sustainability

MDPI

*Article*

# Floodplains as a Suitable Habitat for Freshwater Fish: The Length–Weight Relationships and Condition Factors of Fish Inhabiting a Danube Floodplain in Croatia

**Nera Vuić [1], Ivana Turković Čakalić [1], Miran Koh [1], Viktorija Ergović [1], Barbara Vlaičević [1], Matej Šag [1], Vlatko Rožac [2] and Dubravka Čerba [3,*]**

1 Department of Biology, Josip Juraj Strossmayer University of Osijek, Cara Hadrijana 8/A, 31000 Osijek, Croatia; nera.vuic@biologija.unios.hr (N.V.); iturkovic@biologija.unios.hr (I.T.Č.); miran.koh@biologija.unios.hr (M.K.); viktorija.ergovic@biologija.unios.hr (V.E.); barbara.vlaicevic@biologija.unios.hr (B.V.); msag@biologija.unios.hr (M.Š.)
2 Public Institution Kopački Rit Nature Park, Mali Sakadaš 1, 31327 Kopačevo, Croatia; vlatko.rozac@pp-kopacki-rit.hr
3 Department of Assessment and Aquatic Ecosystems Research, National Water Reference Laboratory of Slovakia, Water Research Institute, Nábr. arm. gen. L. Svobodu 5(7), 81249 Bratislava, Slovakia
* Correspondence: dubravka.cerba@vuvh.sk

**Abstract:** When studying the well-being and fitness of ichthyofauna in a specific area, vital information comes from length–weight relationships (LWRs) and condition factor analyses and calculations. Data were collected from 2015 to 2019 in an area important for fish shelter, feeding, and spawning. Twenty four species belonging to 10 different families were identified from the total 16,895 of caught individuals, with the most abundant species being *Blicca bjoerkna*. The calculation of LWRs was possible for 19 species, ($R^2$ = 0.7049–0.9998 ($p$ < 0.05)), with the values of the mean coefficient $b$ ranging from 2.6831 to 3.5747, indicating an overall positive allometric growth in the fish population. The results of Fulton's and the relative condition factors showed that a total of eight species were in a relatively good condition, although the species in question varied between the two condition factors. Fulton's condition factor showed the highest average value for *Lepomis gibbosus* (1.4956), while *Cobitis elongatoides* had the lowest (0.4739). Contrarily, the relative condition factor showed the highest average value for *Silurus glanis* (1.0524), and the lowest for *Gymnocephalus cernua* (1.0023). The lower values of calculated condition factors in some species could be attributed to sampling being conducted during the colder months of autumn and winter. Future studies should include seasonal sampling in order to achieve a better understanding how various abiotic factors impact the condition factors of these fish species. Nevertheless, this research provided valuable data on the status of the fish population in the floodplain and could be used as a guideline for designing future ichthyofauna studies in this area.

**Keywords:** positive allometric growth; Fulton's factor; relative condition factor; *Blicca bjoerkna*; Kopački Rit; ichthyofauna



**Citation:** Vuić, N.; Turković Čakalić, I.; Koh, M.; Ergović, V.; Vlaičević, B.; Šag, M.; Rožac, V.; Čerba, D. Floodplains as a Suitable Habitat for Freshwater Fish: The Length–Weight Relationships and Condition Factors of Fish Inhabiting a Danube Floodplain in Croatia. *Sustainability* **2024**, *16*, 7566. https://doi.org/10.3390/su16177566

Academic Editors: Vesna Djikanović and Vera P. Nikolić

Received: 22 July 2024
Revised: 28 August 2024
Accepted: 29 August 2024
Published: 1 September 2024



## 1. Introduction

When it comes to the assessment of the various biological, physiological, and ecological characteristics of fish, one mode of measurement has proven to be ever present in fishery studies: the length–weight relationship (LWR) measurement [1]. In fact, data of fish length–weight relationships have been used to monitor fish population dynamics [2], to compare fish populations in different habitats [3], to acquire insights into the health [4] and condition of fish populations [5,6], and even to study the impact of pollutants [7] and parasitism [8] on fish health. Furthermore, the values of length–weight relationships can vary depending on the season and can be affected by changes in environmental conditions, as well as physiological changes such as gonad development [9,10]. The ubiquity of LWR analysis stems partly from its practicality in fieldwork research as it reduces the time and work needed to collect an adequate amount of data on sampled fish by using measured length data to calculate fish weight [11]. Additionally, LWR data can also be used to calculate fish biomass [9,11], which is useful in fish stock assessments [12].

Another important biometric tool in fish ecology is the condition factor, which is primarily used to obtain information about the current well-being of individual fish or the species' population [13]. It is based on the assumption that heavier fish are in a better physiological condition [14], i.e., they are able to feed better and accumulate a greater amount of energy reserves compared to lighter fish of the same length [15]. This kind of logic makes it apparent that fish condition factors are heavily influenced by various biotic and abiotic elements, such as predation, competition, and parasitism, as well as habitat conditions and seasonal fluctuations [16]. There are several different ways to evaluate the condition of fish, with Fulton's condition factor (K) being one of the most prominent in fishery studies [17]. The value of Fulton's condition factor varies with the changes in the nutritional condition of the fish [18] and assumes that the shape of the measured fish does not change with its increase in size [17].

Another type of measurement is the relative condition factor ($K_n$). It shows the deviation of the observed weight of an individual from the average weight calculated via linear regression of the LWR of a collective population sample [10]. While Fulton's condition factor always assumes isometric growth (the fish body shape does not change with growth, but instead follows the cube law), the relative condition factor takes into account the potential deviation of the ideal fish body shape as it increases in size (positive or negative allometric growth) [15,19]. This makes it possible to use the index for comparisons between fish individuals of different lengths and even different species. On the other hand, comparisons between different fish populations are impossible, because a new length–weight regression calculation is needed for every sample of a population within a study [20].

Fish are known to utilize the unique and nutrient-rich habitats of dynamic floodplain ecosystems as feeding, spawning, and nursery grounds, oftentimes leading to a high diversity of fish species in those areas [21–23]. One such important area in Croatia is found within the Kopački Rit Nature Park, which, along with being a floodplain of the rivers Drava and Danube, bears characteristics of a wetland and an inner delta [24]. Kopački Rit is a well-protected floodplain area in the Danubian basin, and its importance is internationally recognized through its inclusion in Natura 2000, as well as the Ramsar and the Important Bird Areas lists [25–29]. One section of the park is also classified as a Special Zoological Reserve. As expected, numerous ichthyofauna studies have been carried out in Kopački Rit throughout the years [30–36], with the latest data confirming the presence of over 50 fish species [36], some of which are classified as endemic to the Danube basin [27]. Despite the rigorous amount of research put into the analysis of fish biodiversity, little to no effort has been put into research and documentation of the condition factor and length–weight relationships of fish species residing in this important floodplain area.

Since information on length–weight relationships and condition factors is crucial for assessing fish biology (i.e., growth patterns, physiology, and health status in general) which helps in the monitoring and management of fish populations, the main goal of this study was to document novel information about the length–weight relationships and condition factors of fish residing in the Kopački Rit Nature Park, along with the additional documentation of fish species and their population numbers.

## 2. Materials and Methods

### *2.1. Study Area*

The Kopački Rit Nature Park is a well-protected floodplain area in the northeastern part of Croatia, situated in-between two large rivers: Drava and Danube (Figure 1). The flooding regime of Kopački Rit is thus determined by these two surrounding rivers, the

Drava and Danube rivers, with the latter having the highest impact on flooding. As such, the inundation area is comprised of various water bodies, some of which are temporarily filled with water, while others, such as shallow lakes, riverside arms, and channels, are permanent [27]. Most of the lakes and ponds in this area are remnants of the river bed, although some are also products of erosion caused by water withdrawal [27]. During flooding, water from the Danube river enters the area at two sides: the northern, through the river's sidearm, Vemeljski Dunavac, and the southern, through the Hulovo channel [24,25,37]. A system of natural earth barriers separates the northern and southern parts, but once the Danube river's water level at the Apatin gauging station increases above 82.50 m a.s.l., the water overflows, connecting the two sides [24]. The dynamics of flooding and subsequent water withdrawal in this area are responsible for the formation of numerous habitats, able to support more than 2000 recorded species [24]. In total, the floodplain area covers a surface of around 180 km$^2$, making it one of the largest conserved floodplains of the Danube [37]. Permanent water bodies, located mostly in the southern part within the Special Zoological Reserve, are especially important to fish as they provide suitable spawning areas for individuals residing within the floodplain, and for individuals who migrate from the Drava and Danube rivers [27].

