Assessment of the State of Ichthyofauna from Danube River – Caleia Branch, Romania: A Sustainable Development Context

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Abstract. Evaluating the state of ichthyofauna at both the Lower Danube level and at the national level contains knowledge gaps regarding species dynamics, with the most complex studies regarding species composition being undertaken more than 50 years ago. Over time, the Danube River - an important navigation route that connects Western Europe with Asia - has suffered a series of anthropogenic interventions that led to river discharge regularization, interruptions of longitudinal/latitudinal connectivity and reductions in floodplain area. These anthropogenic activities may negatively impact suitable fish habitats leading to demographical effects. The Danube is regarded as a river with high species richness that provides a source of income for the local population by the practice of commercial fishing. The area of interest for this study was selected taking into account the fact that, in the last decade, it was subject to hydrotechnical works that aim to redistribute the river discharge to improve navigation conditions. The ichthyofauna population dynamics is analyzed using an 8 year-long dataset that includes baseline data before the project started and a monitoring period after the project ended. The results indicate the presence of 38 fish species (excluding anadromous fish species – sturgeons and shads). The identified fish species are classified in two categories: 1) species of commercial interest and 2) species of Community interest. This study provides evidence that the high mobility capacity of the fish species is the main factor affecting species dynamics as support of the national efforts in action to stop the degradation of aquatic habitats and biodiversity, in response to goal 15 "Life on Earth" of the UN 2030 AGENDA for sustainable development.
1. Introduction

Fish species populations are highly linked to the characteristics of aquatic environments, in particular to habitats that assure the fulfillment of their life history (e.g. foraging, reproduction, growth, etc.). For this reason, fish are organisms that are vulnerable to modifications of the aquatic ecosystems. The state regarding the environments for migratory fish is complex, because they require different environmental conditions in their main life stages of their lifecycle [1].

It is well known that anadromous migratory species are undergoing a drastic reduction in population numbers, an issue found in the majority of the rivers from the European continent. Therefore, there is a need to also focus attention on non-migratory fish species that only have short lateral migrations during flood, when the floodplains are inundated [2].

Worldwide, previous studies have reported that river engineering negatively affects ichthyofauna, upstream from the structures as well as downstream, with great repercussions on species that undergo reproductive migrations [3,4,5,6].

River engineering along the Romanian side of the Danube River has begun in 1964 with the building of the Iron Gates I dam, together with Yugoslavia (now the republic of Serbia). In 1984 the Iron gates II dam started to operate. Following their implementation, early studies that have been made in 1989 and 1991 evaluated the state of the sturgeon species [7,8].

An additional study [9] was done in 1997 with the aim to evaluate the effects of hydropower on the lower course of the Danube. The conclusion was that the impoundments which were formed as a result of blocking the Danube gave rise to a disequilibrium in the structure of the fish fauna.

As a consequence, the 1995 analysis of industrial fishing from the Baszias-Salcia river stretch confirmed the cyprinid waters of that area. The dominant catches were mainly species characteristic of lentic ecosystems like *Carassius gibelio*, *Abramis brama* and *Alburnus alburnus*.

The interruption of the migration routes of the spawning migratory fish species has led to a decline in population numbers for some highly appreciated species (used for human consumption and for commercialization) like *Barbus barbus* and *Acipenser ruthenus*, species that rarely have been found upstream from these hydrotechnical works. Conservation of the susceptible species is a priority in the context of maintaining links in the food chain for a sustainable development in the area related to the three pillars of sustainable development: economic, social and balanced ecosystem.

In addition to the construction of the two massive dams from the Lower Danube, another pressure that negatively affects the ichthyofauna is the significant reduction in floodplain area caused by the conversion to agricultural terrain program during the communist era. A research study undertaken in 2018 concluded that the loss of floodplains led to modifications of the hydrological regime, reduction of important habitats for bird species, changes in sediment composition and degradation or loss of fish spawning habitats [10].

The floodplains of the Danube River spans over 19.5% of its river basin [11]. The study made by the International Commission for the Protection of the Daube River (ICPDR) illustrates data regarding the situation of the floodplains/wetlands of the lower course of the Danube. In 1959 the total surface of these areas was 553.400 ha and the maximum width was 4 km while, at the date of the study (in 2008), after the construction of various hydrotechnical works (which took off after 1962) and the conversion of the floodplains/wetlands to agricultural land, a total area of 462 000 ha have been disconnected from the river (area calculated in 1987).

The loss of approximately 83.5% of the total floodplain area from the lower course of the Danube has led to a decrease in population numbers of the fish fauna by reducing the number of potential spawning habitats [13]. In time, these changes in floodplain area caused the reduction in the population size of important commercial fish species [14].
This study on ichthyofauna from the Caleia branch area is done in order to determine the influence of the bottom sill, constructed to improve navigation on the Danube between 197-195 rkm, on the dynamics of ichthyofauna. It consists of the analysis of the eight year-long dataset resulting from experimental scientific fishing campaigns.

