

## RESEARCH ARTICLE

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## Current status of ephemeral habitats of ancient Crustaceans (Class Branchiopoda) in Serbia with varying degrees of human impact

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**ABSTRACT**

This report presents overview of the current status of several areas with wetland habitats in Serbia inhabited by large branchiopods, ancient crustaceans from Class Branchiopoda. This group of animals is also called "living fossils" in literature due to their Cambrian origin. Similarly like in the other parts of the world, ephemeral large branchiopods' habitats are considered as vulnerable and endangered in Serbia. They are often destroyed, mainly due to agricultural and urban development. Since the habitat status was discussed 15 years ago, some recent checking of main threats and changes are the subject of this article. The most considerable landscape changes occurred due to construction of roads and traffic corridors. Legally protected areas are generally better preserved, and are under a lower anthropogenic pressure. At the end of this analysis we discussed some of the ways that may help to overcome current challenges in preservation and protection of these unique biotopes.

**Key words:** natural wetlands, landscape destruction, Crustaceans, protection

**Introduction**

Habitat destruction is a threat to the entire living world. It is particularly true for specific wetland habitats such as ephemeral pools. Wetlands are generally affected by two significant and pressing environmental issues: the global environmental change and desiccation. These habitats, once numerous and common, are now restricted and disjointed. Investigations of their predictability pointed to increasing sensitivity to climate change, since their durability is closely linked to the precipitation and temperature (Graham, 1997). Land drainage, conversion of natural water in the waste water collectors together with the lowering of groundwater level are the main reasons for habitat loss.

Large branchiopods, ancient crustaceans from the Class Branchiopoda are the group of animals also called "living fossils" in literature due to their Cambrian origin (Briggs, 1976). Typical large branchiopod habitats are natural depressions of short duration. As a rule, water dries up in the summer and freezes in the winter (Schwartz & Jenkins,

2000). However, large branchiopods may also occur in other types of habitats, from small glacial lakes to man-made periodic waters (rice fields, ponds for watering livestock and crops, farming lands, fishponds and fish-spawning areas, different industrial wastewater ponds near the sugar factories, beer factories, salt pans, etc). Water habitats can be highly alkaline and eutrophic, frequently rich in  $\text{NaHCO}_3$ ,  $\text{Mg}^{2+}$ ,  $\text{Ca}^{2+}$ ,  $\text{Cl}^-$  and  $\text{SO}_4^{2-}$ . Despite their rather small surface and ephemerality, ephemeral ponds can be fairly rich (Maeda-Martínez *et al.*, 1997; Petrov & Cvetković, 1997). Species inhabiting such waters are adapted to the changeable chemical composition, daily and seasonal fluctuations in temperature, to high salt concentrations and increased turbidity. They are faced with the constant threat of elimination, and consequently are well adapted to complete their life cycle quickly, and switch to the dormant phase before habitat dries out (Blaustein & Schwartz, 2001).

Since the status of large branchiopod habitats in Serbia was reviewed last time more than fifteen years ago (Petrov & Petrov, 1997), recent checking of main habitat threats and

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landscape changes is the subject of this article. Through the four case studies, our intention was to point to the good examples, as well as to some unfavorable ones observed in different parts of the country.

## Materials and Methods

During the period 2004–2012, several field trips and expeditions were conducted in different parts of Serbia. Large branchiopod specimens from different wetland habitats and pools were collected over this period. Material was sampled from March to November. Samples were taken with a hand net and preserved in 70% ethyl alcohol. In order to explore territory as thoroughly as possible, we included people from diverse fields of research, under the authority of the Faculty of Biology, University in Belgrade in Serbia. Several-year observations data were obtained through the teamwork of University professionals and students, as well as of volunteers from Special Nature Reserves, State Enterprise for Forest Management, and the environmentally focused NGOs. Ephemeral habitats (both regular and disturbed) were revisited each year of investigation. The soil samples from several areas in Serbia were collected.

Representative locations that were analyzed include: 1) ephemeral habitats along the Nišava River in the foothills of Nature Park “Stara Planina” in Eastern Serbia (N 43°18'39.21", E 22°49'33.62"); 2) rare Pannonian forest fragments west of Belgrade (N 44°41'53.74" E 20°12'03.27"); 3) Special Nature Reserve “Slano Kopovo” (N 45°36'47.47", E 20°12'52.96"), and 4) Special Nature Reserve “Zasavica” (N 44°57'32.21", E 19°31'32.70"). Geographical position of investigated sites was determined by GPS.

