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# ESTIMATION OF GROWTH PARAMETERS AND MORTALITY RATE FOR COMMON CARP AND PRUSSIAN CARP FROM DANUBE DELTA

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***Abstract***

*The purpose of this study was to determine the relationships between total length and weight (L - W), to estimate the growth parameters (von Bertalanffy) L∞, k, and the mortality rates (Z, M, F) for the common carp (Cyprinus carpio, Linneaus, 1758) and Prussian carp (Carassius gibelio, Bloch, 1782). Sampling was carried out monthly, from March to September 2021. The relationship between length - weight (L - W) in the study period for common carp was $W=0.0574\times Lt^{2.6437}$, respectively $W=0.0391\times Lt^{2.7831}$ for Prussian carp. The growth parameters for common carp were L∞=86.10 cm and K = 0.87 per year, respectively L∞= 40.95 cm and K 0.67 per year, for Prussian carp. The total (Z), natural (M) and fishing (F) mortality rates were 1.47, 0.82 and 0.65 per year, for common carp, respectively Z=1.65, M=0.85 and F=0.80 for Prussian carp. Regarding the exploitation rate (E) this was 0.44 for the common carp population, respectively 0.48 for Prussian carp, suggesting that both fish population were not in over-exploited condition.*

***Key words****: fisheries resource, fresh water fish, Length-Weight relationship, von Bertalanffy's equation.*

## INTRODUCTION

In Romania, commercial inland fishing takes place in rivers, ponds, and reservoirs, including the Danube River, the Danube Delta, and Danube Delta Biosphere Reserve (EUROFISH, 2021). Cyprinid species are by far the best-represented species of fish from the Romanian fishery. Between cyprinids species common carp (*Cyprinus carpio*, Linnaeus, 1758) and Prussian carp (*Carassius gibelio*, Bloch, 1782) are the most preferred freshwater fish by Romanian consumers. However, in Romania, the average apparent consumption of fish is still low, being estimated at 7.4 kg per capita in 2019 (EUROFISH, 2021).

According to the data provided by the National Agency for Fisheries and Aquaculture (ANPA), cyprinid catches vary between 2000 and 5000 tons per year, while the production from aquaculture is almost double.

The Danube Delta fisheries have declined in the last years, mainly due to the habitat loss by great floodplain and delta impoundments, an aspect that caused the decline fish stocks (Năstase et al., 2017). In this context, the sustainable exploitation of this commercial fish species requires a detailed study of the population and mortality parameters of these populations.

In this context, some population characteristics of common carp and Prussian carp, such as the length and weight distribution, condition factors, length-weight relationship, and some growth parameters and mortality rates, were investigated.

## MATERIALS AND METHODS

*Fishing area.* Scientific fishing was realized during the year 2021 in the Danube Delta, lake-complex Matiția-Merhei (Figure 1). The Deltaic surface of the Matița- Merhei is 24,420 ha total surface area, from which 20,000 ha is aquatic surface, consisting of a total of 106 lakes.

The lake complex includes Merhei lake (1137.47 ha), Matita (641.83 ha), Trei Iezere (433.5 ha), Bogdaproste (400.19 ha), Balbina (427.35 ha) and some small lakes around 50 - 200 ha: Cioticul, Rădăcinoasele, Poludionca, Poludeanca, Iacub, Roșca, Argintiu, Merheiul mic and other lakes around 50 ha (Romanescu, 1996).

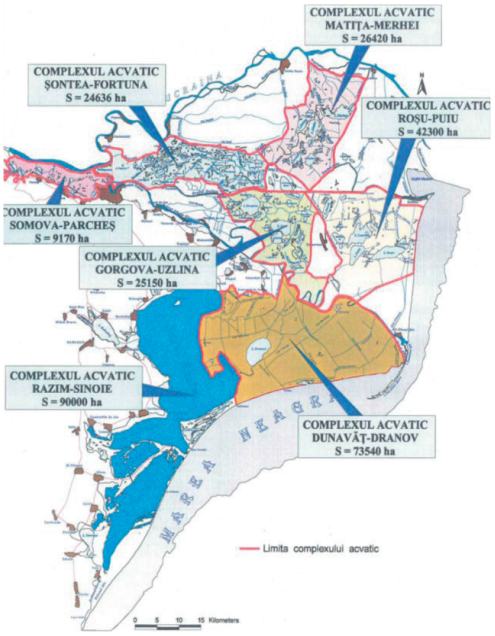


Figure 1. Natural aquatic complexes from the Danube Delta Biosphere Reserve (photo after Năvodaru, 2008)

*Data collection.* All samples were collected during September- October by gillnets (carp nets have a mesh size of 50-60 mm, and those for Prussian carp 40 mm). The assessment of the stock of common carp and Prussian carp in the analyzed area was based on methods of a random collection of representative samples from commercial catches. Throughout the study, 76 common carp and 106 Prussian carps were investigated on the criterion of including all length classes.

