



## Study of the Ichthyological Populations of Lake Dayet Er-Roumi (Morocco): Use of Indices to Analyze the Ichthyofaunistic Biodiversity

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### ABSTRACT

The Dayet Er-Roumi (classified as a Site of Biological and Ecological Interest) is the only permanent natural lake of the region of Khemisset, Morocco. This lake is interesting however it is a poorly known freshwater fish resource. An ichthyological study was carried out during the year 2019, with the aim to characterize the populations, identify and determine the level of species diversity using synthetic indices (the specific richness, the diversity of Shannon, and the equitability). The objective of this study was to know the current state of the fauna resource and assess the impact of anthropogenic pressure, particularly fishing pressure on this resource. The inventory and identification of the fish made it possible to establish a list of seven species, three of which are indigenous: *Barbus* sp., *Tilapia Zilli* and *Anguilla*, while the other four species are introduced with the predominance of the species *Gambusia affinis* and *Cyprinus carpio carpio* in terms of numbers. They represent respectively 33,7% and 21.6 % of the individuals captured. The other species are comparatively moderately to poorly- represented. The calculation of the synthetic indices showed a non-stable state of the population of Lake Dayet Er-Roumi due mainly to a low diversity with the dominance of some species over others. Measures must be taken to better conserve this ichthyological richness.

### INTRODUCTION

The global freshwater fish situation is of concern. One-third of known fish species are extirpated or severely threatened, and about 3-5% are within the IUCN list (international union for conservation of nature) of endangered animals (Maitland, 1995). The main causes of this decline are destruction and anthropization of these fish (water pollution, destruction of fish habitats) in addition to their exploitation in an intensive manner (Hudon *et al.*, 2018).

The diversity and conservation status of freshwater fish vary by region. If the situation of freshwater fish is well known in Europe or North America and protection and conservation programs are in place (FAO, 2012), it is not the same in other regions such as Africa or South America. Indeed, although these regions are characterized by a great diversity of ichthyofauna, their distribution remains imprecise; their taxonomy is questionable, and their status is often imprecise (Maitland, 1995; Keith, 2000).

The ichthyofauna of the continental waters of North Africa in general and Morocco, in particular, is little known in recent years; the knowledge of the ichthyological fauna of lakes, rivers, and water bodies has been a concern for naturalists and scientists (Djidohokpin *et al.*, 2016). This interest is due to two main reasons: 1) the ichthyological fauna of Africa offered by its richness (Daget, 1988) the most complex and wider fields of investigation, hence the attachment of scientists to this important natural laboratory; 2) the increasing intensification of the exploitation of freshwater and brackish fish populations by local populations permanently increase and especially the alarming acceleration of all the processes of degradation of the natural environment make hover the major risk of regression and extinction of the species (Daget *et al.*, 1988; Lévêque, 1994; Lalèyè, 1995).

The Dayet Er-Roumi Lake gathers a very great ichthyological diversity which is not yet well known at the taxonomic level and even less at the level of biology and ecology of the species which populate them. This ichthyological richness is increasingly exploited by local populations, who use various capture techniques. The need to take conservation measures is therefore becoming a major concern. These measures, to be effective, require a good knowledge of the species and the relationships that link them to their environment (Lalèyè *et al.*, 2004). There has never been an exhaustive inventory of the ichthyological fauna of Dayet Er-Roumi Lake; the information available on the ichthyofauna is very fragmentary and old (Mouslih, 1987; Moreau *et al.*, 1988; Yaakoubi, 1994; Azeroual, 2003), therefore, it appears necessary to determine the ichthyological fauna of this lake to establish an ichthyological reference and evaluate the specific richness, etc...

