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Short-term faunistic monitoring of four Sites of Community Importance (SCI) in the Pieniny National Park with suggestions of land management proposal

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Abstract. Sites of Community Importance (SCI) represent rare and endangered biotopes of the Natura 2000 network. The objective of SCI protection and management is to keep their landscape and ecological function as well as their biological diversity in good condition. In our study, four SCI in the buffer zone of Pieniny National Park, Slovakia were investigated. We surveyed selected aquatic and terrestrial invertebrates during a short-term period in early summer 2015, in the water and water dependent biotopes and their coastal zones. The consistent reconnaissance of the actual status of sampling sites was important, as we confirmed the presence of several rare, endangered and Natura Directive species of flies, mayflies and dragonflies as well as terrestrial spiders and ground beetles. Application of the management proposal, which we suggested with respect to the bionomy and habitat requirements of present protected species, should lead to improvement of actual conditions of the monitored SCI.

Key words: terrestrial, aquatic, invertebrates, SCI, PIENAP, management

Introduction

Sites of Community Importance (SCI) as a part of Special Areas of Conservation (SAC) were designated to meet specific conservation objectives achievable by appropriate conservation measures. They also provide a wide range of provisioning, regulation and socio-cultural ecosystem services (IEEP 2002; Schweppe-Kraft 2008; Kettunen *et al.* 2009) dependent on particular species, groups of species, habitat types, vegetation structures or land cover (Bastian 2013).

Natura 2000, an EU-wide network of nature protection areas established under the 1992 Habitats Directive was designed to achieve the aim of the European Community, i.e. "to halt the loss of biodiversity and the degradation of ecosystem services in the EU by 2020, restore them as far as feasible, while stepping up the EU contribution to averting global biodiversity loss" (Viceníková and Polák 2003; COM 2011) and to assure the long-term survival of Europe's most valuable and threatened species and habitats. Its establishment also fulfills a Community obligation under the UN Convention on Biological Diversity. The Natura 2000 network includes nature reserves, however, most of the included land is privately owned and the emphasis is on ensuring its ecological and economically sustainable management.

Our study was carried out according to the framework of objectives of the "Development of management plans for selected sites included in the Natura 2000". The project was focused on a biodiversity inventory of selected invertebrate groups including macrozoobenthos, Diptera and terrestrial Araneae and Coleoptera and the development of a management proposal to maintain the status of four SCI in the Pieniny National Park protective zone: Veľké Osturnianske jazero lake, Malé Osturnianske jazerá lakes, Jarabinský prielom gorge and Plavečské štrkoviská gravel deposit.

In general, the area of Pieniny National Park is faunistically well studied. Information about the fauna and flora of this area were published by Vološčuk (1992) and Razowski (2000), and several papers focusing on the particular animal groups from this area were also published (e. g Arachnida - Svatoň 1990; Coleoptera - Jászay 1997; 1999; 2001; 2007; aquatic invertebrates - Manko and Zaťovičová 2006; Lepidoptera - Panigaj 2008). On the other hand, some taxa and particular areas and sites remained almost ignored. With the exception of the paper published by Šácha (2010), including data on fauna of the Odonata in the Veľké Osturnianske jazero lake and Malé Osturnianske jazerá lakes, there are no other published data on the invertebrate fauna of our researched sites.

The targets of SCI protection are both the Natura Directive species as well as habitat types. At the SCI location we studied, dominant aquatic species included *Bombina variegata* (Linnaeus, 1758), *Castor fiber* (Linnaeus, 1758), *Hamatocaulis vernicosus* (Mitt.) Hedenäs, *Lissotriton montandoni* (Boulenger, 1880) (Veľké Osturnianske jazero lake, Malé Osturnianské jazerá lakes) or *Cottus gobio* (Linnaeus, 1758), *Hucho hucho* (Linnaeus, 1758), *Lutra lutra* (Linnaeus, 1758), and *Castor fiber* (Linnaeus, 1758) (Plavečské štrkoviská gravel deposit). Interesting plants including bogbean (*Menyanthes trifoliata* L.), marsh lousewort (*Pedicularis palustris* L.), lesser tussock sedge (*Carex diandra* Schrank) and round leaved sundew (*Drosera rotundifolia* L.) could be also found here. The targets of habitat protection are mostly water dependent habitats, including natural eutrophic and dystrophic lakes and ponds, transition mires and quaking bogs, petrifying springs, alkaline fens and species-rich *Nardus* grasslands at Veľké Osturnianske jazero lake and Malé Osturnianske jazerá lakes, alpine rivers with ligneous vegetation (*Salix eleagnos* Scop.), species-rich *Nardus* grasslands, hydrophilous tall herb fringe communities of plains and alkaline fens at Jarabinský prielom gorge and alpine rivers with ligneous vegetation at Plavečské štrkoviská gravel deposit.

Therefore the aim of our study was to:

a) create a checklist and characterise assemblages of selected groups of aquatic and terrestrial invertebrates that contribute to the knowledge of invertebrate fauna of Pieniny National Park from four stands representing Sites of Community Importance (SCI) belonging to the Natura 2000 network, (Veľké Osturnianske jazero lake, Malé Osturnianske jazerá lakes, Jarabinský prielom gorge and Plavečské štrkoviská gravel deposit)

b) environmental reconnaissance to aid development of a management proposal with the objective of maintaining the status of of biotopes and their services with regard to the present taxa of aquatic and terrestrial invertebrates.

Material and Methods

Sampling sites

The sampling of terrestrial and aquatic invertebrates was carried out during the 2015 at four sampling sites within localities representing Sites of Community Importance (SCI), belonging to NATURA 2000 network (Fig. 1). The short characterisation of the sampling sites are as follows:

Veľké Osturnianske jazero lake, registered under the code SKUEV0334 (Natura 2000 - Standard data form); N 49° 20.49', E 0° 13.204', elevation 815 m a. s. l., area of water surface 0.25ha, total SCI area 45.51ha. The site lies within the western part of the buffer zone of Pieniny National Park, in near vicinity of Osturňa village. The lake is through-flow, supplied by surface flows as well as underground springs. The coastal zone is dominated by sparsely occurring shrubs and pioneer vegetation (*Salix* sp.), and monocoenose of *Picea abies* (L.) (Vološčuk 1992; Lacika and Ondrejka 2009; Košický and Ivanič 2011).

