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# LENGTH-WEIGHT RELATIONSHIP OF BROWN TROUT (*SALMO TRUTTA*) FROM DIFFERENT RIVER SYSTEMS IN SERBIA

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**Abstract:** The study investigates the length-weight relationships of seven brown trout populations in Serbia. The *b* values range from 2.710 to 3.373, indicating isometric growth in one population, negative allometry in three populations, and positive allometry in another three populations. A comparison with the previous studies shows that growth patterns are generally consistent across the analyzed Serbian populations. However, local environmental conditions and population characteristics may lead to specific growth differences within these river systems.

**Keywords**: *Salmo trutta*, Danube drainage, Length–weight relationships, fisheries management

## Introduction

Brown trout *Salmo trutta* L. is a widespread salmonid species native to Eurasia and North Africa (Behnke, 1986). It represents one of the most culturally, economically, and ecologically important taxa of freshwater fishes (Kershner et al., 2019). Brown trout is characterized by the existence of numerous divergent local populations (Baric et al., 2010) and in response to the ecological heterogeneity of the environment shows remarkable morphological and ecological plasticity, even in a small geographical area (Lobón-Cerviá, 2018). However, despite their high diversity and the presence of distinct, locally specific brown trout populations, brown trout stocks in Serbia have been severely depleted (Veličković et al., 2024).

Length–weight relationships (LWRs) were originally used to provide information on the fish condition and to determine whether the somatic growth was isometric or allometric (Le Cren, 1951; Ricker, 1975). The LWRs are of

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significant relevance in fisheries sciences and management (Mouludi-Saleh et al., 2023), facilitating future studies of fish populations and stocks (Mehanna and Farouk, 2021). In addition, LWRs are a vital tool for stock distinction, ecological models, yield and biomass prediction (Froese, 2006) and contribute baseline data for conservation measures (Ortega-García et al., 2017).

The present study aims to calculate the LWRs for the brown trout from the different river systems on the territory of Serbia.

## Materials and methods

Field research was carried out during 2016. One hundred and forty brown trout specimens were sampled from seven rivers in the Danube drainage on the territory of Serbia (Table 1). Fish sampling was performed using the electrofishing method (Aquatech IG 1300, AquaTech, Kitzbühel, Austria; SRPS, 2008). Specimens were identified according to Kottelat and Freyhof (2007) and measured to the nearest 1 mm (total length, L) and weighed to the nearest 0.1 g (weight, W).

Table 1. Sampling locations in Serbia. Details of samples: *No* – numerical code, population, river system, geographical coordinates.

| *No* | *Population* | *River System* | *Coordinates* |
|---|---|---|---|
| 1 | Ljubovića | Drina | 44°14'11.4" N, 19°28'26.9" E |
| 2 | Gradac | Kolubara | 44°14'59.1" N, 19°53'07.1" E |
| 3 | Đetinja | West Morava | 43°51'47.2" N, 19°37'47.9" E |
| 4 | Visočica | South Morava | 43°10'15.6" N, 22°46'48.9" E |
| 5 | Resava | Great Morava | 44°06'02.0" N, 21°26'14.0" E |
| 6 | Mlava | Danube | 44°15'39.3" N, 21°32'58.3" E |
| 7 | Janjska River | Timok | 43°25'31.8" N, 22°31'07.2" E |

Length–to–weight relationship for total body weight was calculated using the equation $W = aL^b$, where W is the total weight (expressed in grams), L is the total length (expressed in centimetres), $a$ is a coefficient related to body form and $b$ is an exponent indicating isometric growth when equal to 3. The parameters $a$ and $b$ were estimated by linear regression on the transformed equation: $\log(W) = \log(a) + b \log(L)$ (Koutrakis and Tsikliras, 2003).

## Results and discussion

Length–weight relationship is an important tool in fishery biology as it provides general information about the morphology of populations in different habitats (Froese et al., 2011). Brown trout fishery management depends on both habitat and population characteristics of brown trout stocks, whose interaction with life-history traits determines how effectively brown trout realize the growth and reproductive potential of their home streams (Simonović et al., 2020).

The length-weight relationships of analyzed brown trout specimens from the territory of Serbia are presented in Table 2.

