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Jerzy *SZYPUŁA*

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THE LENGTH-WEIGHT RELATIONSHIP AND CONDITION OF PIKE AND PERCH IN LAKE MIEDWIE

ZALEŻNOŚĆ POMIĘDZY DŁUGOŚCIĄ A MASĄ CIAŁA ORAZ KONDYCJĄ SZCZUPAKA I OKONIA Z JEZIORA MIEDWIE

Department of Fish Biology, Agricultural University of Szczecin, Poland

The paper presents the analysis of relationships between variations in Fulton's condition coefficient (K) and the exponent n in the length–weight (L–W) relationship. When $n < 3$, K was observed to decrease with fish size; a reverse was true when $n > 3$. On the other hand, the condition coefficient K' (Bagenal and Tesch 1978) remained constant and not related to fish size, regardless of n. The two coefficients were used to study condition of the Lake Miedwie pike (85 individuals) and perch (316 individuals) and to determine relationships between condition on the one hand and the fish length, weight, water temperature, and feeding intensity on the other. Four mathematical functions (linear, power, log, and exponential) were applied to study the relationships in each species. In addition, relationships between condition and water temperature and feeding intensity were explored by means of multiple regression. Condition of the two species studied was found to be similar to that reported earlier from water bodies of the former USSR, Węgorzewo Lake District, and the River Odra estuary.

INTRODUCTION

Interrelationships and couplings between fish body length and weight on the one hand and condition on the other have already been analysed and described in numerous publications (Le Cren 1951; Tesch 1968; Bagenal and Tesch 1978). While the power function ($W = kL^n$) is commonly used to describe the body length–weight relationship, various methods are used to determine fish condition. The following formulae, serving to describe fish condition, have been applied by the authors referred to above:

$K = W \cdot 100 \cdot L^{-3}$ (Fulton's formula)

$K' = W \cdot 100 \cdot L^{-n}$ (formula used by Bagenal and Tesch)

where: *K* (*K'*), condition coefficient; *W*, fish weight (g); *L*, fish length (cm); *n*, exponent describing the *L–W* relationship.

It should be pointed out that n usually more or less deviates from 3. Thus the Fulton's formula-based approach involves certain inconsistency: as it is evident from the formula, fish weight is divided by the third power of length, while the exponent in the *L–W* relationship differs, as a rule, from 3. As a result, the value of K may vary between the fish differing in size (particularly when n is much different from 3). This has been succintly demonstrated by a small table published on p. 129 of Bagenal and Tesch's (1978) paper: *K* is seen to clearly increase with fish length in the 10-, 20-, and 30-cm long perch, while *K'* is basically constant and equal to 100 times the multiplier *k* in the *L–W* relationship shown on the same page (the exponent *n* is 3.46, i.e. clearly higher than 3).

The present work was aimed at determining, with the two formulae given above, condition of two predacious fish species inhabiting Lake Miedwie: pike and perch. In addition, at attempt was made to explore relationships between condition of the two species on the one hand and their size (body length and weight), water temperature, feeding intensity, and fishing season on the other.

MATERIAL AND METHODS

The basic set of data was provided by measuring body length (standard length, *SL* = *longitudo corporis*) and weighing 85 pike and 316 perch individuals caught in Lake Miedwie within 1997–2000. Data on seasonal changes in water temperature and feeding intensity were derived from Szypuła (2002).

Before setting off to explore relationships between condition of perch and pike and the factors listed in the final part of Introduction, it was deemed necessary to gain insight into changes of condition coefficient *K* in relation to *L–W*. To this end, for a hypothetical species X, body weight of individuals ranging in length from 5 to 50 cm (in 5-cm wide classes) was calculated with the power function $W = 0.001 \cdot L^n$, *n* being set at values ranging from 2.2 to 4.0 (at 0.2 intervals). It was intended to broaden the set of data used by Bagenal and Tesch (1978) with the results obtained. The weights calculated served to determine condition (*K*) of species X; changes of *K* with length of the species at different values of *n* are shown in Figs. 1A and 1B.

