MALACOFAUNA OF SELECTED AREAS IN LITOVELSKÉ POMORAVÍ (CZECH REPUBLIC)*

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The molluscan diversity in the Litovelské Pomoraví Protected Landscape Area (PLA) (Moravia, Czech Republic) was studied. The PLA stretches on the territory of a river alluvial plain and is formed by the meandering river, complex of alluvial forests, meadows, and wetlands. It is part of the European network of nature protection areas Natura 2000. Altogether 10 450 specimens representing 107 mollusc species were found by means of hand collecting and sieving a litter layer during the sampling period April 2012–September 2015 at nine selected sampling sites. Computation of the Jaccard and Sörensen indices showed the degree of similarity between the individual locations based on the number of shared species. The p*rincipal component analysis* based on known ecological characteristics clearly distinguished some locations and indicated the relationships between a particular molluscan group and a locality. The data availability and possibility to assess the succession over time is essential for later evaluation and mapping the natural processes or human impact at naturally important localities.

molluscs, Litovelské Pomoraví Protected Landscape Area, biodiversity, NATURA 2000

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INTRODUCTION

Biodiversity is one of the most important natural resources offered by the Earth ecosystems. Insects and other invertebrates play the key role in litter processing, organic matter decomposition; and thus in the cycle of energy and nutrients in ecosystems. To enhance the conservation of biological diversity and to prevent biodiversity loss in Europe, the Natura 2000 network of nature protection areas has been established, in the Czech Republic currently covering ca. 17.5% of its territory. According to the European Commission Natura 2000 plays a key role in significant reduction of biodiversity losses (Kruk et al., 2010).

Among invertebrates of terrestrial as well as aquatic ecosystems, molluscs constitute a very significant group. Many authors have considered them as a group suitable for examining the patterns and the distribution of terrestrial diversity, as a model group that illustrates changes in local environment over long timescales, and as ecosystem health bioindicators (Killeen, 1998; Lozek, 2005; Kienast et al., 2011; Gerlach et al., 2013; Ramirez, 2013). The significance of molluscs is supported by the International Union for Conservation of Nature (IUCN) Red List of Non-marine Molluscs that just in Europe includes 1233 species (Cuttelod et al., 2011). In the Czech Republic alone more than 50% of the present species (134/249) have

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been placed on the Red List (Beran et al., 2005; Horsak et al., 2013).

Despite all given arguments, there is a lack of faunistic studies in Europe and data on European molluscs in scientific literature (Opermanis et al., 2014). The published faunistic information is very fragmented among different journals, published in non-reviewed journals or elsewhere and therefore not well tracked. This fact significantly complicates the possibility of finding basic information about historical fauna diversity and species distribution not only in protected landscape areas. This hold true despite the fact that the management of protected areas in most European countries includes monitoring and periodic review of conservation objectives, usually at a frequency of at least once a decade (Kruk et al., 2010). The biodiversity data are a very important tool for biodiversity assessment and their accessibility remains a significant constraint on conservation planning (Gaston et al., 2008).

For this study, several important small-scale protected areas within the Litovelské Pomoraví Protected Landscape Area (PLA) were selected due to the presence of alluvial forests and undisturbed natural river dynamics. The landscape is unique and highly valuable on the European scale as a result of natural river flow and closely inter-related conservation and species diversity in the floodplain forests. Thanks to the sensitive approach to land management practiced, the landscape in Pomoraví has retained the mentioned high natural values on a small territory. The wetland section (62 km^2) in Litovelské Pomoraví has been included in the List of Wetlands of International Importance (Ramsar Sites) according to the Ramsar Convention.

The aim of this study is to provide current data on the diversity and status of molluscan population in this valuable and significant European location.

In the site of the PLA, several studies were carried about in the past. Due to the large area of the site, the results are rather from individual small-scale areas within the PLA. Beran (2000) published a comprehensive study on aquatic molluscs. Altogether 43 aquatic species were found at 95 localities under study. In terms of terrestrial molluscs, the main attention of the malacologist was for a long time focused on limestone hill Třesín. Manas (2004) summarized current research on terrestrial mollusc species and added results of his research from this locality. From other studies of terrestrial molluscs, Vasatko (2000a, b) documented two small-scale protected areas of Třesín and Ramena řeky Moravy.