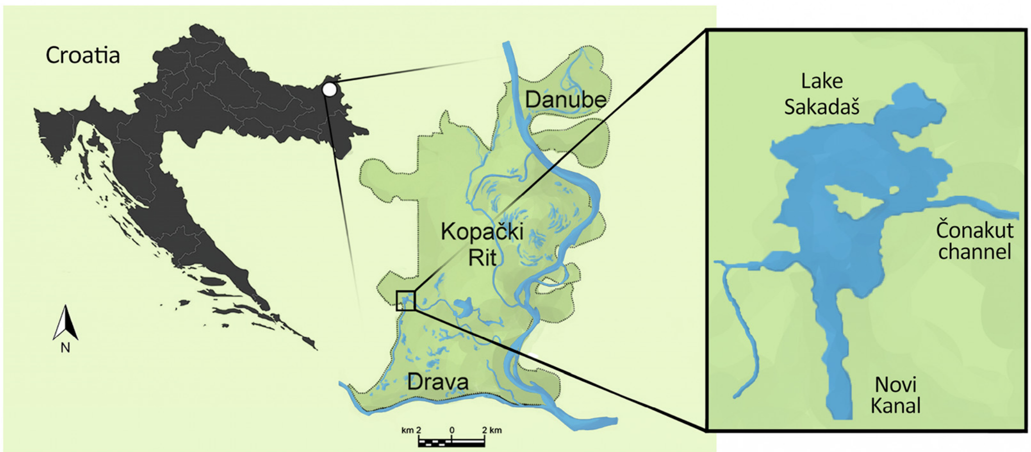


**Figure 1.** The sampling area in the Kopački Rit Nature Park floodplain.

## *2.2. Sampling*

The sampling sites included three different permanent water bodies within the Kopački Rit Nature Park: Lake Sakadaš and the channels Čonakut and Novi Kanal (Figure 1). These water bodies have been shown to be optimal sampling points in terms of net casting and the diversity of fish taxa found, and they have been used in previous ichthyofauna research [34,36,38]. The sampling of the fish was conducted in September and December during the period of 2015 to 2019, excluding the December sampling for the years 2018 and 2019 due to the water at the sampling sites being frozen. Water levels within the wetland during these months are not as prone to extreme changes as they are during the early spring and summer months [39], which makes for a stable and optimal time for fish sampling. This amounted to a total of eight samples, two samples for each of the years 2015–2017, and one sample for 2018 and 2019, respectively.

Gill nets and traditional trap nets of different sizes/lengths and mesh sizes were used. Each net was positioned at designated locations within the mentioned sampling sites and left overnight for a total of 12 h. Afterwards, the captured fish individuals were isolated, counted, and the species were identified based on their morphological characteristics. Using an ichthyometer, the total length (TL) and standard length (SL) of all fish individuals were measured, while the weight of the fish (m) was measured using a digital scale Sirius electronic scale.

The taxonomy and nomenclature of all fish sampled in this study were checked using the FishBase database [40].

*2.3. Length–Weight Relationship*

The measured total length and weight data of the species represented by more than 10 sampled individuals were used to calculate the relationship between the length and weight using the $W = aL^b$ equation [10,41]. In the aforementioned formula, the W represents the calculated weight expressed in g, L is the measured total length in cm, while $a$ is the intercept, and $b$ is the slope. The $a$ and $b$ parameters were calculated using a linear regression analysis of the log-transformed formula $\log(W) = \log(a) + b \log(L)$ [10]. Following the recommendations of Froese [42], any of the visible outliers in the length–weight data, whose values did not follow the general trend of the remaining prevalent data, were removed. The species' length–weight relationship was firstly assessed for each of the sampling seasons, after which the mean value was calculated from all the available $a$ and $b$ parameters (max eight per species). All of the LWR regression calculations were performed using the Microsoft Excel software (Microsoft Office 2016, version 2407) [43]. The calculated $b$ parameter was further used to determine the growth type of a fish (positive/negative allometric or isometric) by using the confidence intervals (CI) to test whether the calculated $b$ value was significantly different from the predicted $b$ value, indicating isometric growth ($b = 3$) where the isometry null hypothesis (H0: $b = 3$) was rejected at a 5% significance level. The isometric type of growth assumes the fish increases equally in length and weight as it grows. On the other hand, if the fish were to increase more in length than in weight during their growth, they would have a negative allometric growth ($b < 3$). If they increased more in weight than in length, a positive allometric growth would be assumed ($b > 3$) [44].

*2.4. Condition Factors*

Two condition factors were used to evaluate the well-being of fish in this study: Fulton's condition factor and the relative condition factor. Fulton's condition factor (K) was calculated using the equation $K = (W \times 100)/TL^3$, where W is the weight of the fish expressed in g and TL is the measured total length of the fish in cm [45]. The equation used for the calculation of the relative condition factor ($K_n$) was $K_n = W/aL^b$ [10], in which W represents the measured weight of the fish in g, and $aL^b$ is the predicted weight of the fish in g at a given length ($a$ and $b$ are the parameters obtained through the assessment of length–weight relationships and L is the measured total length in cm) [42]. All the condition factor data were tested for homogeneity using the Shapiro–Wilk test and for variance using the parametric F-test or non-parametric Fligner–Kileen test. Furthermore, to compare the calculated mean values of Fulton's condition factors and relative condition factors with 1, a parametric one-sample t-test or a non-parametric one-sample Wilcoxon signed rank test was used [46].

*2.5. Statistical Analysis*

All statistical analyses were conducted in R 4.3.1 version, using the package "stats" 4.0.2. version, and were considered significant at 5 % ($p < 0.05$) [47].

## 3. Results

During the study period, a total of 16,895 fish individuals were collected, amounting to 698.25 kg. These values varied yearly, with the total weight per sample ranging from a minimum of 56.432 kg to a maximum of 228.955 kg, and the total number of individuals per sample ranging from 1165 to 6727 individuals. In total, 24 fish species belonging to 10 different families were recorded in this study (Table 1). With a total of ten species, the family Leuciscidae was represented with the highest diversity, followed by the Percidae and Cyprinidae families, represented with five and two identified species, respectively. Each of the remaining seven families included just one species. The most abundant species was *Blicca bjoerkna* with 5564 sampled individuals, followed closely by *Carassius gibelio* (4530), and *Alburnus alburnus* (3078). On the other hand, only one individual of *Chondrostoma nasus* was recorded, making it the species with the lowest number of sampled individuals in this study.

**Table 1.** The minimum, maximum, and mean ± SD of the measured total lengths and weights of all sampled fish species at the three sampling stations in Kopački Rit from 2015 to 2019.

