Tiscia (Szeged) Vol. XVIII, pp. 103—112 (1983)

GROWTH OF PIKE (ESOX LUCIUS L.) IN THE SECTION OF THE TISZA RIVER AT TISZAFÜRED

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(Received January 25, 1981)

Abstract

On the basis of measurements on 204 fish specimens the following relationship was established between the standard body length and body weight of pike:

$$\lg W = -4.811 + 2.930 \lg L_c,$$

where W = body weight in g, L_c = body length in mm.

The following relation was found between standard body length and total body length:

$$L_t = 5.651 + 1.110\, L_c$$

The determination of the age of pike as well as its body length in the single years was performed on the basis of the growth-rings of scales. Growth can be well described by Bertalanffy's equation:

$$l_t = 1008.6[1 - e^{-01695(t+075)}]_x,$$

where l_t = standard body length of pike at the age of "t", e = the base of natural logarithm.

Introduction

Pike has been a very important fish species especially in the tributaries and stagnant waters of the Tisza, and with the establishing of reservoirs it has become increasingly frequent also in the main branch of the river. Therefore it may be important from economical aspect to obtain knowledge about its growth which has not been studied to date Hungarian waters.

This paper reports on growth studies performed on behalf of the Fisheries Research Institute, Szarvas in the section of the Tisza in the water storage area of Kisköre, and presents at the same time the first information in connection with the growth of pike in Hungary.

Materials and Methods

In the examinations, data of 204 fish specimens collected from 1. 3. 1977 to 3. 10. 1980 in the stretch of Tisza at Tiszafüred were used. Standard body lengths of animals (L_c) — distance from nose tip to the base of the caudal fin — varied between 290 mm and 870 mm, and their body weights (W) between 300 g and 7700 g.

The relation between body length and body weight was calculated on the basis of the formula recommended by TESCH (1968):

$$W = a L^b$$

resp. its logarithmic form:

$$\lg W = \lg a + b \lg L,$$

where W = body weight of fish, L = body length, and a and b are constants. The function was fitted to the data by means of the least square method according to SVÁB (1973).

Values of the condition factor (CF) were calculated according to HILE (1936) on the basis of the following relationship:

$$CF = \frac{W}{L^3}$$

where W = body weight in g, L = body length in mm.

Age determinations were performed on the basis of the annuli of scales. Of the scales taken from each fish, 6 were put into slide frames and projected on a blind plexiglas plate by means of a slide projector and on the ten times magnified picture the whole oral radiuses of scales (s) as well as the distance of each winter annulus from the focus of the scale (s_n) were measured with a scale of mm graduation.

The regression analysis performed with the data of whole scale radiuses and body lengths revealed the following relationship (Fig. 1):

$$L_c = 64.70 + 78.558s$$

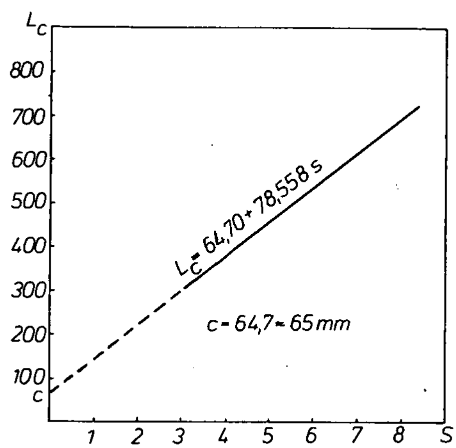

Fig. 1. Relation between standard length (L_c) and the whole radiuses of scales (s) (both in mm) The correction member (c) is given by the point of intersection of the line on the ordinata.

The line does not pass through the origo, i.e. there is no linear proportionality between body length and scale radius, on the other hand, the correction term: c = 65 mm necessary for the back-computation of body length can be obtained from this equation.

Body length of fish at the development of each annulus was back-computed by the method recommended also by TESCH (1968), according to FRASER (1916) and LEE (1920) on the basis of the following relationship

$$l_n = c + \frac{s_n}{s} (L - c),$$

where l_n = body length at the development of the annulus "n", c = the above mentioned correction member and s_n = the distance of annulus "n" from the focus, s = the total scale radius, L = body length at the time of sampling.

For the description of the growth of the pike population, WALFORD's method (1946) and BERTALANFFY's (1957) mathematical growth model recommended also by DICKIE (1968) were used.