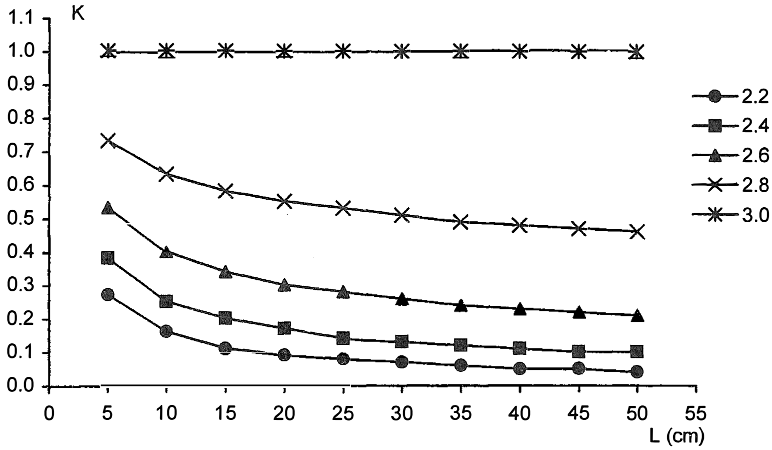

Fig. 1A. Relationship between condition coefficient K and fish length in a hypothetical species X; corresponding fish weights were calculated from the formula: $W = 0.01\ L^{n}$ (numbers to the right of the diagram are values of n within 2.2–3.0)

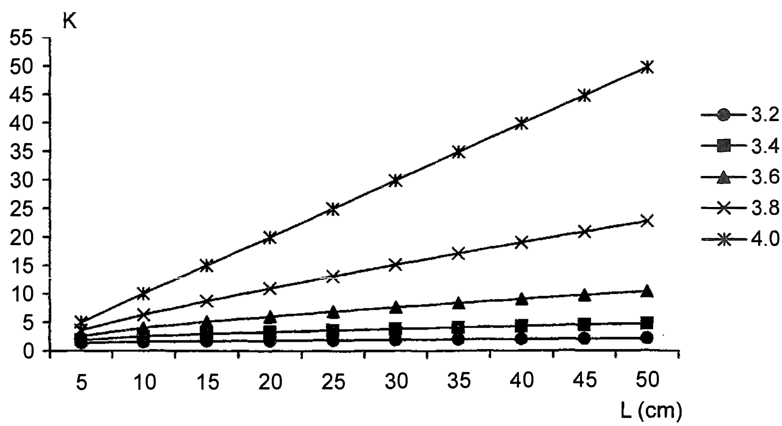

Fig. 1B. Relationship between condition coefficient K and fish length in a hypothetical species X; corresponding fish weights were calculated from the formula: $W = 0.01\ L^{n}$ (numbers to the right of the diagram are values of exponent n within 3.2– 4.0)

As seen in Fig. 1A, when $n < 3$, the increasing length is accompanied by a decrease in K. The decrease is not uniform: it can be very accurately modelled with power function ($K = aL^b$). The good fit of the model is evidenced by the high correlation coefficients r (from $r = -0.9964$ for $n = 2.2$ to $r = -0.9996$ for $n = 2.8$). At $n = 3$, K is, of course, constant and equals 1 (in this case $r = 0.0000$).

When $n > 3$, K increases with increasing length. At n ranging within 3.2–3.8, the increase is non-linear (similarly to the preceding case, the increase is accurately described by power function; at $n = 3.4$ or more, $r = 1.0000$; $r = 0.9999$ at $n = 3.2$ only). At $n = 4.0$, the increase in K is linear ($K = L$).

Changes in K with increasing weight of species X were very similar (a decrease in K at $n < 3$ and an increase at $n > 3$; power function has thus a high potential to mathematically model the relationship, resulting in equally high correlation coefficients).

Subsequently, relationships between condition (K, K') of the Lake Miedwie pike and perch and body length and weight, water temperature, and feeding intensity were determined. The calculations followed determination of the L–W relationships in the two species. In order to possibly accurately and comprehensively analyse the relationships, they were mathematically described with the following 4 functions: linear ($y = a + bx$); power ($y = ax^b$); log ($y = a + b \ln x$); and exponential ($y = ae^{bx}$). Seasonal changes in condition of the two species were explored as well.

To assess the goodness of fit of the four models, values of average absolute differences between empirically found values of K and K' were compared with the results produced by the models. To study similarities in changes of K and K' in relation to season and fish size, the K–K' relationships were described with linear regression equations ($K = a + bK'$). Finally, parameters of multiple regression equation describing the relationship between condition coefficients and temperature (T; °C) and feeding intensity (daily coefficient, DC; ‰o), in the form of K (or K') $= a + bT + cDC$, were calculated.

