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Content

Some features of a bird community formed in a small forest clump within Oltenia Plain (South-West of Romania)

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Abstract

The present study aims to analyse the bio-ecological aspects of an interesting bird community with a mixed species composition, developed in a small deciduous forest clump (S ≈ 12,5 ha), located within the Natura 2000 Site Radomir Forest (ROSPA137 Pădurea Radomir), from Romanați Plain (a subunit of Oltenia Plain), the South-West of Romania. The research has been conducted throughout all the ecological seasons since 2014. There are presented the ecological types of bird species, their phenology, the interspecific relationships, and the threat status of birds observed. We have also calculated the frequency index for each species, in order to show the stability or degree of adaptation of birds to the conditions of this forest ecosystem, which is quite exposed to the actions of the human factor. The ornithological significance of the site under discussion is conferred by the colonies of species of European conservation interest such as *Falco vespertinus, Egretta garzetta*, *Nycticorax nycticorax*. In the taxonomic structure of the analysed bird community, there are also other important species, such as *Coracias garrulus, Lanius collurio, L. minor, Dendrocopos* sp., which were the basis for the inclusion of this area in a special avifauna protection area of the Natura 2000 network.

Keywords: bird community, forest, ROSPA137 Pădurea Radomir, Oltenia Plain.

Introduction

The forest we investigated is included in the Natura 2000 site ROSPA0137 Pădurea Radomir, located within Romanați Plain (a subunit of Oltenia Plain / Romanian Plain), in the South-West of Romania - Fig. 1. From the phyto-geographic point of view, it is part of the forest steppe area (Doniță et al., 1992).

Although it has a small surface (12.5 ha), the considered deciduous forest is an important biotic component of the ROSPA0137 Pădurea Radomir, certifying that even in a reduced natural area there can coexist bird communities counting many species of conservative interest, which fall under protection legislation (Papp & Fântână, 2008; Ridiche et al. 2014a). The entire Avifauna Special Protection Area (SPA) has a surface of 1,233 ha covering several types of biotopes (terrestrial and

aquatic); it conserves 39 species of wild birds, most of them being migratory species protected by the EC Birds Directive, transposed in our country by the Emergency Government Ordinance 57/2007 (G. D. No. 971/2011).

The site ROSPA0137 Pădurea Radomir presents certain geomorphological, hydrographic and ecological features that give it a certain uniqueness in the landscape of the plain ecosystems characteristic to southwestern Romania. It is crossed by two erosional valleys (Eleşteului Valley and Bratei Valley); there appear ponds with a fluctuating level supplied by rainfall and groundwater. In the periods with heavy rainfalls, the accumulated water lasts for a long time and generates habitats for both vertebrate and invertebrate species. At the eastern end of the site, the two valleys communicate in an accumulation called Drăghiceni pool or lake. The aquatic and semi-aquatic biotopes cover about 70 ha of the SPA, but the largest areas of the site are represented by arable land (960.73 ha), mostly cultivated with cereals, sunflower and / or rape.

Pastures also represent a biotope with significant areas (183.85 ha), which, together with cultivated land, provide feeding and nesting places for many bird species that breed within the SPA or just pass through the site (http://www.mmediu.ro/app/webroot/uploads/files/2015-08-25_Plan_management_ROSPA0137_Padurea_Radomir.pdf; Ridiche et al. 2014a).

The forests of ROSPA0137 Pădurea Radomir cover a modest area (about 20 ha). They are represented by several relatively young plantations of acacia - *Robinia pseudacacia* and a mixture of native trees (*Quercus, Fraxinus*, etc.), spontaneous but also planted. In the present study, we aim to highlight the avifauna of the forest ecosystem made up of mixed native trees. The ornithological significance of this ecosystem is conferred by the mixed colonies of species of European conservative interest such as *Egretta garzetta, Nycticorax nycticorax*, *Falco vespertinus* and other important species (*Coracias garrulus, Lanius collurio, L. minor*, etc.), which represented the basis of the inclusion of this area in the special protection area ROSPA0137 Pădurea Radomir, respectively in the network of Natura2000 sites.

Materials and methods

The study incorporates the results of our own observations made during all the ecological seasons from January 2014 to the present.

The forest area under discussion includes a sector with spontaneous and old trees (represented mainly by *Quercus robur* and *Q. pedunculiflora*, among which there appear rare specimens of *Fraxinus* sp., *Populus* sp., *Ulmus* sp. and shrubs such as *Crataegus monogyna, Rosa canina*, etc.), a sector with young trees, made up of *Quercus* sp. and *Fraxinus* sp., and a sector with planted *Robinia pseudacacia* - Fig. 2.

The aquatic and terrestrial habitats adjacent to this mixed forest have also been monitored as they provide the trophic resources for the bird communities from the forest habitat.

In the field, we used different devices – binoculars (Zeiss Jena 10x50 and Bushnell 12x40), Philip's illustrated identification manual (Delin & Svensson, 2016) and a camera (Canon SX50 HS). Observations were made on predetermined transects or in fixed locations (near the nesting or feeding places of birds).

The taxonomic list of birds was compiled according to Hagemeijer & Blair (1997).

Figure 1. Perimeter of Nature 2000 site ROSPA0137 Pădurea Radomir (www.padurearadomir.ro, Ridiche et al. 2014a).

Figure 2. Mixed deciduous forest from the Natura2000 site ROSPA0137 Pădurea Radomir.

We considered the ecological types of the bird species, phenology, breeding issues, interspecific relations, and the threat status of birds observed. We also calculated the frequency index for each species, in order to show the stability or degree of adaptation of birds to the conditions of this forest ecosystem, which is quite exposed to the actions of the human factor. The frequency computation formula is as follows: F% = p x 100 / P, where p = the number of observations when the

species was recorded and P = the total number of observations (Gomoiu & Skolka, 2001). Based on this relationship, there results the following four groups of species: accidental species - with a frequency between 1% and 25% of the total number of observations; rare species - with a frequency ranging from 25.1% to 50% of the total number of observations; constant species - with a frequency ranging from 50.1% to 75% of the total number of observations; euconstant species (very common) - with a frequency ranging from 75.1% to 100% of the total number of observations.

Results and discussions

In Table 1, we synthesized the main bio-ecological characteristics of the bird communities inhabiting, on the one hand, the sector with mixed native species (*Querqus* sp., *Fraxinus* sp. and others) and, on the other hand, the plantation of *Robinia pseudacacia* (non-native and invasive species) from the forest area under study. The qualitative and quantitative differences between the bird communities formed here are obvious.

Table 1. Bio-ecological characteristics of the bird species identified in the mixed deciduous forest ROSPA0137 Pădurea Radomir.

No.	Species	Ecological type	Phenology	Recorded / estimated number of pairs (p.)		Threat status Romania	Threat status Europe
				Querqus sp. sector	*Robinia pseudoacacia* sector		
1	*Nycticorax nycticorax*	A	SV	15-20 p.	-	V	D
2	*Egretta garzetta*	A	SV	20-25 p.	-	E	S
3	*Ardea cinerea*	A	SV	8-10 p.	-	-	S
4	*Falco tinnunculus*	T	R	1-2 p.	5-7 p.	-	D
5	*Falco vespertinus*	T	SV	10-12 p.	-	V	V
6	*Phasianus colchicus*	T	R	x	x	-	S
7	*Columba palumbus*	T	PM	6-8 p.	4-6 p.	-	S
8	*Streptopelia decaocto*	T	R	x	x	-	(S)
9	*Streptopelia turtur*	T	SV	x	x	V	D
10	*Cuculus canorus*	T	SV	x	x	-	D
11	*Asio otus*	T	R	-	x	-	S
12	*Coracias garrulus*	T	SV	1-2 p.	-	-	(D)
13	*Upupa epops*	T	SV	1 p.	x	V	S
14	*Dendrocopos major*	T	R	1 p.?	-	-	S
15	*Turdus merula*	T	PM	x	x	-	S
16	*Sylvia atricapilla*	T	SV	x	x	-	S
17	*Sylvia communis*	T	SV	x	-	-	S
18	*Phylloscopus trochilus*	T	P	-	x	-	S
19	*Parus major*	T	R	x	x	-	S
20	*Oriolus oriolus*	T	SV	x	x	-	S
21	*Lanius excubitor*	T	WV	x	x	-	D
22	*Lanius minor*	T	SV	x	1-2 p.(?)	-	(D)
23	*Garullus glandarius*	T	R	x	-	-	(S)
24	*Pica pica*	T	R	x	≥ 10 p.	-	S

25	*Corvus monedula*	T	R	+ 7 p.	-	-	(S)
26	*Corvus frugilegus*	T	R	150-200 p.	-	-	S
27	*Corvus cornix*	T	R	-	x	-	S
28	*Sturnus vulgaris*	T	PM	x	-	-	S
29	*Passer hispaniolensis*	T	SV	x	-	-	(S)
30	*Passer montanus*	T	R	x	x	-	S
31	*Emberiza calandra*	T	SV	x	x	-	(S)

Legend: Ecological type: A – aquatic; T - terrestrial. Phenology: R – resident; PM – partially migratory; SV – summer visitors; WV – winter visitors; P – passage visitors. Threat status: E – Endangered, V – Vulnerable, D – Declining, S – Secure, () – provisional status.

It is easy to notice that, compared to the acacia plantation which is populated by a small community of common breeding bird species (*Falco tinnunculus, Streptopelia decaocto, Columba palumbus, Pica pica*, etc.), the forest sector with native tree species (*Querqus* sp., *Fraxinus* sp., etc.) is populated by a more diverse and valuable bird community from the faunistic and conservative point of view. In this area, there nest both terrestrial arboreal species, specific to the natural forest ecosystem (*Falco* sp., *Columba palumbus, Coracias garrulus, Upupa epops, Corvus* sp., etc.) and typical aquatic species (*Nycticorax nycticorax, Egretta garzetta, Ardea cinerea*). Both categories of bird species mainly feed on the neighbouring habitats: agricultural lands and meadows provide the necessary trophic resources (insects and other invertebrates, rodents, etc.) especially for the terrestrial species, while the pools along the valleys provide trophic resources (small fish, amphibians, reptiles, etc.) for the aquatic species.

From the phenological point of view, in the forest with native trees, there predominate species that are summer visitors, while in the forest of *Robinia pseudacacia* the dominance of the sedentary species is evident.

From a faunistic point of view, the Ardeidae and Falconidae species are important components in the analyzed bird community. Their presence is well observed starting with the first half of April, when prenuptial manifestations begin, as well as cohabitation efforts with the other species that also have nests in this small forest clump. It is well known that Ardeidae species nest in mixed colonies (with other storks, glossy ibises or cormorants) or in monospecific, colonies located in reedbeds or in tree vegetation near rivers or within wetlands (Onea, 2015; ***, 2015), but cohabitation with non-aquatic species is less common, giving some uniqueness to the bird community that we refer to in this study.

Ardea cinerea is present in the second part of March; the colony is generally small (8-10 pairs), but stable, installed in the tall trees of *Populus alba*.

Nycticorax nycticorax and *Egretta garzetta* usually arrive in the first days of April, and their flocks are unstable from one year to the next. In 2014, these two species had their nests installed in old *Querqus* trees and were relatively equal as number (8-10 p. / 10-12 p.), but, starting with 2015, both species extended the colony in the young trees of *Querqus* and *Fraxinus* so that their flocks grew in number of specimens and the quantitative ratio changed (Ridiche, 2016). In the last 3 years, as the colony moved entirely in the young plantation of *Querqus* sp. and *Fraxinus* sp., we have determined increased mortality among youngsters in both *N. nycticorax* and *E. garzetta*, due to the fact that the size of the newly built nests is smaller and their quality is more precarious and the chickens become vulnerable during violent storms in summer.

The rook (*Corvus frugillegus*) has a significant colony (over 300 nests), mostly located in the tall and old trees from the mixed *Querqus* forest, being the most numerous of the species that make up the bird community under discussion.

The Red-footed Falcon (*Falco vespertinus*), a species of special faunistic interest, stands out both numerically (10-12 p.) and behaviorally, during the pre-nesting period (when it makes efforts to occupy the nests left empty in the *Corvus* colony) or during the reproduction period (beginning in the second half of May or the first decade in June). *Falco tinnunculus* also enters the competition for the empty *Corvus* nests in mid-April, but it populates mainly the acacia plantation where it occupies the nests of *Pica pica*.

A nesting species well represented in both the mixed forest and the plantation of acacia (*Robinia pseudacacia*) is the common wood pigeon (*Columba palumbus*), which has two or more series of chickens, usually nesting in the early days of April.

The list of species reported also includes birds sporadically observed and in small numbers, such as *Streptopelia turtur, Oriolus oriolus, Lanius excubitor, Passer hispaniolensis*, etc., for which we have no clues regarding nesting in the studied area. *Lanius minor,* although rarely observed, has offered us some clues (e.g. territorial behavior) that it could nest at the limit of the plantation of *Robinia pseudacacia.*

As it can be seen in Table 1, some of the bird species under discussion have an unfavourable national (Munteanu, 2005) or European (Hagemeijer & Blair, 1997) conservation status, which is why they have priority for conservation. All the measures necessary to ensure the most appropriate living conditions for these species are included in the management plan of ROSPA0137 Pădurea Radomir (http://www.mmediu.ro/app/webroot/uploads/files/2015-08-25_Plan_management_ROSPA0137_Padurea_Radomir.pdf).

The studied forest is very exposed to anthropogenic actions (Ridiche et al., 2014b); therefore, depending on their vital needs, some of the bird species have developed adaptive strategies and have established a constant relationship with this environment, but others have occasional or sporadic connections. This is reflected in the frequency categories listed in Tables 2 and 3 and in the distribution graph (Fig. 3) resulting from the values of the ecological frequency index calculated for each species identified in the two types of forest sectors.

Table 2. Frequency categories of the bird species identified in the *Querqus* sp. sector of ROSPA0137 Pădurea Radomir.

No.	Euconstant species (EC)	Constant species (C)	Rare species (R)	Accidental species (Acc)
1.	*Falco tinnunculus*	*Phasianus colchicus*	*Streptopelia decaocto*	*Streptopelia turtur*
2.	*Columba palumbus*	*Nycticorax nycticorax*	*Cuculus canorus*	*Turdus merula*
3.	*Parus major*	*Egretta garzetta*	*Sylvia communis*	*Sylvia atricapilla*
4.	*Pica pica*	*Ardea cinerea*	*Oriolus oriolus*	*Lanius excubitor*
5.	*Garullus glandarius*	*Falco vespertinus*	*Lanius minor*	*Emberiza calandra*
6.	*Corvus monedula*	*Coracias garrulus*	*Passer hispaniolensis*	
7.	*Corvus frugilegus*	*Upupa epops*		
8.	*Sturnus vulgaris*	*Dendrocopos major*		
9.	*Passer montanus*			

Table 3. Frequency categories of the bird species identified in the *Robinia pseudacacia* sector of ROSPA0137 Pădurea Radomir.

No.	Euconstant species (EC)	Constant species (C)	Rare species (R)	Accidental species (Acc)
1.	*Columba palumbus*	*Falco tinnunculus*	*Cuculus canorus*	*Streptopelia turtur*
2.	*Streptopelia decaocto*	*Phasianus colchicus*	*Upupa epops*	*Asio otus*
3.	*Parus major*	*Corvus cornix*	*Oriolus oriolus*	*Turdus merula*
4.	*Pica pica*		*Lanius minor*	*Phylloscopus trochilus*
5.	*Passer montanus*			*Sylvia atricapilla*
6.				*Lanius excubitor*
7.				*Emberiza calandra*

From the analysis of the above tables and diagram we can notice that in the mixed forest with native trees, there prevail the euconstant and constant species, which allows us to appreciate that this type of habitat is more functional and stable, ensuring a continuity of optimum living conditions, especially breeding, for the species in the analyzed bird community.
In case of the acacia forest, there predominate birds of the accidental species category, which have an occasional connection with this type of habitat; in the category of very frequent species (euconstant), there are mainly common, anthropophilic birds, which reflects the existence of unfavourable or less favourable conditions for other bird species except for those that are accustomed with the presence of the anthropogenic factor.

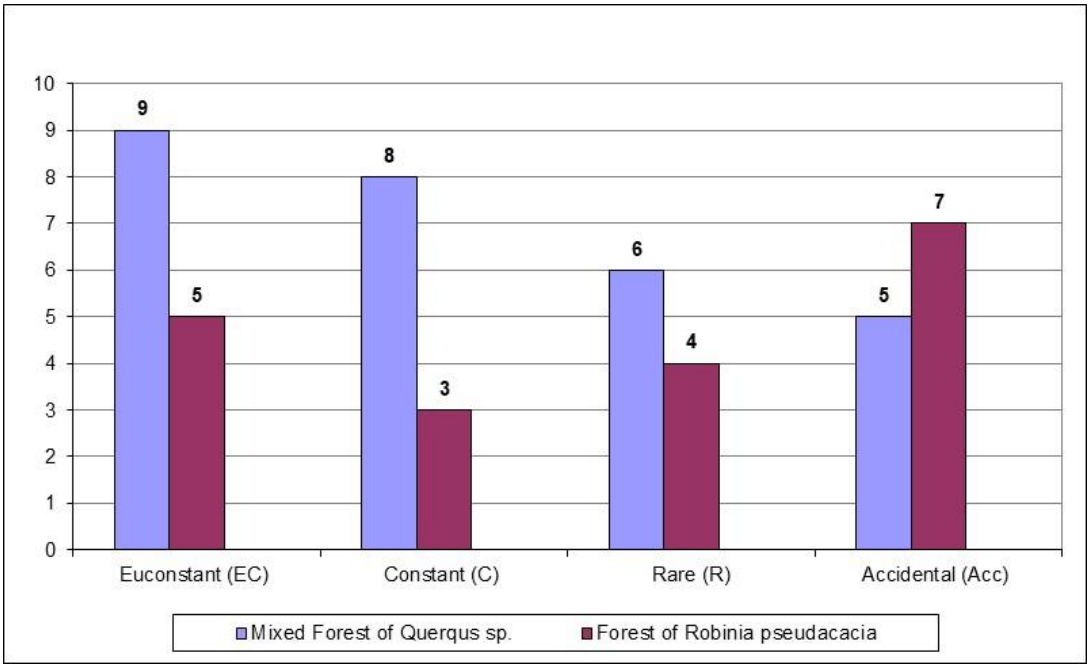

Figure 3. Graphical distribution of the frequency groups of the observed bird species.

Conclusions

The observations made by us from 2014 until now in a small forest clump with deciduous species located within the Natura 2000 site ROSPA0137 Pădurea Radomir

(Romanați Plain / Oltenia Plain, South-West of Romania) help us formulate the following conclusions:

- There are obvious qualitative and quantitative differences between the bird communities inhabiting the sector with native tree species (*Querqus* sp., *Fraxinus* sp. and others), on the one hand, and, on the other hand, the plantation of *Robinia pseudacacia* (non-native and invasive species); the acacia plantation is populated by a small community of nesting birds, consisting mainly of common species (*Falco tinnunculus, Streptopelia decaocto, Columba palumbus, Pica pica*) and rare, small, non-breeding species (*Parus* sp., *Lanius* sp, *Emberiza* sp., etc. present especially at the forest margin), while the sector with native species is populated by a more diversified and valuable faunistic and conservative bird community (*Nycticorax nycticorax, Egretta garzetta, Ardea cinerea, Falco vespertinus F. tinnunculus, Columba palumbus, Coracias garrulus, Lanius* sp., *Corvus* sp., etc.).
- In order to benefit from the trophic resources and nesting sites available in the area, there developed a cohabitation relationship between the aquatic (*Nycticorax nycticorax, Egretta garzetta, Ardea cinerea*) and non-aquatic species (*Falco* sp., *Corvus* sp.) nesting in these colonies, situation that give a certain degree of uniqueness to the bird community referred to in this study.
- From the analysis of the frequency values, we can notice that euconstant and constant species predominate in the mixed forest sector with native trees, which enables us to appreciate that this type of habitat is more functional and stable, providing better living conditions (especially breeding conditions) for the analyzed bird community.
- In the acacia forest, there predominate birds belonging to the category of accidental species, which have an occasional connection with this type of habitat; in the category of very common species (euconstant), there are mainly common, anthropophilic birds, which reflect the existence of unfavorable or less favourable conditions to other bird species, except for those accustomed to presence of the anthropogenic factor.

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Dynamic of birds' fauna on three reservoirs from Barlad River basin (Romania)

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Abstract

We present the results of one medium-term monitoring study on the birds' fauna from the perimeter of three reservoirs in the Barlad River basin: Puscasi, Rapa Albastra and Cuibul Vulturilor. The field study has developed in two periods: in 2006 – 2012 years, respectively, during the 2018 – 2019 years enabling us to evaluate the bird's fauna diversity and to assess the trends of bird populations in the area. No previous ornithological data related to these reservoirs are available before our study. We recorded 145 bird species with different presence status on the investigated reservoirs due the different suitable habitats and anthropogenic influences. The reservoir Cuibul Vulturilor shelters the most important breeding effectives, while the reservoirs Rapa Albastra and Puscasi are more relevant during the migration time. Usual, all the reservoirs are freezing no later than December and not represent wintering areas for waterfowls. The list includes 29 bird species from the Romanian Red Book of Vertebrates.

Keywords: birds, presence, trends, reservoirs, Barlad River

Introduction

Barlad River basin is part of the Siret River Basin, rising from the Moldavian Central Plateau. The total length is about 207 kilometres and present a drainage basin about 7220 km^2, being the most important left tributary of Siret River. The climate is temperate continental. The summers are hot and dry, while the winters are frosty and, usual, dry. In the late spring and early summer, the rainfalls appear to be torrential, especially in the upper sector of basin.

There are some important reservoirs created along ones tributaries of Barlad River in order to control the flooding phenomenon or to create sources of water for localities and fisheries. The most important reservoirs are Puscasi (on Racova River), Solesti (on Vaslui River), Rapa Albastra (on Simila River), Cuibul Vulturilor (on Tutova River) and Piscu Morii (on Pereschev River). We did the present study on the territory of three reservoirs from the right side of Barlad River basin: Puscasi, Rapa Albastra and Cuibul Vulturilor.

The reservoir Puscasi has a surface about 296 hectares; compact reed beds and humid meadows are present in the tail's area and a meadow forest along the valley of Racova River in this sector, while the southern slope of lake is covered by grasslands with scattered bushes and shrubs, small orchards and vineyards.

The reservoir Rapa Albastra covers about 245 ha; the paludous vegetation includes especially large sedges (*Carex sp*., *Scirpus sp*., *Schoenoplectus sp*. etc.) and bulrush (*Typha sp*.), while the reed beds appear on the valley of Simila River forming a large swampy area before the entry in the reservoir. Grasslands with shrubs and

vineyards, respectively, one young deciduous forest cover the slopes of reservoirs in it northern sector, while the dam is on the territory of Simila village.

The reservoir Cuibul Vulturilor is the largest one in the Barlad River basin – 593 ha. The reed beds cover large and compact surface in the tail of the lake, while agricultural lands and some grasslands with shrubs are present on its slopes. Pogana village is located near the tail of reservoir.

The oldest data on the bird fauna from the territory of Vaslui County are about 45 years (Papadopol, 1975), regarding especially wetlands from the Prut River basin. For the Barlad River basin, the ornithological studies are just two, with preliminary aspects on the bird fauna's diversity and seasonal dynamic in the perimeter of Piscu Morii Lake (Gache & Müller, 2010), respectively, on the Valley of Racova River (Gache & Ignat, 2015).

Figure 1. Location of the investigated reservoirs in the Barlad River Basin (Romania)

Material and Methods

We did the field monitoring in two stages, with different period of study for the three investigated reservoirs (figure 1), using the direct observation along transects and

from fixed points to identify the birds, while as counting methods we used the bands and fixed point counting, but also the recording of males' calling activity's.

In the perimeter of Puscasi reservoir, we collected ornithological data starting from 2006 until 2014, respectively, from May 2018 until April 2019, using two transects along the northern and southern banks, including the meadow forest along the Racova Valley before the entry of river into the reservoir.

On the territory of Rapa Albastra reservoir, we did our study starting from 2009 until 2012, respectively, from May 2018 until April 2019, using one transect along the eastern bank. The last transect followed the eastern bank of reservoir Cuibul Vulturilor and we did the field activity starting from 2006 until 2012, respectively, from May 2018 until April 2019.

We used two pairs of field binoculars (Olympus 8-16x40 and Nikon Aculon 8 - 24) and two field-spotting scopes (Hakuba 35x70 and Swarovski 20-60x) to identify and count the birds.

Results

During our study, we recorded 145 bird species on the perimeter and in the proximity of the three investigated reservoirs from the basin of Barlad River (table 1). The bird fauna's diversity is unequal from one reservoir to another: Puscasi reservoir shelters the highest diversity (122 bird species), and on the each of the other two reservoirs, there we met 106 bird species.

The breeding bird fauna is rich as diversity (84 regular and irregular breeding species), but the populations are small-sized for the most species and present constant or negative trends in the area. We notice the significant populations, about tens breeding pairs on the territory of the studied lakes, for some typically aquatic and semi-aquatic bird species as the terns (especially, *Chlidonias hybrida*), gulls (*Larus cachinnans* and *Chroicocephalus ridibundus*), grebes (*Podiceps cristatus* and *Podiceps nigricollis*), waders (especially, *Vanellus vanellus*) and ducks (*Anas platyrhynchos* and *Aythya ferina*). We met, also, breeding populations about up to ten pairs for another bird species that present negative trends in Romania as *Mareca strepera* or *Chlidonias niger*.

All these reservoirs represent significant stopover points for the waterfowls and wader bird species along their migration routes in Eastern Romania. During the spring and autumn passages, the diversity of birds presents the highest value around the year: 120 species. Various bird species can find suitable resting habitats to rest for one or more days, and different feeding resources, providing food to refuel before resuming their migration towards the southern wintering areas. The duck species are dominant, with flocks about hundreds to thousands individuals, while the geese, gulls and waders appear in groups of tens to hundreds individuals during the spring and autumn passages. Between the duck species, we notice the significant migratory populations of species as *Anas platyrhynchos* (up to 1900 individuals during the autumn migration, respectively, 2100 individuals in the spring passage) *Anas crecca* and *Anas querquedula* (flocks about 700 – 800 individuals) *Mareca penelope* and *Aythya ferina* (up to 320 – 480 individuals). The geese species (*Anser anser* and *Anser albifrons*) are crossing the area with flocks about 25 – 120 individuals. From the group of the wader species, we counted flocks about up to 320 - 800 individuals only for the lapwing (*Vanellus vanellus*), common snipe (*Gallinago gallinago*) and ruff

(*Calidris pugnax*), while the redshanks (*Tringa totanus* and *Tringa erythropus*) were present with flocks up to 160 – 230 individuals.

During the wintering time, 45 species formed the bird fauna of the three studied reservoirs, most of them being resident species, especially passerine ones, but some raptor bird species (*Buteo lagopus*, *Falco peregrinus* and *Falco columbarius*) and waterfowls (swans, geese and duck species) were present in the area, too. We observed only two duck species (*Anas platyrhynchos* and *Anas crecca*) with wintering populations about 1300 - 2200 individuals.

During the period of our study, we observed negative trends for the populations of 32 bird species, and positive trends for other 11 ones, but most species have constant presences in the investigated territories. We notice that some species with negative trends are bird species recorded only during the first part of our study and in the perimeter of Cuibul Vulturilor reservoir: *Mergus serrator* (one male, 15th March 2012), *Mergellus albellus* (one pair, 20th March 2011), *Plegadis falcinellus* (2 individuals, 28th April 2011), and *Haematopus ostralegus* (one individual, in August 2011 and 2012). We met the osprey (*Pandion haliaetus*) only once: one individual, in the perimeter of Rapa Albastra Lake on the 11th September 2011.

We identified 29 bird species protected through the Romanian Red Book of Vertebrates (Botnariuc & Tatole, 2005) on the territory of Puscasi, Rapa Albastra and Cuibul Vulturilor reservoirs: two critically endangered species (*Tadorna ferruginea* and *Haliaeetus albicilla*), nine endangered species (only five species typically for the wetland ecosystems) and 18 vulnerable species. We met the Ruddy Shelduck only once, during the spring migration on the marshes area from the tail of Cuibul Vulturilor reservoir (one male, 22nd April 2019), while the White-tailed Eagle was present during the wintering time and in spring passage, only in the same perimeter. We notice the breeding presence of the egrets (*Egretta garzetta* and *Ardea alba*), respectively, Purple Heron (*Ardea purpurea*) and Raven (*Corvus corax*) between the endangered species, another being recorded as wintering visitors (*Falco peregrinus*) or as passage bird species (*Platalea leucorodia*, *Hieraaetus pennatus*, *Circus pygargus* and *Himantopus himantopus*). Three of these protected species (purple heron, spoonbill and peregrine falcon) present negative trends and only one species (black-winged stilt) has positive trends in the investigated territory. Most of the vulnerable bird species appear only during the migration time in the perimeter of Barlad River basin, and nine of these species present negative trends in this region of Romania.

Discussion

In an ornithological approach, the breeding bird fauna represents the most relevant element to analyse the ecological quality of a territory. The suitable habitats for the birds' nesting are different in the study areas, varying from the compact reed beds to the meadow forests. The vegetation has a mosaic aspect on the territory and near the Puscasi reservoir, sheltering 77 breeding bird species. The birds can occupy to nest the reed beds with osier shrubs that cover the tail of the lake, the grasslands with shrubs, small orchards and vineyards from the southern slope, respectively, the wet meadow and the meadow forest along the Racova River before the entry in the reservoir's area. We notice the breeding species in this lake's perimeter of the corncrake (*Crex crex*) and ortolan bunting (*Emberiza hortulana*) that present negative trends in the investigated territory (Gache & Ignat, 2015). The populations

from the mixed breeding colony, formed by grebes (*Podiceps cristatus*, *Podiceps nigricollis* and *Tachybaptus ruficollis*) and terns (*Chlidonias hybrida* and *Chlidonias niger*), present high oscillations from one year to other and we could not identify the reason of this dynamic.

We recorded the lowest diversity of breeding bird fauna in the perimeter of reservoir Cuibul Vulturilor – only 58 species, but the noticeable breeding presences of herons, egrets and grebes are significant for the lower anthropogenic influence in this territory situated in the proximity of a village. We identified 67 breeding bird species on the territory of Rapa Albastra reservoir, but the difference appears especially from the presence of some passerine species typically for the woodlands and grasslands. During the first part of our study, we found the biggest mixed breeding colony on the territory of this reservoir, in the northern edge of it. In June 2011, we counted about 170 pairs of whiskered tern (*Chlidonias hybrida*), 25 pairs of crested grebe (*Podiceps cristatus*), 7 pairs of black-necked grebe (*Podiceps nigricollis*), one pair of red-necked grebe (*Podiceps grisegena*), nine pairs of little grebe (*Tachybaptus ruficollis*), 30 pairs of coot (*Fulica atra*) and seven pairs of ferruginous duck (*Aythya nyroca*). This colony disappeared due to the loss of suitable habitats through secondary ecological succession in the area.

For the migration time, we notice only the increasing of swans' populations from about 38 – 40 individuals to 60 – 65 individuals of *Cygnus olor*, respectively, from 1 - 3 up to 6 – 8 individuals of *Cygnus cygnus*. We mention, also, the vagrant appearance of the species *Cygnus columbianus* (one individual inside one group of 6 Whooper Swans, 2nd March 2019, on the edge area of Puscasi Lake). The reservoirs froze completely in middle December during the last two winters (2017-2018 and 2018-2019), so, the waterfowls were not present as wintering visitors in the area.

Some common bird species as *Perdix perdix*, *Coturnix coturnix*, *Vanellus vanellus* or *Charadrius dubius* present significant negative trends in the investigated territory. We assess that the agricultural practices, but also, the longer and frosty winters represent the reasons for this dynamic in the area.

The reservoirs Puscasi, Cuibul Vulturilor and Rapa Albastra has no protection status. The significant risk factors for the birds' presence on the territory and proximity of these three reservoirs are the loss of suitable habitats, especially, wetlands ones, and the activity of local communities. In the context of the global climate changes, the summers are hot and dryness, so, the marshes areas from the tail of these reservoirs were completely dry in the middle July, while the winters become frosty, and the water of the lakes freezes in the early December, and not in the late January as ten years ago. We notice the extension of the reed beds in the perimeters from the edges areas of the reservoirs Puscasi and Cuibul Vulturilor, and the loss of humid meadows by the secondary ecological succession on the marsh surfaces for the all investigated lakes. The agriculture, grazing and fishing represent the main activities of the local communities in this territory. The fishing activity is uncontrolled, and we recorded the highest influence of it in the perimeter of Puscasi Reservoir. We assess that the disappearance of the breeding colonies (terns, gulls and grebes) in the area was due to the traffic of numerous fishing boats on the surface of this lake. The grazing activity has no significant direct impact, but the big number of the dogs present around the herds of sheep and goats is responsible to decreasing of breeding populations of the bird species that build their nest inside the herbs, on the ground.

