Sterlet (*Acipenser ruthenus* L.) as an object of research, fishery and aquaculture in Serbia

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1 Introduction

Sterlet (*Acipenser ruthenus* L.) represents the smallest sturgeon species in the Danube River Basin, which exclusively inhabits freshwater habitats. While the other sturgeon species are present only on single continents, sterlet is the only sturgeon species that inhabits two continents, both Europe and Asia (Bemis & Kynard 1997).

Most of the sturgeon populations worldwide have experienced significant declines, mainly due to over-fishing, habitat destruction and pollution (Pikitch et al. 2005). At the same time, sturgeons have become popular species for aquaculture cultivation. Many countries have introduced exotic sturgeon species and hybrids in aquaculture facilities and, due to the proximity of fish ponds to natural water bodies, this has often led to unintentional introductions of exotic species and their hybridization with natural species and populations (Ludwig et al. 2009). Danube sterlet is known to hybridize with other sturgeon species, such as the introduced Siberian sturgeon (*Acipenser baerii*), which can lead to a rapid erosion of their autochthonous genetic diversity through the introduction of exotic genotypes (Ludwig et al. 2009).

Sterlet stocks in the Middle Danube have become dependent on stocking measures (Reinartz 2002). Major stocking activities are being conducted by Hungary (on average 100,000 fingerlings/year), and to a small extent by Slovakia, Bulgaria and Austria (Williot et al. 2002; Holčik et al. 2006; Guti & Gaebele 2009; Vassilev pers. comm.). However, stocking efforts are considered to be still insufficient to compensate the impact of unsustainable fishery and other negative factors (Vassilev 2006).

In Serbia and Hungary, sterlet is the only sturgeon species that is still a significant object of commercial and sport fishery (Guti & Gaebele 2009). Nevertheless, while the sterlet populations in Serbia represent an economically important resource, there are still unresolved problems of its unsustainable fishery, of catching the fish below the prescribed body length, as well as a lack of knowledge about its life history which diminishes possibilities for the development and implementation of efficient management measures. Furthermore, potential development of sterlet aquaculture in Serbia for both commercial and conservation purposes is hindered by the present economic problems. As a result, the aim of this study was to review the present status of sterlet in Serbia, primarily the research conducted on sterlet populations, its commercial exploitation and the possibilities of aquaculture development. Based on the presented information and the guidelines provided by both the Action Plan for the Conservation of Sturgeons (Acipenseridae) in the Danube River Basin (AP 2006) and the Action Plan for Sturgeon Species Management in Fishery Waters of Republic Serbia (Lenhardt et al. 2005), the authors present a number of suggestions for further research activities that would provide better understanding of the sterlet ecology and life history, as well as the key management and protection measures that would ensure sustainable use of their populations.

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2 Scientific research on sterlet in Serbia

The first thorough research activities on sterlet biology and ecology were initiated by Janković (1958), and conducted between 1951 and 1957 on the Danube River section between the towns Slankamen (rkm 1215) and Donji Milanovac (rkm 991). These research activities were mainly focused on morphological analyses, length-weight relationship, reproductive cycle, fecundity, nutrition and population age structure. Significant contribution was also provided by Ristić (1970) who, beside other findings, discovered that sterlet can migrate more than 300 km. Even today, this remains the only information on sterlet migrations, which may be surprising when bearing in mind the current wide use of telemetry and satellite tracking in ichthyological research. After these studies, there were only sporadic research activities, mostly focused on sterlet food composition, growth and length-weight relationship (Janković et al. 1994). More detailed analyses were initiated at the beginning of the 21st century. In 2002 and 2003, research conducted on specimens collected from the Danube near Belgrade involved analysis of morphological variability, sterlet growth and its parasites (Kolarević 2004; Lenhardt et al. 2009).

Research of sterlet diet (conducted on 585 specimens that belonged to 0^+ - 8^+ age groups) has revealed that Trichoptera, Chironomidae and Amphipoda were present in sterlet diet throughout the year and represented the main part of its diet (Janković 1958). In a study conducted in 1986, Trichoptera and Chironomidae were again found to be the main source of its food in the Danube River, while its main food in the Danube section between the two dams in the Djerdap gorge were Hirudinea (91%), which is probably due to the shift in benthic fauna composition caused by the impondment by the dam (Janković et al. 1994). The most recent studies of sterlet nutrition, conducted by Lapkina et al. (2005), have shown that Chironomidae were dominant sterlet food in July, while the leeches were dominant in August and September (representatives of six genera and three families). Leeches represented 100% of the sterlet diet during September, which has led to an increased sterlet growth (2.2 g/day), in comparison to its growth in July (1.8 g/day; Lapkina et al. 2005).