RESULTS

Length–weight relationship in the species studies

Fig. 2 illustrates the L–W relationships in the two species. Due to a much wider range of pike body size, the perch individuals were divided into fourteen 5-cm wide length classes and the mean body lengths and weights were calculated for each class. The means were used to determine parameters of the power function serving to describe the L–W relationship. In the case of perch, because of its much narrower size range, a total of 10 length classes were used, each class being 2-cm wide.

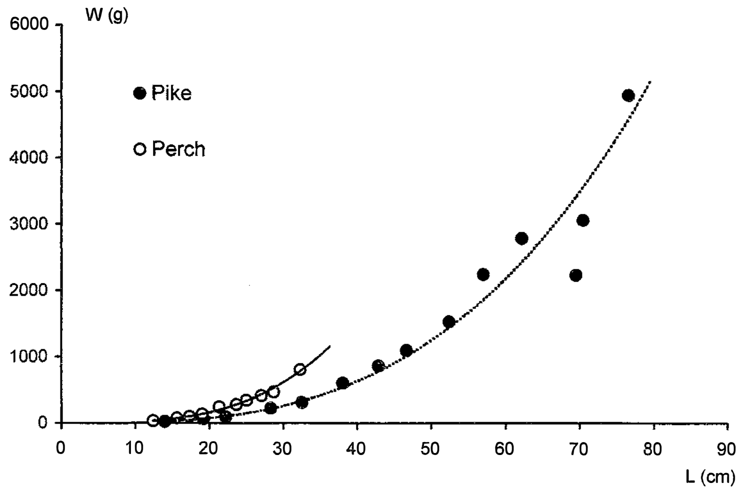

Fig. 2. Relationships between length and weight in Lake Miedwie pike and perch

The two relationships were fairly typical: at identical lengths, the perch weights were about 2 times higher than those of pike. This is naturally caused by a more compact and dorsally curved body shape of perch. The power functions describing mathematically the *L–W* relationships in the two species, shown in Fig. 2, differed primarily in their exponents (higher in perch). Some differences can also be found in the fit of the theoretical curve to the empirical data. All the data points in perch were close to the theoretical curve, while in most pike (larger than 60 cm), the scatter of data points was much wider. In both species, however, the calculated *L–W* relationship was statistically significant (at the confidence level of $u = 0.999$).

Relationships between condition of pike and perch and their length, body weight, water temperature, and feeding intensity

Table 1 summarises parameters of the four functions used to describe the relationship between condition (*K*, *K'*) of pike and its body length (*L*) and weight (*W*). The very low values of b evidence the small changes in pike condition with the increase in size (length and weight). The signs of correlation coefficient r indicate that, in most cases (13 out of 16), the relationship was direct; negative *r*'s (evidencing a reverse relationship) were recorded when *K'* was related to length with the linear (1), power (2), and exponential (4) functions. Generally, the relationships shown in Table 1 were non-significant (too low correlation coefficients *r*).

Table 1

Parameters of relationships between pike condition (K, K') and fish length (L) and weight (W) (1, linear function: $y = a + bx$; 2, power function: $y = ax^b$; 3, log function: $y = a + b \ln x$; 4, exponential function: $y = ae^{bx}$)

Function	K or K'	L or W	a	b	r	Confidence level u
1	K	L	0.9410	0.0009	0.1373	—
1	K'	L	0.8024	–0.0004	–0.0748	—
1	K	W	0.9974	0.0003	0.2368	—
1	K'	W	0.8067	0.0001	0.1414	—
2	K	L	0.8070	0.0505	0.1780	—
2	K'	L	0.7998	–0.0077	–0.0269	—
2	K	W	0.8029	0.0360	0.2209	—
2	K'	W	0.7122	0.0201	0.1187	—
3	K	L	0.7598	0.0602	0.2352	—
3	K'	L	0.7657	0.0052	0.0263	—
3	K	W	0.7444	0.0429	0.2704	—
3	K'	W	0.6751	0.0221	0.1699	—
4	K	L	0.9471	0.0006	0.0799	—
4	K'	L	0.8103	–0.0009	–0.1244	—
4	K	W	0.9929	0.00003	0.1931	—
4	K'	W	0.8026	0.00001	0.1002	—

Negative sign in the Confidence level u column denotes a non-significant relationship.

