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Occurrence of protected species (*Gomphus flavipes*, Odonata, *Palingenia longicauda*, Ephemeroptera) in the Danube River and its deltas (Romania, Slovakia)

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ABSTRACT. Till now, altogether 50 species of dragonflies have been found in the Danube and its arms in Slovakia. One of the most important indicator species is *Gomphus (Stylurus) flavipes*, listed as strictly protected by Appendix II of the Bern Convention. Large population of *Gomphus flavipes* was found in the Malý Dunaj (Small Danube), in the area called Danube's "Inland Delta", in 2000–2001. Watching of dragonflies in the Danube Delta (Romania) demonstrated another large population in 2007–2008. In contrast with these observations are our results, from long-term monitoring of dragonflies in the Danube, in the area influenced by the Gabčíkovo power plant (operational since 1992). Changes in hydromorphology in this section started in 19th century and at present dam represents a significant impact on the functioning of the Danube ecosystem. During 20 years monitoring we found only one larva of *Gomphus flavipes* in the Danube at the site downstream of the dam. Another critically endangered species, mayfly *Palingenia longicauda* was found in the Danube Delta in 2009. We observed emergence of giant mayfly in the Danube's arm in Romania. *Palingenia longicauda* disappeared totally in the 1930s from many European rivers. At present it occurs in Tisza and Rába rivers (Hungary) and has been reintroduced in Lippe and Odra rivers (Germany). New findings of large populations of *Palingenia longicauda* in the Romanian Delta has been unknown till now. Findings of large population of *Gomphus flavipes* in deltas confirm that river deltas are of high importance for aquatic biodiversity conservation.

Key words: *Gomphus flavipes*, *Palingenia longicauda*, Inland Delta, the Danube Delta, Romania, Slovakia

INTRODUCTION

Strictly protected species *Gomphus (Stylurus) flavipes* (Charpentier, 1825) and *Palingenia longicauda* (Olivier, 1791) listed in Appendix II of the Bern Convention [22] require very specific habitat conditions to complete their life cycle. Large populations of these endangered species persist only in small areas of their previous range [1]. River deltas offer suitable conditions to many protected species with specific demands. Deltas present unique ecosystems with natural hydrological regime and hydromorphology and consist of various habitats with flowing and standing water. The Romanian Danube Delta is the second largest river delta in Europe, the Inland Danube Delta is an area between the Danube River and its branch the Malý Dunaj (the Small Danube) which separates downstream of Bratislava in Slovakia. In the Inland Danube Delta some endangered species have found their refugium. Findings of 80 imagoes and 40 exuviae of *Gomphus flavipes* have been reported [14] from the Inland Delta in 2001–2. This endangered species recovers in many of its previous habitats because of improvement of the water quality in the last decades ([7]; [9]).

In the Romanian Danube Delta there are suitable conditions for giant mayfly *Palingenia longicauda* too. The first observation or discusses about occurrence of *Palingenia longicauda* in the Romanian Danube Delta was taken by Soldan et al., 2009 [14]. Findings of these two strictly protected species in the Danube deltas will be discussed.

MATERIALS AND METHODS

The Malý Dunaj (the Small Danube) is a branch of the Danube. In the first 15 km it flows in an artificial channel and then undulates for 120 km parallel to the Danube before it enters to the Váh River in Kolárovo [17]. According to the WFD classification [21] it belongs to large rivers in the Pannonic plain. The localities of the occurrence of *Gomphus flavipes* take place from Jelka (80.5 river km) to Kolárovo (2.5 river km) (before mouth to the Váh River). There is a natural character of banks with well developed riparian vegetation composed of willows and poplar (association *Salici Populetum*).

The swarming of *Gomphus flavipes* and *Palingenia longicauda* was observed on the boat trips in the Danube Delta in Romania (in June 2009) and in the Inland Delta in Slovakia, too. The area of the Danube Delta is about 4,500 km² and there are 3,500 km of arms and canals. The floodplain forest of localities where *Palingenia longicauda* was observed, consisted of willows and poplars. The banks are created by sandy and muddy beaches that in some places pass to steep clay banks

RESULTS AND DISCUSSIONS

First data about the occurrence of dragonflies from the Danube River in Slovakia comes from the last century ([3]; [6]; [19]). One of the most important species inhabiting potamal rivers *Gomphus flavipes* was documented from the Podunajská nížina (The Danubian Lowland). In 1950th was found out one imago near the Danube River in the Podunajská nížina and forty years later one imago was found [11] near the Danube in Bratislava too. Moreover, autochthonous occurrence was confirmed in the Morava (March) River, the tributary of the Danube [10] and at present too (unpublished). During 20 years monitoring of the Slovak stretch of the Danube only one larva of *Gomphus flavipes* has been found out at the locality situated under the Gabčíkovo dam [5]. On the other side large population (80 imagoes, 44 exuviae) of *Gomphus flavipes* was found out in the Malý Dunaj (Small Danube) in

2001 - 2002 [16]. Another large population of *Gomphus flavipes* (exuviae, imagoes) were observed inhabiting the Danube Delta in Romania during occasional sampling at more localities in June 2009.