Malé Osturnianske jazerá lakes, registered under the code SKUEV0335 (Natura 2000 - Standard data form); N 49° 20.254´, E 20° 12.348´, elevation 883 m a. s. l., area of water surface 0.06ha, total SCI area 6.465ha. The site is situated within the buffer zone of the Pieniny National Park, near the border with Poland, in south-west of Veľké Osturnianske jazero lake. The site was designed as a nature reserve in 1984. It features very rich aquatic and wetland communities well adapted to the fluctuating water level. Local aquatic and wetland communities are mostly surrounded by meadows and forests. The site is also prone to landslides following prolonged periods of rain (Vološčuk 1992).

Jarabinský prielom gorge, registered under the code SKUEV0339 (Natura 2000 - Standard data form); N 49° 20.864', E 20° 38.899', elevation 652 m a. s. l.. Jarabinský prielom gorge makes up part of the SCI Pieninské bradlá cliffs – a larger area of limestone cliffs, belonging to the geomorphological unit Ľubovnianska vrchovina highlands and Pieniny (Vološčuk 1992; Košický and Ivanič 2011). It is a water shaped limestone gorge with five cascades and large potholes (5m in diameter, 3m deep) located 630 - 700 m a. s. l. and covering an area of 5.55 ha. The sampling site lies north of Jarabina village in the near vicinity of the local stone quarry. Malý Lipník brook flow through this area, creating entire limestone desks, cascades and waterfalls. Its coastal zone is dominated by *Acer* sp., *Abies alb*a (Mill.) and *Picea abies* (L.) and has forest character.

Plavečské štrkoviská gravel deposit, registered under the code SKUV0338 (Natura 2000 - Standard data form); N 49° 15.534', E 20° 50.872', elevation 480 m a. s. l., total SCI area 66.24ha. This gravel deposit was created through natural reclamation following gravel-sands mining. The stand is located within the meander of the Poprad River, in the vicinity of Plaveč village, within the geomorphological unit of Spišsko – šarišské medzihorie. The area includes extensive water planes, wetlands, flooded forests, the part of Ľubotínka brook and Poprad River (Košický and Ivanič 2011).

Material collection and identification

Terrestrial and aquatic invertebrates were sampled using standard methods on May 14th, June 3rd, and June 17th of 2015. The focus was on the capture of the maximum spectrum of taxa/species possible, rather than on quantitative collection, and therefore, we focused on material sampling possible within the widest spectrum of present microhabitats. Thus, abundance is expressed as an absolute number, not counted as activity abundance.

Aquatic invertebrates were collected with a hydro biological net (0.35mm density) using the "kicking sampling" method. Samples were taken from all presented microhabitats, including the whole flow profile, to a flow depth of 0.75 meters by deep flowing or standing waters. Specimens from submerged wood were hand-collected.

The adults of aquatic invertebrates and flying insects were collected using sweep netting.

Terrestrial invertebrates were collected using five pitfall traps with a 4% formaldehyde water so-

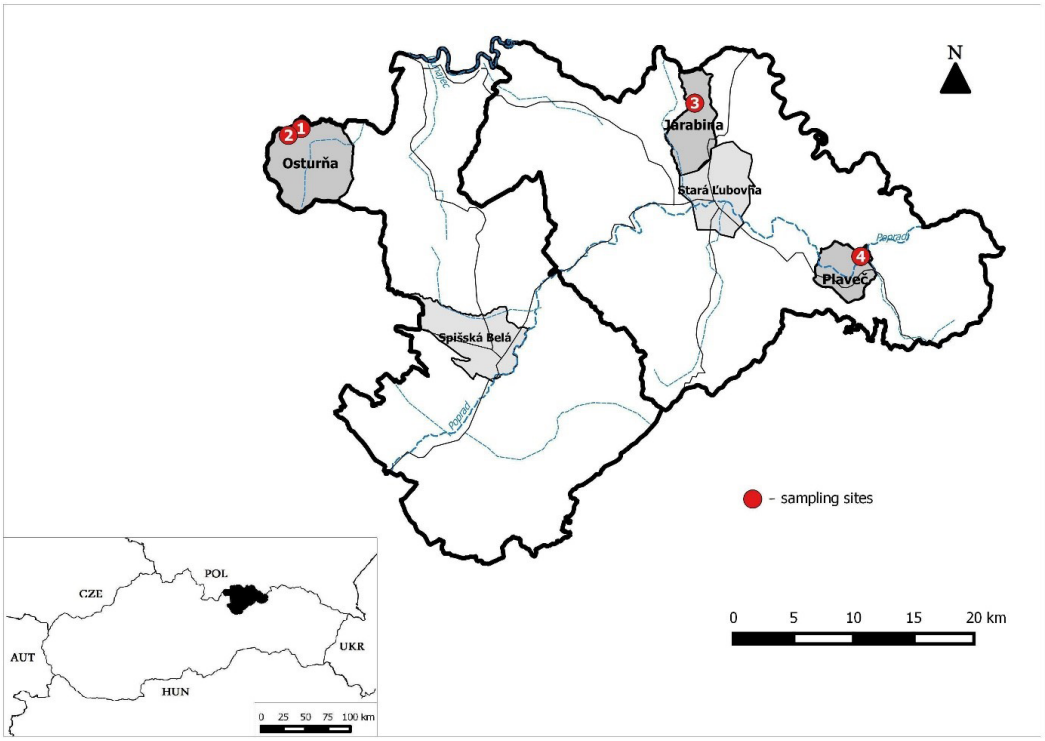

Fig. 1. Map with the position of sampling sites in the northeastern part of Slovakia, Pieninský National Park, 1-Veľké Osturnianske jazero lake, 2-Malé Osturnianske jazerá lakes, 3-Jarabinský prielom gorge, 4-Plavečské štrkoviská gravel deposit.

lution, set in a line within the coastal zone of the studied water planes, between May 14 and June 17, 2015. Spiders were also supplemented with individual collection and vegetation sweeping.