Table 2 presents parameters of functions describing relationships between pike condition and water temperature and feeding intensity. The data on seasonal variability of the two latter factors were derived from Szypuła (2002). In this case, the values of b were as low as those in Table 1; however, values of the correlation coefficient r were rather markedly higher. The type of relationships presented in Table 2 was quite characteristic: the condition-water temperature relationship was always reverse (negative r), while condition was positively related to feeding intensity. In spite of higher r's, the relationships were statistically significant in as few as 4 cases out of 16; the significant relationships were those of K–T and K'–DC described with the power function as well as the K–T and K'–DC ones described with the log function. In all the 4 cases the confidence level was $u = 0.900$.

Table 3 summarises relationships between perch length and weight. All the relationships were direct (positive r). Values of b were somewhat higher, while the values of correlation coefficient r were markedly higher than in pike, the relationships being significant in as many as 12 cases out of 16 (the confidence level u ranged from 0.900 to 0.999). The only non-significant relationships were those between K' and L; values of r in those 4 cases were much different than the remaining ones. While the lowest r in the statistically significant relationship was 0.5095, the highest correlation coefficient among those non-significant relationships was as low as 0.0975.

Table 2

Parameters of relationship between pike condition (*K*, *K'*) and water temperature (*T*) and feeding intensity (*DC*); functions denoted as in Table 1

Function	*K* or *K'*	*T* or *DC*	*a*	*b*	*r*	Confidence level *u*
1	*K*	*T*	1.1463	–0.0081	–0.4442	—
1	*K'*	*T*	0.8921	–0.0044	–0.3392	—
1	*K*	*DC*	1.0292	0.0003	0.2775	—
1	*K'*	*DC*	0.8113	0.0003	0.4051	—
2	*K*	*T*	1.2647	–0.0831	–0.5974	0.900
2	*K'*	*T*	0.9646	–0.0624	–0.4936	—
2	*K*	*DC*	0.8758	0.0449	0.5162	—
2	*K'*	*DC*	0.6849	0.0494	0.6252	0.900
3	*K*	*T*	1.2705	–0.0970	–0.6153	0.900
3	*K'*	*T*	0.9711	–0.0580	–0.5198	—
3	*K*	*DC*	0.8598	0.0481	0.4886	—
3	*K'*	*DC*	0.6710	0.0416	0.5960	0.900
4	*K*	*T*	1.1361	–0.0069	–0.4258	—
4	*K'*	*T*	0.8850	–0.0046	–0.3135	—
4	*K*	*DC*	1.0257	0.0003	0.2933	—
4	*K'*	*DC*	0.8090	0.0004	0.4252	—

Table 3

Parameters of relationship between perch condition (*K*, *K'*) and fish length (*L*) and weight (*W*); functions denoted as in Table 1

Function	*K* or *K'*	*L* or *W*	*a*	*b*	*r*	Confidence level *u*
1	*K*	*L*	1.4298	0.0277	0.8300	0.995
1	*K'*	*L*	0.8294	0.0003	0.0405	—
1	*K*	*W*	1.8284	0.0008	0.8695	0.999
1	*K'*	*W*	0.8213	0.0001	0.5095	0.900
2	*K*	*L*	0.8035	0.3034	0.8622	0.995
2	*K'*	*L*	0.7933	0.0166	0.0885	—
2	*K*	*W*	1.1184	0.1137	0.9784	0.999
2	*K'*	*W*	0.7231	0.0281	0.7008	0.980
3	*K*	*L*	0.2072	0.6001	0.8581	0.995
3	*K'*	*L*	0.7900	0.0150	0.0975	—
3	*K*	*W*	0.8579	0.2260	0.9765	0.999
3	*K'*	*W*	0.7166	0.0233	0.6912	0.980
4	*K*	*L*	1.4953	0.0139	0.8261	0.995
4	*K'*	*L*	0.8296	0.0003	0.0314	—
4	*K*	*W*	1.8293	0.0004	0.8483	0.999
4	*K'*	*W*	0.8208	0.0001	0.5144	0.900

Finally, Table 4 presents parameters of functions describing relationships between perch condition and ambient temperature and feeding intensity. Here all the relationships were reverse (negative *r*'s); only the *K–DC* relationships (4 cases out of 16) were statistically significant.