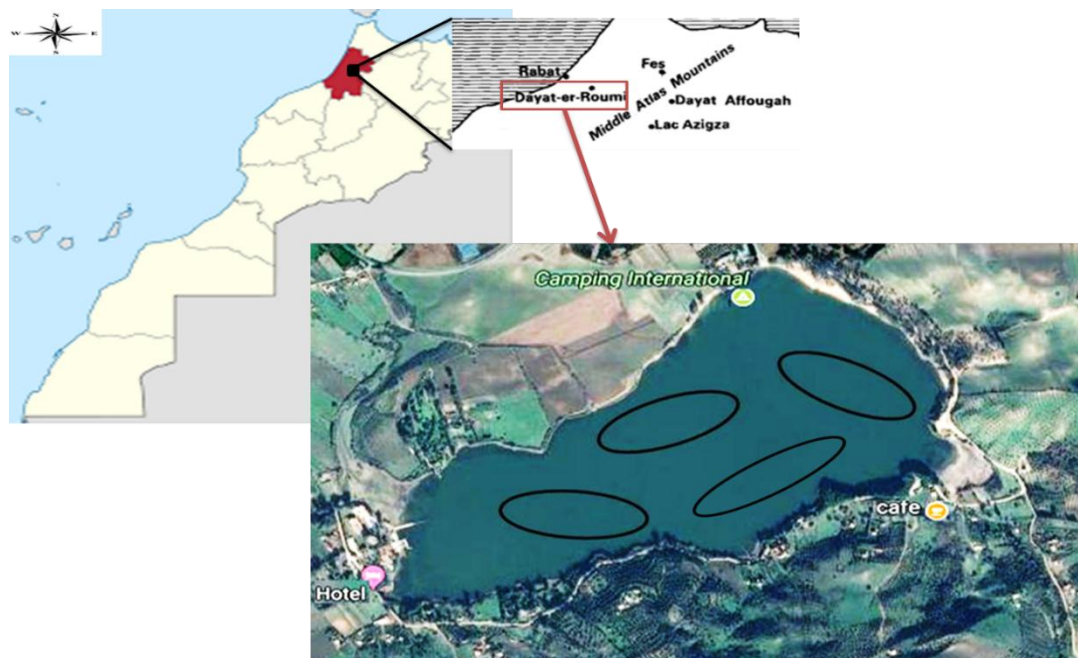
This study is part of this scientific theme. It focused on a specific issue, which is the quantification of specific biodiversity and its variability in relation to anthropogenic pressure. The objectives of this study were to establish an inventory as well as an identification of the ichthyofauna of Lake Dayet Er-Roumi to determine the specific biodiversity and study for the first time the current state of the fish resources of this lake using synthetic indices such as specific richness, Shannon diversity and equitability, etc.

The article was classified into three parts: the first part dealt with generalities about the study area, the sampling and the methods used to analyze the results; the second part dealt with fish populations (inventory and identification of the species present in the catches) and studied their specific biodiversity. The whole was followed by a conclusion.

## MATERIALS AND METHODS

### 1. Description of the study area

Dayet Er-Roumi Lake ( $33^{\circ}45'N$   $-06^{\circ}12'W$ ) is found on the alluvial coastal plain in Rabat to the West and the Middle Atlas Mountains to the East, 15 km southwest of Khemisset. This lake is situated in three rural communities: Ait Houderrane, Ait Ouahi, and Ait Ouribel. It is discriminated by a semi-arid climate with a minimum winter temperature of  $7^{\circ}C$ ; a maximum summer temperature of  $38^{\circ}C$ , and a middling rainy regime. The lake has an area of about 90ha, and a maximum depth of 13.5 m in the middle of the lake. In addition, it is 2 km long and a 400 to 700m width (Mabouhi, 2006). This lake ecosystem is fed by groundwater and two tributaries (Fig.1).



**Fig. 1.** Study area and location of sampling stations

### 2. Sampling

The sampling was carried out at four stations (the choice of stations according to accessibility is possible and easily casting the net) during four seasons: winter, spring, summer and autumn. The method used in this study was fishing with two types of gillnets.

This method has the advantage of being standardized, reproducible, and allows for obtaining semi-quantitative data (Alliod, 2011). The nets used have an area of  $45m^2$  (45 m long by 1m high) and an area of  $700m^2$  (100m long by 7m high) and mesh sizes of 20, 25 and 35mm. The nets are set at 9 am and picked up at noon at 4 pm; the fish are individually unhooked and placed in a water tank. The collected fish are identified and subsequently returned to the water (Fig.2).



**Figure 2.** Fish sampling

### 3. Data analysis

#### 3.1. Identification

To define the fauna richness that has endowed this site, an inventory of fish populations has been made. The identification of the species was based on the perception of experts from the National Centre for Hydrobiology and Fish Farming of Azrou, which is under the high commission for water and forests and the fight against desertification (HCEFLCD).

#### 3.2. Calculation of diversity indices

To exploit and analyze the collected data, statistical studies and calculations of diversity or heterogeneity indices that summarize the main characters of the structure of the ichthyological community were used; among these diversity indices we have in particular: the total specific richness (S), the Shannon diversity index (H') (Shannon, 1948) and the equitability index (E') (Pielou, 1966). Three types of diversity indices used were:

- a. **The species richness.** The species richness S corresponds to the simple counting of the number of species present in the sample.
- b. **Shannon diversity (H').** The Shannon diversity index H' (Shannon, 1948) is used in ecology as a measure of specific diversity (Margalef, 1958; Frontier, 1983):

$$H' = - \sum_{i=1}^s \left( \frac{n_i}{N} \times \log_2 \frac{n_i}{N} \right)$$

Where, S is the total number of species present;

$n_i$  is the number of species in the sample, and

N is the total number of species.