Invertebrates were manually sorted and identified up to the order level.

Material of epigeic spiders (Araneae), ground beetles (Coleoptera: Carabidae), dipterans (Diptera), mayflies (Ephemeroptera), caddisflies (Trichoptera), stoneflies (Plecoptera), dragonflies (Odonata) and aquatic true bugs (Heteroptera) were identified to the species level using appropriate determination keys (Kis 1974; Rozkošný 1980; Heimer and Nentwig 1991; Hůrka 1996; 2005; Nilsson 1997; Waringer and Graf 1997; Bauernfeind and Humpesch 2001; Van Veen 2004; Bauernfeind and Soldán 2012; Krno 2013; Oosterbroek 2015).

Abundance is expressed in absolute numbers. A checklist of determined species of epigeic spiders, ground beetles, dipterans, mayflies, caddisflies, stoneflies and dragonflies (Odonata) is introduced in Appendix A. The rest of identified invertebrate species is introduced in Appendix B.

Material was preserved in ethanol and stored by individual authors (Araneae – Zuzana Krumpálová; terrestrial Coleoptera - Beáta Baranová; Diptera - Jozef Oboňa; Ephemeroptera, Trichoptera - Ľuboš Hrivniak; Plecoptera – Peter Manko; Odonata - Zuzana Matúšová; aquatic true bugs - Barbora Reduciendo Klementová).

We characterised assemblages from their structural view-point and recorded the presence of valuable and indicator species. Software (vers. 3.10 - Hammer et al. 2001) was used to calculate assemblage diversity and evenness.

The development of management proposals

We conducted consistent reconnaissance of the actual status of study stands, observed and evaluated the presence of pioneer vegetation, non-indigenous plant species and estimated successional stage. Additionally, we assessed potential local anthropogenic interventions and indirect human impact.

We evaluated assemblage structure and recorded the presence of rare, endangered and Natura Directive species and discussed management proposal suggestions that aim to induce or maintain the status, natural character as well as the landscape and ecological function of the SCI, respecting habitat and bionomy requirements of present taxa with lay emphasis on protected species.

According to types of studied habitats, our management suggestions are focused mainly on suitable water regime maintenance including:

- water supply improvement and retention, sufficient water level maintenance (standing water)
- avoidance of vulnerable modification of flow regime i.e. anthropogenic intervention into the natural processes forming riverbanks and riverbed, respecting natural or near-to-nature flow regimes and natural hydromorphology (flowing waters)
- creating a functional, structurally diversified riparian buffer zones which will preserve and improve good conditions for aquatic invertebrates and other terrestrial taxa related to aquatic biotopes (Bunn and Arthington 2002; Postel and Richter 2012; Kuglerova et al. 2014);

In the last phase, we finalized our land management proposals for the State Nature Conservancy of the Slovak Republic (Administration of the Pieniny National Park).

Results and Discussion

Assemblage characterisation

Spiders (Araneae)

Overall, 6 species belong to the one of the categories of threatened species (following Gajdoš *et al.* 1999), *Mioxena blanda* (Simon, 1884) – LR (nt), *Alopecosa striatipes* (C.L.Koch, 1839) and *Hahnia helveola* (Simon, 1875) – LR (nc), *Alopecosa pinetorum* (Thorell, 1856) and *Ozyptila rauda* (Simon, 1875) – VU, *Tapinocyba biscissa* (O.P.-Cambridge, 1872) – DD. Ground-living spider assemblages of Veľké Osturnianske jazero lake, Malé Osturnianske jazerá lakes and Jarabinský prielom gorge riparian zones were characterised by a high proportion of forest species with preference to wet and shady habitats (predominance of - *Callobius claustrarius* (Hahn, 1831) and *Coelotes inermis* (L. Koch, 1855)) that reflect habitat conditions and indicate non-disturbed habitats. The proportion of hygrophilous and hemihygrophilous species was more than 85% of all specimens. However, a higher abundance of eurytopic species *Pardosa lugubris* (Walckenaer, 1802) signalled changes in the hydrological regime at these study sites. This means that these habitats continually dried up, confirming the findings of xerophilous spider species there (mainly at Veľké Osturnianske jazero lake and Malé Osturnianske jazerá lakes). The spider *Pardosa monticola* (Clerck, 1757), typical in dry open habitats was predominant at the drier, human influenced sampling site of the Plavečské štrkoviská gravel deposit. Spider assemblage was characterised by a high number of species with a single, unbalanced presence. Additionally, we confirmed the presence of the vulnerable species *O. rauda*, as well as the less at risk species *H. helveola* and *A. striatipes* or *T. biscissa* in this location.

Ground beetles (Coleoptera: Carabidae)

Ground beetle assemblages at Veľké Osturnianske jazero lake and Malé Osturnianske jazerá lakes riparian zones were dominated by large wingless forest species with a preference for wet and shady habitats what in accordance with this stand's characteristic environment. We did not confirm the presence of any of Natura Directive species, though the presence of *Carabus auronitens escheri* (Palliardi, 1825) as well as *Pterostichus aethiops* (Panzer, 1797) and *Pterostichus foveolatus* (Duftschmid, 1812) was interesting. The same structure of ground beetle assemblage was confirmed for the Jarabinský prielom gorge, where the vulnerable red list species protected by Natura 2000, *Carabus variolosus* (Fabricius, 1787) was found. This species inhabits mountain streams and banks and indicates that non-disturbed habitats sensitively react to human disturbances (Holecová and Franc 2001; Veselý *et al.* 2005; Matern *et al.* 2007; 2008). At Plavečské štrkoviská gravel deposit, the ground beetle community was dominated by small, macropterous species typical in dry, open habitats without special requirements for environmental conditions. We did not confirm the presence of any of the Natura 2000 protected species, but we found the two interesting species of note - *Agonum viduum* (Panzer, 1796) and *Chlaenius tibialis* (Dejean, 1826) - at this location (Table 1).

