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RESEARCH ARTICLE

Length-weight relationship and morphometrics of *Osmerus eperlanus* populations from two lakes of northeastern Poland

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Abstract. This study provides the length-weight relationship (LWR) of European smelt (*Osmerus eperlanus*) occurring in two lakes in northeastern Poland. The morphometric characters of the two populations of this species in lakes Dargin and Dejguny were also compared. The LWRs were highly significant ($P < 0.05$) with a high coefficient of determination ($r^2 \geq 0.923$). The estimated *b* values ranged from 3.256 to 3.508. Sixteen of the 26 morphological characters measured differed between the two populations. No sexual dimorphism was observed. The research presents detailed data on the biometric characters of the species that contributes to the assessment of phenotypic plasticity and general morphological variation of the populations.

Keywords: fish, lakes, LWR, morphology, smelt

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Introduction

Fishes of the genus *Osmerus* have a near circumpolar distribution and inhabit areas with various ecological conditions (Nellbring 1989). European smelt (*Osmerus eperlanus*) is a small cold-water fish inhabiting marine waters, river estuaries, and large, deep lakes. In Poland, it occurs in both anadromous and lake forms (Heese 2000). It occurs abundantly in the Szczecin Lagoon, Gdańsk Bay, and the Vistula Lagoon. Its distribution in lakes is similar to that of fish of the genus *Coregonus*. However, it currently does not occur in many of the lakes that it previously inhabited naturally.

The length-weight relationship (LWR) is fundamentally important to fisheries science. Body length and weight are biometric data that are easily measured and are available from many monitoring study datasets (Zuchi et al. 2020). LWR values are used to determine body weight and biomass based on length data, to analyze species growth among regions and in different seasons of the year, and to track changes in growth patterns and fish population dynamics (Froese 2006, Tsionki et al. 2021). Biometric characters are used to determine variation in body shape and proportions among different populations and species. Morphometric variation among populations or stocks can provide the foundation of studies of

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short-term variations caused by the environment, and, therefore, they can be of wider use in fisheries management (Bronte and Moore 2007). The contribution of the present research to the knowledge of LWRs and morphometrics can be useful to fisheries management and the conservation of specific European smelt populations.

Material and methods

Lakes Dargin and Dejguny are located in the Great Masurian Lakes region. Lake Dargin is mesotrophic with a surface area of 3,030 ha, a maximum depth of 37.6 m, and a mean depth of 10.6 m. Lake Dejguny is also mesotrophic with a surface area of 765 ha, a maximum depth of 45 m, and a mean depth of 12 m. European smelt were caught in Lake Dargin in March 2018 with beach seine (10 mm mesh size, 200 m length), while in Lake Dejguny they were caught in September 2021 with pelagic multi-mesh gillnets (6.25–55 mm mesh size, 27.5 m length). These specimens were transported on ice to the laboratory. Morphometric characters were measured to the nearest 0.1 mm with a digital slide caliper; all measurements were recorded on the left side of the body. A total of 26 morphometric characters were analyzed as recommended by Pravdin (1966). Morphometric characters of male and female European smelt from Lake Dargin did not differ significantly statistically ($P > 0.05$), which is why the two sexes were analyzed together. The Mann-Whitney U test was used to determine significant differences in the morphometric characters of the fish caught in both of the lakes.

WLRs were calculated using the equation (Le Cren 1951) $W = a \times TL^b$, where a is the intercept and b is the slope of the logarithmically transformed equation. The outliers of the log (W) over log (TL) plot were removed, and a statistical significance level of r^2 was recorded (Froese 2006). ANOVA was used to evaluate the statistical significance of linear correlations.

Results

LWRs parameters and coefficient of determination (r^2) for European smelt from both lakes are presented in Table 1 and demonstrates positive allometric growth. All regressions were statistically significant ($P < 0.05$). The estimated values of b fluctuated from 3.256 (females from Lake Dargin) to 3.508 (males from Lake Dargin).

The morphometric characters of the European smelt from both of the lakes is presented in Table 2. Most of the morphometric characters differed significantly statistically in the two European smelt populations. Characters dependent on head length differed more frequently between these two populations.

Table 1
Length-weight relationships (LWRs) for smelt (*O. eperlans*) from different lake populations

			TL (cm)		BW (g)					
Lake	Sex	N	min	max	min	max	*a*	*b*	r^2	References
Miedwie (Poland)	Mixed	503	6.5	22.0	1.1	67.8	0.0014	3.540		Trzebiatowski and Gaj 1978
Dargin (Poland)	Male	32	9.1	18.3	2.5	32.6	0.0012	3.508	0.968	Present study
Dargin (Poland)	Female	28	9.8	17.3	3.7	27.5	0.0023	3.256	0.923	Present study
Dejguny (Poland)	Mixed	70	8.4	17.3	2.6	25.5	0.0022	3.321	0.943	Present study