| Family | Species | N | Total Length Range [cm] | | | Total Weight Range [g] | | |
|---|---|---|---|---|---|---|---|---|
| | | | Min | Max | Mean | Min | Max | Mean |
| CENTRARCHIDAE | *Lepomis gibbosus* (Linnaeus, 1758) | 165 | 4.5 | 11.2 | 6.7 ± 1.2 | 1.1 | 26.0 | 5.1 ± 3.8 |
| COBITIDAE | *Cobitis elongatoides* (Băcescu and Mayer, 1969) | 7 | 8.6 | 10.0 | 9.3 ± 0.5 | 3.0 | 6.0 | 3.9 ± 1.1 |
| CYPRINIDAE | *Carassius gibelio* (Bloch, 1782) | 4530 | 3.5 | 44.4 | 9.9 ± 9.1 | 1.0 | 1535.0 | 100.9 ± 274.5 |
| | *Cyprinus carpio* (Linnaeus, 1758) | 515 | 4.0 | 28.0 | 9.6 ± 2.9 | 1.1 | 305.0 | 14.0 ± 10.7 |
| GOBIONIDAE | *Pseudorasbora parva* (Temminck and Schlegel, 1846) | 899 | 4.9 | 11.7 | 7.8 ± 0.9 | 1.1 | 13.0 | 3.9 ± 1.6 |
| ESOCIDAE | *Esox lucius* (Linnaeus, 1758) | 49 | 23.2 | 73.2 | 47.1 ± 9.6 | 75.0 | 3000.0 | 940.4 ± 560.8 |
| ICTALURIDAE | *Ameiurus nebulosus* (Lesueur, 1819) | 21 | 9.6 | 24.5 | 18.7 ± 2.4 | 12.0 | 214.0 | 107.9 ± 44.7 |
| LEUCISCIDAE | *Abramis brama* (Linnaeus, 1758) | 64 | 4.8 | 45.5 | 10.4 ± 6.1 | 1.1 | 1415.0 | 32.4 ± 182.6 |
| | *Alburnus albidus* (Costa, 1838) | 5 | 11.2 | 13.2 | 12.3 ± 0.8 | 8.2 | 24.2 | 16.9 ± 6.2 |
| | *Alburnus alburnus* (Linnaeus, 1758) | 3078 | 5.5 | 16.6 | 9.3 ± 1.8 | 1.0 | 30.0 | 5.4 ± 3.7 |
| | *Leuciscus aspius* (Linnaeus, 1758) | 335 | 8.0 | 69.0 | 20.1 ± 11.6 | 3.0 | 3765.0 | 192.2 ± 584.8 |
| | *Blicca bjoerkna* (Linnaeus, 1758) | 5564 | 3.0 | 20.0 | 8.9 ± 2.3 | 1.0 | 97.0 | 7.9 ± 7.6 |
| | *Chondrostoma nasus* (Linnaeus, 1758) | 1 | 11.8 | 11.8 | 11.8 | 11.0 | 11.0 | 11.0 |
| | *Rutilus* sp. | 4 | 8.4 | 15.5 | 12.5 ± 3.0 | 5.0 | 43.0 | 23.3 ± 15.5 |
| | *Rutilus pigus* (Lacepède, 1803) | 5 | 10.6 | 12.6 | 12.6 ± 0.7 | 8.7 | 17.0 | 17.0 ± 3.3 |
| | *Rutilus rutilus* (Linnaeus, 1758) | 521 | 4.5 | 26.5 | 12.5 ± 3.3 | 1.1 | 155.0 | 23.5 ± 25.1 |
| | *Scardinius erythrophthalmus* (Linnaeus, 1758) | 106 | 5.4 | 28.0 | 16.2 ± 4.8 | 1.1 | 350.0 | 66.6 ± 31.5 |
| PERCIDAE | *Gymnocephalus* sp. | 51 | 5.5 | 11.5 | 8.9 ± 1.4 | 1.1 | 22.0 | 9.2 ± 3.9 |
| | *Gymnocephalus baloni* (Holcík and Hensel, 1974) | 45 | 4.8 | 14 | 6.5 ± 1.7 | 3.0 | 3.0 | 3.3 ± 3.5 |
| | *Gymnocephalus cernua* (Linnaeus, 1758) | 14 | 4.9 | 8.6 | 7.1 ± 1.3 | 1.3 | 7.0 | 3.9 ± 1.7 |
| | *Perca fluviatilis* (Linnaeus, 1758) | 369 | 5.0 | 21.9 | 12.1 ± 3.9 | 1.1 | 201.0 | 30.5 ± 28.7 |
| | *Sander lucioperca* (Linnaeus, 1758) | 177 | 8.5 | 29.5 | 18.2 ± 3.4 | 3.0 | 200.0 | 44.4 ± 30.3 |
| XENOCYPRIDIDAE | *Hypophthalmichthys molitrix* (Valenciennes, 1844) | 203 | 9.6 | 63.5 | 20.3 ± 7.2 | 6.0 | 3145.0 | 125.8 ± 336.4 |
| SILURIDAE | *Silurus glanis* (Linnaeus, 1758) | 167 | 8.5 | 40.0 | 16.9 ± 5.0 | 2.0 | 425.0 | 41.4 ± 45.6 |

Out of the 24 species recorded in this study, the calculation of length–weight relationships was possible for 19 species, as their sample size exceeded 10 individuals. All calculated linear regressions were significant ($p < 0.05$), with the coefficient of determination ($R^2$) ranging from 0.7049 to 0.9998. The values of the mean coefficient *a*, calculated through the LWR equation, ranged from 0.0020 for *Abramis brama* to 0.0210 for *Gymnocephalus baloni*, while the mean coefficient *b* ranged from 2.6831 for *G. baloni* to 3.5747 for *Scardinius erythrophthalmus*, with a collective average of 3.2929, indicating an overall positive allometric growth in the fish population. More specifically, 15 species were shown to have positive allometric growth, while two had negative, and two had isometric growth (Table 2). The length–weight relationships for each of the growth types are plotted in Figure 2. The total length of fish documented in this study ranged from 3.0 cm (*Blicca bjoerkna*) to 73.2 cm (*Esox lucius*), while the total weight ranged from 1.0 g (*Alburnus albidus*) to 3765.0 g (*Leuciscus aspius*).

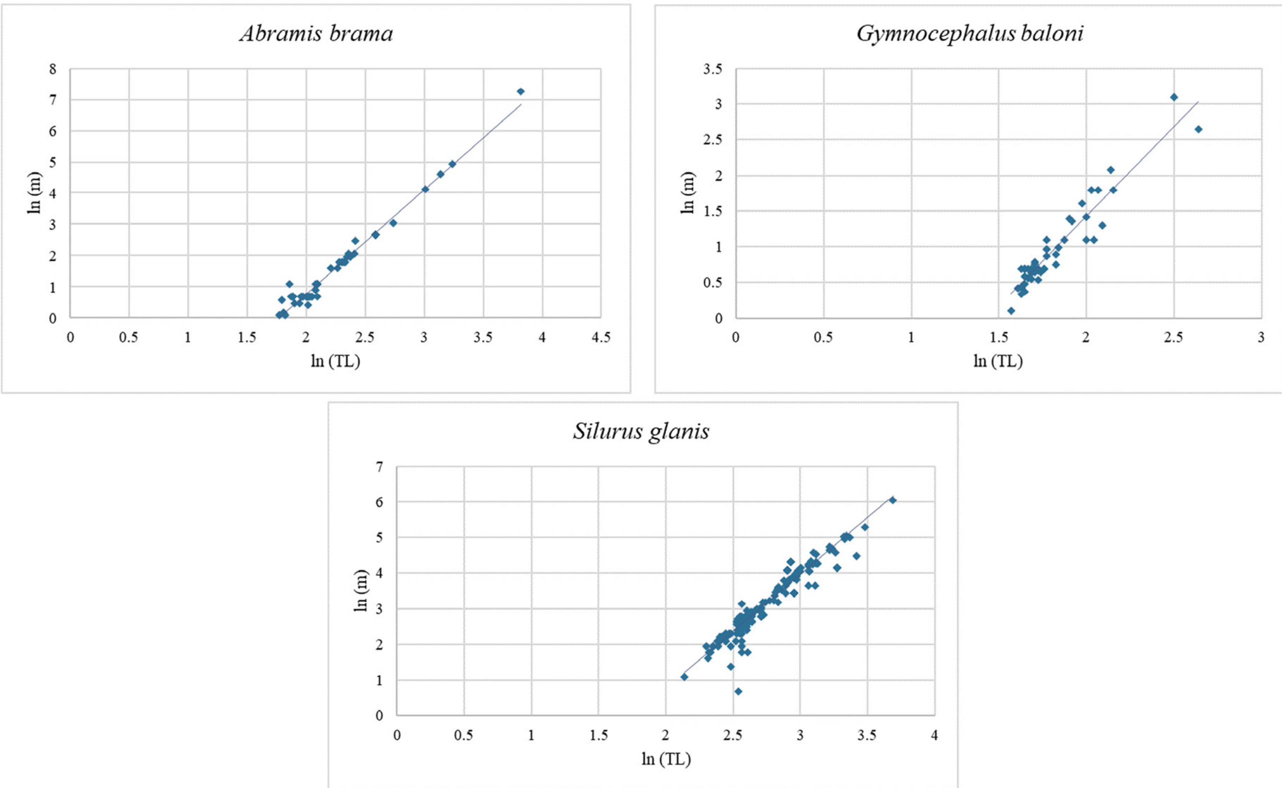


**Figure 2.** Length–weight relationships of three species with different growth types: *Abramis brama*—positive allometric; *Gymnocephalus baloni*—isometric; and *Silurus glanis*—negative allometric.