Flies (Diptera)

The presence of faunistically interesting species of the Syrphidae family, *Anasimyia lineata* (Fabricius, 1787) and *Parhelophilus versicolor* (Fabricius, 1794) was recorded at Veľké Osturnianske jazero lake and Malé Osturnianske jazerá lakes. Both species are rare and occur mostly on the edges of aquatic ecosystems (Speight 2011). In the Jarabinský prielom gorge, we confirmed the presence of extremely rare European species from the family Empididae, *Chelifera aperticauda* (Collin, 1927) (Oboňa *et al.* 2016). In the Plavečské štrkoviská gravel deposit, the presence of species from the family Limoniidae, *Arctoconopa melampodia* (Loew, 1873), *Hexatoma (Hexatoma) bicolor* (Meigen, 1818) and *Hexatoma (Hexatoma) fuscipennis* (Curtis, 1836) were recorded. These species inhabit sand and gravel banks of

	Site n. 1	Site n. 2	Site n. 3	Site n. 4
Spiders				
Taxonomic richness (species)	14	27	15	33
Absolute abundance	116	191	54	296
Diversity H´	1.81	2.26	2.12	2.14
Evenness_e^H/S	0.44	0.36	0.55	0.26
Carabidae species				
Taxonomic richness	11	5	19	24
Absolute abundance	54	38	141	114
Diversity (H)	2.01	1.04	2.21	2.58
Evenness (J)	0.84	0.65	0.75	0.81

Abbreviations and notes: Site n. 1 – Veľké Osturnianske jazero lake, Site n. 2 - Malé Osturnianske jazerá lakes, Site n. 3-Jarabinský prielom gorge, Site n. 4 – Plavečské štrkoviská gravel deposit

Table 1. Characterisation of spiders and ground beetles assemblages of particular sampling sites.

the larger streams and are very sensitive to the destruction of the natural structure of the river as well as habitat pollution (e.g. Podeniene 2002). We also recorded the Slovakian vulnerable species *Atherix ibis* (Fabricius, 1798) from family Athericidae (Jedlička and Stloukalová 2001) at the site (Table 2).

Mayflies (Ephemeroptera)

Cloeon dipterum (L.), widespread across Europe and Asia was the only mayfly species found at Veľké Osturnianske jazero lake and Malé Osturnianske jazerá lakes. Despite the absence of protected species, Jarabinský prielom gorge was characterised by relatively rare mayfly community structure, and instead dominated by rheobionts and rheophilic species of rhithral (mainly metarhithral), preferring stony substrate, feeding as grazers – scrapers and gatherers – and collectors. Such a community is typical for colline and submontane central European streams, and is characteristic of the cliff zones. Two Slovakian endangered species (Deván 2001) sensitive to pollution and change in environmental conditions (Bauernfeind and Soldán 2012) were found in the Plavečské štrkoviská gravel deposit: *Ecdyonurus insignis* (Eaton, 1870) – a rheophilous species of hyporhithral and metarhithral sections of rivers with stony bottom (Derka 2003) and *Oligoneuriella rhenana* (Imhoff, 1852) – a stenotopic filter-feeder, that inhabits montane, sub-montane and occasionally lowland rivers. Their life cycle is short (May to August) (Haybach 2006), and larvae occur in places with a strong current and stony bottom (Elpers and Tomka 1995; Bauernfeind and Soldán 2012). Concerning whole assemblages, a high occurrence of species with a lithal, phytal and pelal preference indicates relatively high microhabitat diversity as the community is supplemented by species with preference to psamal, akal and other microhabitats. The abundance of grazers, - scrapers and gatherers – collectors and the presence of passive filter feeders indicates the presence of fine particular organic matter in the lentic micro- and mesohabitats (Table 2).

Stoneflies (Plecoptera)

Stonefly species found at Veľké Osturnianské jazero lake, belonging to the crenal and rhithral rheophilic fauna and with preference to lithal and phytal are more typical in outlet streams than in lake habitats (f.e *Nemoura cinerea* Retzius, 1783). No stoneflies species was found at Malé Osturnianske jazerá lakes. The Plecoptera assemblage of the Jarabinský prielom gorge consisted of seven species with preference to lithal and forming rheophilic stoneflies conenoses of epirhithral. Plecopterofauna of the Plavečské štrkoviská gravel deposit was lowly taxonomically diversified, but yet relatively highly diversified from the microhabitat preference point of view. It was dominated by species preferring akal, phytal and particular organic matter, which indicates high substrate and microhabitat diversity. Although we did not find any rare or especially interesting species, the presence of the Plecoptera order in itself indicates good environmental conditions and value of the studied aquatic biotopes (Table 2).

Caddisflies (Trichoptera)

The dominant caddisfly species at Veľké Osturnianske jazero lake and Malé Osturnianske jazerá lakes, limnobiont *Limnephilus stigma* (Curtis, 1884) usually inhabits the littoral zone of standing waters or potamal zones of rivers (Zaťovičová and Novikmec 2003). The caddisfly assemblage of Jarabinský pri-

	Site n. 1	Site n. 2	Site n. 3	Site n. 4
Flies				
Taxonomic richness (species)	14	10	20	15
Absolute abundance	86	62	54	76
Number of families	5	5	6	3
Mayflies				
Taxonomic richness (species)	1	1	15	19
Species absolute abundance	101	78	741	294
Number of families	1	1	6	7
Stoneflies				
Taxonomic richness (species)	4	-	7	5
Absolute abundance	17	-	31	59
Number of families	2	-	3	5
Caddisflies				
Taxonomic richness (species)	3	3	14	13
Absolute abundance	20	22	159	56
Number of families	1	1	9	7

Abbreviations and notes: Site n. 1 – Veľké Osturnianske jazero lake, Site n. 2 - Malé Osturnianske jazerá lakes, Site n. 3-Jarabinský prielom gorge, Site n. 4 – Plavečské štrkoviská gravel deposit

Table 2. Characterisation of flies, mayflies, stoneflies and caddisflies assemblages of particular sampling sites.

elom gorge was dominated by rheophilous species which inhabit psammal, akal, lithal, phytal and particulate organic matter. This community is typical of epirhithral – metarhithral zones of montane - colline sections of streams and rivers. Most of these species belong to grazer-scraper and shredder feeding types, and some of them (e.g. *Hydropsyche saxonica* (Mclachlan, 1884)) are particularly sensitive to pollution (Higler and Tolkamp 1982; Móra *et al.* 2004). The caddisfly assemblage of Plavečské štrkoviská gravel deposit, typical for the metarhithral section of submontane – colline rivers, was dominated by rheobiontic and rheophilic species which inhabit akal, lital and phytal zones. In general, we did not recorded any rare or endangered Trichoptera species (Table 2).

