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AGE AND GROWTH RATE OF PIKEPERCH IN THE POMERANIAN BAY IN 1998

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ABSTRACT

A total of 150 pikeperch individuals caught in 1998 in the Pomeranian Bay were examined. The fish were picked out from 4 samples: 3 were obtained in March and 1 in April 1998. The standard methods of length and weight growth rate determination were used. When determining fish age, the verge coefficient was factored in (if Kr > 0.50, 1 was added to the scale annual ring count).
The age and length distributions as well as the growth rate of the individuals examined were very similar to those obtained for the Pomeranian Bay pikeperch in 1995. The fish condition, too, proved identical in both cases. On the other hand, the differences with respect to the pikeperch growth in other areas involved a faster growth of the Pomeranian Bay pikeperch in the first year, or in the first two years of life, the older fish growing faster in other areas.
Key words: pikeperch, growth rate, mathematical growth models, condition coefficient

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INTRODUCTION

Studies on age and growth of pikeperch (*Stizostedion lucioperca* L., 1758), carried out in the Pomeranian Bay in 1998, were aimed mainly at verification of earlier data obtained, with identical methodology, in 1995. The only methodological novelty introduced in 1998 involved using the verge coefficient alongside the scale annual ring count when determining fish age.

An additional aspect of the study concerned a possibility of relating differences in the pikeperch growth rate, if any, to environmental changes associated with the Pomeranian Bay water pollution caused by the River Oder discharge. The study forms a part of the project entitled "The fish growth rate in the unstable environment of the Oder estuary system", carried out by the Department of Fish Biology, Agricultural University of Szczecin.

MATERIALS AND METHODS

The fish studied were caught in the Pomeranian Bay within March-April 1998; the catches were effected with a bottom trawl operated from SNB AR-1, a research vessel owned by the Agricultural University in Szczecin. Three samples (36, 57, and 16 individuals) were obtained in March, the fourth sample (41 individuals) being obtained in April.

A total of 150 individuals measuring 21.4-65.5 cm l.c. (24.3-72.0 cm l.t.) and weighing 105-4695 g (total weight) were examined. Additionally, the verge coefficient, Kr, was calculated using the generally known formula:

$$Kr = \frac{R - r_n}{r_n - r_{n-1}}$$

where:
R – total scale radius;
r_n – scale radius as measured from the centre to the last annual ring;
r_{n-1} – scale radius as measured from the centre to the penultimate annual ring.

The length growth was determined with a number of methods, the back calculations being the principal one. To arrive at an optimal version of the method with respect to the materials on hand, the length (L = l.c.) - total scale radius (R) relationship was determined. The so-called standard length (the length at which scales appear) was considered; according to Heese (1992), the standard length is 2.5 cm. Eventually, the length-scale radius relationship could be presented as the following equation:

$$L = 2.5000 + 11.8413\ R^{0.8141}$$

Due to the non-linearity of the equation, the Vovk's version was used to back-calculate the pikeperch length. Corrected values of the scale radius measured were inserted into the above equation in place of R and the corresponding L values were calculated.

Another method of the length growth rate determination involved calculation of mean lengths in individual age groups. When classifying the individuals examined into appropriate age groups, the scale annual ring counts and the verge coefficient (Kr) were used. The procedure used is described in detail in the RESULTS chapter. The back-calculated data were used to compute parameters of two mathematical length growth models: the von Bertalanffy equation and the modified power function.

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The fish condition was determined by calculating the Fulton coefficient (K). The length-weight relationship of the pikeperch studied was determined using the power function.

The weight growth rate was determined with three methods. The basic one involved converting lengths, back-calculated for each year of life, to weights using the L-W relationship. The remaining two methods involved determining mean weights in age groups and the modified von Bertalanffy equation. In the last case, the equation parameters were determined with a simplified technique. The value of W∞ was determined from the L-W relationship in the following way:

$$W\infty = kL\infty^{n} = 5126 \text{ g}$$

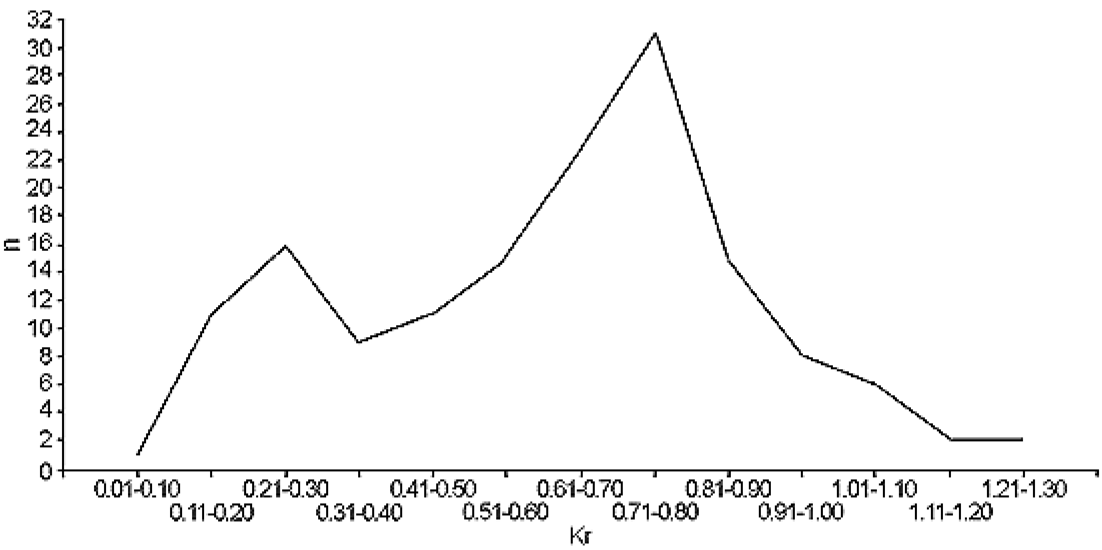
where:

L∞ – corresponds to the asymptotic length as determined when studying the length growth. The remaining parameters of the modified von Bertalanffy equation (K and t_0) are identical to those used in the length growth equation, n being the exponent in the L-W relationship.

RESULTS

The verge coefficient distribution is shown in Fig. 1. Two clear peaks in Kr values are evident: a lower one (n = 16) at 0.21 - 0.30 and a higher one (n = 30) at 0.71 - 0.80. As the theoretical range of Kr should cover 0 - 1 (in practice, there are cases when Kr > 1; there were 10 such cases, i.e., 6.7% only, in the materials studied), the value of 0.50 was used as critical for differentiating between "low" and "high" Kr , the value falling approximately at the trough between the two Kr peaks. This division of Kr values was used when classifying the individuals examined into appropriate age groups. Those individuals with "low" Kr were classified to age groups exclusively on the basis of the scale annual ring count, while those with "high" values were grouped with age classes by 1 year older than accounted for by the annual ring count. This procedure of fish classification into to age group was used when determining the age distribution (Table 1) and when determining length and weight growth rates by calculating means in age groups. On the other hand, age group classification shown when presenting back readings (Table 2) was based exclusively on the annual ring count, hence differences in age distributions shown in Tables 1 and 2.

Fig. 1. Distribution of verge coefficient (Kr) values in examined fish



Distribution of the Kr values suggests that the pikeperch studied were just forming a new scale annual ring. Most (102, that is 68%) individuals showed "high" Kr values, which can be regarded as an evidence that a new annual ring for 1998 had not been formed yet. The remaining individuals (48, i.e., 32%) showed "low" Kr values, thus evidencing the presence of a newly formed 1998 annual ring. Mean Kr values for "low" and "high" groups were 0.29 and 0.77, respectively.

Table 1 presents length and age distributions of the pikeperch examined. Most numerous (48.7%) were the 4-yr-old fish; the 10% threshold was exceeded also by the 3- and 5-yr-olds (19.3 and 16.7%, respectively). Generally, the above three age groups included 84.7% of all the individuals examined. Among the 3-cm-wide length classes, three were prevailing: dominant (28.0%) was the 38.0 - 40.9 cm class, the 35.0 - 37.9 and 41.0 - 43.9 cm classes supplying 20.6 and 15.3% of all the individuals, respectively. The three classes combined accounted for 63.9% of all the individuals. As could be seen, dominance of the three most numerous age groups was much stronger than of the three most numerous length classes.

