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Macroinvertebrate Fauna of Belchishta Wetland, Republic of North Macedonia: Diversity and Conservation Status

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Abstract: This study depicts the results from the extensive monitoring of the invertebrate fauna of Belchishta Wetland, which is the largest preserved wetland in North Macedonia with an area of 137 hectares, including flooded forests and wet habitats. A total of thirty taxa belonging to eight systematic groups were registered, three of them being endemic species. Among the three endemic species, two are on the national list of endangered species. The thirty registered taxa of the invertebrate fauna of Belchishta Wetland point to a pronounced biodiversity, the framework of which includes endemic species with a narrow area of distribution and low abundance. These are justified arguments for the immediate adoption of conservation and protection measures through integral management of the whole Belchishta Wetland.

Key words: Belchishta Wetland, macroinvertebrates, species status, threats, management

Introduction

Wetlands are globally recognised as important habitats for wildlife and human productivity (Horwitz et al. 2012). Wetlands provide numerous ecosystem services including carbon sequestration, water filtration, nutrient retention and flood mitigation (Brander et al. 2013).

Wetland ecosystems rapidly deteriorate due to distinct reasons. The environmental quality gradually declines, and biotic diversity decreases in these habitats. It is estimated that more than 50 % of specific wetland types in Europe, North America, Australia and New Zealand were modified or changed during the twentieth century (Smardon 2015). Anthropogenic activities (urbanization, water and land uses, land cover changes, industrial activity, pollution, climatic change, etc.) have direct and indirect effects on wetlands. Globally, wetlands have declined by 35 % from 1970 to 2015 in areas where data are available (Darrah et al. 2019). Such loss and degradation of wetlands and their ecosystem services is increasingly expressed in global initiatives (e.g., Convention on Biological Diversity Aichi targets, Sustainable Development Goals 6 and 15 and associated targets). The Ramsar Convention (Convention on Wetlands), signed in 1971 and legally effected in 1975, was one of the first modern multilateral environmental agreements advancing protection of wetlands through international collaboration and effective management.

The Belchishta Wetland is one of the largest surviving aquatic habitats of its kind in North Macedonia, covering an area of c. 137 hectares

Fig. 1. Study area and sampling localities in Belchishta Wetland.

with flooded forests and wetlands (Koteski et al. 2017). It is located in the bio-corridor of the brown bear: Debrca – Botun (Stojanov et al. 2010). The Belchishta Wetland is also important as a part of the waterfowl migration corridor. It is considered to host a stable population of otters in its wider area (Micevski & Micevski 2007). It is also specific for the diverse types of wet habitats, especially the flooded fir forest, which covers an area of twenty-three hectares. Less was known whether the wetland represents a significant habitat for the invertebrate fauna, which, besides its important role in the food chains, significantly contributes towards improving and preserving water quality through mineralisation and recycling of organic matters structures and oxygenates the bottom by reworking sediments, recycling nutrients, decomposing organic matter and linking primary production with higher trophic levels (Sarker et al. 2016). Hence, it is used as an indicator for the detection of types and levels of stress in environmental impact studies (Warwick 1993) and since the implementation of the WFD (WFD 2000) became a valuable tool in the assessment of the quality of the water and the health of the aquatic ecosystem (Rosenberg & Resh 1993).

The aim of the present study was to investigate the following three features of the invertebrate fauna: its richness, distribution, and conservation status of the present species.

Materials and Methods

Study area

The Belchishta Wetland is located in the municipality of Debrca between the villages of Novo Selo and Belchishta, about 18.5 km north of Lake Ohrid. The study area included nineteen localities along the main watercourses that flow through the Wetland (BW1, BW2, 16a, 16b); two small springs in the eastern part (BW4 and BW5); the main springs in the north-eastern part (BW8 and BW9), the two main deeper whirlpools on the western part (BW12a-b and BW13a-b) and two whirlpools in the eastern part (BW6 and BW7) and finally, two canals-one with slow running water (BW14 and BW5) and one with stagnant water-BW3 (Fig. 1; Table 1).