The preferred habitat of *Gomphus flavipes* is formed by shallow braided river stretches with shallow, sandy slopes between groins where current velocity is low. The larvae live in sand or between fine particulate matter on the river bottom. They prefer warmer places. The development from egg to adult lasts generally three years so that habitat conditions cannot change too much over such a period [19]. Exuviae can be found very close to the water and their presence can be used by indication of wetland restoration. According to favourable conservation status of species of European importance [4] *Gomphus flavipes* should reach 10 imagoes in 100 m of riparian line. In both deltas such an abundance was reached but only a few individuals for documentation purposes were preserved.

Variations in abundance of population of *Gomphus flavipes* and *Gomphus vulgatissimus* were studied at the Lower–Tisza reach [7]. Authors presented the results of a six–year study on riverine dragonflies emergence based on the systematic collection of exuviae. While the number of species decreased, the abundance of exuviae increased downstream the Tisza River. The total numbers of exuviae differed significantly between the dammed and non–dammed sites. The emergence of gomphids varied in initiation, synchronisation and also in duration between sites as well as between years. The duration of emergence in *Gomphus flavipes* and *Gomphus vulgatissimus* was twice as long at the dammed site, characterised by a higher larval density, as at the other sites. The inter–year variations at the same site might have been attributed to the differences in annual fluctuations in the water temperature, indicating that rising temperatures may influence not only the onset of emergence but the synchrony as well. Abundance, phenology, sex ratio, emergence pattern, mortality and larval emergence behaviour of riverine dragonflies (Odonata: Gomphidae) at the Lower–Tisza reach at Szeged (168–173 rkm) was studied during the emergence period in 2011 [8]. Horváth (2012) [8] found 1,217 exuviae during the emergence period in 2011. Differences in abundance increased towards the south greatly, it could be possible that the southern regions of the Tisza River can provide better conditions for the population of *G. flavipes* [2]. This is in concordance with our findings that stable population of *Gomphus flavipes* can be found only in places with suitable conditions but their density varied inter years and places. The most stable populations are in natural condition which offer first of all Danube deltas.

Palingenia longicauda belongs to the most critically endangered species of the mayflies in Europe. Thanks to its huge size (body length 32–40 mm, up to 100 mm including cerci, length of forewing 25–37 mm; Fig. 1) and well synchronized mass swarming, *Palingenia longicauda* belongs to the most known mayflies in the world. Embryogenesis lasts for 39–45 days. Larvae are fossorial, living metapotamal of larger lowland rivers and requiring a specially defined type of clay and fine silt of substratum ([12]; [13]). They occur most often in a distance of 3 – 7 m from the bank at depths of about 0.3–0.5 m making U–shaped tubes with water current induced by rhythmical movements of gills. The life cycle is semivoltine, lasting most probably three years, then most in mid and late June– early July the imagoes swarm. We documented huge swarms of *Palingenia longicauda* in Canal Mila 35 close below Tulcea on 6th June 2009 at 7.30 pm (Fig. 2).

The review about distribution and ecology of *Palingenia longicauda* has been recently published by Soldán et al. [14]. *Palingenia longicauda* was originally distributed in almost all great and numerous middle–sized European rivers in Western, Central and SE Europe. Larvae are highly sensitive to changes of abiotic factors and disappear rapidly from rivers with regulated banks or sections with organic pollution [12]. *Palingenia longicauda* has disappeared since the end of the 19th century from France, Belgium and Germany. The last records from the Netherlands, Poland, Czech Republic and SW Slovakia are from early 20th century. In SW Europe it is probably extinct since mid 20th century. At present, the species is extinct or at least missing at most of its original area except for relatively small refugia in the Tisza basin in Hungary, Serbia and probably also Slovakia and Ukraine [14]. Former and present distribution of *Palingenia longicauda* with assessment of loss of genetic diversity and its significance for future potential reintroduction of the long–tailed mayfly studied Bálint et al. (2012) [1]. They concluded that massive range losses do not necessarily coincide with genetic impoverishment and that a species' history must be considered when estimating loss of genetic diversity. Titttizer and Andrikovics (2008) [17] try to reintroduce *Palingenia longicauda* in the Lippe and Odra Rivers in Germany. Soldán et al. (2009) [14] have managed to document further refuge in the Danube basin in Romania near Murighiol at the Danube Delta (stretch of the Brațul Sfântu Gheorghe) in June 21st, 2007 and July, 2008. They stated that it might represent either a new, still unknown refuge and/or recovery of the original population(s) caused by downstream drift. In both cases, the specimens have been observed participating in huge swarms. Findings of larvae and exuviae of *Palingenia longicauda* observed in June 6th, 2011 near Tulcea (Zs. Török, pers. comm.) [23] confirm that the population has survived.

In the Danube Delta several hundreds kilometres of canals represent suitable habitat for *Palingenia longicauda* nymphs (pers. observ.). All this findings document, without any doubt, a new great refuge of *Palingenia longicauda* in Europe, probably larger than the previously one known in the Tisza basin. Deltas, first of all in Romania offer both endangered species suitable habitats because they have relatively similar requirements on slowly flowing water, with sandy slopes and fine substratum in warm places.

CONCLUSIONS

The occurrence of large populations of two endangered potamal species *Gomphus flavipes* and *Palingenia longicauda* is reported in the Romanian Danube Delta and the occurrence of large population of *Gomphus flavipes* in the Inland Danube Delta in Slovakia. Results confirm the high importance of river deltas for aquatic biodiversity conservation.

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Fig. 1. Imago of *Palingenia longicauda*



Fig. 2. Swarms of *Palingenia longicauda* on 6 June 2009, in the Romanian Danube Delta.