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Spatial and temporal distribution of the macrozoobenthos community in ponds of Southeastern Serbia

Original Article

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Abstract:

Ponds are a prevalent type of freshwater ecosystems worldwide, but most studies have been traditionally focused on deep stratified lakes. The region of Southeastern Serbia is showcasing the fact that research on this type of small water bodies is scarce. In present study was compared macroinvertebrates community in ponds in Southeastern Serbia, at different altitudes but with similar other parameters. The goals of this study include: determining the composition and structure of macrozoobenthos communities in ponds at different altitudes; determining the seasonal changes in macrozoobenthos communities in these ponds; and determining the microdistribution of macroinvertebrate taxa in these ponds along the gradient of depth. In studied ponds, structuring of communities was mostly contributed to by insect groups. In the lower-altitude pond these were Chironomidae and Coenagrionidae, while in the higher-altitude pond Chironomidae and Dytiscidae. Our study has shown that in most cases the sample of macroinvertebrate community included a greater number of families in autumn than in spring season. The greatest number of families was recorded in samples collected in the shallowest part of the pond, both in the pond with a low and in the pond with a high altitude.

Key words:
macroinvertebrates, ponds, Southeastern Serbia

Apstrakt:

Prostorna i vremenska distribucija makroinvertebratske zajednice u barama jugoistočne Srbije

Iako bare predstavljaju široko rasprostranjene, česte ekosisteme u celom svetu, veliki deo istraživanja je koncentrisan na duboka, stratifikovana jezera. U oblasti jugoistočne Srbije takodje postoji nedostatak istraživanja malih vodenih tela. U ovom istraživanju je uporedjivana makroinvertebratska zajednica u barama koje se karakterišu različitim nadmorskim visinama, dok su sa druge strane, one slične po drugim karakteristikama. Ciljevi ovog istraživanja su bili da se odredi sastav i struktura zajednice makroinvertebrata u barama sa različitom nadmorskom visinom, da se proprate sezonske promene u ovim zajednicama i da se odredi mikrodistribucija predstavnika ove zajednice duž gradijenta dubine. Sastavu zajednice najviše doprinose insekatske grupe. U bari sa nižom nadmorskom visinom najveći doprinos struktuiranju imaju Chironomidae i Coenagrionidae, dok u bari sa većom nadmorskom visinom Chironomidae i Dytiscidae. U istraživanju je konstatovano da u najvećem broju uzoraka zajednica ima u sastavu veći broj familija u jesenjem aspektu nego u prolećnom. Najveći broj familija je konstatovan u najplićim delovima bara koje su bile predmet ovog istraživanja.

Ključne reči:
makroinvertebrate, bare, jugoistočna Srbija

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Introduction

Over a long period of time, conservation activities have mostly been focused on extensive ecosystems, especially those that contain large portions of the Earth's biodiversity (Brooks et al., 2006; Hunter et al., 2017; Savić et al., 2022a). On the other side of the spatial gradient, there are some conservation efforts focused on Small Natural Features in contrast to the large-scale conservation (Hunter et al., 2017). Small Natural Features (SNFs) are analogous to keystone species because they have an ecological im-

portance that is disproportionate to their size; sometimes because they provide resources that constrain key populations or processes that affect a much larger area; sometimes because they support unusually high diversity, abundance, or productivity (Hunter et al., 2017; Savić et al., 2022a). Ponds can be defined as small (1 m^2 to max 5 ha), natural or man-made shallow waterbodies (normally fresh water, but occasionally brackish), which holds water for at least three months of the year or more (Céréghino et al., 2008). This is just one of the possible definitions found in scientific literature, and there are almost as many definitions as there are authors of papers on these ecosystems.

Ponds (and shallow lakes also) are a prevalent type of freshwater ecosystems worldwide, but most studies have been traditionally focused on deep stratified lakes (Hilt et al., 2017). The region of Southeastern Serbia is also showcasing the fact that research on this type of small waterbodies is scarce. They attracted more attention by botanists (Ranđelović et al., 2007), while there are only a few (more recent) papers on macroinvertebrate community of ponds (Đorđević, 2017; Petrović, 2017).