At two of the selected sites (BW12 and BW13), the samples were taken along the depth gradient (BW12a-b, BW13a-b) from two depth points due to the existence of hydro-morphological features

Table 1. Sampling localities in the Belchishta Wetland

Site code	Latitude	Longitude	Site code	Latitude	Longitude
BW1	41°18’3.17”N	20°48’38.34”E	BW11	41°19’2.81”N	20°49’7.72”E
BW2	41°18’12.53”N	20°48’42.70”E	BW12a	41°19’3.95”N	20°49’10.78”E
BW3	41°18’30.89”N	20°48’51.45”E	BW12b	41°19’3.95”N	20°49’10.78”E
BW4	41°18’38.96”N	20°48’46.32”E	BW13a	41°19’4.47”N	20°49’13.46”E
BW5	41°18’37.72”N	20°48’51.98”E	BW13b	41°19’4.47”N	20°49’13.46”E
BW6	41°18’47.43”N	20°48’53.28”E	BW14	41°19’2.25”N	20°49’22.30”E
BW7	41°18’51.62”N	20°48’57.40”E	BW15	41°18’56.16”N	20°49’53.46”E
BW8	41°19’6.32”N	20°48’57.67”E	BW16a	41°18’37.73”N	20°49’1.18”E
BW9	41°19’3.80”N	20°49’1.67”E	BW16b	41°18’37.73”N	20°49’1.18”E
BW10	41°19’3.05”N	20°49’4.48”E			

(differences in bottom quality). Two samples were also taken from the locality BW16 to determine the possible anthropogenic impact on the main water artery – River Sateska – by its biggest tributary River Novoselska Reka, which collected the waste waters of the village of Novo Selo. Thus, the samples were taken from River Sateska (BW16a) and at c. 50 m after the inflow of River Novoselska into River Sateska (BW16b).

The study was carried out in the period June 2020 – May 2021. In 2020, the samples were collected during the fall season whereby the spring samples were collected in 2021. Following the nature of the wetland and the presence of several habitat types, a slightly modified multi-habitat method was used during the research of the macroinvertebrate fauna in the Belchishta Wetland. This method (AQEM/STAR 2002) is a combination and adaptation of ISO 8265:1988 (Water Quality – Methods of biological sampling for benthic macro-invertebrates on stony substrata in shallow freshwaters), ISO 9391:1993 (Water Quality – Methods for biological sampling in deep waters for macroinvertebrates) and ISO 7828:1985 (Water Quality – Methods of hand net sampling of aquatic benthic macroinvertebrates). In fact, this methodology for monitoring and sampling applies the techniques of all three standards but respects the proportions of the present microhabitats (bottom substrates) in rivers. A total of 5 microhabitats were included in the methodology: 3 mineral microhabitats, according to Wentworth table (Tolkamp 1982) (cobbles 64–128 mm, medium coarse 4–8 mm and finer sand particles < 1 mm) and 2 biotic micro habitats (rooted submerged and emergent vegetation).

The main appliance was the hydrobiological net with a long handle, a square frame (25 x 25 cm) and a mesh size of 500 μm as well as a set of 3 or 4 screens of varied sizes for sample sieving holes. A white tray was used for an *in-situ* assessment. The samples were taken from a known surface area with a size of one square meter using a metal frame, which enabled determining the qualitative composition of the benthic fauna.

Macroinvertebrates have been identified under Zeiss binocular microscope using the appropriate taxonomic keys (Aubert 1959, Brinkhurst & Jamieson 1971, Lukin 1976, Hynes 1977, Edington & Hidrew 1981, Waringer & Graf 1997, Wallace et al. 2003, Waringer & Graf 2013, Glöer 2015).

Results

Community structure

During the research, a total of thirty taxa belonging to eight systematic groups – Turbellaria, Oligochaeta, Hirudinea, Gastropoda, Bivalvia, Amphipoda, Isopoda and Insecta, were registered. The overall benthic community structure from all sampling localities (BW1-BW16b) is depicted in Table 2.

The diversity was highest in the group of insects where eleven taxa (8 species and 3 genera) were registered. This group accounted for 38 % of the total biodiversity of the benthic fauna of the Wetland (Fig. 2). The second place, according to the species diversity, belonged to the group of snails that participate with 17 percent in the total diversity, followed by: Oligochaeta, Hirudinea, Turbellaria, Amphipoda, Bivalvia, the least represented order Isopoda.

