



Habitat Richness and Seasonal Occurrence of Large Branchiopods (Crustacea: Branchiopoda) in the Areas of the Ramsar Site “Bardača Wetland” and the Donja Dolina in Bosnia and Herzegovina

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Abstract: Multi-year studies were carried out in the “Bardača Wetland” and Donja Dolina areas in northern Bosnia and Herzegovina. Nine taxa of large branchiopods were found at the surveyed sites. All registered taxa show a continuous seasonal distribution with a partial overlap of temporal occurrence. Based on the environmental characteristics of the water body, the cluster analysis separated two groups of habitats: 1) the zone of flooded pastures around the Sava River and 2) small ponds of different depths, which mainly occur in the pastures outside the floodplain. Within each cluster, several groups of habitats were distinguished. The results of the Spearman correlation analysis showed no correlation between the number of species and the individual environmental parameters. A clear seasonal distribution of taxa can be observed: three taxa occur in late winter and early spring, one in mid-spring and five were reported only in late spring. *Triops cancriformis* was recorded for the first time in Bosnia and Herzegovina. This study suggests that a plentifulness of environmental factors and specific seasonal fluctuations favour species richness rather than single environmental parameters in individual habitats. Due to the study area’s high natural and cultural-historical value, “Bardača” and Donja Dolina should be continuously monitored and protected.

Key words: Branchiopoda, ecology, biodiversity protection, Bosnia and Herzegovina

Introduction

Wetlands are freshwater environments that are of critical importance for biodiversity and its conservation worldwide. They include aquatic habitats with relatively long hydroperiods, as well as less permanent water bodies such as ephemeral ponds and small inland lakes. The hydroperiod gradient is one of the most important gradients structuring

communities in such ecosystems (STOKS & MCPEEK 2003). The duration of inundation and the water table can influence the hydrology of these ecosystems over large areas (PYKE & FISCHER 2005), affecting species distribution. Due to their small size and simple community structure, ephemeral aquatic ecosystems are considered classic sentinel systems that can reflect changes in the health of larger ecosystems (DE MEESTER et al. 2005). Such water bod-

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ies harbour species that cannot survive under more permanent conditions and are generally dependent on the absence of larger invertebrate predators and fish (BRENDONCK et al. 2008). They are important for the hatching and maturation of many animals, such as crustaceans (MILIČIĆ et al. 2022) and amphibians (ŠUKALO & DMITROVIĆ 2023). The temporal dynamics of temporary habitats are important for aquatic invertebrates, adapted to live and reproduce under short-term and unpredictable conditions (BOIX et al. 2004). They are also useful model systems for studying temporal dynamics and monitoring changing communities (DEVÁNOVÁ et al. 2023). Recently, their role in providing ecosystem services has also been increasingly recognised (RINKE et al. 2019, JANSSEN et al. 2021, MEERHOFF & GONZÁLEZ-SAGRARIO 2022). Temporary water bodies are also important from a nature conservation perspective. They can harbour several flagship taxa, such as the large branchiopod crustaceans of the class Branchiopoda (the large branchiopods). The life span of large branchiopods ranges from weeks to months. They are characterised by a diapause of the dormant eggs (embryos), which allows them to survive in conditions that are intolerable for most other aquatic taxa (BRENDONCK et al. 2008). Potential factors influencing their development and temporal and spatial distribution include hydrology, water chemistry, plants and phytoplankton. They are restricted to ponds with pronounced ephemerality, which makes them particularly vulnerable (COLBURN 2004, LUKÁCS et al. 2013). Recently, there has been a growing awareness of their importance, sensitivity and vulnerability to anthropogenic disturbance (BIGGS et al. 2017).

The structural complexity of the “Bardača Wetland” with a mosaic of different microhabitats creates niches suitable for developing a large number of taxa (RADEVIĆ 2007, MATAVULJ et al. 2008). The taxa reported so far from this area are: *Eubranchipus (Siphonophanes) grubii*, *Linderiella* sp., *Lepidurus apus*, *Cyzicus* sp., *Leptesteria dachalacensis*, *Eoleptesteria ticinensis* and *Limnadia lenticularis* (for an overview, see MILIČIĆ et al. 2022, 2023). Large branchiopods were found in small and eutrophic ponds, rain pools or floodplains, often with a complex macrophyte cover. The archaeological site of Donja Dolina is located near the Ramsar site “Bardača Wetland”. This area is also characterised by a mosaic of ephemeral ponds, rain puddles, and flooded pastures, which have not yet been studied concerning the zooplankton and Branchiopoda communities.

