MACROINVERTEBRATES AND FISHES IN THE PART OF THE DANUBE FLOWING THROUGH THE IRON GATE NATIONAL PARK AND POSSIBILITIES OF THEIR PROTECTION UNDER IN SITU AND EX SITU CONDITIONS

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Abstract — Comparison of the results of later investigations of the Danube in the part flowing through in the Iron Gate (Djerdap) National Park with those of research conducted earlier (20 to 40 years ago) shows that changes have occurred in regard to the presence and especially the abundance of certain hydrobionts on this sector of the river, a finding that applies to all groups examined. The paper discusses the potential and results of conservation measures realized through both legal regulations and medium-term plans for the advancement of fishing in this region. In addition to in situ study during the period from 1999 to 2003, a large number of species (especially of macroinvertebrates and fish) were also investigated under artificial conditions (in the Kragujevac Aquarium) in order to gain a better understanding of their ecological characteristics, especially their sensitivity to various environmental stress factors. The presented results indicate that weight of specimens and success of culturing under ex situ conditions are correlated with their sensitivity under natural conditions.

INTRODUCTION

Investigations of the qualitative and quantitative structure of the bottom fauna and fish communities in the run-of-the-river Iron Gate (Djerdap) Reservoir (the part of the Danube lying within the Iron Gate National Park) were initiated in the 1950's. Results of the first research on the bottom fauna and fish communities were used by a number of authors as a basis for monitoring changes that have occurred with the passage of time in this aquatic ecosystem (Janković and Jovičić, 1994). The biological component of the Danube (plankton, ichthyofauna, and to some extent bottom fauna) has been studied by a fairly large number of authors, and this has resulted in the publication of complex monographs (Janković and Jovičić, 1994).

In view of the very dynamic processes and changes occurring as a result of natural phenomena and highly intensive human activities in our country and others through which the Danube flows, constant monitoring of changes in the structure of different communities in the river is of both ecological and practical importance.

The purpose of the present work was to indicate species whose populations are threatened (ones on the IUCN list) (IUCN, 1994, 1995) on the basis of changes in structure of the macroinvertebrate and fish communities, and demonstrate the possibility of combining in situ measures with ex situ study in ensuring their protection.

MATERIAL AND METHODS

Samples of macrozoobenthos and fish were taken during the summer and autumn of 1994, 1995, and 2000 on the sector of the Danube from Veliko Kladiste to Kladovo. An Eckman dredge with a grab area of 125 cm² was used to take bottom samples in the littoral zone (at depths of 1-4 m) and middle of the river (at depths of 10-20 m). Fish were caught with nets ranging in mesh size from 40 to 120 mm. Fixed material was processed in laboratories of the Science Faculty's Institute of Biology and Ecology in Kragujevac. During the period from 2000 to 2003, macrozoobenthos and fish were collected several times for culturing under ex situ conditions in the Aquarium of the Science Faculty in Kragujevac.

In culturing of species under ex situ conditions at the recommended optimal tank volumes given in the works of Axelrod and Burgess (Axelrod & Burgess, 1991) and Riehl and Baensch (Riehl & Baensch, 1997a, 1997b, 1997c), the following 12 parameters were considered: 1 — method of capture and extent of damage
at time of capture; 2 — percent surviving transport; 3 —
start of feeding (speed of adaptation); 4 — growth rate;
5 — response to disturbance and stress (this parameter
was determined only for fish); 6 — feeding under
aquarium conditions; 7 — spawning and reproduction; 8
— percentage of mortality, length of life, and sensitivity
to diseases; 9 — relation to temperature change; 10 —
relation to low oxygen concentrations (less than 2.5 mg/l);
11 — relation to water acidification (pH less than 5); and 12
— relation to water conductivity and organic pollution (E
> 1200 μS/cm³, BOD₅ > 5 mg/l). Evaluation of species
was based on results obtained in the course of two-year
culturing period. A three-point scale was used to measure
the examined characteristics and responses: 1 point for
sensitive species, 2 point for more or less indifferent
ones, and 3 points for adaptive and resistant species. The
results were used to estimate adaptive characteristics,
establish sensitivity to changes, and determine culturing
conditions in an artificial environment for protection of
potentially threatened taxa of macroinvertebrates and fish
in the Danube or restoral of ones that have completely
disappeared from the habitat.

