# POPULATION DYNAMICS AND EXPLOITATION PATTERNS OF COMMON CARP (*CYPRINUS CARPIO*) IN THE DANUBE RIVER, KM 1047–1071

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***Abstract***

*This study evaluates the biological status and population dynamics of the common carp (Cyprinus carpio) in the Danube River, between km 1047–1071. A total of 192 individuals were sampled, and their length-frequency distribution was used to estimate growth and mortality parameters. Growth parameters were estimated using the von Bertalanffy Growth Function, resulting in $L_\infty$=75.6 mm, K=0.63 $year^{-1}$, $t_0$=−0.70 year and the growth performance index Φ'=3.56, indicating moderate growth potential. Mortality analysis showed total mortality (Z=2.07 $year^{-1}$), with natural mortality (M=0.81 $year^{-1}$) and fishing mortality (F=1.26 $year^{-1}$), resulting in an exploitation rate (E=0.61), suggesting high fishing pressure on the population. These results provide a comprehensive overview of the carp population dynamics, supporting sustainable management and conservation strategies in the studied freshwater system.*

***Key words:*** *inland fish, stock assessment, growth parameters, mortality rates, population dynamics*

## INTRODUCTION

*Cyprinus carpio* (Linnaeus, 1758) is one of the most widely distributed freshwater fish species in the world [1] and one of the best - represented freshwater fish species in commercial inland fishing in Romania [2]. The common carp holds significant economic and ecological importance, supporting local livelihoods and regional food security. Its high adaptability to diverse freshwater habitats and relatively fast growth rate makes it a key species for commercial and subsistence production. Ecologically, common carp plays a critical role in aquatic ecosystems by influencing nutrient cycling, sediment dynamics, and the structure of fish communities. As a benthic omnivore, carp regulates benthic invertebrate communities [3,4,5], recycles nutrients through sediment disturbance, and plays a key role in energy transfer within freshwater food webs, thereby contributing to ecosystem balance.

The aim of this study is to highlight the status of carp populations in Romania and to emphasize the importance of continuous monitoring. Although since 2024 the global population of the common carp has been listed as Least Concern by the IUCN Red List [6], the status of this species in the Danube River still raises concerns, as it was listed as Critically Endangered in 1996 and

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continues to face similar threats [7], particularly due to fishing pressure and habitat alterations.

Therefore, annual monitoring represents a key instrument for the sustainable management of fisheries resources and for maintaining the balance of aquatic ecosystems. A comprehensive understanding of the population dynamics, growth patterns, and exploitation of common carp is essential to develop management practices that secure both economic benefits and ecological integrity.

## MATERIAL AND METHOD

The common carp sample was collected through scientific fishing conducted between January and August 2025 between km 1047–1071, from Bazias to Iron Gate I (Fig. 1). A total of 192 individuals were captured and for each individual of common carp (*Cyprinus carpio*), total length (cm), standard length (cm), and height (cm) were recorded using a precision ichthyometer with an accuracy of ±0.01 cm. Weight was measured using a precision field scale with an accuracy of ±0.01 g. Lengths were grouped into 5 cm intervals for subsequent analyses in FISAT II, which were used to estimate growth and mortality parameters.

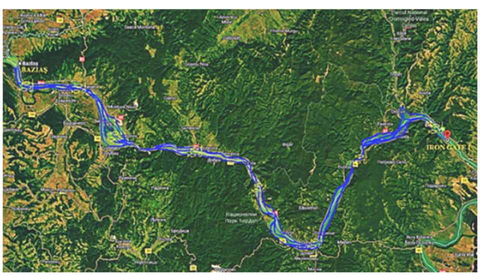

Fig. 1 Analyzed area from km 1047 – 1074 Danube River (Source: original)

Length-frequency distributions were initially visualized using Gaussian histograms and density curves generated in R version 4.5.1, providing an overview of population structure and size composition.

To assess the statistical normality of the length distribution, the Shapiro-Wilk test was performed in XLStat. This test was used to determine whether the observed length data significantly deviated from a normal distribution, which is an important assumption for many parametric analyses and helps to interpret population structure in terms of skewness or concentration around mean reproductive sizes.