In terms of density (ind/m^2), three species of the thirty taxa present, make up more than three-quarters of the total density registered. Among these three species, the highest density was recorded for the species *Gammarus balcanicus* Schäferna, 1923, and it accounts for 32% of the total density of all species. It is followed by the species *G. roeselii* Gervais, 1835 which participates with 26%, and the species

Table 2. Macrozoobenthos species diversity, density and distribution in the Belchishta Wetland

Systematic Group	Species	Fall 2020 Distribution (Locality-BW)	Spring 2021 Distribution (Locality-BW)
Turbellaria	*Crenobia alpina*Dana, 1766	1; 9	1; 9
	Dendrocoelum lacteum Müller, 1774	10	9; 10
Oligochaeta	*Tubifex tubifex* Müller, 1774	4; 14; 16b	4; 14; 16b
	Eiseniella tetraedra Savigny, 1826	4; 14	4; 14
	*Limnodrilus*sp., Claparède, 1862	5	5
	Lumbriculus variegatus Müller, 1774	5	5
Hirudinea	*Erpobdella octoculata* Linnaeus, 1758	2; 4; 6; 7; 14; 15	2; 4; 6; 7; 14; 15
	Glossiphoni acomplanta Linnaeus, 1758	2; 9	2; 9
	Glossiphonia maculosa Linnaeus, 1758	9	9
Gastropoda	*Orientalina curta kicavica* Radoman, 1973	7	7
	Horatia novoselensis Radoman, 1966	3; 5; 9	3; 5; 9
	Anisus vorticulus Troschel, 1834)	6	-
	Planorbis planorbarius Linnaeus, 1758	7; 12b; 14; 16a	12b; 14; 16a
	Ancylus fluviatilis Müller, 1774	7; 8; 10	7; 8; 10
	Lymnaea stagnalis Linnaeus, 1758	3; 6	3; 6
Bivalvia	*Sphaerium corneum* Linnaeus, 1758	3	3
Amphipoda	*Gammarus roeselii* Gervais, 1835	1; 2; 3; 9; 11; 14; 16a	1; 2; 3; 9; 11; 14; 16a
	Gammarus balcanicus Schäferna, 1923	1-4; 8-10; 11; 12; 12b; 13a; 13b; 14	1-4; 8-10; 11; 12; 12b; 13a; 13b; 14
Isopoda	*Asellus aquaticus* Linnaeus, 1758	3; 4; 5; 6; 7	3; 4; 5; 6; 7
Insecta	*Calopteryx virgo* Linnaeus, 1758	1;12a;12b;16a	1;7;12a;12b;16a
	Calopteryx splendens Harris, 1780	12a	12a
	Calopteryx maculate Beauvois, 1805	2	2
	Sericostoma sp.,Latreille, 1825	6; 8	6; 8
	Limnephillus sp.	1; 5	1; 5
	Nepa cinerea Linnaeus, 1758	1; 13a; 13b	1; 13a; 13b
	Notonecta sp.	7; 16a	7; 16a
	Corixa punctata Illiger, 1807	2	2
	Sialis lutaria Linnaeus, 1758	11; 13a; 14	11; 13a; 14
	Chironomus plumosus Linnaeus, 1758	7; 13b	7; 13b
	Hydrophilus piceus Linnaeus, 1758	8; 10	8; 10

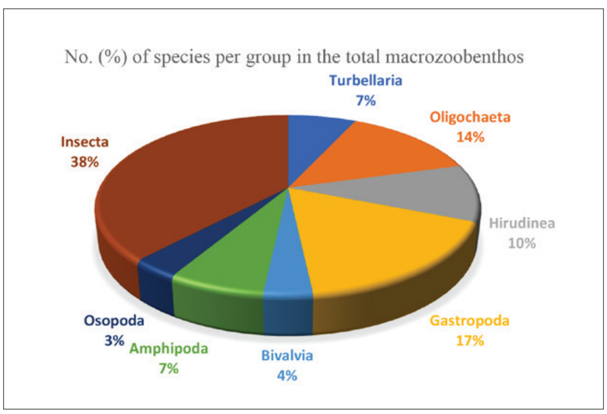

Fig. 2. Species diversity by systematic groups of the macrozoobenthos in Belchishta Wetland.