The aim of this study was to explore the spatial and temporal dynamics of large branchiopods in the Ramsar site “Bardača Wetland” and in the area of

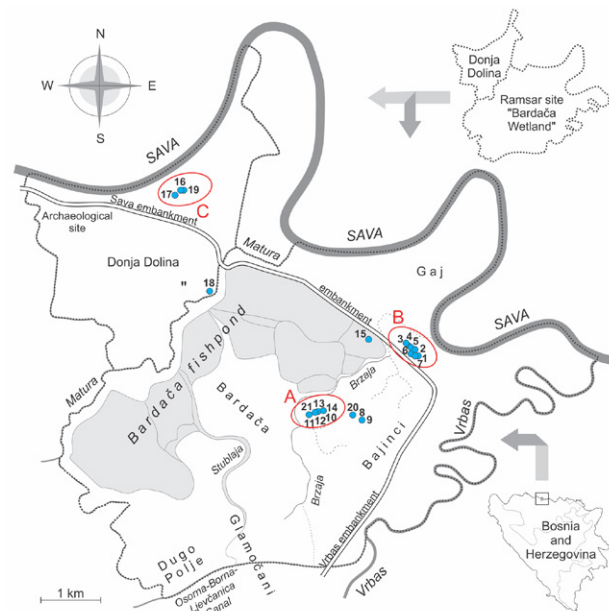


Fig. 1. The map of the „Bardača“ – Donja Dolina study area. Areas inhabited by large branchiopods are numbered.

Donja Dolina in northern Bosnia and Herzegovina, in relation to the physical and chemical parameters of temporary aquatic habitats. Here, we focussed on tracking intermittent aquatic habitats over periods of inundation to observe large branchiopod crustaceans’ spatial and temporal dynamics and changes in their community composition over several years.

Materials and Methods

Research area

The samples were collected in the areas of the Ramsar site “Bardača Wetland” (from 2016 to 2023) and the settlement of Donja Dolina (from 2021 to 2023), which borders the “Bardača” to the west (Figure 1). The surveyed area is located in the northern part of the Republic of Srpska (Bosnia and Herzegovina). “Bardača” is a marshy area bordered by the Sava, Vrbas, Matura Rivers and the Osorna-Borna-Ljevanica canal. The Brzaja River crosses the study area. The area also has several other canals, ponds, and pools. In the past, the largest body of water was a Bardača fishpond for cyprinids, which was created between the Matura and Brzaja Rivers, most of which has now been converted into farmland. The water remains in the fishpond only in the channel-like depressions at the bottom, solely during the wet seasons. The north-eastern border of the fishpond is formed by an embankment built to prevent flooding, which divides the “Bardača” – Donja Dolina area into two parts, a floodplain and a non-floodplain. This area is characterised by a mixture of flooded

Table 1. Habitat characteristics of the studied sites in “Bardača” (sites 1-15 and 20-21) and Donja Dolina (sites 16-19).

Site No	Water characteristics				Habitat (general remarks)
	Temperature (°C)	pH	Conductivity (µS/cm)	Oxygen (mg/l)	
1	24.6	8.20	500	15.0	Puddles on a pasture in the floodplain of the Sava river
2	24.7	8.30	400	14.6	
3	28.8	8.10	500	19.5	
4	24.6	8.20	500	15.0	
5	25.5	8.20	500	17.8	
6	9.3	8.00	800	8.0	
7	15.3	8.50	500	8.7	
8	13.9	7.70	600	4.1	Puddles on a pasture outside the floodplain
9	27.0	8.00	600	6.7	
10	14.9	8.20	250	4.3	
11	16.7	8.20	300	10.8	
12	18.6	8.20	100	11.6	
13	26.4	8.30	300	9.6	
14	25.2	7.40	100	8.0	
15	31.3	8.90	200	10.3	Puddle on the bottom of a dried-up fishpond outside the floodplain
16	20.3	8.51	590	6.5	Puddles on a pasture in the floodplain of the Sava River
17	22.7	7.90	400	6.8	
18	30.3	9.20	420	9.8	Puddle on a dirt road outside the floodplain
19	27.9	8.36	440	11.7	Puddle on a pasture in the floodplain of the Sava River
20	13.7	8.08	360	9.8	Puddles on a pasture outside the floodplain
21	27.1	7.88	433	7.0	
Min.	9.3	7.4	100.0	4.1	A total of 10 puddles are in the floodplain of the Sava river and 11 puddles are outside the floodplain.
Max.	31.30	9.20	800.00	19.50	
Mean	22.32	8.21	418.73	10.27	
St. Dev.	6.25	0.38	171.16	4.16	