Table 2. Descriptive statistics and estimated parameters of brown trout length-weight relationships. *N* – number of analyzed specimens; Min TL – minimum values of Total Length; Max TL – maximum values of Total Length; *a* and *b* – parameters of the equation; SE (*b*) – standard error of *b*; $r^2$ – coefficient of determination.

| Population | *N* | Min TL | Max TL | *a* | *b* | SE (*b*) | $r^2$ |
|---|---|---|---|---|---|---|---|
| 1. Ljubovića | 20 | 16.5 | 26.5 | 0.007 | 3.108 | 0.202 | 0.957 |
| 2. Gradac | 20 | 14 | 36.5 | 0.012 | 2.951 | 0.093 | 0.983 |
| 3. Đetinja | 20 | 13.9 | 37 | 0.010 | 3.004 | 0.104 | 0.979 |
| 4. Visočica | 20 | 10.5 | 24.7 | 0.017 | 2.833 | 0.127 | 0.966 |
| 5. Resava | 20 | 11.4 | 24.2 | 0.004 | 3.373 | 0.097 | 0.985 |
| 6. Mlava | 20 | 10.8 | 37 | 0.006 | 3.186 | 0.057 | 0.994 |
| 7. Janjska River | 20 | 11.7 | 19.6 | 0.220 | 2.710 | 0.124 | 0.964 |

The LWR parameters indicate variations in growth patterns among the studied populations (Table 2). The LWR is influenced by factors such as season, habitat, gonad maturity, sex, diet, stomach fullness, and health (Bagenal and Tesch, 1978; Jan et al., 2018). The *b* value of length-weight relationships provides insight into fish growth, indicating isometric growth when $b = 3$, positive allometry when $b > 3$, and negative allometry when $b < 3$ (Tarkan et al., 2009). Positive or negative allometry suggests a rounder or slimmer body shape, respectively, while isometric growth implies proportional body growth across all dimensions (Jobling, 2008). In the analyzed specimens the expected range of $2.5 < b < 3.5$ is confirmed (Froese, 2006). The *b* values range from 2.710 to 3.373 indicating isometric growth in one population, negative allometry in three populations, and positive allometry in another three populations (Table 2). The highest *b* value (3.373) at Resava River suggests greater weight gain relative to length, whereas the lowest value (2.710) at Janjska River indicates a slower weight increase. While Gonçalves et al. (1997) and Ozaydin and Taskavah (2007) note that *b* values can fluctuate seasonally and across habitats, the similarity in *b*-value ranges between this study (2.710 – 3.373) and Simonović et al. (2020) (2.574 – 3.297) suggests a broadly consistent LWR pattern across different Serbian streams. These findings indicate that growth patterns in brown trout are shaped by ecological conditions, such as food availability, water temperature, and interspecific competition, explaining the slight variations in *b* values across different localities. Moreover, density-dependent growth effects, as described by Simonović and Nikolić (2007), suggest that lower population densities promote higher growth rates, reinforcing the importance of population dynamics in LWR variations.

The coefficient of determination ($r^2$) values are all high (> 0.95), confirming a strong fit of the LWR model. The standard error of *b* varies among populations, with the lowest value observed in the Mlava population (*SE* = 0.057), indicating the most precise estimation of this parameter in this population.

Differences in minimum and maximum Total Lengths across studied locations further highlights variability in population structures, likely influenced by environmental and ecological factors.

A recent study by Veličković et al. (2024) showed that many brown trout populations on the territory of Serbia have low sustainability. Therefore, expanding research in the direction provided in the present study will provide valuable insights into population dynamics and contribute to more effective management strategies. Future studies should also include a broader range of localities for more comprehensive comparisons.

## Conclusion

The analysis of brown trout populations across various streams in different river systems in Serbia provides insights into their growth patterns. The results of estimated *b* values suggest variability in growth dynamics among populations, which local environmental factors, biological interactions, or sample characteristics may influence. While the observed *b* values remain within biologically reasonable limits, further research incorporating population characteristics (e.g. diet, population density, sex, health) and habitat parameters (e.g. stream width and depth, water conductivity, oxygen content, pH) would be necessary to fully understand the ecological drivers of these growth patterns.

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