The sex ratio was calculated, expressing the number of females relative to the number of males (e.g., 1:1, 2:1). A ratio of 1:1 reflects a natural balance and indicates a healthy population, whereas deviations from this value may suggest population imbalance. Following the methodology of Berk and Jones [8] and Pearson [9], the Chi-squared Goodness-of-Fit test was applied to compare the observed distribution with expected proportions ([10].

The Chi-squared value quantifies the difference between observed and expected frequencies in either an independence or goodness-of-fit test. The formula used is:

$$\chi 2=\sum\frac{(Oi-Ei)^2}{Ei}$$

where Oi is the observed frequency for category i, Ei is the expected frequency for category iii, and ∑ denotes the sum over all categories analyzed. A p-value greater than 0.05 suggests that differences between observed and expected values are not statistically significant, indicating no strong evidence to reject the null hypothesis. Conversely, a p-value less than 0.05 indicates statistically significant differences, implying a potential imbalance or deviation from expected proportions in the population.

Growth parameters, including asymptotic length ($L\infty$), growth coefficient (K), and $t_0$, were estimated using the von Bertalanffy growth model, while the growth performance index (Φ’) was calculated to assess the overall condition and growth potential of the population. According to Santos et al. [11], the asymptotic length ($L\infty$) represents the theoretical maximum length that individuals in a population would attain if they were to grow indefinitely, while the growth coefficient (K) quantifies the rate at which this maximum length is approached. The growth performance index (Ø') is a measure of the efficiency of individual fish growth, calculated using the formula Ø' = log10(K) + 2*log10(L∞) [12]. Growth parameters were estimated for both sexes.

The temperature of 17 °C was selected as the average value for the period analyzed in this sector, according to data provided by INHGA (National Institute of Hydrology and Water Management).

Mortality parameters, including natural mortality (M), fishing mortality (F), total mortality (Z), and exploitation rate (E), as well as the m/K ratio, were calculated in FISAT II based on the 5 cm length classes. The length at first sexual maturity ($L_{50}$) and the ratio LC/L∞ were also derived from these data to evaluate the reproductive potential and sustainability of the population under current exploitation levels.

The map of the study area was created using ArcMap version 10.7.1.

This combined methodological approach, integrating statistical normality tests, categorical distribution tests, and growth and mortality modeling, allowed for a comprehensive assessment of the population structure, reproductive status, and exploitation pressure of common carp in the study area.

## RESULTS AND DISCUSSIONS

The analyzed sample included 192 common carp individuals, with a total biomass of 635.6 kg and an average weight of 3.31 kg (±1.51 kg). Lengths ranged from 42 cm to 92 cm, with a mean length of 59.19 cm (±7.87 cm), indicating a relatively uniform population centered around average reproductive sizes (Table 1).

Table 1 Morphological parameters for the common carp population in 2025

| Specie | Nr.ex | TW (kg) | TW.av. (kg) | TLmin (cm) | TLmax (cm) | TL.av. (cm) |
|---|---|---|---|---|---|---|
| *Cyprinus carpio* | 192 | 635.6 | 3.31±1.51 | 42 | 92 | 59.19±7.87 |

The length-class distribution shows a structure dominated by individuals between 52–66 cm, which accounts for over 85% of the total sample. The peak occurs in the 52–56 cm class (89 individuals), followed by 57–61 cm (41 individuals) and 62–66 cm (37 individuals). Small (42–51 cm) and large (>67 cm) classes are poorly represented, with fewer than 10 individuals each.

Histogram analysis (Fig. 2) confirms this structure: the population is dominated by mature individuals around the mean reproductive size. The density curve superimposed on the histogram shows a slightly right-skewed distribution, suggesting the presence of a small number of individuals larger than the mean, but not a significant deviation from normality.

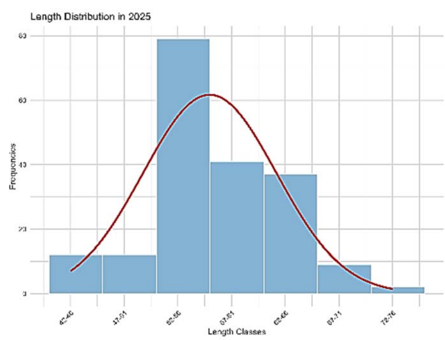


Fig. 2 Length-class distribution of the common carp population in 2025

The absence of very small fish (<50 cm) can be explained either by high juvenile mortality or by gear selectivity, which does not retain smaller individuals. Similarly, the low number of very large fish (>70 cm) may reflect either targeted fishing of large individuals or their natural rarity.