H' varies between 0, in the case where the population consists of only one species, and  $\log_2 S$  in the case where all the species present are present with an equivalent abundance (generally  $H' = 4.5$  or  $5$  for the most diverse populations). In the following, the term "diversity" is used in reference to the Shannon index.

- c. **Equitability (R).** The equitability index R (Pielou, 1966) makes it possible to measure equitability (a term that some ecologists refute, preferring that of regularity) or even the distribution of the species in the stand with respect to an equal theoretical distribution for all species (Barbault, 1992):

$$R = \frac{H'}{H_{max}} \text{ avec } H_{max} = \log_2 S$$

The R value varies between 0 (only one species dominates) and 1 (all species have the same abundance). Equitability considers the maximum potential diversity of the system ( $H'_{max}$ ); that is, the capacity of the system to accept S species in equivalent proportions. R is, therefore, a sort of synthesis of the other two indices.

## RESULTS

### 1. Composition of fish communities

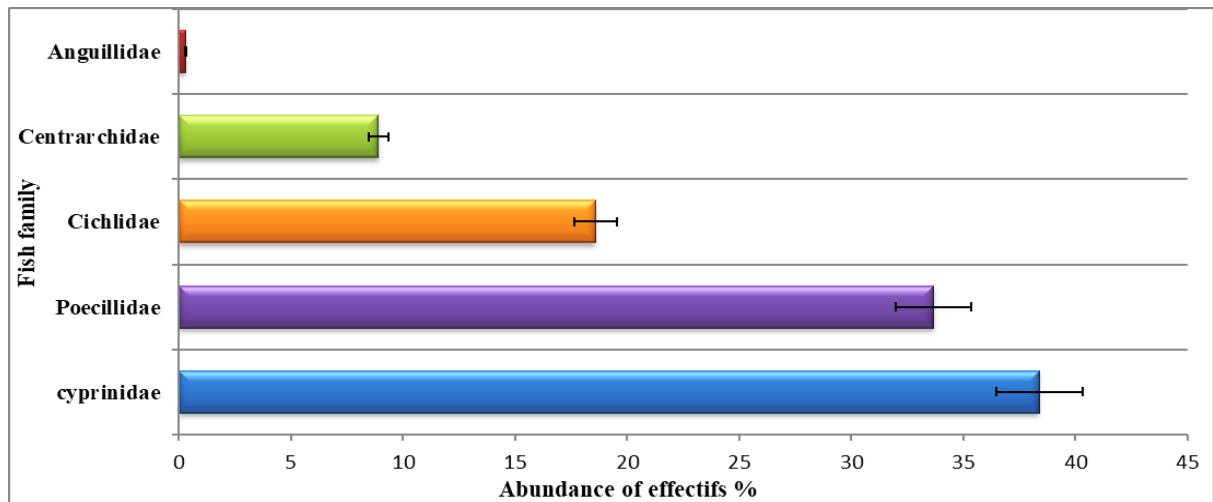
The fish species encountered during the different sampling missions are a total of 7 species (table 1) belonging to five families, with three native species of Morocco and five allochthonous species. Table (1) illustrates the presence of an autochthonous species "*Anguilla anguilla*" in the red list (it is in critical danger of extinction).

### 2. Abundances of the different families of fish caught

With 338 individuals captured, the Cyprinidae and the Poecillidae represent the dominant families of Lake Dayet Er-Roumi, they respectively represent 38.4% and 33.7% of the fish assessed. The Cichlidae come in third position followed by the Centrarchidae in fourth position, these two families represent 27.6% of the fish inventoried in the lake. In the last position comes the Anguillidae with a single individual, or 0.3% (Fig.3).