Table 1. Length and age composition of the fish examined

Length class [l.c. cm]	Age group								n	%
	I	II	III	IV	V	VI	VII	VIII		
20.0–22.9	1	–	–	–	–	–	–	–	1	0.7
26.0–28.9	–	3	3	–	–	–	–	–	6	4.0
29.0–31.9	–	5	2	1	–	–	–	–	8	5.3
32.0–34.9	–	–	12	–	–	–	–	–	12	8.0
35.0–37.9	–	–	10	21	–	–	–	–	31	20.6
38.0–40.9	–	–	2	33	7	–	–	–	42	28.0
41.0–43.9	–	–	–	17	6	–	–	–	23	15.3
44.0–46.9	–	–	–	1	8	1	–	–	10	6.7
47.0–49.9	–	–	–	–	3	4	–	–	7	4.7
50.0–52.9	–	–	–	–	1	3	1	–	5	3.3
53.0–55.9	–	–	–	–	–	1	1	–	2	1.3
56.0–58.9	–	–	–	–	–	–	–	1	1	0.7
59.0–61.9	–	–	–	–	–	–	–	1	1	0.7
65.0–67.9	–	–	–	–	–	–	–	1	1	0.7
n	1	8	29	73	25	9	2	3	150	100.0
%	0.7	5.3	19.3	48.7	16.7	6.0	1.3	2.0		

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Table 2 shows the pikeperch length growth, worked out with the back calculation method. It is only the l_1 length of the first age group that is clearly lower than the corresponding l_1 values of the older age groups. Mean lengths of individual age groups in subsequent years of life differed slightly only, which, i.a., can be taken as an evidence that it was appropriate to use the Vovk's technique of pikeperch length back calculation. Mean lengths ($\bar{x}$) and their increments (Δl) in consecutive years of life point to a characteristic growth history: a very high increment in the first year of life, an almost half that in the second year, and gradually decreasing increments subsequently.

Table 2. Pikeperch length growth as determined with back calculations

Age group	n	Length [l. c. cm]							
		l_1	l_2	l_3	l_4	l_5	l_6	l_7	l_8
I	1	16.4	–	–	–	–	–	–	–
II	22	18.6	27.0	–	–	–	–	–	–
III	72	19.6	27.6	34.1	–	–	–	–	–
IV	35	19.2	27.4	34.0	39.5	–	–	–	–
V	14	20.0	28.4	35.3	41.2	46.2	–	–	–
VI	3	18.9	27.6	35.0	41.7	47.9	52.5	–	–
VII	2	19.5	27.4	35.8	41.9	46.7	51.0	54.6	–
VIII	1	19.7	27.1	34.9	41.3	45.3	48.7	52.5	55.1
$\bar{x}$		19.4	27.5	34.3	40.2	46.5	51.4	53.9	55.1
SD		1.46	1.70	1.63	1.92	1.62	2.53	2.27	–
v		7.5	6.2	4.8	4.8	3.5	4.9	4.2	–
Δl		19.4	8.1	6.8	5.9	6.3	4.9	2.5	1.2
n		150	149	127	55	20	6	3	1

The relatively limited scatter of length data should be emphasised. The highest coefficient of variation (v), recorded in the first year of life, was 7.5% only; the scatter of length data in the subsequent years was still more confined, the coefficient of variation ranging from 3.5% for l_5 to 6.2% for l_2.

The back-calculated results served as a basis for calculating two mathematical growth models: the von Bertalanffy equation and the modified power function. The respective models can be formulated as:

$$L_t = 68.7[1 - e^{-0.1958(t+0.6573)}]$$

$$L_t = 41.2692t^{0.3148} - 22.8845$$

The results are summarised in Table 3; for comparative purposes, the table contains also the back-calculated length data (treated as a basis on which to compare other results) and the data determined with means in age groups.

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Table 3. Pikeperch length growth as calculated with different methods (l. c. cm)

Age group	Method			
	back calculations	mean length in age group	von Bertalanffy equation	modified power function
I	19.4	21.4	19.0	18.4
II	27.5	29.0	27.9	28.4
III	34.3	34.2	35.1	35.4
IV	40.2	39.1	41.1	41.0
V	46.5	43.3	46.0	45.6
VI	51.4	49.7	50.0	49.7
VII	53.9	53.9	53.4	53.9
VIII	55.1	60.5	56.1	56.5