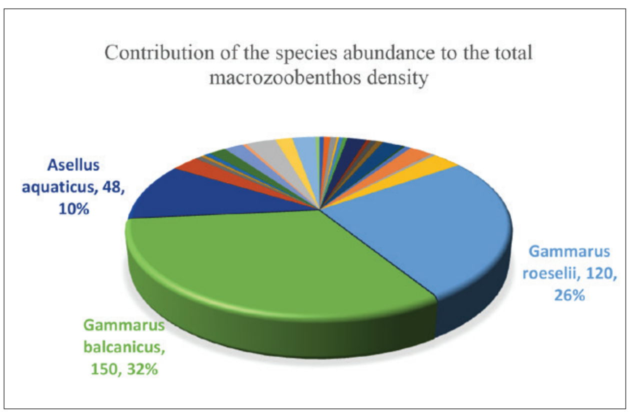

Fig. 3. Species density of the macrozoobenthos in Belchishta Wetland.

Asellus aquaticus Linnaeus, 1758 which accounts for 10%of the total density of all registered species (Fig. 3). The species *E. octoculata* Linnaeus, 1758 and *Calopteryx virgo* Linnaeus, 1758 are present in five localities each, or these two species inhabit 26% of the total territory of the swamp. The other species are considered significantly less abundant, and they inhabit the swamp territory within 5 to 26 percent.

Species spatial distribution

Even though most of the sampling localities are in proximity, (less than 100 m) the local hydro morphological difference, and the presence of microhabitats have contributed to differences regarding the distribution of the macrozoobenthos along the sampling localities.

Thus, localities BW1 and BW2 (Fig. 1) are in the lower reaches of the main water artery which creates the major tributary of Lake Ohrid, the River Sateska. The species diversity in these two localities is identical, i.e., six taxa were registered in each locality. The species composition is different, whereby representatives of the genus *Gammarus* dominate in both localities. Furthermore, the ratio of the species *G. balcanicus* and *G. roeselii* is similar, with the representatives of *G. balcanicus* predominating.

The sites BW3, BW4, BW5 are in the immediate vicinity of the church (BW3), i.e., in the springs in the yard of the church (BW4, BW5). Six species were registered in the locality BW3, where again the ratio of the two amphipod species was in favor of the species *G. balcanicus*. In addition to the amphipod representatives, only one representative of the isopods- *Asellus aquaticus*, was registered in this locality. Among the registered species was the endemic snail *Horatia novoselensis* Radoman, 1966 which is a characteristic endemic to the Belchishta Wetland. Five species were registered in the BW4 site, with two representatives of Oligochaeta, while *Asellus aquaticus* dominates in number, which is also the case with the BW5 site, but qualitatively poorer for one species compared to the BW4 site, despite their proximity. The endemic species of snail *H. novoselensis* was again present in this locality.

Locations BW6 and BW7 are in the whirlpools on the northeastern side of Belchishta Wetland. In the locality BW6 four species of benthic fauna were registered, whereby *A. aquaticus* dominated in number. This is the only site where only one representative of *Anisus vorticulus* Troschel, 1834, the snail listed in Annex II of the European Habitats Directive, was registered. Only in the locality BW7, the endemic species of snail for the Ohrid region (Budzakoska Gjoreska 2012) *Orientalina curta kicevica* Radoman, 1973 was registered. At the same time, this, and the locality BW14 were characterized by the greatest biodiversity, i.e., only in these two localities were registered seven species of benthic fauna.

Locations BW8, BW9 are in the springs themselves (BW8) i.e., downstream at 30-50 m is the locality BW9. In the locality BW8, four representatives of the benthic fauna were registered, and the species *Ancylus fluviatilis* Müller, 1774 slightly dominated over *G. balcanicus*. At site BW9, six species have been registered. The species *G. balcanicus* was by far the most dominant. In this locality, two of the six species present (33%) were endemic: *Horatia novoselensis* and *Glossiphonia maculosa* Linnaeus, 1758.

In the locality BW10 four species were registered and the species *G. balcanicus* makes up almost three-quarters of the total density of the present macrozoobenthos community. The BW11 locality was poor considering diversity. Only three species have been registered, one insect species *Sialis lutaria* Linnaeus, 1758, and the other two are the gammarid forms *G. roeselii* and *G. balcanicus* which are present in almost identical proportions.