Walford claims that the following relationship exists between body length (l_t) and the body length of the preceding year (l_{t-1}):

$$l_t = a + bl_{t-1}$$

According to Bertalanffy, body length (l_t) can be expressed at any t point of time (year) with the following equation:

$$l_t = L_\infty[1 - e^{-K(t-t_0)}],$$

where L_∞ = the maximal (asymptotic) body length; K = growth rate at which body length approximates L_∞, t_0 = the hypothetical time point at which body length is equal to zero; e = the base of natural logarithm.

The distribution according to age group of the 204 fish used in the examinations was the following: (1+): 3 fish, (2+): 89 fish, (3+): 82 fish, (4+): 21 fish, (5+): 6 fish, (7+): 1 fish, (8+): 1 fish, (9+): 1 fish. Though the markings were the usual ones, according to which e.g. (1+) = two-summer-old, (2+) = three-summer-old, etc., there were also such specimens which were caught at the end of first year of their life (catchings in March), when namely the development of the winter growth-ring had just ended. Such specimens were ranged into the next summer age group, e.g. the two-year-old ones figure in the age group of (2+), namely in the group of the three-summer-old fish.

Results

The relationship between body length and body weight of pike can be described by the following allometric equation:

$$\lg W = -4.811 + 2.930 \lg L_c,$$

where W is given in g, and L_c in mm (Fig. 2).

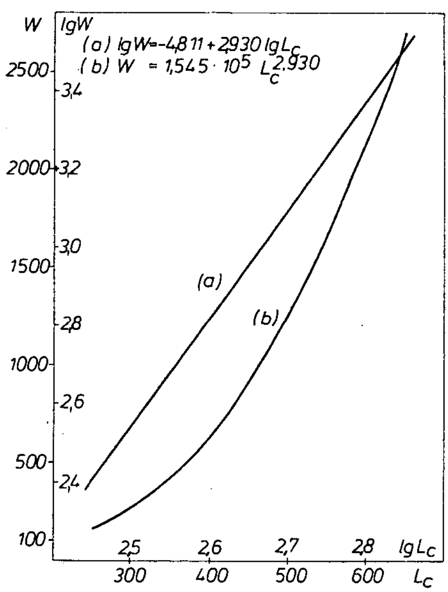

Fig. 2. Allometric relation between body length and body weight. L_c = standard body length in mm, W = body weight in g.

Table 1. *Body lengths of pike obtained by back-computation on the basis of scales (Standard length in mm, body weight in g)*

		(1+)	(2+)	(3+)	(4+)	(5+)	(7+)	(8+)	(9+)	L_c	W
	a	291	197	164	171	224					
l_1	b	329	313	333	311	283					
	c	314	251.2	245.9	237.9	259.5	281	224	247	249.5	163
	a		267	235	238	336					
l_2	b		445	476	451	435					
	c		359.6	356.4	340.7	397.3	418	330	370	367.4	507
	a			301	316	423					
l_3	b			582	543	561					
	c			434.6	425.8	508.7	556	429	493	474.5	1073
	a				372	503					
l_4					642	653					
	c				488.2	593.3	634	514	597	565.3	1791
	a					583					
l_5	b					704					
	c					648.7	713	549	662	643.2	2615
l_6							782	598	707	695.7	3291
l_7							831	641	753	741.7	3970
l_8								676	798	737.0	3897
l_9									833	833	5578

a: minimum, b: maximum, c: average within an age group, L_c: averages of the age groups, W: body weight.

Considering the fact that in many cases the whole length is given instead of the standard length, it is advisable to know the relation between the two:

$$L_t = 5.651 + 1.110 L_c$$

Table 1 presents the values of the body lengths of the studied age groups in the different years, as calculated on the basis of the growth-rings of scales.

In the computation of the combined averages of age groups the data of the age group (1+) were not considered, since owing to the mesh size of the fish-baskets used for collecting, only specimens of fast growth were caught, and these did not represent the actual conditions of measurement of the particular age group.

In the column "Body weight" of Table 1, values of body weights corresponding to average body length and calculated on the basis of the allometric equation described in the foregoing are given.

Using the average values of the body lengths of the single age groups, WALFORD's growth line was constructed together with the $x = l_{t-1}$ data pertaining to $y = l_t$ (Fig. 3).

