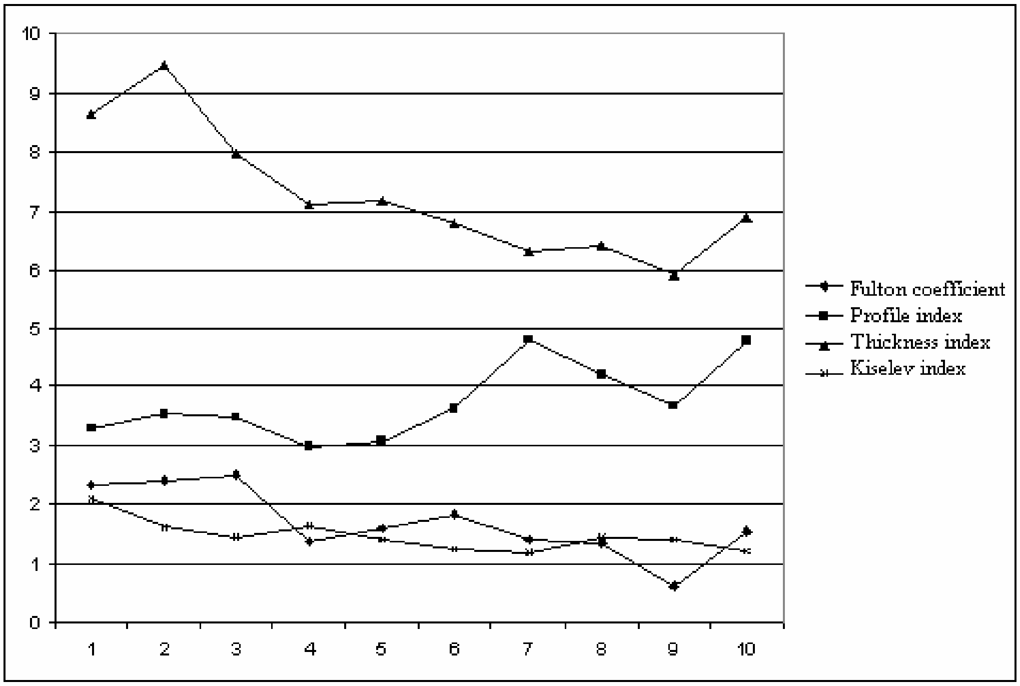

Fig. 6 Biometric indices for the bitterling population