The presence of multiple length classes reflects a heterogeneous population with effective recruitment and survival rates [13]. In contrast, the predominance of a single length class may indicate overfishing, elevated mortality, or unfavorable environmental conditions, while the absence of certain classes may reveal deficiencies in recruitment or survival within the population.

The Shapiro-Wilk test statistically confirms what is observed visually: the distribution is not perfectly normal. The test results indicate that the data do not follow a normal distribution ($p < 0.05$), supporting the visual observations from the histogram, where the strong concentration in the 52–56 cm interval and right-skewed shape generate significant deviations from an ideal Gaussian distribution.

Compared to Stroe et al. [2, 14, 15], the 2025 carp population in the Chiscani area shows a more diverse size structure and slightly larger lengths. The same situation occurs also comparing the analyzed samples with the one from Bitina pond, Romania [16] in 2021 (TL ranging between 29.5 cm and 46.5 cm; TW varying from 0.645 kg to 2.085 kg). This suggests that the 2025 population contains proportionally larger and heavier individuals, suggesting the presence of more mature cohorts and a size structure shifted toward larger fish compared to the earlier dataset.

The sex structure of the carp population is nearly balanced, with a slight predominance of males (F/M = 0.86). This ratio does not raise concerns and ensures good reproductive capacity, which supports the observations from the length and mortality analyses, indicating that the stock is healthy and sustainably exploited.

The analysis of the sex ratio involves examining the numerical distribution of females and males within a population and provides valuable insights into population structure and can be used to assess both the health and dynamics of the population.

The Chi-squared test results for 2025 show a Chi-squared value of 1.0208 and a p-value of 0.3123. The null hypothesis assumes that there are no significant differences between the compared categories or that the observed distribution fits the expected distribution, while the alternative hypothesis assumes significant differences. The relatively low Chi-squared value suggests a small discrepancy between observed and expected data, and the p-value, being much higher than the classic significance threshold $\alpha = 0.05$, indicates that there is insufficient evidence to reject the null hypothesis. In conclusion, there are no statistically significant differences between the analyzed categorie and the expected distribution, resulting in a nearly balanced sex structure.

Compared to the historical data reported by Ciolac [17], where F/M values ranged from 0.42 to 0.65 in 1996, and the recent trends (ranged from 0,82 to 0,94) observed between 2023–2024 by Stroe et al. [15] in the Chiscani area, our results indicate a substantially higher proportion of females relative to males.

**Growth parameters and mortality rates**

The parameter values obtained for this common carp (Cyprinus carpio) population indicate a species with rapid growth and a theoretical maximum length ($L\infty$) of 75.6 cm. The growth coefficient $K = 0.63$ suggests that individuals reach near their maximum size relatively quickly, reflecting a fast life cycle and high biological productivity, which is also supported by the growth potential value $\Phi = 3.56$. The negative $t0$ value (-0.70) is normal and represents the theoretical age at which length would be zero, as expected in the von Bertalanffy growth model.

Compared to 2019–2023 data for the total lenght of the Danube [14], the results reported in the literature by Gheorghe et al. [18] at Braila Km 170-196 and the 2021 data from the Danube Delta [2], the 2025 common carp population shows a slightly larger asymptotic length and moderate growth.

Estimated population parameters indicate that natural mortality (M = 0.81) reflects losses caused by natural factors such as disease, predation, or aging, while fishing mortality (F = 1.26) shows that fishing is the main source of loss, nearly two times higher than natural mortality (Figure 3).

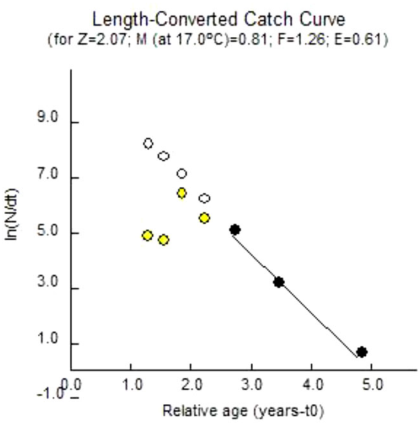


Figure 3 Length-Converted Catch Curve

Total mortality (Z = 2.07), combining natural and fishing effects, indicates that over two-thirds of the population are lost annually. The exploitation rate (E = 0.61) shows that 73% of total mortality is due to fishing, exceeding sustainable thresholds (E ≈ 0.5). However, this does not necessarily mean overexploitation, since the catch from scientific fishing may include smaller individuals, and the population's length distribution and recruitment of young cohorts strongly influence its status.