2. Experimental

2.1. Study area

Scientific fishing was done in eight river sections following the SR EN 14011/2003 electrofishing protocol. Transects were selected so that a comparison could be made between the areas possibly affected by the bottom sill construction and adjacent areas. The transects were located as follows: two on the Caleia branch, close to the bottom sill; two transects on the Old Danube, upstream from the Caleia branch; two transects on the Vâlciu branch and on the Old Danube. The last four transects were selected as control, to be used in the analysis of the dynamics of ichthyofauna (figure 1).

![Figure 1. Location of scientific electrofishing section.](image1.png)

![Figure 2. Bank electrofishing.](image2.png)

![Figure 3. Trawl electrofishing.](image3.png)
2.2. Methodology for the analysis of ichthyofauna structure

Scientific fishing was carried out to determine the species present at the Caleia branch study area, according to the license of scientific fishing issued by the National Agency of Fishing and Aquaculture using two methods:

1. Bank electrofishing at a low depth using a spoon-net to capture the fish (figure 2);
2. Bottom trawl electrofishing (figure 3), a method used in 2011 and 2012, after which it was discontinued because it resulted in equipment loss and high operational costs.

Using the first method resulted in a more efficient capture of pelagic fish as well as some benthic species sampled from the bank areas, while the second method had better results on benthic species sampled from the banks and the channel. During scientific fishing, GPS coordinates were collected to spatially identify the realized transects. Each transect had a length of approximately 400 m. Determination of biometric measurements were made using an ichthyometer with a precision of 1mm and an electronic weighting scales with a1g/5 kg precision.

2.3. Methodology for the characterization of ichthyofauna

The diversity of ichthyofauna from the study area was characterized using several ecological metrics such as: relative abundance, species dominance and species constancy; indices used in the elaboration of several research studies [15;16;17;18]. The calculation of these indices was done with the following formulas:

Relative abundance was calculated using the equation:

\[ A = \frac{n_i}{N} \times 100 \]  

(1)

\( A \) = relative abundance;
\( n_i \) = number of individuals from a certain species belonging to the total samples;
\( N \) = number of the total individuals from all the samples.

Species dominance was calculated using the equation:

\[ D_A = \frac{n_A}{N} \times 100 \]  

(2)

\( D_A \) = dominance of species A;
\( n_A \) = the total number of individuals belonging to species A, identified from the samples;
\( N \) = the total number of individuals belonging to all the species from the samples.

After calculating the species dominance, the fish species can be classified into one of the following five dominance classes [18]:

- D1 – subrecedent (under 1, 1 %);
- D2 – recedent (between 1, 1 – 2 %);
- D3 – subdominant (between 2, 1 – 5 %);
- D4 – dominant (between 5, 1 – 10 %);
- D5 – eudominant (over 10 %).

Species constancy was calculated with the following equation:
\[ C_A = \frac{n_{pA}}{N_p} \times 100 \]  \quad (3), where:

CA = constancy of species A;
npA = number of samples where species A can be found;
Np = total sample size.

Depending on the result, the species were classified as follows:
- C1 – accidental (present in 0 – 25% of the samples);
- C2 – accessory (present in 25, 1 – 50% of the samples);
- C3 – constant (present in over 50% of the samples).

3. Results and Discussion

3.1. Ichthyofauna structure at the Caleia branch-Old Danube study area

Scientific fishing was done during eight field campaigns undertaken in the time period of 2011-2018. During this time, in order to realize a comparison between the eight campaigns, the same representative locations and transects are sampled (to the extent that this was possible).

Using trawl electrofishing on 16 transects (limited to the 2011-2012 campaigns because a high rate of equipment loss make this method unfeasible) and 64 transects of bank electrofishing led to the identification of 38 species, with the exception of sturgeon and shad species (table 1).