Table 4

Parameters of relationship between perch condition (*K*, *K'*) and water temperature (*T*) and feeding intensity (*DC*); functions denoted as in Table 1

Function	*K* or *K'*	*T* or *DC*	*a*	*b*	*r*	Confidence level *u*
1	*K*	*T*	2.2249	–0.0097	–0.4894	—
1	*K'*	*T*	0.8704	–0.0012	–0.1231	—
1	*K*	*DC*	2.1974	–0.0006	–0.8240	0.990
1	*K'*	*DC*	0.8824	–0.0002	–0.5169	—
2	*K*	*T*	2.3286	–0.0422	–0.4493	—
2	*K'*	*T*	0.8966	–0.0204	–0.1840	—
2	*K*	*DC*	2.3960	–0.0282	–0.5983	0.900
2	*K'*	*DC*	0.9123	–0.0145	–0.2596	—
3	*K*	*T*	2.3142	–0.0863	–0.4529	—
3	*K'*	*T*	0.8913	–0.0150	–0.1587	—
3	*K*	*DC*	2.3693	–0.0570	–0.5955	0.900
3	*K'*	*DC*	0.9062	–0.0111	–0.2336	—
4	*K*	*T*	2.2301	–0.0048	–0.4895	—
4	*K'*	*T*	0.8728	–0.0018	–0.1545	—
4	*K*	*DC*	2.2011	–0.0003	–0.8335	0.990
4	*K'*	*DC*	0.8831	–0.0002	–0.5474	—

Seasonal changes in perch and pike condition

Fig. 3 shows seasonal changes in condition of the two species, as expressed with the two condition coefficients (*K* and *K*'). The period covered by observations extended from February until November (except for September) in pike and from March until November (all months) in perch.

The highest condition coefficient *K* in pike was recorded in February; subsequently, the values of *K* were observed to clearly decrease until the minimum in April. The minimum was most likely a result of the pike spawning, which takes place in April, and the concurrent body weight reduction caused by the release of eggs and sperm. *K* was observed to increase again within April–September, the growing trend being basically maintained until November; a slight decrease was recorded only within August–October.

Changes in the pike *K*' proceeded in a very similar manner except that the values of *K*' were somewhat lower than those of *K*. The mean *K* (arithmetic mean of monthly data) was 1.06, while the mean *K*' was 0.85, i.e. 80.2% of the mean *K*.

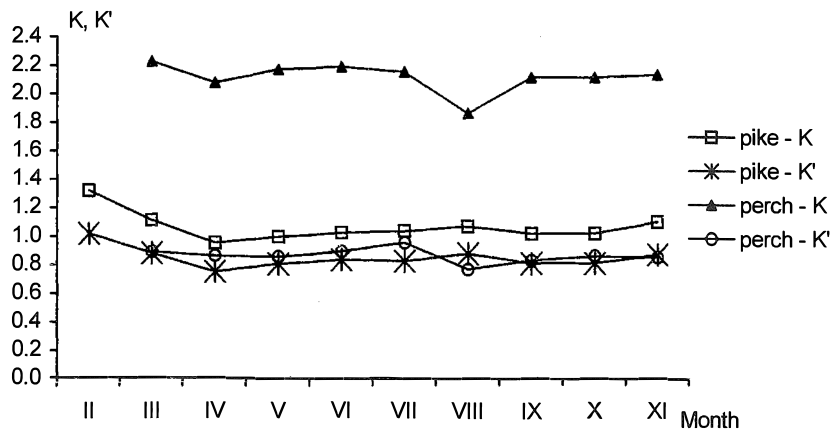

Fig. 3. Seasonal changes in condition coefficients *K* and *K'* in Lake Miedwie pike and perch

When applied to perch, the two condition coefficients produced somewhat larger differences in seasonal condition changes. Firstly, the difference between the highest and the lowest *K* values was almost twice that observed in *K'* (0.37 and 0.19, respectively). In addition, the highest *K* was recorded in March, the highest *K'* being recorded in July. The actual values of the two condition coefficients recorded in the same month differed as well: the mean *K* was 2.11, while the mean *K'* was as low as 0.86, i.e., 40.8% of the mean *K*. The two condition coefficients dropped to the minimum in August. The mean condition coefficients calculated from data for all the fish examined were slightly different than the mean values reported above (calculated from monthly averages): in pike, $\overline{K}$ = 1.03 and $\overline{K}'$ = 0.82; in perch, $\overline{K}$ = 2.13 and $\overline{K}'$ = 0.86.