Table 1. Bird species from some reservoirs in the Barlad River Basin: presence, trends and protection status

No.	Species	Presence			Trends	Romanian Red Book of Vertebrates
		Cuibul Vulturilor	Rapa Albastra	Puscasi		
1.	Phasianus colchicus	-	-	B, M, W	0	-
2.	Perdix perdix	-	B, M, W	B, M, W	-1	-
3.	Coturnix coturnix	-	-	B, M	-1	-
4.	Cygnus olor	M, W	B, M, W	M, W	0	-
5.	Cygnus cygnus	M, W	-	M, W	+1	-
6.	Cygnus columbianus	-	-	M, W	+1	-
7.	Anser anser	M, W	-	-	-1	-
8.	Anser albifrons	-	M, W	-	+1	-
9.	Anas platyrhynchos	B, M, W	B, M, W	B, M, W	0	-
10.	Anas acuta	M	M, W	M	+1	-
11.	Anas crecca	M, W	M, W	M, W	0	-
12.	Anas querquedula	B, M	B, M	B, M	0	-
13.	Mareca strepera	B, M	B, M	B, M	0	-
14.	Mareca penelope	M, W	M, W	M	-1	-
15.	Spathula clypeata	M	M	M	0	-
16.	Tadorna tadorna	M, W	-	M	0	V
17.	Tadorna ferruginea	-	M	-	0	CE
18.	Aythya fuligula	-	M, W	M	0	-
19.	Aythya nyroca	B, M	B, M	M	0	V
20.	Aythya ferina	B, M, W	B, M, W	B, M, W	0	-
21.	Bucephala clangula	M	M	M, W	0	V
22.	Mergus merganser	-	-	M	-1	-
23.	Mergus serrator	M	-	-	-1	-
24.	Mergellus albellus	M	-	-	-1	V
25.	Gavia arctica	M, W	M	-	0	-
26.	Phalacrocorax carbo	M, W	M, W	M	0	-
27.	Microcarbo pygmeus	-	M	-	-1	V
28.	Botaurus stellaris	B, M	B, M	-	-1	-
29.	Ixobrychus minutus	B, M	-	-	+1	-
30.	Nycticorax nycticorax	B, M	B, M	B, M	0	V
31.	Ardeola ralloides	-	-	B, M	-1	V
32.	Egretta garzetta	B, M	B, M	B, M	0	En
33.	Ardea alba	B, M	B, M	M	0	En
34.	Ardea cinerea	B, M	B, M	B, M	0	-
35.	Ardea purpurea	B, M	M	-	-1	En
36.	Plegadis falcinellus	M	-	-	-1	V
37.	Platalea leucorodia	M	-	-	-1	En
38.	Ciconia ciconia	B, M	B, M	B, M	0	V
39.	Ciconia nigra	-	M	M	-1	V
40.	Haliaeetus albicilla	-	M	-	0	CE
41.	Clanga pomarina	-	-	M	0	V
42.	Hieraaetus pennatus	-	-	M	0	En
43.	Buteo buteo	M, W	M, W	M, W	0	-
44.	Buteo lagopus	W	W	W	+1	-
45.	Pernis apivorus	-	-	M	0	V
46.	Accipiter gentilis	W	-	W	0	-
47.	Accipiter nisus	-	-	W	0	-
48.	Circus aeruginosus	B, M	M	M	0	-
49.	Circus pygargus	-	-	M	0	En
50.	Circus cyaneus	-	M	M	0	-
51.	Pandion haliaetus	-	M	-	-1	V
52.	Falco peregrinus	-	-	W	-1	En
53.	Falco columbarius	-	-	W	0	-

54.	Falco subbuteo	M	M	B, M	0	-
55.	Falco tinnunculus	M	M	B, M	0	-
56.	Grus grus	M	-	-	-1	V
57.	Rallus aquaticus	M	-	-	-1	-
58.	Crex crex	-	-	B, M	-1	V
59.	Gallinula chloropus	B, M	-	B, M	0	-
60.	Fulica atra	B, M	B, M	B, M, W	0	-
61.	Gallinago gallinago	M	M	M	0	-
62.	Lymnocryptes minimus	M	-	M	0	-
63.	Calidris pugnax	M	M	M	+1	-
64.	Calidris alpina	M	M	-	0	-
65.	Numenius arquata	-	-	M	-1	-
66.	Limosa limosa	M	-	M	0	-
67.	Actitis hypoleucos	M	-	M	0	-
68.	Tringa ochropus	M	M	M	0	-
69.	Tringa glareola	M	-	M	0	-
70.	Tringa nebularia	M	M	M	+1	-
71.	Tringa stagnatilis	M	M	-	0	-
72.	Tringa totanus	M	M	M	0	-
73.	Tringa erythropus	M	M	M	0	-
74.	Vanllus vanellus	B, M	B, M	B, M	0	-
75.	Charadrius hiaticula	M	-	-	-1	-
76.	Charadrius dubius	-	B, M	B, M	-1	-
77.	Pluvialis squatarola	M	-	-	-1	-
78.	Haematopus ostralegus	M	-	-	-1	V
79.	Himantopus himantopus	M	M	M	+1	En
80.	Larus fuscus	M	M	-	0	-
81.	Larus cachinnans	B, M, W	B, M, W	B, M, W	0	-
82.	Hydrocoloeus minutus	-	-	M	-1	-
83.	Chroicocephalus ridibundus	B, M, W	B, M, W	B, M, W	0	-
84.	Chlidonias niger	-	M	B, M	-1	-
85.	Chlidonias hybrida	B, M	B, M	B, M	-1	-
86.	Chlidonias leucopterus	-	M	-	-1	-
87.	Sterna hirundo	M	M	B, M	-1	-
88.	Podiceps cristatus	B, M	B, M	B, M	+1	
89.	Podiceps grisegena	M	B, M	M	0	-
90.	Podiceps nigricollis	B, M	B, M	B, M	+1	-
91.	Tachybaptus ruficollis	M	B, M	B, M	-1	-
92.	Columba palumbus	M	M	B, M	0	-
93.	Streptopelia decaocto	B, W	B, W	B, W	0	-
94.	Streptopelia turtur	M	M	B, M	0	V
95.	Cuculus canorus	B, M	B, M	B, M	0	-
96.	Athene noctua	B, W	-	B, W	0	-
97.	Alcedo atthis	B, M	-	-	-1	-
98.	Merops apiaster	B, M	B, M	B, M	0	-
99.	Upupa epops	-	B, M	B, M	0	V
100.	Dendrocopos major	B, W	B, W	B, W	0	-
101.	Dendrocopos syriacus	B, W	B, W	B, W	0	-
102.	Lanius collurio	-	B, M	B, M	0	-
103.	Lanius minor	B, M	B, M	B, M	0	-
104.	Lanius excubitor	W	W	W	0	-
105.	Pica pica	B, W	B, W	B, W	0	-
106.	Garrulus glandarius	-	B, W	B, W	0	-
107.	Corvus monedula	B, W	B, W	B, W	0	-
108.	Corvus frugilegus	B, W	B, W	B, W	0	-
109.	Corvus cornix	B, W	B, W	B, W	0	-
110.	Corvus corax	W	W	W	0	En
111.	Poecile palustris	-	-	B, W	0	-
112.	Parus major	B, W	B, W	B, W	0	-

113.	Cyanistes coeruleus	B, W	B, W	B, W	0	-
114.	Galerida cristata	B, W	B, W	B, W	0	-
115.	Alauda arvensis	B, M	B, M	B, M	0	-
116.	Riparia riparia	B, M	B, M	B, M	0	-
117.	Hirundo rustica	B, M	B, M	B, M	0	-
118.	Delichon urbicum	B, M	B, M	B, M	0	-
119.	Locustella luscinioides	B, M	B, M	B, M	0	-
120.	Acrocephalus scirpaceus	B, M	B, M	B, M	0	-
121.	Acrocephalus schoenobaenus	B, M	B, M	B, M	0	-
122.	Acrocephalus arundinaceus	B, M	B, M	B, M	0	-
123.	Sylvia communis	B, M	B, M	B, M	0	-
124.	Sylvia curruca	B, M	B, M	B, M	0	-
125.	Certhia familiaris	-	-	B, W	0	-
126.	Ficedula parva	B, M	B, M	B, M	0	-
127.	Luscinia megarhynchos	-	B, M	B, M	0	-
128.	Saxicola rubetra	-	B, M	B, M	0	-
129.	Saxicola torquata	M	B, M	B, M	0	-
130.	Oenanthe oenanthe	-	B, M	B, M	0	-
131.	Turdus merula	-	B, M	B, M	0	-
132.	Turdus pilaris	W	M, W	M, W	0	-
133.	Turdus philomelos	-	B, M	B, M	0	-
134.	Sturnus vulgaris	B, M	B, M	B, M	0	-
135.	Passer domesticus	B, W	B, W	B, W	0	-
136.	Passer montanus	B, W	B, W	B, W	0	-
137.	Anthus campestris	B, M	B, M	B, M	0	-
138.	Motacilla flava	B, M	B, M	B, M	0	-
139.	Motacilla alba	B, M	B, M	B, M	0	-
140.	Fringilla coelebs	-	B, M, W	B, M, W	0	-
141.	Chloris chloris	B, M	B, M	B, M	0	-
142.	Carduelis carduelis	B, M	B, M	B, M	0	-
143.	Emberiza calandra	B, M	B, M	B, M	0	-
144.	Emberiza hortulana	-	-	B, M	-1	-
145.	Emberiza schoeniclus	B, M, W	B, M, W	B, M, W	0	-

Legend
Presence: B – breeding season, M – migration time, W – wintering time; Romanian Red Book: CE – critically endangered species, En – endangered species, V – vulnerable species.

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Assess the risks for the air traffic safety due the wetland bird species around Iasi International Airport (Romania)

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Abstract

We did our field study from March 2017 until June 2018, following to evaluate the bird's fauna diversity in the perimeter of five reservoirs along Ciric River valley and another one on Chirita Rivulet from vicinity of Iasi International Airport, but also to assess the potential risks for the air traffic safety due to the birds' movement. The list of bird's fauna includes 106 species with unequal presence as populations and phenology activity on the investigated reservoirs. During the breeding time, the biggest risks for the air traffic safety is due to the raptors that use the surrounding open lands as feeding territories, but also the doves and passerines that use to form large and medium flocks during the post-reproductive period. We recorded significant passage populations for species representing high risk for air traffic safety as *Ciconia ciconia*, raptors (*Clanga clanga*, *Clanga pomarina*, *Pernis apivorus*, *Buteo buteo*, *Buteo lagopus*, *Milvus migrans*, *Falco subbuteo* and *Falco tinnunculus*), ducks (*Anas sp*. and *Aythya sp*.), gulls and terns (*Larus cachinnans*, *Chroicocephalus ridibundus* and *Chlidonias hybrida*).

Keywords: birds, reservoirs, airport, air traffic safety

Introduction

Iasi International Airport is located in the north-eastern side of Iasi city at 8 kilometres distance from the city central area, on the plateau above Ciric forest. The altitude is about 180 metres. It is one of the oldest accredited airports in Romania, first demonstrative sport flights being organised in 1905, while the first commercial flights began in 1926. The airport was destroyed during the World Second War and restored just in 1966. During the last decade, the administration upgraded the airport's runways and facilities to allow the increasing volume of domestic and international flights.

The Ciric forest covers a surface about 250 hectares and represents the western border of the airport, the access road crossing the forest and the complex of Ciric reservoirs. Five reservoirs were created on the Ciric River in this area: Dorobant (70 ha), Aroneanu (23 ha), Ciric II (11.3 ha), Ciric I (10.7) and Ciric III, named also Venetia (7 ha). Chirita reservoir is located on the confluence area of Chirita and Sapte Oameni rivulets, in the south-eastern side of the airport and has a surface about 78 ha. The distances from the airport's perimeter to the neighbourhood wetlands are about 2.55 – 5 km to the reservoirs Dorobant, Aroneanu and Chirita, respectively, 0.9 – 1.35 km to the complex Ciric I – III.

The suitable habitats for birds in this territory are woodlands, open aquatic surfaces, compact reed beds (in the northern edges for the all six reservoirs, but also one large area along Ciric River in the sector between Ciric I and Ciric III reservoirs), grasslands with scattered shrubs and clusters of trees, cultivated lands (cereals, sunflower, orchards and vineyards).

Despite the long history of the collisions between birds and aircraft during the flight, in Romania, we have official reports just beginning from the 2010 year. The Romanian Civil Aviation Safety Investigation and Analyses Authority reported 1246 incidents due to the bird' strikes during the period of the years 2010 – 2017. For the public and experts, it is still difficult to obtain certain data about this topic. There are just very few studies related to the birds' presence and risks for the air traffic safety in Romania (Petrescu, 2002; Ridiche & Munteanu, 2015; Ridiche *et al*. 2016).

Material and Methods

We did our field study starting from March 2017 until June 2018, following especially the bird's fauna present on the wetlands surrounding the airport's territory on the western and south-eastern sides. Each of the investigated six reservoirs represented one stationery and we visited its monthly during the winter, respectively, twice per month during the migration period and in the breeding season. We did ornithological census along transects and two – four fixed points at each stationery on the eastern banks of reservoirs Dorobant – Aroneanu, respectively, on the western bank of the complex Ciric I – III. For the Chirita reservoir we used two transects with several fixed points along the eastern and western banks. The birds' recording was visually and auditory, too.

We used two pairs of field binoculars (Olympus 8-16x40 and Nikon Aculon 8 - 24) and a field spotting scope (Swarovski 20-60x) to identify and count the birds.

Results

We recorded 106 bird species during our study, but we focus our analysis on 80 birds species, mostly related to the wetland habitats, including the aquatic surfaces and surrounding open lands (table 1), following to assess the risks generated to the air traffic safety by the movements of the birds in these areas from the vicinity of Iasi International Airport. The other present bird species are woodland typically species that are not going far away from the forest edges to search food resources, mostly flying low (no higher than tens metres). We included in our analysis some of this group species due to their movements outside of the forest's perimeter and gregarious behaviour during the migration (for example, *Turdus pilaris* and *Sturnus vulgaris*) or wintering time (*Fringilla coelebs*, *Fringilla montifringilla*, *Spinus spinus* and *Carduelis carduelis*).

The presence of the analysed 80 bird species is different from a wetland to another. The Chirita reservoir presented the higher diversity of bird' fauna, with 61 species. On the northern reservoirs, Dorobant – Aroneanu, we recorded 55 species and in the perimeter of the complex Ciric, we observed 45 bird species.

In the wetlands' perimeter, the diversity and the population of breeding bird species present low values. The suitable habitats cover small surfaces and the

anthropogenic influence is high on all the investigated reservoirs. We notice that the breeding presence of some species is not related to the habitats from reservoirs' perimeters, but the birds use its territories and the adjacent open lands as a feeding territory (*Ciconia ciconia*, *Falco subbuteo*, *Falco tinnunculus*, *Apus apus*, *Merops apiaster*, *Upupa epops*, *Hirundo rustica* or *Delichon urbicum*).

Table 1. Birds recorded on wetlands and open lands from vicinity of Iasi International Airports: presence and estimated risk for air traffic safety.

No	Species	Dorobant-Aroneanu	Ciric I - III	Chirita	Risk for air traffic
1.	*Cygnus olor*	M	M, W	M, B, W	X, XXX
2.	*Anser anser*	-	-	M	X, XXX
3.	*Anas platyrhynchos*	M	M, B	M, B, W	X, XXX
4.	*Anas crecca*	M	-	M, W	XX
5.	*Anas querquedula*	-	-	M	XX
6.	*Mareca strepera*	-	-	M	X
7.	*Mareca penelope*	-	-	M	X, XXX
8.	*Spathula clypeata*	M	-	M	X
9.	*Aythya fuligula*	-	-	M	X, XXX
10.	*Aythya ferina*	-	-	M	X, XXX
11.	*Gavia arctica*	-	M	M	X
12.	*Ixobrychus minutus*	B	B	B	-
13.	*Nycticorax nycticorax*	B	B	B	X
14.	*Egretta garzetta*	M, B	-	-	X
15.	*Ardea alba*	M	M	-	X
16.	*Ardea cinerea*	M, W	M, B	-	X
17.	*Plegadis falcinellus*	M	-	-	X
18.	*Ciconia ciconia*	M	M	M, B	X, XXX
19.	*Clanga clanga*	M	-	-	X
20.	*Clanga pomarina*	M	-	-	X
21.	*Circaetus gallicus*	M	-	M	X
22.	*Buteo buteo*	M, B, W	M, B, W	M, W	X
23.	*Buteo lagopus*	M	-	-	X
24.	*Pernis apivorus*	M	M	M	X
25.	*Accipiter gentilis*	M, W	M, W	M, W	X
26.	*Accipiter nisus*	W	-	W	X
27.	*Milvus migrans*	-	-	M	X
28.	*Circus aeruginosus*	M, B	-	M, B	X
29.	*Falco columbarius*	W	-	-	X
30.	*Falco vespertinus*	-	-	M	X
31.	*Falco subbuteo*	-	M, B	M, B	X
32.	*Falco tinnunculus*	-	M, B	M, B	X
33.	*Crex crex*	-	B	-	-
34.	*Fulica atra*	M, B	-	M, B	-
35.	*Gallinula chloropus*	B	B	B	-
36.	*Gallinago gallinago*	M	-	-	XX
37.	*Tringa glareola*	M	-	-	XX
38.	*Vanellus vanellus*	M	-	-	XX
39.	*Charadrius dubius*	M	-	-	XX
40.	*Larus fuscus*	-	-	M, W	X, XXX
41.	*Larus cachinnans*	M, W	M, W	M, B, W	X, XXX
42.	*Chroicocephalus ridibundus*	M	M	M, B	X, XXX
43.	*Chlidonias hybrida*	M, B	-	M	XX
44.	*Sterna hirundo*	M, B	-	M	XX
45.	*Podiceps cristatus*	M	-	M, B, W	-
46.	*Columba livia domestica*	M, B, W	-	-	X, XXX

47.	*Columba palumbus*	-	M, B	-	X, XXX
48.	*Streptopelia turtur*	M	M, B	-	X
49.	*Streptopelia decaocto*	B, W	B, W	B, W	X, XXX
50.	*Cuculus canorus*	-	B	B	-
51.	*Apus apus*	-	M, B	M	XX
52.	*Merops apiaster*	M, B	M, B	M, B	-
53.	*Alcedo atthis*	B	B	-	-
54.	*Upupa epops*	-	B	M, B	-
55.	*Lanius collurio*	M, B	-	M, B	-
56.	*Lanius minor*	M, B	-	M, B	-
57.	*Lanius excubitor*	-	-	W	-
58.	*Pica pica*	B, W	B, W	B, W	X
59.	*Corvus monedula*	W	B, W	W	XX
60.	*Corvus frugilegus*	B, W	B, W	B, W	XXX
61.	*Corvus cornix*	-	B, W	W	X
62.	*Corvus corax*	-	B, W	W	X
63.	*Alauda arvensis*	-	-	M, B	-
64.	*Galerida cristata*	-	-	M, B, W	-
65.	*Hirundo rustica*	M, B	M, B	M, B	XX
66.	*Delichon urbicum*	M, B	M, B	M, B	XX
67.	*Riparia riparia*	M	-	M	-
68.	*Locustella luscinioides*	-	M	M	-
69.	*Acrocephalus arundinaceus*	M, B	M, B	M, B	-
70.	*Acrocephalus scirpaceus*	M, B	M, B	M, B	-
71.	*Turdus pilaris*	W	W	-	XX
72.	*Sturnus vulgaris*	M, B	M, B	M, B	XX
73.	*Passer domesticus*	B, W	B, W	B, W	XX
74.	*Passer montanus*	B, W	B, W	B, W	XX
75.	*Motacilla alba*	M, B	M, B	M, B	-
76.	*Motacilla flava*	M, B	M, B	M, B	-
77.	*Fringilla coelebs*	B, W	B, W	-	XX
78.	*Fringilla montifringilla*	-	W	W	XX
79.	*Spinus spinus*	M, W	M, W	M, W	XX
80.	*Carduelis carduelis*	W	B, W	W	XX

Legend
Presence: M – migration time, B – breeding period, W – wintering time; Risk for air traffic: X – large/medium-sized birds flying solitary or in small groups (< 10 individuals); XX – small/medium-sized birds flying in medium/large flocks (tens – hundreds individuals); XXX – large/medium sized birds flying in medium/large flocks (tens – hundreds individuals).

During the migration time, we recorded 59 bird species, some of them with tens or hundreds of individuals (ducks, storks, gulls, swallows, martins and starlings). We can consider the valley of Ciric River as a flyway at least for the diurnal raptors, storks and gulls, while Chirita reservoir is significant for the migration of ducks, raptors and gulls. In March - April, we recorded groups of 26 – 32 individuals of raptors species (*Clanga clanga*, *Clanga pomarina*, *Buteo buteo*, *Buteo lagopus*, *Pernis apivorus*, *Accipiter gentilis* and *Falco tinnunculus*), crossing the area per one fixed point near the reservoirs Dorobant-Aroneanu, respectively, Chirita. In August – September, in the same fixed points, we observed "waves" of 18 – 21 individuals representing the species as *Buteo buteo*, *Circaetus gallicus*, *Milvus migrans*, *Falco vespertinus*, *Falco subbuteo* and *Falco tinnunculus*. In the morning of 23 August 2017, we surprised the migration of white storks (*Ciconia ciconia*) over Ciric Valley, groups of about 92 – 135 birds soaring in the perimeter of the reservoir Dorobant and glide starting from the limit of the reservoir Aroneanu - complex Ciric over the forest. During about 25 minutes, we counted 657 individuals split in six flocks coming from the north and

north-eastern directions to glide in the south-eastern direction. For the ducks, we recorded the larger size populations during the autumn migration, especially on the perimeter of the Chirita reservoir (about 700 individuals of *Anas platyrhynchos*, *Anas crecca* and *Aythya ferina* on the 17th November 2017). We observed the passage of gulls starting from September until early December, in flocks about tens to 488 individuals of *Larus cachinnans* over Ciric Valley, respectively, 282 – 560 individuals of *Chroicocephalus ridibundus* and 820 – 1600 individuals of *Larus cachinnans* in the perimeter of Chirita Valley.

In April and August – September, the small passerines *Hirundo rustica*, *Delichon urbicum* and *Riparia riparia* are crossing the area; we counted groups about 80 – 350 individuals for each of the six investigated reservoirs. The starling (*Sturnus vulgaris*) was present with flocks reuniting 130 – 800 individuals in the perimeter Dorobant - Aroneanu, respectively, about 210 – 1900 individuals in the area of the reservoir Chirita, during August – October months.

In the wetlands' area, the wintering bird fauna reunited 26 species, the aquatic bird species being present just in November, early December and February because the reservoirs freeze during the last decade of December.

Discussion

There are previous ornithological studies in the area but focused on the birds from the Ciric forest (Gache, 2004; Croitoru, 2009). The only old data regarding the aquatic and wetlands bird's fauna in the area included just the perimeter of complex Ciric I – III and Chirita reservoir (Gache, 2002). Despite the history of about one century of flight in this perimeter and recent development of the airport, there it is not any study regarding the birds' presence and potential risks of collision with the aircraft.

In the early age of aircraft's flight, the collision risk with birds was lower due the noisy and slowly flight, but the modern turbine-powered aircraft are more quiet and fast. Nowadays, the collision of the aircraft with birds and other wildlife can occur more frequently and the damages can be very high in the structural and engine failure but especially in the loss of human lives. During the last decades, numerous experts approach the topic of bird' strikes and air traffic safety (Thorpe, 1999; Knauer *et al*. 2000). The large airports around the world have and environmental team that survey, evaluate and manage the presence of birds and other wildlife on the territory and near the airport. More recently, the biologists began to study changes in physiology and behaviour of birds induced by noisy of the aircraft's landing and take-off (Wolfenden, 2017).

The bird species that have a corporal mass greater than 1.8 kilograms exceed the international standards related to airframe and engine certification in wildlife strikes incidents (Cleary & Dolbeer, 2005). The majority of the recorded species of waterfowls, gulls, herons, storks and diurnal raptors in the wetlands and open lands' perimeter from the neighbourhood of the Iasi International Airport present this category of corporal mass and fly highly. Moreover, some of them use to form large flocks during the winter period and in the migration time, too (geese, ducks, storks and gulls), increasing the risks of serious damages if strikes incidents appear.

The soaring birds (*Ciconia ciconia*, diurnal raptors and especially *Larus cachinnans* from the gulls' group) represent potential risks for the air traffic safety when the aircraft flying at 500 – 2000 m height, including during their solitary flight

because these bird species use soaring and flying highly. In the same category of risk, we include some typical wetland species recorded during our study as breeding species in the area (*Cygnus olor*, *Anas platyrhynchos*, *Ardea cinerea* or *Circus aeruginosus*) or as passage species (*Anser anser*, *Mareca penelope*, *Aythya ferina* and *Aythya fuligula*, but also the small-sized ducks as *Anas crecca* and *Anas querquedula*).

During our field activity, we could observe the landing approach of aircraft over the valley of Ciric River at very low high (600 – 800 m) only about 20 minutes before an significant passage of the white storks (*Ciconia ciconia*). We found a similar situation related to the planes that take-off through the area where hundreds gulls were soaring and gliding above the Chirita Valley, respectively, 3 – 6 common kestrels (*Falco tinnunculus*) and 1 – 3 hobbies (*Falco subbuteo*) occupy their hunting territories on the large grasslands and cultivated lands from the western side of the Chirita reservoir. The common kestrel is breeding in the clusters of trees from the south-western limit of Chirita reservoir and, probably, also in old trees from the territory of one former military unit, near the Iasi Sportive Airfields located on the western side of Chirita Valley, while the hobby is breeding on the high buildings from adjacent Tatarasi district. We notice that the common kestrel soar and use the warm airwaves, touching heights about 1800 m.

Some medium and small-sized bird species that we recorded in the study area present risk of collision with landing or taking off aircraft through their gregarious life and manner of flight. For example, the doves (Columbidae) present a rapid flight in very dense flocks. The swallows and martins (Hirundinidae) fly by changing very often the direction of movement, forming large flocks during the migration. At the end of the breeding season but, especially, during the migration period, the starlings (Sturnidae) can form huge flocks, reuniting hundreds to thousands of individuals, flying rapidly and changing continuously the direction, but also the aspect of flocks.

During our field activity along the sector of Dorobant-Aroneanu reservoirs, we met several times large flocks of domestic doves (*Columba livia domestica*) – up to 37 individuals. During the migration time, we recorded similar flocks reuniting up to 18 – 32 common wood pigeons (*Columba palumbus*) in the same perimeter. For the starlings (*Sturnus vulgaris*) and rooks (*Corvus frugilegus*), we observed large flocks on the territories of the reservoirs Aroneanu - Dorobant, but also in the adjacent open lands area of the Chirita reservoir. Moreover, the rooks are present there around the year especially on the western side territory of the Chirita Valley due to the proximity of a former military unit where the birds are forming a very large breeding colony.

During the wintering time, even small passerines can present a risk of collision with aircraft, especially on the airports' territories. Some species as *Turdus pilaris*, *Fringilla coelebs*, *Fringilla montifringilla*, *Spinus spinus* and *Carduelis carduelis* form monospecific or mixed flocks and leave the woodland searching food (seed and fruits) in the open lands with shrubs and clusters of trees. We met this kind of flocks, but we assess that they cannot represent risks for the air traffic in the study area because use to fly under 100 m height.

The air travel has become a commonplace around the world, but the birds are still using the skies and it is necessary to manage better the internal perimeters and the surroundings areas of airports to limit the action of suitable factors that can attract the birds. For example, it is very important to eliminate the shrubs and briers from the airport neighbourhood (resenting suitable nesting and feeding habitats for different bird species), but also to limit the perimeters covered by herbaceous vegetation that attract mice and, finally, the raptor bird species. In some specific

sites, we cannot - even it is not desirable - change completely the landscape to increase the air traffic safety, but the airports' managers can change the timetable of flights and can find better solutions for the directions of landing or taking off to limit the collision risks with birds.

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Actual status of rare and protected bird species in the basin of Siret River (Romania)

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Abstract

We present the actual status of the rare and protected birds identified on the territory of Romanian basin of Siret River in the context of large national debates about the impact of Nature 2000's network on the regional economic development and hostile position of some authorities representatives regarding the bird' species conservation issues. Our field monitoring on birds' fauna began in the summer of 1991 and is still ongoing, covering the territory of five from the seven Nature 2000 sites designated in the area. We identified 219 bird species in the investigated basin of Siret River. From these, 72 species have one or double protection status through the Birds' Directive (63 species in Annex 1) or Romanian Red Book (43 species); we give data about their presence and distribution in the area, populations, and trends. We notice strong negative trends for some bird species during the last about three decades due to the anthropogenic impact, loss of the wetland's surfaces and climate changes.

Keywords: bird species, presence, status, trends, Siret River

Introduction

Siret River rises from Ukrainian Carpathians, its valley being located on the eastern edge of Carpathians and is one the most important tributary of the Danube River in the proximity of the Danube Delta. With a total length of 647 kilometres (km), about 96% from its hydrological basin is situated on the Romania territory. Here, it receives the waters of 70 from all its 73 tributaries, the most important of them coming from the Carpathians area and giving a high risk of flooding phenomenon, especially in the late spring and during the first part of the summer. Numerous technical arrangements have been implement to control the flooding risks in the area during the 20th century, resulting in some large and very large reservoirs in the Valley of Siret River and its tributaries.

On the Romanian territory of Siret River basin, from the north to the south, there were designated seven Nature 2000 sites: ROSPA0110 Reservoirs Rogojesti-Bucecea, ROSPA0064 Falticeni Lakes, ROSPA0125 Reservoirs Vaduri-Pangarati, ROSPA0072 Middle Siret Meadow, ROSPA0063 Buhusi-Bacau-Beresti, ROSPA0071 Lower Siret Meadow and ROSPA0077 Maxineni Lake. All of them had former status of Important Birds Areas in Romania, designated by the Romanian Ornithological Society (SOR/Birdlife Romania) and were regular monitored from the early '90s (Papp & Fantana, 2008). Most of them present ornithological relevance especially during the migration and wintering time, Siret Valley representing one very important flyway in eastern Romania, but there are some important areas for the birds' breeding season, too.

The vegetation forms a mosaic of habitats: rivers and large open water surfaces, marshes and compact reed beds, meadows with willows and poplars, islands and gravel areas. The adjacent perimeters can be covered by deciduous forests (especially, in the middle sector of the basin, as near the ROSPA0063 Buhusi-Bacau-Beresti) and mixed forest (in the mountain sector, for example ROSPA0125 Reservoirs Vaduri-Pangarati).

The climate is temperate continental. In the southern sector, the summers are dry and hot, while the winters are dry and frosty. In the middle sector of Siret River basin, the rainfalls can be torrential, producing huge flooding phenomenon, especially in May and June; the winter is quiet cold but with high snowfalls. The climate is mild in the mountain sector, where the lakes are freezing just rarely, but the snowfalls can present high levels.

Despite the ornithological importance of the area, the number of studies on the birds' fauna from this territory is not great, most of them being related to the middle sector (Feneru, 2002; Rang, 2002; Müller *et al*. 2005; Gache, 2012, respectively, 2018) and to the mountain sector of Bistrita River (Papadopol, 1963; Munteanu & Maties, 1983; Munteanu, 2000; Cozma & Gache, 2008). To the lower sector of the basin, there are just some pointed studies (Gache, 1994; Arcan & Gache, 2008, respectively, 2010; Dragomir *et al*. 2016, respectively, 2018).

Material and Methods

We did ornithological surveys and regular monitoring activities on the territory of five from the seven Nature 2000 sites (figure 1). We did not visit the ROSPA0110 Reservoirs Rogojesti-Bucecea and the ROSPA0077 Maxineni Lake.

During the whole period of study, we used the transect observation method and different suitable counting methods for each group of bird species (fixed points of counting, bands counting, circle counting or night counting), establishing the stations and transects during the first visit and keeping them always. We used two pairs of field binoculars (Olympus 8-16x40 and Nikon Aculon 8 - 24) and two field-spotting scopes (Hakuba 35x70 and Swarovski 20-60x) to identify and count the birds.

Our field works started in the summer of 1991 in the lower sector of Siret River basin where we established five stations along Siret Valley, including the Lozova, Potcoava and Talabasca marshes, respectively, the reservoirs Movileni and Calimanesti (ROSPA0071 Lower Siret Meadow), visiting it during the periods: 1991 – 1994, 2004 – 2010, 2012 – 2013 and 2015 – 2016.

In 2011, we have been started our birds' monitoring activities in the middle sector of the basin and is still on going, visiting 28 stations along Siret Valley in the meadow area (ROSPA0072 Middle Siret Meadow), but also the reservoirs Lilieci, Bacau, Galbeni, Racaciuni and Beresti (ROSPA0063 Buhusi-Bacau-Beresti) and Garleni Lake, too. In the upper sector, we visited just three stations in 2015 – 2016 (ROSPA0064 Falticeni Lakes).

The perimeters of Batca-Doamnei reservoir and ROSPA0125 Vaduri-Pangarati (the reservoirs Vaduri and Pangarati) from the mountain sector of Bistrita River were included in our study for the wintering and autumn migration time in 2006 and is still ongoing, in three stations.

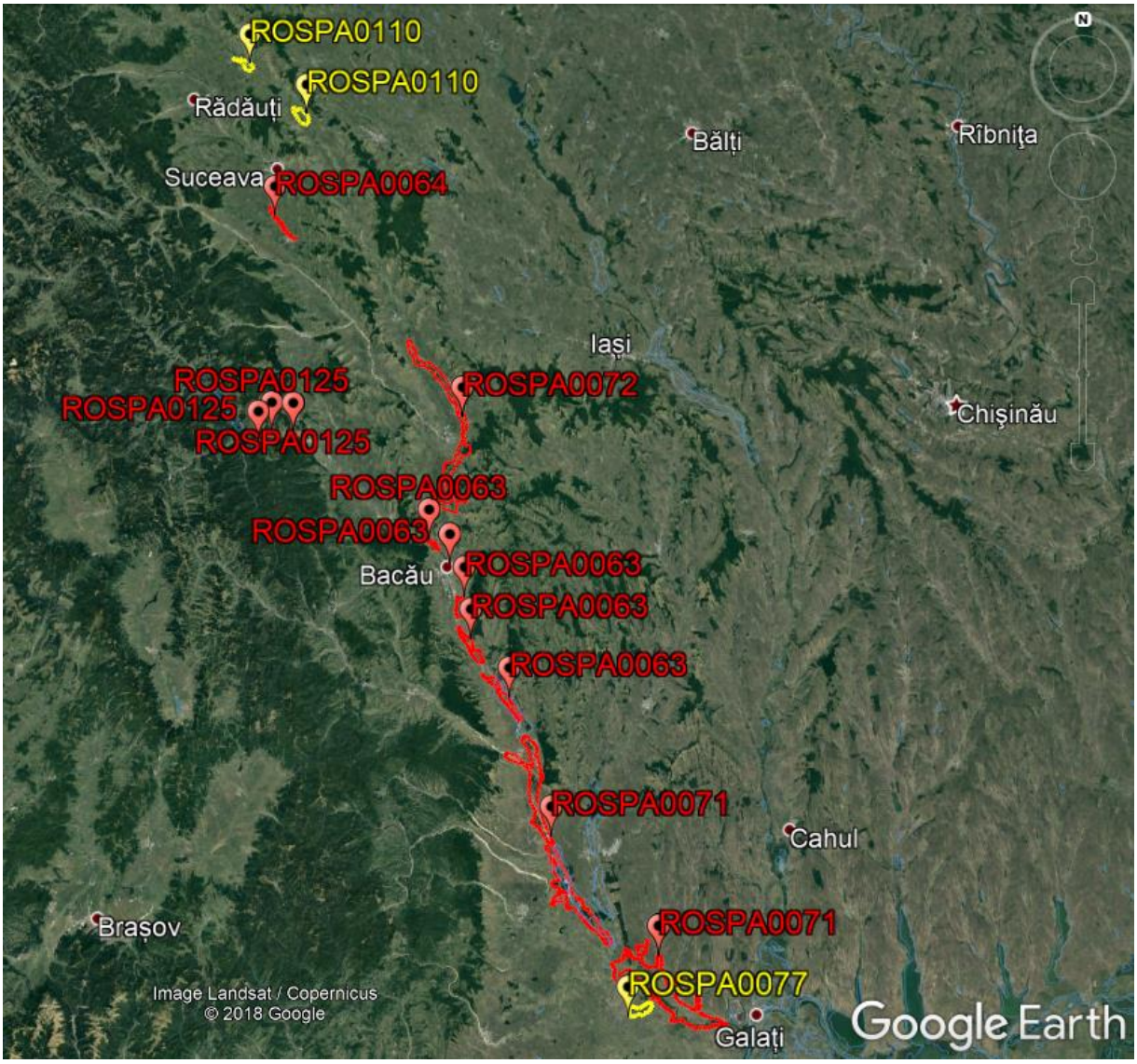

Figure 1. Location of the ROSPAs (Nature 2000 sites) in the Siret River Basin (Romania) – in red, the investigated sites.

Results

On the territories of the investigated five Nature 2000 sites from the Siret River's basin, the list of bird fauna includes 219 bird species, some of them met only once or twice during our study and only in the southern sector or the middle part of the basin. The distribution of these bird species in the area is unequal due to the general aspect of the suitable habitats and their different surfaces, respectively, due to the types and level of the anthropogenic impact.

Regarding the ornithological relevance, the territories of the ROSPA0071 Lower Siret Meadow and ROSPA0072 Middle Siret Meadow are significant during the breeding season (especially, in the southern sector, on the territories of Lozova, Potcoava and Talabasca marshes) and in the migration time. The most northern investigated site, ROSPA0064 Falticeni Lakes, is relevant especially during the migration time and just partially for the breeding season – the birds' diversity is high,

but present small-sized populations. The territory of the site ROSPA0063 Buhusi-Bacau-Beresti and the adjacent reservoir Garleni shelter very large populations of typical aquatic birds during the period of migration and are significant as wintering areas for waterfowls, too. During the winter, the larger populations of waterfowls are present on the mountain reservoirs included in the territory of the ROSPA0125 Vaduri-Pangarati site and the reservoir Batca-Doamnei from its proximity.

We recorded 132 certainly breeding bird species, and another 16 species are irregular or probably breeding species in this territory. The diversity of typical bird species for the aquatic habitats and wetlands is not rich during the breeding season and most of them present small-sized breeding populations. For example, the suitable breeding habitats for these groups of birds cover large surfaces in the middle part of the basin, on the territory of ROSPA0063 Buhusi-Bacau-Beresti, but the anthropogenic pressure is very high and the breeding populations of birds are very small.