In conclusion, the data suggest that this common carp population is biologically productive but under substantial fishing pressure. Effective resource management should carefully monitor length distributions and regulate catches to maintain a balance between natural and fishing-induced mortality. The values obtained are consistent and provide a clear picture of the population's biological condition and the anthropogenic pressures it faces.

The length at first sexual maturity ($L_{50}$ = 51.38 cm) is below the sample mean (59 cm), indicating that most fish are capable of reproduction before they are fully exploited, ensuring natural recruitment. The ratio $LC/L\infty$ = 0.68 is the ratio of the length at first capture (Lc) to the theoretical maximum length (Linf = 75.6 cm). A value of 0.68 means that fishing starts at about two-thirds of the maximum size, which is reasonable for management practices aiming to protect juveniles.

The ratio m/K compares natural mortality (M) with the population growth coefficient (K), providing an indication of population dynamics and regeneration potential. m/K = 1.29 is the ratio of natural mortality (M) to the von Bertalanffy growth coefficient (K). Values between roughly 1 and 2 are typical for fast-growing fish with moderate natural mortality. In this case, 1.29 suggests a balanced relationship between growth and natural mortality, indicating a relatively productive population.

Total and fishing mortality (Z = 2.07, F = 1.26) are higher than in previous years [14], resulting in a high exploitation rate (E = 0.61), while most individuals are mature (mean length 59.19 ± 7.87 cm, L50 = 51.38 cm). The growth performance index (Φ' = 3.56) indicates a generally healthy population, but the high fishing pressure highlights the need for careful management to ensure sustainability.

## CONCLUSIONS

The analysis of the common carp population in the Moldova Nouă section of the Danube River (KM 1047–1071) during January–August 2025 indicates a population dominated by mature individuals of moderate size. Length-frequency distribution shows a clear concentration between 52–66 cm, representing over 85% of the sampled individuals, while very small and very large fish are underrepresented. The slight right-skewness observed in the distribution reflects a limited number of larger specimens without significantly deviating from normality.

The sex ratio is nearly balanced, with a slight predominance of males (F/M = 0.86), ensuring adequate reproductive potential. Statistical analyses confirm the observed patterns: the Shapiro-Wilk test indicated a non-normal distribution of lengths, while the Chi-squared test showed no significant deviations between observed and expected categories, supporting the structural observations.

Growth parameters derived from the von Bertalanffy model indicate a moderate-to-fast growth rate ($L\infty = 96.6$ cm, $K = 0.38$) and good population condition ($\Phi' = 3.55$). Mortality analysis shows that fishing mortality ($F = 1.46$) is substantially higher than natural mortality ($M = 0.54$), leading to a high exploitation rate ($E = 0.73$) and a total mortality of $Z = 2.04$, indicating a high anthropogenic pressure on the population. The m/K ratio (1.42) further indicates that natural mortality exceeds the intrinsic growth rate, highlighting the vulnerability of the population to overexploitation.

The length at first sexual maturity ($L_{50} = 51.38$ cm) and the $LC/L\infty$ ratio (0.53) suggest that most individuals contribute to reproduction and that the population maintains a balance between growth and exploitation.

Overall, the population appears healthy but strongly influenced by fishing pressure. Management measures should focus on regulating fishing intensity to reduce exploitation, preserve larger individuals, and ensure sustainable population dynamics in the long term.