Site BW12 is in the big blue whirlpool. Two points along the depth gradient have been explored at this site: BW12a, at a depth of 0.3-0.5 m, and BW12b at a depth of 2 m. The composition of the fauna at the bottom at a depth of 0.3-0.5 m consists of three species of which two are representatives of the class Insecta: *Calopteryx splendens* Harris, 1780 and *Calopteryx virgo* Linnaeus, 1758, while the third species is *G. balcanicus*. At a depth of 2 m, the species composition is again poor and represented by three species, among which *G. balcanicus* significantly dominates.

In the smaller blue whirlpool (BW13), the samples are taken in an identical way. At both depth points, (BW13a and BW13b) three species are registered, with three-quarters of the total density of the species present being the population of the species *G. balcanicus.*

The BW14 site is the second richest site in terms of present diversity. Seven species were registered here, among which the species *G. roeselii* dominates in number with the density of its population. All registered species belong to the group of cosmopolitan species. The site BW15 is one of the two sites characterized by the lowest biodiversity, i.e., sites in which only one species was registered. Only the leech *Erpobdella octoculata* was registered in this locality.

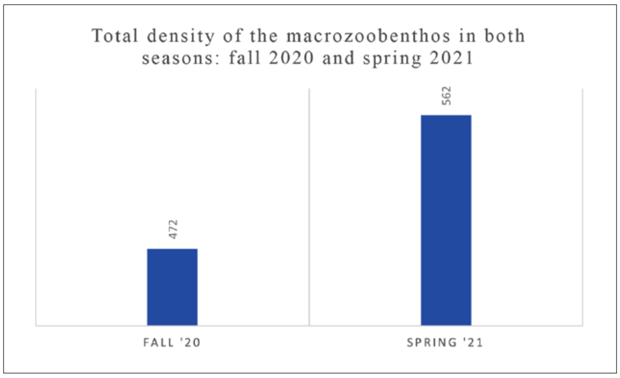

Fig. 4. Seasonal changes in the total density of the macrozoobenthos in Belchishta Wetland.

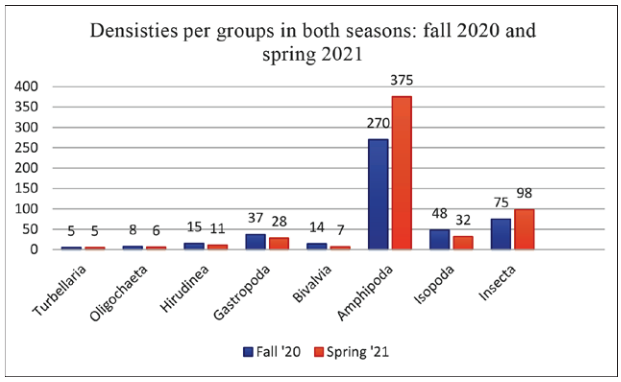

Fig. 5. Seasonal changes in the density of the groups of macrozoobenthos in Belchishta Wetland.

Locations BW16a and BW16b, although close to each other, differ in the composition of benthic fauna. Namely, as mentioned in the initial part, the locality BW16a is located on the main water artery of the Wetland where there were no visible negative anthropogenic influences. The habitat was in its natural state, preserved from any influences, primarily due to the inaccessibility and protection with dense swamp vegetation. Four species were registered in this locality, on a sandy rocky bottom. The population of *G. roeselii* significantly dominates over the other two species.

The location BW16b was located 30 meters downstream from the place of inflow of River Novoselska Reka. At the place of collection, a muddy substrate with a faint odour of decomposing substances of organic origin was noticed, originating from the surrounding arable land, or from the wastewater from the resident households of Novo Selo, because of the non-functionality of the treatment plant located along River Novoselska Reka. Thus, as mentioned above, this site was characterized by the poorest quality composition. Only one species of the Oligochaeta group was recorded in samples from this site, indicating increased trophy and visual presence of organic matter in the water.

By comparing the total densities of the macrozoobenthos in both seasons of sampling (late spring 2021 and fall 2020 there is a clearer picture of the changes in the density which are seasonally triggered. Thus, as shown in Fig. 4, the total density of the macrozoobenthos in all localities is higher in spring than in fall. However, Fig. 5 depicts that no spring increase in the density is recorded for all systematic groups. The most noticeable is the spring increase in the density within the group of Insecta and Amphipoda. The other groups either do not show an increase or even the density decreases (Fig. 5).

