Study of the growth of three species: *Micropterus salmoides* (Lacépède, 1802), *Cyprinus carpio* (Linneaus, 1758) and *Oreochromis niloticus* (Linnaeus, 1758) in Moroccan continental waters

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Abstract. The growth parameters of three species were studied for the first time in the Al-Massira Dam. A total of 137 individuals were examined during this study between September 2020 and January 2021. The estimation of growth parameters was carried out by size structure analysis using FISAT II software. The growth parameters of *Micropterus salmoides*, *Cyprinus carpio* and *Oreochromis niloticus* are respectively: \(L= 35.11 \text{ cm}, K= 0.58 \text{ year}^{-1}, t_0= 0.57 \text{ year}\); \(L= 44.85 \text{ cm}, K= 2.60 \text{ year}^{-1}, t_0= 1.27 \text{ year}\) and \(L= 45.26 \text{ cm}, K= 0.32 \text{ year}^{-1}, t_0= 0.33 \text{ year}\). Thus, the Von Bertalanffy growth equations are written respectively: \(L(t) = 35.11 (1-e^{-0.58(t+0.57)})\), \(L(t) = 44.85 (1-e^{-2.60(t+1.27)})\) and \(L(t) = 45.26 (1-e^{-0.32(t+0.33)})\).

Keywords: Al-Massira Dam, *Micropterus salmoides*, *Cyprinus carpio*, *Oreochromis niloticus*, Growth.

1 Introduction

Growth refers metabolically to the amount of energy used to increase body weight and length[1,2]. Growth studies have often been used to analyse the structure and dynamics of fish populations. Similarly, in fisheries ecology, growth is an indicator of fish habitat quality [3].

Growth processes in fish are conditioned by habitat quality[4,5,6]. Similarly, several other factors can influence fish growth: seasons[5], age and physiological condition[2], and sex[6].

Indeed, studies on the ichthyofauna of freshwater in Morocco have not been pervasive and have generally been limited to the systematic side, except for a few works[9,10,11,12,13]. Studies concerning the ecology and biology of fishes in rivers and reservoirs are few. For a long time, studies have been carried out on the determination and knowledge of the traits of fish populations in different aquatic environments. Among the characteristics generally studied are size, growth, size-weight relationship, age and others.

In this context, this work is about the study of some parameters of the growth of three species of the Al-Massira Dam which are: *Micropterus salmoides*, *Cyprinus carpio* and *Oreochromis niloticus*, to ensure sustainable exploitation of these species.

2 Materials and Methods

The Al-Massira Dam is located on the main course of the Oued Oum Erbia, 70 km south of Settat. The climate of the reservoir area is of semi-arid to arid Mediterranean type. It is characterised by hard waters (total hardness in the epilimnion varies from 127 mg/l to 367 mg/l and Ca\(^{2+}\) from 24 mg/l to 78 mg/l) and an alkaline pH between 8 and 9[8]. Thus, the reservoir is classified as an oligotrophic to mesotrophic system. The Al Massira Reservoir is one of the largest Moroccan reservoirs, with multiple uses: drinking water, agriculture, industry and energy.

The fish examined were collected monthly between September 2020 and January 2021. The three species (black bass, common carp and tilapia) come from the Al-Massira Dam. On each specimen, the total length (TL) was determined using an ichthyometer.

The analysis of the growth parameters of the three species was carried out based on size-frequency data of 124 specimens ranging in size from 17.5 to 34 cm for black bass, 14.5 to 43 cm for common carp and 10.5 to 43 cm for tilapia. Programmes incorporated in the FISAT II software[9] were used for this analysis.

2.1 Determination of growth parameters

The study of growth was determined using the Von Bertalanffy model [16], whose equation is:
\[ L_t = L_\infty (1 - e^{K(t - t_0)}) \]  

With: \( L_t \) = length of the fish at time \( t \) considered (cm); \( L_\infty \) = asymptotic length (cm), it is the length that the species could reach if it continues to live and grow infinitely; \( K \) = the growth coefficient characterising the speed with which the species grows towards \( L_\infty \) (year\(^{-1}\)); \( t_0 \) = theoretical age of the fish when its size is zero (year).

2.1.1 Asymptotic length \( L_\infty \)

The asymptotic length \( L_\infty \) is interpreted as the average length of very or infinitely aged fish\[10\]. The estimation of this parameter is done by different methods:

- **Pauly’s method\[11\]:**
  
  In this method, \( L_\infty \) depends on the size of the largest fish measured in the \( L_{\max} \) sample:

  \[ L_\infty = \frac{L_{\max}}{0.95} \]  

- **ELEFAN I method\[12\]:**
  
  The ELEFAN (Electronic Length Frequency Analysis) method was first proposed by\[12\] and modified by\[20, 17, 21, 22\]. The most recent description can be found in\[14\]. This method estimates growth parameters by length-frequency analysis. It increases the objectivity and reliability of the growth curves obtained.