and non-flooded zones, where the water lasts long enough to “cover” much of the season. This area’s most important human settlements are the villages of Bardača, Bajinci, Gaj, Dugo Polje, Glamočani and Donja Dolina. The humid habitats in Donja Dolina are used as cattle pastures in the dry season (pers. obs.). The geological structure of the wider area is dominated by alluvial sediments with a high groundwater table (MARKOVIĆ & BEGOVIĆ 2007).

Data collection

A large area with ephemeral water bodies of different origins explored in this study is located at altitudes between 86 and 90 m above sea level. The surveys were carried out in monthly field campaigns from February to June and less frequently from July

to January. After the dry parts of the season, the field surveys usually took place seven to ten days after the first rains. Large branchiopods were collected with hand nets (mesh size: 500 to 1000 µm) and fixed in 96% ethanol and/or buffered formalin. The sampled material was identified according to EDER & HÖDL (1996), BRTEK & MURA (1999), MARTIN & BOYCE (2004) and ROGERS et al. (2019). Four physicochemical parameters of the water (temperature, pH, conductivity and dissolved oxygen concentration) were measured in the 21 selected representative small water bodies using the HI98127, HI98130, HI9142 and Nahita field devices. In smaller puddles, these parameters were measured once by making slight circular movements in the water with the device’s probe until a stable value was reached.

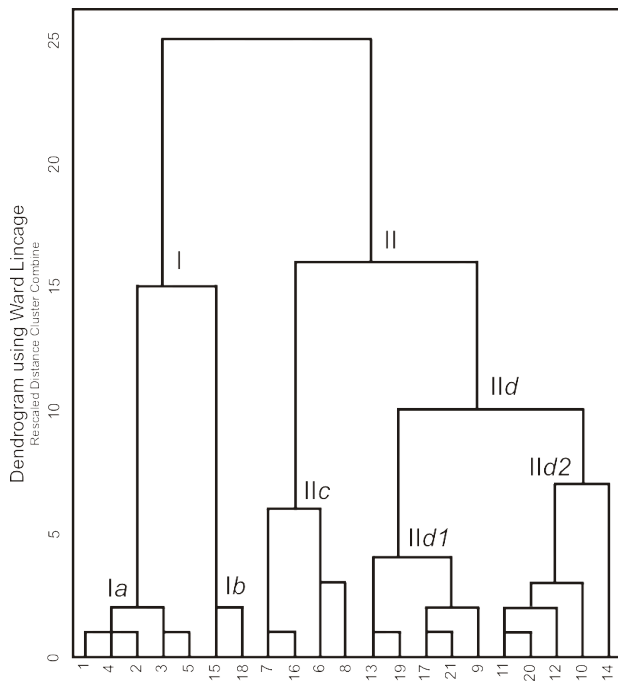


Fig. 2. Cluster analysis based on the physical and chemical characteristics of the habitats. The numbers on the abscissa correspond to the ordinal numbers of the analysed sites, Figure 1.

In larger and longer-lasting puddles, the parameters were measured in the same way but several times in succession to obtain an average value that was as accurate as possible.

Statistical analysis

Statistical analyses were performed using SPSS 17.0 (SPSS for Windows, Rel. 17.0.0.2008, Chicago: SPSS Inc). For cluster analysis based on environmental data, centred and standardised environmental data were classified using the Ward Linkage method. The relationship between the number of species and the environmental variables was analysed using Spearman's correlation analysis.

Results

Characteristics of the habitat

The most important characteristics of the 21 ephemeral water bodies with large branchiopods in the "Bardača Wetland" and Donja Dolina areas are listed in Table 1.