Knowledge of spatial and temporal distribution patterns reduces bias in the analysis of data and allows the elaboration of sampling strategies. This type of information is particularly needed for the communities of macrozoobenthos in ponds because they are poorly studied (Oertli, 1995). Space and time may be perceived as the two axes along which the changes in macroinvertebrate community come about. These changes may pertain to composition and structure of the community, its diversity, biomass and productivity, etc. The spatial distribution of macroinvertebrates depends on various factors, depending on which spatial scale is observed. Regarding the micro-distribution, the key factors recognized in the previous studies included heterogeneity of substrate (Heino, 2000), depth of water body and oxygen concentration (Brinkhurst, 2002), interaction with other organisms and presence of aquatic plants (Waters & San Giovanni, 2002) etc. Temporal variations in fauna can exist at scales ranging from minutes to years (Oertli, 1995). In the present study we will investigate temporal variations in macroinvertebrate communities in terms of seasonal changes. Considering mentioned, the goals of this study include: 1) determining the composition and structure of macrozoobenthos communities in ponds at different altitudes; 2) determining the seasonal changes in macrozoobenthos communities in these ponds; and 3) determining the microdistribution of macroinvertebrate taxa in these ponds along the gradient of depth.

Materials and Methods

The selected study sites included two ponds in Southeastern Serbia. One is situated in the close vicinity of City of Niš (43°17′40.2”N, 21°55′45.9”E) at the altitude of 294 m above sea level, while the other is at Vlasina Plateau (42°40′42.2”N, 22°21′17.2”E) at the altitude of 1212 m (**Fig. 1**). Average annual temperature on localities are 11.65 °C and 5.72 °C, respectively.

Fig. 1. Map of the study area

Samples were collected in two seasons: in late May and late September, according to the following procedure: five spots were selected at each pond and one sample was taken at each point. Samples were taken during a transect, first sample at depth of 30 cm and each following sample at distance of 2 m toward the deepest part of the pond (**Fig. 2A** and **2B**). Each sample of macrozoobenthos was collected with a net with square frame 30 x 30 cm, mesh size 300 μm and size of sampled surface 0.30 m x 0.30 m. During the sampling process, the frame was placed vertically at the bottom of the pond and pulled along the bottom in the same length as the side of the frame (30 cm). The collected material was transferred to plastic bags and then conserved

Fig. 2. Sampling transects in: **A** - pond in the vicinity of Niš; **B** – pond of the Vlasina plateau

in 70% ethyl alcohol. Identification of material was performed by using following keys: Belfiore (1983), Nilsson (1997), Vallenduuk & Pillot (2007).

SIMPER analysis was used for analysing the year and seasonal structuring of the community, as well as for analysis and comparison of community structure along the gradient of depth. In other words, SIMPER analysis was performed to test differences within faunal composition of groups, dissimilarities between and similarities within the above groups. This analysis was performed using statistical program Primer 7.0 (Clarke & Gorley, 2015).

Results

The samples at the pond in vicinity of Niš included representatives of 14 families (550 individuals), with 9 families recorded during the spring sampling and 10 families in the autumn sampling. At the annual level, the best-represented family was Coenagrionidae (**Fig. 3A**). The spring aspect was dominated by family Chironomidae and the autumn aspect by family Coenagrionidae (**Fig. 3B** and **3C**).