Fulton's condition factor was calculated for each of the 24 recorded species in this study and was expressed as an average, excluding *Chondrostoma nasus,* for which the condition data were available from just one individual caught during the whole study. The highest average Fulton's condition factor was calculated for *Lepomis gibbosus* (1.4956), while *Cobitis elongatoides* had the lowest average factor value (0.4739). Condition factors whose values were significantly higher than 1.0 ($p < 0.05$) indicated an overall good condition and such values were documented in a total of 8 species in this study, while the remaining 15 species (excluding *C. nasus* due to a lack of data) were proven to be in a poorer condition (Figure 3).

**Table 2.** The calculated values of length–weight parameters and condition factors for species sampled at the three sampling locations in Kopački Rit from 2015 to 2019.

| Family | Species | Length–Weight Relationship Parameters | | | | | GT | Condition Factors | |
|---|---|---|---|---|---|---|---|---|---|
| | | *n* | Mean *a* | Mean *b* | CI (b) | $R^2$ Range | | K | $K_n$ |
| *Centrarchidae* | *Lepomis gibbosus* (Linnaeus, 1758) | 2 | 0.0096 | 3.3016 | 2.9061–3.6972 | 0.7244–0.9848 | $A^+$ | 1.4956 | 1.0226 |
| *Cobitidae* | *Cobitis elongatoides* (Băcescu and Mayer, 1969) | 0 | - | - | - | - | - | 0.4739 | - |
| *Cyprinidae* | *Carassius gibelio* (Bloch, 1782) | 8 | 0.0072 | 3.2739 | 3.2127–3.3350 | 0.9343–0.9966 | $A^+$ | 1.3213 | 1.0226 |
| | *Cyprinus carpio* (Linnaeus, 1758) | 3 | 0.0057 | 3.3296 | 3.0950–3.5642 | 0.9207–0.9501 | $A^+$ | 1.0826 | 1.0224 |
| *Gobionidae* | *Pseudorasbora parva* (Temminck and Schlegel, 1846) | 4 | 0.0027 | 3.5573 | 3.4167–3.6978 | 0.7049–0.9452 | $A^+$ | 0.7829 | 1.0171 |
| *Esocidae* | *Esox lucius* (Linnaeus, 1758) | 3 | 0.0049 | 3.1517 | 2.9669–3.3365 | 0.951–0.9876 | $A^+$ | 0.7246 | 1.0050 |
| *Ictaluridae* | *Ameiurus nebulosus* (Lesueur, 1819) | 1 | 0.0049 | 3.3658 | - | 0.941 | $A^+$ | 1.4283 | 1.0050 |
| *Leuciscidae* | *Abramis brama* (Linnaeus, 1758) | 3 | 0.0020 | 3.4954 | 3.3752–3.6155 | 0.9377–0.9998 | $A^+$ | 0.6181 | 1.0124 |
| | *Alburnus albidus* (Costa, 1838) | 0 | - | - | - | - | - | 0.8769 | - |
| | *Alburnus alburnus* (Linnaeus, 1758) | 6 | 0.0024 | 3.5257 | 3.2341–3.8172 | 0.818–0.9877 | $A^+$ | 0.5959 | 1.0338 |
| | *Leuciscus aspius* (Linnaeus, 1758) | 8 | 0.0052 | 3.1853 | 3.0369–3.3338 | 0.903–0.9987 | $A^+$ | 0.7776 | 1.0104 |
| | *Blicca bjoerkna* (Linnaeus, 1758) | 8 | 0.0060 | 3.2385 | 3.0895–3.3875 | 0.7316–0.9677 | $A^+$ | 0.8765 | 1.0227 |
| | *Chondrostoma nasus* (Linnaeus, 1758) | 0 | - | - | - | - | - | 0.6695 | - |
| | *Rutilus sp.* | 0 | - | - | - | - | - | 1.0004 | - |
| | *Rutilus pigus* (Lacepède, 1803) | 0 | - | - | - | - | - | 0.8501 | - |
| | *Rutilus rutilus* (Linnaeus, 1758) | 8 | 0.0048 | 3.3008 | 3.1734–3.4282 | 0.7887–0.9942 | $A^+$ | 0.8809 | 1.0221 |
| | *Scardinius erythrophthalmus* (Linnaeus, 1758) | 5 | 0.0024 | 3.5747 | 3.4465–3.7028 | 0.9312–0.9976 | $A^+$ | 1.1316 | 1.0116 |
| *Percidae* | *Gymnocephalus sp.* | 1 | 0.0083 | 3.1677 | - | 0.827 | I | 1.2034 | 1.0287 |
| | *Gymnocephalus baloni* (Holcík and Hensel, 1974) | 2 | 0.0210 | 2.6831 | 2.5107–2.8555 | 0.8783–0.9307 | I | 1.0924 | 1.0106 |
| | *Gymnocephalus cernua* (Linnaeus, 1758) | 2 | 0.0171 | 2.7328 | 2.6480–2.8176 | 0.955–0.9873 | $A^-$ | 1.0280 | 1.0024 |
| | *Perca fluviatilis* (Linnaeus, 1758) | 5 | 0.0042 | 3.4771 | 3.2185–3.7356 | 0.8553–0.9942 | $A^+$ | 1.1331 | 1.0161 |
| | *Sander lucioperca* (Linnaeus, 1758) | 4 | 0.0042 | 3.2006 | 3.0260–3.3752 | 0.8056–0.9853 | $A^+$ | 0.6745 | 1.0107 |
| *Xenocyprididae* | *Hypophthalmichthys molitrix* (Valenciennes, 1844) | 5 | 0.0032 | 3.3847 | 3.2424–3.5269 | 0.8496–0.9995 | $A^+$ | 0.7018 | 1.0205 |
| *Siluridae* | *Silurus glanis* (Linnaeus, 1758) | 3 | 0.0146 | 2.8989 | 2.5191–3.2787 | 0.908–0.9993 | $A^-$ | 0.6600 | 1.0524 |

Note: *n* = number of calculated LWR; CI = confidence intervals for parameter *b*; GT = growth types ($A^+$: positive allometric, $A^-$: negative allometric, I: isometric); K = Fulton's condition factor; $K_n$ = relative condition factor.

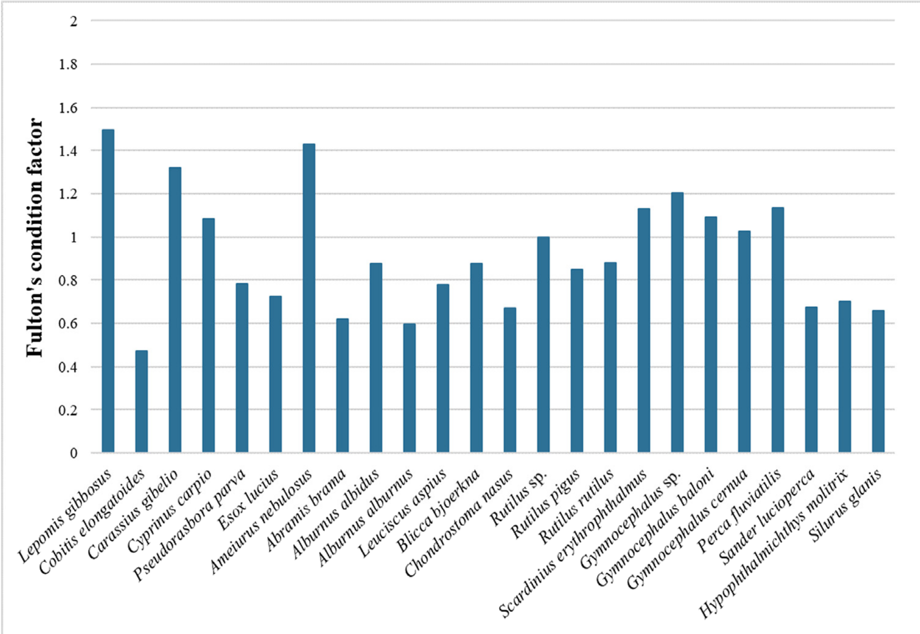


**Figure 3.** The average values of Fulton's condition factor for 24 species of fish sampled in the Kopački Rit Nature Park floodplain from 2015 to 2019.