Dragonflies (Odonata)

A rare (Šácha 2010) and vulnerable (David 2001) dragonfly Coenagrion hastulatum (Charpentier, 1825) was found at Veľké Osturnianske jazero lake and Malé Osturnianske jazerá lakes. The species inhabits littoral zones of peatlands, and dystrophic and oligotrophic lakes (with low pH values) with a dense occurrence of macrophytes (*Carex* spp.) and is very sensitive to habitat degradation, including the meliorations of wetlands, exploitation of peat, pollution, damage of littoral zones as well as the natural succession of ponds (Dolný *et al.* 2007). At the Plavečské štrkoviská gravel deposit (its part Poprad River), we recorded the rheophilic species *Onychogomphus forcipatus* (Linnaeus, 1758), belonging to the vulnerable species list in Slovakia (David 2001). This species inhabits colline and submontane sections of rivers, with a preference for gravel and sandy bottoms (Bulánková 2003; Petrovičová and David 2013) and is sensitive to the destruction of natural bank structure, regulation of rivers, and the exploitation of gravel (Dolný *et al.* 2007; Petrovičová and David 2013).

Sites characterisation and land management proposal

Veľké Osturnianske jazero lake and Malé Osturnianske jazerá lakes

The Lakes area was of a larger scale in the past, as evidenced by their boggy surroundings. Reduction of the lake habitats can even be observed nowadays as the lakes are being gradually overgrown with vegetation spreading from adjacent forest stands and abandoned meadows. The changes in monthly precipitation (Hlavcova and Cunderlik 1998) and in snow cover durations and snow-melt related water supply (Vojtek *et al.* 2003) contribute to their drying-out. Lakes are in a state of desiccation, and the process seems to be irreversible. Thus, the most valuable part of this site - aquatic and wetland communities- are under threat. In general, the site is not exposed to direct anthropogenic disturbances.

Suggested management proposals that encourage desiccation mitigation include:

- Place opened, dewatering channels against the road direction. These channels would drain rain water in the direction of the lake;
- In the forest which separates road and lakes to clear cut narrow corridors to prevent encourage the flow of water toward the lake;
- Both sites could excavate several deep holes able to maintain a higher amount of precipitation during rainy season. Such artificial microhabitats could play a pivotal role as refuges for local aquatic faunal communities during the dry period;
- Remove succession pioneer vegetation and part of pine monoculture within the lakes coastal zone, clear-cut of self-seeding trees and shrubs to create small coastal islands and broaden the coastal zone. This could help to increase microhabitat heterogeneity in the area as well as delay the source of pioneer vegetation;
- Build up a dam in the lowest point of both lakes, that could help to keep the water in the lake bodies. The biomass harvested in the proposed step above could be used to accomplish this.

Jarabinský prielom gorge

This site is an enclave of water canyon adjoined by wide xerothermic meadows, grazing land and rocks, creating specific conditions for the existence of isolated hygrophilous invertebrates (e.g. ground living spiders or beetles). The monitored area is used for trekking. Several maintenance projects including fallen tree removal as well as an entry path at the upper meadow are in progress. The stone quarry adjacent at the bottom of the gorge increases dust particulate in the air, while the surrounding upper localised meadows are used for cattle or sheep grazing. However, in general, the site is not exposed to a large degree anthropogenic disturbances. Suggested management proposal are as follows:

- Maintain natural character of the coastal zone including vegetation coverage;
- Continually manage the meadows and grazing land;
- Respect natural formation/succession processes of brook-basin and surrounding habitats;
- Avoid flow modifications such as flow regulation; and
- Minimise risk of organic or chemical pollution.

Plavečské štrkoviská gravel deposit

When compared to the others, this site is exposed to a higher degree of anthropogenic impact. Because part of the gravel deposit is used for a fishery, there is greater human and vehicle activity, and regular harvesting occurs in grassy areas. Habitats surrounding the water reservoir are relatively monotonous from a structureal point of view. The more structurally diversified habitats are those within the Poprad River coastal zone. During the monitoring season, the stream-bed of Ľubotínka Brook was excavating using heavy machinery. As a result, coastal zone vegetation was destroyed on the left river bank for about three kilometers.

Suggested management arrangements are as follows:

- Regulate and clearly eliminate human and agro-activities;
- Avoid use of flow modification, including regulation and modification of the hydrological regime;
- Remove a portion of the bank's woody vegetation which has overgrown sand and gravel banks to create 'un-treed islands'.

Conclusions

Results obtained within our study indicate that short-term faunistic monitoring including several invertebrate groups could paint an adequate portrait of actual SCI status and lead to the development of necessary management actions. The fact that short-term monitoring is more respectful of local faunal communities paired with its cost effectiveness should not be ignored. Within the Veľké Osturnianske jazero lake and Malé Osturnianske jazerá lakes region we recommended active management interventions necessary to decelerate the unfavorable process of desiccation, while within the Jarabinský prielom gorge and Plavečské štrkoviská gravel deposit we recommend minimal intervention, and maintain that a "hands-free" management approach would be the best fir. Individual accession to management of a particular SCI is necessary to ensure their landscape and ecological function as well as their biological diversity and resilience.

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Appendix A

Checklist of determined terrestrial spiders, ground beetles, flies, mayflies, stoneflies, caddishflies and dragonflies species and number of encaptured specimens found at four SCI sites, Veľké Osturnianske jazero lake, Male Osturnianske jazerá lakes, Jarabinský prielom gorge and Plavečské štrkoviská gravel deposit, Pieniny National Park, in the early summer 2015. Abbreviations and notes: Site n. 1-Veľké Osturnianske jazero lake, Site n. 2-Malé Osturnianske jazerá lakes, Site n. 3-Jarabinský prielom gorge, Site n. 4-Plavečské štrkoviská gravel deposit.