The comparison of localities along the gradient of depth at the annual level has shown that the greatest

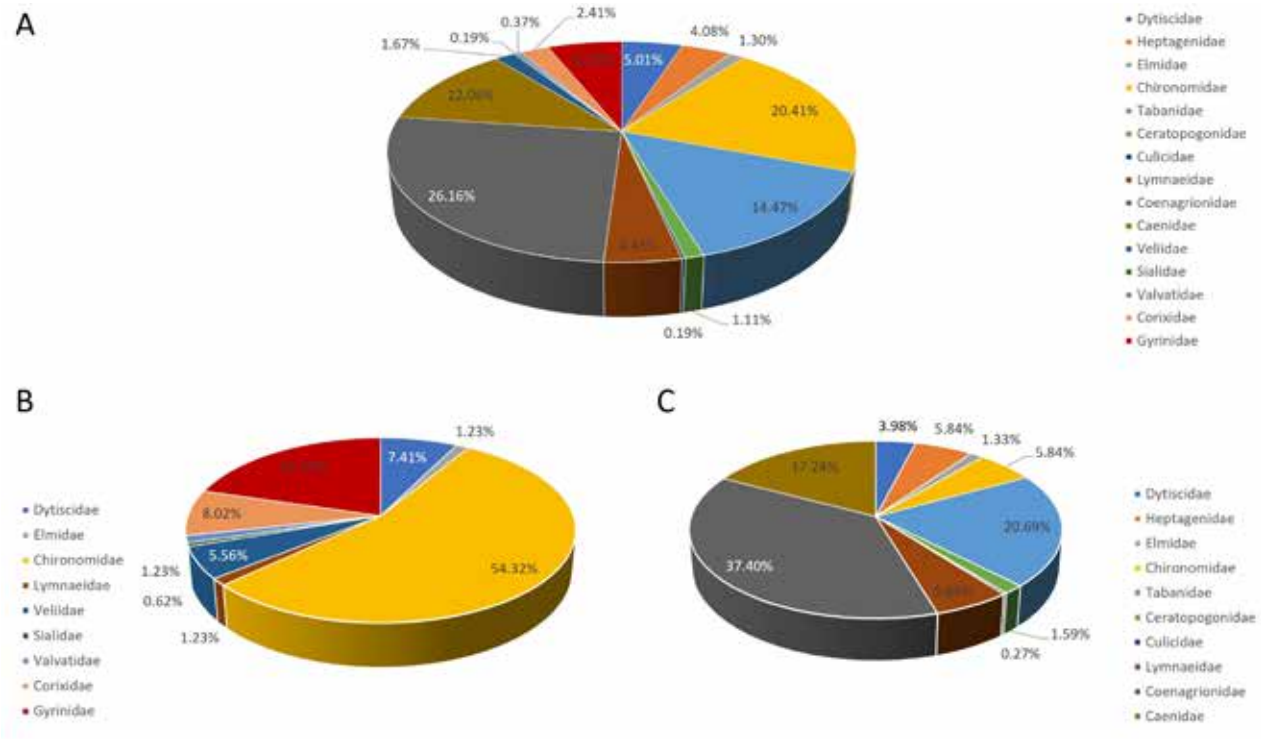

Fig. 3. Percentages of macrozoobenthos groups (at family level) in pond in vicinity of Niš: **A** - annual; **B** – in spring period; **C** – in autumn period

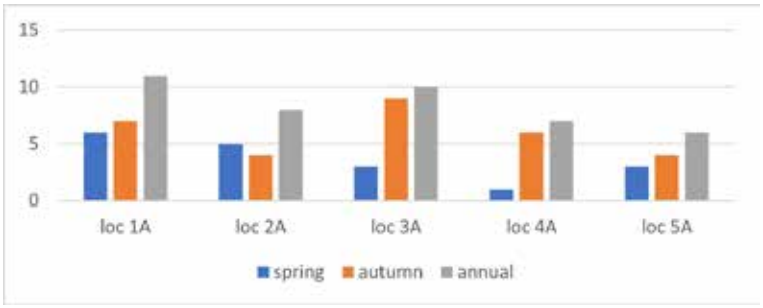

Fig. 4. Annual number of benthic macroinvertebrate families in pond in vicinity of Niš, their seasonal dynamic and distribution along depth gradient (where loc 1A is the shallowest and loc 5A is the deepest)

number of families was recorded at the locality with shallowest water, while the smallest number was recorded at the locality with deepest water (**Fig. 4**). In four out of five localities, the number of families was greater in autumn that during the spring period.