**Table 1.** Dayet Er-Roumi Lake ichthyofauna inventory and their status in the IUCN Red List 2022

Family	Species	Their status in the IUCN Red List	Species origin
Cichlidae	<i>Coptodon zillii</i>	LC (Least Concern)	autochthon
Centrarchidae	<i>Lepomis gibbosus</i>	LC (Least Concern)	introduced
	<i>Micropterus salmoides</i>	LC (Least Concern)	introduced
Poeciliidae	<i>Gambusia affinis</i>	LC (Least Concern)	introduced
Cyprinidae	<i>Barbus sp</i>	–	autochthon
	<i>Cyprinus carpio</i>	Vu (Vulnerable)	introduced
	<i>Cyprinus carpio carpio</i>		
Anguillidae	<i>Anguilla anguilla</i>	CR (Critically Endangered)	autochthon



**Fig. 3.** Abundances of the different families of fish caught

### 3. Abundance of the different species of fish caught

With 338 individuals caught in the whole lake, two introduced and dominant species in terms of numbers are *Gambusia affinis* and *Cyprinus carpio carpio* (Fig.4). They represent respectively 33.7% and 21.6% of the total number of individuals captured. The other species caught are comparatively moderately to weakly represented, among these species, we observe in a decreasing order the species *Coptodon zillii* with 63 individuals (18.7%), then the species *Cyprinus carpio* with 52 individuals (15.3%), followed by *Lepomis gibbosus* with 29 individuals (8.6%), after the species *Barbus* sp. with 5 individuals (1.5%) and finally *Micropterus salmoides* and *Anguilla anguilla* with only one individual captured each (0.35%).

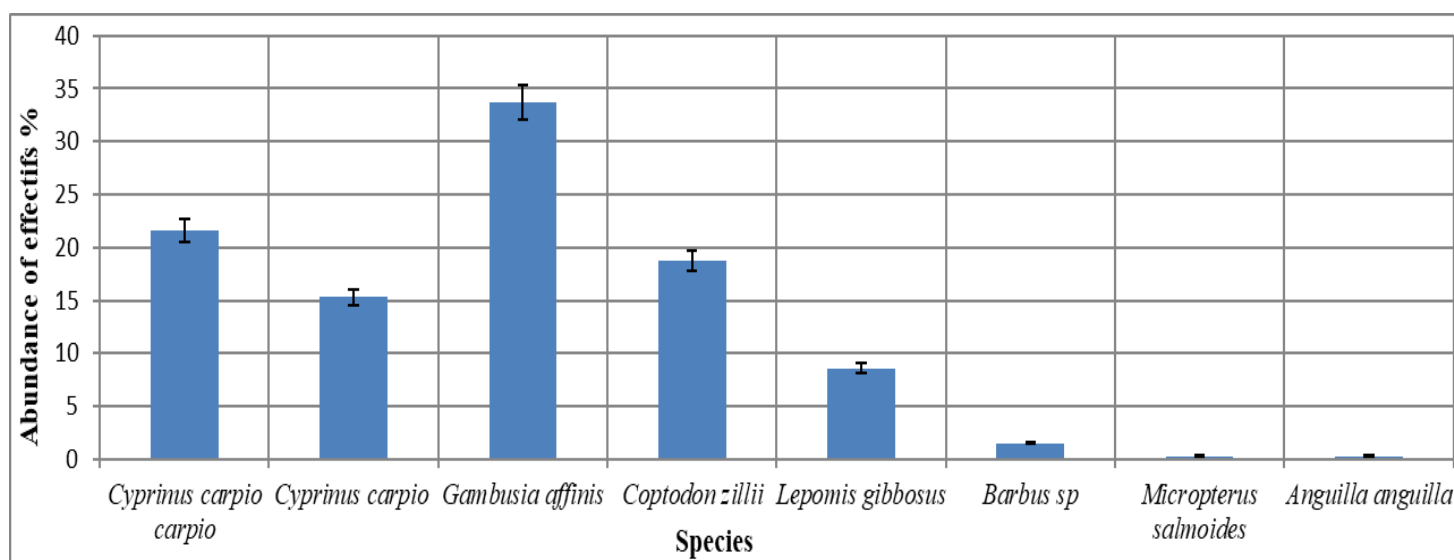


Fig. 4. Abundances of the different species of fish caught

### 4. Diversity indices

The species richness of the lake is generally low, with only 7 species and one subspecies captured. The Shannon  $H'$  index is 0.59 indicating that the population of Lake Dayet Er-Roumi is not diversified. The equitability index (which provides information on the homogeneity of captures and the balance of the population) is 0.7 ( $R < 0.80$ ), which reflects a state of non-stability of the population of Lake Dayet Er -Roumi. Based on these results, it is deduced that, Lake Dayet Er-Roumi has low to moderate diversity.

Table 2. Diversity indices of the Lake Dayet Er-Roumi

<b>Effective</b>	338
<b>Specific richness</b>	7
<b>Diversity of Shannon</b>	0.59
<b>Equitability</b>	0.7

## DISCUSSION

The study of the fish fauna of Lake Dayet Er-Roumi shows that there are 7 species and one subspecies of which 3 species are autochthonous (*Coptodon zillii*, *Barbus* sp. and *Anguilla anguilla*) and 5 allochthonous or introduced (*Lepomis gibbosus*, *Micropterus salmoides*, *Gambusia affinis*, *Cyprinus carpio carpio* and *Cyprinus carpio*). Among indigenous fish, *Anguilla anguilla* is classified in the IUCN red list as a species in critical danger of extinction.