		Site n. 1	Site n. 2	Site n. 3	Site n. 4
Araneae					
Dysderidae	*Harpactea rubicunda* (C.L.Koch, 1839)				1
Theridiidae	*Theridion pictum* (Walckenaer, 1802)				2
Linyphiidae	*Ceratinella brevis* (Wider, 1834)	2			
	Diplocephalus cristatus (Blackwall, 1833)	3			1
	Diplocephalus helleri (L.Koch, 1869)	1			
	Entelecara acuminata (Wider, 1834)		2		
	Erigone dentipalpis (Wider, 1834)			1	2
	Kaestneria dorsalis (Wider, 1834)				3
	Mughiphantes mughi (Fickert, 1875)		3		
	Tenuiphantes mengei (Kulczynski, 1887)		1		
	Tenuiphantes tenebricola (Wider, 1834)	3		1	
	Maso sundevalli (Westring, 1851)		1		
	Mioxena blanda (Simon, 1884)		1		
	Oedothorax retusus (Westring, 1851)				2
	Syedra gracilis (Menge, 1869)		1		
	Tapinocyba biscissa (O.P.-Cambridge, 1872)		2		3
	Walckenaeria atrotibialis (O.P.-Cambridge, 1878)			1	1
	Walckenaeria cucullata (C.L.Koch, 1836)		1		
	Walckenaeria mitrata (Menge, 1868)	1			
	Walckenaeria obtusa (Blackwall, 1836)				1
Tetragnathidae	*Pachygnatha degeeri* (Sundevall, 1830)				3
	Pachygnatha listeri (Sundevall, 1830)	1			
	Tetragnatha extensa (Linnaeus, 1758)				3
	Tetragnatha montana (Simon, 1874)				2
	Tetragnatha pinicola (L.Koch, 1870)		1		
Araneidae	*Araneus diadematus* (Clerck, 1757)				1
	Araneus marmoreus (Clerck, 1757)		1		
	Araniella cucurbitina (Clerck, 1757)		3		
	Hypsosinga albovittata (Westring, 1851)				2
	Larinioides cornutus (Clerck, 1757)			1	
	Singa nitidula (C.L.Koch, 1845)				1
Lycosidae	*Alopecosa cuneata* (Clerck, 1757)		1		
	Alopecosa pinetorum (Thorell, 1856)			5	
	Alopecosa striatipes (C.L.Koch, 1839)				2
	Alopecosa trabalis (Clerck, 1757)		14		
	Pardosa amentata (Clerck, 1757)	13	8		32
	Pardosa monticola (Clerck, 1757)				141
	Pardosa prativaga (L.Koch, 1870)				20
	Pardosa lugubris (Walckenaer, 1802)	17	20	2	
	Pardosa sp.			5	
	Piratula hygrophila (Thorell, 1872)			3	
	Trochosa ruricola (De Geer, 1778)				22

	Trochosa spinipalpis (F.O.P.-Cambridge, 1895)	3	7		
	Trochosa terricola (Thorell, 1856)		14	1	
Pisauridae	*Pisaura mirabilis* (Clerck, 1757)				1
Agelenidae	*Tegenaria campestris* (C.L.Koch, 1834)		2	2	
Hahniidae	*Hahnia helveola* (Simon, 1875)				5
	Hahnia pusilla (C.L.Koch, 1841)	1			17
Amaurobiidae	*Callobius claustrarius* (Hahn, 1831)	50	75	19	
	Coelotes inermis (L.Koch, 1855)	18	20	10	
Liocranidae	*Agroeca brunnea* (Blackwall, 1833)	2			
	Liocranoeca striata (Kulczynski, 1882)	1	1		
	Scotina celans (Blackwall, 1841)				1
Phrurolitidae	*Phrurolithus festivus* (C.L.Koch, 1835)				9
Clubionidae	*Clubiona lutescens* (Westring, 1851)			1	
	Clubiona stagnatilis (Kulczynski, 1897)				1
	Clubiona sp.			1	
Gnaphosidae	*Drassodes pubescens* (Thorell, 1856)				5
	Zelotes subterraneus (C.L.Koch, 1833)		1	1	
Philodromidae	*Philodromus collinus* (C.L.Koch, 1835)		6		
Thomisidae	*Diaea dorsata* (Fabricius, 1777)		1		2
	Ozyptila praticola (C.L.Koch, 1837)		1		1
	Ozyptila rauda (Simon, 1875)				2
	Ozyptila simplex (O.P.-Cambridge, 1862)				2
	Xysticus cristatus (Clerck, 1757)		2		4
	Xysticus ulmi (Hahn, 1831)				1
Salticidae	*Ballus chalybeius* (Walckenaer, 1802)		1		
Coleoptera					
Carabidae	*Abax carinatus* (Duftschmid, 1812)			2	
	Abax parallelepipedus (Piller & Mitterpacher, 1783)			55	
	Abax parallelus (Duftschmid, 1812)			14	
	Agonum muelleri (Herbst, 1784)				2
	Agonum viduum (Panzer, 1797)				1
	Amara erratica (Duftschmid, 1812)				15
	Amara spp. (Bonelli, 1810)				4
	Anysodactylus binotatus (Fabricius, 1787)				1
	Asaphidion pallipes (Duftschmid, 1812)				3
	Bembidion guttula (Fabricius, 1779)				6
	Bembidion lampros (Herbst, 1784)				19
	Bembidion assimile (Gyllenhal, 1810)				2
	Calathus fuscipes (Goeze, 1777)				3
	Carabus auronitens escheri (Palliardi, 1825)	7		1	
	Carabus glabratus (Paykull, 1790)	8	2	12	
	Carabus granulatus (Linnaeus, 1758)			1	1
	Carabus hortensis (Linnaeus, 1758)			1	
	Carabus variolous (Fabricius, 1787)			2	
	Carabus violaceus (Linnaeus, 1758)	5		1	1
	Cymindis humeralis (Fourcroy, 1785)				1
	Harpalus afinis (Schrank 1781)				10
	Harpalus latus (Linnaeus, 1758)	2	3	2	1
	Harpalus luteicornis (Duftschmid, 1812)				1
	Chlaenius tibialis (Dejean, 1826)				2
	Molops piceus (Panzer, 1793)	18	25	8	