The samples from the pond at the Vlasina Plateau included representatives of 8 families (241 1ndividuals) (**Fig. 5A**), where both spring and autumn samples were represented by 5 families each. At the annual level, the best-represented family was Chironomidae,

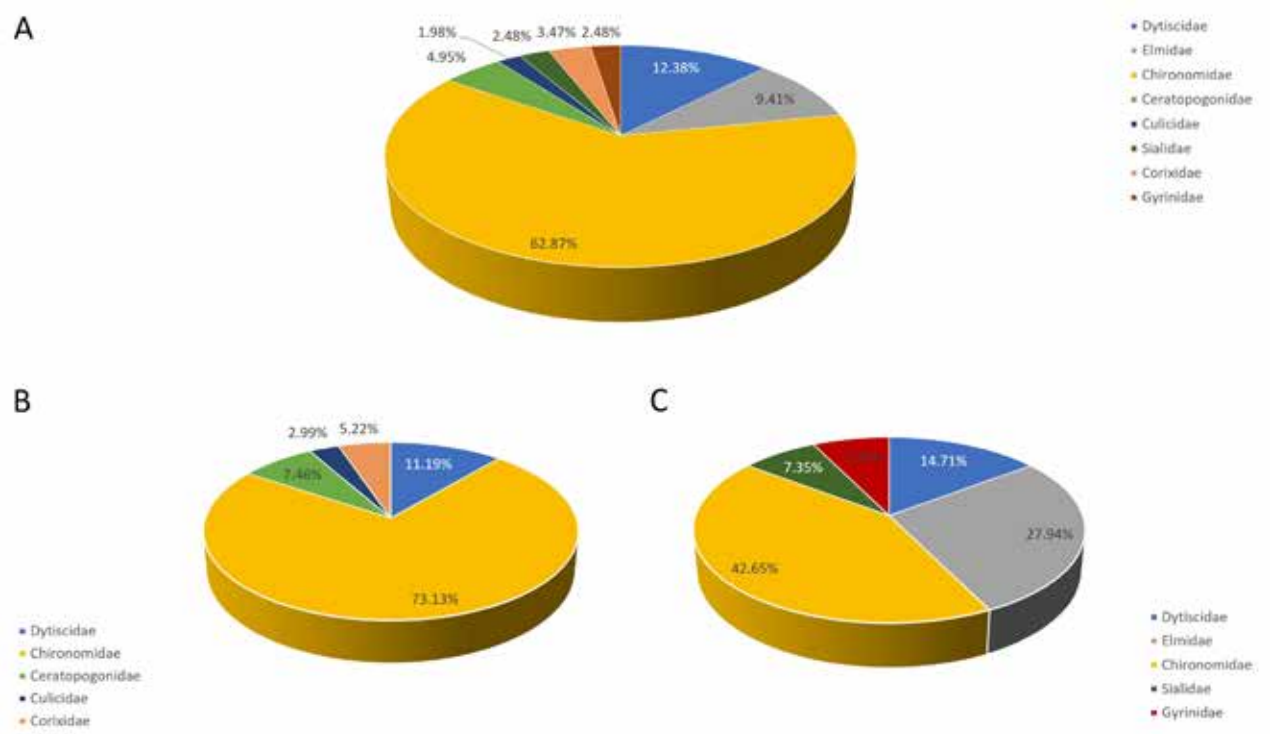

Fig. 5. Percentages of macrozoobenthos groups (at family level) in pond on Vlasina plateau: **A** - annual; **B** – in spring period; **C** – in autumn period