The total length (TL, cm), fork length (FL, cm) and height (h, cm) was measured using an ichtyometer to the nearest 0.1 cm, whereas the weight (W, g) was measured using the electronic weighing scale to the nearest 0.01 g.

*The estimation of the growth parameters and mortality*. The determination of the length-weight relationship (L - W) for the fishing population was done using the equation:

$W = a \times L^b$, where: W - individual weight (g).

The growth parameters ($L\infty$, k, $t_0$) were estimated by the length frequency analysis using the ELEFAN model from the FiSAT II program. The estimation of mortality rates was done according to Pauly (1980) and Pauly (1983). Total mortality (Z) was determined using the length converted catch curve analysis (Ricker, 1975) from FiSAT II computer software package. The natural mortality (M) was estimated by the Pauly's empirical formula (Pauly, 1980), using a mean surface temperature (T).

$$\text{Log M} = -0.0066 - 0.279*\text{Log}(L\infty) + 0.6543*\text{Log}(k) + 0.4634*\text{Log}(T),$$

where: $L\infty$ represent the asymptotic length, T is the mean annual temperature of water (12°C) and k refers to the growth rate coefficient of Von Bertalanffy.

Fishing mortality (F) was calculated using the relationship: F=Z-M (Gulland, 1971), where: Z is the total mortality, F is the fishing mortality and M is the natural mortality. The exploitation level (E) was obtained using the relationship: E=F/Z (Gulland, 1971). If the exploitation rate registered values under 0.5, fish stocks are easily exploited and if the E values are between 0.5-1, the stocks are heavily exploited.

*Data analysis.* The length frequency data was pooled into groups with 3 cm length interval. For data analysis we use Microsoft Excel 2019 and the software package FiSAT II (FAO-ICLARM Stock Assessment Tool).

## RESULTS AND DISCUSSIONS

Table 1 presents the mean values of the individual weight, total length, fork length and height of the population of carp and Prussian carp.

Table 1. Mean, minimum and maximum values of weight, total lengths, fork length and height of common carp and Prussian carp population collected from the study area

| Fish species | | Weight (g) | Total length (cm) | Fork length (cm) | Height (cm) |
|---|---|---|---|---|---|
| *Cyprinus carpio* | Mean±SD | 1939±897 | 50.51±7.49 | 49.96±7.21 | 14.6±2.31 |
| | Min.-Max. | 1200-6350 | 40-81 | 37-71 | 14-22 |
| *Carassius gibelio* | Mean±SD | 471.1±248.4 | 28.26±4.94 | 24.97±3.19 | 10.6±2.27 |
| | Min.-Max. | 200-1300 | 21.6-41 | 20.1-34 | 7.9-16 |

A total of 76 common carp were sampled, 53.95% females and 46.05% males. The total length of all individuals varied from 40 cm to 81 cm and the mean total length was calculated as 50.51±7.49 cm. Dominant length groups were between 43-46 cm, followed by 49 cm and 54-56 cm, respectively (Figure 2).

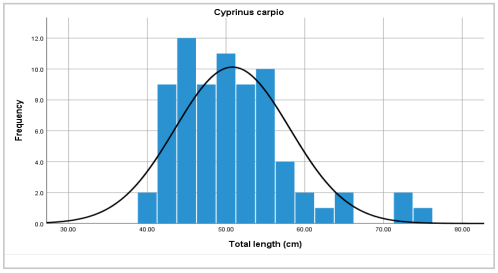


Figure 2. Length-frequency distribution of *Cyprinus carpio*

Regarding the Prussian carp, 106 specimens were sampled 71.69% females and 28.30% males. The total length of all individuals varied from 21.6 cm to 41 cm and the mean total weight was calculated 28.26±4.94 cm (Table 1). Dominant length groups were between 24-25 cm, followed by 23 cm and 28-29 cm respectively (Figure 3).

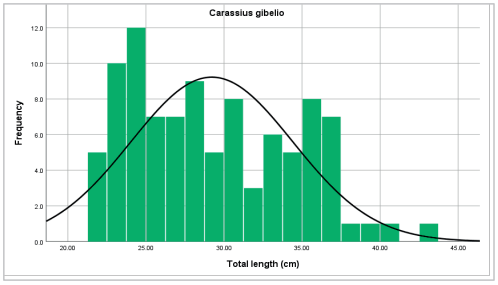


Figure 3. Length-frequency distribution of *Carassius gibelio*

The estimation of the a, b coefficients from the equation $W = a \times L^b$ for the carp and Prussian carp population was determined from the regression between length and mass. The length-weight relationship of the carp population was $W=0.0574\times Lt^{2.64}$ (Figure 4), respectively $W=0.0391\times Lt^{2.78}$ for Prussian carp (Figure 5). The slope values of the length-weight relationship showed that fish body length increased allometrically with total length, both in the case of common carp (b=2.64) and Prussian carp (b=2.78). Usually, the values of these coefficients are variable from one year to another, as a result of the physiological processes of growth, fattening, sexual maturation, reflecting the specific adaptation and creating the unity species-environment (Năvodaru, 2008; Serajuddin et al., 2013). In general, the length increments decrease with increasing fish age, while the weight increase with growing fish weight.