Precision of determining the pike and perch condition versus length (*L*), weight (*W*), water temperature (*T*), and feeding intensity (*DC*) relationships

To check, in more detail, the goodness of fit of the functions describing the relationships (summarised in Tables 1–4), values of average absolute differences between empirical values of *K* and *K'* and the values calculated with the mathematical models used were compared. In this way, an additional criterion (complementing the correlation coefficients r and confidence levels u in Tables 1–4) with which to assess the precision of each function was obtained. The average absolute differences are summarised in Tables 5 (pike) and 6 (perch) as absolute values ($\overline{\Delta K}$, $\overline{\Delta K'}$) and percentages; in the latter case, each absolute difference is presented as a percentage of the mean *K* or *K'*.

Table 5

Average absolute differences ($\overline{\Delta K}$, $\overline{\Delta K'}$) between empirical values of condition coefficients (*K*, *K'*) and values calculated from equations describing relationships between pike condition and length (*L*), weight (*W*), water temperature (*T*), and feeding intensity (*DC*); functions denoted as in Table 1

Average absolute difference	Function			
	1	2	3	4
$\overline{\Delta K}$ (*L*)	0.102 (10.39)	0.102 (10.39)	0.100 (10.18)	0.109 (11.10)
$\overline{\Delta K}$ (*W*)	0.114 (11.61)	0.106 (10.79)	0.104 (10.59)	0.113 (11.51)
$\overline{\Delta K}$ (*T*)	0.066 (6.20)	0.060 (5.64)	0.061 (5.73)	0.062 (5.83)
$\overline{\Delta K}$ (*DC*)	0.072 (6.77)	0.063 (5.92)	0.062 (5.83)	0.072 (6.77)
$\overline{\Delta K'}$ (*L*)	0.081 (7.70)	0.082 (7.79)	0.086 (8.17)	0.084 (7.98)
$\overline{\Delta K'}$ (*W*)	0.094 (8.94)	0.089 (8.46)	0.086 (8.17)	0.092 (8.75)
$\overline{\Delta K'}$ (*T*)	0.050 (5.90)	0.047 (5.54)	0.047 (5.54)	0.048 (5.66)
$\overline{\Delta K'}$ (*DC*)	0.048 (5.66)	0.039 (4.60)	0.038 (4.48)	0.049 (5.78)

The value in brackets represents the average absolute difference in per cent of the mean *K* (or *K'*)

Table 6

Average absolute differences ($\overline{\Delta K}$, $\overline{\Delta K'}$) between empirical values of condition coefficients (*K*, *K'*) and values calculated from equations describing relationships between perch condition and length (*L*), weight (*W*), water temperature (*T*), and feeding intensity (*DC*); functions denoted as in Table 1

Average absolute difference	Function			
	1	2	3	4
$\overline{\Delta K}$ (*L*)	0.089 (4.35)	0.082 (4.01)	0.082 (4.01)	0.092 (4.50)
$\overline{\Delta K}$ (*W*)	0.073 (3.48)	0.035 (1.67)	0.033 (1.57)	0.084 (4.01)
$\overline{\Delta K}$ (*T*)	0.070 (3.31)	0.069 (3.26)	0.068 (3.22)	0.068 (3.22)
$\overline{\Delta K}$ (*DC*)	0.046 (2.18)	0.064 (3.03)	0.063 (2.98)	0.046 (2.18)
$\overline{\Delta K'}$ (*L*)	0.037 (4.43)	0.037 (4.43)	0.036 (4.31)	0.037 (4.43)
$\overline{\Delta K'}$ (*W*)	0.022 (2.61)	0.018 (2.13)	0.018 (2.13)	0.022 (2.61)
$\overline{\Delta K'}$ (*T*)	0.036 (4.20)	0.036 (4.20)	0.036 (4.20)	0.036 (4.20)
$\overline{\Delta K'}$ (*DC*)	0.032 (3.73)	0.036 (4.20)	0.037 (4.32)	0.034 (3.97)

In pike, the lowest average absolute differences were most frequently arrived at when log function was applied, the highest differences being produced by linear function. All the values given in Table 5 (as percentages) ranged within 4.48–11.61.

No such clear advantage (in terms of precision) of any of the four functions could be detected in perch (Table 6). In some cases (*K–W*, *K'–L'*), the results produced by different functions were quite similar, and almost identical in one case (*K'–T*). The average absolute differences (as percentages) were much lower than those in pike and ranged within 1.57–4.50.