Since the relative condition factor calculation depends on the availability of length–weight regression data, information was available for 19 species in this study (Figure 4). A good condition was noted in eight species, with three being the same species confirmed through Fulton's condition factor, *L. gibbosus*, *Carassius gibelio*, and *Cyprinus carpio*, while the remaining five differed in comparison to the other index. *Silurus glanis* had the highest recorded average relative condition factor (1.0524), while the lowest average factor was recorded for *Gymnocephalus cernua* (1.0023) (Table 2). The average values of the Fulton's condition factors and relative condition factors for each of the fish species sampled in this study are shown in Table 2.

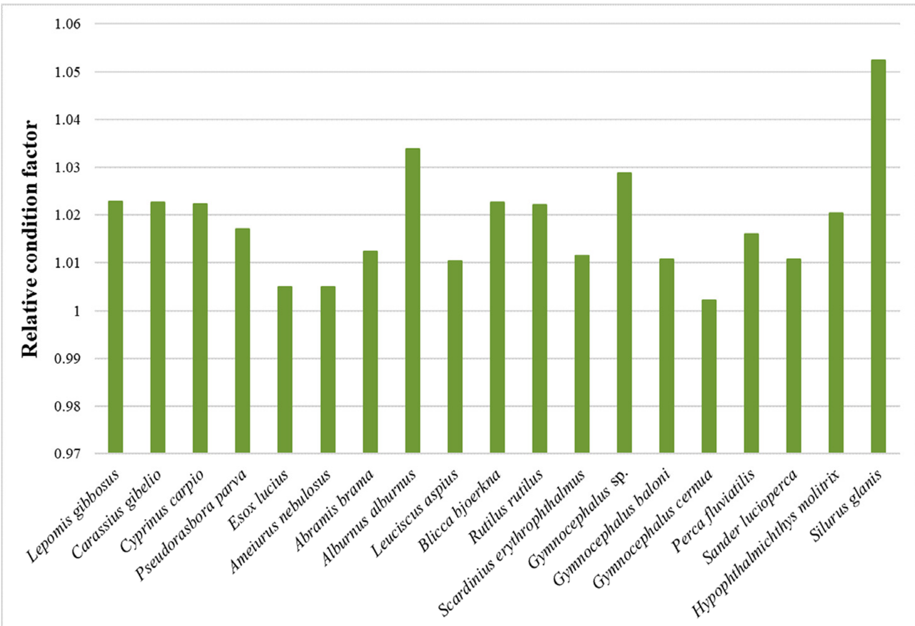


**Figure 4.** The average values of the relative condition factor for 19 species of fish sampled in the Kopački Rit Nature Park floodplain from 2015 to 2019.

## 4. Discussion

The *b* coefficient of the length–weight relationships is commonly used as an indicator of fish growth patterns [48], with Froese [42] stating that values of this coefficient tend to generally range from 2.5 to 3.5. Similar results are shown in this study, as the calculated means of the *b* coefficient ranged from 2.6831 for *Gymnocephalus baloni*, to 3.5747 for *Scardinius erythrophthalmus*. The presence of *b* coefficient values that were not within the given range was noted while calculating the separate LWR for each of the sampling seasons, such as 2.3800 for *G. baloni*, 2.4746 for *Silurus glanis*, and 4.1266 for *Alburnus alburnus*. The most probable cause for these kinds of results could be due to the lack of a sufficient number of individuals per sample, as smaller sample sizes tend to give more extreme values of the *b* parameter [16,49]. Nonetheless, the average *b* coefficient of all recorded species in this study was shown to be above 3 (3.2929, to be exact), indicating overall positive allometric growth. Such results suggest that as the fish grew, they increased more in weight than in length, giving them an overall rounder body shape. The higher values of the *b* coefficient in this study could have been partly affected by the habitat type, or more specifically, the slow-moving waters of the researched floodplain area. Shukor et al. [50] stated that lower *b* values could be found in fish residing in fast-moving waters, while slower-moving waters tend to give fish higher *b* values. The values of this coefficient can also be influenced by the water temperature, the type of sampling, and the current food availability [51,52]. Since the LWR is known to change in accordance with physiological changes highly dependent on the season, such as spawning [53], future studies should include the sampling of fish in each of the seasons to obtain a better view of the changes and the overall range of the length–weight relationships for all of the analyzed species.

Out of the 24 fish species recorded and analyzed in this study, ten belonged to the family Leuciscidae. The morphological and physiological characteristics of species within this group vary considerably, granting the family-wide distribution across the northern parts of Eurasia [54]. One such species is the *Blicca bjoerkna*, known to mostly reside in slow-moving waters across the central and northern parts of Europe [55]. With the nutrient-rich, slow-moving waterbodies of Kopački Rit falling into the similar category of suitable habitats for this species, it had the highest number of sampled individuals in this study, with a total of 5564. The dominance of this species was recorded in other ichthyofauna research conducted in this area [32,36]. Another species with an extremely high number of sampled individuals in this study was the Prussian carp (*Carassius gibelio*). Belonging to the family Cyprinidae, this invasive fish is known to inhabit a wide variety of freshwater ecosystems, increasing in number rapidly via gynogenetic reproduction, making it a strong competitor for native fish species like the Common carp (*Cyprinus carpio*) [34,56,57]. Water fluctuation in this floodplain area allows for the constant refreshment of nutrients, allowing a wide variety of fish species to reside in this area [24], as seen by the number and diversity of fish taxa recorded in the 5 years of sampling in this study. The results of both Fulton's condition factors and the relative condition factors showed that a total of eight species were in a relatively good condition, although the species in question varied between the two condition factors. More specifically, Fulton's condition factor showed good condition for the species *Lepomis gibbosus*, *Carassius gibelio*, *Cyprinus carpio*, *Ameiurus nebulosus*, *Scardinus erythrophthalmus*, *Gymnocephalus* sp., *G. baloni,* and *G. cernua*, while the relative condition factor showed good condition for *L. gibbosus*, *C. gibelio*, *C. carpio*, *Pseudorasbora parva*, *Blicca bjoerkna*, *Rutilus rutilus*, *Hypophthalmichthys molitrix*, and *S. glanis*. The reason for these differences most likely lies in the fact that Fulton's condition factor always assumes isometric growth for all fish, while the relative condition factor takes into account the potential variations in the type of growth [17]. For example, in this study, *S. glanis* was a species with a negative allometric type of growth ($b < 3$), which, according to Fulton's condition factor results, was shown to be in a poor condition, with an average value of 0.6600. Contrary to this, the relative condition factor, with an average value of 1.0524, showed good condition. A study on three marine fish species by Muchlisin et al. [58] pointed out that Fulton's condition factor tends to give lower values for species with negative allometric growth, meaning that the species with isometric growth had a higher Fulton's condition factor compared to the two species whose growth showed to be negative allometric.

The values of fish condition factors can additionally be influenced by various factors, such as water quality [3], food availability [59], and parasitism [15], as well as the fish's age and sex [60]. The negative impact of parasitism was successfully detected through the calculation of the Fulton's condition factor in *C. gibelio* inhabiting waters of the Kopački Rit Nature Park [8]. Water temperature also plays a vital role in changes in condition factors [61], as fish experience physiological changes closely related to seasonal temperature oscillations, most notably through gonadal development and spawning [62]. In that sense, the condition factor for fish that spawn in the early spring or early summer months (such as esocids and cyprinids) tends to be relatively higher during warmer periods when food is plentiful and the fish have enough time to recover from spawning [46,63]. A decrease in condition factor values is often noted after spawning and during the colder months [64] when fish feed less and rely on their lipid reserves as a means to survive food scarcity [61].

