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SHORT COMMUNICATION

Weight-length relationships for three fishes (*Leuciscus leuciscus*, *Phoxinus phoxinus, Salmo trutta*) from the Strwiąż River (Dniester River drainage)

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Abstract. Weight-length relationships were investigated for three fish species, *i.e.*, *Leuciscus leuciscus* (L.), *Phoxinus phoxinus* (L.), and *Salmo trutta* L., which occur commonly in the Strwiąż River, a tributary of the Dniester River (Black Sea Basin). It was found that the allometric model of regression fitted the three species much better than did the isometric one in the terms of the coefficient of determination (r^2). The best fitted values of parameter *a* (intercept) were estimated as 0.038, 0.004, and 0.008, respectively, whereas parameter *b* (slope) values were 2.596, 3.408, and 3.106, respectively.

Keywords: biometrics, ichthyofauna, weight-length relationships, Strwiąż River

The weight-length relationship is widely recognized as an important tool in fisheries sciences, especially in ecology, population dynamics, and stock management (e.g., Lagler et al. 1962, Froese 2006, Abdoli et al. 2008, Ferreira et al. 2008, Vaslet et al. 2008, Epler et al. 2009). These relationships permit estimating the weight of a specimen easily when only its total length is known. For this reason, these relationships are useful when rapid estimations of biomass are necessary (e.g., Froese 2006, Vaslet et al. 2008). Two of the species investigated, the common dace, *Leuciscus leuciscus* (L.), and the European minnow, *Phoxinus phoxinus* (L.), are small-sized cyprinids that are highly abundant throughout southern Poland. The last species investigated, the brown trout, *Salmo trutta* L. (often referred to as *S. trutta* morpha *fario* or *S. trutta fario*, due to many ambiguities in classification of brown trout populations; only the name of the species *sensu lato* is used in this paper), is a salmonid fish of great economic importance, especially for anglers. The aim of the current study was to characterize weight-length relationships for the three most abundant fishes of the Strwiąż River in the Dniester River drainage area of the Black Sea basin (Fig. 1).

During the ichthyological monitoring of the Strwiąż River (Fig. 1) conducted in July 2008, among others, 15 specimens of *L. leuciscus*, 67 of *P. phoxinus*, and 63 of *S. trutta* were harvested using an IG-600T portable battery-powered electroshocker (135-255 V, 100 Hz). The fish were anesthetized by immersion in a water solution of Propiscin (Etomidate, 0.2 ml dm^{-3}). Then they were measured for total length (abbreviated as L, from the

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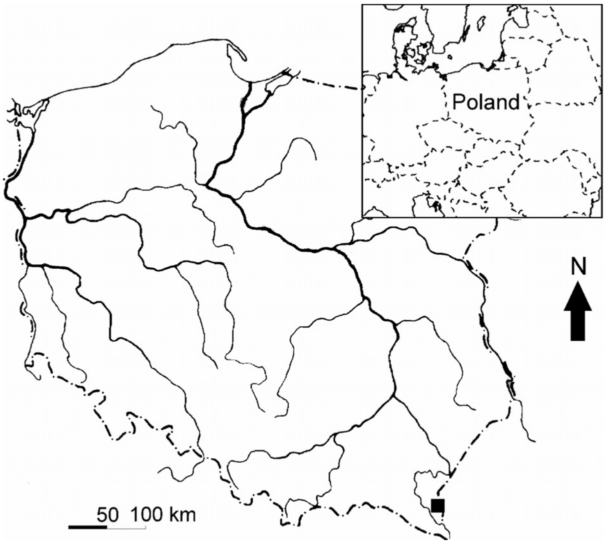

Figure 1. Study area. The Strwiąż River is marked with a black box.

anterior-most point of the head, whether the upper or lower jaw, to the posterior-most point of the caudal fin when stretched) to the nearest 0.5 cm using a standard measuring board, and weighed (W) to the nearest 0.1 g. The basic descriptive statistics (arithmetic mean ± standard deviation) were calculated for both total length and weight in each species.

Weight (W) was regressed on total length (L) using two different models of regression, i.e., linear $W = bL + a$ (which refers to isometric growth), and exponential $W = aL^b$ (allometric growth), where a was the intercept and *b* was the regression coefficient (slope). The most effective model was chosen according to the coefficient of determination (r^2), calculated as the squared coefficient of correlation (r) between the observed and predicted weight values. It is widely accepted that the exponential model explains observed variability better than the linear one (e.g., Lagler et al. 1962, Froese 2006). Nonetheless, this opinion was verified, and both models were used in the present study. All calculations were performed using SAS 9.1 software.

The *L. leuciscus* specimens analyzed were 10-24 cm in total length (arithmetic mean ± SD; 21.7 ± 3.3 cm) and 9-143 g in weight (115.5 ± 33.6 g); *P. phoxinus* were 5-10 cm in total length (6.9 ± 1.1 cm) and 1-10 g in weight (3.1 ± 1.9 g); and *S. trutta* were 6.5-23 cm in total length (8.8 ± 4.4 cm) and 2-135 g in weight (15.1 ± 33.9 g). In each case, the exponential model fitted the data analyzed better than did the linear model (Table 1), as is usually the case in the literature (e.g., Lagler et al. 1962, Froese 2006, Abdoli et al. 2008, Ferreira et al. 2008, Vaslet et al. 2008). The coefficient of determination (r^2) was very high at 0.937 in *L. leuciscus*, 0.911 in *P. phoxinus*, and 0.997 in *S. trutta*, in comparison to that for the linear model at 0.868, 0.797, and 0.965, respectively. The following equations were obtained: $W = 0.038L^{2.594}$ for *L. leuciscus*, $W = 0.004L^{3.408}$ for *P. phoxinus*, and $W = 0.008L^{3.106}$ for *S. trutta*.

