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Stanisław *KRZYKAWSKI*

LENGTH GROWTH OF ARCTIC CHARR, *SALVELINUS ALPINUS* (L., 1758) IN THE HORNS UNDREGION

CHARAKTERYS TYKAWZROSTU DŁUGOŚ CIGOLCA *SALVELINUS ALPINUS* (L., 1758) Z REJONU HORNS UNDU

Faculty of Sea Fisheries and Food Technology,
Academy of Agriculture,
Szczecin, Poland

Results of studies on length and age composition and length growth rate of the Arctic charr in River Revelva and Lake Svartvatnet are presented. The growth rate was determined from scales, by back calculations utilizing the Rosa Lee formula. The data obtained served to characterize growth of the species in the area by means of the von Bertalanffy equation.

INTRODUCTION

The Arctic charr, *Salvelinus alpinus* (L.),widely distributed along the entire northern coast of the Arctic Sea and in water bodies of numerous Arctic islands is an important target species of local fisheries.

Nowhere in the existing literature on the species' length growth have the von Bertalanffy equation parameters been determined, the equation constituting a basis from which to estimate abundance and biomass of the species as well as its population dynamics.

The present work has been thus devoted to examining the Arctic charr population inhabiting River Revelva and Lake Svartvatnet with the purpose of describing its length and age composition and determining its length growth rate with the aid of the von Bertalanffy equation.

MATERIALS AND METHODS

Materials for the present work were collected within 1985–1986. In 1985, 23 individuals were caught from River Revelva, while the 38 specimens obtained in 1986 were caught from Lake Svartvatnet.

Scales collected from all 61 individuals served to estimate the fish age and growth rate. The scales were collected from above the lateral line behind the dorsal fin, as recommended by Jones (1959).

Age determinations and measurements of annuli (to 0.01 mm) were made in transmitted light of a Zeiss measuring microscope on scales placed between two glass slides. The measurements were made along the longer radius of a scale, in its oral part where the annual rings are better separated and more conspicuous. The fish total length and scale oral radius relationship on the material studied was calculated and presented by Krzykawski and Radziun (this volume). The relationship could be expressed as the following linear regression equation:

$$L = 1.8763 + 40.4118R;$$

the correlation coefficient is $r = 0.918$.

The above equation served as a basis for back calculations of growth rate, for which the Rosa Lee formula below was used:

$$l_n = \frac{r_n}{R}(L - c) + c$$

where: L = fish length at capture
R = total scale radius
l_n = fish length at age n
r_n = scale radius at age n
c = fish length when scales appear;

"c" was assumed as equal to 1.9 cm, as found from the relationship given above.

The data obtained from back readings on scales include mean values, standard deviations, and coefficients of variation.

The length values back read from scales served as empirical values to be substituted into the von Bertalanffy equation (Beverton and Holt, 1957), used commonly by ichthyologists to describe fish growth rate.

The von Bertalanffy mathematical model was also calculated using empirical data obtained by back readings from otoliths collected from an Arctic charr individual caught in Lake Svartvatnet (Krzykawski and Radziun, 1993).

RESULTS

Length and age

The length distribution and age composition are described based on data obtained from examining scales of 23 individuals caught in River Revelva in 1985. The results are presented in Fig. 1. The fish length ranged from 5.6 to 65 cm (42.7 cm mean length). Length classes of 42.1–43.0 cm and 44.1–45.0 cm were most abundant. The fish age ranged from 1 to 9 years, individuals at age 7 being most abundant. The mean age was 6.48 years.

Length and growth of the Lake Svartvatnet Arctic charr were analyzed on scales of 38 individuals caught in 1986. Fig. 2 shows the respective distributions. The indivi-