The cluster analysis results based on the environmental data showed a division into two main groups of habitats (Figure 2). The two most prominent clusters (Cluster I and Cluster II) differed in terms of physical and chemical characteristics. Cluster *Ia* included aquatic habitats in the zone of

flooded meadows around the Sava River. These habitats in the meadows between the Sava River and the artificial embankment were well oxygenated (14.6–19.5 mg/l), and the water temperature was 24.6–28.8°C. The pH was 8.10–8.30, and the conductivity was 400–500 $\mu\text{S}/\text{cm}$. Cluster *Ib* consisted of shallow puddles on the opposite side of the artificial embankment and outside the floodplain in the area of high anthropogenic pressure. Higher water temperatures (30.3–31.3°C) and a higher pH (8.90–9.20) were measured in these habitats. The values for oxygen (9.8–10.3 mg/l) and conductivity (200 to 420 $\mu\text{S}/\text{cm}$) were lower in the puddles of Cluster *Ib* than in the flooded pastures of Cluster *Ia*.

A large number of aquatic habitats of different depths were grouped within Cluster II. This group is divided into two main clusters: *IIC* and *IId*. Cluster *IIC* was mainly comprised of deeper puddles in the floodplains of the area with a relatively low water temperature (9.3–20.3°C). The puddles occurred mainly in flooded pastures near riverbeds or as remnants after water abstraction. They usually had a muddy bottom, but there were also pools with submerged aquatic plants, detritus and filamentous Chlorophyta. The oxygen content was 4.1–8.7 mg/l, and the pH was 7.70–8.51. The conductivity in these ponds ranged from 500 to 800 $\mu\text{S}/\text{cm}$.

Cluster *IId* is divided into two groups of habitats (labelled *IId1* and *IId2* in Figure 2). Cluster *IId1* consisted of various puddles located mainly in the non-flooded areas. These were mostly puddles in a pasture filled with rainwater. Some puddles had a muddy bottom with sparse Charophyta and *Juncus* vegetation. They were generally shallower than the puddles grouped in Cluster *IIC* and had relatively low oxygen content (6.7–11.7 mg/l), a water temperature of 22.7–27.9°C, and a pH of 7.88–8.36. The conductivity of the water was between 300 and 600 $\mu\text{S}/\text{cm}$. Cluster *IId2* comprised pools in the pasture outside the floodplain, with a temperature of 13.7–25.2°C, a lower oxygen content (from 4.3 to 11.6 mg/l) and a pH of 7.40–8.20. The lowest conductivity of all analysed habitats was measured in these pools (100–360 $\mu\text{S}/\text{cm}$).

Spatial distribution and seasonal occurrence of large branchiopods

In 2016–2023, nine taxa of large branchiopods (genus and species) were found in the "Bardača" – Donja Dolina area. The distribution of different taxa in the Ramsar site "Bardača Wetland" and Donja Dolina showed a specific spatial and seasonal pattern, alternating seasonal overlaps of species with similar ecological niches (Table 2, Table 3). Some habitats

Table 2. Spatial distribution of large branchiopods in the temporary waters of “Bardača” (sites 1-15 and 20-21) and Donja Dolina (sites 16-19) for period 2016–2023 (the ordinal numbers of the localities correspond to the numbers in the cluster diagram, Figure 2).

Species	Localities																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Order Anostraca																					
<i>Branchipus schaefferi</i> Fischer, 1834																	+	+	+		+
<i>Eubranchipus</i> (<i>Siphonoph.</i>) <i>grubii</i> (Dybowski, 1860)										+	+	+					+			+	
<i>Linderiella</i> sp. Brtek, 1964													+								
Order Notostraca																					
<i>Triops cancriformis</i> (Bosc, 1801)																					+
<i>Lepidurus apus</i> (Linnaeus, 1758)	+	+	+		+														+		
Order Spinicaudata																					
<i>Cyzicus</i> sp. Audouin, 1837				+	+	+	+	+	+							+	+		+		
<i>Leptestheria dahalacensis</i> (Rüppell, 1837)															+		+				+
<i>Eoleptestheria ticinensis</i> (Balsamo-Crivelli, 1859)													+	+		+					
<i>Limnadia lenticularis</i> (Linnaeus, 1761)													+	+			+				
Total number of species	1	1	1	1	2	1	1	1	1	1	1	1	3	2	1	2	5	1	3	1	3

Table 3. Seasonal occurrence of large branchiopods in “Bardača” and Donja Dolina (all taxons and seasons pooled) based on the study period 2016–2023.