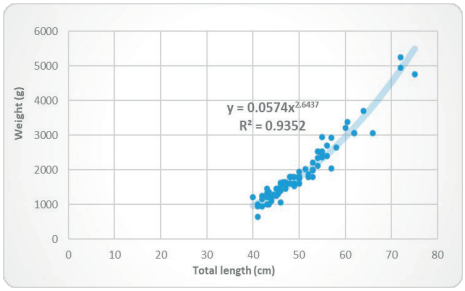


Figure 4. Length-Weight relationship for the common carp population

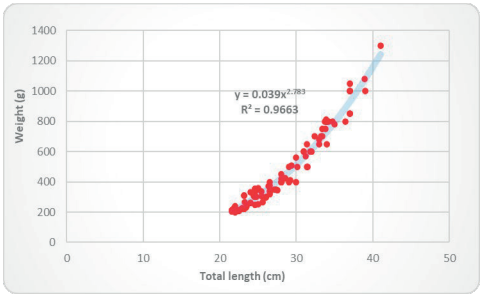


Figure 5. Length-Weight relationship for the Prussian carp population

*Growth parameters*. For growth parameter estimation, the data set for common carp and Prussian carp was used to calculate Von Bertalanffy growth parameters, which was shown in Table 2. The L∞ and k for common carp were estimated as 86.10 cm and 0.87 $year^{-1}$ from length frequency data using ELEFAN I by FiSAT II software, while for Prussian carp, the L∞ and k for common carp were estimated as 40.95 cm and 0.67 $year^{-1}$.

*The mortality and exploitation rates.* The total mortality (Z) was estimated through the linearized curved catch method based on the length frequency structure where the Bertalanffy's equation is used to convert lengths in ages.

Table 2. Parameters of the von Bertalanffy growth equation for common carp and Prussian carp population at Matița-Merhei

| Species | $L_\infty$ | k | $t_0$ | Z | M | F | E |
|---|---|---|---|---|---|---|---|
| *Cyprinus carpio* | 86.10 | 0.87 | -0.077 | 1.47 | 0.82 | 0.65 | 0.44 |
| *Carassius gibelio* | 40.95 | 0.67 | -1.37 | 1.65 | 0.85 | 0.80 | 0.48 |

Note: $L\infty$ - asymptotic length; k - growth rate coefficient of Von Bertalanffy; Z - total mortality; M - natural mortality; F - fishing mortality; E - exploitation rate.

For common carp, the total mortality was 1.47 per year while the natural mortality (M) was found to be 0.82 per year and the estimated fishing mortality (F) was 0.65 per year. For Prussian carp, the total mortality was 1.65 per year while the natural mortality (M) was found to be 0.85 per year and the estimated fishing mortality (F) was 0.80 per year.

In order to maintain optimal fish stocks, estimating of mortality rates are important to avoid the over-exploitation of fishery resources. In our study, the exploitation ratio for common carp was found to be 0.44, while for Prussian carp was 0.48, suggesting that both fish populations were not in over-exploited condition. The previous studies of Ibănescu et al. (2011) found for common carp from Danube River (km 170-km 196) an asymptotic length of $L_\infty$ -87.15 cm, k - 0.260 year$^{-1}$, while total mortality (Z) was 0.85 per year, natural mortality (M) was 0.37 per year, and mortality due to fishing (F) was 0.48 per year. The authors state that the population is overexploited by fishing or poaching, reaching an exploitation rate (E) of 0.56. Also, the same author, found for Prussian carp (Danube River, km 170-km 196) an asymptotic length of $L_\infty$ - 39.38 cm, k - 0.63 year$^{-1}$, while total mortality was 2.29 year$^{-1}$, natural mortality 0.826 year$^{-1}$, fishing mortality 1.46 year$^{-1}$ and the exploitation rate 0.63 aspect which demonstrates that the Prussian carp population from the studied sector is overexploited, both by legal and illegal fishing (Ibănescu et al., 2012). In a similar study from 2006, at the same fishing area (Matița-Merhei), Năvodaru et al., 2008, reported for *Carassius gibelio* (total length min-max. between 18÷31.7 cm, and weight min-max between 142-797 g) an asymptotic length of 41.3 c, k - 0.21 year$^{-1}$, while natural mortality and total mortality was lower compared with our study (M - 0.41 year$^{-1}$ and Z - 1.3 year$^{-1}$).

## CONCLUSIONS

In order to avoid the over-exploitation of fishery resources it is important to estimate the growth and mortality rates of fish stocks. From the results of our study, it can be concluded:

- the length-weight relationship of the studied population showed an allometric growth pattern, fish body length increased with total length;
- the most abundant are the carp fishes with a size range between 43-46 cm and the Prussian carp 24-25 cm;
- the studied population of *Cyprinus carpio* and *Carassius gibelio* from the Matița-Merhei area isn`t in a situation of overexploitation.

However, changes in the population structure and stock size must be monitored continuously and further studies are recommended for this fishing area.

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