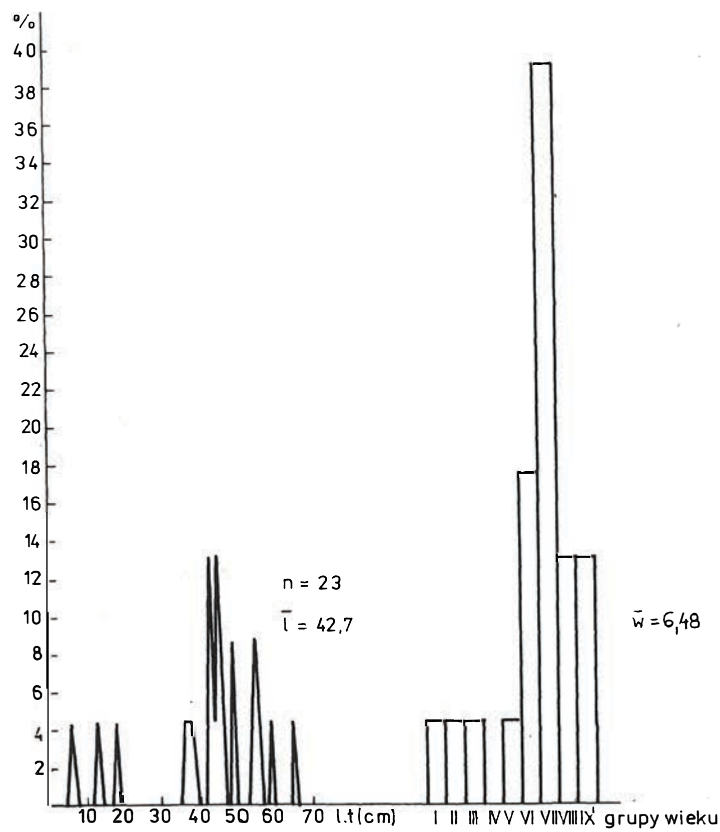

Fig. 1. Scale-based length and age distributions of the Arctic charr from River Revelva

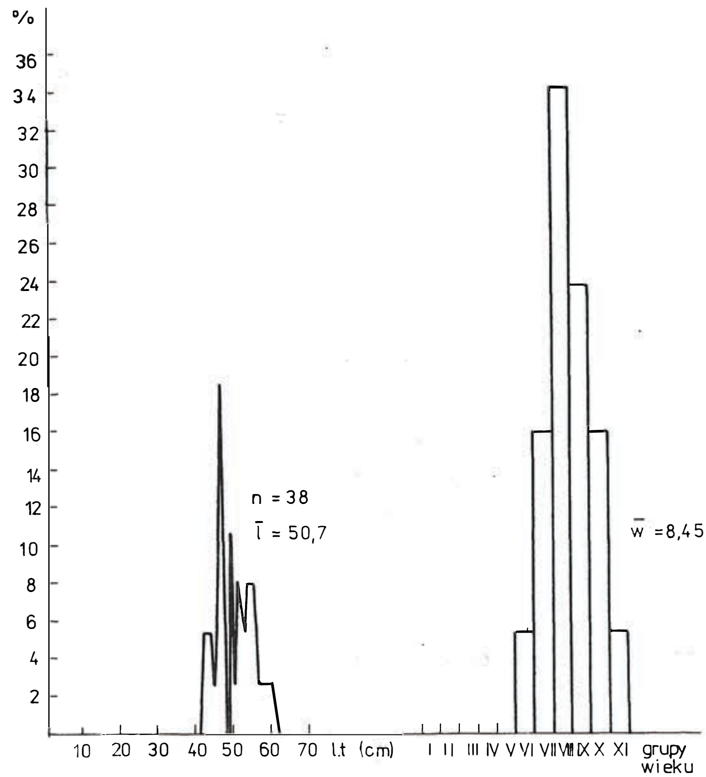

Fig. 2. Scale-based length and age distributions of the Arctic charr from Lake Svartvatnet

duals examined measured from 42.5 to 60.7 cm, the 46.1–47.0 cm ones being most abundant. The mean length was 50.7 cm. The fish age varied from 6 to 11 years, 8-years-old individuals being most abundant. The mean age was 8.45 years.

A comparison of the Revelva and Svartvatnet individuals shows the lake individuals to have a clearly higher (by 8 cm) mean length. Those individuals were also older than the river ones.

Length growth rate

Table 1 shows the Revelva fish growth rate as calculated by back readings from scales, while Fig. 3 presents the growth and annual increments curve plotted with the aid of the von Bertalanffy equation. The highest growth rate occurs in the first year of life. Further on, the growth rate decreases somewhat (except from year 8). Rather high coefficients of variation evidence a substantial variability in mean lengths of different age groups.