RESULTS AND DISCUSSION

Analysis of data on structure of the macrozoobenthos community before construction of the Iron Gate Dam on the Danube and immediately after its construction and comparison of these data with the results of our investigations during 1994, 1995, and 2000-2003 indicate that

certain global changes have occurred in the structure of
this community. Among these changes are decrease in the
abundance of populations of Ponto-Caspian Amphipoda,
some species of gastropods, and bivalves, and increase in the abundance of pelophilous and phytophilous forms of the group Oligochaeta and pulmonate gastropods.

According to the data of Tomič (Tomic, 1959), species of Gastropoda of the Prosobranchia group — Theodoxus
dambivilais, Th. Transversalis, Fagotia acicularis, and F.
Esperii — were encountered more frequently and in greater
numbers than at the time of our investigations. On the
other hand, later investigations observed dense populations of cosmopolitan pelophilophytophilous snails of the genera Physa, Limnea, and Planorbis (Simić et al.,
1996, 1997). The indicated species of snails of the genera
Physa, Limnea, and Planorbis are not mentioned as
present in the Yugoslav part of the Danube in the work
of Pujin (1990). The same work calls attention to high
abundance of the resistant species Bithynia tentaculata,
something that was likewise recorded in investigations of the Danube in the Iron Gate region during 1994, 1995,

Changes are also evident in the bivalve community.
The high numerical abundance reported by Tadić
(1960a, 1960b) for several subspecies of Unio crassus,
U. pictorum, and U. timidus, as well as for species of the
genus Anodonta, was not confirmed in the investigations
of 1994, 1995, and 2000, when a decrease was observed
in the abundance of populations of the species U. timidus
and U. crassus, while the species U. pictorum were not
recorded. On the other hand, very abundant populations of bivalves resistant to pollution (species of the genera
Sphaerium and Pisidium) were then encountered, and
especially great expansion of the population was recorded
for the bivalve Dreisena polymorpha. Dominance of re-
sistant species of bivalves of the genera Sphaerium and
Pisidium and the species Dreisena polymorpha was also

The abundance of amphipodic crustaceans, espe-
cially species of Ponto-Caspian origin, has also declined
significantly in the Iron Gate region. Of eight species
with several subspecies recorded earlier (Karaman,
1953), only the species Dikerogammarus haemobaphes,
Corophium curvispinum, Gammarus ssp., and (consider-
ably more rarely) species of the genus Pontogammarus
were encountered in later years.

The earlier recorded great changes in composition of
the fish community (Janković and Jovičić, 1994)
were only confirmed by results of the most recent investi-
gations, which showed complete disappearance of species of the families Clupeidae and Acienceridae. The only
member of the family Acienceridae still present is the
sterlet, which due to poor conditions for spawning in the
Iron Gate Reservoir has retreated upstream, so that only
sexually immature young individuals remain in the reser-
voir. The main cause of the disappearance of these species
is the physical barrier that arose after construction of the
dam. Certain changes also occurred after the introduction
(since 1970) of allochthonous Asiatic species of fish (sil-
ver carp, bighead, grass carp, and common wild goldfish),
which adapted well in these waters and exerted pressure on certain autochthonous species, especially the Danube
carp. Decrease in the abundance of populations has also
been observed for the species Gymnocephalus baloni, G.
cermus, Zingel streber, and Tinca tinca, while the species
Carassius carassius, Leucispius delineatus, Gobio kes-
leri, Chalcides squaloides, Gasterosteus aculeatus,
and Pungitius platypus are especially rare and can be
designated potentially endangered species. In grassy lit-
toral habitats, there has been an increase in abundance of
the species Sygnathus abaster, which was not recorded in
any great numbers earlier.
Conservation and improvement of the existing state of macrozoobenthos and fish communities in the part of the Danube flowing through the Iron Gate National Park is possible through implementation of a series of measures for in situ protection of aquatic ecosystems and the greatest possible preservation of habitat quality. These goals are undeniably very difficult to achieve in view of the international nature of the Danube. However, it is essential that managers of the Iron Gate National Park ensure constant well organized monitoring of animal communities throughout its territory, especially communities of rare and endangered species living in it. Also needed are measures aimed at removing causes of the threat to these species (eutrophication, pollution, competition, etc.). Especially important is proper management of the fish fund, meaning more intensive fishing of silver carp, bighead, grass carp, and pike on the one hand, and limited fishing of rarer species, especially economically significant ones such as carp, perch, and sterlet on the other, as well as total prohibition of fishing and annihilation of certain rare and endangered species (crucian carp, tench, ruffe, and streber). Adequate measures are needed to pro-

Table 1. Taxa of macrozoobenthos and fish present in the Iron Gate Reservoir and results of culturing them under ex situ conditions.