During the migration time, the bird fauna's diversity present the highest values around the year and the larger populations for the all principal groups of typical aquatic and wetlands bird species are recorded especially in the autumn passage, most of them presenting flocks about hundreds and thousands of individuals in the investigated territories. The group of waterfowls (ducks, geese, swans, cormorants and coots) is the most representative in this period of the year as diversity (26 species) and size of populations (22,500 – 38,300 individuals as total waterfowls during one day of survey). For example, in October – November, for the mallard (*Anas platyrhynchos*), we recorded a total population about of 16,000 individuals only on the reservoirs reunited in the ROSPA0063 Buhusi-Bacau-Beresti site. In the same period, the coot (*Fulica atra*) was present with a flock about 6800 individuals only in the perimeter of the reservoir Racaciuni from the same area.

We notice an interesting aspect regarding the presence of geese (*Anser anser* and *Anser albifrons*) on the territory of the Siret River basin. During the spring, we met the geese only in the southern part, in the area of Talabasca marsh. In the same area, we recorded a significant autumn passage of the geese during the first decade of November, flocks of 60 – 210 individuals of greylag goose (*Anser anser*) and greater white-fronted goose (*Anser albifrons*) crossing the territory from the north-eastern direction to the south. On the 4th November 2012, we counted about 6,000 geese during about 40 minutes but only about 3,800 of them stopped-over resting and feeding in the area for some days. One week later, there were present only about 500 greater white-fronted geese. During ten years of ornithological surveys, we did not observe a similar population of geese upper on the territory of the Siret River and its tributaries, the larger flocks reuniting 430 greylag geese, respectively, 680 greater white-fronted geese. For this reason, we assume that the geese are coming along the eastern flyway following the Valley of Prut River, where we counted even 19,600 individuals of *Anser albifrons* during the autumn migration.

The waders represent the second group as significant diversity (26 species) and presence during the migration time, especially, in the autumn one when we counted a total population about 2600 – 3200 individuals. Most of the wader species were present with flocks about of tens individuals. The species *Limosa limosa*, *Calidris pugnax*, *Numenius arquata*, *Vanellus vanellus*, *Tringa totanus* and *Tringa erythropus* presented the larger sized-populations, each of them with flocks of more than 350 individuals up to 1,150 individuals.

The big reservoirs created along the Valley of Siret River and Bistrita River (as it most important tributary) represent the most important wintering areas for the

waterfowls in Eastern Romania. The birds arrive starting from the early November and stay there until the last decade of February in the mountain sector, respectively, to the end of March and early April on the reservoirs from the Siret Valley (Garleni, Lilieci, Bacau, Galbeni, Racaciuni, Beresti, Calimanesti and Movileni). The swans (*Cygnus olor*, *Cygnus cygnus* and *Cygnus columbianus*) present a wintering population about of 1,560 – 3,180 individuals, while the group of the ducks has the highest diversity (10 – 15 species, from one year to other) and a total population about of 12,000 – 51,350 individuals. The great cormorant (*Phalacrocorax carbo*) appears as winter visitor with flocks about of 110 – 480 individuals and the coot (*Fulica atra*) is present with a total wintering population about of 1,250 – 7,500 individuals.

We recorded 72 bird species with protection status through the Birds' Directive, and the Romanian Red Book of Vertebrates on the territories of the investigated five Nature 2000 sites in the basin of Siret River. As we see in table 1, 64 of these bird species appear in Annex 1 of the Birds' Directive as species that need implementation of special conservation measures concerning their habitats to ensure their survival in the area of distribution. Another 58 of the recorded bird species on the studied territory are in Annex 2 as species that may be hunted under the national legislation without jeopardising conservation efforts in their area of distribution.

During our field activity, we met 43 bird species mentioned with three different conservation status in the Romanian Red Book of Vertebrates (Botnariuc & Tatole, 2005). The authors included in this list only three categories of those classified in the Red List of the International Union for Conservation of Nature and Natural Resources (IUCN): critically endangered species, endangered species and vulnerable species. They established the conservation status for each species through criteria as the population size and trends on the territory of Romania during the last about five decades. We observed six critically endangered bird species, 12 endangered bird species, and 26 vulnerable bird species on the monitored territory of Siret River basin.

We notice that 34 bird species appear in Annex 1 of Birds' Directive and the Romanian Red Book, 29 bird species are present only in Annex 1, and others nine bird species have conservation status only in our country. In table 1, we present data on their presence, respectively, the trends their population in the area. For the breeding season and wintering period, when the birds' mobility is low, the values represent the sum of the bird groups counted in the all investigated territory. For the migration time, the data represent the minimum and maximum population estimated or counted during one day of field survey in one area, taking account of the all five monitored Nature 2000 sites. As we can see, most of these bird species present small populations, even during the migration time appearing in flocks about of tens, at most hundreds of individuals (with few exceptions).

In terms of trends, almost half from the protected bird species recorded in the study area (34 species) have stable populations in this territory. For 26 of these bird species, we notices a positive trend, while for 12 species, we found a negative trend of the population in the perimeter of the investigated Nature 2000 sites.

Table 1. Protected bird species in the basin of Siret River: presence, population and protection status

No	Species	Migration (individuals)	Breeding (pairs)	Wintering (Individuals)	Trends	Birds' Directive Annex 1	Romanian Red Book
146.	Cygnus cygnus	112 - 320	-	187- 800	+1	+	-
147.	Branta ruficollis	0 - 2	-	-	-1	+	En
148.	Tadorna tadorna	17 - 45	1 – 5?	-	0	-	V
149.	Netta rufina	0 - 6	-	-	-1	-	En
150.	Aythya nyroca	156 - 470	10 – 17	-	0	+	V
151.	Bucephala clangula	56 - 280	-	92 – 680	+1	-	V
152.	Mergellus albellus	14 - 72	-	32 - 180	0	+	V
153.	Gavia arctica	4 - 26	-	-	0	+	-
154.	Microcarbo pygmeus	40 - 188	-	-	-1	+	V
155.	Pelecanus onocrotalus	56 - 175	-	-	0	+	V
156.	Pelecanus crispus	0 - 1	-	-	0	+	V
157.	Botaurus stellaris	1 – 3	14 – 21	-	-1	+	-
158.	Ardeola ralloides	35 – 63	18 – 29	-	-1	+	V
159.	Ixobrychus minutus	35 – 57	43 – 60	-	+1	+	-
160.	Nycticorax nycticorax	15 - 30	30 – 60	-	0	+	V
161.	Egretta garzetta	120 - 270	28 – 52	-	0	+	En
162.	Ardea alba	64 - 162	13 – 32	8 – 25	0	+	En
163.	Ardea purpurea	36 – 68	12 - 17	-	0	+	En
164.	Plegadis falcinellus	20 - 33	1 – 3?	-	0	+	V
165.	Platalea leucorodia	40 - 122	4 - 11	-	-1	+	En
166.	Ciconia ciconia	1480 - 13430	33 - 60	-	0	+	V
167.	Ciconia nigra	3 - 15	2 – 5?	-	0	+	V
168.	Haliaeetus albicilla	0 - 2	0 – 1?	1 – 2	0	+	CE
169.	Aquila heliaca	1 - 3	1?	-	-1	+	CE
170.	Clanga pomarina	4 – 82	-	-	0	+	V
171.	Hieraaetus pennatus	0 - 3	-	-	-1	+	En
172.	Circaetus gallicus	0 - 7	-	-	-1	+	V
173.	Buteo rufinus	1 - 5	-	-	+1	+	V
174.	Pernis apivorus	22 - 34	1 – 3?	-	0	+	V
175.	Milvus milvus	0 - 6	-	-	0	+	En
176.	Milvus migrans	1 - 12	-	-	0	+	CE
177.	Circus pygargus	0 - 4	-	-	0	+	En
178.	Circus aeruginosus	12 – 20	8 - 15	-	+1	+	-
179.	Circus cyaneus	0 - 3	-	2 - 3	0	+	-
180.	Falco peregrinus	-	-	2 - 3	+1	+	En
181.	Falco columbarius	3 - 5	-	2 - 7	0	+	-
182.	Falco vespertinus	1 - 7	-	-	-1	+	V
183.	Falco naumanni	0 - 1	0 – 1?	-	-1	+	V
184.	Grus grus	0 - 3	-	-	0	+	V
185.	Porzana porzana	x	1 – 2?	-	-1	+	-
186.	Porzana parva	x	2 – 3?	-	-1	+	-
187.	Crex crex	x	25 - 33	-	-1	+	V
188.	Haematopus ostralegus	0 - 3	0 – 1?	-	+1	-	V
189.	Calidris pugnax	320 - 580	-	-	+1	+	-
190.	Numenius tenuirostris	0 - 1	-	-	0	+	CE
191.	Recurvirostra avosetta	13 - 36	2 – 4?	-	-1	+	V

192.	Himantopus himantopus	8 - 18	3 - 9	-	-1	+	En
193.	Glareola pratincola	0 - 14	-	-	-1	-	V
194.	Hydrocoloeus minutus	20 - 42	-	-	-1	+	-
195.	Chlidonias hybrida	52 - 210	45 – 67	-	0	+	-
196.	Chlidonias niger	38 - 82	7 - 23	-	-1	+	-
197.	Gelochelidon nilotica	0 - 2	-	-	-1	+	CE
198.	Sterna hirundo	58 – 146	65 – 180	-	+1	+	-
199.	Streptopelia turtur	37 - 92	60 – 75	-	+1	-	V
200.	Tyto alba	x	1 – 3?	15 - 19	0	-	V
201.	Caprimulgus europaeus	x	10 - 15	-	-1	+	-
202.	Coracias garrulus	-	4 - 7	-	-1	+	-
203.	Alcedo atthis	7 - 11	10 – 15	-	0	+	-
204.	Upupa epops	1 - 8	7 - 10	-	0	-	V
205.	Picus canus	x	7 - 13	x	0	+	-
206.	Dendrocopos syriacus	x	37 – 53	x	+1	+	-
207.	Dendrocopos leucotos	x	2 – 4?	x	-1	+	-
208.	Dendrocopos medius	x	5 - 7	x	0	+	-
209.	Lanius collurio	x	92 – 150	-	+1	+	-
210.	Lanius minor	x	61 - 88	-	0	+	-
211.	Corvus corax	x	8 - 10	2 - 4	+1	-	En
212.	Lullula arborea	x	x	-	0	+	-
213.	Calandrella brachydactyla	12 - 18	2 – 5?	-	-1	+	-
214.	Ficedula albicollis	x	5 - 7	-	0	+	-
215.	Ficedula parva	x	16 - 25	-	0	+	-
216.	Anthus campestris	18 – 24	37 – 62	-	0	+	-
217.	Emberiza hortulana	4 - 13	1 – 4?	-	-1	+	-

Legend
Breeding: 1? – probably or irregular breeding species, x – non-counted effectives; Trends: 0 – constant, -1 – negative, +1 – positive; Birds' Directive: + - bird species that need implementation of conservation measures; Romanian Red Book: CE – critically endangered species, En – endangered species, V – vulnerable species.

Discussion

Between the analysed bird species, 29 bird species recorded during our study appear in Annex 1 of Birds' Directive but have not conservation status through the Romanian Red Book of Vertebrates. Most of them present constant or positive trends as breeding species in the area – 18 certainly breeding species and five as irregular or probably breeding species. We recorded negative trends for the all irregular or probably bird species (*Porzana porzana*, *Porzana parva*, *Dendrocopos leucotos*, *Calandrella brachydactyla* respectively, *Emberiza hortulana*) and two regular breeding species (*Botaurus stellaris* and *Chlidonias niger*). Another three species (*Gavia arctica*, *Calidris pugnax* and *Hydrocoloeus minutus*) appear during the period of migration, the little gull presenting negative trends in this territory. The winter visitors present positive trends (*Cygnus cygnus*) or small-sized but constant populations (*Circus cyaneus* and *Falco columbarius*).

Nine bird species present in the investigated territory have protection status only at the national level, through the Romanian Red Book of Vertebrates, like endangered species (*Netta rufina* and *Corvus corax*), respectively, vulnerable bird species (*Tadorna tadorna*, *Bucephala clangula*, *Haematopus ostralegus*, *Glareola pratincola*, *Streptopelia turtur*, *Tyto alba* and *Upupa epops*). We notice the slight positive trends of raven's population beyond more than four decades of conservation efforts and for turtle dove, but also the probably breeding presence of the common shelduck in the perimeter of Talabasca marsh and ROSPA0072 Middle Siret Meadow. Two species have negative trends, but they are incidentally appearance in this area (*Netta rufina* and *Glareola pratincola*). During the last decade, the wintering population of the common goldeneye has increased year by year on the territories of the reservoirs from the ROSPA0125 Vaduri-Pangarati and ROSPA0063 Buhusi-Bacau-Beresti sites. The oystercatcher became a regular summer presence in the middle sector of the investigated territory, and we surprised even mating displays during the summer of 2014 in the perimeter of Beresti reservoir.

The larger group of protected bird species recorded during our study is that of the 34 species that have double conservation status through the Romanian Red Book of Vertebrates and Annex 1 of the Birds' Directive. Five bird species recorded on the territory of Siret River basin form the group of critically endangered species, most of them appearing as passage presence in the area. Moreover, two of them have negative trends, not only in the study territory but also in our country: *Aquila heliaca* and *Gelochelidon nilotica*. We met the white-tailed eagle (*Haliaeetus albicilla*) especially during the period of migration, and in the wintering time, but this big eagle could have a breeding pair in the proximity of ROSPA0063 Buhusi-Bacau-Beresti site. We observed adults and juvenile birds, several times, in this area. The eastern imperial eagle (*Aquila heliaca*) appears rarely but could be at least irregular breeding species on the territory of ROSPA0072 Middle Siret Meadow where we recorded adult birds during the whole nesting period and one juvenile bird fighting with some starlings (*Sturnus vulgaris*) and rooks (*Corvus frugilegus*) in the August 2017. The other three bird species were present during the migration time – only the black kite (*Milvus migrans*) as constant presence during the autumn passage, while we surprised the slender-billed curlew (*Numenius tenuirostris*) only once, on the 5th September 2008 in the perimeter of Talabasca marsh.

During our monitoring activities, we recorded ten endangered bird species, four of them presenting negative trends in the area – two as breeding species (*Platalea leucorodia* and *Himantopus himantopus*), especially in the lower sector of Siret River basin, while two species appear only during the autumn migration (*Hieraaetus pennatus* and *Branta ruficollis*). For the red-breasted goose, we have only one recording, in November 2011, when we surprise the presence of two individuals inside a group about 500 white-fronted geese (*Anser albifrons*). Three breeding species of herons have constant trends in the investigated Nature 2000 sites, while the raptor species (*Egretta garzetta*, *Ardea alba* and *Ardea purpurea*) appear during the migration (*Milvus milvus* and *Circus pyrgagus*) or in the wintering time (*Falco peregrinus*).

The group of the vulnerable bird species present the highest diversity in the investigated five Nature 2000 sites – 19 species. The pelicans (*Pelecanus onocrotalus* and *Pelecanus crispus*) appear in the late summer only in the southern sector, wandering around in search of feeding territories, while the pygmy cormorant (*Microcabo pygmeus*) became a rare species in the area during the last ten years. The Valley of Siret River is the most important flyway for the white storks (*Ciconia*

ciconia) in Eastern Romania during the autumn migration – we counted even more than 13,400 individuals crossing the middle sector during only one day in the last decade of August. We identified another important flyway for diurnal raptor species during the autumn migration in the middle sector, too – we surprised the passage of ten individuals of species as *Clanga pomarina*, *Circaetus gallicus*, *Buteo buteo*, *Buteo rufinus*, *Pernis apivorus* and *Falco vespertinus* during only one day in the last decade of September. We notice a significant negative trend for the breeding populations of the corncrake (*Crex crex*) and the pied avocet (*Recurvirostra avosetta*) due to the degradation of suitable habitats.

On the territory of the Siret River basin, the risk factors for the birds' conservation are different from one sector to another. The loss of wetland' surfaces and degradation of the suitable habitats as a result of secondary ecological succession represent the most important influence factors for bird fauna in the lower part of this basin. The water flow oscillations in the late spring-early summer and the autumn-winter uncontrolled hunting-games in proximity, and even on the territories of Nature 2000 sites, have a very high impact on the birds' presence in the middle sector of Siret River basin.

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Birds as bioindicators to assess the environmental quality in the ROSPA0158 Ciurbesti Lake - Barca hayfields (Romania)

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Abstract

We did monthly surveys starting from June 2018 until May 2019, evaluating the bird's fauna diversity in the perimeter of ROSPA0158 Ciurbesti Lake – Barca hayfields. During our study, we recorded 92 bird species, 22 of them included in Annex 1 of Birds' Directive. We notice the presence of eight bird species that do not appear in the official presentation of the ROSPA0158: *Mergellus albellus*, *Nycticorax nycticorax*, *Egretta garzetta*, *Ciconia ciconia*, *Himantopus himantopus*, *Sterna hirundo*, *Chlidonias hybrida* and *Alcedo atthis*. We mention the passage of two European globally threatened bird species in the area: *Aythya nyroca* and *Clanga clanga*. We present the local status of the bird species used as bioindicators and a proposal for a project to the sustainable development strategy of local communities in the surrounding areas of Nature 2000 site.

Keywords: birds, bioindicators, Nature 2000 network, sustainable development

Introduction

The ROSPA0158 Ciurbesti Lake - Barca hayfields, part of Nature 2000 network, is located 5 kilometres southern from Iasi city: 27°28'69" eastern longitude and 47°06'33" northern latitude (Brinzan, 2013). The surface of the site is about 521 hectares and overlaps about 148 hectares with ROSCI0077 Barca hayfields.

Ciurbesti Lake is a reservoir created through a dam on Valea Locii River, tributary of Nicolina River from Bahlui River basin. The reservoir appeared in 1963 for flood control, irrigation and fisheries, but was affected by warping. For this reason, but also to control the flooding risks in the vicinity of the lake, another dam was built, creating the Barca-Manjesti ponds.

The climate is temperate continental, with hot and dry summers; torrential rainfalls phenomenon appears in June - July, while the winters are cold.

The main habitats on the territory of Nature 2000 sites are large aquatic surfaces with *Magnopotamion* or *Hydrocharition* - type vegetation. Also, large reed compact beds are present in front of Ciurbesti dam, in the tail area of the lake and in the western edge of Barca-Manjesti ponds. In the north-eastern side of Ciurbesti Lake, there is a deciduous forest, but also some clusters of trees and shrubs are present along the northern and southern banks. On the south slope of the Barca-Manjesti ponds, a large area of grasslands with shrubs is present. We mention the presence of species as *Iris aphylla hungarica*, *Pulsatilla grandis*, *Arytrura musculus* and *Spermophilus citellus* like protected species found on the territory of the site.

The Nature 2000 site has no custodian and is under the management of the National Agency for Natural Protected Areas that is in an on-going process of organizing. The National Agency of Romanian Waters administers the water bodies (Ciurbesti Lake, respectively Barca-Manjesti ponds) from the perimeter of the site. The present use of the aquatic surfaces is as traditional fisheries, especially for sport fishing activities.

There are some previous ornithological data from this site (Gache, 2002; Müller, 2004; Ion *et al*. 2011) used to establish the protected area status.

Material and Methods

We did monthly surveys in the investigated area starting June 2018 until May 2019, using the transects and fixed-points monitoring methods. We established three transects along the northern borders of Ciurbesti Lake and Barca-Manjesti ponds, with five fixed-points (Ciurbesti dam, south of Lunca Cetatuii village, south-eastern of Ciurbesti village, Barca ponds and Manjesti ponds) that enabled us recording all the seen and heard bird species in the area. We focused our study on the perimeter of the lake and ponds, with their vicinities, but did not monitor the woodland areas.

We used two pairs of field binoculars (Olympus 8-16x40 and Bresser 10x42) and a field spotting scope (Swarovski 20-60x) to identify and count the birds.

Results

On the territory of ROSPA0158 Ciurbesti Lake - Barca hayfields, we recorded 92 bird species (table 1). As breeding bird fauna, we recorded 63 certainly breeding species and 8 probably breeding species, all of them presenting small-sized populations in the area. Although there are large surfaces covered by suitable habitats for the birds' breeding, the human presence and activity are constant and at medium to a high level, in the most area of the site. The breeding populations of typically wetland species are concentrating in the sector from the front of the dam and in the tail area of the Ciurbesti Lake, respectively, only in the tail area of the Barca ponds and on the whole perimeter of the Manjesti pond.

In the wintering time, the birds' diversity present the lowest value of all year round – we met just 31 species from November 2018 to February 2019. Moreover, the aquatic and semi-aquatic bird species are present no late than the end of November because the lake and ponds freeze completely in early December. The resident species dominate the wintering bird fauna, mixed flocks of passerines (*Spinus spinus*, *Carduelis carduelis*, *Linaria cannabina* and *Emberiza citrinella*) searching seeds and fruits in the shrubs and reed beds' perimeter. The diurnal raptors (*Buteo buteo* or *Accipiter gentilis*) and *Lanius excubitor* use the solitary trees as a point to still-hunting their potential preys, sometimes in adjacent areas of villages.

The diversity of bird fauna on the territory of ROSPA0158 Ciurbesti Lake - Barca hayfields and adjacent areas of the site was highest during the migration period, when we recorded all the 92 bird species, but 17 of them are resident species here and the group of passage species was different in spring, respectively, in autumn migration. The winter visitors left the area just in March (*Spinus spinus*), even in early April (*Lanius excubitor*). We observed some passage species as *Anser anser*, *Anser*

albifrons, *Mergellus albellus*, *Clanga clanga* or *Podiceps grisegena* only during the autumn, when we recorded the highest values for the specific diversity of bird fauna and in the population size for all the groups of birds. During the spring passage, we observed small-sized populations, including for some bird species as *Circaetus gallicus*, *Pernis apivorus*, *Milvus migrans* or *Motacilla cinerea* that we met only during this period of the year.

Table 1. Bird species recorded on the territory of ROSPA0158 Ciurbesti Lake - Barca hayfields: presence and protection status

No.	Species	Presence			Birds Directive Annex 1	Romanian Red Book
		Migration (individuals)	Breeding (pairs)	Wintering (Individuals)		
1.	*Phasianus colchicus*	x	3 - 4	x	-	-
2.	*Coturnix coturnix*	x	3 - 6	-	-	-
3.	*Cygnus olor*	1 - 4	1 - 2	2 - 7	-	-
4.	*Anser anser*	0 - 32	-	-	-	-
5.	*Anser albifrons*	0 - 20	-	0 - 20	-	-
6.	*Anas platyrhynchos*	6 - 68	3 - 5	0 - 68	-	-
7.	*Anas strepera*	2 - 4	1 – 2?	-	-	-
8.	*Anas querquedula*	2 - 17	1 - 2?	-	-	-
9.	*Aythya nyroca*	1 - 42	-	-	+	V
10.	*Aythya ferina*	3 - 6	1 - 2	-	-	-
11.	*Mergellus albellus*	0 - 1	-	-	+	V
12.	*Phalacrocorax carbo*	1 - 3	-	0 - 1	-	-
13.	*Ixobrychus minutus*	1 - 3	2 - 3	-	+	-
14.	*Nycticorax nycticorax*	1 - 11	2 - 3?	-	+	V
15.	*Egretta garzetta*	0 - 3	1 - 3?	-	+	V
16.	*Ardea alba*	1 - 4	1 - 2?	0 - 4	+	V
17.	*Ardea cinerea*	1 - 51	2 - 3	0 - 2	-	-
18.	*Ardea purpurea*	1 - 2	1 - 2?	-	+	V
19.	*Ciconia ciconia*	1 - 87	2 - 4	-	+	V
20.	*Clanga clanga*	0 - 3	-	-	+	En
21.	*Circaetus gallicus*	0 - 4	-	-	+	V
22.	*Buteo buteo*	1 - 5	-	2 - 3	-	-
23.	*Pernis apivorus*	0 - 1	-	-	+	V
24.	*Accipiter gentilis*	1 - 2	1 - 2	1 - 2	-	-
25.	*Milvus migrans*	0 - 1	-	-	+	En
26.	*Circus aeruginosus*	1 - 8	1 - 2	-	+	-
27.	*Circus pygargus*	0 - 2	-	-	+	T
28.	*Falco tinnunculus*	2 - 4	1 - 3	-	-	-
29.	*Gallinula chloropus*	2 - 5	2 - 3	-	-	-
30.	*Fulica atra*	6 - 174	10 - 14	0 - 35	-	-
31.	*Calidris falcinellus*	2 - 5	-	-	-	-
32.	*Tringa ochropus*	2 - 5	-	-	-	-
33.	*Tringa totanus*	2 - 7	-	-	-	-
34.	*Vanellus vanellus*	2 - 10	2 - 5	-	-	-
35.	*Charadrius dubius*	2 - 3	-	-	-	-
36.	*Himantopus himantopus*	0 - 1	-	-	+	T
37.	*Larus cachinnans*	4 - 180	5 - 7	2 - 161	-	-
38.	*Chroicocephalus ridibundus*	2 - 322	3 - 6	0 - 32	-	-
39.	*Chlidonias hybrida*	10 - 12	8 - 10	-	+	-
40.	*Sterna hirundo*	1 - 12	2 - 4	-	+	-
41.	*Podiceps cristatus*	26 - 50	10 - 13	0 - 1	-	-
42.	*Podiceps grisegena*	0 - 2	-	-	-	-
43.	*Columba palumbus*	8 - 13	4 - 5	-	-	-
44.	*Streptopelia turtur*	7 - 11	3 - 4	-	-	V
45.	*Streptopelia decaocto*	x	8 - 10	x	-	-

46.	*Cuculus canorus*	x	7 - 9	-	-	-
47.	*Apus apus*	1 - 3	-	-	-	-
48.	*Alcedo atthis*	0 - 1	1	-	+	-
49.	*Merops apiaster*	11 - 32	8 - 10	-	-	-
50.	*Upupa epops*	2 - 5	1 - 2	-	-	V
51.	*Picus viridis*	x	3 - 4	x	-	-
52.	*Dendrocopos major*	x	5 - 6	x	-	-
53.	*Dendrocopos syriacus*	x	7 - 9	x	+	-
54.	*Oriolus oriolus*	x	5 - 6	-	-	-
55.	*Lanius collurio*	5 - 11	6 - 8	-	+	-
56.	*Lanius minor*	3 - 8	2 - 3	-	+	-
57.	*Lanius excubitor*	2 - 7	-	3 – 5	-	-
58.	*Pica pica*	x	3 - 5	x	-	-
59.	*Corvus monedula*	x	2 - 4	x	-	-
60.	*Corvus frugilegus*	x	50 - 52	x	-	-
61.	*Corvus cornix*	x	3 - 4	x	-	-
62.	*Corvus corax*	x	1 – 2?	2 - 4	-	T
63.	*Cyanistes caeruleus*	x	x	x	-	-
64.	*Parus major*	x	x	x	-	-
65.	*Panurus biarmicus*	x	5 - 7	-	-	-
66.	*Galerida cristata*	x	6 - 8	x	-	-
67.	*Alauda arvensis*	x	12 - 14	-	-	-
68.	*Riparia riparia*	60 - 80	48 - 56	-	-	-
69.	*Hirundo rustica*	110 - 150	x	-	-	-
70.	*Delichon urbicum*	120 - 270	x	-	-	-
71.	*Phylloscopus collybita*	x	x	-	-	-
72.	*Locustella luscinioides*	x	2 - 4	-	-	-
73.	*Acrocephalus scirpaceus*	x	12 - 14	-	-	-
74.	*Acrocephalus arundinaceus*	x	20 - 25	-	-	-
75.	*Hippolais icterina*	x	x	-	-	-
76.	*Sylvia communis*	x	x	-	-	-
77.	*Sylvia curruca*	x	x	-	-	-
78.	*Saxicola rubetra*	x	2 - 3	-	-	-
79.	*Sturnus vulgaris*	280 - 1700	x	-	-	-
80.	*Passer domesticus*	x	x	x	-	-
81.	*Passer montanus*	x	x	x	-	-
82.	*Motacilla flava*	5 - 11	3 - 6	-	-	-
83.	*Motacilla cinerea*	0 - 1	-	-	-	-
84.	*Motacilla alba*	5 - 7	3 - 4	-	-	-
85.	*Chloris chloris*	x	x	-	-	-
86.	*Spinus spinus*	x	-	30 - 52	-	-
87.	*Carduelis carduelis*	x	x	35 - 67	-	-
88.	*Linaria cannabina*	x	x	5 - 13	-	-
89.	*Emberiza calandra*	x	7 - 10	-	-	-
90.	*Emberiza citrinella*	x	x	x	-	-
91.	*Emberiza hortulana*	x	1 – 2?	-	+	-
92.	*Emberiza schoeniclus*	x	3 - 5	2 - 7	-	-

Legend
Presence: 1? – probably breeding species, x – non-counted species; Romanian Red Book: En – endangered species, T – threatened species, V – vulnerable species.

During our field activity, we observed the bird fauna's diversity and it seasonal dynamic to update the previous data and evaluate the present status. In addition, we looked to the activities of local community inside and in the adjacent territory of ROSPA0158 Ciurbesti Lake - Barca hayfields to assess the impact on the bird fauna. Regarding the use of lands, there are no changes on the ROSPA's territory, but we observed a small increase in the size of the cultivated areas near the Nature 2000

site's limit and the extension of building perimeters from the edge of surrounding villages.

Agriculture is the main activity of the local community in this region. The agricultural lands cover large surfaces at the limits of the protected area, but do not extend to the edge of Ciurbesti Lake and Barca-Manjesti ponds. Some herbaceous vegetation stripes with shrubs and bushes sectors, but also some clusters of trees are present between the cultivated areas. The risk of contamination appears during the torrential rainfalls that wash the cultivated slopes around Barca-Manjesti ponds and can bring residues of pesticides and chemical fertilizers in the water. In November 2018, we found dispersed poisoned grains of wheat on these agricultural lands, probably, to control the rodents but these seeds can kill numerous bird species that are searching food around the area during the wintering time. In the spring and fall, during the time of ploughing and sowing, but also in the summer during the harvesting time, we observed groups of storks and gulls feeding, respectively, some diurnal raptors hunting mice on these areas.

Grazing has a low impact on the quality of meadows due an obviously decreasing in the number of cattle, sheep and goats in the area, their farming becoming an insignificant activity for the local community during the last decade. In one sector near Ciurbesti village, we met several times one herd of cattle going-in and drinking water directly from the lake in one point used as a feeding area by swans (*Cygnus olor*), herons (*Ardea alba* and *Ardea cinerea*) and coots (*Fulica atra*).

As we noticed during our visits, the fishing activity is completely uncontrolled in the perimeter of the Ciurbesti Lake, where we could count even 28 – 32 fishermen around the lake and one or two motor-boats crossing the water' surface. This is a critical disturbance factor during the breeding season and the migration period. The sector of Barca-Manjesti ponds has fishing management and the sport fishing activity is going on in just two designated areas in the middle part of the ponds' perimeter. For this reason, the breeding birds are using the compact reed beds that cover the tail of Barca ponds and all the suitable habitats from the perimeter of Manjesti pond where the cars' access is impossible. Even during the migration time, the larger groups of gulls (Laridae), ducks (*Anas sp*. and *Aythya sp*.) and coots (*Fulica atra*) were present inside the perimeter of the Manjesti pond and in the middle open waters of the Ciurbesti Lake.

The vegetation fires represent another problem with high impact on the biodiversity in the area. During the last years, the practice of burning the remains of plants from the agricultural lands becomes common and, sometimes, due the long periods of drought, it is quiet easy to lose control and have huge fires that need the action of firefighters (for example, in the night of the 28th October 2018, in adjacent sector of Barca ponds).

The uncontrolled and unrestricted recreational activities present a medium to high impact on the birds' presence in the area, especially in the perimeter of Ciurbesti Lake. The occasional anglers can stay one by one, especially on the southern bank until the edge of the tail perimeter with compact reed beds vegetation. In front of the dam, we met teenagers swimming around, disturbing the breeding populations of terns and gulls. Along the north-western and southern banks of Ciurbesti Lake, we found numerous fireplaces randomly arranged during picnic activities without regard to minimum rules of protection against the risk of burning the surrounding vegetation. All these "tourists" leave a lot of remains and garbage in the area, too.

Discussion

The birds serve like sensitive bioindicators for very different changes in the biocoenoses from a territory. The bird communities can suffer significant changes in their specific diversity and population size due to the fragmentation of ecosystems and loss of suitable habitats, when face to the appearance of invasive species or the introduction of non-native species in their territory (Maciuca, 2003).

Several bird spescies enable us to survey the quality of some abiotic elements like waters and soils using chemical and biochemical analyses in determining the presence of pollutants – for example, organochlorine compounds, heavy metals, persistent organic pollutants etc. Usual, the birds occupy high levels in the trophic pyramids and accumulate in their tissues the ingested substances through their food, including from preys. Some of the bird species present on the territory of ROSPA0158 Ciurbesti Lake - Barca hayfields and adjacent perimeter can serve as bioindicators for the level of various pollutants from ecosystems. For example, the mallard (*Anas platyrhynchos*) accumulates mercury in tissues, especially inside the liver, kidneys and pectoral muscles (Żarski *et al*. 2017) and the great egret (*Ardea alba*) accumulates different heavy metals in the cells of the liver (Silva & Saiki, 2012). The accumulation of organochlorine compounds has been proved in the case of the great-crested grebe (*Podiceps cristatus*), affecting the thickness of the eggshell (Cortinovis et al. 2008) and for the kingfisher (*Alcedo atthis*) that presented a higher level of pollutants in the pectoral muscles than their preys – small fishes (Mo *et al*. 2013). Correlated with the agricultural practices from the territory – use of pesticides and preserving of shrubs, the shrikes' (*Lanius sp*.) presence represents one of the most relevant bioindicators for the quality of the open country habitats (Takács *et al*. 2004).

During our field surveys on the territory of ROSPA0158 Ciurbesti Lake - Barca hayfields and adjacent areas, we recorded 16 species that appear in the Romanian Red Book of Vertebrates (Munteanu, 2005) and 22 species included in Annex 1 of Birds' Directive, as species that need the implementation of special management measures in order to avoid their disappearance. Almost all of them can represent relevant bioindicators in assessing the environment's quality from a territory by their presence and distribution inside different habitats during the annual biological cycle and by their breeding populations or their size populations during the migration and wintering time (Padoa-Schioppa *et al*. 2006). The presences of various species and significant sized-populations of ducks and geese in a wetland's perimeter indicate a low level of anthropogenic influence, these species being sensitive to the hunting activity (Ion *et al*. 2011).

The bird species included in the Romanian Red Book of Vertebrates present status as endangered species – *Clanga clanga* and *Milvus migrans*, as threatened species – *Circus pygargus*, *Himantopus himantopus* and *Corvus corax*, respectively, as vulnerable species – *Aythya nyroca*, *Mergellus albellus*, *Nycticorax nycticorax*, *Egretta garzetta*, *Ardea alba*, *Ardea purpurea*, *Ciconia ciconia*, *Circaetus gallicus*, *Pernis apivorus*, *Streptopelia turtur* and *Upupa epops*. All these species need the implementation of specific conservation measures in order to avoid the risk of disappearance, presenting an obviously decline of populations in our country.

Of the 22 bird species present in Annex 1 of Birds' Directive, only eight appear in the official standard form presentation of the Nature 2000 site (Brinzan, 2013). During our study, we observed 14 bird species that are not on the list of species present in site's standard form. We recorded part of them only during the migration time:

Mergellus albellus, *Clanga clanga*, *Circaetus gallicus*, *Pernis apivorus*, *Milvus migrans*, *Circus pygargus* and *Himantopus himantopus*. Five species are breeding on the territory of ROSPA0158 Ciurbesti Lake - Barca hayfields or in its vicinity, using this perimeter as a feeding area: *Ciconia ciconia*, *Chlidonias hybrida*, *Sterna hirundo* and *Dendrocopos syriacus*, respectively, *Alcedo atthis* that has the nest somewhere along Valea Locii River, in the north from Ciurbesti dam. Another two species could breed here: *Nycticorax nycticorax* and *Egretta garzetta* especially in the compact reed beds located between Barca and Manjesti ponds. Some of these species present negative trends on the territory of our country, being included in the Romanian Red Book of Vertebrates. For this reason, it is important to update the standard form of the site by including them between the species that need the implementation of specific action and conservation measures in this perimeter.