Table 1

Growth rate of the Arctic charr in River Revelva
as back read from scales

Age group	Length (cm) in years of life									No. of individuals
	l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	
I	4.0									1
II	6.8	10.8								1
III	9.8	13.4	16.1							1
V	8.9	13.7	18.5	26.4	32.5					1
VI	9.4	14.8	21.8	29.9	35.8	41.6				4
VII	8.3	13.8	19.7	25.9	31.6	36.4	41.5			9
VIII	9.6	14.7	22.0	28.1	35.2	41.9	48.2	53.7		3
IX	8.2	13.7	18.1	23.3	28.4	33.8	40.8	47.0	51.5	3
arithmetic mean	8.5	13.9	20.0	26.7	32.5	38.0	42.7	50.3	51.5	23
standard deviation	1.69	1.84	3.55	4.89	5.52	5.88	4.44	6.84	2.46	–
coefficient of variation	19.88	13.24	17.75	18.31	16.98	15.47	10.40	13.60	4.78	–

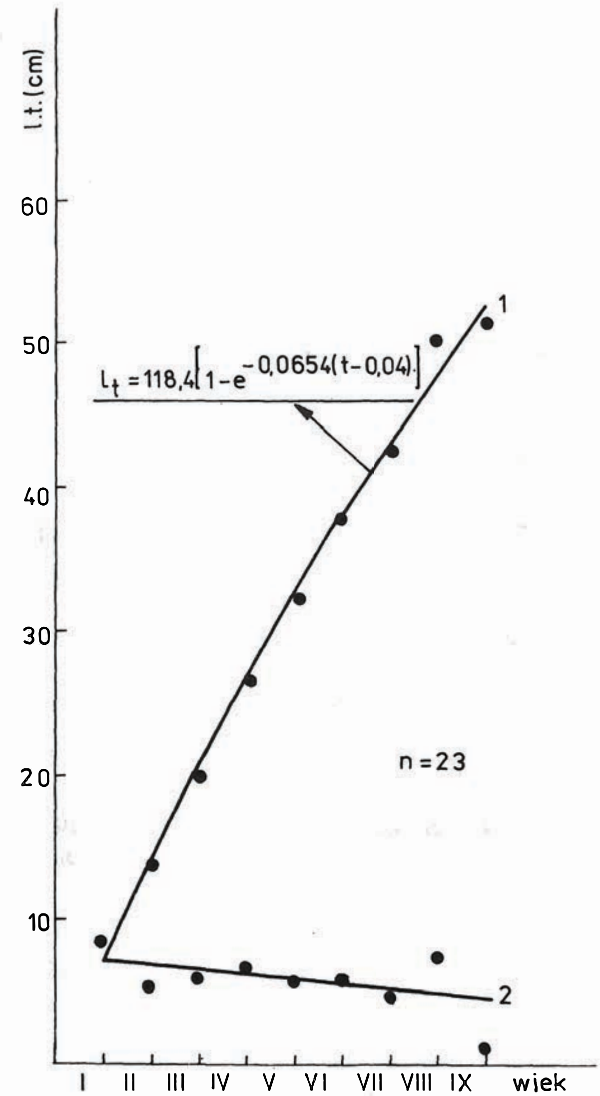

Fig. 3. Growth curve (1) and annual increment curve (2) of the Arctic charr from River Revelva, plotted from the von Bertalanffy equation. Points denote empirical values back read from scales

Table 2

Growth rate of the Arctic charr from Lake Svartvatnet
as back read from scales

Age group	Length (cm) in years of life											No. of individuals
	l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8	l_9	l_{10}	l_{11}	
VI	10.4	15.9	22.7	29.3	36.0	43.1						2
VII	9.2	15.6	20.5	25.8	32.4	37.9	45.1					6
VIII	9.2	15.1	20.1	25.4	30.8	36.0	41.4	46.1				13
IX	9.2	14.5	19.5	24.7	29.9	35.0	40.0	45.3	50.5			9
X	9.6	15.0	19.8	24.1	29.4	34.6	39.4	43.8	49.2	53.6		6
XI	7.5	11.7	16.3	19.3	22.6	27.3	31.3	35.9	40.9	46.9	51.3	2
arithmetic mean	9.2	15.0	19.9	25.0	30.5	35.7	40.8	44.7	48.9	51.9	51.3	38
standard deviation	1.56	1.94	2.45	3.02	3.66	4.00	4.43	3.74	4.09	4.94	11.03	–
coefficient of variation	16.96	12.93	12.31	12.08	12.00	11.20	10.86	8.37	8.36	9.52	21.50	–