Table 1

Weight-length relationships of the three species from Strwiąż River. Abbreviations: I – isometric; A – allometric model of growth; a – intercept; *b* – coefficient of regression (slope); $CL_{95\%}$ – 95% confidence limits; P – probability level; r^2 – coefficient of determination

Species	Model	*a*	$CL_{95\%}$	*b*	$CL_{95\%}$	P	r^2
Leuciscus leuciscus	I	-90.743	(-137.257)-(-44.230)	9.510	7.388-11.632	0.0001	0.868
	A	0.038	-0.095-0.171	2.596	1.468-3.725	0.0001	0.937
Phoxinus phoxinus	I	-7.847	(-9.235)-(-6.459)	1.585	1.387-1.784	0.0001	0.797
	A	0.004	0.001-0.007	3.408	3.023-3.794	0.0001	0.911
Salmo trutta	I	-51.323	(-54.957)-(-47.689)	7.529	7.161-7.898	0.0001	0.965
	A	0.008	0.005-0.012	3.106	2.963-3.249	0.0001	0.997

In each case, both parameters were highly significant (P < 0.0001). Exponent *b* (slope) varied from 2.594 to 3.408, which concurs with observations of various authors who found that, in most cases, this parameter ranges from 2.5 to 4.0, and most frequently is near 3.0 (Lagler et al. 1962, Froese 2006, Abdoli et al. 2008, Ferreira et al. 2008, Vaslet et al. 2008). In all three species, parameter *b* did not differ significantly from a value of 3.0 (P > 0.05). In both *P. phoxinus* and *S. trutta*, exponent (*b*) was very close to values cited in the literature, such as 3.408 vs. 3.421 (Oscoz et al. 2005) and 3.349 (224 specimens from the Gállego River; Leunda et al. 2006) in the former, and 3.106 vs. 3.003 (Shuck 1942) in the latter species. However, quite different estimations were also noted. Sigler (1951) calculated the exponent for *S. trutta* as 2.960 and Papageorgiou et al. (1983) as 2.950. The first author studied 286 brown trout, while the second examined 1074 individuals. Some precise estimates can be found in the literature regarding *P. phoxinus*, and these ranged from 2.432 (89 specimens from Caldares River; Leunda et al. 2006) to 3.190 (42; Miranda et al. 2006). The exponent estimated for *L. leuciscus* is quite different from the value in Wüstemann and Kammerad (1995), which was 2.596 vs. 3.152, but both estimates could be strongly affected by the small number of fish analyzed (15 and 28 specimens, respectively). Matthews (1971) reported a value of 2.860 for *L. leuciscus* from the Thames River, which is much closer to the result obtained in the current study.

Nevertheless, the differences observed cannot be explained only in the terms of the different number of fish studied. They might also be due to individual, population-specific characteristics affected by local environmental conditions. The values of the exponent for one species often vary from river to river. For example, Leunda et al. (2006) calculated the exponent for *P. phoxinus* as 3.349 (224 specimens) in the Gállego, as 3.085 (27) in the Atares, and as 2.432 (89) in the Caldares rivers.

The results presented contribute to the knowledge about the weight-length relationships of three freshwater fishes. It is known that weight-length parameters depend on factors including biological and environmental, as well as geographical and temporal, such as the age and condition of the fish or the season of year when samples are collected (Lagler et al. 1962, Froese 2006, Ferreira et al. 2008, Vaslet et al. 2008). When using the results presented in this study, it should borne in mind that the samples were taken in summer and the number of fish examined was limited.

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Streszczenie

Zależność pomiędzy masą ciała a długością całkowitą u trzech gatunków ryb (*Leuciscus leuciscus*, *Phoxinus phoxinus* i *Salmo trutta*) z rzeki Strwiąż (dorzecze Dniestru)

Zbadano zależność pomiędzy masą ciała (W) a długością całkowitą (L) trzech gatunków ryb pospolicie występujących w rzece Strwiąż, dopływie Dniestru (zlewisko Morza Czarnego): jelca, *Leuciscus leuciscus* (L.), strzebli potokowej, *Phoxinus phoxinus* (L.) oraz pstrąga potokowego, *Salmo trutta* L. Ryby zostały pozyskane w trakcie elektropołowów, uśpione, a następnie zmierzone (L ± 0,5 cm), zważone (W ± 0,1 g) i wypuszczone do wody. Dane zostały przeanalizowane z użyciem dwóch modeli regresji: liniowego ($W = bL + a$) oraz allometrycznego ($W = aL^b$). W każdym wypadku stwierdzono, że drugi model dużo lepiej opisuje zależność pomiędzy masą ciała a długością ryby. Ostatecznie wyznaczono następujące równania regresji: $W = 0{,}038L^{2{,}594}$ dla jelca ($r^2 = 0{,}937$), $W = 0{,}004L^{3{,}408}$ ($r^2 = 0{,}911$) dla strzebli potokowej oraz $W = 0{,}008L^{3{,}106}$ ($r^2 = 0{,}997$) dla pstrąga potokowego (tab. 1). Oszacowanie wszystkich parametrów było wysoce istotne ($P < 0{,}0001$). Uzyskane wartości parametru *b* przedyskutowano w kontekście danych literaturowych.