There are no significant changes in the temporal distribution of the species during the spring and fall season (Table 2). An exception to this is the species *Anisus vorticulus*, which has not been registered in the samples from spring 2021. Minor changes in the distribution are recorded for *Dendrocoelum lacteum* Müller, 1774 and *Calopteryx virgo*: these two species increased their distribution from one to two localities, respectively in spring 2021, unlike the species *Planorbis planorbarius* Linnaeus, 1758 whose distribution has decreased from four localities in the fall of 2020 to three localities in spring 2021.

Conservation status of the registered species

Table 3 depicts the status of registered species in terms of their importance and conservation status in several international rankings, including status based on national species assessment lists. Out of 30 registered taxa, 10% or three are endemic while the rest are cosmopolitan species (Trajanovski 2005, Trajanovski et al. 2015). Of the three endemic species, two species (*Orientalina curta kicevica* and *Glossiphonia maculosa*) are endemic species for Lake Ohrid and its watershed, while the species *Horatia novoselensis* is an endemic species found only in Belchishta Wetland (Budzakoska Gjoreska 2012). All three species are in the northeastern part of the Wetland, either in the springs or in the big whirlpools. The density of the two endemic snails is still within the boundaries from 1-25 ind./m^2, the same as during the research from 2009-2012 (Budzakoska Gjoreska 2012; Budzakoska et al. 2012). However, table 3 shows that these two snails are on the list of wild (native) species. Due to their narrow distribution area and reduced population density, both species are listed on the national list of endangered species.

Glossiphonia maculosa, although endemic, for now, given its stable population density and wide

Table 3. Conservation status of the macrozoobenthos species in Belchishta Wetland

Name	International			National				
	Hab. Dir. 92/43/EEC	**Bern Conven.**	**IUCN red list**	**Mk/Balk.end.**	**Rare, end. spec.**	**Strictly prot. wild spec.**	**Wild spec.**	**National Red List**
Glossiphonia maculosa Linnaeus, 1758			Not evaluated		*			
Orientalina curta kicavica Radoman, 1973			Not evaluated		*		*	*
Horatia novoselensis Radoman, 1966			Not evaluated		*		*	*
Anisus vorticulus Troschel, 1834	*		NT					
Planorbis planorbarius Linnaeus, 1758			LC					
Ancylus fluviatilis Müller, 1774			LC					
Lymnaea stagnalis Linnaeus, 1758			LC					
Sphaerium corneum Linnaeus, 1758			LC					
Gammarus balcanicus Schäferna, 1923			Not evaluated	*				
Gammarus roeselii Gervais, 1835			LC					
Calopteryx virgo Linnaeus, 1758			LC					
Calopteryx splendens Harris, 1780			LC					
Calopteryx maculate Beauvois, 1805			LC					

distribution area, especially in Lake Ohrid, is not considered endangered.

Among the registered species is the species *Anisus vorticulus*, a snail which according to the categorization of IUCN is in the group of endangered species (NT) (IUCN Red List of Threatened Species 2022, Trajanovski 2005, Trajanovski et al. 2015, Wysocka et al. 2014). Due to the rapid decline in population density in Europe, this species is on the list of species in Annex 2, i.e., a species that is of particular importance to the community and needs urgent protection through the designation of special conservation areas. The fact this species has only been registered during the fall period and in only one locality with only one specimen, points out to the conclusion that it is at the edge of extinction in the Wetland. To protect its survival, it is necessary to include it on the list of endangered species in the national framework, but at the same time it is necessary to determine and implement measures for its immediate protection.

Among these species is the species *Gammarus balcanicus,* a Balkan endemic which is distributed in its central and south-eastern parts (Pljakic 1952). Based on the frequency of encounters and the abundance with which it occurs, this species has not been proposed for evaluation (Trajanovski, 2005, Trajanovski et al. 2015).

Eight species of the thirty registered taxa that have a cosmopolitan character are on the IUCN endangered species list, however, their status is assessed as LC (Least Concerned), i.e., in the group of species for which no protection measures are currently required (IUCN Red List of Threatened Species 2022)

The other species have not yet been evaluated nationally or in Europe or internationally. Among these species is the species *Gammarus roeselii* Gervais, 1835, which in many EU countries has been assessed as an invasive species. As suggested for Lake Ohrid (Trajanovski 2019) this species due to its long-term stable population density and limited distribution in the coastal waters, has been considered native to the Ohrid region (Karaman 1976).