	Nebria brevicolis (Fabricius, 1792)	2	1		24
	Ophonus azureus (Fabricius, 1792)				1
	Platynus assimilis (Paykull, 1790)			7	
	Poecilus cupreus (Linnaeus, 1758)				4
	Poecilus versicolor (Sturm, 1824)				7
	Pterostichus aethiops (Panzer, 1797)	2	7	12	
	Pterostichus anthracinus (Illiger, 1798)				1
	Pterostichus burmeisteri (Illiger, 1798)	6		3	
	Pterostichus foveolatus (Duftschmid, 1812)			4	
	Pterostichus melanarius (Illiger, 1798)			1	3
	Pterostichus niger (Schaller, 1783)	1		3	
	Pterostichus oblongopunctatus (Fabricius, 1787)	1		8	1
	Trichotichnus laevicolis (Fabricius, 1787)	2		4	
Diptera					
Athericidae	*Atherix ibis (Fabricius, 1798)*			2	
	Ibisia marginata (Fabricius, 1781)			6	
Dixidae	*Dixella aestivalis (Meigen, 1818)*	14	9		
Empididae	*Dolichocephala irrorata (Fallén, 1816)*			4	
	Dolichocephala oblongogutata (Dale 1878)			1	
	Chelifera aperticauda (Collin, 1927)			1	
	Wiedemannia braueri (Mik, 1880)				6
Limoniidae	*Arctoconopa melampodia (Loew, 1873)*				20
	Dactylolabis (Dactylolabis) transversa (Meigen, 1804)			7	
	Dicranomyia (Melanolimonia) caledonica (Edwards, 1926)			6	
	Dicranomyia (Melanolimonia) occidua (Edwards, 1926)			2	
	Dicranomyia conchifera (Strobl, 1901)		1		
	Dicranomyia mitis (Meigen, 1830)			4	
	Dicranomyia ornata (Meigen, 1818)				1
	Dicranota modesta (Osten Sacken, 1869)		1		2
	Epiphragma ocellare (Linnaeus, 1761)			1	
	Epiphragma ocellare (Linnaeus, 1761)				2
	Erioptera flava (Brunetti, 1912)	19	7		
	Erioptera griseipennis (Meigen, 1838)				2
	Helius (Helius) longirostris (Meigen, 1818)	3			
	Hexatoma (Hexatoma) bicolor (Meigen, 1818)				4
	Hexatoma (Hexatoma) fuscipennis (Curtis, 1836)				15
	Hoplolabis (Parilisia) areolata (Siebke, 1872)				10
	Limonia macrostigma (Schummel, 1829)			2	
	Limonia nigropunctata (Schummel, 1829)				1
	Limonia nubeculosa (Meigen, 1804)			3	
	Limonia phragmitidis (Schrank, 1781)				2
	Metalimnobia quadrimaculata (Linnaeus, 1761)	1			
	Molophilus ater (Meigen, 1804)	23	22		
	Molophilus pseudopropinquus (Mendl, 1973)				5
	Ormosia lineata (Meigen, 1804)			1	
	Phylidorea ferruginea (Meigen, 1818)	12	12		
	Pseudolimnophila (Pseudolimnophila) lucorum (Meigen, 1818)	4			1
	Rhabdomastix subparva (Starý, 1971)				
	Symplecta hybrida (Meigen, 1804)				3

	Tasiocera (Dasymolophilus) exigua (Savchenko, 1973)			5	
Pediciidae	*Dicranota fuscipennis* (Lackschewitz, 1940)			1	
	Tricyphona immaculata (Meigen, 1804)	1	3	1	2
Ptychopteridae	*Ptychoptera scutellaris* (Meigen, 1818)	2			
Syrphidae	*Anasimyia lineata* (Fabricius, 1787)	2	3		
	Meliscaeva auricollis (Meigen, 1822)	2	2		
	Parhelophilus versicolor (Fabricius, 1794)	1			
	Platycheirus granditarsus (Förster, 1771)	1			
	Rhingia rostrata (Linnaeus, 1758)			2	
	Sphaerophoria philantha (Meigen, 1822)	1			
Tipulidae	*Dolichopeza albipes* (Ström, 1768)			1	
	Nephrotoma appendiculata (Pierre, 1919)			2	
	Tipula luna (Westhoff, 1879)		2		
	Tipula maxima (Poda, 1761)			2	
Ephemeroptera					
Leptophlebiidae	*Habroleptoides confusa* (Sartori & Jacob, 1986)			14	11
	Habrophlebia lauta (Eaton, 1884)			8	
	Paraleptophlebia (Lestage, 1917) sp.			5	
Caenidae	*Caenis* (Stephens, 1835) sp.				1
	Caenis luctuosa (Burmeister, 1839)				3
	Caenis robusta (Eaton, 1885)				3
	Caenis horaria (Linnaeus, 1758)				4
Ephemerelidae	*Ephemerella mucronata* (Bengtsson, 1909)			1	
	Ephemerella ignita (Poda, 1796)				52
	Torleya major (Klapánek, 1905)			1	
Ephemeridae	*Ephemera danica* (Muller, 1764)			12	3
Baetidae	*Baetis alpinus* (Pictet, 1843-1845)			3	
	Baetis fuscatus/scambus			1	8
	Baetis lutheri (Muller-Liebenau, 1967)			412	
	Baetis rhodani (Pictet, 1843-1845)			91	38
	Baetis vardarensis (Ikonomov, 1962)				1
	Baetis vernus (Curtis, 1834)				23
	Baetis muticus (Linnaeus, 1758)			145	8
	Baetis niger (Linnaeus, 1761)			2	
	Centroptilum luteolum (Muller, 1776)			38	
	Cloeon dipterum (Linnaeus, 1761)	101	78		30
Heptageniidae	*Ecdyonurus insignis* (Eaton, 1870)				11
	Ecdyonurus macani (Thomas & Sowa, 1970)				2
	Ecdyonurus torrentis (Kimmins, 1942)				2
	Ecdyonurus cf. stanmachi (Sowa, 1971)			7	
	Epeorus assimilis (Eaton, 1885)			1	
	Electrogena (Zurwerra & Tomka, 1985) sp.				1
	Rhithrogena semicolorata (Curtis, 1834)				29
Oligoneuridae	*Oligoneuriela rhenana* (Imhoff, 1852)				64
Plecoptera					
Nemouridae	*Protonemura auberti* (Illies, 1954)	1		7	
	Protonemura intricata (Ris, 1902)			11	4
	Nemoura cinerea (Retzius, 1783)	11			
	Nemoura marginata (Pictet, 1835)			1	
Leuctridae	*Leuctra albida* (Kempny, 1899)	1			
	Leuctra aurita (Navas, 1919)				3