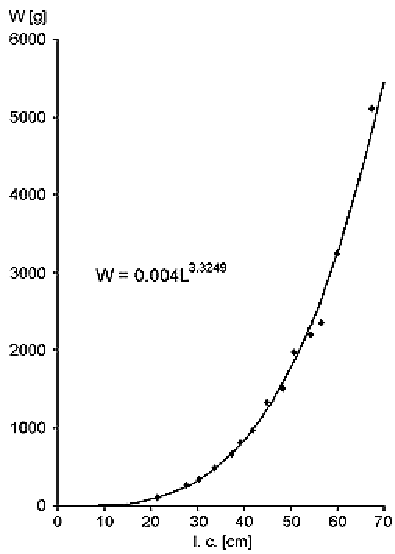
The two models allow to fairly accurately characterise the pikeperch length growth, the von Bertalanffy model proving to be most precise. The results obtained with that model differed from the back-calculated data by 0.74, on the average, while the lengths calculated with the modified power function differed slightly more (by 0.97 cm). Clearly larger differences (by 1.87 on the average) appeared when the back-calculated data were compared with means in age groups.

Fig. 2 illustrates the length-weight relationship for the pikeperch studied. The relationship was described with the following power function:

$$W = 0.0040\ L^{3.3249}$$

where W is fish weight (g) and L is fish length (l.c.; cm). As can be seen in the plot, the curve illustrating the relationship runs very close to the data points corresponding to mean weights in consecutive length classes.

Fig. 2. Length-weight relationship in pikeperch



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Results of weight growth determination, obtained with all the three methods described in detail in MATERIALS AND METHODS, are summarised in Table 4.

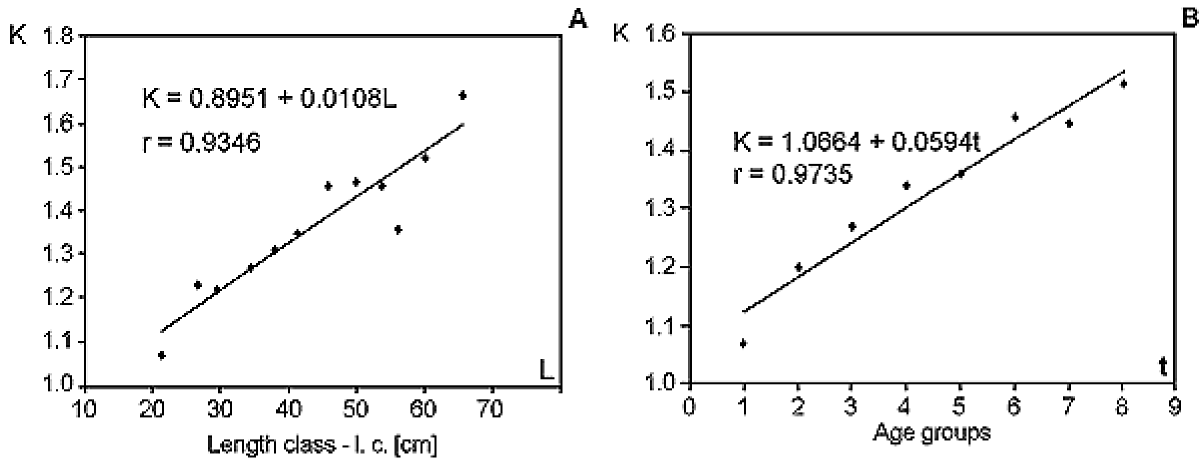
Table 4. Pikeperch weight growth as calculated with different methods (g)

Age group	Method		
	length to weight conversion	mean weight in age group	modified von Bertalanffy equation
I	77	105	72
II	244	296	255
III	509	523	551
IV	863	812	929
V	1400	1126	1351
VI	1954	1807	1787
VII	2288	2277	2213
VIII	2462	3463	2612

Comparison of length to weight conversion with data obtained with the other two methods showed that the modified von Bertalanffy equation produced lower differences (71 g on the average), while differences between mean weights in age groups data and those yielded by the basic method were almost three times as high (198 g on the average). It should be emphasised that such a pronounced difference was caused by a large discrepancy (more than 1000 g) between weights in the eighth year of life.

The average condition coefficient, K, calculated from the Fulton formula, was 1.33. Changes in the condition coefficient, observed in individual length classes and age groups showed a clear tendency to increase with fish length and age. Fig. 3 illustrates relationships between K and the fish length and weight as described by linear regression equations. Both cases produced high correlation coefficients (0.9346 and 0.9735) which, together with the number of degrees of freedom, evidence statistical significance of both regressions (Parker, 1978).