Since the sampling in this study was conducted during the colder months of autumn and winter, it can be assumed that the overall condition of most fish species started to slowly decline after its assumed peak during the summer months. Similar to length–weight relationships, future studies should include seasonal sampling in order to better understand how various abiotic factors impact the condition factor of fish species residing in this area. One very important abiotic factor that should be taken into consideration in future research is the impact of climate change on the structure and condition of fish populations in this protected area. Climatological data for this area show an increase in annual mean water and air temperatures [24], with air temperatures deviating the most during spring and summer months [27]. Within the Nature Park, these deviations can further be seen as increases in flooding fluctuations, or prolonged drought seasons [65], which then have the potential to negatively impact the stability of numerous habitats present in the floodplain area, while also contributing to the spread of invasive species [66].

Besides constant monitoring to ensure the stability of fish populations, more measures should be put in place to minimize the negative effects of illegal and unregulated fishing, as well as to minimize the spread and negative impact of invasive species on the endangered native fish species residing in this area.

## 5. Conclusions

The analyzed results indicate that the floodplain area of the Kopački Rit Nature Park presents an important and suitable habitat for many fish species from the Danube river, providing adequate shelter and food to allow overall positive allometric growth. This research provided the first valuable data on length–weight relationships and condition factors of different fish species in the Special Zoological Reserve in the Kopački Rit Nature Park, which can be a guideline for establishing future studies of ichthyofauna in floodplain water bodies.

**Author Contributions:** Conceptualization, N.V., I.T.Č. and D.Č.; methodology, D.Č., M.K., V.R., I.T.Č., V.E., B.V., M.Š. and N.V.; validation, D.Č., I.T.Č. and N.V.; formal analysis, N.V.; investigation, D.Č., I.T.Č., M.K., V.E., B.V., M.Š., V.R. and N.V.; resources, D.Č. and V.R.; writing—original draft preparation, N.V., I.T.Č. and D.Č.; writing—review and editing, M.K., V.E., B.V., M.Š., V.R., D.Č., I.T.Č. and N.V.; visualization, N.V.; supervision, D.Č. and V.R.; funding acquisition, D.Č. All authors have read and agreed to the published version of the manuscript.

**Funding:** This research received no external funding.

**Institutional Review Board Statement:** Perennial sampling and research have been conducted within the scope of the "Yearly program of protection, management, preservation, promotion and utilization of Kopački Rit Nature Park", including ichthyofauna. Collection for research purposes was approved by the Ministry of Environmental Protection and Nature who issued corresponding permits for the research (UP/I-612-07/16-48/141; 517-07-1-1-1-16-4; UP/I-612-07/19-48/158; 517-05-1-1-19-4). We were also obligated to remove all allochthonous and invasive species from the natural environment.

**Informed Consent Statement:** Not applicable.

**Data Availability Statement:** The data presented in this study are available upon request from the corresponding author.

**Acknowledgments:** This research was conducted in cooperation with the Public Institution of the Kopački Rit Nature Park within their perennial monitoring of ichthyocenoses. We would like to thank our colleagues from the PI Kopački Rit Nature Park for their kind cooperation. Furthermore, the authors would like to thank Ivana Vukšić, Matija Kresonja, and other colleagues and students for their help in fieldwork activities.

**Conflicts of Interest:** The authors declare no conflicts of interest.

## References

1. Santos, M.N.; Gaspar, M.B.; Vasconcelos, P.; Monteiro, C.C. Weight-Length Relationships for 50 Selected Fish Species of the Algarve Coast (Southern Portugal). *Fish. Res.* **2002**, *59*, 289–295. [CrossRef]
2. Sultana, R.; Alam, M.S.; Nazrul, K.S.; Mamun, A.; Al Mamun, M.A. Length-Weight Relationship and Population Dynamics Study of the Giant Catfish (*Arius thalassinus*) in the Bay of Bengal Coast of Bangladesh. *Res. Agric. Livest. Fish.* **2020**, *6*, 439–444. [CrossRef]
3. Stavrescu-Bedivan, M.; Scaeteanu, G.; Madjar, R.M.; Matei, P.; Tobă, G. Comparative Study of Length-Weight Relationship, Size Structure and Fulton's Condition Factor for Prussian Carp from Different Romanian Aquatic Ecosystems. *AgroLife Sci. J.* **2015**, *4*, 132–139.
4. Schneider, J.C.; Laarman, P.W.; Gowing, H. Length-Weight Relationships. In *Manual of Fisheries Survey Methods II with Periodic Updates*; James, C., Ed.; Michigan Department of Natural Resources: Ann Arbor, MI, USA, 2000; pp. 1–16.
5. Petrakis, G.; Stergiou, K.I. Weight-Length Relationships for 33 Fish Species in Greek Waters. *Fish. Res.* **1995**, *21*, 465–469. [CrossRef]
6. Stewart, K.M. Changes in Condition and Maturation of the *Oreochromis niloticus* L. Population of Ferguson's Gulf, Lake Turkana, Kenya. *J. Fish Biol.* **1988**, *33*, 181–188. [CrossRef]
7. Rajput, V. The Length-Weight Relationship, Condition Factor and Impact of Fluoride Concentration in *Tor tor* (Mahasheer) of Lake Bhimtal, India. *Ribarstvo* **2011**, *69*, 63–69.
8. Vuić, N.; Turković Čakalić, I.; Vlaičević, B.; Stojković Piperac, M.; Čerba, D. The Influence of *Contracaecum* Larvae (Nematoda, Anisakidae) Parasitism on the Population of Prussian Carp (*Carassius gibelio*) in Lake Sakadaš, Croatia. *Pathogens* **2022**, *11*, 600. [CrossRef]
9. Miller, S.J.; VanGenechten, D.T.; Cichra, C.E. Length-Weight Relationships and an Evaluation of Fish-Size and Seasonal Effects on Relative Condition (Kn) of Fishes from the Wekiva River. *Florida Sci.* **2015**, *78*, 1–19. Available online: http://www.jstor.org/stable/24321839 (accessed on 21 July 2024).
10. Le Cren, E.D. The Length-Weight Relationship and Seasonal Cycle in Gonad Weight and Condition in the Perch (*Perca fluviatilis*). *J. Anim. Ecol.* **1951**, *20*, 201–219. [CrossRef]
11. Kimmerer, W.; Avent, S.R.; Bollens, S.M.; Feyrer, F.; Grimaldo, L.F.; Moyle, P.B.; Nobriga, M.; Visintainer, T. Variability in Length–Weight Relationships Used to Estimate Biomass of Estuarine Fish from Survey Data. *Trans. Am. Fish. Soc.* **2005**, *134*, 481–495. [CrossRef]
12. Evagelopoulos, A.; Batjakas, I.; Koutsoubas, D. Length-Weight Relationships of 9 Commercial Fish Species from the North Aegean Sea. *Acta Adriat.* **2017**, *58*, 187–192. [CrossRef]
13. De Giosa, M.; Czerniejewski, P.; Rybczyk, A. Seasonal Changes in Condition Factor and Weight-Length Relationship of Invasive *Carassius gibelio* (Bloch, 1782) from Leszczynskie Lakeland, Poland. *Adv. Zool.* **2014**, *2014*, 678763. [CrossRef]
14. Abera, L.; Getahun, A.; Lemma, B. Assessment of Length-Weight Relationship, Sex Ratio and Condition Factor of Common Carp (*Cyprinus carpio* Linnaeus, 1758) in Lake Ziway, Ethiopia. *Glob. J. Fish. Aquac.* **2015**, *3*, 192–197.
15. Neff, B.D.; Cargnelli, L.M. Relationships between Condition Factors, Parasite Load and Paternity in Bluegill Sunfish, *Lepomis macrochirus*. *Environ. Biol. Fishes* **2004**, *71*, 297–304. [CrossRef]
16. Famoofo, O.O.; Abdul, W.O. Biometry, Condition Factors and Length-Weight Relationships of Sixteen Fish Species in Iwopin Fresh-Water Ecotype of Lekki Lagoon, Ogun State, Southwest Nigeria. *Heliyon* **2020**, *6*, e02957. [CrossRef] [PubMed]
17. Blackwell, B.G.; Brown, M.L.; Willis, D.W. Relative Weight (Wr) Status and Current Use in Fisheries Assessment and Management. *Rev. Fish. Sci.* **2000**, *8*, 1–44. [CrossRef]
18. Jin, S.; Yan, X.; Zhang, H.; Fan, W. Weight-Length Relationships and Fulton's Condition Factors of Skipjack Tuna (*Katsuwonus pelamis*) in the Western and Central Pacific Ocean. *PeerJ* **2015**, *3*, e758. [CrossRef]
19. Scott Cone, R. The Need to Reconsider the Use of Condition Indices in Fishery Science. *Trans. Am. Fish. Soc.* **1989**, *118*, 510–514. [CrossRef]
20. Murphy, B.R.; Willis, D.W.; Springer, T.A. The Relative Weight Index in Fisheries Management: Status and Needs. *Fisheries* **1991**, *16*, 30–38. [CrossRef]