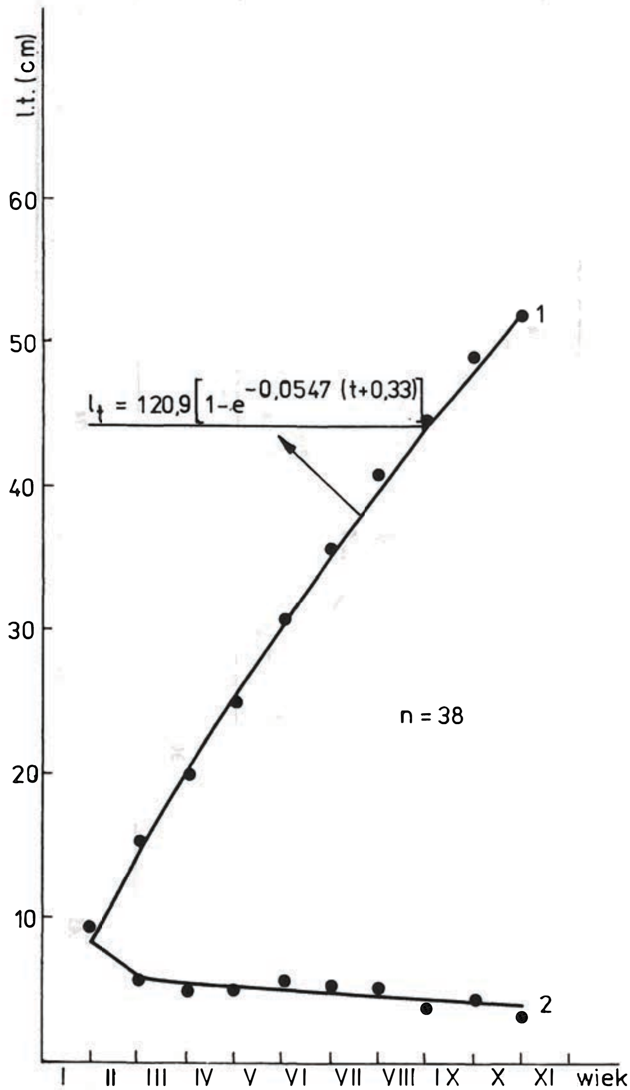

Fig. 4. Growth curve (1) and annual increment curve (2) of the Arctic charr from Lake Svartvatnet, plotted from the von Bertalanffy equation. Points denote empirical values back read from scales