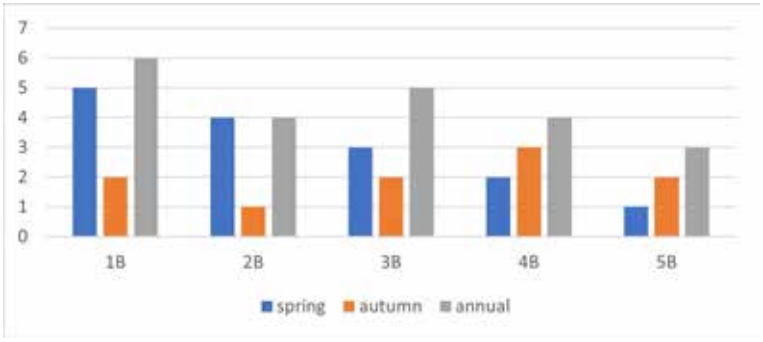

Fig. 6. Annual number of benthic macroinvertebrate families in pond on Vlasina plateau, their seasonal dynamic and distribution along depth gradient (where 1B is the shallowest and loc 5B is the deepest)

both in spring and autumn periods (**Fig. 5B**, **Fig. 5C**), respectively.

Just as in the pond in vicinity of Niš, at the annual level the sample from the shallowest locality included the greatest number of families and the sample from the deepest locality included the lowest number of families (**Fig. 6**). In four of the five localities, the number of families was greater in autumn that during the spring period, just as in the first pond.

The SIMPER analysis at the annual level has shown that samples from the

pond in vicinity of Niš did not show high average similarity (41.46), while the samples from the pond at Vlasina Plateau have shown somewhat higher levels of similarity (58.24). The structuring of the community at the pond in vicinity of Niš was mostly contributed to by families Chironomidae (34.64%) and Coenagrionidae (25.6%). The structuring of community in the pond at Vlasina Plateau was also mostly contributed to by family Chironomidae (75.23%) while the next family was Dytiscidae (14.27%). At the annual level, the communities of the two ponds have shown high percent of differences according to SIMPER analysis (70.04).

Regarding the seasonal aspects of the community, by far the greatest impact on community structure at the vicinity of Niš during the spring aspect was shown by Chironomidae (89.96) with negligible presence of Ceratopogonidae (4.41). The difference between samples from the two ponds was not particularly high (45.95%).

During the autumn aspect, the community structure of the pond in vicinity of Niš was mostly

Table 1. SIMPER analysis of five groups of macroinvertebrates divided along the gradient of pond depth

	Group I and II: average dissimilarity=65.08
	Group I and III: average dissimilarity=52.47
	Group I and IV: average dissimilarity=54.29
Group I: average similarity=27.38	**Group I and V:** average dissimilarity=53.07
Group II: average similarity=20.00	**Group II and III:** average dissimilarity=77.01
Group III: average similarity=24.88	**Group II and IV:** average dissimilarity=64.18
Group IV: average similarity=37.91	**Group II and V:** average dissimilarity=63.82
Group V: average similarity=31.58	**Group III and IV:** average dissimilarity=53.87
	Group III and V: average dissimilarity=60.49
	Group IV and V: average dissimilarity=54.64

Family	Av. Abund.	Contrib. %	Cum. %
Group I			
Chironomidae	21	65.22	65.22
Corixidae	4	17.39	82.61
Dytiscidae	9.5	13.04	95.65
Group II			
Dytiscidae	7.5	45.49	45.45
Chironomidae	21	27.27	72.73
Corixidae	4.5	27.27	100
Group III			
Chironomidae	21	66.67	66.67
Elmidae	6.5	18.52	85.19
Ceratopogonidae	4	7.41	92.59
Group IV			
Chironomidae	32.5	86.21	86.21
Dytiscidae	4	13.79	100
Group V			
Chironomidae	23	100	100

determined by families Coenagrionidae (42.43), Tabanidae (20.71) and Caenidae (16.79). On the other hand, the most dominant family in the community at Vlasina Plateau was Chironomidae (50.9), but Elmidae (39.6) were also significant.