21. Stoffers, T.; Buijse, A.D.; Geerling, G.W.; Jans, L.H.; Schoor, M.M.; Poos, J.J.; Verreth, J.A.J.; Nagelkerke, L.A.J. Freshwater Fish Biodiversity Restoration in Floodplain Rivers Requires Connectivity and Habitat Heterogeneity at Multiple Spatial Scales. *Sci. Total Environ.* **2022**, *838*, 156509. [CrossRef] [PubMed]
22. Burgess, O.; Pine, W.E., III; Walsh, S.J. Importance of Floodplain Connectivity to Fish Populations in the Apalachicola River, Florida. *River Res. Appl.* **2012**, *30*, 132–133. [CrossRef]
23. Lubinski, K. Chapter 2: Floodplain River Ecology and the Concept of River Ecological Health. In *Ecological Status and Trends of the Upper Mississippi River System 1998: A Report of the Long Term Resource Monitoring Program*; Cox, J.D., Wenger, M.V., Eds.; U.S. Geological Survey, Upper Midwest Environmental Sciences Center: La Crosse, WI, USA, 1999; pp. 1–12.
24. Tadić, L.; Bonacci, O.; Dadić, T. Dynamics of the Kopački Rit (Croatia) Wetland Floodplain Water Regime. *Environ. Earth Sci.* **2014**, *71*, 3559–3570. [CrossRef]
25. Schwarz, U. *Landschaftsökologische Charakterisierung Des Kopački Rit Unter Besonderer Berücksichtigung von Flusslandschaftsformen Sowie Deren Genese Und Typologie*; Universität Wien: Wien, Austria, 2005.
26. Ramsar. Information Sheet on Ramsar Wetlands—Nature Park Kopacki Rit. Available online: https://rsis.ramsar.org/RISapp/files/RISrep/HR583RIS_1910_en.pdf (accessed on 4 December 2023).
27. Benčina, L.; Rožac, V.; Bolšec, B. *Plan Upravljanja Parkom Prirode Kopački Rit*; Tikveš: Lug, Hrvatska, 2010.
28. Čerba, D.; Koh, M.; Vlaičević, B.; Čakalić, I.T.; Milošević, D.; Piperac, M.S. Diversity of Periphytic Chironomidae on Different Substrate Types in a Floodplain Aquatic Ecosystem. *Diversity* **2022**, *14*, 264. [CrossRef]
29. Sommerwerk, N.; Bloesch, J.; Baumgartner, C.; Bittl, T.; Čerba, D.; Csányi, B.; Davideanu, G.; Dokulil, M.; Frank, G.; Grecu, I.; et al. The Danube River Basin. In *Rivers of Europe*; Tockner, K., Zarfl, C., Robinson, C.T., Eds.; Elsevier: Amsterdam, The Netherlands, 2022; p. 922.
30. Mikuska, J. Ecological Properties of the Fish Fauna in the Kopački Rit Special Zoology Reserve. In *Zbornik radova III. znanstvenog sabora Slavonije i Baranje*; Čalić, D., Roglić, J., Eds.; Jugoslavenska akademija znanosti i umjetnosti, Zavod za znanstveni rad Osijek: Osijek, Croatia, 1983; pp. 1021–1026.
31. Homen, Z.; Mikuska, P.; Radanović, P.; Mikuska, Z. Kvalitativni i Kvantitativni Sastav Ribljeg Fonda Dunava i Poplavnog Područja u Kopačkom Ritu. *Ribar. Jugosl.* **1991**, *46*, 27–30.
32. Čerba, D.; Balković, I.; Koh, M.; Vuković, A.; Ergović, V.; Turković Čakalić, I.; Stević, F. Ihtiofauna Parka Prirode Kopački Rit. In *10. Međunarodni gospodarsko-znanstveni skup o akvakulturi „Hrvatska Akvakultura u Europskoj Uniji—Sadašnjost i Budućnost"*; Hrvatska gospodarska komora (HGK): Vukovar, Croatia, 2014; pp. 2–4.
33. Jelkić, D.; Opačak, A.; Ozimec, S.; Bolšec, B.; Rožac, V.; Mikulić, D. Status Populacije Riba u Parku Prirode "Kopački Rit.". In *Kopački rit Jučer, Danas, Sutra*; Ozimec, S., Bolšec, B., Kučera, S., Rožac, V., Eds.; Public Instituition "Kopački Rit Nature Park": Kopačevo, Croatia, 2014; pp. 11–12.
34. Opačak, A.; Jelkić, D.; Ozimec, S.; Lužaić, R.; Opačić, D.; Rožac, V.; Mikulić, D.; Bolšec, B.; Kučera, S. Status Populacije Srebrnog Karasa—Babuške (*Carassiuss gibelio* Bloch, 1783.) u Ribljoj Zajednici Kopačkog Rita. In *Kopački rit Jučer, Danas, Sutra*; Rožac, V., Bolšec, B., Kučera, S., Tot Forjan, R., Eds.; Public Instituition "Kopački Rit Nature Park": Kopačevo, Croatia, 2015; pp. 1–23.
35. Opačak, A.; Jelkić, D.; Lužaić, R.; Opačić, D.; Mikulić, D.; Rožac, V.; Bolšec, B.; Kučera, S. Sastav Riblje Zajednice u Ribolovnim Vodama Parka Prirode "Kopački Rit". In *Kopački rit Jučer, Danas, Sutra*; Ozimec, S., Bogut, I., Rožac, V., Stević, F., Bolšec, B., Baković, A., Eds.; Public Instituition "Kopački Rit Nature Park": Kopačevo, Croatia, 2017; pp. 69–70.
36. Vereš, M.; Rožac, V.; Čerba, D.; Kučera, S.; Bolšec, B.; Jurčević Agić, I.; Bogdanović, T.; Koh, M.; Kresonja, M.; Šag, M.; et al. Monitoring Ihtiofaune u Posebnom Zoološkom Rezervatu Kopački Rit. In *Kopački rit Jučer, Danas, Sutra*; Ozimec, S., Bogut, I., Bogdanović, T., Jurčević Agić, I., Rožac, V., Stević, F., Popović, Ž., Bolšec, B., Vereš, M., Eds.; Public Instituition "Kopački Rit Nature Park": Kopačevo, Croatia, 2019; pp. 144–145.
37. Bonacci, O.; Tadić, Z.; Moržan, A.; Radeljak, I. *Plan Upravljanja Parkom Prirode Kopački Rit*; Sektorska studija: Hidrologija i meteorologija. Ministarstvo zaštite okoliša i prostornog uređenja. Projekt obnove istočne Slavonije, Baranje i zapadnog Srijema; Hidroing d.o.o. za projektiranje i inženjering: Osijek, Croatia, 2002.
38. Jelkić, D.; Opačak, A.; Ozimec, S.; Lužaić, R.; Rožac, V. The Distribution of the Ponto-Caspian Goby in Kopački rit. In *7. Kopački rit Jučer, Danas, Sutra*; Ozimec, S., Bogut, I., Rožac, V., Stević, F., Popović, Ž., Bolšec, B., Baković, A., Vereš, M., Eds.; Public Instituition "Kopački Rit Nature Park": Kopačevo, Croatia, 2018; pp. 52–53.
39. Tadić, L.; Dadić, T.; Barač, B. Flood Frequency Modelling of the Kopački Rit Nature Park [Modeliranje Učestalosti Plavljenja Parka Prirode Kopački Rit]. *Teh. Vjesn.* **2013**, *20*, 51–57.
40. Froese, R.; Pauly, D. FishBase. Available online: www.fishbase.org (accessed on 22 November 2023).
41. Falsone, F.; Geraci, M.L.; Scannella, D.; Gancitano, V.; Di Maio, F.; Sardo, G.; Quattrocchi, F.; Vitale, S. Length–Weight Relationships of 52 Species from the South of Sicily (Central Mediterranean Sea). *Fishes* **2022**, *7*, 92. [CrossRef]
42. Froese, R. Cube Law, Condition Factor and Weight-Length Relationships: History, Meta-Analysis and Recommendations. *J. Appl. Ichthyol.* **2006**, *22*, 241–253. [CrossRef]
43. Microsoft Corporation. Microsoft Excel. 2018. Available online: https://office.microsoft.com/excel (accessed on 21 July 2024).
44. Karachle, P.K.; Stergiou, K.I. Morphometrics and Allometry in Fishes. In *Morphometrics*; Wahl, C., Ed.; InTech: London, UK, 2012; pp. 65–86.
45. Treer, T.; Piria, M.; Šprem, N. The Relationship between Condition and Form Factors of Freshwater Fishes of Croatia. *J. Appl. Ichthyol.* **2009**, *25*, 608–610. [CrossRef]