## ACKNOWLEDGMENTS

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## REFERENCES

1.Froese, R.; Pauly, D. (Eds.) *FishBase*. World Wide Web Electronic Publication, **2016**. Available online: www.fishbase.org.
2. Stroe MD, Crețu M, Ibănescu DC, Stanciu S Ștefan, Patriche N. Estimation of Growth Parameters and Mortality Rate for Common Carp and Prussian Carp from Danube Delta. *Scientific Papers. Series D. Animal Science*. **2022**; *LXV*(2), 432–436.
3. Zambrano, L.; Hinojosa, D. Direct and indirect effects of carp (*Cyprinus carpio* L.) on macrophyte and benthic communities in experimental shallow ponds in central Mexico. *Hydrobiologia*. **1999**, 408, 131–138. https://doi.org/10.1023/A:1017085129620.
4. Oțel, V. *Atlas of Fish in the Danube Delta Biosphere Reserve*; Danube Delta Technological Information Center: Tulcea, Romania, **2007**; ISBN 978-973-88117-0-6.
5. Stancheva, M.; Merdzhanova, A.; Dobreva, D.A.; Makedonski, L. Common Carp (*Cyprinus carpio*) and European Catfish (*Silurus glanis*) from the Danube River as Sources of Fat-Soluble Vitamins and Fatty Acids. *Czech J. Food Sci.* 2014, 32 (1), 16-24.
6. Ford, M. *Cyprinus carpio*. The IUCN Red List of Threatened Species 2024: e.T6181A3107721. **2024.** Available online: https://dx.doi.org/10.2305/IUCN.UK.2024-2.RLTS.T6181A3107721.en (accessed on 18 September 2025).
7. Kottelat, M. *Cyprinus carpio* (River Danube subpopulation). The IUCN Red List of Threatened Species 1996: e.T6180A12556019. **1996.** Available online:

https://dx.doi.org/10.2305/IUCN.UK.1996.RLTS.T6180A12556019.en (accessed on 18 September 2025).
8. Berk RH, Jones DH. Goodness-of-fit test statistics that dominate the Kolmogorov statistics. *Z Wahrscheinlichkeitstheorie Verw Gebiete*. **1979**, 47(1), 47–59. doi:10.1007/BF00533250.
9. Pearson K. X. On the criterion that a given system of deviations from the probable in the case of a correlated system of variables is such that it can be reasonably supposed to have arisen from random sampling. *Philos Mag J Sci*. **1900**, *50*(302), 157–75. doi:10.1080/14786440009463897.
10. Rashid R. Length-Weight Relationship of Common Carp (*Cyprinus carpio* L., 1758) from Taqtaq Region of Little Zab River, Northern Iraq. *Turk J For Sci*. **2018,** *13*(2), 69–72.
11. Santos R, Peixoto UI, Medeiros-Leal W, Novoa-Pabon A, Pinho M. Growth Parameters and Mortality Rates Estimated for Seven Data-Deficient Fishes from the Azores Based on Length-Frequency Data. *Life*. **2022**, 12:778.
12. Munro JL, Pauly D. A simple method for comparing the growth of fishes and invertebrates. *Fishbyte*. **1983,** *1*(1), 5–6.
13. 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. doi:10.7717/peerj.758.
14. Stroe, M. D., Dobre, A., Crețu, M., Tenciu, M., Dima, F. M., & Patriche, N. Overall Effects of Climate Change on Economically Valuable Fish Population in the Danube River. *Sci Pap Ser D Anim Sci*. **2024**, *67*(1), 799–810.
15. Stroe DM, Dobre A, Dima MF, Dediu L, Macoveiu (Dobre) AN, Rochard E. Effects of climate change on *Cyprinus carpio* (Linnaeus, 1758) in the Danube River (2021–2024): Analysis of sex ratios, condition and length-class distribution. *Scientific Papers. Series D. Animal Science*. **2025**, *LXIII*(1), 789–800. ISSN 2285-5750.
16.Stavrescu-Bedivan MM, Madjar RM, Sion IA, Vasilescaeteanu G. Assessment of Water Quality and Biometric Analysis for Common Carp *Cyprinus Carpio* L., 1758: A Case Study from Bițina Pond (Ilfov County, Romania). *Agrolife*. **2022**, *11*(2), 191–200. https://doi.usamvb.ro/?doi=10.17930/AGL2022225.
17. Ciolac A. Migration of fishes in Romanian Danube River (No. 1). *Applied Ecology and Environmental Research*. **2004**, *2*(1), 143–163.
18. Gheorghe DC, Enache IB, Cristea V, Răzlog GP. Characteristics of the population growth and mortality of carp in the Danube (Km 170–Km 196). *Lucrări Ştiinţifice – Seria Zootehnie*. **2011**, *55*, 346–351.