Taxon/Month	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG	SEP	OCT	NOV	DEC
Anostraca												
<i>B. schaefferi</i> Fischer, 1834					+	+						
<i>E. grubii</i> (Dybowski, 1860)		+	+	+								
<i>Linderiella</i> Brtek, 1964						+						
Notostraca												
<i>T. cancriformis</i> (Bosc, 1801)					+	+						
<i>L. apus</i> (Linnaeus, 1758)		+	+	+								
Spinicaudata												
<i>Cyzicus</i> Audouin, 1837		+	+	+	+	+					+	
<i>L. dahalacensis</i> (Rüppell, 1837)					+	+						
<i>E. ticinensis</i> (Balsamo-Crivelli, 1859)				+	+	+						
<i>L. lenticularis</i> (Linnaeus, 1761)					+	+						

were colonised from February to the end of April. *Lepidurus apus* occurred first, followed by *Cyzicus* sp. Spatially, these species inhabited the parts of the studied area with puddles in flooded pastures (Cluster *Ia* in Figure 2). *Cyzicus* occurred in flooded pastures at the latest in April and then again in autumn. This species also inhabited deeper puddles in flood-

ed pastures (mainly corresponding to Cluster *Iic*). In mid-April, *Eoleptestheria ticinensis* appeared at one locality (No. 16) from the same Cluster *Iic*.

Puddles with cold to moderately warm water, with relatively low conductivity and lower oxygen content than at the other sites, were colonised in late winter and early spring. These sites (most from

Table 4. Results of the correlation analysis between the number of species found in a habitat and the parameters of that habitat.

			Water temperature (°C)	pH value	Conductivity (µS/cm)	Oxygen concentration (mg/l)
Spearman's rho	Number of species	Correlation Coefficient	.274	-.132	-.128	-.156
		Sig. (2-tailed)	.229	.568	.581	.500
		N	21	21	21	21



Fig. 3. *Triops cancriformis* (A) in the village of Bajinci, near the Brzaja River (B) – the habitat corresponds to study site 21.

Cluster *IId2*) were located outside the floodplain. They were colonised by the species *Eubbranchipus (Siphonophanes) grubii* from February to mid-April. *Eoleptesteria ticinensis* and *Limnadia lenticularis* (May-June) also appeared in seasons with favourable hydrological conditions and with the increase of external temperature at some sites (as in puddle 14 from the same cluster).

The habitats in mid to late spring that were inhabited by *Branchipus schaefferi*, *Linderiella* sp., *Cyzicus* sp., *Eoleptesteria ticinensis*, *Triops cancriformis*, *Leptesteria dahalacensis* and *Limnadia lenticularis* belonged to the grazing puddles, mostly outside the floodplains, which mainly correspond to the sites of Cluster *IId1*. The species *B. schaefferi* and *L. dahalacensis* also occurred in the shallow puddles of Cluster *Ib* in spring, from mid to late May.

The largest number of taxa per site (across all seasons) was five (at site 17), three taxa were found

at sites 13, 19 and 21, and up to two taxa of large branchiopods were found at sites 5, 14 and 16.

However, the correlation analysis of species diversity, as well as physical and chemical parameters in each habitat, showed that there was no correlation between the number of species found in a particular habitat and any single parameter of that habitat (Table 4).

Most favourable zones for large branchiopods

Based on the data from the entire area of “Bardača” – Donja Dolina, three zones can be distinguished that are best suited for the development of large branchiopods (the most favourable locations correspond to the zones circled in red in Figure 1). The first zone (labelled A in Figure 1) consisted of late winter and early spring habitats belonging to sites 10, 11, 12 and 13, 14 and 21 (the late spring habitats). The habitats are located in the central part of the Ramsar site

“Bardača”, in the non-flooded zone in the village of Bajinci, near the Brzaja River. This zone included puddles on pastures with the early spring species *E. grubii* and the late spring habitats with *B. schaefferi*, *Lindieriella* sp., *L. dahalacensis*, *E. ticinensis*, *L. lenticularis* and *T. cancriformis* (Figure 3).