- **Powell’s method\[15\]-Wetherall's method \[16\]:**
  
  This method is a particular application of Von Bertalanffy’s equation\[17\], allowing the determination of the parameter \( L_\infty \) and the \( Z/K \) ratio from the following linear equation:

  \[ L_m - L' = a + b L' \]  

  Where: \( L_m \) = the average length (cm), calculated from \( L' \), \( L' \) = the lower limit of each size class (cm), \( a \) = original ordinate, \( b \) = slope of the regression line.

  The results are cumulated from the bottom to the top of the size-frequency distribution.

  \[ L_\infty = -a/bZ/K = -(1 + b)/b \]  

  Where: \( K \) = the coefficient of catabolism, \( Z \) = the total mortality rate.

2.1.2. The catabolism coefficient \( K \)

According to\[14\], the catabolism coefficient \( K \) is the curvature parameter that determines how fast the fish will reach \( L_\infty \). It is also the stress coefficient, which is estimated based on comparative studies of the growth of the species studied. Pauly and Munro \[18\] use the following relationship:

\[ \phi = \log_{10} (K) + 2 \log_{10} (L_\infty) \]  

Where: \( \phi \) = average growth rate.

The growth parameter \( K \) in a defined stock is deducted from the following formula:

\[ K = 10 (\phi - 2 \log_{10} (L_\infty)) \]  

2.1.3. Hypothetical age \( t_0 \)

The hypothetical age, or the initial condition parameter, \( t_0 \), determines the time point or the fish at length zero. The determination of this parameter is done by the relation of Pauly (1980)\[19\]:

\[ \log_{10} (t_0) = -0.3922 - 0.2752 \times \log_{10} (L_\infty) - 1.038 \times \log_{10} (K) \]  

3. Results

3.1. Estimation of the asymptotic size \( L_\infty \)

The values of the asymptotic lengths \( L_\infty \) obtained for the three species (Black bass, carp and tilapia) by the Pauly method\[11\] are overall greater than that of the maximum sizes observed (Table 1).

Table 1. Asymptotic length estimated by the Pauly method.

| Species               | Micropterus salmoides | Cyprinus carpio | Oreochromis niloticus |
|-----------------------|-----------------------|-----------------|-----------------------|
| \( L_{\max} \) (cm)   | 34                    | 34              | 43                    |
| \( L_\infty \) (cm)   | 35.79                 | 35.79           | 45.26                 |

The analysis of the size-frequency distributions processed by the ELEFAN I program of the FiSAT II software allows an automatic search for the values of \( L_\infty \) (Figure 1).

Table 2 summarizes the values obtained by the K Scan tab.

Table 2. Asymptotic length estimated by the ELEFAN method.

| Species               | Micropterus salmoides | Cyprinus carpio | Oreochromis niloticus |
|-----------------------|-----------------------|-----------------|-----------------------|
| \( L_\infty \)        | 35.18                 | 44.63           | 47.78                 |

The analysis of the size-frequency distributions processed by the ELEFAN I program of the FiSAT II software allows an automatic search for the values of \( L_\infty \) (Figure 1).
The values obtained for $L\infty$ for black bass, common carp and tilapia by Powell–Wetherall method [24,25] are respectively equal to 35.13 cm, 44.85 cm and 45.26 cm.

3.2. Coefficient of catabolism $K$ and hypothetical age $t_0$

The different values of $\phi$ 'obtained by the different authors in various regions and allowing the estimation of $\phi'$ for the three species are reported in Table 3. The $\phi'$ obtained from these results is 2.86 for black bass, 5.60 for common carp and 2.82 for tilapia. Thus, the values of the specific growth rate ($K$) and $t_0$ are respectively 0.58 year$^{-1}$ and 0.57 year for the black bass, 2.60 years$^{-1}$ and 1.27 years for the common carp. For tilapia, the values of $K$ and $t_0$ are respectively 0.32 year$^{-1}$ and 0.33 year.

Table 3 represents the Von Bertalanffy equations[28] for the three species obtained from the growth parameters $L\infty$, $K$ and $t_0$ calculated during this study.

Table 3. Growth equations from Von Bertalanffy.

| Species               | Von Bertalanffy's equation           |
|-----------------------|-------------------------------------|
| Micropterus salmoides | $L(t) = 35.11 \left(1 - e^{-0.58(t-0.57)}\right)$ |
| Cyprinus carpio       | $L(t) = 44.85 \left(1 - e^{-2.60(t-1.27)}\right)$ |
| Oreochromis niloticus | $L(t) = 45.26 \left(1 - e^{-0.32(t-0.33)}\right)$ |

4 Discussion

The linear growth of the three species: black bass, common carp and tilapia from Al-Massira Dam, was studied through the modal progression method based on size-frequency data.[28] model for linear growth was applied for all three species. This model remains, because of its flexibility, the most widely used in estimating linear growth.

