# Length–weight relationship of brown trout in selected rivers of the West Morava River system (Serbia)

**Tijana Z. Veličković[1], Aleksandra M. Milošković[2]*, Milena D. Radenković[1], Nataša M. Kojadinović[1], Đorđe D. Gajić[3], Vladica M. Simić[1]**

[1] University of Kragujevac, Faculty of Science, Department of Biology and Ecology, Radoja Domanovića 12, 34000 Kragujevac, Serbia;
[2] University of Kragujevac, Institute for Information Technologies, Department of Science, Jovana Cvijića bb, 34000 Kragujevac, Serbia
[3] University of Belgrade, Faculty of Biology, Studentski trg 16, 11000 Belgrade, Serbia

* Corresponding author aleksandra@uni.kg.ac.rs
DOI: 10.46793/ICCBIKG25.364V

**Abstract**: This study investigates the length–weight relationships of brown trout from five rivers in the Golija Nature Park within the West Morava River system in Serbia. The calculated *b* values ranged from 2.881 to 3.947, indicating a spectrum of growth types: negative allometric, isometric, and positive allometric, while all coefficients of determination exceeded 0.9, confirming strong model fits. These differences in growth types likely reflect local habitat conditions, food availability, and density-dependent factors. Notably, the analysis revealed that certain populations exhibit slower weight gain relative to length, which may be a sign of environmental stress or reduced food availability. In light of recent assessments showing that a significant portion of trout populations in this region are of low or critically low sustainability, our findings underscore the urgency of site-specific monitoring. The results contribute to establishing a reference framework for future conservation efforts.

**Keywords**: *Salmo trutta*, length–weight relationships, Golija, Serbia, fish ecology

## 1. Introduction

In the context of increasing anthropogenic pressures on freshwater ecosystems the conservation of aquatic species requires detailed knowledge of local population characteristics [1]. This includes understanding growth dynamics, which are influenced by both biological traits and extrinsic environmental conditions. Moreover, population-specific growth patterns through length–weight relationships (LWRs) can provide crucial insights for species monitoring and management [2, 3]. Length–weight relationships are used to infer fish condition, somatic growth (isometric or allometric), and aid in ecological modeling, biomass estimation, and conservation planning [4, 5].

Brown trout (*Salmo trutta* L.) is one of the most ecologically and economically important salmonid species, naturally distributed across Eurasia and North Africa [6], including the Balkan Peninsula. This species displays significant ecological and

morphological plasticity even within short geographical distances [7]. However, recent research has highlighted concerning trends of population decline and low sustainability across Serbia, with particularly alarming developments observed within designated protected areas, such as the Golija Nature Park [8].

This study reports the LWRs of brown trout collected from five tributaries belonging to the West Morava River system, situated within the Golija Nature Park, with the goal of contributing baseline data for future conservation and fisheries management efforts.

## 2. Methodology

Field sampling was carried out in 2019, during which 90 brown trout specimens were collected from five tributaries of the West Morava River within the Golija Nature Park in Serbia (Table 1). The fish were sampled using the electrofishing method (Aquatech IG 1300, AquaTech, Kitzbühel, Austria) [9]. Specimens were identified [10], measured to the nearest millimeter for total length (L) and weighed to the nearest gram for total weight (W).

The relationship between length and weight for the total body weight was computed using the equation: $W = aL^b$, where W denotes total weight (expressed in grams) and L denotes total length (expressed in centimeters). The coefficient $a$ pertains to body form, while $b$ is an exponent reflecting isometric growth when equal to 3. The parameters $a$ and $b$ were estimated through linear regression based on the transformed equation: $\log(W) = \log(a) + b \log(L)$ [4].

## 3. Results and Discussion

Understanding population-specific growth patterns is very useful for assessing ecological status and defining conservation priorities for brown trout [11, 12]. Growth parameters such as the LWRs offer insights into the ecological conditions, physiological responses, and overall health of populations.

While recent research [13] calculated LWRs for several brown trout populations, including the Đetinja River within the West Morava system, this study extends the analysis to its previously unexamined tributaries. This broader geographic coverage allows for a more comprehensive understanding of intraspecific growth variation, especially given the reported low sustainability of brown trout populations in Serbia [8].

Table 1 presents the descriptive statistics and LWR parameters for five analysed brown trout populations. The values of the exponent $b$ ranged from 2.881 to 3.947, indicating a spectrum of growth types: negative allometric ($b < 3$), isometric ($b \approx 3$), and positive allometric ($b > 3$). These differences likely reflect environmental variation, food availability, hydrological conditions, and interpopulation structure [3, 14, 15].