Another favourable habitat for the development of large branchiopods (zone labelled B in Figure 1) is located northeast of zone A, in the floodplain between the Sava River and the protective embankment near the village of Bajinci. It was a zone of flooded pastures (sites 1–7) which persisted for a relatively long time during the season, where a very abundant population of *L. apus* occurred in early to mid-spring. In addition to *L. apus*, *Cyzicus* sp. also occurred, both in early to mid-spring and in autumn.

The third zone (labelled C in Figure 1) consisted of puddles on the flooded pastures near the village of Donja Dolina in the western part of the study area with sites 16, 17 and 19. These were the early to late spring habitats with the occurrence of large branchiopods: *B. schaefferi*, *Cyzicus* sp., *L. dahalacensis*, *E. ticinensis* and *L. lenticularis*. In addition, *E. grubii* and *L. apus* were also found in this zone in 2023.

Discussion

Due to its landscape and hydrological characteristics, the “Bardača Wetland” and the surrounding area represent a unique natural complex of lentic and lotic ecosystems, including intermittent water bodies. Based on the hydrological characteristics of the studied sites in the area of “Bardača” – Donja Dolina, two groups of ephemeral lentic habitats can be found: 1) flooded pastures in the floodplain of the Sava River and 2) small aquatic habitats (ponds and puddles) in flooded and non-flooded areas. The first group includes standing aquatic habitats ranging from “lake-like” during a flood period to the numerous isolated ephemeral ponds left after water withdrawal. All habitats were critically influenced by precipitation and groundwater levels. Such habitats inherently provide a variety of ecological benefits to a given area, such as water filtration, flood control or the provision of food and water (MEERHOFF & GONZÁLEZ-SAGRARIO 2022). To the known natural values of the “Bardača Wetland”, the well-known prehistoric archaeological site of Donja Dolina in the western part of the study area should also be added, which was not previously known to be favourable for the development of large branchiopods. Apart from its cultural value, this site proved to be an area with great ecosystem potential, as a total of

seven large branchiopod taxa were found mainly in the puddles on arable land and pastures. However, the ephemeral habitats in this area are under significant human impact and can be considered fragile.

The relatively high diversity of large branchiopods in “Bardača” – Donja Dolina was closely related to the diversity of habitats that characterise this alluvial plain. Looking at the whole area, the sites belonging to wide-flooded pastures or shallow puddles in the region with high anthropogenic pressure were characterised by lower species diversity (mostly one species per habitat). On the other hand, at sites with a mixture of rainwater puddles, deeper puddles or small remnants in a pasture after water withdrawal, several species occurred sympatrically (syntopically and synchronously) during the season. According to DEVÁNOVÁ et al. (2023), such habitats proved to be suitable for processes that promote short-term dynamics in assemblages and changes in composition over time. These processes may also be associated with differences in species survival strategies and colonisation abilities, temporal resource partitioning, predator avoidance, facilitation, and chance for colonisation, hatching and survival (BOIX et al. 2016).

Although the physical and chemical parameters of the water played an essential role in shaping the temporary habitats, they were not directly related to the number of species found in the individual habitats of the area studied. Similar studies in the ephemeral freshwater wetlands revealed that the spatial and temporal distribution and dynamics of biotic communities are not primarily dependent on changing environmental conditions but on other processes related to the different survival strategies of species and their biotic interactions (DEVÁNOVÁ et al. 2023, BOIX et al. 2016).

Freshwater habitats with different hydroperiods and flooding patterns can harbour different species (COLBURN 2004). The fauna collected during our field studies consisted of a total of nine large branchiopod taxa belonging to three orders: *B. schaefferi*, *E. grubii* and *Lindieriella* sp. (Anostraca), *T. cancriformis* and *L. apus* (Notostraca), and *Cyzicus* sp., *L. dahalacensis*, *E. ticinensis* and *L. lenticularis* (Spinicaudata). The seasonal distribution of the different taxa showed a successive shift and partial seasonal overlap of species with similar ecological niches. In late winter to early spring (February–April), *E. grubii*, *L. apus* and *Cyzicus* appeared. In mid-spring (second half of April), *E. ticinensis* appeared, while *B. schaefferi*, *T. cancriformis*, *L. dahalacensis*, *L. lenticularis* and *Lindieriella* sp. occurred in late spring. *Cyzicus* was present in this

area for the most prolonged period (from February to June), with an interruption during the summer dry season and again in November. This was the only taxon sampled during the autumn season in the area studied. *Cyzicus* showed the highest eurythermia compared to other taxa, as it tolerates a wide range of physical and chemical variables of the water. Compared to other species in the area, it tolerated lower oxygen concentrations and higher conductivity. This is probably one reason for its more frequent occurrence in the “Bardača” and neighbouring regions. A similar seasonal occurrence has also been observed in the large alluvial area of Lonjsko Polje in Croatia (POPOVIĆ & GOTTSTEIN-MATOČEC 2006).