Table 3 compares the parameters of the Von Bertalanffy equation [28] and the growth performance index ($\phi$) in black bass, common carp and tilapia in different geographic regions. Thus, the performance index values are almost for all the species studied except for small differences, which are slight.

The asymptotic length $L\infty$ values were found during this study for the different three species from region to region with few exceptions. Indeed, this value is close to that found by[29] and[30] for black bass and that found by[31] for common carp. For tilapia, $L\infty$ is close to that revealed by the work of[32] and[33].

As for the catabolism coefficient $K$, it represents the highest value compared to that found by other authors in common carp [34,35,36,37] and black bass[38,29,30,39,40]. In tilapia, the value of $K$ is close to that found by[41], higher than that obtained by[42] and[33] and lower than that obtained by[43,44,32].

The hypothetical age values $t_0$ from the many studies carried out in different regions by different authors seem to be different from those we found for the three species. Only the results obtained by[44] in Ethiopia are close in the tilapia species.

The difference between the different values of the growth parameters of the different authors is explained by the fact that the growth parameters can vary from one stock to another within the same species, that is to say that the growth parameters of a given species can have different values depending on the areas of its distribution. Likewise, successive cohorts can develop differently depending on
environmental conditions[16], especially temperature. According to[45], temperature plays a significant role because it acts not only on the production of available food but also on the physiology of individuals. According to [46], the temperature is the most critical factor limiting the growth of fish.

5 Conclusion

This study clarified the knowledge of the growth of three fish populations (Micropterus salmoides, Cyprinus carpio and Oreochromis niloticus) in particular in the Al-Massira Dam reservoir. Thus, the results show a good growth of these populations with reference to other studies in other geographical areas. Further studies need to be carried out over more extended periods for a good understanding of the biology of these species, to arrive at more conclusive results for the proper management of fisheries resources.

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### Table 3. Growth parameters of black bass, common carp and tilapia in different regions.  

| Species                  | Geographic area | L∞ (cm) | K       | t0       | φ’      | Reference                                      |
|--------------------------|-----------------|---------|---------|----------|---------|------------------------------------------------|
| **Micropterus salmoides**| North America   | 52.9    | 0.15    | -0.024   | 2.87    | Beamesderfer and al. (1995)                    |
|                          | Italy           | 51.0    | 0.282   | -0.13    | 2.76    | Lorenzoni and al. (1996)                       |
|                          | Japan           | 34.1    | 0.498   | -0.07    | 2.76    | Froese and Pauly (1998)                        |
|                          | Kenya           | 50.8    | 0.46    | -0.01    | 3.07    | Britton and Harper (2005)                      |
|                          | South Africa    | 42.0    | 0.33    | -0.22    | 2.77    | Taylor and al. (2017)                          |
|                          | Morocco         | 35.13   | 0.58    | -0.57    | 2.86    | This study                                     |
| **Cyprinus carpio**      | Turkey          | 54.53   | 0.140   | -0.753   | 6.03    | Cengiziler and Erdem (1989)                    |
|                          | Kenya           | 72.76   | 0.172   | -0.446   | 6.82    | Alp and Balik (2000)                           |
|                          | Algeria         | 46.39   | 0.153   | -1.922   | 5.80    | Karatas and al. (2007)                         |
|                          | Algeria         | 36.75   | 0.46    | -0.33    | 2.77    | Lotfi and Talet (2019)                         |
|                          | Kenya           | 73.5    | 1.05    | -0.95    | 3.72    | Mutelhya and al. (2020)                        |
|                          | Morocco         | 44.85   | 2.60    | -1.27    | 5.60    | This study                                     |
|                          | Kenya           | 64.6    | 0.25    | 3.00     | 2.60    | Getabu (1992)                                 |
|                          | Bangladesh      | 55.6    | 0.39    | 3.08     | 2.60    | Ahmed and al. (2003)                          |
|                          | Ethiopia        | 28.1    | 0.43    | 2.53     | 2.60    | Tesfaye and Wolff (2015)                       |
|                          | Mexico          | 17.88   | 0.3409  | -1.543   | 2.60    | Gómez-Márquez and al. (2008)                   |
|                          | Ethiopia        | 44.5    | 0.41    | -0.36    | 2.90    | Tesfaye and Wolff (2015)                       |
|                          | Ethiopia        | 45.1    | 0.21    | -0.514   | 2.63    | Degsera and al. (2020)                        |
|                          | Morocco         | 45.26   | 0.32    | -0.33    | 2.82    | This study                                     |
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