Fig. 3. Changes in condition coefficient (K) with length (A) and age (B) of pikeperch



DISCUSSION

When the verge coefficient is taken into account during classification of fish individuals into age groups, a better fit of mean lengths determined for consecutive age groups to the results of back calculations is obtained. A comparison of the relevant data in Table 3 (first and second column) allows to note that the data oscillate in a way: larger mean lengths in age groups are alternated by higher back-calculated data. Although the average difference between mean lengths in age groups and back-calculated data is almost twice that when the mathematical growth models are applied, that difference is only 4.6% of the average pikeperch length calculated from back-calculated data for the first 8 years of life. It should be borne in mind that this situation could occur because the samples were collected when a new annual ring was just forming on the scales. Most probably, differences between mean lengths in age groups and back-calculated lengths would still have been reduced, if the number of individuals without a new annual ring ("high" Kr) had been more or less equal to that of individuals showing the already formed new ring ("low" Kr). Unfortunately, the materials on hand were dominated (68% of all fish) by those individuals with "high" Kr.

A comparison of data of this study with the results obtained, with identical methodology, from the Pomeranian Bay in 1995 (Szypuła, 1996) shows some differences between length and age distributions yielded by both studies. The fish studied in 1995 were dominated by the 32-34.5 cm class, the 38-40.9 cm class dominating in this study. The age distributions were less different, the 3-yr-old individuals predominating in both cases. It should be remembered that when classifying fish into age groups in 1995, the verge coefficient was not taken into account, the scale annual ring count being used only; for this reason, the 1995 data on age distribution should be compared with Table 2 of this study. In the 1995 materials, fewer age groups were recorded (groups II-VI vs. groups I-VIII in 1998).

In the two studies, the lengths (l.c.) in consecutive years of life were most similar in the second and third year of life. In the remaining years, slightly longer fish were recorded in 1995 (the maximum difference of 2.3 cm was observed in the sixth year of life). The scatted of data in 1995 was quite pronounced (11.2% coefficient of variation in the first year of life vs. 7.5% in 1998).

Earlier (1974-1977) studies on age and growth of the pikeperch in Lake Dąbie and River Regalica (Krzykawski, Szypuła 1982) showed a high similarity in the age composition of the fish examined. The 3-yr-old individuals predominated among the Lake Dąbie fish, the Regalica materials being dominated by the 3-yr-olds as well, with a slightly lower contribution of the 4-yr-olds. The number of age groups in Lake Dąbie was higher (from group 0+ to X), that in Regalica (from group II to VIII) being similar to the number in the present study.

Characteristic were differences in the length growth rate. The Lake Dąbie and Regalica pikeperch grew at a clearly slower rate during the first 2 years of life. A reverse situation was observed in subsequent years, the length differences (in favour of the Lake Dąbie and Regalica individuals) increasing gradually to reach 14.2 and 12.3 cm, respectively, in the eighth year of life. It is possible that the length data for the Pomeranian Bay pikeperch are not fully representative due to the very low number of individuals examined. A similar situation (a clearly lower growth rate in the first year of life, the rate picking up and differences gradually increasing as of the third year) is observed when the results of this study are compared with data reported by Korycki (1976) and Nagięć (1961); however, the length differences, particularly those in the eighth year of life, were not as great. The present data and the results published by the authors referred to above show similar trends with respect to the weight growth rate.

The length-growth relationships for the Pomeranian Bay pikeperch in 1995 and 1998 were very similar. Mean values of the condition coefficients were identical in the two years (K = 1.33). Changes in the condition coefficient relative to the fish length and age, too, proceeded in a similar manner (values of K increased in both years with fish size and age).

CONCLUSIONS

1. The growth of length and weight of the Pomeranian Bay pikeperch in 1998 was very similar to corresponding results obtained in 1995. Very similar were also the length-weight relationship and condition, as well as the relationship of the latter with the fish length and age.
2. Earlier data on growth of pikeperch in other areas (Lake Dąbie, River Regalica, lakes near Węgorzewo) pointed to a slower growth in the first two years of life and a faster growth later on. Particularly large differences (with respect to the Pomeranian Bay pikeperch) were recorded in older fish.
3. Using the verge coefficient when classifying individuals into age groups allows a better fit of data on mean lengths in age groups to back-calculated results. An additional prerequisite calls for collecting materials for the analyses when a new annual ring is being formed on scales.

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