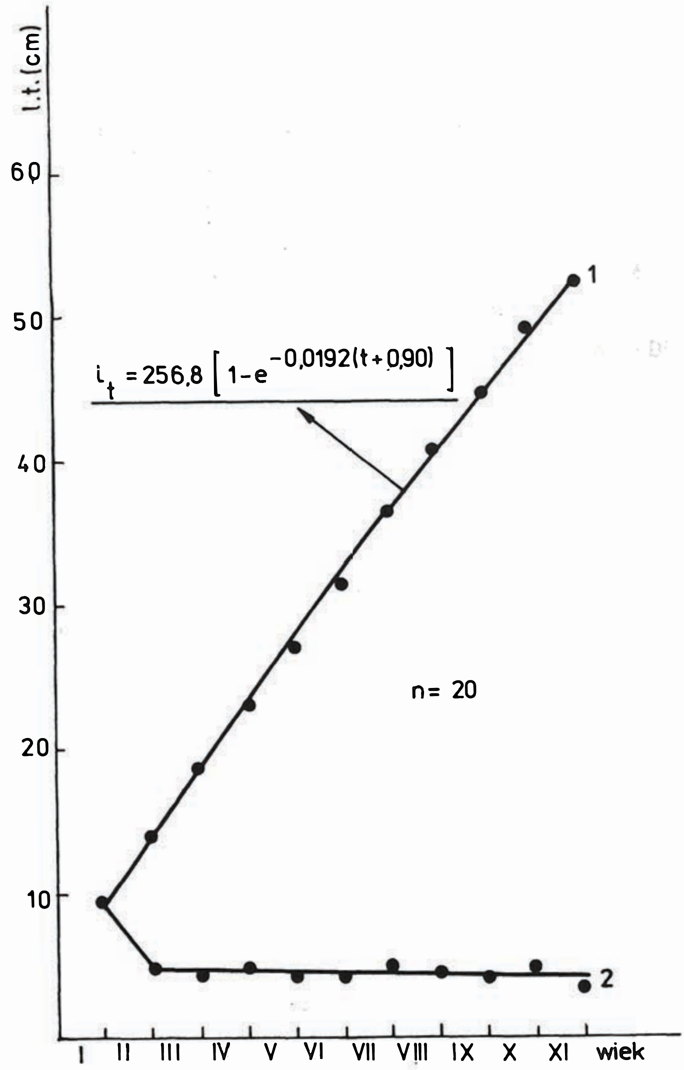

Fig. 5. Growth curve (1) and annual increment curve (2) of the Arctic charr from Lake Svartvatnet, plotted from the von Bertalanffy equation. Points denote empirical values back read from otoliths

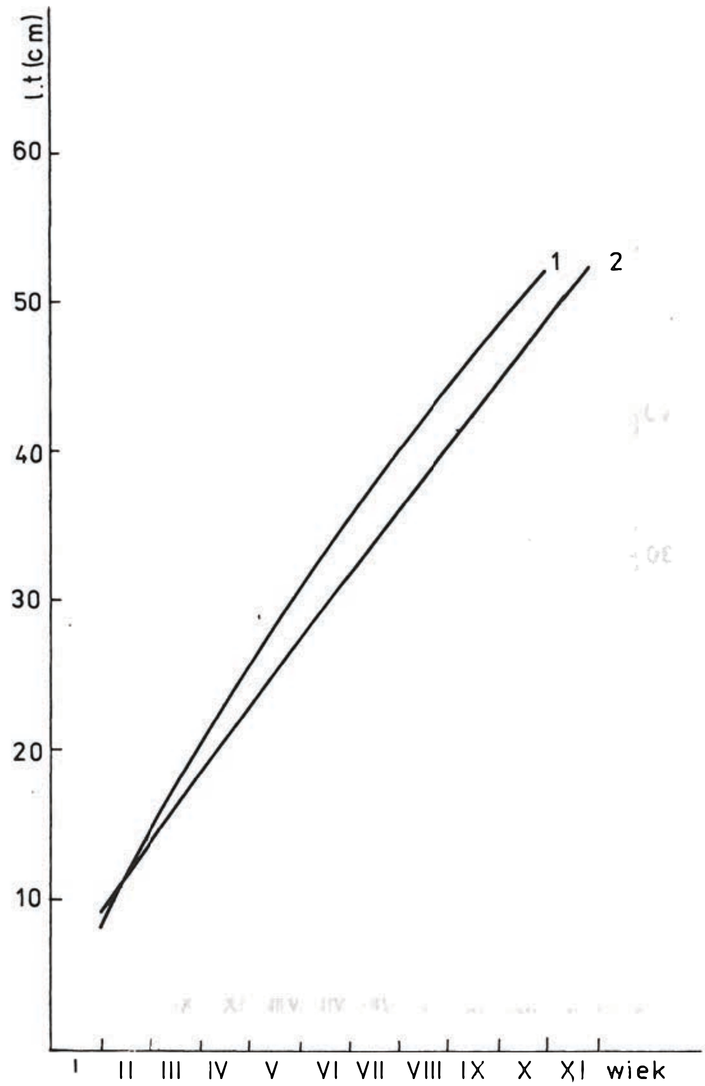

Fig. 6. Growth rates of the Revelva (1) and Svartvatnet (2) populations from the von Bertalanffy equation (empirical values back read from scales)

Data on the Svartvatnet fish growth rate, as back calculated from scales, are summarized in Table 2; a relevant curve plotted from the von Bertalanffy equation is presented in Fig. 4. In Lake Svartvatnet, too, the highest growth rate is found in the fish's first year of life, a very slow decrease being observed in subsequent years. Variation in mean lengths of fishes belonging to different age groups are relatively extensive in this case, as well.