The ROSPA0158 Ciurbesti Lake - Barca hayfields does have not a custodian. The Iasi County Agency of Environment Protection prepared in 2016 a set of minimum conservation measures for the birds and other wildlife included in the official site' standard form, but there is no management plan for it. This involves evaluating the biodiversity's present status in the Nature 2000 site, identifying the risk factors, assessing the local community's activities and adjacent localities development plans, as well as a large consulting with the all stakeholders from the area. Implementing environmentally friendly practices in fisheries and agriculture can bring more attractiveness to the local food production, especially now that more and more people are interested in natural and organic food.

Developing studies on different topics related to the environmental issues in the area seems to be convenient through the involvement of students from various Iasi city's universities due to the proximity of Nature 2000 site with the southern edge of Iasi city (Lunca Cetatuii district has a public transport connection with the city).

The proximity to Iasi city and the easy access by car to the limits of Nature 2000 site represent good reasons to develop a schedule of recreational activities, which could increase the visibility of the area among the large public. There are opportunities to easier management of the sport fishing and picnic activities around the Ciurbesti Lake and the Barca-Manjesti ponds, respecting some rules for preventing the negative influence in the biodiversity of the area, as well as creating other kinds of recreational events. In the neighbourhood of the site, for example, some local NGOs and entrepreneurs, with the support of Miroslava Village Hall and specialists from the "Al. I. Cuza" University from Iasi, organised a sport event to the large public *Iasi in Trail*. The fourth edition took place in middle April 2019 and attracts more than 500 participants in three competitions: Iasi Forests Marathon, Barnova Forest Half-Marathon and Repedea Natural Reserve Cross. A birdwatching activity to the large public, with free access, was organised by *MaiBine Association* with different partners in the afternoon of the 15th June 2019 along the future touristic transect Iasi Old Forests, involving 23 participants (age being from children to retirees).

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3D Virtualization on the Guard of Ecology

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Abstract
In the modern world, the level of digital technologies usage in application to the ecological problems is still very low. At the same time the problem of ecology every year is getting even harder. Climate changes have influence not only on the human beings or animals but also to all the floral areas. Therefore plants, that are also forming a climate, have to face stressful circumstances. In our research, we consider how new technologies could solve the problem of plants' survival in complicated circumstances. In this paper, it is described which technologies should be used and what kind of data is required for not only observation of the existing problem but also for the prediction of possible issues. We suggest to use 3D modelling using data from sensors cause this method gives representative and well-visualized results that are easy to understand.

Key words: survival of plants, gadgets, IT, greenery, virtualization, 3D representation

Introduction

In the past years the problem of poor state of ecology that comes to even worse becomes more and more important. It happens because of various reasons such as climate changes, Greenhouse effect, pollution and different kinds of anthropogenic influence to the nature. In this conditions it is important to think about the ways how to keep ecological situation in a positive state and how to predict possible problems that could somehow appear in the future. Bad ecological situation always influences all organisms such as animals or plants, but it is important that plants also have a great impact to the climate forming and ecological situation vice versa. Because of this it is important to observe changes to the plants and trees especially.

Looking through this problem we suggest to use information technologies and 3D modelling in particular for the task of ecological modelling to track the changes to a tree in dynamics and how strong it can be in the urban environment with specific wind force in this area.

Ecological Modelling

Ecological modelling is a tool for environmental managing such as observing the processes of environmental changes and predictions of the sates that particular conditions could lead to.

Popularity of ecological modelling rose significantly during the 1970s according to Jorgensen (2008) and it becomes a more widely used tool in the last decades.

Jorgensen (2016) tells that at the beginning, our it was based on rudimentary solutions like introduction of various environmental technologies but later management was expanded by extensive use of models assisted by use of more advanced technologies, regulatory and legislative initiatives. This was necessary as the environmental problems turned out to exhibit an almost ever-increasing complexity. This discipline was developing due to development of proper techniques, computer power, and adequate software, together with the recognition of existence of environmental problems, as well as the establishment of sufficient knowledge on ecological processes, how they are regulated, and hence how to retain ecosystem properties. Ecological models can be used for survey, to reveal system properties, establish research priorities, and to test scientific hypotheses.

Ecological modelling is closely connected to system analysis, mathematical modelling and sustainable development. These areas describe sustainable managements of resources and how it could be achieved. In Park et al. (2015) authors notice that the sustainability assessment implies a systemic perspective to address the close relationships between the environmental and socioeconomic processes, and ecological modelling contributes to facilitating the development of sustainable management planning of target ecosystems. Sustainability is a very wide term that has three main aspects that include environmental, economic, and social domains as it is shown on the Figure 1 (WCED, 1987).

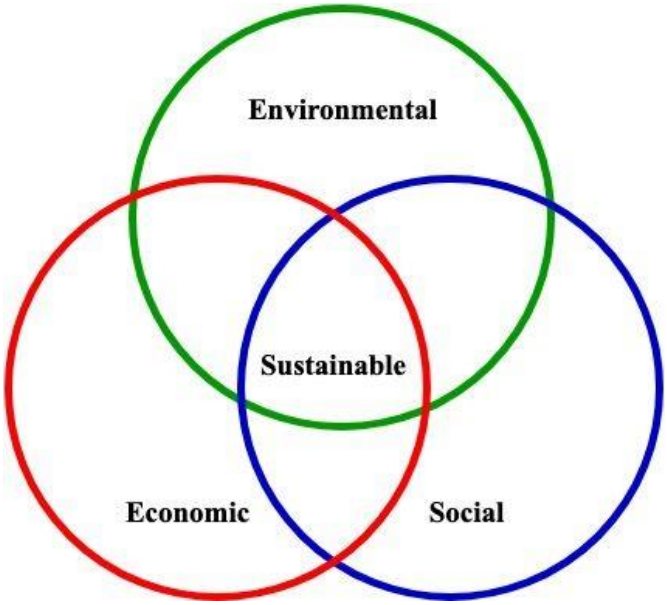

Figure 1. Main aspects of sustainability. In general.

Some researchers point out that environmental sustainability is the main goal for future development (Odum and Barrett, 2005). Environmental sustainability is the ability of the environment to support a defined level of natural capital and resources

(Goodland, 1995). Economic sustainability is the ability of an economy to support a defined level of economic production indefinitely. Social sustainability is the ability of a social system, such as a country, family, or organization, to function at a defined level of social well-being and harmony indefinitely (Thwink.org, URL).

On Figure 2 we would like to show the dynamics of the web requests worldwide of four terms: sustainability, global warming, ecosystem services and climate change. Data was taken through Google Trends web-service (Google Trends, URL). The statistics shows that the interest of the people in this topic worldwide is increasing during the time.

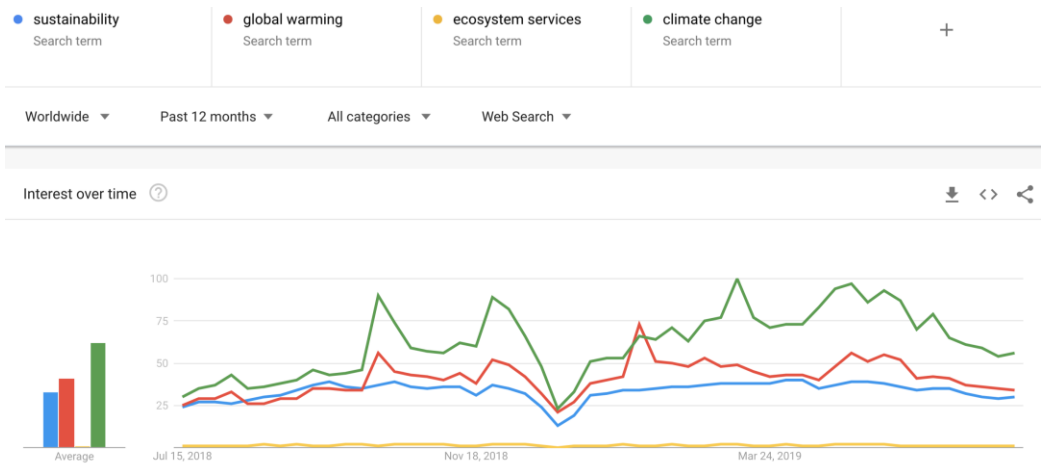

Figure 2. Concurrency of search requests frequency for terms: sustainability, global warming, ecosystem services and climate change

The development of these areas in scientific papers could be seen using Google Books Ngram Viewer service (Google Books Ngram Viewer, URL) that creates a graph using frequencies of any word or short sentence using yearly counts of ngrams found in the selected period of time, that could be chosen in range from 1800 till 2008.

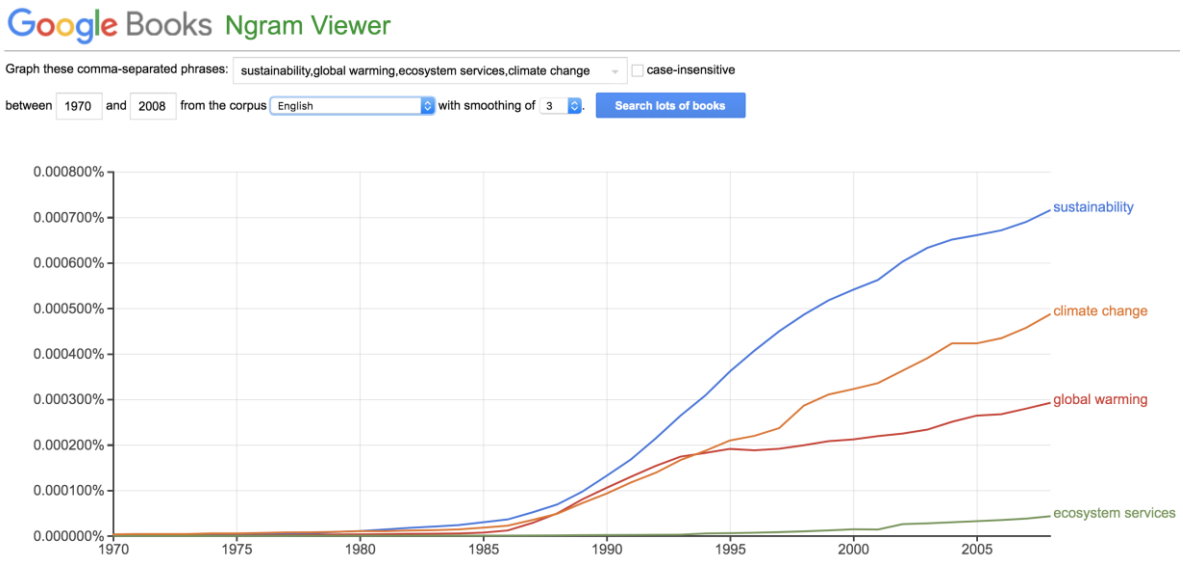

Figure 3. Concurrency of scientific papers appearance for terms: sustainability, global warming, ecosystem services and climate change

3D-Modelling

Information technologies and modelling in the modern world are widely used for different kinds of tasks. Behind 3D modelling we understand the process of digital three-dimensional object representation construction.

The term 3D visualization is used synonymously with 3D graphics, 3D rendering, computer generated imagery (CGI), and other terms. They all basically refer to the process by which graphical content is created using 3D software. It's a technology that has become mainstream over the last few decades and has evolved into one of the most viable options for producing high-quality digital content (Upwork.com, URL).

Tendency mentioned above takes place 3D visualization methods give good representative results that could be analyzed and evaluated not only by the experts but also by other users. For example, in Sochenkova & Podzharaya (2018) it was shown how the 3D modelling could be used for people with disabilities in aim to help them to explore the museum that could not be adapted to them in case of the building construction. In Podzharaya & Sochenkova (2018) and Sochenkova et al. (2018) authors also show how this technology could help to save cultural heritage with built models. In Sochenkova, Podzharaya & Samouylov (2019) authors show usage of mentioned 3D-modelling in application emergency systems.

3D visualization services are not limited to the consumer product industry. Many other industries can also benefit from these services— ecology, medicine, pharmaceutics and others. If visual content in any capacity is required, 3D visualization services may be the perfect solution, also in ecology.

Taking into account all of that it is interesting to look for the possibilities of 3D-modelling usage for the ecological tasks. 3D visualization of the stability of tree is mainly applied to describe an extreme or average situation. It was, however, acknowledged that other model types to solve more comprehensive modeling problems were urgently needed. The stability of the tree, danger for people etc. In this research, we consider 3D visualization in aim to track the changes to a tree under the strong winds in dynamics.

Methodology of 3D-Visualization Usage in Application to Ecological Modelling

It is interesting to track how stressful circumstances for the life of a tree are influencing this tree. The parameters of the functional state and vertical stability are specified by high temporal dynamics (daily, seasonal, perennial) and spatial heterogeneity, which is determined by both natural (age, species, climate) factors and anthropogenic influence (physical root damage, air pollution, etc.).
In the city wind has different trajectory, because high buildings and long streets make something like a "canyon effect".

Diagnosing signs of stability in the early stages allows you to identify problem situations and take preventive measures. To find out their condition and determine the stressful situation and factors for them, special devices could be used.
For measuring the stability of the tree, we need to put a set of accelerometer sensors on a particular one. It is important to notice that the center of gravity of this tree as long as the force of gravity applied on the tree by devices have to be taken into

account. It is important since if the number of the devices is too high or the center of the gravity is moved in case of devices installation, the experiment will not be relevant and representative because the chance of tree falling down gets much higher.

Also, the 3D-Model of this tree is needed. In the mathematical representation the tree will look like a graph, but in three-dimensional space.

Data from accelerometer need to be collected and transmitted to the storage. Using online data from devices in pivot points the model is changing by moving pivot points and edges connected to them.

Collected data are also interesting but for the task of tree state prediction.

Conclusion

In this paper, it was pointed out that modern technologies could not only harm the nature, but could also be used in aim to protect it. Therefore, 3D modelling is suggested to be applied for the task of observing and predicting life of the tree under the wind force in urban environment with specifications of this area.

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Bioaccumulation of Lead, Cadmium and Chromium in *S. letnica* and *S. ohridnus* at Ohrid Lake

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Abstract

The purpose of this study was, the measurement of Lead (Pb), Cadmium (Cd) and Chromium (Cr) in the, muscles, gills, liver, intestines and eggs of the 2 species in Ohrid Lake (*Salmo Letnica* and *Salmothymus Ohridanae)*. The samples were taken from 5 different locations in the coast, from the city of Pogradec to the Lin. They were taken during the winter and summer. The comparison of heavy metal values in the muscles and organs showed statistically different values ($P<0.05$). The highest concentration of lead was found in the intestines with values 0.21 ± 0.4 ppm and the lowest was found in the eggs 0.03 ± 0.01 ppm. Cadmium had the highest value in the liver 0.68 ± 0.19 ppm and the lowest in the eggs 0.08 ± 0.02ppm. The concentration of Chromium varied 0.27 ±0.05 ppm in the liver and the lowest value in the eggs 0.1 ± 0.01 ppm. The comparison of the metal samples obtained in the muscles result with a higher concentration in the summer session than in winter. Based on the results of this study, the presence of the heavy metals accumulated in the tissues of *S. letnica* and *S. ohridane* were in the allowed norms according the EU standards for the heavy metals for the Pb and Cr. The Cd in several zone was over the limits according the EU standards but in the allowed rates according the FAO and WHO standards.

Key words: heavy metals, fish, pollution, Ohrid Lake, s. letnica, s. ohridanus.

Introduction

Lake Ohrid is situated in the southwestern of North Macedonia and eastern Albania, more in detail it is characterized with a height 695 meters above sea level and covers a total area of 358.2 square kilometers where 2/3 of it belongs to Republic of North Macedonia and the remaining part to Republic of Albania. It is 14.8 kilometers wide and 30.8 kilometers long at its maximum extent with a shoreline of 87.53 kilometers. Being one of the most ancient and deepest lakes (with an average of depth 164 meters and a maximum depth is 289 meters), it has a rich flora and fauna and is unique in a number of endemic species (Avramovskiat al 2004). Total area of the watershed is about 3,932 square kilometers, and although in Albanian side the river flow is substantially less, its main contributors are Pogradec and Verdova rivers. Other inflows derive from springs that flow into the southern part of the lake, at St.Naum, Drilon and Tushemisht.

Taking into consideration a chemical point of view, the water of the lake and its sources appears to be in good levels with an alkaline reaction (pH 7.1-7.6), favorable for the development of flora and fauna in the respective waters. Typical fish growing in Lake Ohrid are: (i) *Salmo letnica* (also known as Koran), (ii) *Salmo thymus ohridanus* (also known as Belushka), (iii) *Salmo letnica lumi* (also known as koran of a river origin), (iv) *Cyprins carpio* (also known as Krap), (v) *Chondrostoma nasus ohridanus* (also known as Skobuzi), (vi) *Barbus merdinalis petenyi* (also known as Mërena), (vii) *Leuciscus cephalus albus* (also known as Kleni), (viii) *Rutilus rubilio ohridanus* (also known as Gurneci), (ix) *Alburnus albidus alborella* (also known as Pllashtia), (x) *Anguilla Anguilla* (also known as Ngjala) (Avramoski et al 2003; Rakaj & Flloko 1995).
Salmo Letnica (Karaman, 1924) or also known as Koran, and *Salmothymus ohridanus* (Steindachner, 1824) also known as Belushke are both the most preferred species by the customers, not only in the study area but also beyond it.

*Salmo Letnica (*koran) is an endemic species of Lake Ohrid which reaches its sexual maturity at the age of four when their body weight reaches a certain weight, more in detail 450 to 500 grams referring to males and 230 to 250 grams referring to females. Their body is covered with long epileptic scales dominated by black spots containing red dots on it. The muscle has white color tending in rose. At the age of two, *Salmo Letnica's* body size varies from 22.5-23 cm of height and 35-85 gr of weight. At the age of ten, body size reaches a height of 57 cm and a weight of 2700 gr. Their reproduction dates in winter (specially January-February) in the vicinity of underground springs. After reproduction, the female leaves to reaching the depth and does not encounter fishing until the successive fall. This endemic species is fed with other fish as Merena, Cironka, Gurnec etc (Rakaj et al 1995).
Salmo Thymus Ohridanus (Belushka) is found in the depth of 40-60 m, and reaches its sexual maturity at the age of 3-4. Regarding to body sizes, it varies from 20.5 cm of height and 85 gr of weight at the age of 3, and 32.5 cm of height and 360 gr of weight at the age of 9. Their feeding method is the same as Koran. (Rakaj, 1995; Rakaj et al 1995).

Both the above mentioned species have a high organoleptic and economic value, and are also seen as significant sources of income for local inhabitants. There are identified a variety of factors as main contributors on the reduction of species in Lake Ohrid watershed population such as: (i) tourism, (ii) lake line urbanization, (ii) reduction of water quality, (iv) urban waste etc. Those factors but not only have led to demolition or damage of spawning sites for fish production and consequently affected the drop on numbers of fish in Lake Ohrid (GIZ, 2015).
The protection of lake water quality is a very valuable step for the protection of living organisms growing in it. Pollution or infection of lake water can be caused by numerous factors such as discharge of untreated sewage waters, urban waste, water quality of rivers and those flowing into the lake etc. (Cullaj et al 2000; Avramovski et al 2004).

Authors Avramovski et al 2004, Malaj et al 2012; Hoxha M. 2016; Shehu et al 2017 in their publications on water pollution and sediments of Lake Ohrid for Albanian side have concluded metal waste traces both in water and sediment samples in some of the areas, mainly in Gur i Kuq, Cervenakë, Hudenisht, Pojske, Piskupat, also known as areas of historical industrial mining activities. Furthermore, presence of such metals in these areas, increases levels of pollution in sediments, water, flora and fauna of the lake. Moreover, natural serpentine soils of Pogradec area are another risk in endangering water quality of Lake Ohrid (Bani et al 2013). Heavy metals, without exception, cause health problems in all living beings, including aquatic organisms

causing numerous biochemical and histological changes including death (Bonanno et al 2016). Field studies and laboratory experiments indicate that bioaccumulation of heavy metals in fish muscles depends mainly from heavy metals concentration in surrounding water, period of exposure (Yujun Yi et al 2011), pH, water hardness etc. Fishes not only represent an important part of human food diet (as are being considered to be on top of food chain of aquatic ecosystem), but are also advised as environmental indicators in assessing the contamination of aquatic environment based on identification of a number of toxic substances including metal waste (Noel et al 2013;Ahmad & Sarah 2015). The purpose of this study is to evaluate the level of some heavy metals (Pb, Cd, and Cr) in muscles and some of the organs (liver, gills, intestine and eggs) in *Salmo Letnica* and *Salmo Thymus Ohridanus*, sampled in the Albanian side of Lake Ohrid.

Materials and methods

Study was conducted in the period 2014-2016, where 65 *Salmo letnica* (koran) and 35 *Salmo thymus ohridanus* (belushke) were sampled in Pogradec area (Lake Ohrid, Republic of Albania side). Five sampling points were selected: (1) Pogradec, (2) Gur i kuq/ Cervenake, (3) Hudenisht- Pojske, (4) Piskupat, and (5) Lin.

Figure 1. Sampling of Salmo letnica (koran) and Salmo thymus ohridanus (belushke).

Data processing and sampling preparation

Samples are selected randomly by local fishermen in the respective areas. Immediately after collection, samples are washed with distilled water and stored in a coolant container. For each sample, the data recorded are size, body weight, body length, sampling season, nutrition, and living habitat are gathered. Each group of fish is divided in two groups according to their body size:

Salmo letnica: (i) Small group with an average body weight of 150 to 600 grams, and (ii) Large group with an average body weight of 600 to 1500 grams.

Salmo thymus ohridanus: (i) Small group with an average body weight of 100 to 250 gr, and (ii)Large group with an average body weight of 260- 350 gr.

Sample preparation for analytical evaluation is made at the Laboratory of Diagnosis, Faculty of Veterinary Medicine, Agricultural University of Tirana. Preparatory procedure includes scaling, organs harvesting, skin removal and filleting. Scale removal is made with disinfected steel knifes in order to prevent further contamination. Internal organs are treated carefully so specific injury does not occur. Then, procedure is followed by skin removal and filleting. Several muscles are collected from different parts of the body, creating therefore a representative sample. After treatment, samples are then put in a plastic container and stored at a temperature of -20°C. Analytical evaluation is conducted at the Department of Public Health and Livestock, Faculty of Veterinary Medicine, University of Bari. Further procedures in sample treatment are the same as those made for muscles and organs. From each sample, 5 gr of mass is taken and homogenized with a blender, its disaggregation is achieved using 8 ml of Nitric Acid (HNO_3, 65%) and 3 ml of Perchloric Acid (HCl, 70%). Sample burnt was accomplished with the DK6 Heating Digester (Velp Scientifica), for a period of 4 hours at an increasing temperature from 90°C to 210°C. After digesting, samples are diluted with deionized water at 25 milliliter volume (Mohammed E et al 2017). Evaluation of Cadmium (Cd), Lead (Pb) and Chromium (Cr) is done using Solar Seria M-UNICAM, with a wavelength of 228.8 nm (Absorbing spectrophotometer device with atomic and graphite furnace). The analytical procedure is evaluated using certified reference materials (BCR 668). In order to have a minimal error, each sample is analyzed in two copies where the percentage error does not exceed 7%. Metal values are expressed in milligrams per kilogram of wet weight.

Statistical analysis of the obtained data was carried out using XLSTAT statistical software. First, ANOVA statistical modeling was employed to find any likely significant differences of heavy metals concentration in *Salmo letnica* and *Salmo thymus ohridanus* samples.. Data from the two periods (May and December) were compared using t-test.$P < 0.05$ was considering significant.

Results and discussions

- **Heavy metals concentration in muscles**

The main scope of this research is the assessment of three heavy metals (Pb, Cd, Cr) in *Salmo letnica* and *Salmo thymus ohridanus*. Values obtained from their analytical evaluation according to their sampling sites are reflected in the tables and figures as following.

Table 1 Average values and standard deviations of metals in Salmo letnica (Koran) and Salmo thymus ohridanus (Belushke) based on sampling sites (ppm).

	Pb		Cd		Cr	
	S. ohridanus	***S. letnica***	***S. ohridanus***	***S. letnica***	***S. ohridanus***	***S. letnica***
Pogradec	0.06 ± 0.006	0.05 ±0.013	0.10 ± 0.007	0.13± 0.03	0.14 ±0.02	0.15±0.04
G.Kuq /Çervenake	0.07 ± 0.04	0.09±0.022	0.12 ± 0.013	0.14± 0.03	0.18 ± 0.03	0.20 ±0.02
Hudenisht /Pojske	0.068 ± 0.01	0.06±0.013	0.12 ± 0.03	0.12 ±0.017	0.21 ± 0.04	0.23 ±0.03
Piskupat	0.07 ± 0.012	0.08 ± 0.017	0.09 ± 0.02	0.09±0.02	0.25 ± 0.03	0.27 ± 0.04
Lin	0.05 ± 0.006	0.058± 0.01	0.08 ± 0.012	0.1 ±0.02	0.12 ± 0.04	0.13± 0.03

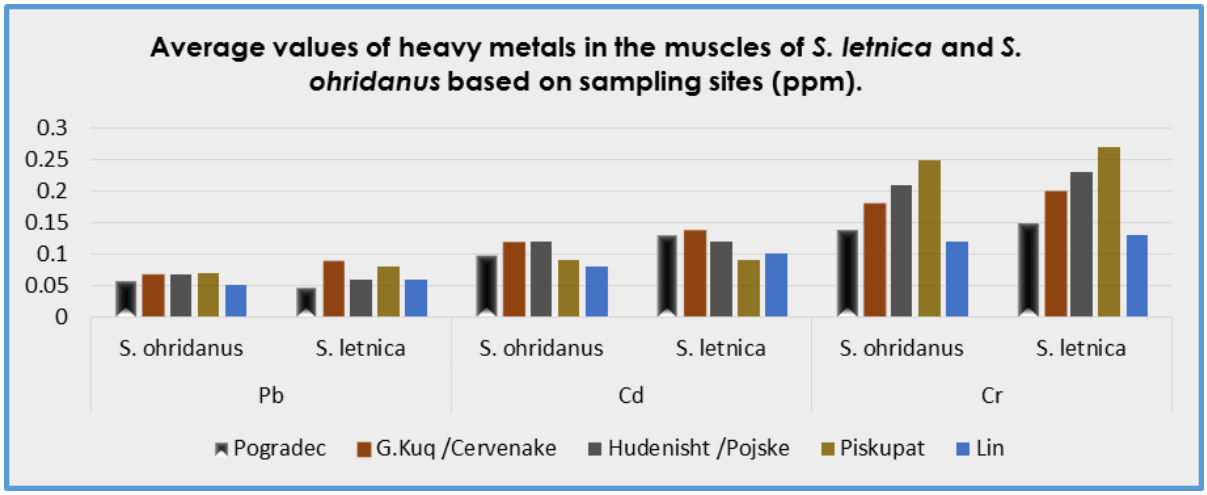

Figure 2. Average values of heavy metals in the muscles of S. letnica and S. ohridanus based on sampling sites (ppm.)

Referring to the values presented in table (1) and figure(2) above, it is noticeable the presence of heavy metals in both species of five respective sampling areas taken into consideration in this study.

Lead (Pb), even though in low concentrations is known as a toxic element and there are no known functions in biochemical processes. Measured values *in S. ohridanus* and *S. letnica* muscles vary from 0.05 ± 0.006 ppm to 0.09 ± 0.04 ppm. Referring to sampling areas, lead is identified to have higher values in fish muscles sampled in Guri i Kuq / Çervenakë area (0.09 ppm) than in fish muscles in Lin and Pogradec (0.05 ppm).

Cadmium is well known for its high toxicity, especially for aquatic organisms. Its accumulation in liver and kidney causes functional deterioration of these two organs. The Cd values in this study range from 0.08 ± 0.012 ppm to 0.12 ± 0.013 ppm in *S. ohridanus* and 0.09 ± 0.02 to 0.14 ± 0.013 ppm in *S. letnica*. Furthermore, the presence of such heavy metal is noticed in the five sampling areas taken into consideration for the purposes of this study. Also, the highest values were observed in Gur i Kuq/ Çervenakë and in Hudenisht/Pojskë sampling areas.

Chromium appears to have its highest values at Piskupat with 0.27 ± 0.04 ppm and in Hudenisht/Pojskëwith 0.23 ± 0.03 ppm,and its lower presence in Pogradec and Lin sampling areas with an average of 0.013 - 0.14 ppm.

Comparison of the average values of heavy metals between *S. letnica* and *S. ohridanus* did not show any significant variation. Although such comparison did not result with any significant difference, the highest values are found at Piskupat, Gur i Kuq/ Çervenakë and Hudenisht/ Pojskë sampling areas, while samples collected in Lin and Pogradec have resulted in lower values (table 2 and figure 3).

Authors Malaj et al. 2012, Shehu et al.(2017), Dalo et al.(2019) have published a series of studies on heavy metals contamination in water, sediments, vegetation and environment along lake Ohrid. So, based on their studies it is noticed a significant amount of heavy metals contamination in sediments, water, vegetation and soil along Lake Ohrid (Albania side). Malaj et al (2012), in his study on distribution of a vast range of heavy metals in Lake Ohrid, has published various values for a given number of sampling areas. According to Malaj et al (2012),chromium values near the sediments and water streams flowing into lake Ohrid, are at their highest amount in Çervenakë, Hudenisht, Gur i Kuq, Pojskë(549 ± 14; 515 ± 19; 417 ± 52 and 320 ± 22 mg / kg of dry weight), while regarding water samples obtained in these areas chromium varies from 7.12 ± 0.17 µg/l; 3. 8 ± 0.9 µg/l and 4.77 ± 0.28 µg/l at Çervenakë station. Likewise, author Shehu A et al.(2017) reported higher chromium amounts in Pojske, Çervenakë stations and lower amounts in Lin and Tushemisht stations. Moreover, author Dalo et al.(2019), in a study on the presence of heavy metals in sediments, water and *Phragmites australis* has introduced high values of chromium in the vicinity of the former Iron- Nickel Mine in Pogradec. Similarly, chromium values found in *S.letnica* and *S. ohridanus* sampled in these respective stations have resulted in higher values than those sampled in other stations. While the Pb and Cd values in the sampled fish muscle result higher in the areas where, according to Malaj et al. 2012, these metals result in higher values of cervenake floating water samples at 2.59 ± 0.15 µg / l, and Guri I Kuq 2.87 ± 0.37 µg / l. According to studies made by Hoxhaj, M (2016);Malaj et al. (2012); Shehu et al. (2017)pollution of water, sediments and respective flora and fauna in the Albanian side of lake Ohrid derives mostly from remains of old waste of the former mining industries, waste spilled uncontrollably by companies that exploit mining and underwater resources, and natural serpentine lands of Pogradec district (Bani et al. 2013).The current activity of chromium mine in Pojske, which even though works on reduced capacities, plays an important role in the pollution of the surrounding environment. Sealed and conserved mines, have an impact (although a lower impact) on the ecological balance of lake, as well as the pollution of environment and destruction of tourism areas. Despite mines are closed, presence of mining reserves has exacerbated the landscape of the area, becoming a major threat of lake Ohrid pollution (Albanian side). Industrial activities and min eral reserves are exposed constantly to precipitation that transport solid particles to the streams and later to lake Ohrid (GIZ 2015, Hoxhaj, M. 2016). According to this author, there are numerous streams and rivers whose waters flow into lake Ohrid with asignificant impact on pollution. More in detail, water streams, rivers and affected areas are numbered as follows: (i)Sream of Qershia; - waters carry metal residues from the former chromium mine of Pojska and flow into lake Ohrid (Pojska area), (ii) Stream of Mulleza (or Tre Boshtet); - waters carry the remains of Fe-Ni enrichment sterilization of Gur i Kuq mining zone and flow into lake Ohrid (between Hudenisht and Pojska

area), (iii) Stream of Kullovoza and Kalova river;- water transports the remains of metals deriving from two chromium exploitation galleries of Memelisht and flow into lake Ohrid (Memelisht area), and (iv) Kisha river, Terhan river; - waters carry sterile materials from Fe-Ni mines of Gur i Kuq and flow into lake Ohrid. Also, an important role related to lake pollution is played by the mining remains (damps) left in the vicinity of Cervenake and Pojske. All of the above factors contribute in pollution of sediments, lake Ohrid water and its respective biota.

Distribution of heavy metals in organs

In addition to the assessment of heavy metals in *S.letnica* and *S. ohridanus* muscles, is also evaluated the presence of such heavy metals in their organs as gills, liver, intestine and eggs. Both muscles and other different organs of fish are known for their accumulative properties of a wide range of heavy metals. For the purposes of this study, muscles are selected the most edible part of fish, being also a major resource of proteins and largely consumed by population (Olusola& Festus 2015).Meanwhile, fish heads and bones are used in the production of food additives, liver of some fish is considered consumable, therefore the assessment of heavy metals and other pollutants in such organs is indispensable.

In the table 2, are introduced the average values and standard deviations of Pb, Cd and Cr in organs of both species taken into consideration in this study.

Table 2 Average values of heavy metals found in organs of S. letnica and S. ohridanus (mg/kg wet weight).

	Pb		**Cd**		**Cr**	
Organs	***S. letnica***	***S. ohridanus***	***S. letnica***	***S. ohridanus***	***S. letnica***	***S. ohridanus***
Gills	0.13 ±0.06	0.1 ± 0.03	0.34±0.09	0.33 ±0.09	0.19 ± 0.03	0.18 ± 0.03
Liver	0.11 ± 0.02	0.09 ± 0.02	0.66 ± 0.2	0.68 ± 0.19	0.27 ±0.05	0.26 ±0.05
Gut	0.02 ± 0.01	0.01 ± 0.3	0.13 ± 0.06	0.11 ± 0.04	0.14 ± 0.16	0.15 ± 0.16
Eggs	0.03 ± 0.01	0.03 ± 0.02	0.09 ± 0.02	0.08 ± 0.02	0.1 ± 0.01	0.1 ± 0.05
Muscle	0.07 ± 0.02	0.06 ± 0.02	0.11 ± 0.02	0.09 ± 0.01	0.16 ± 0.05	0.14 ± 0.06

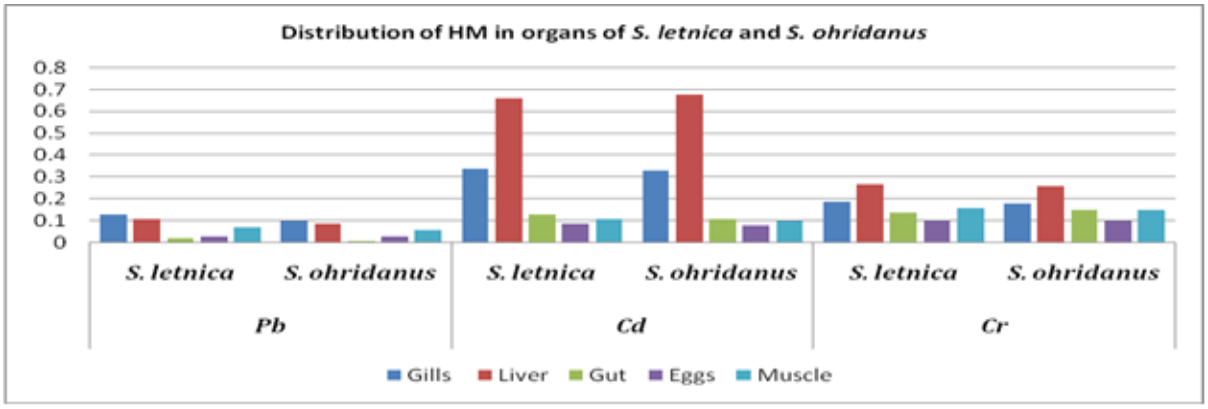

Figure 3. Distribution of heavy metals in organs of *S.letnica* and *S. ohridanus*.