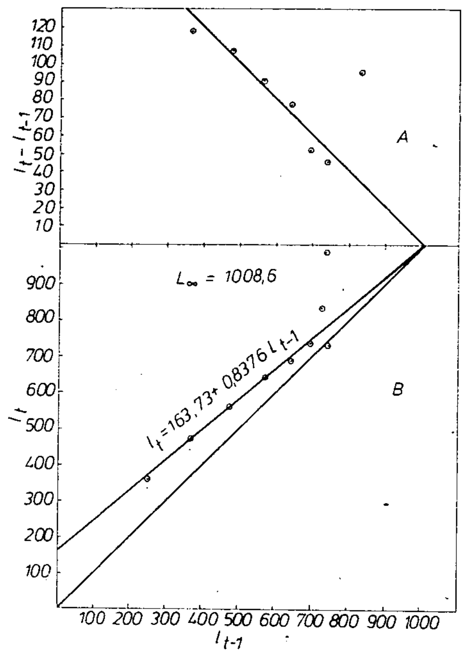

Fig. 3. Alternative illustration (WALFORD-plot) of the differences between the body lengths of consecutive years (A), and the values of body lengths in successive years (B). (l_t : body length at the age of "t", l_{t-1} : body length one year earlier, in mm). Asymptotic body length: 1008.6 mm is given by the abscissa value of the point of intersection of the line fitted to the points and the diagonal drawn at an angle of 45 degrees from the origo.

The line fitted to the points by means of the linear regression analisis can be described by the following equation:

$$l_t = 163.733 + 0{,}8376\ l_{t-1}$$

from which the asymptotic body length is

$$L\infty = \frac{a}{1-b} = 1008{,}6 \text{ mm}.$$

If the values for $\ln (L\infty - l_t)$ are represented in the function of time, we obtain a line (Fig. 4) which can be described with the following equation:

$$\ln (L\infty - l_t) = 6.7898 - 0.1695t.$$

From this we can determine the other parameters of BERTALANFFY's equation:

$$t_0 = \frac{\ln L\infty - a}{b} = -0.746 \approx -0.75 \text{ year},$$

$$K = \frac{\ln L\infty - \ln (L\infty - l)}{t - t_0} = 0.1695$$

Thus the equation describing the growth of the pike population of the river section is

$$l_t = 1008.6\,[1 - e^{-0.1695\,(t + 0.75)}]$$

Fig. 5 shows the average body lengths obtained by back-computation on the basis of this equation for the single years.

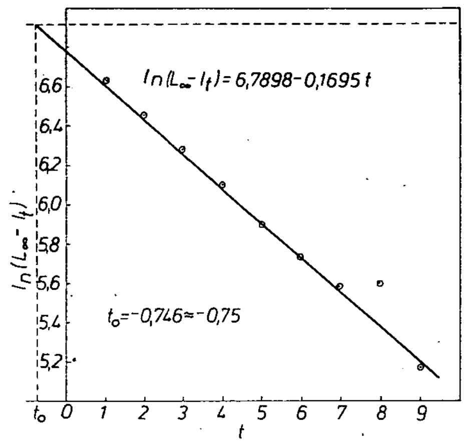

Fig. 4. Illustration of the natural logarithm of the lack of unsaturation (the difference of asymptotic body length and body lengths in the single years in mm) in the function of time. The constant of BERTALANFFY's equation is given by the rise of the line.

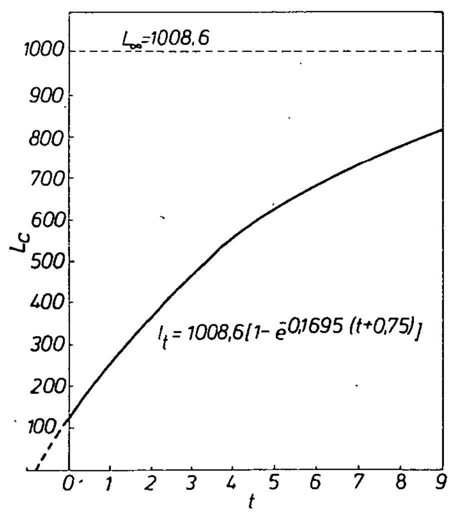

Fig. 5. Growth of pike according to the growth model proposed by BERTALANFFY (L_c = standard length in mm, t = time in years).