The 1990s were characterized by a significant development in the field of biomarkers, and the use of certain fish parameters as biomarkers to obtain early-warning signals of environmental risks (Van der Oost et al. 2003). As a bottom feeding species, sterlet is exposed to contaminants from both water and sediments, so it could represent a good indicator of water and sediment pollution (Poleksić et al. 2010). The main problem in utilization of sterlet as indicator species is its ability to migrate to great distances, so it can only indicate the state of a section of the river, and not of specific localities. Activity of antioxidant enzymes in sterlet liver, and aspartate and alanine aminotransferase in blood sera were used in sterlet from the Danube near Novi Sad (rkm 1253-1276) as biomarkers that respond to the presence of pollutants (Stanić et al. 2006). Heavy metal analysis of different sterlet tissues (liver, muscle tissue, gills and intestines) have revealed that the liver was the main heavy metal storage tissue, while the muscles accumulated the lowest levels of heavy metals. Sub-lethal histo-pathological changes were most pronounced in the liver and skin (Poleksić et al. 2010). Heavy metal concentrations in the sterlet muscle were below maximum threshold values and at acceptable levels for human consumption, except partly for cadmium.

The hypothesis of the existence of two different morphs of sterlet, one with a short, blunted snout, and the other with the long, pointed snout, was first introduced by Berg (1923), but it still remains unresolved. Based on 300 analysed sterlet specimens (both juvenile and adult male and female specimens), Janković (1958) concluded that it is difficult to confirm the hypothesis of two sterlet morphs. On the other hand, based on 5,137 analysed specimens, Ristić (1971) found some proof that might confirm the existence of two distinct sterlet morphs, but he avoided to make a final conclusion about this hypothesis. According to the data provided by Ristić (1971), short-snout sterlet was mostly present at spawning sites in the first half of the spawning season (11 March – 23 April), while the long-snout sterlet was present during the second part of the spawning season (28 April – 31 May). Results of a more recent study, conducted on juvenile sterlet specimens (Kolarević 2004) were not able to offer a conclusive answer to this question, while the study by Ognjanović et al. (2008) indicated a possible co-existence of two sterlet morphs in the middle stretch of the Danube River. However, all existing studies were so far mostly oriented on morphological analysis, so there is a need to combine morphological and genetic analysis in future research to provide a clear result.

Within the genetic analysis of sterlet in Serbia, primers for ten microsatellite loci were tested, in order to assess intraspecific and intrapopulation polymorphism (Cvijanović et al. 2009).

In a recent study by Jarić et al. (2009), population viability analysis in a Vortex simulation model has been conducted in order to assess the state of the six Danube sturgeon species, their future risk of extinction and to determine the most suitable conservation and management measures. Population viability analysis has revealed a large sensitivity of the sterlet populations to changes in natural mortality, age at maturity, fecundity and spawning frequency. It was also confirmed that the sterlet populations are highly susceptible to even moderate levels of commercial fishery. Population modeling was also used to assess the potential population growth rate of the Danube sterlet (Jarić et al. 2009).

3 Commercial sterlet fishery in Serbia

During 1951-1954, based on 2,000 studied specimens, Janković (1958) concluded that the sterlet catch was mostly comprised of 3^+ age specimens, as well as a significant portion of 1^+ and 2^+ specimens. Bearing in mind that the sterlet males and females can reach maturity in the second and third year of life, respectively, but mostly mature at age 3-4 (males) and 4-5 (females), observed fishery practices clearly seemed to be unsustainable (Janković 1958). Based on a study by Ristić (1969), sterlet catch in Serbia during 1948-1967 was mostly comprised of age 2^+-4^+ specimens, while the sterlet catch in the upper Danube section in Serbia was mostly comprised of specimens below 4^+ (99 %). Based on 467 sterlet specimens analyzed, collected from fishermen catch during 2002-2003, Kolarević (2004) has determined that the sterlet catch was mostly comprised of 0^+ and 1^+ age specimens. Construction of Djerdap I and II dams had significant impact on sterlet fishery, with notable increase of sterlet catch during that period, especially in the lower Danube section, with maximum catch in 1969 (23,615 kg) and 1984 (17,960 kg) (Lenhardt et al. 2004). Maximum annual sterlet catch in Serbia was in 1988 (79,978 kg). As a result of political and economic changes in Serbia during the end of 20th and the beginning of 21st century, data on sterlet catch for this period was fairly unreliable, due to untrustworthy official statistics and significant presence of illegal fishery. With the introduction of the new law on fishery (Anonymous 2009), quality of official catch statistics is expected to significantly improve in near future.

According to the national legislation, minimum prescribed standard body length of sterlet specimens in Serbia is 40 cm, while the temporary ban on sterlet catch lasts from 1 March to 31 May. Nevertheless, regardless of the existing national legislation, there is still a significant catch of specimens below the prescribed length, as well as fishing activities during the temporary ban on sterlet catch (according to the personal communication with commercial fishermen and the availability of sterlet on market). While most of the neighbouring countries have conducted regular supportive stocking activities, so far there was no such stocking of sterlet populations performed in Serbia.