Table 2
Morphometric data of European smelt (*O. eperlanus*) from lakes Dargin and Dejguny

	Dargin (n = 60)			Dejguny (n = 20)			
Character	mean	range	SD	mean	range	SD	P
TL (mm)	114.9	90.6-183.0	16.6	97.3	84.3-105.7	5.9	<0.05
FL (mm)	109.1	86.2-173.0	16.3	86.9	76.9-94.1	4.9	<0.05
SL (mm)	98.3	78.4-155.0	14.1	83.1	72.5-91.9	5.2	<0.05
Percentage of standard length							
Head length	22.4	15.7-27.0	3.8	19.5	16.1-22.7	1.8	<0.05
Predorsal distance	52.1	49.4-55.8	1.4	53.5	51.2-55.5	1.3	<0.05
Postdorsal distance	40.3	36.3-44.2	1.6	41.1	37.7-43.1	1.4	<0.05
Body depth	15.8	12.4-22.5	2.0	14.9	13.5-16.2	0.8	ns
Preanal distance	75.2	54.9-9-82.0	3.5	74.5	64.6-78.8	3.2	ns
Minimum body depth	5.2	4.4-6.4	0.4	5.1	4.5-5.9	0.4	ns
Caudal peduncle length	12.9	8.8-20.3	1.8	13.4	11.5-16.5	1.4	ns
C fin length	18.2	13.2-21.9	2.2	19.3	16.3-21.5	1.1	ns
P fin length	16.3	11.7-19.1	1.6	15.3	12.8-17.3	1.2	<0.05
V fin length	14.8	12.2-18.2	1.4	13.2	11.1-15.1	1.0	<0.05
D fin height	15.9	12.0-18.8	1.4	15.6	14.1-16.9	0.8	ns
A fin height	9.6	6.7-12.7	1.3	9.4	7.5-11.1	0.9	ns
D fin base length	7.1	5.0-9.4	0.9	7.4	6.6-8.5	0.6	ns
A fin base length	11.7	6.8-23.9	2.6	10.5	7.3-13.2	1.8	ns
P-V distance	32.8	27.6-46.6	2.7	29.1	26.1-32.0	1.5	<0.05
V-A distance	24.1	10.7-33.4	2.8	26.2	21.9-35.3	3.4	<0.05
Adipose fin length	4.0	2.1-5.3	0.7	3.1	2.3-4.1	0.5	<0.05
Percentage of head length							
Preorbital distance	30.7	24.8-59.2	4.6	26.3	22.2-30.3	2.3	<0.05
Eye diameter	26.3	18.3-34.9	3.8	22.7	20.1-26.0	1.5	<0.05
Postorbital distance	48.4	40.5-62.6	4.5	49.8	45.6-55.8	2.7	ns
Head depth	48.0	37.5-65.1	5.4	39.7	36.9-44.5	1.7	<0.05
Head width	32.4	23.4-43.5	4.7	24.4	21.2-28.4	1.8	<0.05
Mandible length	44.2	30.8-62.9	6.7	31.1	23.1-36.8	3.4	<0.05

Discussion

European smelt inhabit marine waters, estuaries, and large lakes. The species is slow growing and has a short life cycle. However, this species is important locally for fisheries because of its shoal distribution (Sterligova and Ilmast 2017, Sendek and Bogdanov 2019, Tammiksaar and Kangur 2020). LWR values are an important tool for fisheries management and scientists for comparing, for example, the condition and population growth of fish populations (Verreycken et al. 2011). The value of exponent *b* is usually close to 3, but it can fluctuate from 2 to 4. A value of 3 indicates that fish are growing symmetrically or isometrically, while values other than 3 indicate allometric growth. LWR values have been determined rarely for European smelt. FishBase (Froese and Pauly 2021) only has data for three locations. These indicate that European smelt exhibits allometric growth. The value of exponent *b* for the populations analyzed in the present research was

similar to that of the population in Lake Miedwie (Trzebiatowski and Gaj 1978).

Fish exhibit higher variation in morphometric characters both within and among populations than do other vertebrates, and they are more susceptible to environmentally induced morphological variation. Not a lot of biometric data are available from studies on European smelt (Shpilev et al. 2005), especially those concerning to lake populations (Rembiszewski 1970). Populations in Poland exhibit significant variation in head length, caudal peduncle height and length, and anal fin height (Rembiszewski 1970). In comparison to that of Lake Dejguny, the population from Lake Dargin had larger body sizes and relatively longer heads. These differences affected some of the characters regarding head shape. However, caudal peduncle length and the smallest body depth were similar in the smelt inhabiting both of the lakes. The morphometric differentiation determined in the samples from both of the lakes suggested a link between the range of morphometric differentiation and environmental separation. Lake Dejguny is smaller and more isolated, while Lake Dargin is part of a larger lake complex with a combined surface area of nearly 102.8 km^2. The differences noted in European smelt populations from lakes that differ environmentally probably stems from the high degree of plasticity in this species.

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