## Results

Here we present our recently field observations and results of several years' investigations in Serbia through four case studies, as follows:

### Case-study 1

The first report refers to the pools located along the edge of the alluvial flat of Nišava River in Eastern Serbia. The habitats are settled near the Serbian-Bulgarian border in the foothills of the Nature Park “Stara Planina”. Four large branchiopod taxa were found in this area: *Branchipus schaefferi* Fischer, 1834, *B. intermedius* Orghidan, 1947, *Leptestheria* sp. Sars, and *Imnadia* sp. Hertzog, 1935. Large

part of this area is under alternately interspersed meadows, fields, orchards, pastures, small villages, forest complexes, woods, water surfaces and agricultural lands, with moderately using of pesticides and fertilizers in agricultural production. Habitat disturbing started in 2005, due to reconstruction of an international railway branch via Sofia (Republic of Bulgaria). Part of affected area was leveled with heavy mechanization, but despite this, the large branchiopod habitats still existed in 2005 (Figure 1a). However, in 2006 a construction of an international highway Corridor 10 started. The wide surface of natural lands was destroyed, upper layer of the soil was completely removed, and road infrastructure occupied the whole area (Figure 1b). As a result, the landscape has been completely changed, and previously existing large branchiopod habitats were lost forever (Figure 1c and 1d).



**Figure 1.** Area along the Nišava River: a) Water habitats in 2005 (reconstructed railway tracks can be seen in the background); b) Destroyed natural lands (2006); c) Area of the construction of the international highway (2012); d) A road infrastructure (2013).

### Case-study 2

This report refers to the forest and hunting area Crni Lug which situated in Northern Serbia (Srem District) near the valley of the Sava River. Five large branchiopod taxa were recorded in this territory. Three of them: *Chirocephalus diaphanus* Prévost, 1803, *Chirocephalus brevipalpis* (Orghidan, 1953) and *Lepidurus apus* (Linnaeus, 1758) were found in this area for the first time. Until 2010, several wet habitats were recorded in this area, and ephemeral ponds were separated by bushy vegetation (Figure 2a). However, in

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2011 the local administration started preparations for a road construction. They cut vegetation and filled ground depressions with gravel (Figure 2b). The only few samples of large branchiopods (*Lepidurus* sp. and *C. brevipalpis*) were found in remains of previously wide flooded area (Figure 2c). However, severe and irreversible site destruction was happened next year (in 2012), caused by the regional road construction when majority of habitats vanished forever (Figure 2d). Also, arid weather conditions during that season seriously influenced the water regime. As a result, water no longer existed nor in meadows nor in the hunting area. At the beginning of 2013, thanks to favorable and wet conditions, we noted one species (*Lepidurus* sp.) again. In spite of destruction of significant part of habitats, it encouraged us to expect the reestablishing of large branchiopod assemblages in the future.



**Figure 2.** Hunting area Crni Lug: a) Untouched flooded zone (2010); b) View of the area after men intervention (2011); c) Ephemeral habitats remained in the hunting area; d) Regional road built in 2012.

### Case-study 3

The objective of this Case study is the area of some of the last surviving alkaline lakes in Europe. By regulation of the Government of the Republic of Serbia, “Slano Kopovo” was declared as Special Nature Reserve of the first category. It is also protected under the Ramsar Convention and put into the list of wetland habitats of great international importance (Ramsar, 2013). “Slano Kopovo” is a centre of distinctive biological diversity of wildlife in the region, with specific salt marsh communities (especially highly specialized invertebrates). It features unique Pannonian habitats typified

by alkaline wet meadows, sporadic muddy and shallow ponds and lakes (Figure 3a). Ponds usually become dry during the hot summer months, but are very numerous during spring and autumn. The lake is a nesting place of a number of bird species, declared as Important Bird Area (Puzović *et al.*, 2009). Large branchiopods living in the lake and its vicinity are inevitable link in the food chain, since they serve as food for many birds (Boros *et al.*, 2006). Large branchiopods inhabiting alkaline water bodies (*Branchinecta ferox* (Milne-Edwards, 1840), *Branchinecta orientalis* G.O. Sars, 1903 and *Chirocephalus carnuntanus* (Brauer, 1877) are secured for survival due to the strict habitat protection. Ponds situated on the edges of the Natural Reserve (derived from the tracks of the agricultural mechanization) are populated by *C. diaphanus* and *B. schaefferi*. However, often these ponds are filled with gravel (Figure 3b), since people use them during the working seasons for maneuvering with agricultural mechanization.



**Figure 3.** Special Nature Reserve “Slano Kopovo”: a) Typical salt marsh landscapes in northern Serbia; b) Roadway near the entrance of Natural Reserve, filled with gravel.

### Case-study 4

A Special Nature Reserve “Zasavica” in Northern Serbia represents a mosaic of various wetland and forest ecosystems stretching along the flow of the river Zasavica, the 33.1 km long right tributary of Sava River. This Reserve is listed as Ramsar site (declared in 2009). This is a residence of numerous rare bird species, and is declared as Important Bird Area (Puzović *et al.*, 2009). “Zasavica” is also considered as a refugee area for plant and animal species “which escaped” from the urbanized and unprotected neighboring territory. For example, *Chirocephalus brevipalpis*, species with highly restricted distribution in Europe, appears regularly in this area. Although there were some fluctuations in the water regime over years, to date main habitats remained unchanged (Figure 4).

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**Figure 4.** The Special Nature Reserve “Zasavica”: wet pasture ‘Valjevac’ – habitat of *Chirocephalus brevipalpis*, species with highly restricted distribution in Europe.