	Leuctra braueri (Kempny, 1898)			1	
	Leuctra hippopus (Kempny, 1899)	4		2	
	Leuctra inermis (Kempny, 1899)			4	
Perlodidae	*Isoperla oxylepis* (Despax, 1936)				44
Perlidae	*Perla marginata* (Panzer, 1799)			5	3
Chloroperlidae	*Siphonoperla torrentium* (Pictet, 1841)				5
Trichoptera					
Rhyacophilidae	*Rhyacophila* (Pictet, 1834) sp.			9	
	Rhyacophila dorsalis (Curtis, 1834)				4
	Rhyacophila obliterata (McLachlan, 1863)			3	
	Rhyacophila tristis (Pictet, 1835)			20	
Philopotamidae	*Philopotamus montanus* (Donovan, 1813)			3	
Hydropsychidae	*Hydropsyche* (Pictet, 1834) sp.			9	
	Hydropsyche incognita (Pitsch, 1933)				14
	Hydropsyche instabilis (Curtis, 1834)			33	6
	Hydropsyche saxonica (McLachlan, 1884)			2	
Polycentropodidae	*Holocentropus* (McLachlan, 1878) sp.				1
	Polycentropus flavomaculatus (Pictet, 1834)			2	
Psychomyiidae	*Psychomyia pussila* (Fabricius, 1781)				4
	Tinodes rostocki (McLachlan 1878)			11	
Limnephilidae spp.	*Anabolia furcata* (Brauer, 1857)				2
	Anabolia brevipennis (Curtis, 1834)		5		
	Limnephilus (Leach,1815) sp.	5	5		2
	Limnephilus auricula (Curtis, 1834)	1			
	Limnephilus stigma (Curtis, 1834)	14	12		
	Chaetopteryx fusca/villosa				3
	Allogamus auricolis (Pictet, 1834)			6	
	Halesus digitatus/tesselatus			21	1
	Potamophilax luctuosus/latipennis			6	
Lepidostomatidae	*Lasiocephala basalis* (Kolenati, 1848)				6
	Lepidostoma hirtum (Fabricius, 1775)				8
Leptoceridae	*Athripsodes aterrimus* (Stephens, 1836)				3
	Athripsodes bilineatus (Linnaeus, 1758)				2
Sericostomatidae	*Sericostoma personatum* (Spencer, 1826)			2	
Odontoceridae	*Odontocerum albicorne* (Scopoli, 1763)			5	
Odonata					
Calopterygidae	*Calopteryx splendens* (Harris, 1782)				2
	Calopteryx virgo (Linnaeus, 1758)				3
Platycnemidae	*Platycnemis pennipes* (Pallas, 1771)				20
Coenagrionidae	*Ischnura elegans* (Vander Linden, 1823)				1
	Coenagrion hastulatum (Charpentier, 1825)	2	2		
	Coenagrion hastulatum (Charpentier, 1825) *(exuvium)*	5			
	Coenagrion puella (Linnaeus, 1758)	1	1		
Aeshnidae	*Aeshna cyanea* (Muller, 1764)		1		2
Gomphidae	*Onychogomphus forcipatus* (Linnaeus, 1758)				1

Appendix B

Checklist of determined flatworms, isopods, malacostracan crustaceans, water true bugs and lacewings species and number of encaptured specimens found at four SCI sites, Veľké Osturnianske jazero lake, Male Osturnianske jazerá lakes, Jarabinský prielom gorge and Plavečské štrkoviská gravel deposit, Pieniny National Park, in the early summer 2015. Abbreviations and notes: Site n.1-Veľké Osturnianske jazero lake, Site n.2-Malé Osturnianske jazerá lakes, Site n.3-Jarabinský prielom gorge, Site n.4-Plavečské štrkoviská gravel deposit.

		Site n.1	Site n.2	Site n.3	Site n.4
Turbellaria					
Dugesiidae	*Dugesia gonocephala* (Dugés, 1830)			12	
Isopoda					
Asellidae	*Asellus aquaticus* (Linnaeus, 1758)				6
Amphipoda					
Gammaridae	*Gammarus fossarum* (Koch, 1836)			126	22
Heteroptera					
Notonectidae	*Notonecta* (Linnaeus, 1758) sp.	2			3
	Notonecta glauca (Linnaeus, 1758)	2	1		
	Notonecta viridis (Delcourt, 1909)				1
Corixidae	*Hesperocorixa* (Kirkaldy, 1908) sp.	6			
	Hesperocorixa linnaei (Fieber, 1848)	2			
	Hesperocorixa sahlbergi (Fieber, 1848)	1	1		
	Sigara (Fabricius, 1775) sp.				1
	Sigara nigrolineata (Fieber, 1848)				1
Gerridae	*Gerris* (Fabricius, 1794) sp.	4			5
	Gerris lacustris (Linnaeus, 1758)	8	3		3
Neuroptera					
Sialidae	*Sialis lutaria* (Linnaeus, 1758)		2		
Sisyridae	*Sisyra sp.*	1			