46. Rahman, M.; Hossain, Y.; Jewel, A.S.; Rahman, M.M.; Jasmine, S.; Abdallah, E.M.; Ohtomi, J. Population Structure, Length-Weight and Length-Length Relationships, and Condition- and Form-Factors of the Pool Barb *Puntius sophore* (Hamilton, 1822) (Cyprinidae) from the Chalan Beel, North-Central Bangladesh. *Sains Malays.* **2012**, *41*, 795–802.
47. R Core Team. *R: A Language and Environment for Statistical Computing*; R Foundation for Statistical Computing: Vienna, Austria, 2020.
48. Chu, W.S.; Hou, Y.Y.; Ueng, Y.T.; Wang, J.P. Correlation between the Length and Weight of *Arius maculatus* off the Southwestern Coast of Taiwan. *Braz. Arch. Biol. Technol.* **2012**, *55*, 705–708. [CrossRef]
49. Pauly, D. Length-Weight Relationship. In *Fish Population Dynamics in Tropical Waters: A Manual for Use with Programmable Calculators*; International Center for Living Aquatic Resources Management: Manila, Philippines, 1984; p. 325.
50. Shukor, M.N.; Samat, A.; Ahmad, A.K.; Ruziaton, J. Comparative Analysis of Length-Weight Relationship of *Rasbora sumatrana* in Relation to the Physicochemical Characteristics in Different Geographical Areas in Peninsular Malaysia. *Malays. Appl. Biol.* **2008**, *37*, 21–29.
51. Frota, L.O.; Costa, P.A.S.; Braga, A.C. Length-Weight Relationships of Marine Fishes from the Central Brazilian Coast. *NAGA WorldFish Cent. Q.* **2004**, *27*, 20–26.
52. Muchlisin, Z.A.; Musman, M.; Siti Azizah, M.N. Length-Weight Relationships and Condition Factors of Two Threatened Fishes, *Rasbora tawarensis* and *Poropuntius tawarensis*, Endemic to Lake Laut Tawar, Aceh Province, Indonesia. *J. Appl. Ichthyol.* **2010**, *26*, 949–953. [CrossRef]
53. Jelkić, D.; Opačak, A. Seasonal Changes in the Condition Factor and Gonado-Somatic Index of *Carassius gibelio* From the Kopački Rit Nature Park, Croatia. *Poljoprivreda* **2023**, *29*, 43–48. [CrossRef]
54. Schönhuth, S.; Vukić, J.; Šanda, R.; Yang, L.; Mayden, R.L. Phylogenetic Relationships and Classification of the Holarctic Family Leuciscidae (Cypriniformes: Cyprinoidei). *Mol. Phylogenet. Evol.* **2018**, *127*, 781–799. [CrossRef]
55. Maitland, P.S.; Linsell, K. *Philip's Guide to Freshwater Fish of Britain and Europe*; Philip's: London, UK, 2006.
56. Markovčić, M.; Brigić, A.; Buj, I.; Ćaleta, M.; Mustafić, P.; Zanella, D. *Crvena Knjiga Slatkovodnih Riba Hrvatske*; Markovčić, M., Brigić, A., Eds.; Ministarstvo kulture, Državni zavod za zaštitu prirode, Republika Hrvatska: Zagreb, Croatia, 2006.
57. Tomljanović, T.; Fabijanić, N.; Treer, T.; Matulić, D.; Piria, M.; Šprem, N.; Aničić, I.; Safner, R. Utjecaj Invazivne Vrste Riba Babuške (Carassius Gibelio) Na Sastav Ihtiocenoze u Republici Hrvatskoj. In *47th Croatian and 7th International Symposium on Agriculture*; Pospišil, M., Ed.; University of Zagreb, Faculty of Agricultur: Zagreb, Croatia, 2012; pp. 634–636.
58. Muchlisin, Z.A.; Fransiska, V.; Muhammadar, A.A.; Fauzi, M.; Batubara, A.S. Dužinsko Maseni Odnos Te Kondicijsko Stanje Triju Dominantnih Vrsta Morskih Riba Uhvaćenih Tradicionalnim Ulovom Mrežom u Ulelhee Zaljevu, Banda Aceh, Indonezija. *Ribar. Croat. J. Fish.* **2017**, *75*, 104–112. [CrossRef]
59. Pathak, A.K.; Mir, J.I.; Rebello, S.C. Length Weight Relationship and Condition Factor of Selected Freshwater Fish Species Found in River Ganga, Gomti and Rapti, India. *J. Environ. Biol.* **2013**, *34*, 951–956.
60. Ndiaye, W.; Diouf, K.; Samba, O.; Ndiaye, P.; Panfili, J. The Length-Weight Relationship and Condition Factor of White Grouper (*Epinephelus aeneus*, Geoffroy Saint Hilaire, 1817) at the South-West Coast of Senegal, West Africa. *Int. J. Adv. Res.* **2015**, *3*, 145–153.
61. Jisr, N.; Younes, G.; Sukhn, C.; El-Dakdouki, M.H. Length-Weight Relationships and Relative Condition Factor of Fish Inhabiting the Marine Area of the Eastern Mediterranean City, Tripoli-Lebanon. *Egypt. J. Aquat. Res.* **2018**, *44*, 299–305. [CrossRef]
62. Wootton, R.J. Reproduction. In *Ecology of Teleost Fishes*; Springer: Dordrecht, The Netherlands, 1990; pp. 159–195. [CrossRef]
63. Wootton, R.J.; Smith, C. *Reproductive Biology of Teleost Fishes*; John Wiley & Sons: Hoboken, NJ, USA, 2014. [CrossRef]
64. Kurup, B.M.; Samuel, C.T. Length-Weight Relationship and Relative Condition Factor in *Daysciaena albida* (Cuv.) and *Gerres filamentosus* (Cuv.). *Fish. Technol.* **1987**, *24*, 88–92.
65. Damjanović, I.; Bezik, D.; Sučić, H.; Eberhard, M.; Kolarić, D.; Kralj, M.; Benkotić, S.; Turić, N.; Bekina, H. Climate Changes and Flooding Dynamics of the Kopački Rit Nature Park. In *12. Kopački rit Jučer, Danas, Sutra*; Ozimec, S., Bogut, I., Bašić, I., Rožac, V., Stević, F., Popović, Ž., Eds.; Public Instituition "Kopački Rit Nature Park": Kopačevo, Croatia, 2023; pp. 40–41.
66. Ozimec, S.; Deže, D. Effects of Climate Change on the Habitat Diversity in Kopački Rit Nature Park (Croatia). In *The Role and Status of Modern Agriculture in Climate Change*; Faculty of Agrobiotechnical Sciences Osijek: Osijek, Croatia, 2023; p. 45.