Discussion

It became evident as soon as the data of the caught fish were recorded, that there were considerable differences in weight between specimens of identical length. In addition to the amount of food found in the stomach, another factor was also instrumental in that, namely, owing to the fact that collecting was performed continuously, specimens worn by spawning and autumn ones in best physical condition were equally represented in the examination material. This mode of sample taking can be more useful if we want to obtain a picture on the average condition of the population.

The value of the b constant of the equation, i.e. that of the so-called allometric exponent expressing the relation between length and weight was less than 3 (2.930), showing that the growth rate of body weight of pike fell behind the growth rate of body length, and suggests that with the increasing of body length the condition of fish worsened somewhat, as it is seen in Table 2. Just the reverse of that could be observed in the case of the pike-perch population of this stretch of the Tisza, despite the fact that sample taking was here too continuous (HARKA 1977). Since there are no data at our disposal in connection with other places, it cannot be decided whether this low value of the exponent ($b<3$) is characteristic of the species, or the local population only.

Only in a small proportion of the scales examined where the annuli as discernible as in Fig. 6. Thus the possibility of error cannot be excluded in the establishing of the age of older specimens, resp. in the determination of the radiuses of the growth-rings. Because of this, the results obtained are rather of exploratory nature, and ignoring the finer changes of growth rate, only the growth process itself will be discussed.

Int he Tisza, the growth of pike is rather unequal, as it is apparent from the data contained in Table 1. In addition to natural unequal growth, another factor also contributes to the variation of body lengh of specimens of identical age, namely that with the more drastic changes of the water level the fish leave their natural environment and thus the population of the river bed and that of the storage area providing more advantageous conditions for fish are exchanged in some measure. However, for the high bank of the river bed, there is no possibility for a continuous exchange at the present level of impounding and therefore the growth data still pertain fistly to the impounded section of the river and the affluents in constant connection with it.

For the description resp. modelling of growth, the methods recommended by WALFORD and BERTALANFFY were used. Table 3 contains data on body lengths for

Table 2. *Changes in body length, weight and condition of pike*

Age year	Standard length mm	Total length mm	Body weight g	Condition 10^5 CF
1	259	293	182	1.0475
2	376	423	542	1.0196
3	475	533	1076	1.0039
4	558	625	1724	0.9923
5	628	703	2438	0.9844
6	687	768	3172	0.9783
7	734	820	3850	0.9736
8	780	871	4601	0.9695
9	815	910	5232	0.9665

Table 3. *Comparison of standard lengths calculated by Walford's method, Bertalanffy's equation and on the basis of scales*

Age year	Body length (mm) calculated on the basis of		
	scales	WALFORD'S method	BERTALANFFY'S equation
1	249.5	300.9	258.8
2	367.4	415.7	375.7
3	474.5	512.0	474.5
4	563.3	592.6	557.7
5	643.2	660.0	628.0
6	695.7	716.6	687.3
7	741.7	764.0	737.4
8	737.0	803.6	779.7
9	833.0	836.8	815.4

Table 4. *Growth of pike in some other areas in Europe (in cm)*

Age	After 1964 Bodensee	Hegemann Tuusala lake Finland	Ristić 1963 Yugoslavia	Present study	Domacsev S.U. Ilmen lake	Berg 1948 S.U. Dniester	Balon 1967 Slovakia	Gyurkó 1972 Romania	Present study
0+	12	9	—	—	—	—	—	—	—
1	—	—	—	29.3	24.5	—	23	23	25.9
1+	28	18	36	—	—	23.0	—	—	—
2	—	—	—	42.3	36.6	—	34	28	37.6
2+	42	27	46	—	—	31.0	—	—	—
3	—	—	—	53.3	48.8	—	42	34	47.5
3+	56	32	60	—	—	41.6	—	—	—
4	—	—	—	62.5	61.0	—	47	41	55.8
4+	68	38	70	—	—	—	—	—	—
5	—	—	—	70.3	—	—	59	45	62.8
5+	77	50	78	—	—	—	—	—	—
6	—	—	—	76.8	—	—	68	49	68.7
6+	89	56	83	—	—	—	—	—	—
7	—	—	—	82.0	—	—	76	55	73.4
7+	98	65	—	—	—	—	—	—	—
8	—	—	—	81.7	—	—	—	61	78.0
8+	107	69	89	—	—	—	—	—	—
9	—	—	—	91.0	—	—	85	—	81.5
9+	114	73	—	—	—	—	—	—	—
	Total length					Standard length			

The values relating to Yugoslavia are averages computed from the data pertaining to the back-water of Biserno ostrovo at Csurog, which was studied by RISTI .