Discussion

In general, according to the number of registered invertebrate taxa, and based on the examined localities, Belchishta Wetland is characterized by medium biodiversity (per unit square) that is at the level of biodiversity of the remaining coastal sources of Lake Ohrid, i.e., the biodiversity that is within the limits of biodiversity as in other wetland ecosystems of the Balkans (Marinković et al. 2021, Zejneli & Dumi 2016, Laušević & Bartula 2016, Pacifici et al. 2018).

The macrozoobenthos community structure is determined by the spatial difference between the complexity of habitats (Shostell & Williams 2007, Tews et al. 2004) The absence of richness of microhabitats is the major reason for the moderate biodiversity of the macrozoobenthos of Belchishta Wetland, unlike Lake Ohrid in which in the vertical profile, could be distinguished over 15 different microhabitats (Trajanovski 2005). Only three mineral habitats and two biotic ones have been identified in the sampling localities in Belchishta Wetland.

Table 2 shows that the species have a different spatial distribution. Both species, which are characterized by the largest abundance from Amphipoda (*G. balcanicus* and *G. roeselii*), also have the largest distribution in Belchishta Wetland. Thus, the species *G. balcanicus is* present in 13 localities or in percentage, this species inhabits 68 percent of the territory of Belchishta Wetland. Next is the species *G. roeselii* which is present in eleven examined localities, or this species inhabits 58% of the swamp territory. Their wide distribution and abundance could be a result of the evolutionary and ecophysiological adaptations for scavenging, opportunistic omnivores feeding on heavily decaying detrital leaves and other fine and coarse organic detritus and grow and survive best on those that have been conditioned by the colonization of microbes and fungi(Glazier 2014).

As explained in the section Results, the highest species richness has been recorded in the locality BW14. Here four microhabitats (out of 5) have been identified, i.e. all the microhabitats except the pebbles. Thus, on the mixture of sandy-muddy bottom and the presence of macrophyte vegetation, seven macroinvertebrate species have been recorded. The presence of the macrophyte vegetation, in this as well as in the other four localities with the highest diversity (BW1, BW2, BW3, and BW9) gives an additional complexity due to its importance for the macrozoobenthos (food, shelter) which represents a key variable determining the total diversity of the community (Trajanovski 2013; Meerhoff et al. 2003). In these localities qualitatively predominates the representatives of the Gastropoda groups thus, sandy silt, and aquatic plants benefit the mollusk growth and reproduction (Harman 1972; Donohue et al. 2003).

Even though class Insecta is the most diverse group out of all eight systematic groups present in Belchishta Wetland, only two taxa are present from the group of EPT (Ephemeroptera, Trichoptera, and Plecoptera) which are indicators of clean and well-oxygenated stream waters (Karr 1991, Rosenberg & Resh 1993). The reason for such a poor EPT community composition could be again, the absence of diverse microhabitats, which could lead directly to a decline in the diversity abundance of these three groups (Beisel et al. 2000, Flecker & Feifarek 1994, Newell et al. 1998).

The nutrient level and sediment sizes directly or indirectly affected the macrozoobenthos community structure (Beisel et al. 2000). In this context, the constant water flow present in all sampling localities in Belchishta Wetland, could influence the permanent replacement of the food resources along the water course, which results in both increased diversity and densities of the present species especially in the sampling points BW1 and BW2.

Regarding the temporal changes in the density of the macrozoobenthic community, the spring increase in the density of the populations is triggered by the increase of temperature, as a primary physical parameter that directly influences the physical and chemical processes in the aquatic ecosystems and the intensity of the basic turnover processes of the energy and the matter (Dodson, 2005). The slight increase in the temperature in spring vs fall, (11°C in spring vs 9°C in fall) could initiate changes in the general physical and chemical features of the wetland thus reflecting itself on the structure and distribution of the benthic communities of the Wetland. It is thought that temperature is one of the key factors affecting both the number of taxa and their density due to its effect on metabolic rate, reproduction, emergence patterns of insects, and body size (Hussain et al. 2012).

However, the increase in the population density of some of the groups such as Calopterigidae, could be related to their ecophysiological adaptation of the food resources in this case the increase of the population of Chironomidae which Calopterigidae praying on (Córdoba-Aguilar 2003).