Interrelationships between the two condition coefficients and their relationship with temperature and feeding intensity as determined with multiple regression

To finally check if the patterns of changes in the condition coefficients K and K' were similar in the two species, a linear regression equation describing the relationship between K and K' was calculated. Condition changes resulting from fishing season and from fish length and weight were taken into account. In pike, the regression equation was derived from 40 pairs of empirical data, 31 pairs serving as a basis for the regression equation in perch. The following equations were obtained:

Pike: $K = 0.0148 - 1.2390\,K'$ ($r = 0.9770$; $u = 0.999$)

Perch: $K = -0.2574 + 2.7930\,K'$ ($r = 0.6477$; $u = 0.999$)

In both species direct relationships were revealed, thus evidencing a similarity of the two patterns. Although a much higher r was obtained in pike, both regressions were highly significant ($u = 0.999$), no doubt a result of a high number of degrees of freedom.

Finally, relationships between condition coefficients of the Lake Miedwie pike and perch on the one hand and water temperature and feeding intensity on the other were determined by means of multiple regression. Similarly to the situation described in section d) for simple regressions, the precision of calculations was determined by computing average absolute differences ($\overline{\Delta K}, \overline{\Delta K'}$) between empirical data for the condition coefficients (K, K') and the results produced by the multiple regression equations. The source variables were the condition coefficients, water temperature, and feeding intensity, as determined for each month of the period of study (Szypuła 2002). The following multiple regression equations were obtained:

Pike:
$K = 1.1202 - 0.0119\,T + 0.0006\,DC$
$\overline{\Delta K} = 0.058$ (5.45%)
$K' = 0.8700 - 0.0075\,T + 0.0005\,DC$
$\overline{\Delta K'} = 0.040$ (4.27%)

Perch:
$K = 2.1620 + 0.0050\,T - 0.0010\,DC$
$\overline{\Delta K} = 0.059$ (2.79%)
$K' = 0.8253 + 0.0089\,T - 0.0005\,DC$
$\overline{\Delta K'} = 0.041$ (4.76%)

The precision of the multiple regression equations obtained was relatively high: in three cases, the average difference was about 5% of the mean condition coefficient. In the fourth case (K in perch), the precision was still higher, the difference amounting to less than 3%.

DISCUSSION

The condition coefficient *K vs* fish length relationship in a hypothetical species X, described in "Materials and methods" clearly shows that at the *L–W* exponents markedly different than 3, Fulton's coefficient may introduce a considerable error when used to determine fish condition. The error results from *K* being different in fish differing in size (increasing *K* when $n > 3$ and decreasing *K* when $n < 3$). Particularly large irregularities may emerge when effects of various factors (e.g. season, fishing area) on fish condition are studied on individuals differing markedly in their body size. In such cases, it is virtually impossible to draw reliable conclusions regarding effects of a given factor on fish condition. On the other hand, reliable conclusions can be drawn when *K*', a fish size-independent coefficient, is used.

When, however, *K*' is used to determine fish condition, it should be borne in mind that values of the coefficient are strongly on the exponent n in the *L–W* relationship (which is a consequence of the formula used to calculate *K*'). It may happen that *L–W* relationships of comparable samples (or subsamples) will considerably differ in their *n*'s; as a result, individuals, identical in terms of their length and weight but belonging to different samples, will show large differences in condition as determined with *K*', an obviously unacceptable outcome. To avoid it, the *L–W* relationship, common to all the individuals examined, should be first determined. Then the values of *K*' will be fully comparable. However, application of *K*' to determine fish condition may introduce difficulties when one will attempt to compare one's results with those published by other authors, with no possibility of determining the common *L–W* relationship.

When comparing the present results with earlier data collected from other water bodies, fish condition as determined with Fulton's coefficient (*K*) only was considered, as any data obtained with *K*' would not be fully comparable (cf. The discussion above). Pike condition in the former USSR (0.94 in the Ob. River; 1.01 in Lake Baikal; 0.82 in Lake Ilmen; Berg 1949) was similar (perhaps with the exception of Lake Ilmen) to condition of the Lake Miedwie pike (1.03). On the other hand, the pike caught in the Węgorzewo Lake District (Antosiak 1961) showed a somewhat better condition (1.16).

The Odra estuary perch was generally characterised by a slightly better condition (2.24 in the Szczecin Lagoon; 2.30 in the Pomeranian Bay; 1.84 in Lake Dąbie; 2.20 = average for the entire estuary) than the perch caught in Lake Miedwie (2.13) (Szypuła 1994, 1998, 1999; Szypuła and Rybczyk 2001).