4 Possibilities of sterlet aquaculture development in Serbia

After the construction of Djerdap I dam, a hatchery for artificial spawning of sturgeon was constructed few kilometres downstream of the dam, as a compensation for disrupted migration route of anadromous sturgeon species. Artificial spawning of Danube sturgeon species, among others of sterlet, was successfully performed at this facility. However, despite many favourable conditions, sturgeon aquaculture in Serbia has remained undeveloped until the present time. Nowadays, there is only one sturgeon aquaculture facility in Serbia, but unfortunately even that one close to be shut down, due to economic problems. With the aim to promote development of sturgeon aquaculture in Serbia, a cross-border Cooperation Programme between Serbia and Hungary was initiated in 2007 and financed by the EU – EAR. The Project ''Sustainable use of the sterlet and development of sterlet aquaculture in Serbia and Hungary'' was conducted by the Institute for Multidisciplinary Research (Belgrade) and the Research Institute for Fisheries, Aquaculture and Irrigation (HAKI - Szarvas). One of the results of this project was the development of the Handbook for sterlet aquaculture. However, due to the present economic situation in Serbia, private aquaculture facilities are not motivated to introduce the cultivation of new species. The only possibility to develop sterlet aquaculture in Serbia seems to be a development of a project that would also involve private companies, and whose main goal would be artificial spawning and cultivation of sterlet.

5 Actions required for achieving sustainable use of sterlet populations in Serbia

In accordance with the guidelines provided by both Strugeon Action Plans (AP 2006, Lenhardt et al. 2005), and based on the state-of-the-art sterlet research in Serbia, as well as of the sterlet commercial fishery and sterlet aquaculture development possibilities, a number of activities required for achieving the sustainable use of sterlet in Serbia are presented in Figure 1.

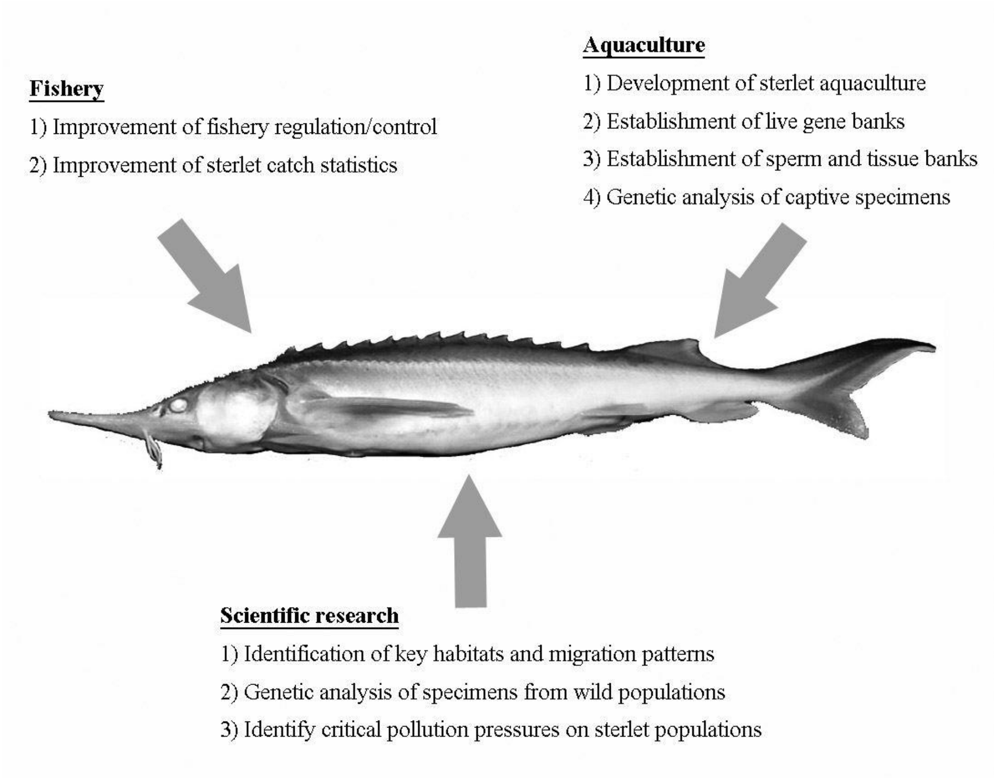

Figure 1. *Actions required in the field of scientific research, fishery management and aquaculture development for achieving sustainable use of sterlet populations in Serbia.*

6 Conclusions

While the sterlet is considered as an economically important species in Serbia, many issues that are related to its management and protection still remain unresolved, such as the unsatisfactory control of sterlet fishery, unreliable official catch statistics, undeveloped sterlet aquaculture and the lack of knowledge on its life history. In order to improve the present situation, it would be necessary to identify key sterlet habitats and to develop adequate measures of their protection, and to impose more efficient control of fishery, trade and more reliable official catch statistics. Cooperation between scientific institutions and private aquaculture enterprises, through the development of mutual projects, could be an important step towards the development of sterlet aquaculture in Serbia.

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