The protection of the general biodiversity of the Wetland seems inevitable under the increasing pressure and the status of the species assessed throughout this study. Furthermore, losing many principal functions and values, with profound consequences in the form of altered water regime, illegal hunting, significant conflicts over the use of resources, and loss of livelihood opportunities, like the cases in the Mediterranean and the world-affected wetlands (Burcea et al. 2020, Newton et al. 2020, Martínez-Megías & Rico 2022). However, the knowledge base on wetland resources, status, pollution sources and key management issues is limited and there is no adequate policy guidance in Belchishta Wetland.

The threats arising from activities that are connected to agriculture and aquaculture include aspects that are linked with the non-timber forest products collection for commercial purposes and the livestock farming and ranching that is performed in the area. The modifications that come from the anthropogenic influence may result in a negative implication on the ecosystem. In fact, the farmers and the local populations are using the area for different purposes and there are cases when they are modifying the ecosystem due to some needs. The pollution is the most dangerous threat to the wetland as an ecosystem. Since the surrounding areas of the wetland are agricultural areas and that there are settlements and villages along the borders of the wetland, it is evident that there is a huge pressure coming from pollution arising from agricultural activities and households. In fact, the area is famous for more intensive agriculture and not organic, while the villages are lacking treatment facilities for waste waters. Thus, the pesticides and the toxic organic and inorganic substances are easily draining in the soil and through the underground waters are jeopardizing the ecosystem.

The management of the wetland is still very sectoral and does not recognize the multiple functions of the wetlands. Furthermore, the existing experiences for sustainable wetland management in the Municipality of Debrca are not available or used by key stakeholders. Planning for land use and resources in this swamp is limited and plans are rarely practiced. Coordination of field activities in wetlands is too difficult and wetland management skills are insufficient.

Belchishta Wetland ecosystem belongs to the EMERALD network and there has been conducted a Valorisation Study for its proclamation a protected area – a Nature Park. The proclamation is still in procedure and there is no management body dedicated to the wetland, nor there is a Management Plan developed for this area. Nevertheless, the threats and pressures for the Belchishta wetland are numerous but they can be classified into three major groups, i.e., agriculture and aquaculture, natural system modifications, and pollution.

To improve management, we recommend implementing adaptive management frameworks, with stakeholders, targeting measurable indicators responsive to drivers that guide management and track ecological character effectively. This means incorporating social-ecological dynamics (Cilliers et al. 2013), with indicators representing ecological character, tracking ecosystem change (Keith et al. 2013; Bland et al. 2017). With globally available historical data (e.g., palaeoecological, remote sensing), past and future scenario analyses can guide management choices (Kopf et al. 2015) and develop a strategy for ecosystem services management (Zdraveski et al. 2015).

Conclusions

The Belchishta Wetland is one of the naturally best-preserved wetlands in North Macedonia which besides its importance as a corridor for the brown bear and migration corridor of waterfowls, it also represents an important habitat harbouring rich and diverse macrozoobenthic communities. Eight systematic group of the fauna of the macrozoobenthos with 30 taxa have been identified within the Belchishta Wetland with different spatial and temporal distribution. The species status regarding the areal of distribution point to presence of three endemic species for the Ohrid region (one is strict endemic of the Wetland) and one Balkan endemic. Regarding the abundance, distribution, and protection, only one species is listed in the Annex II, whereby the others are either not evaluated or their IUCN status is LC (Least Concern). Two of the species are on the National list of species with limited distribution and measures of protection are needed to ensure their further existence and stable population densities. The following measures are of immediate character to sustain the Wetland and its biodiversity as well as its natural state and functionality:

- Proclamation of the area and its designation of at least Nature Park according to IUCN.

Establishment of Management Body which is going to be responsible for the management of the area.

- Preparation and implementation of adequate strategic documents which will enable sustainable tourism development on one side and the protection of the environment on the other.

- Development of an environmental education programme for local population and stakeholders, stressing the aspects of invasive and alien species and the proper collecting of non-timber forest products.

- Development of monitoring plan within the strategic documents, which will be implemented frequently and establishing of control of the state of the biological and physic-chemical parameters in the wetland.

- Motivation of the local population to transform its agriculture from intensive towards organic through providing of logistical, scientific, and financial support.

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