## Discussion

Threat of extinction of the vulnerable ecosystems such as ephemeral ponds is mainly associated with anthropogenic land usage. Wetlands rapidly disappear due to the expansion of agriculture, urban settlements, growth of industrial and recreational areas, and roads. In addition, many habitats are heavily influenced by the chemicals used in agriculture (pesticides, fertilizers), pollution from traffic and industry and by domestic waste waters. All together, they are leading to accelerated eutrophication.

By the beginning of the last century, majority of wetlands in Serbia had been mainly untouched. Many of them were known as the large branchiopod habitats (Petrov & Petrov, 1997). In the meantime, vast wetland areas were turned into croplands, or drained due to construction of urban infrastructure and tourist facilities. Protective dams were constructed around lowland rivers, and reduced the flood zones along the riverbeds. Almost entire territory of northern Serbia (the area noted for the greatest large branchiopod diversity (Petrov *et al.*, 1999), was intersected by a network of irrigation channels, which reduced the level of groundwater. Excessive use of inland water in synergy with the global climate change (higher temperatures, lack of rainfall) resulted in water lowering and consequently led to desiccation of many shallow water surfaces and ponds. Large parts of flooded areas in Serbia were re-forested by man with black poplar (*Populus nigra* L.) and with allochthonous Canadian poplar tree for commercial reasons. Such activities led to serious disturbance of the hydrographic regime and

physical and chemical damaging of wetlands. It further resulted in reduction of habitats suitable for occurrence of many aquatic organisms. In the rest of the country anthropogenic pressure is lower. However, building of artificial dams across the river valleys reduced the flood zone around the banks of big rivers and their tributaries (Velika Morava River, South Morava River, Nišava River, lower course of the Drina River). An intensive melioration was also one of the most frequent reasons of habitat loss, particularly in the river valleys suitable for agricultural activities. In recent times, considerable landscape changes occurred due to construction of traffic corridors. Huge interventions were observed in Eastern Serbia in the area along the Nišava River, where there were noted several habitats with *Branchipus* populations (Cvetković *et al.*, 2005; Cvetković & Petrov, 2007). Similar example was observed in the forest and hunting area Crni Lug where we found genus *Lepidurus*, a taxon with a very limited distribution in Serbia (Petrov & Petrov, 1997; Lukić *et al.*, 2012).

Legally protected areas, as habitats of numerous important species are generally better preserved. Those areas, as a rule, are under lower anthropogenic pressure. Special Nature Reserve “Zasavica” is an excellent example of well-preserved natural land: a complex habitat composition of these marshy lowlands provides good conditions for survival of numerous, rare and diverse wildlife (Stanković, 2006). The management of the nature reserve conducts permanent actions to raise the public awareness, and provides ecological education for the pupils and citizens. We can confirm a presence of stable populations of rare crustaceans, previously reported from this area (Petrov *et al.*, 2007). On the other hand, in the Special Nature Reserve “Slano Kopovo” some harmful impacts can be seen on the edges of protected area, despite of the strict legal protection.

Many wetland habitats in Serbia are still outside the boundaries of the protected areas and under the risk to be destroyed without permanent monitoring and conservation. Making collection of soil samples with deposited eggs ('egg banks') and their translocation from threatened areas is seen as a sustainable way for long-term species preservation (Brendonck, 1996). From this reason, soil samples from several areas in Serbia were collected over the past few years in order to reintroducing affected species into new suitable natural habitats.

The issue of habitat lost and habitat protection of vulnerable natural habitats requires a higher public

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awareness. There are some good examples in Europe, and the most prominent one is from Austria (Hödl & Rieder, 1993; Löfler, 1994). The Austrian environmental activists and volunteers have been organized several petitions and donations in order to purchase nature-important lands from local farmers across the country (Eder & Hödl, 2002). Similar projects to increasing citizens' knowledge about significance and conservation of salt marshes have been implemented in Spain (Curado *et al.*, 2013). The last few years, professionals from different fields as well as students and volunteers from the environmentally focused NGOs, followed this path in Serbia in order to protect vulnerable ephemeral habitats and find balance between sustainability and regional development.

During the 20<sup>th</sup> century wetland landscapes in Serbia have been fairly limited in space, isolated and disjuncted to the smaller, disconnected and scattered secondary surfaces. Many of them have disappeared due to human activities. Two cases from Special Nature Reserves in this study are good examples which illustrate how persistent implementation of protective measures can maintain stable habitat conditions for many rare and relic taxa. The scientific-popular approach, rising of public awareness, and education of citizens could also be good pathways for better protection of wetland areas. In the cases of inevitable destruction of natural aquatic habitats because of rapid urban or agricultural development, a good and sustainable way to finding balance may be a sampling of soil with deposited eggs from the bottom of the ephemeral pools and removing them into new suitable habitats. Also, considering that habitat loss is still possible, a good strategy to protection can be to put as many as possible wetland habitats under better control and protection. This should help in saving rare Serbian crustaceans from extinction.

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