Concentration of lead (Pb) resulted to be present in all organs. Furthermore, results presented in Table 2 and Figure 3 reveal that Pb in its highest values is indicated to be in gills and liver, while in its lower values is indicated to be in eggs and intestine.

(Pb: gills> liver> muscle> eggs> intestine). Lead amounts in *S. letnica* vary as following: 0.13 ± 0.06 ppm in the gills, 0.11 ± 0.02 ppm in the liver, 0.02 ± 0.01 ppm in the intestine, 0.03 ± 0.01 ppm in eggs, and 0.07 ± 0.02 ppm in the muscle. Values established in *S. ohridanus* are approximately the same as those in *S. letnica*. Comparison of results on organs of both species (*S. letnica* and *S. ohridanus*) resulted to have substantial variations. More in detail, differences in the bioaccumulation of lead were observed between gills-muscle, gills- intestine, gills- eggs, liver-eggs and liver- intestine (P<0,0005). Meanwhile comparison of results between gills and liver did not appear to have any significant difference, moreover such results were approximately the same. The same, author Akan, (2012), Marchet, P. et al.(2019) has reported the differences between accumulation of Pb in gills- liver and gills-intestine and intestine-muscle. In distinction to our results these authors did not find any difference in Pb values in liver-muscle and gill- muscle. Also, authors Shovon et al.(2017); Abarshi et al.(2017) have published higher values of Pb in gills and liver than in other organs.

Concentration of cadmium was assessed with the following values: gills of *S. letnica* containing 0.34±0.09 ppm, and gills of *S. ohridanus* containing 0.33 ± 0.09 ppm, liver of *S. letnica* containing 0.66 ± 0.2 ppm, and liver of *S. orhidanus* containing 0.68 ± 0.19 ppm, Intestine of *S. letnica* containing 013 ± 0.06ppm, and intestine of *S. ohridanus* containing 0.11 ± 0.04 ppm, and eggs of S.letnica containing 0.09 ± 0.02 ppm and eggs of *S. ohridanus* containing 0.08 ± 0.02 ppm. Bioaccumulation results to be higher in liver, followed by gills, while other organs contain lower concentration of cadmium. More in detail, concentration of cadmium in the organs of both species taken into consideration varies in the respective order: liver> gills> intestine> muscle> eggs. The authenticity of such varieties in values between organs resulted to be substantial. More in detail, liver- gills (P<0,005), and liver-muscle; liver-eggs; liver-intestine (P<0,0005). Differences in the bioaccumulation of cadmium were also observed between gills-intestine, gills-eggs and gills-muscles (P< 0,0005), while differences between muscle, intestine and eggs were statistically unrecognized. The results on bioaccumulation of Cd in organs are consistent with other authors as Marchett et al.(2019); Cogun, H. Y. et al.(2006); Ulturhan. (2017), while authors Aliu & Aliu (2012) have reported higher values of Cd in bone and liver.

On the other hand, chromium resulted to have higher bioaccumulation in liver with 0.27 ± 0.05 ppm in *S. letnica* and 0.26 ± 0.05 ppm in *S. ohridanus*. Followed by gills with 0.19 ± 0.03ppm in *S. letnica* and 0.18 ± 0.03ppm in S. ohridanus, intestines with 0.14 ± 0.16 ppm and even lower in eggs with 0.1 ± 0.01 ppm (Cr: liver > gills > intestine= muslce > eggs). Major differences are notices in accumulation of chromium between organs as following: liver-muscle, and liver-gills (P<0,005), liver-eggs (P<0,0005), and gills-eggs (P<0,05). Results of differences on accumulation of chromium in other organs are statistically unprovable. Results of this study are in line with reporting of Marchett, P et al.(2019), but differ from reports of Vinodhini, M.(2007 where according to them Cr has higher accumulation in muscles than in other organs.

Comparison of results regarding heavy metals concentration in organs of *S. letnica* and *S. ohridanus* did not indicate any major difference between them (P>0,05). In both species, liver and gills were the organs with the highest concentration of heavy metals. Findings similar to this study have been reported by authors Latifi et al.(2017) where cadmium and lead values were found to be higher in liver and gills. Other Moselhy et al. (2014) have introduced higher concentration of lead in gills than in other organs. Also, Akan et al. (2012), Jithesh & Radhakrishnan

(2016), Aliu & Aliu (2012)., Olusola & Festus (2015) have concluded that heavy metals accumulate more in organs than in muscles. Accumulation of heavy metals in different levels of concentration can be attributed to the proximity of organs with the environment in which the sample lives, its physiological state, presence of binding ions that have affinity with metals, and the role of tissues in the process of detoxification (Jithesh & Radhakrishnan 2016). Looking at this prospective, gills are in direct contact with the polluted environment, while other organs like liver, kidneys and muscle can accumulate heavy metals through blood cells. Also, gills have a structured organism and a high vascularity making these organs more suitable for the accumulation of heavy metals (Olgunoğlu et al. 2015). Other authors as Olusola & Festus (2015), findings related to higher concentrations in gills are enlighten with the fact that heavy metals form a compound with mucus present in the gills. Moreover, this bond or complex is impossible to be removed from the gills before its preparation for analysis. Accumulation of heavy metals with high concentrations in liver binds to many factors as for example the metabolic processes that develop in this organ (Twari-Fufeyin P& Ekaye SA 2007, Zhao et al. 2012), the ability of some heavy metals to link with metallothionein (Al-Ghanim et al 2016). So many authors considered the liver and gills as a good monitor for water pollution from metals because their concentrations accumulated in these organs are often proportional to those present in the environment Jezierska, B. & Witeska M. (2006).

Relation between seasons and heavy metals concentration

In many publication regarding the presence of heavy metals in biota, sea sediments, lake sediments or rivers, it is noticeable the relationship between the sampling season and the concentration of heavy metals resulted in them. Authors Ahmed & Hossam et al. (2013), Salem et al. (2014), Jithesh et al. (2017), Rajeshkumar & Xiaoyu (2018) etc, in their research studies have concluded that accumulation of some heavy metals in water and biota varies depending on sampling season.

The samples of both species taken into consideration for the purposes of this study were grouped according to the seasons. Specifically, Season 1 as Autumn/Winter season (September- February), and Season 2 as Spring/Summer season (March-August).

Table 3 Distribution of heavy metals depending on sampling season.

	Pb		Cd		Cr	
Seasons	S. letnica	S. ohridanus	S. letnica	S. ohridanus	S. letnica	S. ohridanus
Autumn/ Winter	0.026±0.009	0.024±0.013	0.06 ± 0.009^{a}	0.05±0.04^{b}	0.12 ± 0.01^{c}	0.11± 0.04^{d}
Spring/S ummer	0.04 ± 0.02	0,035 ± 0.01	0.1± 0.02^{a}	0.09±0.05^{b}	0.2 ± 0.02^{c}	0.2± 0.04^{d}

Where a, b, c, and d indicate statistically the difference between an average of heavy metal concentration found in two seasons (P<0,05)

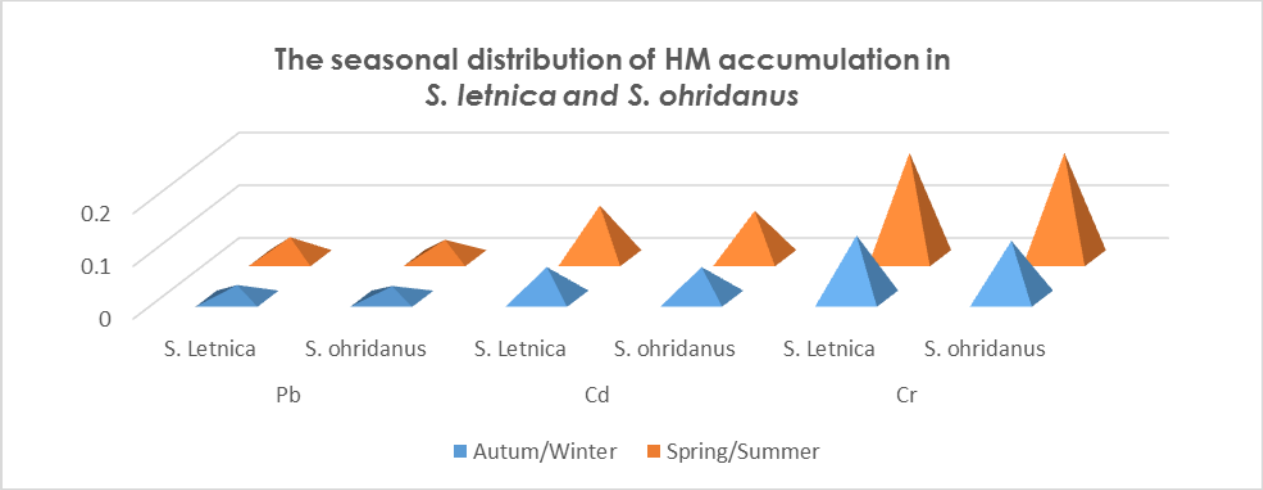

Figure 4 Seasonal distribution of heavy metal accumulation in S. letnica and S. ohridanus.

In table 3 and figure 4 above are introduced the amount of heavy metals present in fish muscles depending on sampling season. As it can be seen, heavy metals in the muscles of fish sampled in Season 2 (Spring/Summer) have resulted higher than those sampled in Season 1 (Autumn/Winter) ($P<0,05$). The statistically confirmed differences resulted especially in chromium and cadmium values of both fish species.

According to Bahnasawy et al (2011), these seasonal differences might occur due to fluctuations in the amount of water flowing into the lake deriving from agricultural drainage, sewage water or industrial waste. While authors Ali & Abdel-Satar (2005) attributed the increase of heavy metal concentrations in water during hot seasons (spring and summer) to the increment in the rate of release of such metals from sediments to the surface of water under the effect of hot temperatures, and also to the raise of fermentation process that occurs as a result of decomposition of the organic matter.

Jezierska & Witeska. (2006) in their study indicate that environmental factors play an important role in the accumulation of heavy metals in fish. While Kock et al (1996), explains the fact that higher amounts of cadmium in liver and kidney are identified during summer season when water temperature is higher, with the increment of the degree of metabolism of substances. From the study conducted by Douben (1989), the rate of absorption and elimination of cadmium by *Noemacheilus barbatulus* was increased with the increase of water temperature. According to this author, in a high temperature condition, cadmium absorption is higher than its elimination. Water temperature can cause differences in the deposition of heavy metals in different organs. High temperatures promote the accumulation of cadmium, especially in organs as kidneys and livers (Yang & Chen, 1996; Cogun H. Y. et al 2006, Cogun H. Y. et al 2017), in their study it was reported that progressive growth of heavy metals accumulation in tissues matched with the period of summer temperature. Laboratory experiments have shown that changes in temperature can affect the increase and decrease of heavy metals concentration due to the changes in metabolism and excretion of different species (Yang dhe Chen, 1996).

Concentration of heavy metals in the muscles of *S. letnica* and *S. ohridanus* depending on their body size

In order to indicate the degree of accumulation of heavy metals depending on the body size of fish, the samples are divided into two groups: (i) Large group and (ii) Small group. Respectively, for *S. letnica* the small group consisted of fish with an average body weight of 150 to 600 grams and the large group consisted of fish with an average body weight of 600 to 1500 grams. While for *S. ohridanus* in the small group were introduced fish with an average body weight of 100 to 250 grams, and the large group were introduced fish with an average body weight of 260-350 grams.

Table 4 Average values and standard deviation of heavy metals concentration in the muscles of S. letnica and S. ohridanus depending on their body size.

	Pb		Cd		Cr	
	Large	**Small**	**Large**	**Small**	**Large**	**Small**
S.letnica	0.082 ± 0.02^{a}	0.04 ± 0.02^{a}	0.11 ± 0.022^{c}	0.07 ± 0.025^{c}	0.17 ± 0.05^{d}	0.14 ± 0.03^{d}
S. ohridanus	0.06 ± 0.015^{b}	0.04 ± 0.02^{b}	0.09 ± 0.03	$0.07 \quad 0.02$	0.14 ± 0.03	0.11 ± 0.04

Where, a- (P<0,005), b-(P<0,05), c- (P<0,005), and d- (P<0,5).

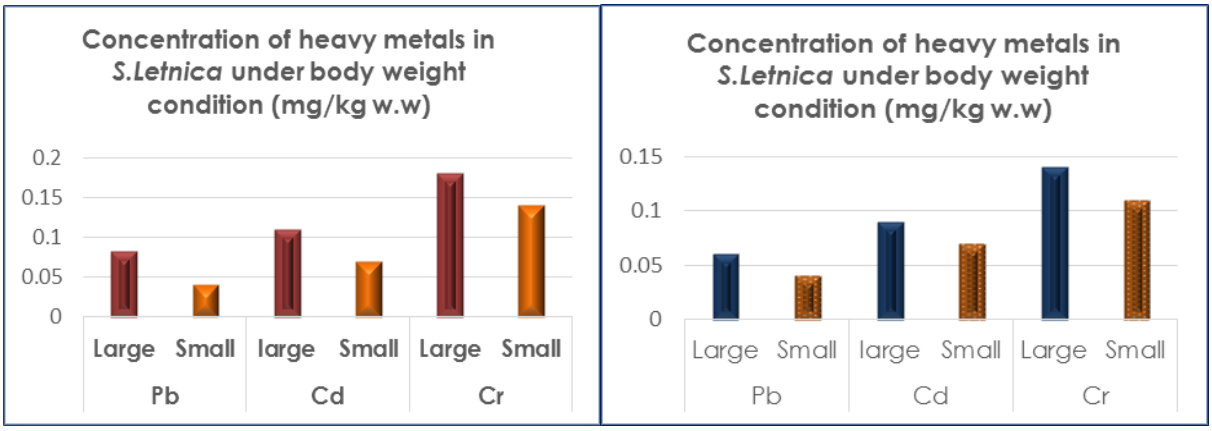

Figure 5 Average values and standard deviation of heavy metals concentration in the muscles of S. letnica and S. ohridanus depending on their body size.

In table 4 and figure 5 above, it is shown the difference between fish groups (small size and large size). Fish with smaller body size demonstrate to have lower concentration of heavy metals than fish with larger body size. These differences vary significantly for Pb, Cd (P<0.005) and Cr (P<0.05) in *S. letnica* and Pb (P< 0.05) in *S. ohridanus*. While cadmium and chromium in *S. ohridanus* did not show any important correlation.

It is well known the fact that body size can influence the concentration of heavy metals in aquatic organisms. However, the dependence between body size and heavy metals concentration is a complex issue widely discussed. Many studies indicate a positive correlation between the size of organism and concentration of heavy metals. Authors Farkas et al(2003), Adams, D.H. (2004), Soliman, I. Z. (2006), Yi & Zhang (2012), Bashir et al (2012), Saulick et al. (2017) in their research studies have reported a positive correlation between the body size of biota and accumulation of heavy metals. This can be attributed to the way of feeding, period of living in a

polluted environment and the active metabolic activity of adult organisms. However, other studies (Yap et al (2009), Canli & Atli 2003) indicate a negative correlation between body size and heavy metal concentration. Heavy metals concentration is higher in small body sized organisms, based on the fact that in small organisms the activity of metallothionein protein is higher and their low efficiency detoxification mechanisms.

Comparison of metal values with permissible limits for public consumption

According to EU (2014., 2015) and FAO/WHO (1989), the permitted limits for lead concentration in fish muscled must not exceed 0.30 mg/kg-1 wet weight. While FAO/WHO (1983) stated that the permitted limits for lead concentration in fish muscles at 0.50 mg/kg-1 wet weight. Lead values obtained from analytical evaluation of both species *S. letnica* and *S. ohridanus* were within the permitted limits.

According to EU (2014,2015), FAO/WHO 1989, FAO/WHO 1983, cadmium concentration must not exceed limits of 0.050 mg/kg-1 wet weight. In our study, cadmium concentration levels exceed the recommended limits in both species and in all sampling sites. Regarding chromium, concentration values were within the permitted limits as specified by EU (0.5 mg/kg-1 wet weight) and FAO/WHO 1989 (1.0 mg/kg-1 wet weight).

Conclusions

Referring to the study in question, it can be concluded that a higher concentration of heavy metals is found in liver and gills, and a lower concentration of heavy metals is found in muscles and eggs. The average concentration of heavy metals in organs has noticeable differences even though it cannot be always statistically verified. Cadmium and chromium represent the highest tendency for accumulation in organs. Accumulation of heavy metals was found at the highest levels in samples taken in spring/summer season. There was a significant difference in the accumulation of heavy metals in different organs of both species The values of heavy metals in the muscles was well below the allowed values for Pb and Cr. Cadmium was in the critical limit for general public consumption. The results of this study are backed by previous studies as well from different authors and they all agree that the government officials appointed for the protection of the environment should undertake different reforms and start programs that will benefit the lake water and will eliminate the different factors that pollute the lake . The continued monitor of the flora and fauna of this lake should serve as a bio indicator for the protection of the lake water in the years to come

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Lead Contamination of Seawater and Fish from Bar Region (Montenegro)

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Abstract

The heavy metal contamination of the environment, especially aquatic ecosystems, has alarmingly increased because of traffic emissions, fossil fuel burning, mining, industry, pesticides application, trash deposition and incineration. Lead (plumbum, Pb) concentrations are variable in the coastal seawater, as they are conditioned by the river inputs, salinity, redox gradients, currents, circulation speed, tides, temperatures and depth. In order to obtain data on Pb contamination, the water was sampled twice a year at five localities, on two depths. The fish were collected from the daily catch of the local fisherman by the random principal choice. The Pb contaminations of water samples and fish muscle tissue were tested applying Atomic Absorption Spectroscopy (HG/CV-AAS) by the Thermo electron S2 AA System. The highest concentration of Pb was detected in water sampled in summer, at Volujica locality (6.14 μg/dm^3). The presence of Pb was detected in all prospected fish species. The highest concentrations and above MAC were obtained in muscle tissue of *Trachurus mediterraneus* sampled in Sutomore (1.12 mg/kg). The continuous monitoring of Pb and other heavy metals in marine water, sediment and fish is more than necessary in order to prevent human and animal diseases and environment pollution.

Keywords: Lead, contamination, seawater, fish, Atomic Absorption Spectroscopy

Introduction

Lead (plumbum, Pb) is a natural toxic metal with cumulative effect, often found in the Earth's crust. According to WHO (Worlds Health Organisation, 2018), its widespread use has resulted in extensive environmental contamination, human exposure and significant public health problems in many parts of the world. The main sources of the soil, air and water contaminations are mining, smelting, heavy industry, recycling activities, and in some countries, the continued use of leaded paint, pipes, gasoline, and leaded aviation fuel. More than three quarters of the global lead consumption is for the lead-acid batteries manufactured for the motor vehicles (WHO, 2018). However, many other products, very often used, contain significant lead concentrations: pigments, paints, solder, stained glass, lead crystal glassware, ammunition, ceramic glazes, jewellery, toys, some cosmetics and traditional medicines.

Lead is a toxic metal whose widespread and frequent use has caused extensive environmental and health problems, especially in the developing countries (WHO, 2018). Lead is a cumulative toxicant which has multiple and serious effects on different human organs, mainly neurological, haematological, gastrointestinal, cardiovascular and renal systems (Kragulj et al. 2018). Children, especially foetuses, are predominantly vulnerable to the neurotoxic effects of lead, and relatively low levels can cause serious and irreversible neurological damages. Lead easily penetrates the body through the skin, mouth and respiratory organs. It is stored in the human body in bones, teeth, liver, lungs, kidney, spleen and brain. Furthermore, lead represents the great danger to human health, as it can pass from the maternal to foetal blood compartments and the blood-brain barrier. The recent reduction of the lead usage in petrol (gasoline), paints, pipes and solder have induced the new main way of human intoxication, which is according to (Maradani et al. 2016), usually associated with dietary intake of poisoned marine organisms.

Lead concentrations are variable in the seawater, as they are conditioned by the contamination source, freshwater inputs, salinity, redox gradients, currents, circulation speed, tides, temperatures and depth. Depending on the physical and chemical characteristics of the seawater, heavy metals can occur in a large number of different chemical forms, compounds and ions. The most frequent forms of lead in seawater are: $PbCO_3$, $Pb(CO_3)_2^{2-}$ and $PbCl^+$.

The accumulation of heavy metals in marine biota is influenced by numerous physical, chemical, biological and environmental factors. The heavy metal concentrations in the tissues of marine organisms is in a correspondence to the concentrations of metals in the water habitat (Kragulj et al. 2018). The heavy metal bioaccumulation is conditioned by the chemical form of the metal, which varies depending on the locality, seawater depth, pH, temperature and salinity. It is even possible that metal contaminants mutually interact, and one metal could inhibit or facilitate the accumulation of another by a particular organism (Kragulj et al. 2018).

The aim of this research was to acquire the data on lead contamination in fish and seawater samples from Bar region in Montenegro.

Material and Methods

The fish and water were sampled from five localities in Bar region: Utjeha, Volujica, Bar, Šušanj and Sutomore, twice a year, in summer and winter. The water samples were taken from the boat with a Friedinger sampler (1 dm^3), at two depths of the water column and two points regarding the coast distance (coastal seawater and open sea). The water was stored in the dark polyethylene bottles and preserved with nitric acid (1:1). The fish were collected from the daily catch of the local anglers by the random principal choice.

The water and fish samples were prepared for lead testing according to Rice et al. (2017). The lead contamination was tested using Atomic Absorption Spectroscopy (AAS) by the Thermo electron S2 AA System. The standard metal solution (stock solution, 1000 mg/L) was made by dissolving 1 g of metal or its salt (calculated on 1 g of metal) in hydrochloric acid (1:1). Diluting the stock solution (with water), a series of lower concentrations of metal were prepared.

Results

The detected lead concentrations in water samples are presented in Table 1.

Table 1. Lead contamination of seawater samples (µg/dm^3)

Locality	Depth (m)	Coastal sea		Depth (m)	Open sea	
		Summer	Winter		Summer	Winter
Utjeha	0.5	2.35	0.00	5	2.15	1.21
	3	3.33	1.30	10	0.18	0.90
Volujica	0.5	3.66	1.10	10	2.91	0.00
	5	6.14	2.23	20	3.71	0.54
Bar	0.5	3.28	2.00	5	1.19	0.00
	5	4.11	3.01	10	3.35	0.99
Šušanj	0.5	2.39	2.59	5	2.28	1.53
	5	4.03	3.15	10	2.87	0.00
Sutomore	0.5	1.98	0.28	10	1.07	0.24
	3	3.73	1.23	20	2.29	0.00

The presence of lead was detected in muscle tissue of all prospected fish species with different concentrations (Table 2.). The following species were tested: *Mullus surmuletus* Linnaeus, 1758 (Surmullet or Striped red mullet); *Oblada melanura* (Linnaeus, 1758) (Saddled seabream); *Lophius budegassa* Spinola, 1807 (Blackbellied angler); *Merluccius merluccius* (Linnaeus, 1758) (European hake); *Raja montagui* Fowler, 1910 (Spotted ray); *Raja miraletus* Linnaeus, 1758 (Brown ray); *Solea solea* (Linnaeus, 1758) (Common sole); *Mugil cephalus* Linnaeus, 1758 (Flathead grey mullet); *Diplodus annularis* (Linnaeus, 1758) (Annular seabream); *Dentex dentex* (Linnaeus, 1758) (Common dentex); *Sardinella aurita* Valenciennes, 1847 (Round sardinella); *Pagellus erythrinus* (Linnaeus, 1758) (Common pandora) and *Trachurus mediterraneus* (Steindachner, 1868) (Mediterranean horse mackerel).

Table 2. Lead contamination of fish muscle tissue

Locality	Fish species	Average concentration of detected Pb (mg/kg)	Diet and food**
Utjeha	*Mullus surmuletus*	0.10	zooplankton, zoobenthos, plants, nekton, detritus
	Oblada melanura	0.75*	zooplankton, zoobenthos
	Lophius budegassa	0.10	zoobenthos, nekton
Volujica	*Merluccius merluccius*	0.25	zoobenthos, plants, nekton, zooplankton,
	Raja montagui	0.10	zoobenthos, nekton, zooplankton
	Raja miraletus	0.10	zoobenthos, nekton, zooplankton
Bar	*Solea solea*	0.20	zooplankton, zoobenthos, plants, nekton, detritus
	Mugil cephalus	0.78*	zooplankton, zoobenthos, detritus, plants
	Raja miraletus	0.10	zoobenthos, nekton, zooplankton
Šušanj	*Diplodus annularis*	0.39	zooplankton, zoobenthos, plants, nekton
	Dentex dentex	0.72*	zoobenthos, nekton
	Sardinella aurita	0.25	zooplankton, zoobenthos, plants, nekton
Sutomore	*Pagellus erythrinus*	0.10	zooplankton, zoobenthos, nekton
	Trachurus mediterraneus	1.12*	zooplankton, zoobenthos, plants, nekton
	Raja miraletus	0.10	zoobenthos, nekton, zooplankton

*results above the maximum permissible concentrations (MPC) according to Commission Regulation (EC) No 1881/2006 and Official Gazette of Montenegro 81/2009
** according to www.fishbase.in

Discussion

The lead concentrations in water samples varied depending on locality, season and the distance from the coast. The highest concentration of lead was detected in water sampled in summer, at Volujica locality (6.14 µg/dm^3).

In general, higher lead concentrations are observed in coastal sea during summer at all five localities. This can be explained by the inflow of freshwater rich in nutrients, the discharge of industrial, agricultural and municipal wastewater and wet deposition from the atmosphere (Kragulj et al. 2018). Beside anthropogenic influence, numerous natural abiotic and biotic factors influence seasonal and spatial patterns of lead concentrations in seawater: size of the water body, currents, circulation speed, tides, temperatures, depth, submarine outflows, atmospheric precipitation, freshwater flow and even marine wildlife density and diversity.

The lead concentrations above the maximum permissible concentrations (MPC) according to Commission Regulation (EC) No 1881/2006 and Official Gazette of

Montenegro 81/2009, have been found in muscles of four fish species: *T. mediterraneus*, *D. dentex*, *M. cephalus* and *O. melanura*. The obtained results are in accordance with Tepe (2009) who reported 0.11-1.15 mg/kg of lead in eight Mediterranean Sea fish species, 1.15 mg/kg in muscles of *M. cephalus* and 0.27 mg/kg in *P. erythrinus*. According to the same author, the main reasons of fish contamination by lead are fish's diet and the residues of ship waste dumped into the Mediterranean Sea.

Consequential to the lead contamination in water, the presence of this metal in fish tissues also demonstrate the differences regarding the geographic region: 0.33–0.93 mg/kg was reported for Black and Aegean seas (Uluozlu et al. 2007), 0.01– 0.15 mg/kg for Ria de Averio in Portugal (Cid et al. 2001), and 0.11–0.89 mg/kg in muscles and 0.38–4.48 mg/kg in livers of fish from the coastal waters of Turkey (Tepe et al. 2008). According to Lombardi et al. (2010), there is no difference in lead concentrations between male and female fish, but Maradani et al. (2016) emphasized that the amount of heavy metals in a fish depends on several factors: the climate, fish's diet, metabolism, age, size, weight and gender. Cogun et al. (2006) noted that cannier and deep water fish had higher concentrations of heavy metals in their gills and livers, and the lower in muscle tissues.

Fish represent precise, suitable and economically justified bioindicators and biomonitors for marine pollution analyses. In addition, a large number of fish species are usually used in human and animal diet, especially in the coastal regions. The continuous monitoring of lead and other heavy metal concentrations in water, sediment and fish is obligatory in order to prevent human and animal diseases and environment pollution.

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Preliminary study of trophic relation between diatoms and endemic species *Drusus ramae* Marinković-Gospodnetić (1970) (Insecta: Trichoptera) at the Lištica spring, Bosnia and Herzegovina

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Abstract

The purpose of preliminary study was to establish the existence of trophic relation between diatoms and endemic species Drusus ramae in the Lištica spring, Bosnia and Herzegovina. We were taken samples two times from different types of substrates (limestone rock, genera Fontinalis moss and Trichoptera: larva case of Drusus ramae) at the rheocrene spring. In the same time, physical and chemical conditions were measured. Data of physical and chemical conditions in the Lištica spring were shown good aeration, low temperature values, pH typical for carbonate bed/origin and generally oligotrophic conditions. Samples from different types of substrates were shown great variety in diatom taxa as well as their different dominance considering the substrates. Diatoms were we determined on the Fontinalis moss and limestone rock substrates indicate that pioneer taxa comes primarily on these substrates, while on the larva case of D. ramae species that have a longer colonization time. Based on our results it is possible that species D. ramae feed on diatom taxa, uses them in cases construction and grows. Also it uses them as a source of energy. Lištica spring is important refuge for preserving and conservation freshwater diatoms and endemic species Drusus ramae. Uncontrolled management, capturing of springs, and modification of spring can result in destroying habitats for endemic species and therefore the reduction of the diversity of rare taxa in the future.

Keywords: diatoms; *Drusus ramae*; karstic spring; trophic relation

Introduction

Karst is very specific geomorphological phenomenon characterized by the rapid filtering surface waters in the ground as well as small number of surface water

flows. Most of the filtering is happening beneath the surface. In karst as a specific type of landscape karst springs are common place where underground water comes out to the surface creating apparent flow. Springs are mostly small, but complex and species rich ecosystems, with mosaic structure and high level of individuality as well as mostly stable physical and chemical conditions (Cantonati *et. al*., 2006). A common characteristic of karstic springs, whether permanent or temporary, is the strong dependence of discharge on precipitation. As a consequence, the ratio between minimum and maximum discharge is great (1:60, or more) (Milanović, 2006). Due its specificity, karstic springs and rivers belong to a group of vulnerable aquatic ecosystems.

Climate change and anthropogenic impacts on ecosystems have a significant impact on vulnerability. That being said, there are certain requests for the implementation of comprehensive methodological approaches to the assessment of the actual status of these ecosystems as well as in monitoring the levels of changes occurring in ecosystems (Li Li *et al*., 2010).

Community in freshwater ecosystems are sensitive indicators of water status, because they integrate and maintain the influence of various environmental factors, various types of contamination, degradation, fragmentation of habitats etc. (Norris & Barbour, 2009). Faunal, microfloral and hydro-chemical research are important for assessing the level of changes in spring ecosystems (Kwiatkowska et al., 2016).

Some organisms, referred to as bioindicators, can play an important role in assessing a state of naturalness of springs waters (Holt & Miller, 2011; Kwiatkowska et al., 2016). Macroinvertebrates and diatoms are the most commonly used bioindicators in freshwater biomonitoring. According to Martin & Fernandez (2012) the advantage of using diatoms as bioindicators reflects in their fast reproduction and short life cycle that is significant in the case of short-term changes in the environment. They are the most abundant and represent the largest biomass of primary producers in springs.

Great number of benthic macroinvertebrates inhabit springs and streams at least in one part of their life cycle. They are used as bioindicators for their easy identification and sampling as well as for the reason that most of the species have complex life cycle and sensitive life phases such as stage of larva who respond to stress and environmental changes faster (Barbour *et. al*., 1999). Species *Drusus ramie* Marinković-Gospodnetić (1970) belongs to the order of benthic macroinvertebrates that are used as bioindicators-Trichoptera.

The aim of this preliminary study was to establish the existence of trophic relation between diatoms and species *D. ramae*.

Study area

The study area is located in western part of Herzegovina, Bosnia and Herzegovina. Western Herzegovina belongs to one of the High Karst zones; the Orogenic Accumulated Karst (Herak, 1977). The Lištica River flows out under the Cigansko brdo from several cracks. With its flow it belongs to basin of Mostarsko blato and it is right tributary of the Neretva River and along with the Neretva River it belongs to Adriatic Sea basin. The spring is located at altitude of 310 meters and on coordinates: N = 43°2'46.8'' and E = 17°35'47.9''. The spring is rheocrene type, water flows out from highly broken limestone that are covered with moss.

The type of rocks in Lištica springs are the Lower Cretaceous dolomites. There are no signs of organic pollution.

Material and Methods

The research was carried out through several stages: field research, measuring of physical and chemical conditions, sampling, laboratory treatment of materials, making permanent microscopic slides and diatoms determination. The study was conducted on August 27th 2015 and on April 21st 2016 at the Lištica spring. Water temperature, pH, electrical conductivity, dissolved oxygen, oxygen saturation and salinity were measured in situ using ecological probe (WTW Multi-Parameter Instruments, Germany).

Samples for diatoms were taken in accordance to European Standard EN 13 946 (2014). They were taken scraping the material (with scalpel or toothbrush) from rock surface. Epiphytic diatoms were collected from the genus *Fontinalis* moss and from the larva case of the *D. ramae*. Epiphyton was removed from all the fragments using a toothbrush and diatoms were cleaned and mounted on permanent slides according to standard European and French protocols (Kelly et al. 1998, AFNOR 2000, CEN 2002). All samples were fixated on the field with 4% formaldehyde until further laboratory treatment. To the preparation of permanent slides was preceded by cleaning frustules from organic matter. The diatoms were identified at a high magnification (100x). Counting of taxa was made in arbitrary transcriptions counting 400 frustules on a light microscope with the contrast (DIC) on magnification 1000x.

Species were determined using relevant scientific literature and keys; Krammer & Lange-Bertalot (1986-1991), Lange-Bertalot & Krammer (1989), Lange-Bertalot & Metzeltin (1996), Lange-Bertalot (1993, 2001), Krammer (2000-2003), Krammer & Lange-Bertalot (1997a, 1997b, 2004), Levkov (2009).

The *D. ramae* larvae were collected using tweezers and, after the isolation on field, were storage in special labeled bottles and conserved with 4 % formaldehyde. We just determined diatoms on surface larvae.

Results and Discussion

Values of the physical and chemical conditions measured in the Lištica spring are shown in Table 1.

Table 1. Values of physical and chemical conditions in the Lištica spring.

Date of sampling	Temperature (°C)	pH	Conductivity (µS/cm)	Dissolved oxygen (mg/L)	Oxygen Saturation (%)	Salinity (‰)
27.8.2015.	8,7	7	375	13,6	120	0,1
21.4.2016.	9,3	7	458	14,6	130	0,1

Values of physical and chemical conditions show good aeration, pH typical for carbonate bed/origin and generally oligotrophic conditions. According to physical and chemical conditions Lištica spring has a high ecological status (Official Gazette BiH). Almost all karstic springs have a low water temperature (8-12°C) with small annual fluctuations, high oxygen concentration (8-12 mg L^{-1}), neutral pH and high carbon dioxide (up to 60 mg L^{-1}) (Blagojević, 1976; Dedić et al., 2015) which is in agreement with our results. The conductivity in springs is in dependence about

porosity of rock aquifers. Also, depends about water temperature. Higher water temperature causes and higher conductivity which also confirm our results. Samples of diatoms were taken on two occasions from the Lištica spring from three different type of substrates. A total of 26 taxa of diatoms were determined. The list of taxa is shown in the Table 2.

Table 2. List of determined taxa in the Lištica spring on different types of substrates (six samples).