The precision of mathematical models of the relationships between fish condition and body size (length and weight) and temperature and feeding intensity differed (sometimes substantially so), depending on a function used or on a relationship being analysed. Particularly spectacular differences were evident in the case of the perch condition *vs.* body length and weight relationships. The *K*'–*L* relationships described with the four functions were non-significant, the mean r being 0.0645. The mean r for the remaining 12 cases was almost 12 times higher (0.7887) and all the relationships were significant at a confidence level ranging within 0.900–0.999.

CONCLUSIONS

1. Application of Fulton's coefficient for condition assessment is possible without additional constraints only when the *L–W* relationship exponent is very close to 3 or when both average lengths and weights and their ranges in the samples studied are similar.
2. When the *L–W* relationship exponent is markedly different from 3, the fully reliable results may be obtained by using *K*'. However, calculation of *K*' should be preceded by determining the *L–W* relationship common for the entire material studied.
3. The Lake Miedwie pike and perch condition was similar to data reported earlier for other areas (pike in water bodies of the former USSR and in the Węgorzewo Lake District; perch in River Odra estuary).
4. Individual mathematical functions, used to assess the relationships between pike and perch condition and the fish size, water temperature, and feeding intensity frequently produced results that differed in their precision. In the case of pike, the most precise results were obtained with log function, the lowest precision being typical of linear function. In the case of perch, no function showed any clear advantage over the rest, the results produced by different functions being frequently very similar or even identical.

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Jerzy *SZYPUŁA*

ZALEŻNOŚĆ POMIĘDZY DŁUGOŚCIĄ A MASĄ CIAŁA ORAZ KONDYCJA SZCZUPAKA I OKONIA Z JEZIORA MIEDWIE.

STRESZCZENIE

Początkowym etapem niniejszego opracowania było sprawdzenie, jak zmienia się wartość współczynnika kondycji Fultona (*K*) w miarę zwiększania się rozmiarów badanych ryb, w zależności od wykładnika potęgi „*n*" w zależności *L*/*W*. W tym celu dla hipotetycznego gatunku „X", uwzględniając zakres długości 5–50 cm, obliczono teoretyczne masy ryb (dla długości co 5 cm) stosując równanie $W = 0{,}01L^n$; wartość wykładnika potęgi „*n*" przyjęto w zakresie 2,2–4,0 (co 0,2). Obliczone w ten sposób masy posłużyły do wyliczania wartości *K*. W przypadkach gdy „*n*" < 3 wartość K zmniejszała się u coraz to większych ryb; gdy *n* > 3 zmiany K przebiegały odwrotnie.

Następnie dysponując materiałem obejmującym 85 szczupaków i 316 okoni z jeziora Miedwie, łowionych w latach 1997–2000, określono przy zastosowaniu dwóch współczynników *K* i *K'* (przy czym ta ostatnia wersja współczynnika kondycji polega na podzieleniu 100-krotnej wartości masy ryby przez „*n*" – tą potęgę jej długości, gdzie „*n*" jest wykładnikiem potęgi zależności *L*/*W*) kondycję badanych gatunków, oraz jej zależność od rozmiarów ryb, temperatury środowiska i intensywności żerowania, stosując w każdym przypadku 4 funkcje matematyczne: prostoliniową, potęgową, logarytmiczną i wykładniczą. Odnotowano w niektórych przypadkach znaczne rozbieżności w dokładności poszczególnych funkcji. Przedstawiono również sezonowe zmiany kondycji obydwu gatunków, a w końcowym etapie pracy – także równoczesne zależności kondycji od temperatury i intensywności żerowania, wyliczone przy zastosowaniu regresji trzycechowej.

Wyniki uzyskane dla szczupaka i okonia z jeziora Miedwie były stosunkowo bliskie wartościom współczynników kondycji, podawanym dla innych akwenów (uzyskanym we wcześniejszych badaniach). Kondycja szczupaka z jeziora Miedwie (*K* = 1,03) była podobna, jak w akwenach byłego ZSRR (średnio *K* = 0,92); nieco lepszą kondycją charakteryzował się szczupak z jezior węgorzewskich (*K* = 1,16). W przypadku okonia wyniki dotyczące jeziora Miedwie (*K* = 2,13) były również zbliżone do danych, dotyczących estuarium ujścia Odry (*K* = 2,20).

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Author's address:

Jerzy Szypuła PhD DSc Prof
Department of Fish Biology
Agricultural University of Szczecin
Kazimierza Królewicza 4, 71-550 Szczecin, Poland