Fig. 5 shows curves of growth rate and annual increments of the Lake Svartvatnet fish, plotted based on the von Bertalanffy equation. The empirical data used in the model were obtained from growth rate values back read from otoliths, published by Krzykawski and Radziun (1993).

Fig. 6 contains growth curves plotted from the von Bertalanffy equation for the Arctic charr of the two water bodies studied. Although the increment in the first year of life is in the River Revelva fish lower than that in the Lake Svartvatnet population, the former show a higher growth rate.

DISCUSSION

The analysis of back calculated growth rate data in Tables 1 and 2 shows the variation of mean lengths in different age groups to be relatively extensive. This observation conforms to that of Johnson (in Balon, 1980) who found a great scatter of Arctic charr body lengths between age groups.

A comparison between growth rates of the Svartvatnet and Revelva population (Fig. 6) shows the latter to have a higher growth rate. The difference in growth rate may indicate that the two populations examined belong, perhaps, to different forms. As reported by Rembiszewski (in Kowalska et al., 1973), the species studied occurs both in migratory and stationary forms, the latter inhabiting only lakes. The rather large differences found between length and age distributions could lend support to the above suggestion. However, the suggestion ought to be verified by studies, more detailed and based on much larger samples than it was possible in this work, on biology of both populations.

Interesting is the comparison of the von Bertalanffy growth rates for the Svartvatnet population presented in Fig. 7. The curve denoted by 1 was plotted from data obtained from back readings on scales, while empirical data serving to plot the curve denoted by 2 were obtained from otoliths.

The two growth curves, pertaining to the population living in the same area, differ rather markedly. The growth rate obtained from otoliths is lower than that calculated from scales. One should, however, bear in mind that scales (growth curve 1) were collected from a number of individuals that was larger (38) than that belonging

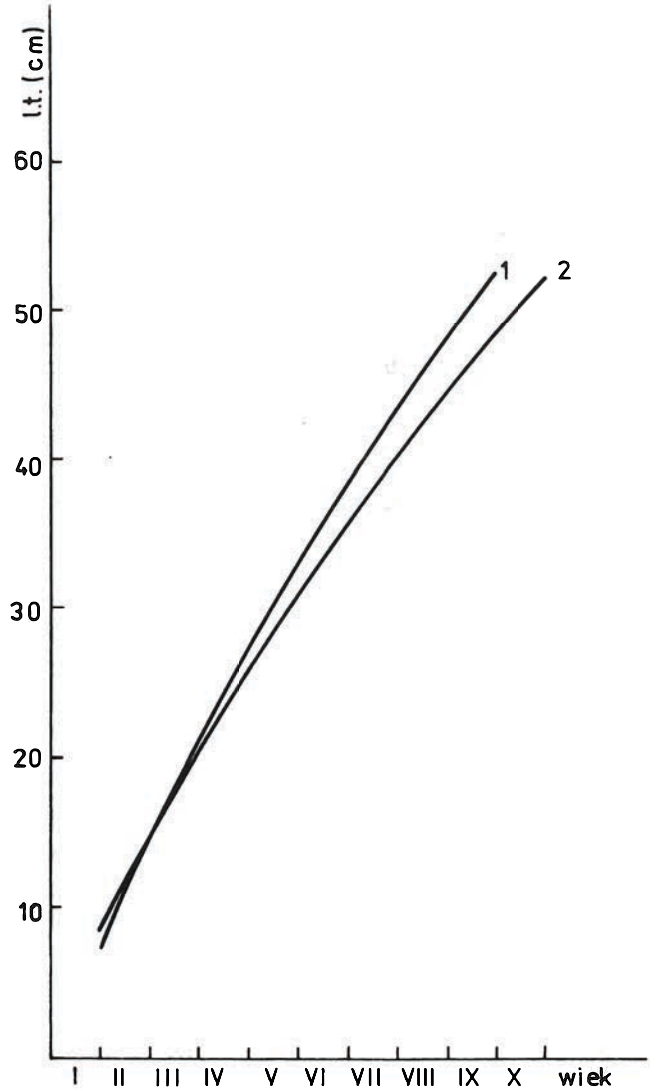

Fig. 7. The Svartvatnet population growth rate from the von Bertalanffy equation: 1, empirical values back read from scales; 2, empirical values back read from otoliths