Taxa	**Rock**	**Moss**	***D. ramae***
Achnanthidium minutissimum (Kützing) Czarnecki	+	+	+
Amphora pediculus (Kützing) Grunow			+
Caloneis bacillum (Grunow) Cleve		+	
Cocconeis neodiminuta Krammer		+	
Cocconeis placentula Ehrenberg	+	+	+
Cocconeis placentula var. *euglypta* (Ehrenberg) Grunow	+	+	+
Cocconeis placentula var. *lineata* (Ehrenberg) Van Huerck	+	+	+
Cymbella affinis Kützing	+		
Cymbella tumida (Brébisson) Van Huerck	+		
Denticula sp.	+		
Diatoma mesodon (Ehrenberg) Kützing	+	+	+
Diatoma vulgaris var. *linearis* Grunow	+	+	
Encyonema ventricosum (C. Agardh) Grunow	+	+	+
Fragilaria capucina var. *vaucheriae* (Kützing) Lange-Bertalot		+	+
Gomphonema sp.	+	+	
Gyrosigma scalproides (Rabenhorst) Cleve			+
Meridion circulare (Greville) C. Agardh	+	+	+
Navicula cari Ehrenberg	+	+	+
Navicula cryptocephala Kützing		+	
Navicula tripunctata (O.F. Müller) Bory		+	
Nitzschia dissipata (Kützing) Rabenhorst			+
Pinnularia sp.		+	
Planothidium lanceolatum (Brébisson ex Kützing) Lange-Bertalot		+	+
Rhoicosphenia abbreviata (C. Agardh) Lange-Bertalot	+	+	+

Taxa	Rock	Moss	*D. ramae*
Staurosirella pinnata (Ehrenberg) D.M. Williams & Round		+	
Ulnaria ulna (Nitzsch) Compére			+

Achnanthidium minutissimum (Kützing) Czarnecki, *Cocconeis placentula* Ehrenberg, *Cocconeis placentula* var. *euglypta* (Ehrenberg) Grunow, *Cocconeis placentula* var. *lineata* (Ehrenberg) Van Huerck, *Diatoma mesodon* (Ehrenberg) Kützing, *Meridion circulare* (Greville) C. Agardh, *Navicula cari* Ehrenberg, *Rhoicosphenia abbreviata* (C. Agardh) Lange-Bertalot were presented in all samples. All taxas are cosmopolitan with wide range of distribution. The most abundant generas on different substrates were; *Cocconeis* (on the moss), *Navicula* (on the rock) and *Fragilaria* (on the larva case of *D. ramae*). The most abundant taxa on the larva case of *D. ramae* was *Fragilaria capucina* var. *vaucheriae*. The highest number of taxa were represented on the moss substrate (19).

According to Plenković-Moraj (2008) *Cocconeis placentula* Ehrenberg as some species of genus *Navicula* consider as pioneer taxas that come on different substrates. Other reason for high abundance and frequency of those taxa on some substrates is that they respond very well on stress and have ability of reproduction with relative high level of growth so they manage to inhabit area before other species. Pioneer taxa prepare substrate for other taxa and colonization process. Elevated species and species on short stands as well as the one on long stands and diatoms in rosettes come after pioneer species (*Achnatidium*, *Synedra*, *Fragilaria*, *Meridion*). That goes in favor obtained our results. Dominant taxa on the larva case of *Drusus ramae* was *Fragilaria capucina* var. *vaucheraie* (Kützing) Lange-Bertalot. It is cosmopolitan taxa and belongs to taxas that requires moderate oxygen saturation and prefers eutraphentic habitats (Van Damm, 1994). Different diatoms, especially taxa that have longer colonization time on larva case of *Drusus ramae* suggest on the existence of specific relation between *Drusus ramae* and the diatoms in the Lištica spring. Based on the results it is possible that *Drusus ramae* has been feeding on diatom taxa, uses them in the construction of its larva cases as well as it cultivates them and uses as the source of the energy. According to Cantonati (1998) the diversity of diatoms communities is greater in late spring and early summer. On the Lištica spring was noticed the increase in the diversity of species at end of the August. According to Van Dam (1994) 21 taxas in our research showed certain indicator values which are showed in Table 3.

Table 3. Diatom classification based on ecological factors (van Dam *et. al.*, 1994).

	R	Indicator organisms	No. of species	%
Water pH	1	Acidobiontic, pH < 5,5	-	-
	2	Acidophilous, pH < 7	-	-
	3	Circumneutral, pH ≈ 7	3	11,5
	4	Alkaliphilous, pH ≥ 7	18	69,2
	5	Alkalibiontic, pH > 7	1	3,9
	6	Indifferent	-	-
	O_2	**Oxygen saturation (%)**	**No. of species**	**%**
	1	Continuously high, 100 %	6	23,1

O_2	2	Fairly high, above 75 %	8	30,8
	3	Moderate, above 50 %	7	3,9
	4	Low, above 30 %	-	-
	5	Very low, about 10 %	-	-
Trophicity	**T**	**Type of habitat**	**No. of species**	**%**
	1	Oligotraphentic	-	-
	2	Oligo-mesotraphentic	1	3,8
	3	Mesotraphentic	2	7,7
	4	Meso-eutraphentic	3	11,5
	5	Eutraphentic	11	42,3
	6	Hypereutraphentic	6	23,1
	7	Oligo- to eutraphenticx	-	-

According to the list of indicative values (van Damm et. al., 1994), highest number of taxas in the Lištica spring are alkaliphilous (69.2 %) and circumneutral (11.5 %) which coincides with measured values of water pH. Species which requires fairly high (75 %) and continuously high (100 %) oxygen saturation are the most abundant species in the spring. Measured values of oxygen saturation were above 120 % which support our results. Regarding measured values of trophicity, trophic index of diatoms indicate on the eutraphentic and oligo-to eutraphentic spring status. According to Van Damme et. al. (1994), even 42.3% of species indicate to eutraphentic status of spring which is in contrast with estimated ecological status of the spring. Only 23.1% of species prefer habitat that correspond to the description of trophic status of the spring (oligo-to eutraphentic habitat). This certainly does not describe real status of spring area, but it speaks of non-applicability of values which are not designed for the taxa in the karstic spring. Springs are recognized as hotspots for freshwater biodiversity conservation. Diatoms in karstic springs have received little attention in Bosnia and Herzegovina, despite the fact that springs provide specific conditions that cannot be found in any other freshwater ecosystem. Also in spite of their great importance in terms of general environmental changes.

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Genus *Polygonia* Hübner, 1818 (Lepidoptera: Papilionoidea: Nymphalidae) from Bosnia and Herzegovina with an emphasis on south slopes of the Prenj-Mtn.

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Abstract

The aforesaid genus in Bosnia and Herzegovina is represented by two species: *P. c-album* (Linnaeus, 1758) is typically continental, while the other, P. aegea (Cramer, 1775) is typically Mediterranean, so the marginalization level of mentioned species (in Bosnia and Herzegovina) is an interesting scientific question. We have discovered that individuals of both species are regularly found on the mountain Prenj and its geographical position in this paper is emphasized.

Keywords: *Polygonia*. *c-album*, *egea*, *Nymphalidae*, butterflies, biodiversity, Prenj, Bosnia and Herzegovina

Introduction

The research of daily butterfly fauna in Bosnia and Herzegovina has a long tradition. Unfortunately, the explorations have been reduced to several groups (daily butterflies), while the data on many of them, even the ones of the most attractive species, are very old (Lelo, 2008; Žujo Zekić et al., 2009).

Members of the genus Polygonia (Hubner, 1818) belong to medium-sized butterfly species, with a very unusual wing shape.

The genus Polygonia (Hubner, 1818) in Bosnia and Herzegovina is represented with two species: *P. c-album* (Linnaeus, 1758) and *P. egea* (Cramer, 1775) (Lelo, 2008).
Polygonia c-album species inhabits the area of Northern Africa, Europe, Turkey, Central Asia, Northern China, Korea and Japan.

The time of the flight is from June to August during winter until June, in two generations. It inhabits light forests, flower meadows and gardens, and in the hills up

to 2000 meters above sea level. The larvae feed on the plants from various genera: *Ribes, Urtica, Salix, Humulus, Corylus, Ulmus*, etc. All over Bosnia and Herzegovina the usual species is present as well. However, it is significantly rarer and it has been replaced by the species *Polygonia egea* (Lelo, 2004; 2008; 2016).

The species *Polygonia egea* inhabits the area of Southeast France, Italy, Southern Balkan Peninsula, Greece, Turkey, Middle East, Iran and Northern India.

The time of the flight is in two generations, the first from May to June and the second from August until the first snows. This species inhabits warm habitats, on the rocks up to approximately 1700 meters above sea level. The larvae feed on primarily plant *Parietaria officinalis* and less often the species: *Urtica dioica, Salix caprea* and *Ulmus glabra*. In Bosnia and Herzegovina it inhabits southern areas of the country (Lelo, 2004; 2008; 2016).

In this paper we have attempted to establish the range of diversification within the genus Polygonia (Nymphalidae, Nymphalini), based on knowledge of the areal of ovipositorial species, the host plant *Parietaria officinalis*.

Material and Methods

The data on distribution of the genus Polygonia (Hubner, 1818) in Bosnia and Herzegovina have been collected from larger number of papers and many field research by the authors (Rebel, 1904; Sijarić, 1966; Sijarić 1971; Sijarić 1991; Lelo, 2002; Lelo, 2008). The research of daily butterfly fauna of south slopes of the Prenj-Mtn. in different time periods has shown many variations in the species distribution. A certain number of butterflies has been collected and processed by standard methods (Lelo, 2008). The identification of individuals has been done by the Key for identification of daily butterfly (Lelo, 2008; Popović & Đurić, 2011). A map of temporary distribution of observed species has been made in the map of Bosnia and Herzegovina according to Google Earth Pro program.

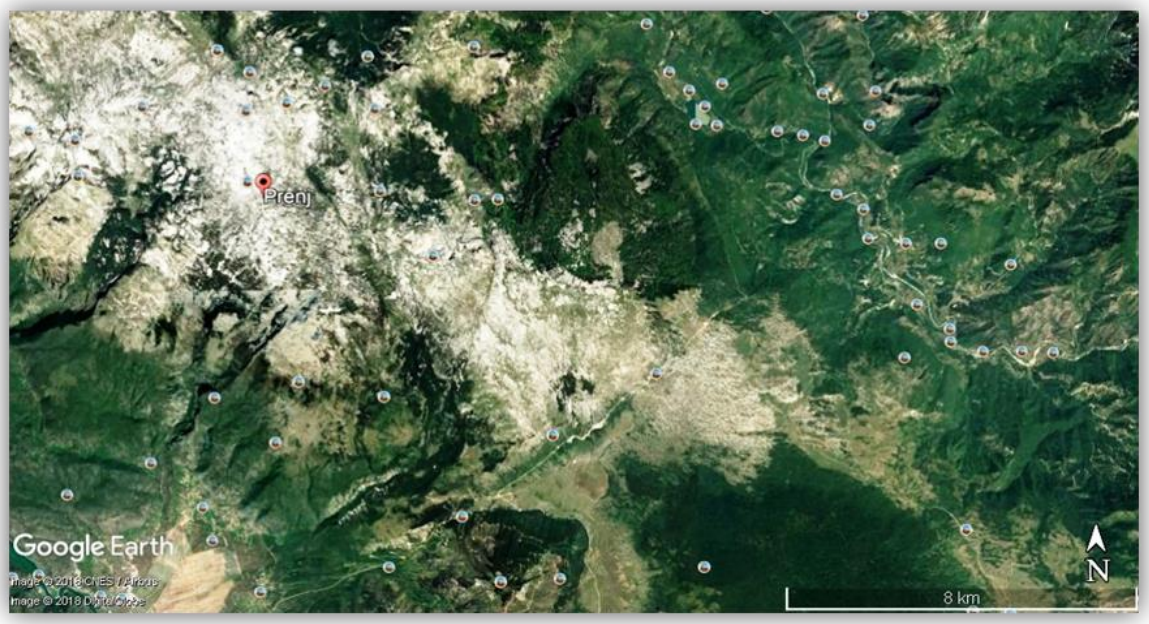

Figure 1. The view of Prenj-Mtn. (source: Google Earth Pro)

Results and Discussion

The research of butterflies from south slopes of the Prenj-Mtn. is done in view of displaying biodiversity of this area, specifically to create an entomological profile. The research has been conducted in period from end of April to September 2017-2019. With field research on south slopes of the Prenj-Mtn. (2017/2019) there has been collected a total of fourteen individuals of the species *Polygonia c-album*.
By examining a series of lepidopterological papers it has been stated that *Polygonia c-album* is widespread and common species in Bosnia and Herzegovina and so far it has been cited in various accessible papers in many localities all over Bosnia and Herzegovina.

Figure 2. The top view (right) and underside view (left) of the species *Polygonia c – album* Linnaeus, 1758 (Rošca, 30.07. 2017, leg. A. Šunje)

With the field research on the south slopes of the Prenj-Mtn. (2017/2018) there has been collected a toal of three individuals of the species *Polygonia egea*, while an up-to-date research (2019) confirmed the finding of the Prenj-Mtn. locality, by catching three individuals of the species *Polygonia egea*. The individuals of the listed species have been spotted exclusively along the edges of the road on ovipositorial plant *Parietaria officinalis*. With previous research and accessible data in mind (Lelo, 2008), this species has not been listed within the examined area at this altitude, therefore this is a new finding of this species in Bosnia and Herzegovina.

Figure 3. The top view (right) and underside view (left) of the body side of the species *Polygonia egea* Cramer, 1775 (Rošca, 12.08.2018, leg. A. Šunje)

During areal and habitat condition analysis for the species *Polygonia egea* Cramer, 1775 it has been moved a step further by following microhabitat and ovipositorial plant species *Parietaria officinalis* L. For the listed plant species it is known that it grows in moist forests, ports, „slomovima", as well as on „grohotu", desolate places and low parts in an area all over to Prealps (around 600 meters).

In Bosnia and Herzegovina for the species *Parietaria officinalis* we record a relatively scarce number of findings; in the area of Bosnia it is widespread around Krupa, Ključ, Jajce, Banjaluka, Travnik, Žepče, Vranduk, Zenica, Srebrenik, Zvornik, Fojnica, Sarajevo, Foča, Sutjeska valley, at Šuljaga, Malovan, Kamešnica, Šator, Dinara, near Livno, and some other places, while in Herzegovina it is scattered, near Konjic, in Idbar valley in the Prenj-Mtn., in Grabovica valley, on the Čvrsnica Mtn., at Glogovo, at Hum near Mostar, towards Metković (Beck, 1906).

To these current findings from reference literature we add the finding of the species *Parietaria officinalis* on area of Rošca at an altitude from 400 to 950 meters, where it has been found and examined the species of butterfly *Polygonia egea* Cramer, 1775. This species of butterfly, of the folk name *the White Fox (Little Fox),* has been expected to be found precisely close to the foster plant, among which are mentioned – in addition to *Parietaria officinalis* – species *Urtica dioica, Salix caprea* i *Ulmus glabra.* In the following section there is an image of the species *Parietaria officinalis* (Illustration 4.) as well as the associated map of this plant species distribution in the area of Bosnia and Herzegovina (Illustration 5) which contains all the previous findings and an addition with current findings of the author herself.

Figure 4. *Parietaria officinalis* (photo by Šunje, A. 2019)

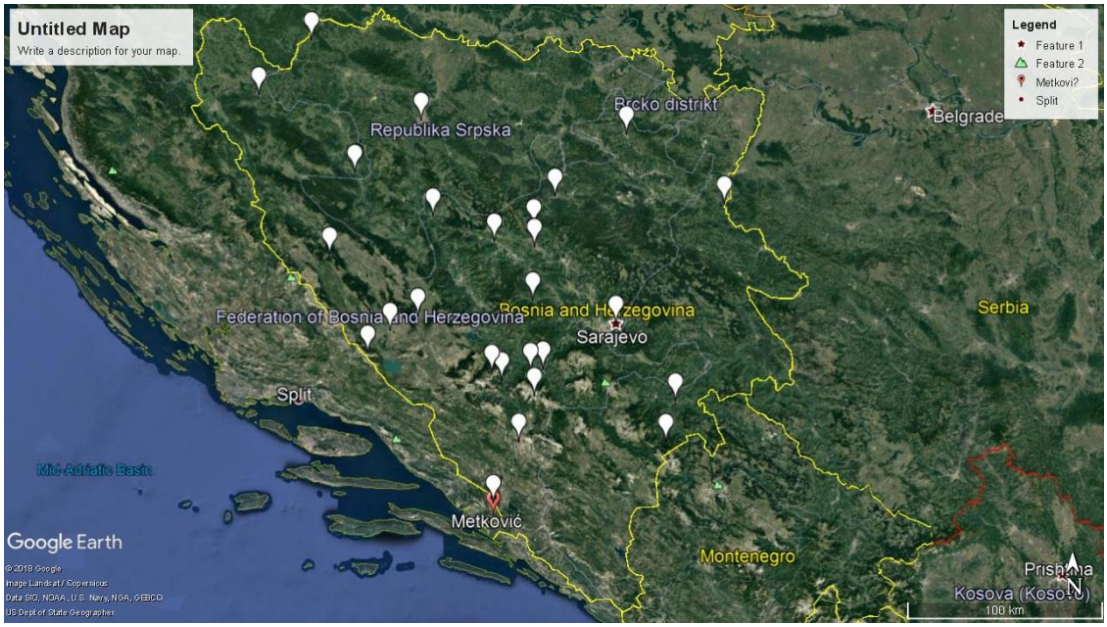

Figure 5. The distribution map of the species *Parietaria officinalis*; Krupa, Ključ, Jajce, Banja Luka, Travnik, Žepče, Vranduk, Zenica, Srebrenik, Zvornik, Fojnica, Sarajevo, Foča, Sutjeska valley, at Šuljaga, Malovan, Kamešnica, Šator, Dinara, near Livno, near Konjic, in the Idbar valley in the Prenj-Mtn., Rošce on the Prenj-Mtn., in Grabovica valley, on the Čvrsnica Mtn., at Glogovo, at Hum near Mostar, towards Metković (Beck, 1906.) (Google Earth Pro).

Conclusion

Listed results present a correct confirmation of findings of the species *P. egea* (Cramer, 1775) and we believe that this is a proof of existence of the species on the south slopes of the Prenj-Mtn., as well as the need for a thorough analysis of the stated species areal in a wider area of Herzegovina, with a review of foster plant distribution *Parietaria officinalis,* on wich the female butterfly lays the eggs.

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State optimization of newly planted *Aesculus* L. in urban greeneries by selecting more resistant species in Lithuania

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Abstract

The article reviews the introduction of plants of *Aesculus* L. in two of Lithuanian cities, 13 streets. The variety and state of these newly panted trees are presented. Regarding to data of 2009–2018, in order to limit the spread of *Cameraria ohridella* and restricting other damages worsening the state of *Aesculus*, *A. carnea* 'Briotii' is currently planted. In 2009–2013 planted *A. hippocastanum* 'Baumannii' under our conditions were of a very poor state (defoliation, dechromation – up to 3 grades, necrosis – up to 2.27 grades, strong tree bark tears – 3.96).

Keywords: *Aesculus L.*, street greenery, newly planted, state, diversity, Lithuania.

Introduction

Aesculus hippocastanum L. Arrived to Western Europe in 16th-7th centuries from Constantinople (Küstler 1999). Earlier these trees growing in Lithuanian greeneries were of rather good state, and since 2002–2004 they have become highly vulnerable to invasive fungus, causing mildew – *Erysiphe flexuosa* (Peck) U. Braun & S. Takamatsu and also to invasive pest – *Cameraria ohridella* Deschka and Dimic. (Grigaliūnaitė *et al*. 2004). *C. ohridella* for the first time was detected in Macedonia and in 1986 was described as a new species (Deschka & Dimic 1986). In a short time it spread throughout the Europe and in 2002 was found in Lithuania (Snieškienė *et al*. 2011).

In Europe, the problem of selection of woody plants for urban greeneries is constantly being addressed. The main requirements for today's urban greeneries are the durability, long-lastingness of the greenery, decorative features (Januškevičius & Navys 2012). The monitoring of the state of greeneries in European countries was started several years ago and the results are evident: derived new tree varieties, suitable for urban areas (Vainauskienė 2013). Since 2009 in Lithuania the program "On Monitoring of the State of Greeneries and Green Plantations" was implemented (2008). Assessing the state of newly developed varieties, the suitability for growing under certain conditions is determined.

The aim of the work – to indicate the diversity and state of newly planted *Aesculus* L. genus plants in street greeneries.

Material and Methods

The monitoring of *Aesculus* L. genus trees planted in street greeneries was carried out in 2009–2018 in two cities: in 2008–2014, 154 *A. hippocastanum* 'Baumannii' trees were planted in four streets and in 2015–2017 – 269 *Aesculus* x *carnea* Hayne 'Briotii' in six streets.

Injuries of non-infectious origin (defoliation, dechromation, leaf necrosis, number of dry branches, stem injuries), intensity of fungal diseases and pests were assessed from July to August on a scale of 0–4 grades. Valuated were damages on entire tree: 0 grades – injured 10% of foliage, 1 grade – 11–30%, 2 – 31–60 %, 3 –61–80 %, 4 injured 81–100 % (Juronis *et al*. 1999). Fungal diseases identified according to W. A. Sinclair & H. H. Lyon, (2005), pests – in accordance to G. Deschka & N. Dimic (1986).

T he average grade of the damage intensity calculated by the formula:

$$V = \Sigma (n \cdot b) / N;$$

were V – average damage grade, $\Sigma (n \cdot b)$ – the sum of the multiplication values of even injured (in grades) plants and damage significance, N – number of plants assessed.

Results

In 2009–2018 during the monitoring on the state of newly planted greeneries in two Lithuanian cities (Alytus, Kaunas), was assessed in protective street green plantations *A. hippocastanum* 'Baumannii' and *A. carnea* Hayne 'Briotii' cultivars were planted replacing *A. hippocastanum* L. Seedling of 4–5 years old were planted at appropriate depth in well-prepared areas, 80 to 100 cm wide and 60 cm deep pits filled with soil with plenty of water. Under the trees area of 1–1.5 m^2 is left uncoated or trees are panted in the lawn, tied to a stake.

The factors determining the state changes of newly planted *A. hippocastanum* 'Baumannii' and *A. carnea* 'Briotii' at street greeneries are given in Table 1.

During the entire observation period, the seedlings of *A. hippocastanum* 'Baumannii' were in poor state, although they grew in different growing sites (Table 1). They were damaged by injuries of non-infectious origin on various grades: defoliation, dechromation was up to 3±0.1 grades (2013, 2014); leaf necrosis appeared not every year, in 2015 were estimated to be up to 2.27±0.1 grades; number of dry branches fluctuated around 0 grades and at Putinai street in 2016–2018 have increased from 1.15±0.09 to 1.82±0.1 grades. A very relevant problem on 'Baumannii' cultivar is stem damages. Damage grade increased as plants grew: increased tears, bark loosening and detected dead wood harvester – fungus *Schizophyllum commune* Fr. (Table 2). For the second year after planting, there were found dried trees (3 tress).

The injuries of *Erysiphe flexuosa* (Peck) U. Braun & S. Takam., the invasive causative agent of mildew on chestnuts, were observed on 'Baumannii', growing at 3 streets (Table 2) and spot disease was detected in all growing sites while not annually (Table 1). Injuries of *Cameraria ohridella*, most damaging on chestnuts were observed annually from 0.01±0.1 to 3±0.14 grades. On extremely poor 'Baumannii' in Sudvaju street (poor growth, low accretion, leaf necrosis), *Cameraria ohridella* was found less than on chestnuts in other streets (2.12±0.15) (Table 1).

Table 1. A variety and state of newly planted Aesculus L) at street plantations in Lithuania, 2009–2018

Street	Year of planting; number	Years	Defoliation. dechromation	Leaf necrosis	Dry branches	Damage of stems	Diseases		Pest
							Erysiphe flexuosa	*Phyllosticta pavia*	*Cameraria ohridella*
Aesculus hippocastanum 'Baumannii'									
Margio	2008; 29	2009	0.19±0.2		0.16±0.2				1.19±0.2
		2010	0.18±0.3		0.1±0.2	0.68±0.3			1.0±0.4
		2011	0.43±0.2		0.1±0.2	0.25±0.3			1.79±0.2
		2012	0.32±0.2		0.1±0.2	0.42±0.3			1.62±0.2
		2013	0.52±0.3		0.1±0.2	0.42±0.3			2.89±0.1
		2014	0.88±0.2	0.06±0.3	0.16±0.3	0.44±0.3			1.41±0.2
		2015	0.35±0.3	0.65±0.3	0.41±0.3	0.18±0.3		0.18±0.3	0.47±0.3
		2016	0.47±0.1		0.47±0.1	1.82±0.2			1.06±0.3
		2017	0.26±0.3		0.35±0.4	1±0.2		1.63±0.2	1±0.2
		2018	1±0.6	1±0.1	0.29±0.3	1±0.2		1.63±0.0	1.71±0.3
Sudvaju	2009; 26	2009	0.72±0.2	0.72±0.2	0.58±0.2				0.01±0.1
		2010	0.12±0.2		0.12±0.2	0.1±0.1			0.41±0.1
		2011	1.33±0.2		0.14±0.2	0.1±0.1			1.21±0.2
		2012	0,73±0,2	1.04±0.2	0.14±0.2	3.96±0.2			0.74±0.23
		2013	0,23±0,2	1.15±0.1	0.14±0.2	2.16±0.2		1.08±0.2	1.12±0.2
		2014	0.15±0.2		0.46±0.2				1±0.2
		2015	0.12±0.2	0.06±0.2	0.47±0.2	2±0.2			0.01±0.1
		2016	0.32±0.2	0.52±0.2	0.13±0.2	3.39±0.2		0.8±0.24	1±0.2
		2017	0.15±0.2		0.15±0.2	3.4±0.2		0.2±0.21	0.15±0.2
		2018	0.62±0.2	0.32±0.2	0.12±0.2	3.4±0.2			1±0.2
Putinu	2013; 47	2014	2.7±0.1		0±0.1			1.9±0.15	1.9±0.2
		2015	0.24±0.1	1.19±0.1	0±0.1			1.32±0.1	0.01±0.1
		2016	1.28±0.2	1.19±0.1	1.15±0.1			1±0.15	0.01±0.1
		2017	0.19±0.1		1.16±0.1	1.35±0.1			1.35±0.1
		2018	0.32±0.1	1.62±0.1	1.82±0.1	1.1±0.1		1±0.15	2.54±0.2

Gedimino	2013, 2014; 52	2013 2014	3±0.14 3±0.14	0±0.1 2±0.1	0±0.1 0±0.1	0±0.1 0±0.1		0.1±0.13 1.14±0.1	3±0.1 3±0.1
		2015	0.17±0.1	2.27±0.1	0.33±0.1	0.21±0.1			0.41±0.2
		2016	0.11±0.1	0.11±0.1	0.55±0.1	0.31±0.1	0.16±0.1		0.81±0.1
		2017	0.21±0.1	0.21±0.1	0.55±0.1	0.31±0.1	0.16±0.1		0.81±0.1
		2018	0.22±0.1	0.30±0.1	0.60±0.1	0.31±0.1	0.18±0.1		0.81±0.1
Aesculus carnea 'Briotii'									
Perl und	2016; 75	2016					0.48±0.1		0.25±0.1
		2017	0.01±0.3						
		2018	1.03±0.1	0.31±0.1	0.21±0.1				0.08±0.1
Basanaviciat s	2014–2017; 109	2015							
		2016		0.52±0.1			2.79±0.2		0.14±0.2
		2017		0.01±0.2					0.01±0.0
		2018		0.53±0.1	0.12±0.0		2±0.1	0.82±0.1	
Geliu rato	2015; 5	2015							
		2016					2±0.9		
		2017							
		2018							
Minties rato	2015; 17	2015							
		2016					2±0.9		
		2017			0.01±0.8				
		2018							
Moletu	2015; 48	2015							
		2016		0.6±0.07					0.51±0.0
		2017							
		2018	0.08±0.1	0.69±0.1	0.23±0.1				
Vyduno	2015; 15	2015							
		2016					0.5±0.3	1.73±0.2	0.7±0.3
		2017	0.54±0.1						
		2018							0.11±0.1

Table 2. The damage type of stems of Aesculus hippocastanum 'Baumannii'.

Street (city)	Years	Percentage of damaged trees	Character of injuring
Gedimino (Kaunas)	2013–2018	88–96	Every year tear of the bark increased. Since 2015 the bark has started to peel off; on 30 percent of trees develop *Schizophyllum commune*
Sudvajų (Alytus)	2010 2011 2012 2013	3,8 3,8 12 84	1 stem damaged by 2 grades, others – around 1 grade 1 stem damaged by 2 grades, others – around 1 grade 1 dead tree; develops *Schizophyllum commune*. Healthy only 4 stems Wounds heel slightly, but small new ones appear
	2014–2016	34,6	5 trees injured by 2 grades, 4 – 3 grades, others by 1 grade; 1 dead tree; develops *Schizophyllum commune*
	2017	98	Develops *Schizophyllum commune*, 95 percent of stems peel off, 11 trees injured by 3 grades
	2018	100	Stems are injured up to 3.4 grades. Spread the wood-breakers lichen fungus and *Schizophyllum commune*.
Putinu (Alytus)	2017	35	13 trees are injured by 3 grades
	2018	35	Injuries do not increase
Margio (Alytus)	2009 2010 2011 2012 2013	61 61 6 21,1 22	2 cracked tree stems – 4 grades, 9 – 2 grades Wounds heel, but appear new cracks Bark peels off from the wounds, *Schizophyllum commune* develop 100 percent of stems are injured by 1–2 grades, develops *Schizophyllum commune* 100 percent of stems are injured by 1–2 grades, develops *Schizophyllum commune*
	2014 2015 2016	11,8 17,6	Cracked stems of 2 trees, 3 grades; large areas of bark are peeling off; 1 dead tree of them, develop *Schizophyllum commune* 3 of trees – 2 grades, rot intensify; develop *Schizophyllum commune*. Stems are cracking; bark is peeling off, rot. 2 dead trees.
	2017–2018		Damaged 100 percent, bark is peeling off: 10 trees – 3 grades, 1–5 grades

Discussion

An evaluation of the 10-year study suggests that *Aesculus hippocastanum* 'Baumannii' should not be grown under our conditions. Their state was very poor; trees were weak with greatly damaged stems. Stem injuries intensified as a plant grew: increased tears, bark loosening. Evolved fungus *Schizophyllum commune*, the dead wood harvester. Part of the trees have dried off.

Aesculus carnea 'Briotii' planted in 2015–2017 was observed to have significantly less and non-annual injuries. The above-mentioned damages had no effect on decorativeness of *A. carnea* 'Briotii'.

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A simplified LC/MS-MS method for the detection, identification and quantification of over 100 pesticides in sour cherries as a complex matrix

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Abstract

In routine multiresidue pesticide analysis several hundred pesticides can be targeted in a single sample. In the study the LC-MS/MS system (Agilent 6410B Triple Quadrupole) was used in positive mode with Electrospray Ionization (+ESI) for determination of 109 pesticides in sour cherries. The data acquisition and quantification was conducted using MassHunter Workstation software B.06.00. The chromatography separation was achieved by Zorbax Ecllipse XDB C18 column. Sour cherry samples were extracted using a QuEChERS procedure. The method validation was performed according to DG-SANTE/11813/2017 guidelines. For all the investigated pesticides the recovery was between 66.9 and 119.7% with the RSD<20%. The LOQs were 0.01 mg/kg. Seven pesticides were detected in 34 sour cherries samples, analysed during 2019. The most frequent detected pesticides were acetamiprid, dodin and spinosad. The multiple detections were present in % of the analysed sour cherry samples. There were no sour cherry samples exceeding the maximum residue levels set by the Regulation (EC) No 396/2005 and Off. Gaz. RS 22/2018.

Keywords: LC-MS/MS, pesticide residues, sour cherries.

Introduction

Recent years have seen a clear trend of encouraging people to consume the unprocessed food. An active lifestyle and a balanced diet have a decisive impact on protecting human health. Fresh fruits and vegetables hold a prominent place in this diet as they are a rich source of fiber and several vitamins and minerals

essential for health. According to the World Health Organization (WHO), consumption of fruits and vegetables in Europe constituted over 30% of consumer diet (Stachniuk, 2018).

Considering that pesticides have potentially harmful effects on the environment and pose health risks for consumers, many countries have established maximum residue levels (MRLs) in agricultural products, according to the European Community (EC) Regulation No. 396/2005. Republic of Serbia also has National Regulation established through Official Gazette RS No 22/2018. In order to control the food quality, a reliable, rapid, cost-effective, and high-throughput method is necessary for the detection of pesticide residues in sour cherries.

In the last ten years in Republic of Serbia, fruit exports have been the only bright spot in foreign trade with the world. The average annual fruit production in Serbia is 1.453 million tons, with an upward trend in production. Orchards take up 163,310 ha (without strawberries), or 4.8% of the total agricultural land area, which is little considering the favourable climatic and land conditions for cultivating fruit trees. The most common are plums, then apples, cherries, raspberries and peaches (Keserović et al., 2016).

It is a great challenge to determine the levels of multiple pesticides simultaneously in sour cherries using high-performance liquid chromatography (HPLC) methods due to a great variety of pesticides in this matrix and high interference from other compounds. Sour cherries are rather demanding as a matrix in which the pesticide residues are determined due to present pigments. The presence of pigments such as chlorophyll, carothenoids and anthocyanins in extract is a potential problem in pesticide analyses (Bursić et al., 2016). To solve this problem, the QuEChERS (quick, easy, cheap, effective, rugged and safe) method, which is an additional clean-up step based on dispersive solid phase extraction (d-SPE), has been developed and widely used before injection to the LC-MS/MS detection system (Huang et al., 2019). The QuEChERS methodology combined with the benefits of tandem mass spectrometry (MS/MS) greatly simplified the total analytical procedures to detect low levels of multiresidues with reliable and acceptable quality of results (Lee et al., 2017). Since different kinds of pesticides could remain in the sour cherries samples, it is necessary to use a validated method to detect as many pesticide classes as possible, according to SANTE 11813/2017.

The LC-MS/MS methodology established in this study was applied to the quantitative and qualitative analyses of 109 pesticide residues in 34 sour cherries samples, which were collected at markets of Republic of Serbia, during 2019.

Material and Methods

Chemicals and reagents. Acetonitrile (HPLC grade) was purchased from J.T.Baker. The QuEChERS kits were purchased from Agilent. Certified standards of 109 pesticides studied were purchased from Dr. Ehrenstorfer and CPA chem. All the standards had purities exceeding 97.0%. Stock solutions were prepared in methanol, acetonitrile, or acetone (depends of solubility) at nearest 1.0 mg/mL. Working standard solutions (standard mix of 109 pesticides) were prepared in acetonitrile at 10 µg/mL and 1 µg/mL. These solutions were used to prepare calibration standards from 0.01 to 0.10 µg/mL, for getting the analytical curves in the solvent and for spiking samples („recovery calibration").

Samples extraction and clean-up procedures. The sour cherries samples were extracted by QuEChERS method described by Anastassiades et al. (2003). For extraction, 10.0 g of the sour cherries sample were weighed into a 50 mL polypropylene centrifuge tube, the internal standard (IS) and 10 mL of acetonitrile were added and the solution was stirred for 1 min using a vortex mixer. Then, 4.0 g of anhydrous $MgSO_4$, 1.0 g NaCl, 1.0 g of trisodium citrate dihydrate and 0.5 g of disodium hydrogen citrate sesquihydrate were added to the tube and the solution was stirred again (1 min), followed by centrifugation for 5 min (4000 rpm). Aliquot of 6 mL of the extract was transferred to 15 mL polypropylene centrifuge tube containing 900 mg of anhydrous $MgSO_4$, 150 mg of PSA and 15 mg of GBC. The extract was vigorously shaken for 1 min. After centrifugation for 5 min aliquot was filtrated through PTFE 0.45 µm filter and injected into the LC-MS/MS.