DOMACSEV'S data were taken over from BERG (1948).

the single years of life as estimated on the basis of the two relationships. Comparison of these with the measurements computed on the basis of scales shows, that the values computed according to BERTALANFFY render a much better approach possible. We can accept BERTALANFFY'S equation for the description of the growth rate of the pike population not only because it is more modern, but also because it permits a more exact approach.

Since there are no other data available concerning the growth of pike in Hungary, we can perform comparison only with other areas of Europe (Table 4).

Comparison is, however, very difficult, since the age of fish is given by some authors in summers, by others in whole years, and body length is given also either in whole length (L_c) or in standard length (L_c). For the sake of a better survey, the ages expressed in summers and years are shown in increasing order in a table, and both the whole and the standard lengths of the Tisza population are also presented there.

The growth of pike in the stretch of the Tisza at Tiszafüred bears greatest resemblance to Slovakian and Yugoslavian data, and is faster than than those of the pike populations of the Dniester and Rumania.

Because the data reported here primarily pertain to a river — even though it is an impounded section of the river — there is reson for believing that the growth rate of pike is favourable in the whcle storage area.

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A csuka (Esox Lucius L.) növekedése a Tisza folyó Tiszafüredi szakaszán

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Kivonat

A vizsgált 204 halpéldány alapján a csuka standard testhossza és testtömege közötti összefüggés a következő:

$$\lg W = -4{,}811 + 2{,}930 \lg L_c,$$

ahol W a testtömeg g-ban, L_c a testhossz mm-ben.

A standard testhossz a teljes testhosszal az alábbi viszonyban áll:

$$L_t = 5,651 + 1,110 L_c.$$

A csuka korának és az egyes életévekben elért testhosszának a meghatározása pikkely-évgyűrűk alapján történt. A növekedés jól leírható a Bertalanffy-egyenlettel:

$$l_t = 1008,6\ [1 - e^{-0.1695\ (t+0.75)}],$$

amelyben l_t a csuka standard hossza t éves korban, e a természetes logaritmus alapszáma.

Rast štuke (Esox lucius L.) na deonici reke Tise Tiszafüred

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Abstrakt

Odnos izmedju standardne dužine i težine tela štuke na osnovu 204 analiziranih primeraka iznosi:

$$\lg W = -4,811 + 2,930 \lg L_c,$$

gde je W težina u g, L_c dužina tela u mm.

Standardna dužina sa opštom dužinom tela stoji u sledećem odnosu:

$$L_t = 5,651 + 1,110 L_c.$$

Utvrdjivanje starosti i u pojedinim godinama dostignutog rasta stuke vršeno je na osnovu godova-prstenova na krljuštima. Prirast je izražen jednačinom po Bertalanffy-u:

$$l_t = 1008,6\ 1 - e^{-0.1695\ (t+0.75)}],$$

gde je l_t standardna dužina štuke u t uzrastu, dok je e osnovni broj prirodnog logaritma.

ПРИРОСТ ЩУКИ (ESOX LUCIUS L.) НА ТИСАФЮРЕДСКОМ УЧАСТКЕ РЕКИ ТИСЫ

А. Харка

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Резюме

На основании проведенных исследований на 204 экземплярах рыб, взаимосвязь между стандартной длиной щуки и массой её тела следующая:

$$\lg W = -4,811 + 2,930 \lg L_c,$$

где W масса тела в граммах, L_c — длина тела в миллиметрах.

Стандартная длина тела с максимальной длиной тела находитса в нижеследующем отношении:

$$L_t = 5,651 + 1,110\ L_c$$

Век щуки ежегодный прирост длины тела определяется на основании годичных колец чешуи. Прирост хорошо может быть выражен уравнением Бертолонффи:

$$l_t = 1008,6\,[1 - {}_e - 0,1695\ (t + 0,75)]$$

где l_t стандартная длина шуки t — в годичном возрасте, е естественное основное число логарифма.