to the group yielding otoliths (20), which could have affected the results. It seems, however, that the main cause of the large difference found between the two growth rates (Fig. 7) lies in the difference between results obtained when determining growth rate from scales and otoliths. The age read from scales is, as a rule, underestimated by two years on the average (hence the seemingly higher growth rate in scales-based calculations), as reported by Gullestad (1974), Dutil and Power (1977), as well as Krzykawski and Radziun 1993).

CONCLUSIONS

1. The Arctic charr population in River Revelva consisted of individuals of length ranging within 5.6 – 65 cm and age range of 1–9 years. The mean body length and age were 42.7 cm and 6.48 years, respectively. The fish of the age group 7 were most abundant.

2. Lake Svartvatnet was inhabited by an Arctic charr population with individuals of length and age ranging within 42.5 – 60.7 cm and 6 to 11 years, respectively. The mean length and age were 50.7 cm and 8.45 years, respectively. The fish aged 8 years were most abundant.

3. Growth rates of the two populations proceeded along similar courses, hence a similar shape of the growth curves. The highest growth rate occurred in the first year of life, the rate decreasing slowly later on.

4. The River Revelva population showed a higher growth rate than the Lake Svartvatnet one.

5. The von Bertalanffy equation describes the species' growth rate pretty accurately.

The growth equations for the two populations are as follows:

the Revelva:

$$l_t = 118.4 \left[1 - e^{-0.0654\,(t - 0.04)} \right]$$

the Svartvatnet

$$l_t = 120.9 \left[1 - e^{-0.0547\,(t + 0.33)} \right]$$

6. The scales-based growth rate is an overestimate due to underestimated age data read from scales.

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Stanisław *KRZYKAWSKI*

CHARAKTERYSTYKA WZROSTU DŁUGOŚCI GOLCA *SALVELINUS ALPINUS* (L., 1758) Z REJONU HORNSUNDU

STRESZCZENIE

Celem pracy było zbadanie składu długościowego i wiekowego oraz określenie tempa wzrostu długości przy zastosowaniu modelu v. Bertalanffy'ego. Badania przeprowadzono na rybach pochodzących z rzeki Revelva oraz jeziora Svartvatnet. Tempo wzrostu długości określone zostało na podstawie łusek pobranych z 61 ryb (23 osobniki — z rzeki Revelva, 38 — z jeziora Svartvatnet).

Porównując populacje pod względem długości i wieku, stwierdzono, że średnia długość golców z jeziora Svartvatnet była wyraźnie większa. Również pod względem długowieczności ryby z jeziora znacznie przeważały nad tymi, które pozyskano w rzece Revelva (rys. 1 i 2).

Tempo wzrostu długości golca w dwóch badanych akwenach charakteryzuje się podobnym przebiegiem w ciągu jego życia (rys. 3, 4, 5), w wyniku czego krzywe wzrostowe przyjmują podobny kształt. Najszybszy wzrost ma miejsce w pierwszym roku życia, w dalszych latach zaznacza się powolny spadek szybkości wzrostu.

Szybszym tempem wzrostu długości charakteryzuje się golec z rzeki Revelva, a wolniejszym — z jeziora Svartvatnet (tab. 1 i 2 oraz rys. 6). Równania wzrostu długości dla tych akwenów przedstawiają się następująco:

Rzeka Revelva: $$l_t = 118{,}4\,[1 - e^{-0{,}0654\,(t - 0{,}04)}]$$

Jezioro Svartvatnet: $$l_t = 120{,}9\,[1 - e^{-0{,}0547\,(t + 0{,}33)}]$$

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Author's address:

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Prof. dr hab. Stanisław Krzykawski
Zakład Systematyki Ryb
Akademia Rolnicza
ul. K. Królewicza 4
71–550 Szczecin
Polska (Poland)