The species *E. grubii* and *L. apus* mainly favoured colder waters from late winter to mid-spring. *E. grubii* favoured ponds with relatively low temperatures and low oxygen concentrations. This species was usually found in the habitats of the non-flooded zone of “Bardača”, where it occurred almost regularly in high population densities. This is the only known population in the geographical region of the Western Balkans (MILIČIĆ et al. 2022). A very abundant population of *L. apus* appeared in “Bardača” in early and mid-spring. This species was found exclusively in floodplain habitats. This is the largest known population of *L. apus* in Bosnia and Herzegovina to date, which regularly occurred in the well-oxygenated floodplain meadows (MILIČIĆ et al. 2022, 2023). *L. apus* is also widespread in the floodplains of the middle and lower parts of Central European rivers, where it usually occurs in mass populations (EDER et al. 1997, PETROV & CVETKOVIĆ 1997, KOJAKOVIĆ & GOTTSTEIN MATOČEC 2003, SCHERNHAMMER et al. 2020). Mainly thermophilic taxa with a narrower tolerance range were *L. dahalacensis*, *E. ticinensis*, *B. schaefferi*, *Lindieriella* sp., *L. lenticularis*, and *T. cancriformis*.

Most of the large branchiopods found in the “Bardača” – Donja Dolina area are widespread throughout Europe (see BRTEK & THIERY 1995) and also occur seasonally in neighbouring countries (EDER et al. 1997, PETROV & CVETKOVIĆ 1997, KOJAKOVIĆ & GOTTSTEIN MATOČEC 2003, POPOVIĆ & GOTTSTEIN-MATOČEC 2006). The discovery of the notostracan species *T. cancriformis* is a novelty for the “Bardača” wetland and represents the first discovery of this species in Bosnia and Herzegovina. The population consisted mainly of juvenile specimens found in late spring in richly vegetated puddles in a pasture near the village of Bajinci. A certain speciality of the “Bardača” – Donja Dolina and the entire region of the Western Balkans was the occurrence of the genus *Lindieriella*. To date, only two

European species of this genus have been described from south-east France (THIERY & CHAMPEAU 1988) and south-west Spain (ALONSO & GARCÍA-DE-LOMAS 2009). Recently, *B. schaefferi* was recorded for the first time in the “Bardača” Wetland (ŠKONDRIĆ et al. 2022). This species was previously known only from the south-eastern and eastern parts of Bosnia and Herzegovina (PROTIĆ 1927, PETROV & MARINČEK 1991), and its occurrence in the western parts of the country was confirmed for the first time in this study.

Large branchiopods gained particular attention as true specialists of temporary water bodies, able to perceive slight changes in the habitat’s ecology (PULLIN 2002). However, their natural floodplain habitats have been heavily modified worldwide, and much of them have been converted into agricultural landscapes (LUKÁCS et al. 2013). The regularity of the occurrence of habitats with different physical and chemical conditions during the season and several taxa occurring in them has declared the “Bardača” Ramsar site a very valuable wetland in Europe that deserves special attention. The complexity of habitats, the occurrence of a large number of taxa and the stable populations that occurred almost regularly in the humid parts of the season make the entire area of “Bardača” – Donja Dolina a candidate for special protection in Bosnia and Herzegovina, especially for habitats where several species occur together.

Conclusions

A variety of ephemeral habitats in the area of “Bardača” – Donja Dolina support a large diversity in a relatively small area. The abundance of small and shallow freshwater pools offers a wide range of ecological gradients in terms of size and length of the water period. Several taxa of large branchiopods have been recorded, with some rare taxa such as *Lindieriella* sp. The risk of extinction of local habitats and species is increasingly high and requires continuous monitoring and protection as the whole area is exposed to various anthropogenic impacts.

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