LC-MS/MS analysis. Chromatographic analysis was performed using a liquid chromatography tandem mass spectrometry with electrospray ionisation (LC/MS-MS), 6410 Agilent Technologies. The separation was performed using a Zorbax Eclipse XDBC18 column (50 mmx4.6mm id 1.8 µm,) at 25°C mobile phase consisted of methanol with 0.1% formic acid (solvent A) and 0,1% formic acid in water (solvent B), with the following gradient: 0 min-90% B; 2 min-90% B; 15 min 20% B; 20min- 15% B; 25min- 5% B and then returning to the initial conditions in 5 min, with a total time of 30 min. The mobile phase flow rate was maintained at 0.4 mL min-1 and the injection volume was 5 µL. The MS source temperature was set at 350 °C, nitrogen gas flow 10 Lmin-1, nebulizer pressure 40 psi. The target ion transition with highest intensity (primary ion transition) was used for quantitation, whereas the second target ion transition was used for confirmation. The instrument uses MassHunter software version B.06.00 (Agilent Technologies, 2012) for quantitation and confirmation.

Method validation. Linearity, LOD, LOQ, matrix effect, recovery and precision were determined according to SANTE/11813/2017. The evaluation of the linearity range was checked for for fortification levels (0.01, 0.02, 0.05 and 0.1 µg/mL) in organic solvent and matrix. Recovery was obtained by spiking sour cherries in the concentration rage from 0.01 to 0.1 mg/kg. Limit of detection (LOD) was estimated in the MRM mode analysis as the lowest concentration level that yielded S/N ratio of five.

Results

Linearity and matrix effect. According to the results, the compounds showed good response in the range of 0.01 to 0.1 µg/mL (Figure 1). Therefore the method is selective, showing good linearity, expressed by the values of R^2>0.99 for all investigated pesticides. Matrix effect was estimated on matrix and solvent calibration slope ratio and it indicate on a strong influence for 85 pesticides.

LOD and LOQ. LOQs were established on 0.01 mg/kg and was conformed experimentally while the LODs were calculated by MassHunter software and all values were below 0.005 mg/kg.

Recovery. Recovery studies were assessed at two levels, spiking blank sour cherries samples at 0.01, and 0.1 mg/kg in five replicates. The 107 from 109 analyzed pesticides showed recovery ranging from 66.9 and 119.7% except methoxyfenozide and hexythiazox, 56.8 and 36.8%, respectively. Repetabilities (%RSD) were between

1.36 and 17.72%. Generally, the accuracy and precision results were satisfactory to all investigated pesticides, according Document SANTE/11813/2017.

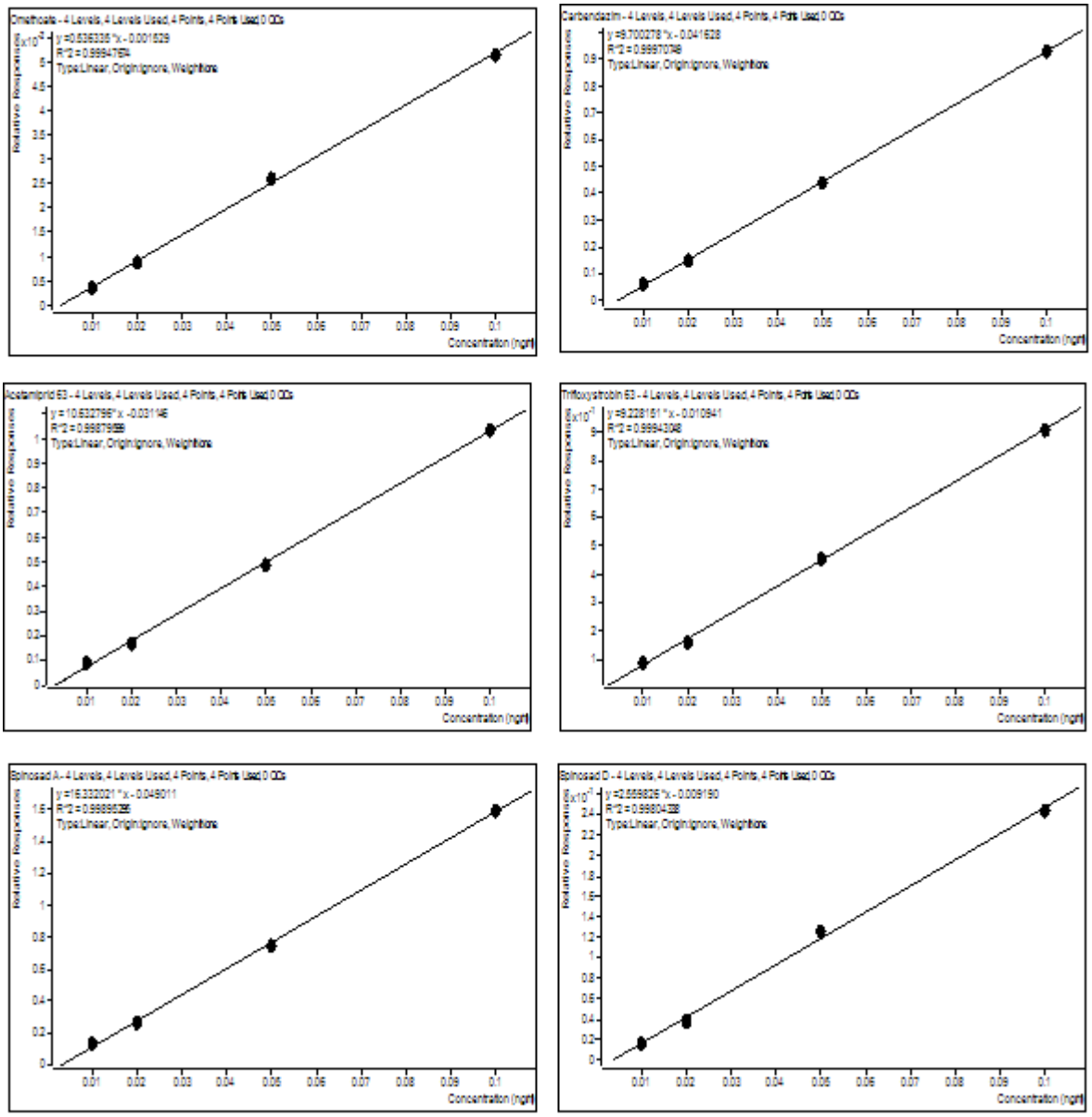

Figure 1. Calibration curves of same detected pesticides

Sample analyses. According to validation parameters LC-MS/MS is suitable technique for qualitative and quantitative analysis of pesticide residues in sour cherries samples.

All detected pesticides are given in table 1.

Table 1. Detected pesticides in sour cherries samples (mg/kg)

Sample No.	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**
Pesticide																	
acetamiprid	0.013	<	0.025	0.013	0.045	0.044	0.053	<	0.013	0.004	0.004	<	<	0.045	0.038	<	0.025
dodin	<	<	0.101	<	0.075	0.353	<	<	<	<	<	<	<	<	0.196	<	0.101
carbendazim	<	<	0.022	<	<	<	<	<	<	<	<	<	<	<	<	<	0.022
omethoate	<	<	0.01	<	0.005	<	<	<	<	<	<	<	<	<	<	<	0.01
prohloraz	<	<	<	0.006	0.012	<	<	<	<	<	<	<	<	<	<	<	<
spinosad**	<	<	0.015	<	0.002	<	<	<	0.002	<	<	<	<	<	<	<	0.015
trifloxystrobin	<	<	<	<	<	<	0.006	<	<	<	<	<	<	<	<	<	<
Sample No.	**18**	**19**	**20**	**21**	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**	**31**	**32**	**33**	**34**
Pesticide																	
acetamiprid	0.011	0.003	<	0.018	<	<	0.061	0.026	<	<	0.007	<	<	<	<	0.052	<
dodin	<	<	<	<	<	<	<	0.207	<	<	<	<	<	<	<	0.451	0.058
carbendazim	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
omethoate	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	0.009
prohloraz	<	<	<	0.009	<	<	<	<	<	<	<	<	<	<	<	<	0.027
spinosad**	<	<	<	<	<	<	<	<	0.004	<	<	<	<	<	<	<	0.003
trifloxystrobin	<	<	<	<	<	<	0.010	<	<	<	<	<	<	<	<	<	0.004

< LOQ (0.01 mg/kg)
*value below LOQ and upper LOD
** Spinosad (sum of spinosyn A & D)

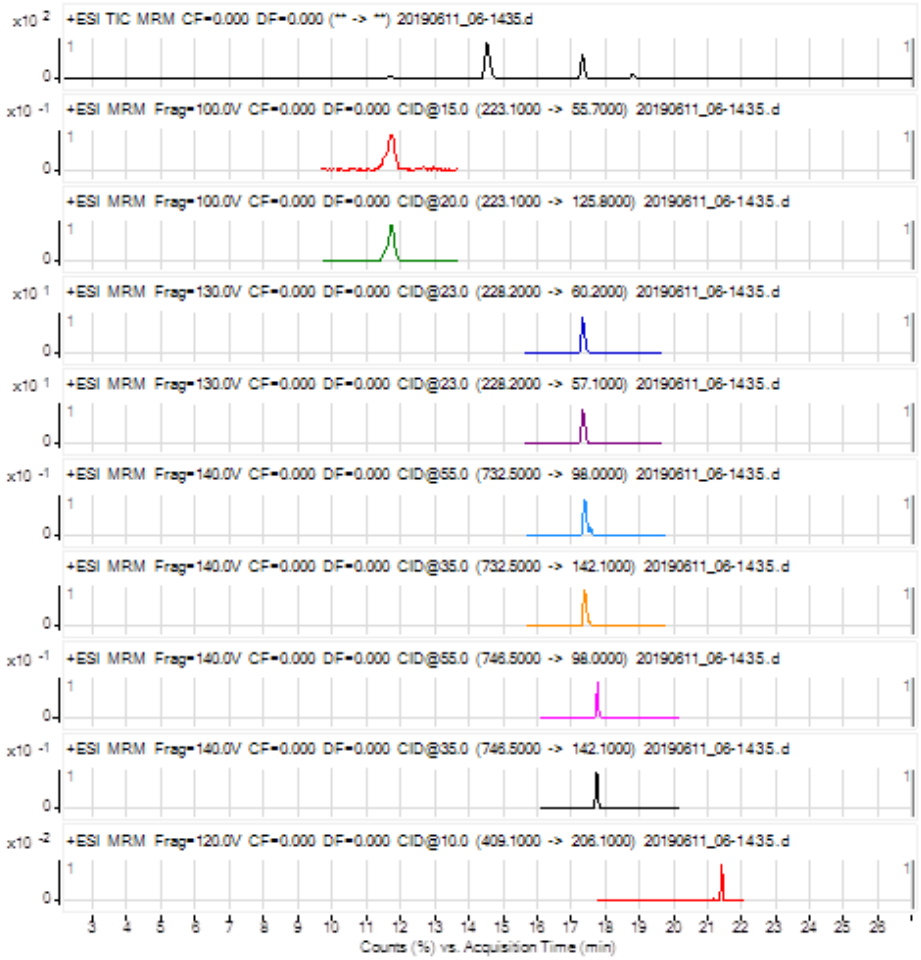

Figure 2. LC-MS/MS chromatogram of sample containing residue of pesticides

Discussion

The aim of the research is to evaluate pesticide residue contamination of fresh sour cherries samples from Serbian markets, and to estimate the multiresidue LC-MS/MS method effectiveness expressed as the proportion of pesticides detected in food samples to the total number of pesticides analyzed by multiresidue methods. A total of 34 samples were analyzed using LC-MS/MS method for the determination of 109 pesticides. The proportion of pesticides detected during our study to the total number of analyzed pesticides amounted to 7%. QuEChERS extraction, matrix-matched calibration and dynamic multiple reaction monitoring method were used. In order to obtain a competative product for the market it is necessary to apply many treatments of the fruits aimed at the control of diseases and pests. On Serbian market there are 46 compounds registered for the use in cherry protection, of which 19 are insecticides, 5 acaricides and 22 fungicides (Petrović and Sekulić, 2017). Since cherry fruit is predominantly used as fresh food and to a lesser extent in food processing there is a justified concern that, due to a great number of treatments, cherry fruit can contain pesticide residues above the maximum residue levels – MRLs (Stojanović et al., 2017; Bursić et al., 2017).

Residues of 7 compounds, mainly fungicides and insecticides, were detected in 21 samples. All the detections were below MRLs (EC/396/2005, Off. Gaz. RS 22/2018). A

total of 13 samples contained more than one pesticide residue, while the 17.65% were with single detection. Pesticide residues were not detected in 13 samples, which is 38.24% of all analysed samples. The most frequently detected pesticides were acetamiprid, dodin and spinosad.

The detections pointed out that several found pesticides are not registered in the Republic of Serbia for sour cherries protection (omethoate, spinosad and trifloxystrobin). Given suggests that farmers should comply with the principles of good agricultural practices (GAP) and only use products that are registered for the use in the Republic of Serbia.

Acknowledgments

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Assessment the risk degree of the Seveso plants

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Abstract

Although Montenegro is not a producer of hazardous chemicals, it as a tourist destination and country with all forms of traffic - water, air, road and railway - is a place where transport and storage of significant quantities of hazardous substances are carried out. This research analyses the influence of the amount of hazard substances on the shape and extent of the accidental hazards of Seveso plants. It underlines necessity of recognizing important factors that affects the security of chemical plants. As subject of the investigation were two selected LPG storages with different spatial positions, environmental surroundings, structures, various types of pressure vessels, as well different stored quantities of LPG. Based on the obtained results, the quantity of dangerous chemical is not the basic measure of the potential scope and consequence of hazard. The chemical risk management methodology must cover more criteria in order to be expedient and useful. For the purpose of real risk assessment and chemical protection planning, the main legislative instruments that regulate this issue, apart from laws and strategies for emergencies, must include a rulebook on the methodology for assessment of the chemical and environmental hazard, the measures of preparation and the measures to remove the consequences.

Key words: ecology, risk, policy, hazard, LPG, Seveso, plant, storage, vessels, chemicals

Introduction

Prosperous country plans its own progress based on the strategic goals that are managed during the time. Not only economic indicators measure level of economic development of a society, but also environmental, social and technological. Rate of clean technologies in total industrial production, the level of soil degradation, the share of healthy foods in the total, give figures for development degree monitoring. Development strategies are defined through priority sectors and key development areas such as transport, agriculture, energy, environmental protection, industry, tourism and education. Nevertheless, strategic polices are interconnected so the development of one is not possible without considering the others. Establishment and implementation of eco-management into the state strategic framework through the policy of environmental protection who is in line with the local and EU polices is among them and cannot be viewed without consideration of energy polices.

Environmental catastrophes related to industrial and natural disasters with their frequency and devastating effect can significantly impede the sustainable development of a society, produce new risks and affect the increase in disaster-related losses. Such losses would affect the economic, social, health, cultural and ecological frameworks. Because hazards from chemicals, nuclear power or terrorism, appears to influence the regulation and management of these technologies, it is important to understand perceiving and evaluation of risks (Johnson and Tversky 1983: Aven 1992).

Hazardous accidental results from dispersion of a hazard substance in to the environment, and with sufficient consequences to effect the natural environment. Different kind of substances released and mixed with the air can cause different kinds of intoxications, fires or explosions due to chemical properties, stoichiometric relations and type of movement through the space (AICE, 1994). Substances grouped in nine formal classes of products are classify as hazardous substances (ADR/RID/ADN 2019). Classes two, three and nine (gases, flammable liquids and various hazardous substances and products) include by-products such a compressed natural gas, residues or intermediates of crude oil i.e. liquefied petroleum gas, petrol, diesel, fuel oil and bitumen (Aleksic et al. 2017a; Aleksic et al. 2017b). Chemical hazards caused by these substances may lead to physical and/or health risks as well environmental pollutions. It can also results from an emission of toxic vapours from the combustion of certain substances. Even small amount of dangerous substance in this regard can be fatal. Therefore, transportation, storage and handling for hazardous materials is regulated and performed in accordance with the provisions of international agreements and recommendations of local laws (ADR/RID/ADN 2019; COTIF 2006; ICAO 2016; Seveso II 2012). LPG or propane-butane is flammable mixture of hydrocarbon gases (Class 2; UN 1965) used as fuel for industrial and household applications. As two component, liquid mixture is stored in steel pressure vessels like bottles, larger gas cylinders or and storage tanks. Considering storage tank design, depending on capacity, purpose and spatial conditions it differs. May be shaped as spherical pressure vessel so-called Horton's spheres or cylindrical pressure vessel - aboveground and underground, also called bullet tank (Aleksic et al. 2017a). Pressure vessel with stored amount of dangerous chemical who operate with is consider as Seveso plant (Seveso II 2012). Usage of LPG in most cases refer to risks of unexpected fires and explosions and belong to unwanted events (Bris et. al. 2014), and are worthy of attention and analysis. Part of the environment policy is oriented to the risk assessment of chemical accidentals and the application of safety measures. In this regard, the chemical process plants, storages of hazardous goods, the sales and transport of dangerous chemicals, regardless of how much represented in the overall state economy, are certainly among the main disaster risk factors. Most countries of the former Yugoslavia regulate the local chemical protection policy based on the list of hazardous substances and their quantities in accordance with the Seveso Directive (Annex I) representing a base for all other regulations. Therefore, correct, precise statements, translations and provisions are mandatory.

Risk assessment process, since multidisciplinary is complex task but in the frame of chemical hazard even more. Toward general definitions and standard terms, a risky event is a phenomenon or activity that can produce adverse effects and unwanted consequences - loss or injury (Bernstein, 1996). Process of identification and evaluation of risk is possible by use of multiple approaches: a case study; sensitivity analysis; deterministic methods; probabilistic methods. All of them have advantages and disadvantages. Process risks arises from technical systems from either routine

external effects or abnormal conditions that are not part of the basic design concept (Whipple and Starr 1980). However, they are always inevitably associated with risks of decision-making and uncertainties (Aven 2015; Frankl 1988). Methodology for determining the risk of chemical accidents is probabilistic and based on the estimated likelihood and effects of such an event. Level of risk can be expressed qualitatively or quantitatively and most often by, at least, three possible ranks - low, medium and high. It includes two fields: risk assessment of the process plant and risk assessment of the environment hazard. Prime refers to the types, characteristics, amount of chemical substances, their position on the site, then type of processes, process conditions, energy sources, types of equipment, state and age of equipment, analysis of process management system, possible scenarios, places of probable accidents and estimation of consequences. The second relates to the assessment of the number of injured people and vulnerable objects in the environment that may be affected (schools, hospitals, children's playgrounds, bus stations etc.).

In this research will be investigated influence of the amount of hazard substances on the shape and extent of the LPG accidental hazards. For the test, examples were selected two depots for LPG as industrial objects and Seveso plants with a certain risk potential of chemical hazard. We analysed possible events not certain, with higher likelihood to happen.

Material and Methods

Two different LPG depots have been selected and modelled (Figure 1). First (LPG depot 1 in further text) with lower storage capacity cca 190 m3 of propane-butane mixture is located in the urban environment, with the denser position of neighbouring buildings, a greater number of obstacles that could increase the speed of fire spread and the likelihood of detonation. It consists four horizontal aboveground tanks (3x60 m3 + 1x10 m3), compressor/pump room, bottling plant, gas station, car wash and café, cage for LPG containers, office building and parking. Near depot, there are also a public road, bakery, bus station and private properties (in radius less than 700m).

Other storage (LPG depot 2 in further text) is located in the industrial area and have larger storage capacity with of propane-butane mixture. Consists sphere tank (1000 m3), horizontal aboveground tank (100m3), compressor/pump room, gas station, office building, parking, tank truck loading rack and rail loading rack. Near this depot are positioned public roads, cage for LPG containers and private properties (in radius less than 700m).

2.1. Data base

Basic data related to depots (Table 1—2) were took over the official web databases (www.mre.gov.rs; https://epa.org.me/2018/03/02/obavjestenja-seveso). Site data, chemical data, atmospheric parameters and coordinates for the locations (Table 1), were collected from the official public databases (www.meteo.co.me). They relate to the elements of the installations and their spatial layout, distances of objects in regard to Seveso plants, capacities of the pressure vessels. Details were modelled (capacities of bottling plants, maturity and dimensions of the equipment, number of employees, types of connections, dimensions of the pressure vessels etc.).Data's important for the research calculation are presented at the tables and text below.

For selected scenarios, unfavourable meteorological condition – lack of wind has been adopted.

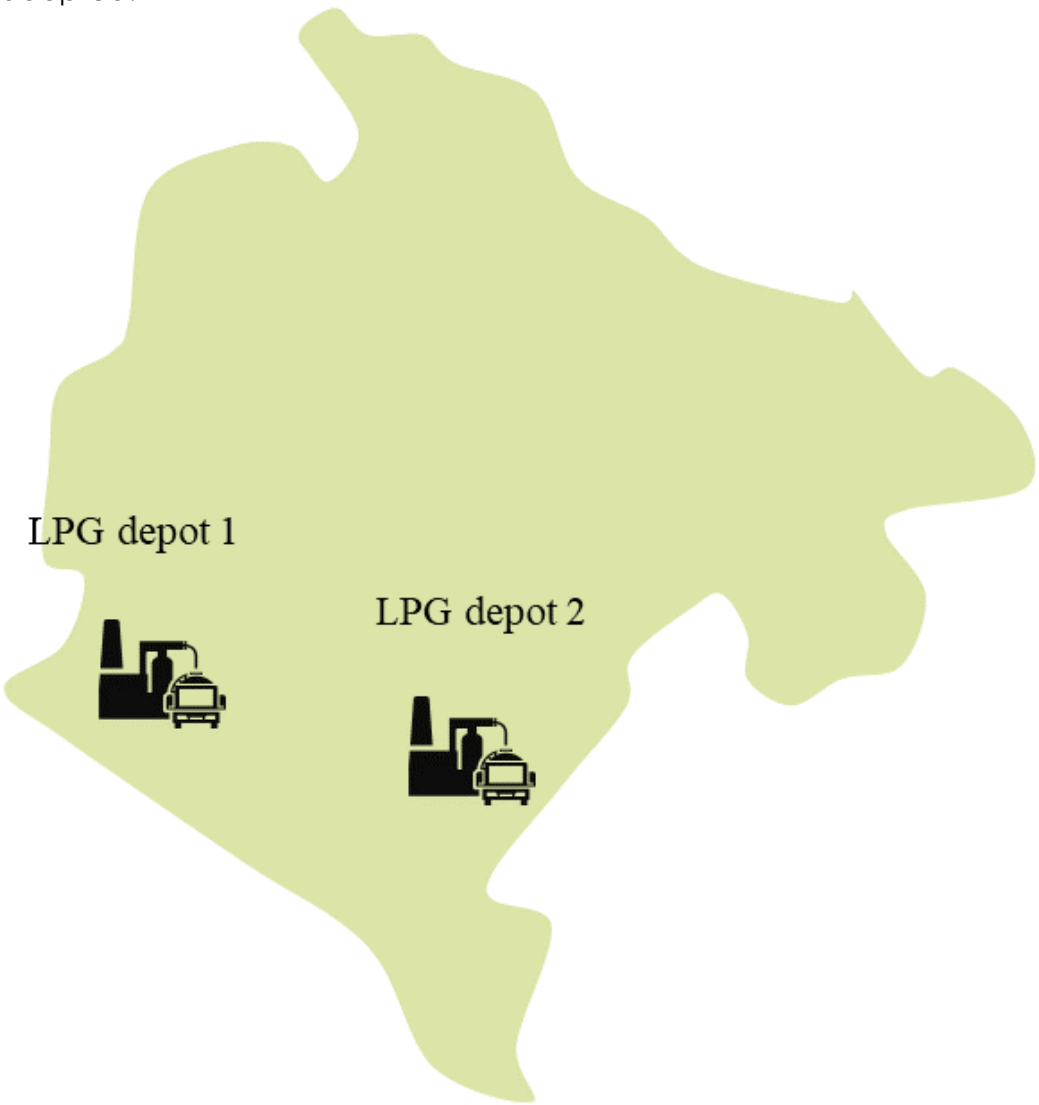

Figure 6. Selected depots

Table 5. Atmospheric and spatial parameters

Data	LPG depot 1	LPG depot 2
Wind	1,5m/s	1,5m/s
Cloud cover	clear	clear
Air temperature [°C]	37	37
Stability class	F	F
Relative humidity	57%	53%
Inversion height	no	no
Time zone	UTC+1 (CET)	UTC+1 (CET)
Latitude	42°41'57''N	42°39'57''N
Longitude	18°71'.67''E	19°23'54''E

As a model substance was used LPG produced by INA d.d. Quality specification with physical-chemical parameters from the official web site (https://www.ina.hr/).

Number of employees, nearby objects, data's concerning natural and cultural heritage, related to important effects are downloaded from official databases and web sites (available at http://www.inacg.me/; http://www.energogas.net/; https://epa.org.me/). Data's concerning tanks are presented at the table below (Table 2).

Table 6. Types and capacities of LPG pressure vessels

Characteristics	**LPG depot 1**	**LPG depot 2**
Number of tanks	4	3
Age	up to 10 yr	>10 yr
Cylinder tanks		
10 [m^3]	1	-
60 [m^3]	3	-
100 [m^3]	-	1
200 [m^3]	-	1
Spherical tank		
1000 [m^3]	-	1

2.2. Risk hazard assessment methodology

Based on the rulebook on the methodology for chemical hazard, risk assessment of the Seveso plant is performed through the three main steps: danger identification, analysis of consequences and risk determination. Every step has several sub steps. Even though they were calculated, we will show those relevant for understanding the results.

In this research potential scenarios and modelling the effects of LPG leaks, fires and/or explosions were assessed with Fault Tree Analysis (FTA), Event Tree Analysis (ETA) and Aloha® 5.4.4 software (available at www.epa,gov).

Used methodology for the risk assessment, criterions for likelihoods consequences and risk acceptance, list and criterions for quantities of dangerous goods, were took over the official data bases available at web sites (www.epa.gov.me).

Scenarios of individual cases of leaking with immediate or subsequent fires and explosions will be analysed. It implies that on this kind of objects high level of HSE culture is present but according to the literature references, human errors are the most common causes of potential hazards (Nivolianitou et al, 2012). In this regard, for both depots as main cause of accidentals were considered mechanical failures (on connecting hoses and tank equipment) combined with human errors. We analysed few characteristic, due to modelled characteristics of the installations. In parts with road or rail tanker unloading racks, frequent failures with uncontrolled LPG discharges can be expected on the connection hoses. As other considered case was selected case of leaking on the compressor or the pump. Example of failure with LPG bottle cylinders was also analysed since both depots seem to have bottling plants and/or bottling warehouses. Finally, cancellations at tank equipment caused by human error during sampling or draining is also used as a test case.

Position and constitution of the installation elements (racks, tanks, bottling cages, compressors etc.) enables domino effects, but concerning the theme of the

research, they were not analysed at this study. It will be a part of the further researches. In accordance with the Seveso regulation and having in mind holistic dimension of the risk assessment of the chemical hazards, study hypothesis will be to conduct examination just for the Seveso plants, not for the wider environment. The current risk analysis studies involve processes of the receipt, storing, filling operations.

Results

Risk degree of the Seveso plants assessment includes few steps. In the first step, main dangers are identified. Second step comprises modelling the effects of the hazard accident, third step vulnerability analysis and in fourth step assessed consequences of such an events. In the final fifth step, a risk assessment was performed based on the parameters obtained in the previous steps.

3.1. Danger identification

Selected depots can be considered as complex each in its own way, since consisting different types of the process equipment, underground pipes, different kind of business buildings and offices, different frequencies and ways of fuel unloading's. Sources of failures have been found among a few main groups:

- human errors,
- measuring and control equipment, mechanical equipment,
- quality of hazard substance,
- natural and elemental disasters.

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- quality of hazard substance,
- natural and elemental disasters.

Due to the complexities of depots, theoretically many failures could happen (Figures 2 and 3).

Each of them lead to the main accidentals i.e. LPG release, Jet fire, Flash fire or VCE (vapour cloud explosion). Consequences of such events could be injuries of humans and objects by thermal radiation or shock wave (Figure 4). The assumption is that both installations have fire and gas detection sensors with a control panel and audio / visual alarms but that system failed for unknown reasons.

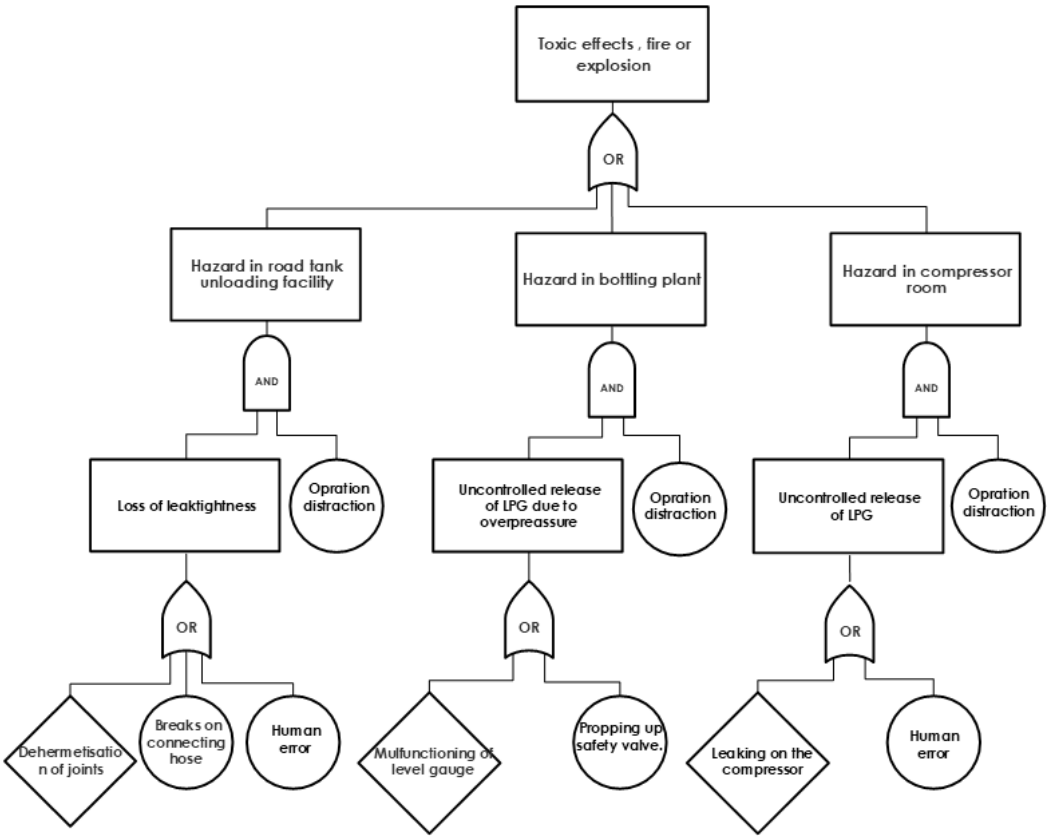

Figure 7. Fault three analysis: LPG depot

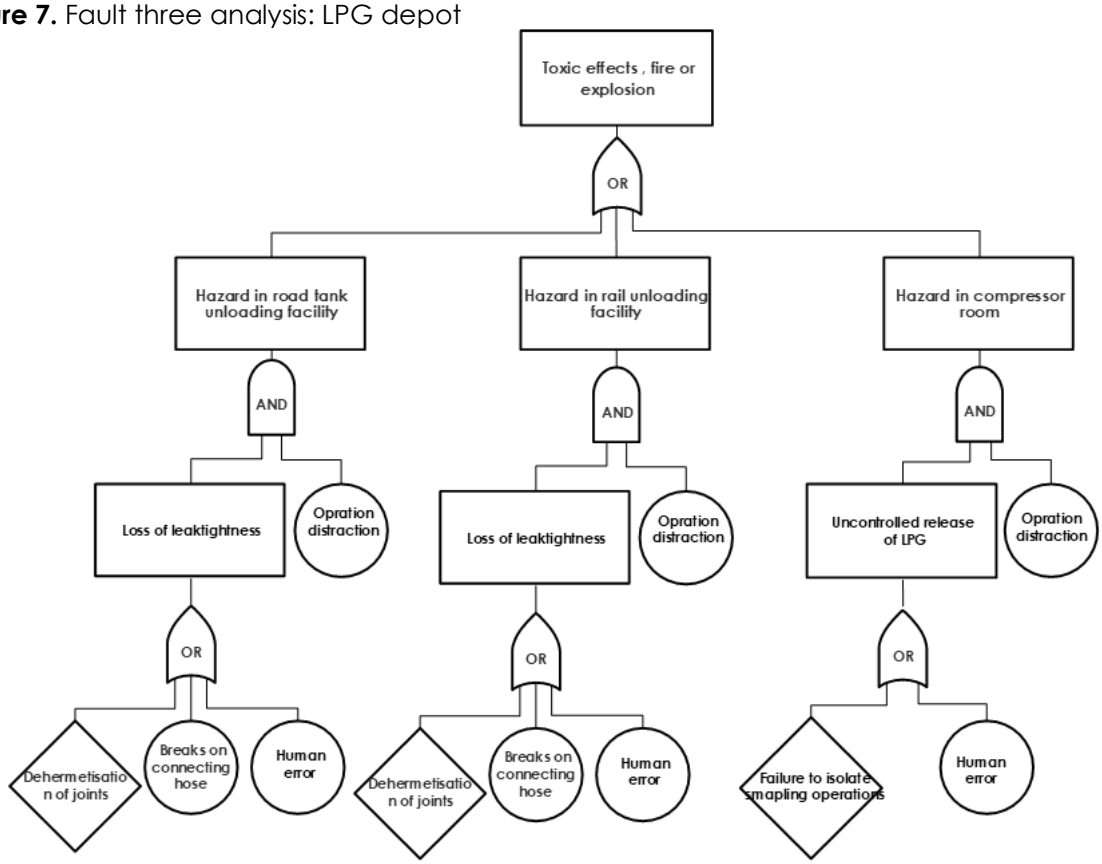

Figure 8. Fault three analysis: LPG depot 2.

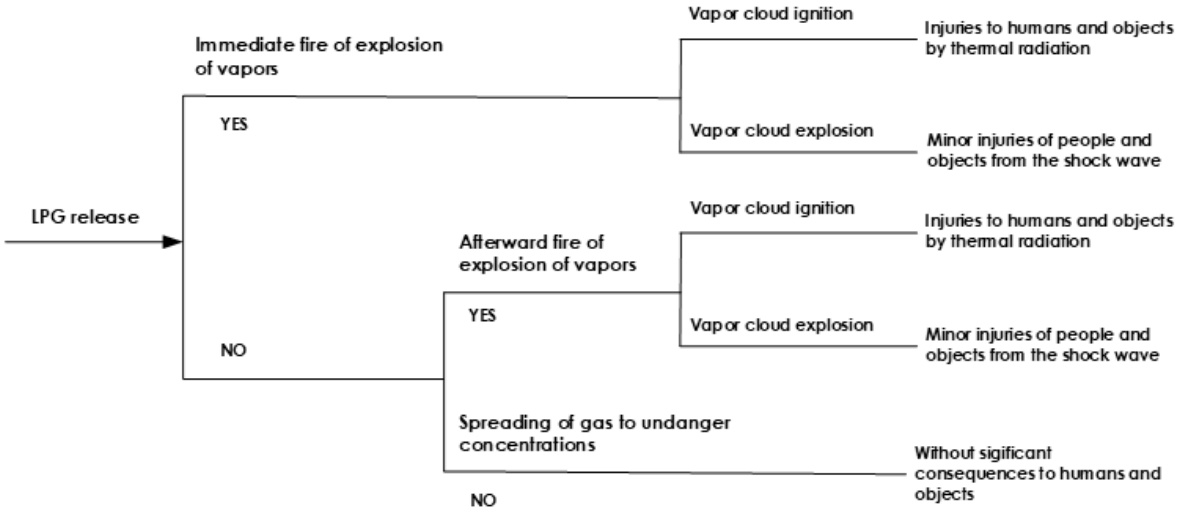

Figure 9. Event three analysis.