For the needs of analysing microdistribution of families, the samples were divided into five groups along the gradient of pond depth. The SIMPER analysis has shown that family Chironomidae is significantly contributing to structuring at all depths. The value was highest in the first sample from the shallowest water (65.22%). In the second group of samples, taken at slightly greater depth, the most dominant family was Dytiscidae (45.45%) while Chironomidae was only second. In the third group, Chironomidae (66.6%) were joined by Elmidae (18.52%), while in the fourth and fifth groups Chironomidae became dominant again (**Tab. 1**).

Discussion

The variation of water temperature across spatio-temporal gradients is one of the key abiotic drivers that shape the distribution, ecology and biology of freshwater macroinvertebrates (Vannote et al., 1980). Latitudinal and altitudinal gradients are recognized as ecological analogues and drivers of environmental gradients, with both being considered proxies of temperature variation (Dos Santos et al., 2018; Rendoll Cárcamo et al., 2019). Several studies have focused on temperature and elevation gradient effects on freshwater macroinvertebrates in Central Europe (Novikmec et al., 2015), South America (Nieto et al., 2016; Shah et al., 2017; Dos Santos et al., 2018) etc. Nevertheless, region of Balkans, have received little attention in this regard. Considering mentioned, here was compared macroinvertebrates community in ponds at different altitudes but with similar other parameters (similar pond size, way of water supply and hydrological regime). In our research greater number of familia was detected in the pond with lower altitude which is in concordance with the claim that different types of diversity are showing a similar pattern with values decreasing as elevation increased (Rendoll Cárcamo et al., 2019). The samples at the pond in vicinity of Niš included representatives of 14 families, while samples from the pond at the Vlasina Plateau included representatives of 8 families. Although inhabited by a smaller number of taxa, ponds at high elevations are a specific type of small waterbodies leading to high regional diversity (Hamerlík et al., 2014; Rendoll Cárcamo et al., 2019). In the studied ponds, the total number of individuals (550 vs. 241) and abundance decreased with increase of altitude, matching the results by Rendoll Cárcamo et al. (2019).

The SIMPER analysis at the annual level has shown that samples from the pond in vicinity of Niš did not show high average similarity (41.46), while the samples from the pond at Vlasina Plateau have shown somewhat higher levels of similarity (58.24). In other words, this fact indicates a more uniform community at high altitude, similar to some similar investigation in other geographic regions (Rendoll Cárcamo et al., 2019).

In both studied ponds, structuring of communities was mostly contributed to by insect groups. In the lower-altitude pond these were Chironomidae and Coenagrionidae, while in the higher-altitude pond Chironomidae and Dytiscidae. The predominance of chironomids is a common pattern in European high altitude stagnant water bodies (Fjellheim et al., 2009). Role of representatives of order Odonata in community structuring is somewhat less commonly observed in ponds (Thornhill et al., 2017). Our study has shown that in most cases the sample of macroinvertebrate community included a greater number of families in autumn than in spring season. There is still an ongoing debate in scientific circles on the best season to sample aquatic macroinvertebrates in ponds for biodiversity assessment, but our results match those from studies in northern Europe where autumn is the most suitable period (Hill et al., 2016).

In both ponds, the greatest number of families was recorded in samples collected in the shallowest part of the pond. One possible reason is the fact that more different microhabitats are situated in this zone than in others. The second possible reason may pertain to development of riparian vegetation. Therefore, conservation of riparian vegetation in both lotic and lentic ecosystems is seemingly crucial as it supports high values of macroinvertebrates diversity (Savić et al., 2022b).

Conclusions

Our results have shown that ponds at higher altitudes were inhabited by a more uniform community of macroinvertebrates. Although hosting a smaller diversity of macroinvertebrate communities than ponds at lower altitudes, the high-altitude ponds significantly contribute to regional diversity and therefore should be given more attention. This study also contributes to the debate on the best season to sample aquatic macroinvertebrates in ponds for biodiversity assessment: it is the autumn aspect. The future research will likely be directed toward studies of a larger number of small waterbodies of this and similar types.

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