### Table 1. Presence/absence of identified fish species.

| Index | Species name             | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 | 2018 |
|-------|--------------------------|------|------|------|------|------|------|------|------|
| 1     | Abramis brama           | +    | +    | +    | +    | +    | +    | +    | +    |
| 2     | Abramis sapa            | +    | -    | -    | -    | -    | -    | -    | -    |
| 3     | Alburnus alburnus       | +    | +    | +    | +    | +    | +    | +    | +    |
| 4     | Aspius aspius           | -    | +    | +    | +    | +    | +    | +    | +    |
| 5     | Ameiurus nebulosus      | -    | -    | -    | -    | -    | -    | +    | +    |
| 6     | Blicca bjoerkna         | +    | +    | +    | +    | -    | -    | -    | -    |
| 7     | Barbus barbus           | +    | +    | -    | -    | -    | +    | +    | +    |
| 8     | Benthophilus stellatus  | +    | -    | -    | -    | -    | -    | -    | -    |
| 9     | Carassius gibelio       | -    | +    | +    | +    | +    | +    | +    | +    |
| 10    | Chondrostoma nasus      | -    | +    | +    | -    | +    | +    | +    | +    |
| 11    | Cobitis sp.             | +    | -    | +    | -    | -    | -    | +    | +    |
| 12    | Cyprinus carpio         | +    | +    | +    | +    | -    | +    | +    | +    |
| 13    | Esox lucius             | -    | +    | +    | +    | +    | +    | +    | +    |
| 14    | Eudontomyzon mariae     | +    | -    | -    | -    | -    | -    | -    | -    |
Analyzing the data from table 1 shows that 38 fish species are identified during the eight years of monitoring and, if the sturgeons (family Acipenseridae) and the shads (family Clupeidae) are added,
then the grand total becomes 43 identified fish species. According to the literature, 102 fish species used to occur in the Danube [18, 19]. Therefore, the number of identified fish species from the eight monitoring campaigns represents 42% from the total number reported in the literature.

By analyzing the results of presence/absence of species, two scenarios are identified, that correspond to the sampling techniques used. Thus, some species’ presence proved to be permanent, being captured in all the eight monitoring campaigns: Abramis brama, Alburnus alburnus, Rutilus rutilus, Sander lucioperca, while others like Carassius gibelio, Cyprinus carpio, Aspius aspius, Esox lucius, Vimba vimba and Silurus glanis were captured in all except one monitoring campaign. This latter fact can be correlated with the applied fishing technique. Therefore, it can be observed that these species were missing in the monitoring companies which used trawling, a method that favors the capture of benthic species.

Calculating the abundance of the identified fish species from the 2011-2018 time period (figure 4) illustrates the fact that the most abundant species are Alburnus alburnus, Carassius gibelio, Rutilus rutilus, Rhodeus amarus, while species from the Gymnocephalus, Lota and Misgurnus genus are less abundant. Those latter species may be less abundant because of the selectivity of the bank electrofishing sampling technique that favors the capture of pelagic species.
Species constancy categorized the fish species in three classes as follows: constant species, accessory species and accidental species. Figure 5 shows that the largest fraction corresponds to the accidental species class. This fact may be caused by the trawling fishing techniques as well, a method that did not prove to be feasible because of the high risk of equipment loss (tangling to objects from the river bed).

Species dominance is presented in figure 6, where the distribution of the fish species according to the five dominance classes can be seen. Analyzing the fraction of each of the dominance classes reveals that, for the study area, D1 class – subrecedent species – has the highest percent (50%) while D5 class – eudominant species – has the lowest percent. Species dominance is strictly impacted by the number of captured individuals and their abundance. Moreover, the species whose numbers were identified as larger are in the superior classes D5 and D4. This reveals that there is an extremely small number of species with lots of individuals.

Taking into account the fact that a high number of individuals belong to the species from the Ciprinidae family confirms the cyprinid waters of the study area, the fish communities being dominated by these species, whose presence is confirmed in every one of the eight monitoring campaigns.

To identify the influence of the bottom sill on the dynamics of the ichthyofauna, the data from table 1 and figure 7 were analyzed. The bottom sill was built between 2011 and 2014 when there were no observations of large variations in the captured species. Nevertheless, figure 7 shows the least number of species captured between 2015 and 2016. This fact may not be directly influenced by the bottom sill rather by the variation of environmental conditions encountered during the sampling campaigns. For example, an alternate explication may be that the small number of species captured between 2015 and 2016 is caused by the scientific fishing being done in the summertime (August) when the water temperature is very high and the fish retreat to the deep, thus drastically decreasing the efficiency of bank electrofishing.

![Figure 7. The least number of species captured between 2015 and 2016.](image-url)
An additional variable of the research consists in the species dynamics presented in table 1 by their presence/absence in the study area. Here, we can conclude that species dynamics may be influenced by the high mobility of fish species, the selectivity of the fishing methodology and the variation of the abiotic from one monitoring campaign to the other.

4. Conclusions

This study, undertaken between 2011 and 2018 at the Caleia branch of the Danube River, confirms that 42% of fish species predicted from the literature are present at the study area. This provides evidence that the study area has complex species richness. In order to establish a causal link between some missing species and the influence of the bottom sill, additional research is needed for a minimum period of 15 years. Taking into account the anthropogenic modifications caused by river engineering projects on the Danube’s course, further research should provide the evidence necessary for the evaluation of the species composition and update the present literature.

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