The analysis of all fish caught allowed to assess the relative abundances for each species, *Gambusia affinis* (belonging to the family of Poecillidae) is predominant in the catches, it represents more than 33.7% of the fish in terms of relative abundance, then we find the subspecies *Cyprinus carpio carpio*, which is part of the family of cyprinidae. This subspecies is abundant; it represents 21.6% of the fish counted. Then, in the family of Cichlidae, the species *Coptodon zillii* is moderately present. *Lepomis gibbosus* (8.6%), *Barbus* sp. (1.5%), *Micropterus salmoides* (0.35%) and *Anguilla anguilla* (0.35%) are infrequent.

The two invasive and dominant families in Lake Dayet Er-Roumi are the cyprinidae and the poecillidae; they respectively represent 38.4% and 33.7% of the fish inventoried. The cichlidae also present a rather remarkable position compared to the two other inventoried families, the Centrarchidae and the Anguillidae.

*Cyprinus carpio carpio* and *Gambusia affinis* are invasive in Lake Dayet Er-Roumi; these allochthonous fish can have harmful effects on the ichthyological state of the lake inducing a fragile biodiversity. The first introductions of fish began in the twenties of the last century (**Mouslih, 1987**), generally, the purpose of these introductions is to develop sport fishing and enrich the ichthyological fauna of the freshwaters of the country, but some species are characterized by the predominance in almost all water bodies of the country. **Mouslih (1987)** found that blind introductions without prior scientific study of their potential impacts on the local ichthyofauna would have caused the disappearance of an endemic Moroccan species, the common and mirror carp being responsible for some mechanical and organic pollution. The potential impacts of these introductions on native species are numerous: food and spatial competition, hybridization and predation on native species. Sometimes, these introductions cause a decline in the populations of certain autochthonous species and even their disappearance (**Bianco, 1995**). Among the introduced and invasive species, there is sun perch and gambusia which are considered harmful species (**Welcomme, 1992**).

Some species had been previously reported by various authors. Indeed, **Robbins and MacCrimmon (1974)**, **Mouslih (1987)**, **Moreau et al. (1988)** and **Yaakoubi (1994)** state that *Micropterus salmoides* (Lacepède, 1802) introduced in the lake Dayet Er-Roumi. While, **Mouslih (1987)**, **Moreau et al. (1988)** and **Farid et al. (2017)** revealed that common carp (*Cyprinus carpio*) and mirror carp (*Cyprinus carpio carpio*) are well acclimated in the lake and other Moroccan waterbodies.



**Azeroual (2003)** reported the presence of *Atherina hepsetus* in the lake, while we did not encounter this species during the study, either it disappeared from the lake or it was not caught during fishing. We had to mention that during the sampling, the tributary (station S7) was dry during summer. The chromium analysis showed the absence of this metal during the four seasons in lake water and its tributaries.

Regarding the calculated diversity indices, they showed that Lake Dayet Er-Roumi has an unstable status. The Shannon Index is 0.59 reflecting an undiversified stand, and the Equity Index shows low to moderate diversity. These results show an imbalance in the distribution of fish species and reflect a relatively unstable state of the lake.

## **CONCLUSION**

A better knowledge of the ichthyological state of the lake will allow us to consider more balanced and sustainable management of our aquatic heritage. According to the study, we find that the ichthyological fauna of the Lake Dayet Er-Roumi is characterized by an average richness with seven species belonging to five families, this study made it possible to update the list of the ichthyological fauna of the lake. Several species were added while other species which had been previously reported by various authors and local populations were not found, either they disappeared from the lake or they retreated to habitats that have not yet been sampled. The calculation of the diversity indices shows a very low ecological diversity with almost a homogeneity of the environment, which reflects an invasive and dominance of some species over others, this indicates that the lake is in an unstable ecological state.

The results of these ichthyological studies will be used as reference data for the Dayet Er-Roumi Lake ichthyofauna. This lac can accommodate species not yet reported, so it is necessary to continue the inventory effort.

To adopt adequate conservation measures for the ichthyological resources of Lake Dayet Er-Roumi, permanent monitoring of the state of the ichthyological fauna's Lake and sensitization of the local population are important in the development of appropriate measures to take arrangements, etc. to avoid a drastic erosion of the lake's biodiversity.

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