**Table 1**. Sampling locations, 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*) | $r^2$ |
|---|---|---|---|---|---|---|---|
| Studenica | 19 | 7.8 | 20.0 | 0.0009 | 3.947 | 0.318 | 0.901 |
| Brevina | 19 | 9.0 | 18.5 | 0.00137 | 3.732 | 0.023 | 0.999 |
| Brvenica | 14 | 11.0 | 25.0 | 0.00745 | 3.085 | 0.039 | 0.998 |
| Golijska River | 19 | 8.0 | 23.8 | 0.0021 | 3.512 | 0.049 | 0.997 |
| Brusnička River | 19 | 9.5 | 25.0 | 0.01362 | 2.881 | 0.034 | 0.998 |

The highest *b* value was recorded in the Studenica population, indicating strong positive allometric growth, though with the lowest model fit ($r^2$ = 0.901; SE = 0.318; Table 1), suggesting variability in the data, likely due to unbalanced size-class representation. Conversely, the Brevina population showed consistent results (*b* = 3.732; $r^2$ = 0.999), indicating stable growth conditions and high model reliability. Populations from Brvenica and Golijska River demonstrated near-isometric to moderately positive allometric growth, respectively, with excellent model fits ($r^2$ > 0.99; Table 1). The Brusnička River population displayed the lowest *b* value (Table 1), suggesting negative allometry, possibly influenced by limited resource availability. These findings are consistent with the density-dependent growth mechanisms observed by Simonović & Nikolić [12] in Serbian streams, where higher growth rates are linked to lower population densities. The variation in *b* values among sites likely reflects differences in stream productivity, density dependence, or ecological pressures such as temperature regimes and substrate composition. For instance, populations inhabiting less disturbed or spring-fed streams often show more consistent and higher *b* values, while those from degraded or intermittently stressed habitats exhibit signs of growth limitation [11].

## 4. Conclusions

Understanding the length–weight relationships of brown trout across different habitats offers more than just insight into growth patterns—it reflects the broader health of freshwater ecosystems. Given the increasing anthropogenic pressures and signs of population instability even in the protected areas across Serbia, such studies are crucial for informing conservation priorities. Moving forward, integrating biometric data with genetic, ecological, and habitat-quality assessments will be key to designing effective management strategies tailored to each local population. This approach can serve as a model for freshwater fish conservation in other vulnerable river systems.

## Acknowledgment

This research is funded by the Ministry of Education and Ministry of Science, Technological Development and Innovation, Republic of Serbia, Grants: No. 451-03-136/2025-03/200378 and 451-03-136/2025-03/200122.

## References


[1] D. Dudgeon, A.H. Arthington, M.O. Gessner, Z.I. Kawabata, D.J. Knowler, C. Lévêque, C.A. Sullivan, *Freshwater biodiversity: importance, threats, status and conservation challenges*, Biological Reviews, 81 (2006) 163–182.

[2] E.D. Le Cren, *The length–weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis)*, Journal of Animal Ecology, 20 (1951) 201–219.

[3] R. Froese, *Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations*, Journal of Applied Ichthyology, 22 (2006) 241–253.

[4] E.T. Koutrakis, A.C. Tsikliras, *Length–weight relationships of fishes from three northern Aegean estuarine systems (Greece)*, Journal of Applied Ichthyology, 19 (2003) 258–260.

[5] S. Ortega-García, C. Sepúlveda, S. Aalbers, U. Jakes-Cota, R. Rodríguez-Sánchez, *Age, growth, and length-weight relationship of roosterfish (Nematistius pectoralis) in the eastern Pacific Ocean*, Fishery Bulletin, 115 (2017) 117–124.

[6] R.J. Behnke, *Brown trout*, Trout, 27 (1986) 42–47.

[7] J. Lobón-Cerviá, *Introduction: Princess of the streams: The brown trout Salmo trutta L. as aquatic royalty*, In: J. Lobón-Cerviá and N. Sanz (Eds.), Brown trout: Biology, Ecology and Management, Wiley, New York, USA (2018) 17–63.

[8] T. Veličković, S. Marić, D. Stanković, A. Milošković, M. Radenković, R. Šanda, J. Vukić, S. Đuretanović, N. Kojadinović, M. Jakovljević, V. Simić, *Sustainability assessment of brown trout populations in Serbia (Central Balkans) using the modified ESHIPPO Model*, Fishes, 9(11) (2024) 423.

[9] SRPS EN 14011, Water quality — *Sampling of fish with electricity*, Institute for Standardization of Serbia (2008).

[10] M. Kottelat, J. Freyhof., *Handbook of European freshwater fishes*, Kottelat, Cornol, Switzerland and Freyhof, Berlin, Germany (2007).

[11] K.M. Myrvold, B.P. Kennedy, *Density dependence and its impact on individual growth rates in an age-structured stream salmonid population*, Ecosphere, 6 (2015) 1–16.

[12] P. Simonović, V. Nikolić, *Density-dependence of growth characteristics and maturation in stream-dwelling resident brown trout, Salmo trutta*, in Serbia, Fisheries Management and Ecology, 14 (2007) 1–6.

[13] T. Veličković, S. Marić, M. Radenković, A. Milošković, Đ. Gajić, P. Simović, V. Simić, *Length–weight relationship of brown trout (Salmo trutta) from different river systems in Serbia*, 3rd International Symposium on Biotechnology, Faculty of Agronomy in Čačak, University of Kragujevac (2025) 363–368.

[14] M. Jobling, *Environmental Biology of Fishes*, Fish & Fisheries Series Vol. 16, Springer Netherlands, Dordrecht (1994).

[15] P. Simonović, A. Marić, D. Škraba Jurlina, T. Kanjuh, V. Nikolić, *Determination of resident brown trout Salmo trutta features by their habitat characteristics in streams of Serbia*, Biologia, 75 (2020) 103–114.