Danger identification was assessed for all selected examples of failures. First scenario consideration was given to the LPG unloading (road and rail) cistern to the storage tank. Uncontrolled cracking or disconnection of the hose (pipe dimensions for the gas phase: 6m x 2''road; 12m x 2'' rail, and for the liquid phase: 6m x 3''road; 12m x 3'' rail) from the transport vehicle caused the discharge of fuel into the surrounding environment. This scenario implies that the two safety valves (one on the side of the tanker and the other on the side of the storage tank) will be closed, so LPG just from the hose is discharged into the outer environment. The maximum of LPG content is released 6 up to maximum 12 kg refer to the content of the liquid LPG inside a connecting hose (road or rail).

Second scenario consideration was given to the bottling container failure. Uncontrolled cracking of the pressure relief valve from LPG bottle caused the discharge of fuel into the surrounding environment. This scenario implies that the maximum of LPG content released in this the case is up to 0.4 g/s refer to the dimensions of the valve, internal pressure in the bottle and past time.

Third scenario consideration was given to LPG compressor failure (65 CFM or 110m3/h), provided for unloading of bulk LPG because of the pressure regulator failure who caused uncontrolled leakage. This scenario implies that LPG content released in this the case is up to 3.7 kg/s refer to the cca 20% of the total compressor capacity.

Fourth scenario consideration was given to the malfunction on the sphere tank on LPG depot 2 during sampling operations. LPG release from the storage due to carless operators and the malfunctions of the equipment's. By fault valve left open after doing cleaning the tank, opening of wrong valve during sampling operation, filling line not coupled to hose properly, operator not vigilant to alarm and at the same time pump not stopped. This scenario implies that the maximum of LPG content released in this the case is up to 0,3 kg/s refer to the dimensions of the valve and flow rate.

3.2. Modelling of effects of accidental hazards

According to the fault event trees, modeling of events has been conducted. For the limits of flammability of LPG were adopted lower (2%) and upper (9.5%). Off all possible models, selected effects are:

1. Effect 1 - cloud dispersion of gases, vapors and aerosols and solid particles at ground level, for the most unfavorable meteorological conditions (wind velocity 1.5 m/s, stability class F, maximal temperature (tree years average) for a shorter period of time (1−30 minutes).
2. Effect 2 - flammable area of vapor cloud.
3. Effect 3 – VCE.

Table 7. Effects of failures on LPG depot 1

	Failure in connection pipe during tank truck unloading	**Failure in bottling plant**	**Failure related to LPG compressor**
Release duration	60 sec	60 sec	60 sec
Release Rate	0.1 kg/s	4E-4 kg/s	3.71 kg/s
Toxic area, IDLH [m]	11	11	127
Flammable area of vapor cloud, LEL = Flame Pockets [m]	11	11	69
Over pressure from VCE due to ignition [m]			
8 psi (destruction of buildings)	LOC	LOC	LOC
3.5 psi (serious injury likely)	16	<10	LOC
1 psi (shatters glass)	35	13	LOC
Over pressure from due to explosion VCE [m]			
8 psi (destruction of buildings)	23	11	76
3.5 psi (serious injury likely)	34	13	101
1 psi (shatters glass)	75	19	195

Table 8. Effects of failures on LPG depot 2

	Failure in connection pipe during road tanker unloading	**Failure in connection pipe during rail tanker unloading**	**Failure related to tank**
Release duration	60 sec	60 sec	60 sec
Release Rate	0.1 kg/s	0.2kg/s	0.3 kg/s
Toxic area, IDLH [m]	24	31	49
Flammable area of vapor cloud, LEL = Flame Pockets [m]	11	11	17
Over pressure from VCE due to ignition [m]			
8 psi (destruction of buildings)	LOC	LOC	LOC
3.5 psi (serious injury likely)	LOC	LOC	LOC
1 psi (shatters glass)	LOC	LOC	LOC
Over pressure from due to explosion VCE [m]			
8 psi (destruction of buildings)	22	10	19
3.5 psi (serious injury likely)	31	30	27
1 psi (shatters glass)	68	64	57

3.3. Analysis of vulnerability

According to selected failures, scenarios and effects of accidental, vulnerability analysis is performed in order to determine the width of the vulnerable zones and the extent of the incidence, the impact of hazards on humans and objects.

Table 9. Threat zones in defined cases of failures on LPG depot 1[m]

Object	Failure 1	Failure 2	Failure 3
Cage for LPG bottles	16	-	23
Parking	18	31	30
Gas station	16	2	28
Horizontal LPG aboveground tank, 60m^3	26	29	5
Compressor room	28	23	-
Road	40	34	50
Cafe	41	27	43
LPG bottling plant	45	28	13
The car wash	50	34	37
Bus station	51	40	66
Bakery	71	67	91
Office building with parking	72	57	54

Table 10. Threat zones in defined cases of failures on LPG depot 2 [m]

Object	Failure 1	Failure 2	Failure 3
Horizontal LPG aboveground tank, 100m^3	22	111,2	21
Building 1	23	71	62,7
Horizontal LPG aboveground tank, 200m^3	27	114,8	14,4
Sphere tank, 1000 m^3	45	134,7	-
Building 2	91	16,86	114,44
Rail load rack	92	-	100,6
Road tanker load rack	-	87,71	43,27
Road	92	74,6	93,9
Cage for LPG bottles	98	108.5	129,67
Office building with parking	100	51.56	129,65
Gas station	108	140,2	142,87
Neighbor business building	137	220,8	130,5
Private house	198	148,41	175,07
Parking	333	387,54	295,6

Analysis of vulnerability included:

- identification of vulnerable objects,
- assessment of possible level of accident,
- assessment of vulnerable zone width.

In case of possible accidentals, the relevant minimum spacing from the spilling point is one that is characteristic for the effects of toxic vapors influences. For LPG depot 1 in case of failures due to road tanker unloading rack and LPG bottle cage it is 12m, while in case of failure due to compressor it is 127 m. For LPG depot 2 in case of failures due to road tanker unloading rack toxic zone is at 24, in case of failures due to rail tanker unloading rack at 31m, while in case of failure due to tank it is 47m.

(a)

(b)

Figure 10. Vulnerable zones: (a) LPG depot 1; (b) LPG depot 2.

Safe zone in worst case for LPG 1 is in radius greater than 196m, whilst for LPG 2 is in radius greater than 68m (Figure 5).

3.4. Analysis of consequences

Goal of this step is predicting the extent of the possible consequences of the injury and the magnitude of the damage. Indicators that determine the extent of the consequences are possible number of deaths, injuries with burns, intoxications without persistent consequences, possible material damage and contamination of environmental factors.

Observation is conducted for the zone up to 200 m, with regard to the source of accident. In case of VCE, vulnerable zones are defined due to over pressure in the function of distances.

Table 11. Consequence, probability and risk analysis

	LPG depot 1			**LPG depot 2**		
	Failure 1	Failure 2	Failure 3	Failure 1	Failure 2	Failure 3
N° of casualty people	-	-	-	-	-	-
N° of serious injured	3-6	1-2	3-6	1-2	1-2	1
Destruction of buildings	-	yes	yes*	-	yes	yes*
Shatters glass	yes	yes	yes	yes	yes	yes
Consequence**	significant	significant	significant	significant	significant	significant
Probability**	10^0-10^{-1}	10^0-10^{-1}	10^0-10^{-1}	10^0-10^{-1}	10^0-10^{-1}	10^0-10^{-1}
RISK**	**high**	**high**	**high**	**high**	**high**	**high**

* Possibility of tanks deformation. Domino effects in this study were not considered.
** Rule of provision of the plan of prevention and plan of protection („Official Gazette of Montenegro ", 52/16 available at https://epa.org.me/).

For the given conditions among a few analysed scenarios as referent was used that one with a consequent VCE, although it has a low probability to happen due to suggested released quantities. So referent-threated zones are those related to such scenario.

Probabilities was not calculated according to event trees, since details of the equipment are not known. Criterions of harmful effects, consequences and probabilities are downloaded from the public database (www.epa.org.me).

Discussion

When we talk about a chemical plant or a Seveso plant, we refer to a vessel or equipment with specific complexity, quality and capacity performing technological process with certain hazardous substances. According to the definition, Seveso plant is a facility where activities are present and dangerous substances can be present in equal or greater quantities than prescribed (Seveso II 2012).

Chemical hazard risk assessment of the Seveso plants was performed through the three main steps: danger identification, analysis of consequences and risk determination. Every step has several sub steps.

Bearing in mind that during the designing process, legal regulations have been respected as well as in the field of fire protection, we have chosen possible scenarios caused by human error or equipment failures. According to selected scenarios, we analysed influence of the released quantities of LPG in the environment. For the purpose of this research were selected three possible types of failures: related to unloading, bottling plant and tanks. At the fault tree are shown main minimal cuts. Big events as overfilling the tanks, ruptures on vessels etc. were not included in this study due to low probability to happen. Testing the impact of small and large quantities of LPG on the risk degree of Seveso plant has been conducted for the failures with higher and medium probability.

First is in the urban city environment, with high complexity of the spatial layout of objects, high attendance with great number customers and high surrounding population. Objects densely placed with certain mutually potent influences. With maximum possible temperature of 37°C, humidity of 57%, 1,5 m/sec wind speed, with minimal amounts of released fuel in duration of 1 minute we analysed possible

hazards. As presented at the table 3 the amounts of the released substance for the first and second selected scenarios does not exceed 6 kg and that quantity is not enough for serious human intoxications i.e. deaths and influence of the environment. So safe zone is in radius of more than 12 m concerning centre of the toxic release. In case that compressor fails, consequences would be greater with regard to the higher amount of released LPG. In such case, safe zone due to intoxications is in radius greater than 128 m whilst fires are possible in radius less than 69 m. VCE is theoretically possible although less likely and in regard with over pressure and the distance of vulnerable objects. In case that happen, one or more workers could be seriously injured at a distance of 77-102 m, and a damage of shatter glass in a radius of 195 m.

Vulnerable zones includes all objects at the depot and surrounding as well – bus station, bakery on the other side of the road and parking near gas station, so assessed consequences are SIGNIFICANT and risk is HIGH.

S econd depot is in the open environment, away from the inhabited area with lower complexity of the spatial layout of objects, and less customer attendance. LPG tanks are grouped with respectable distance to the rail unloading rack and buildings. With maximum possible temperature of 37°C, humidity of 53%, wind speed 1,5 m/sec, with minimal amounts of released fuel in duration of 1 minute we also analysed possible hazards. As presented at the table 4 the amounts of the released substance for the first and second selected scenarios does not exceed 18 kg and that quantity is not enough for serious human intoxications i.e. deaths and influence of the environment. So safe zone is in radius of more than 25 i.e. 32 m concerning centres of the toxic release in cases of failures with car or rail connection pipes. In case of malfunction during sampling, consequences would be greater with regard to the greater amount of the released substance in this case 18 kg. So safe zone due to intoxication is in radius grater then 50m. If a blast of a vapour cloud happen, there would be more serious damage to the buildings, shattering and serious injuries to the workers. Depending on the scenario, damage to the reservoir or objects could also occur. Such consequences are less probable and are not further analysed in this paper.

Most vulnerable object is central building placed in the middle of the depot and road tanker loading facility between the tanks and that building. In case of accidental on LPG depot 2 assessed consequences are also SIGNIFICANT and risk is HIGH.

Conclusion

Development of industrial cogeneration and small cogeneration for the service sector and households envisaged by the EU Directive (Directive 2012/27/EU) in Montenegro will provoke greater use of liquefied petroleum gas and liquid fuels as cogeneration fuels. Consequently, the increase of LPG in trade and traffic over the next decade is certain. That raises the issue of chemical accidents and regulations in this field.

Accidental scenario imply the condition that might lead to a major accident and the potential consequences, which in most cases is the loss of a hazardous substance or the change of state of a solid substance, combined with particular conditions that eventually lead to a fire, explosion, and/or toxic release. Some sites like warehouses and fuel storage depots may have only a few credible accident scenarios, but as more processes are present on the site, larger number of potential generated accident scenarios can be, and larger potential to domino effects.

Technological or nuclear disasters do not only arise from the quantity of the hazardous substance but also the conditions or factors that bring this substance into a state of transformation of the aggregate state, fire, explosion or toxicity. The amount of the substance is only one of the criteria's in the overall level of risk of chemical accidents that need to be considered. In other words, it is not the absolute measure of hazards although is directly related to it. The amount of the chemical is one of the criteria with share in the total risk and important number for the accidental records related to EU regulations - appearance subject to reports, polices, safety reports etc.).

For the selected scenarios and types of failures on both depots, rated risk is HIGH for all scenarios. Taking into account the obtained results, and fact that depots are very different, we can conclude that the quantity of stored hazard substance in the Seveso plant is not mandatory numerically related to the risk of the plant. Risk degree is related to many factors such as the physical characteristics of the plant, the maturity of the equipment, and the levels of operator's training, the preventive maintenance of the installation, the position and mutual distance between objects as well as the number of people likely to be at the point of the accident. Material Factor represents the energy potential of a particular chemical or its mixture with other chemicals. Expresses the flammability and reactivity of the substance respectively. Hazard identification involves the estimation of Fire & Explosion Indices for the major storage units in the facility to give the relative severity of the units from the fire point of view. Therefore, it is not an absolute measure of risk degree and cannot be equalled with risk of Seveso plant.

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The ground beetles fauna (Coleoptera, Carabidae) of natural and anthropogenic habitats in Khibiny polar mountain massif

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Abstract
During 2008-2018 a total of 40 ground beetle species from 17 genera we found in ten mountains of the Khibiny massif along an altitudinal gradient from 220 to 1093 meters above sea level. Twenty species are new, additionally to 28 species early knowing for this polar mountain massif from literature sources (Poppius 1905; Fridolin 1936; Rossolimo 1989; Lindroth 1992; Anufriev & Kataev 1999). New species have been collected or in open, heated mountain tundra sites, or in anthropogenically disturbed, mainly pyrogenic, area in the intermountain valley. Both, natural mountain tundra biotopes and burnt mountain taiga forest, attracting of thermophilic and light-requiring carabid species. It was concluded that pyrogenic ecosystems enrich the ground beetle fauna of the Khibiny polar mountain massif.

Keywords: ground beetles, local fauna, altitudinal distribution, polar mountains, felling and pyrogenic ecosystems.

Introduction

Khibiny alkaline massif (KhM) is the largest mountain range at the Kola Peninsula (KP) with elevations up to 1208 meters above sea level (a. s. l.). KhM is located in the northern taiga, in a distance of 150 km from Arctic Circle, 67° N, 33° E (**Fig. 1A**), and different from surrounding plains at an altitude of 150-200 meters a. s. l. by climatic conditions, soil types and diversity of plant associations (Yakovlev 1961; Shmakova *et al* 2008; Pereverzev 2010). These factors determine the specificity of the local fauna. Over ten-year period we investigated the soil invertebrate fauna of the KhM including ground beetles. Actual knowledge on species riches and distribution of carabids in this polar mountain massif are summarized in offered report.

Material and Methods

Field works were performed during 2008-2018 in ten mountains in different parts of the rounded KhM: northern (Partomchorr and Rischorr Mts), western (Umechorr Mt), southern (Ajkyajvenchorr and Lovchorr Mts), south-eastern (Suolaiv Mt) and central part (Poachvumchorr, Kukisvumchorr, Vudjyavrchorr, and Uksporr Mts). These unpronounceable mountains names are predominantly of Suomi (Laplanders) origin.

As a whole, 34 biotopes were investigated: 31 nature and 3 anthropogenically disturbed biotopes (**Fig. 1B, C**). The collection points correspond to the local fauna (Penev 1996). The biotopes characteristic are given in the **table1**.

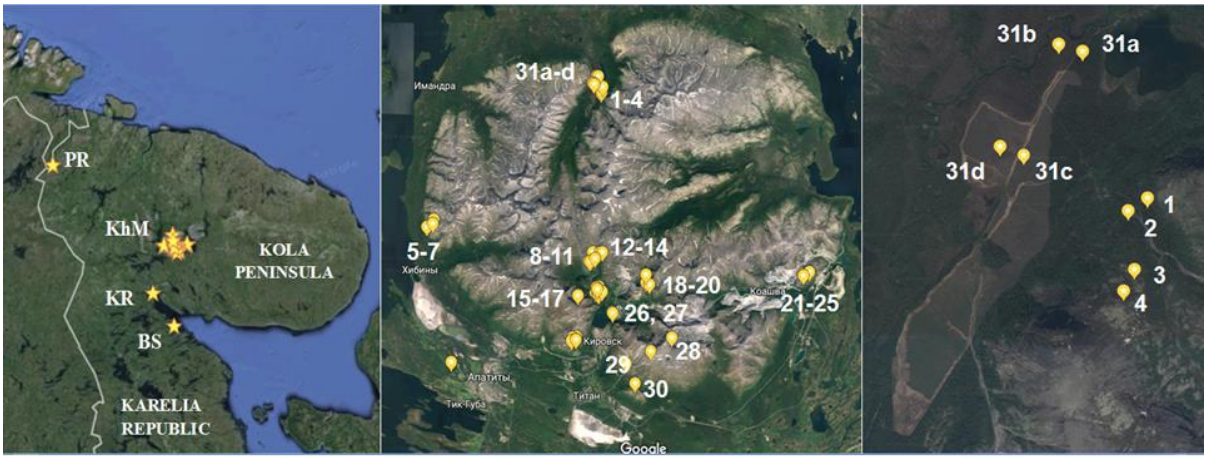

Figure 1. Location of the Khibiny mountain massif (A) and studied natural (B) and anthropogenically disturbed biotopes (C).
A: KhM – Khibiny mountain massif, PR – Pasvik Nature Reserve, KR – Kandalaksha Nature Reserve, BS – White Sea Biological Station. B: studied mountains and numbers of biotopes: Partomchorr (1), Rischorr (2-4), Umechorr (5-7), Poachvumchorr (8-11), Kukisvumchorr (12-14), Vudjyavrchorr (15-17), Uksporr (18-20), Suolaiv (21-25), Ajkyajvenchorr (26, 27), Lovchorr (28-30), intermountain valley (31a-d).

Nature biotopes were situated on different slopes in altitudes from 235 to 1093 m a. s. l. in the borders of four main mountain vegetative belts: *taiga*, *forest-tundra*, *tundra,* and *high-mountain rocky desert*. Coniferous rare-stand spruce (*Picea obovata*) and pine (*Pinus sylvestris*) forests with shrub, grass, and mosses communities are grown in the mountain taiga. The tortuous birches (*Betula tortuosa*) are forming the forests-tundra belt. Shrub, lichen-shrub, and lichen-shrub-mosses associations are typical for the mountain tundra. The fragmentary lichen-shrub-grassy cover on the rocky bedrock is presented in the desert on a high-mountain plateau. The *dark (high-humus) illuvial-humus podzol soils* form under mountain forests, and *podzolic-podbur soils* are typical for the mountain tundra (Pereverzev 2010). Both types of soils consist of a large amount of organic substances and formed on alkaline nepheline-syenite rocks with rich minerals composition (Ponomareva 1940; Mineralogy … 1978).

Three disturbed sites (burnt pine forest, pine forest felling, and burnt pine forest felling), and control pine shrub-lichen-mossy forest were located in the intermountain valley at altitudes of 220-236 m a. s. l. Felling was made in 2012 as a result of industrial deforestation for construction of mining plant. In the hot summer 2013, significant part of the forest felling was burned out. Then the ground fire spread on the surrounding pine forest. The total pyrogenic area is estimated at 6 ha. Fauna of the burnt pine forest and a control one was studied in 2015 and 2018, third and fifth years after the fire. The forest felling and the burnt forest felling were investigated in 2018.

In each biotope we used two trapping methods: litter sampling and pitfall (Barber) traps with 4% formaldehyde (Barber 1931; Ghilarov 1975). Litter samples 25 x 25 cm^2 on the depth 5-7 cm have been collected in 8-10 replications twice a vegetation season, in June, after the snow melting, and in September. From 20 to 40 traps of 500 ml were used in each biotope depending on heterogeneity of the plant cover. The

period of traps exposure was 2-3 months from June to August-September. Beetles were extracted by hand sorting and electric heating of litters. All collected material is stored in the Institute of Industrial Ecological Problems of the North (INEP KSC RAS, Apatity, Russia). The systematic and nomenclature of Carabidae family is given by the "Catalogue of Palaearctic Coleoptera" (Löbl & Smetana 2003).

Results

During a ten-year study in total of 1905 exemplars of carabids imago were collected in nature biotopes, in particular: in the mountain taiga – 512 ex belonging to 14 species, in the forest-tundra belt – 934 ex (21 species), in the mountain tundra – 457 ex (28 species), and in the rocky desert – 2 ex of 2 species.

Additionally 528 individuals were trapped in 2015 and 2018 in anthropogenically disturbed sites: in the burnt pine forest – 286 ind (13 species), on the pine forest felling – 14 ind (5 species), and on the burnt pine forest felling – 228 beetles of 14 species. As a result, 40 species of ground beetles belonging to 17 genera, 15 tribes, and 6 supertribes of the Carabinae subfamily were captured in the KhM (**table 2**).

Discussion

In results of the Finnish and Swedish expeditions at the KP in the end of 19th century, the first of 13 carabid species were noted to the KhM: *Nebria rufescens* (Ström, 1768), *Notiophilus aquaticus* (Linnaeus, 1758), *N. reitteri* Späth, 1899, *Carabus nitens* Linnaeus, 1758, *Bembidion hasti* Sahlberg, 1827, *B. velox* (Linnaeus, 1761), *B. virens* Gyllenhall, 1827, *Patrobus septentrionis* Dejean, 1828, *Calathus micropterus* (Duftschmid, 1812), *Amara brunnea* (Gyllenhal, 1810), *Curtonotus aulica* (Panzer, 1797), *Pelophila borealis* (Paykull, 1790), and *Elaphrus riparius* (Linnaeus, 1758) (Poppius 1905; Lindroth 1992).

A similar number of 13-14 species was collected in the KhM later (Rossolimo 1989; Anufriev & Kataev 1999), and the list of mountain carabides supplemented by the next 14 species: *Notiophilus biguttatus* (Fabricius, 1779), *N. germinyi* Fauvel, 1863, *Carabiis glabratus* Paykull, 1790, *Cychrus caraboides* (Linnaeus, 1758), *Loricera pilicornis* (Fabricius, 1775), *Miscodera arctica* (Paykull, 1798), *Bembidion bipunctatum* (Linnaeus, 1761), *B. yukonum* (Fall, 1926), *Patrobus assimilis* Chaudoir, 1844, *Pterostichus brevicornis* (Kirby, 1837), *Calathus melanocephalus* (Linnaeus, 1758), *Amara quenseli* (Schönherr, 1806), *Harpalus laevipes* Zetterstedt, 1828, and *Cymindis vaporariorum* Linnaeus, 1758.

Additionally, *Carabus problematicus* Herbst 1786 was mentioned for the KhM in the monograph of V. Y. Fridolin (1936). In results, 28 ground beetle species were known for the massif from literary sources. Most of them are widespread within KhM, as our research has shown.

During our ten-year work, we have added of 20 new species to existing list of ground beetles. Half of them, *Carabus violaceus* Linnaeus, 1758, *Agonum ericeti* (Panzer, 1809), *A. fuliginosum* (Panzer, 1809), *Amara equestris* (Duftschmid, 1812), *Harpalus latus* (Linnaeus, 1758), *H. luteicornis* (Duftschmid, 1812), *H. tardus* (Panzer, 1796), *Dyschiriodes globosus* (Herbst, 1783), *Amara praetermissa* (C. R. Sahlberg, 1827), and *A. interstitialis* Dejean, 1828 were caught only in one or two biotopes, mainly in the mountain tundra, the first six species in a single copy. These ground beetles can be considered as "rare" in the KhM.

Table 1. Characteristic of biotopes studied in the Khibiny Mountain Massif in 2008-2018

Mountain	Slop	Belt	Altitude*, m a. s. l.	Biotope	Geographical coordinates*	Biotopes numbering
Nature biotopes						
Partomchorr	SE	Mountain taiga	290-310	Old-growth pine-spruce shrub-lichen forest	67°49'39"N, 33°40'18"E	1
Rischorr	N	Tundra	430	Lichen-shrub tundra	67°49'17", 33°40'04"	2
	NE	Forest-tundra	360-380	Birch crooked shrub-lichen forest	67°49'22", 33°40'10"	3
	NE	Mountain taiga	290-310	Spruce-birch shrub-mossy-lichen forest	67°49'36", 33°40'06"	4
Umechorr	SW	Tundra	480-505	Shrub-lichen-mossy tundra	67°42'27", 33°15'10"	5
		Forest tundra	430-440	Wet birch crooked shrub-mossy forest	67°42'13", 33°15'00"	6
		Mountain taiga	315-330	Pine shrub forest	67°42'03", 33°14'06"	7
Poachvumchorr	N	Tundra	400-420	Shrub-moss-lichen tundra	67°40'44", 33°38'53"	8
	SE	Forest-tundra	395-400	Birch mossy-grass forest	67°40'21", 33°39'11"	9
	S	Forest-tundra	395-410	Birch grassy forest	67°40'15", 33°38'16"	10
	S	Mountain taiga	390-400	Spruce grass-shrub green mossy forest	67°40'14", 33°38'29"	11
Kukisvumchorr	S	Tundra	500-520	Shrub-lichen-mossy tundra	67°40'43", 33°40'18"	12
		Forest-tundra	430-450	Birch shrub-grassy forest	67°40'43", 33°39'56"	13
		Mountain taiga	340-350	Spruce grassy wet forest	67°39'32", 33°40'15"	14
Vudjyavrchorr	NE	Tundra	480-485	Lichen-shrub tundra	67°38'41", 33°39'26"	15
		Forest-tundra	390-410	Birch crooked shrub-grassy forest	67°38'49", 33°39'24"	16
		Mountain taiga	360-380	Spruce grassy-shrub green mossy forest	67°38'53", 33°39'45"	17
Uksporr	plateau	High-mountain tundra	710-730	Shrub-lichen-mossy tundra	67°39'32", 33°46'44"	18
	SE	Tundra	625-645	Shrub-lichen-mossy tundra	67°39'06", 33°46'44"	19
	SE	Forest-tundra	460-490	Birch crooked shrub forest	67°38'59", 33°47'17"	20
Suolaiv	SE	Forest-tundra	280-310	Birch crooked shrub-grassy forest	67°39'39", 34°11'03"	21
		Mountain taiga	250	Spruce grassy-shrub forest	67°39'37", 34°11'06"	22
	NW	Tundra	385-390	Mossy-shrub tundra	67°39'32", 34°10'03"	23
		Forest-tundra	330-340	Birch crooked shrub-grassy forest	67°39'30", 34°10'13"	24
		Mountain taiga	265-280	Spruce shrub-grassy forest	67°39'26", 34°10'14"	25
Ajkyajvenchorr	NW	Tundra	480	Lichen-shrub tundra	67°37'27", 33°41'49"	26
		Forest-tundra	430-445	Birch crooked shrub-mossy forest	67°37'29", 33°41'43"	27

Lovchorr	plateau	High-mountain rocky desert	1093	Grassy-moss-lichen fragmentation cover	67°36'11", 33°50'35"	28
	S	High-mountain tundra	735	Lichen-shrub-mossy tundra	67°35'26", 33°47'27"	29
	N	Forest-tundra	452-457	Birch crooked lichen-shrub forest	67°34'45", 33°43'22"	30
Intermountain valley			235	Pine-spruce shrub-lichen-mossy forest	67°50'15", 33°39'37"	31a
Anthropogenically disturbed sites						
Burnt forest	Intermountain valley		236	Pyrogenic blueberry-cereal pine forest	67°50'16", 33°39'23"	31b
Forest felling			221	Pine forest felling with remaining shrub-lichen-mossy litter	67°36'11", 33°50'35"	31c
Burning felling			220	Pyrogenic pine forest felling with rare herbs and cereals clumps	67°49'51", 33°38'46"	31d

Note: *Coordinates, slopes exposition, and the altitude above sea level measured with the field navigator Garmin eTrex-30.

Table 2. *List of ground beetles (Coleoptera, Carabidae) collected in the Khibiny Mountain Massif in 2008-2018*

Tribe	Genera	Species	Number of biotope
Nebriini Laporte, 1834			
	Nebria Latreille, 1825		
		Nebria rufescens (Ström, 1768)	5*, 23*, 30*
Notiophilini Motschulsky, 1850			
	Notiophilus Duméril, 1806		
		Notiophilus aquaticus (Linnaeus, 1758)	8*, 10*, 19, 27, 29*, 30*, 31a,b,d
		Notiophilus biguttatus (Fabricius, 1779)	7, 10, 11, 15-17, 19, 21, 22, 24, 27, 31a,b
		Notiophilus germinyi Fauvel, 1863	13, 23, 26, 29, 31b,c,d
		Notiophilus reitteri Spaeth, 1900	12*-14, 30
Carabini Latreille, 1802			
	Carabus Linnaeus, 1758		
		Carabus glabratus Paykull, 1790	2, 3, 7, 8, 10, 12, 13, 20-25, 29, 31b
		Carabus nitens Linnaeus, 1758	5*, 8
		Carabus violaceus Linnaeus, 1758	8*
Cychrini Laporte, 1834			
	Cychrus Fabricius, 1794		

Cychrus caraboides (Linnaeus, 1758)	1, 3, 5, 7, 8, 10, 12, 13, 20-25, 27, 30
Loricerini Bonelli, 1810	
Loricera Latreille, 1802	
Loricera pilicornis (Fabricius, 1755)	11, 12, 14
Dyschiriini Kolbe, 1880	
Dyschiriodes Jeannel, 1941	
Dyschiriodes globosus (Herbst, 1783)	10
Broscini Hope, 1838	
Miscodera Eschscholtz, 1830	
Miscodera arctica (Paykull, 1798)	8*, 18*, 20*, 26, 30, 31b,c,d
Bembidiini Stephens, 1827	
Bembidion Latreille, 1802	
Bembidion properans (Stephens, 1829)	31b*
Patrobini Kirby, 1837	
Patrobus Dejean, 1821	
Patrobus assimilis Chaudoir, 1844	8, 10, 12-17, 19, 22, 27, 29, 30
Patrobus septentrionis Dejean, 1828	14, 15*, 17*, 26*, 30*
Pterostichini Bonelli, 1810	
Pterostichus Bonelli, 1810	
Pterostichus adstrictus Eschscholtz, 1823	31d
Pterostichus brevicornis (Kirby, 1837)	1, 3, 8, 10-13, 15, 18-22, 26-28, 30, 31a,b,d*
Pterostichus oblongopunctatus (Fabricius, 1787)	31b,d
Sphodrini Laporte, 1834	
Calathus Bonelli, 1810	
Calathus melanocephalus (Linnaeus, 1758)	6, 8, 9, 17, 19, 26, 27, 29, 30
Calathus micropterus (Duftschmid, 1812)	1, 3, 5-7, 9-14, 15, 17-24, 27, 30, 31a,b,c,d
Platynini Bonelli, 1810	
Agonum Bonelli, 1810	
Agonum ericeti (Panzer, 1809)	8*
Agonum fuliginosum (Panzer, 1809)	11*
Zabrini Bonelli, 1810	
Amara Bonelli, 1810	
Amara brunnea (Gyllenhal, 1810)	8, 10, 11-13, 15, 16, 18-22, 26-30
Amara equestris (Duftschmid, 1812)	15*
Amara erratica (Duftschmid, 1812)	5*, 14*, 18-20*, 26, 29, 31b,c*,d

		Amara famelica (Zimmermann, 1832)	31d
		Amara interstitialis Dejean, 1828	20*, 26*
		Amara lunicollis Schiødte, 1837	31b,c*,d
		Amara praetermissa (C. Sahlberg 1827)	5, 29
		Amara quenseli (Schönherr, 1806)	31d
	Curtonotus Stephens, 1827		
		Curtonotus alpinus (Paykull, 1790)	2, 8, 15, 18, 20, 26, 30
		Curtonotus hyperboreus (Dejean, 1831)	3, 27, 30
Harpalini Bonelli, 1810			
	Dicheirotrichus Jacquelin du Val, 1857		
		Dicheirotrichus cognatus (Gyllenhal, 1827)	31d*
	Harpalus Latreille, 1802		
		Harpalus tardus (Panzer, 1796)	26
		Harpalus laevipes Zetterstedt, 1828	5*, 6, 18, 20, 29*, 31b*,d*
		Harpalus latus (Linnaeus, 1758)	26*
		Harpalus luteicornis (Duftschmid, 1812)	29*
		Harpalus nigritarsis C. R. Sahlberg, 1827	31d*
		Harpalus solitaris Dejean, 1829	31a*,b*
Lebiini Bonelli, 1810			
	Cymindis Latreille, 1806		
		Cymindis vaporariorum (Linnaeus, 1758)	26
15 tribes	**17 genera**	**40 species**	**34 biotopes**

Note: *species caught in a single copy.

Another eight species we have collected only in anthropogenically disturbed, mainly pyrogenic, area of the KhM. *Bembidion properans* Stephens, 1828 and *Harpalus solitaris* Dejean, 1829 were inhabited the burnt pine forest with regenerating blueberry-cereal cover. *Amara famelica* (Zimmermann, 1832), *Dicheirotrichus cognatus* (Gyllenhal, 1827), and *Harpalus nigritarsis* C. R. Sahlberg, 1827 preferred a twice disturbed area, such as a burnt felling with rare herbs and cereals clumps. *Pterostichus adstrictus* Eschscholtz, 1823, *Pt. oblongopunctatus* (Fabricius, 1787), and *Amara lunicollis* Schiødte, 1837 meet in burning sites, forest and felling. Thus, pyrogenic ecosystems enrich the ground beetle fauna of KhM by some thermophilic and light-requiring species. During the two study periods in 2015 and 2018, on three anthropogenic sites a total of 18 species were identified.

Similarly, in natural conditions of the polar KhM, ground beetles prefer open, well-heated areas of the mountain tundra and forest-tundra, compared to the mountain taiga. Diversity of beetles increases along altitude gradient from 14 species in coniferous pine and spruce forests of the mountain-taiga belt to 21 species in the forest-tundra belt, and to 28 species in the mountain tundra. In the upper belts the diversity of ground beetles enrich by additional species of such genera as *Amara (A. equestris, A. interstitialis,* and *A. praetermissa*), *Carabus (C. nitens* and *C. violaceus*), and *Notiophilus (N. aquaticus* and *N. germinyi)* and due to an appearance of *Miscodera, Curtonotus, Harpalus, Dyschiriodes, Nabria*, and *Cymindis* genera.

Conclusions

Over a ten-year research in the Khibiny mountain massif we have identified of 40 ground beetles species belonging to 17 genera. Finds of representatives of 20 species are new to this polar massif. Contrariwise, we have not found the following eight species known for the KhM from the literature sources: *Curtonotus aulica*, *Pelophila borealis*, *Elaphrus riparius, Carabus problematicus,* and five species of *Bembidion* genus – *B. bipunctatum, B. hasti*, *B. velox, B. virens*, *B. yukonum* (Poppius 1905; Fridolin 1936; Rossolimo 1989; Lindroth 1992; Anufriev & Kataev 1999). Taking into account the literature data, the local fauna of ground beetles includes in the Khibiny mountain massif no less 49 species of 19 genera. This data is comparable to species reaches of ground beetles in well-studied areas of the Pasvik Nature Reserve (47 species), Kandalaksha Nature Reserve (48 species), White Sea Biological Station (46 species) (**Fig. 1A**), and south tundra of Kanin peninsula (39 species) (Byzova et al 1986; Filippov & Shuvalov 2006; Tchesunov et al 2008; Trushitsyna 2019). On the basis of the results of previous and our own long term studies, it can be concluded that the species composition of carabids fauna in the Khibiny mountain massif is revealed almost completely. Information about the species diversity of ground beetles and characteristics of their habitats in the KhM are summarized in the database, according to the GBIF standard.

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