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*1 — method of capture and extent of damage at time of capture
2 — percent surviving transport
3 — start of feeding
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11 — relation to water acidification (pH less than 5)
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tect spawning grounds and stop illegal fishing. It is especially important to document and monitor populations of potentially endangered taxa. For taxa shown by thorough investigations to be critically threatened, *ex situ* measures of protection are needed in addition to *in situ* ones in order to clarify adaptive characteristics of the taxa in question, determine their sensitivity to various factors, and establish the possibility of their artificial propagation. The results presented in Table 1 indicate that the majority of species can be cultured under *ex situ* conditions.

Globally considered, species that have become rare in the natural habitat and are highly threatened exhibited lower adaptability to *ex situ* treatment. This applies to species which develop frequently and massively under natural conditions in our part of the Danube. It is also evident that the sensitivity of less adaptive species to the examined factors is different. Thus, the presence of certain food is a crucial factor for the treated snails of the group Prossobranchia (*Theodoxus*, *Fagotia*) and bivalves of the genera *Unio* and *Anodonta*, whose sensitivity to environmental factors (*t*, *O*₂, *pH*, *Ep*) is on average greater than in the treated species of pulmonate snails and bivalves of the genera *Sphaerium* and *Dreissena*. Amphipodic crustaceans also manifest different sensitivity: it can be seen from the obtained results that Ponto-Caspian species of the genera *Dicerogammarus* and *Corophium* are more sensitive than the species *Gammarus* ssp.

Of the treated species of fish, it is evident that the species *Carassius carassius* and *Cyprinus carpio* for the most exhibit good adaptability and adjust well to the examined environmental parameters, whereas their populations under natural conditions are significantly reduced (especially the population of *Carassius carassius*). In this case, the reasons why they are threatened should be sought in competitive relations and poor conditions for spawning, but also in overfishing. Species of fish of the genera *Gymnocephalus* and *Zingel* manifest poorer adaptability to food and the examined environmental parameters.

*Ex situ* treatment gives us a better picture of factors than can be the main cause of the threatened status of a species in its natural habitat. This enables us to undertake adequate protection measures *in situ*. Apart from its experimental significance, *ex situ* treatment is especially important as a means of ensuring the reproduction of rare and endangered taxa. In view of the poor conditions for spawning in the Iron Gate Reservoir, the spawning pond intended for sturgeon should be activated, since it can be relatively easily adapted for spawning of other fish species inhabiting the Danube.

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MACROBESKICHMEJÃCI I RIBE U DELO DUNAVA KROZ NACIONALNI PARK "JERDAP" (AKUMULACIJA "JERDAP") I MOGUÊNOSTI ZASHTITE U IN SITU I EX SITU UСLOVIMA

V. SIMITIÊ I SNEŽANA SIMITIÊ

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Проучавањем библиографских података о истраживању Дунава у сектору кроз НП Ђердап од пре 20 и 40 година са резултатима истраживања спроведеним у периоду од 2000 до 2003 године, констатоване су значајне промене у структури целокупне хидробионценозе. У насељу фаяне две из групе мекуцица и амфицихних ракова запажају се крупне промене које се огледају у доминацији еуривалентних, космополитских и експланзивних врста као што су Dreissenia polymorpha, Sphaerium spp, Pissidium spp, Corophium curvispinum и DiceroGammarus haemobaphes. Са друге стране, запажа се мање и ређе присуство понто-каспијских амфицода као што су врсте рода Pontogammarus и пужева из групе Proosobranchia (Theodoxus spp, Fagotia spp.). У насељу риба потврђују се резултати ранијих истраживања у којима се констатује одсуство или веома ретко (појединачно) присуство врста из породица Clupeidae (харинге) и Acipenseridae (изузев кечиге — Acipenser ruthenus) и све веће присуство алохтоних азијских врста као што су бели и сиви толстолобик, бели амур и посебно, сребрни караш (бабушка).

Осим мера ин ситу заштите које се спроводе на подручју НП Ђердап, истраживања спроведена у акваријумима показала су да је највећи број дунавских врста макробескимења и риба могуће успешно гајити и одржавати у оваквим вештачким, ex situ условима. Показало се међутим, да су врсте које су означене као угрожене теже за одржавање у вештачким условима од оних које то за сада нису. Овакви резултати говоре о њиховој оштрој већој осетљивости, па самом тим и мањим шансама за опстанак у промењеним условима водене средине.