MATERIAL AND METHODS

Localities description

Litovelské Pomoraví PLA (49°42.2′N, 17°6.0′E; area 96 km^2; 210–345 m a.s.l.) was established in 1990 on the territory of the Morava river alluvial plain between the urban areas of Olomouc and Mohelnice. Forests cover 56% of the area, agricultural lands 27% (9.5% of which are meadows), water bodies 8%, and other usage makes up 9%. As a source of miscellaneous faunal and floral diversity, the PLA was incorporated in the European system of Natura 2000 and has been declared a Special Protection Area (SPA) – Bird Area (Special Protection Area for birds) in order to protect the kingfisher (*Alcedo atthis*), collared flycatcher (*Ficedula albicollis*), and middle spotted woodpecker (*Dendrocopos medius*). The naturally meandering Morava river branches out into inland delta – a network of periodic and permanent sidestreams, branches, and pools, that forms the core of the PLA and is the main natural phenomenon of this area. The area also includes the accompanying complex of valuable alluvial forests, wet alluvial meadows and wetlands, as well as the karst territory (Třesín hill).

The data were collected during a four-year period (2012–2015) from five national nature monuments (NNM) and four national nature reserves (NNR) within the PLA:

(1) Hrdibořice Fishponds NNM (49°29.0′N, 17°13.4′E; area 37.7 ha, 206 m a.s.l.). The national nature monument includes fishponds and surrounding meadows. This territory is of special significance due to the extent of the calcareous soil substrate, which makes it one of the most important peatland habitats in Moravia. The protected area is a notable refuge for rare plant and animal species in the centre of intensively farmed landscape.

(2) Chropyně Fishpond NNM (49°21.2′N, 17°22.2′E; area 24.36 ha; 191 m a.s.l.). The locality lies on rich deposits of sand and gravel, which are overlain by alluvial deposits. The soil around the fishpond is of the Fluvisol and Gley types. The Chropyně Fishpond is an important ornithological locality and is home for notable and rare species of ground beetle *Pterostrichus aterrimus*, amphibians and grass snake (*Natrix natrix*).

(3) Křéby NNM (49°17.2′N, 17°10.9′E; area 3.52 ha; 228–277 m a.s.l.). This monument was declared to protect three enclaves of grassland on the right-bank valley slope of the Tištínka Stream. It lies in the warm climatic region (average annual temperature is about 9°C). The geological basement is predominantly built of calcareous clays and sands and the soil covering is predominantly of Cambisols and brown soils.

(4) Na Skále NNM (49°33.3′N, 17°10.6′E; area 4.56 ha; 242–263 m a.s.l.). The monument was declared in 1977. The protected area consists of a rugged terrain depression at the place of a former limestone quarry with fragments of previously extensive sub-xerothermal grass-herb (Sedo-Scleranthetea class and *Bromion erecti* alliance) and shrub (*Prunion spinosae* alliance) communities. The most notable is the subspecies of large thyme (*Thymus pulegioides* ssp. *carniolicus*), in the Czech Republic detectable only here.

(5) Třesín NNM (49°42.6′N, 17°0.2′E; area 143 ha; 344.9 m a.s.l.). The protected area consists of predominantly forested Třesín hill and includes also fragments of a natural beechwood forest. In terms of molluscan fauna an important element in the landscape are northeastern wetland habitats. The locality represents the northern border for several thermophilous herb species in Moravia. The fauna at Třesín has not been fully documented. Until now, a total of 55 species of terrestrial molluscs have been recorded.

(6) Ramena řeky Moravy NNR (49°40.9′N, 17°8.9′E; area 71.19 ha; 218–230 m a.s.l.). The NNR was declared in 1990. The subject of protection is the unique ecosystem of the Morava river lowland flow with meanders and the near-natural forest and forest-free ecosystems, with the representation of typical and endangered species of wild animals and plants.

The territory represents the core area of the alluvial part of Litovelské Pomoraví. The NNR is included in the Litovelské Pomoraví SPA – Bird Area and the proposed Litovelské Pomoraví Site of Community Importance within the Natura 2000 system.

(7) Zástudánčí NNR (49°24.0′N, 17°18.6′E; area 100.64 ha; 195–198 m a.s.l.). The geological basement of the NNR is built of Neogene and Quaternary sediments, covered with alluvial soils. The subject of protection is the preserved alluvial forest (consisting mostly of poplar, ash, and oak) with characteristic flora and fauna along the unregulated river channel of the Morava river. Due to the geomorphological position and climatic conditions Zástudánčí NNR ranks among the warmest localities in the Czech Republic. The preserved nature of the biotopes is reflected in the flora composition with many thermophilous species.

(8) Špraněk NNR (49°40.0′N, 16°54.6′E; area 28.7 ha; 388–539 m a.s.l.). The reserve covers forested Špraněk hill (539 m) with karst rock formations and an extensive network of caves and rare thermophilous vegetation. The majority of the reserve is forested, calciphilous beechwoods predominate. The rock arch under the Zkamenělý zámek is the largest formation of its kind in Moravia. Špraněk NNR is included in the proposed Špraněk Site of Community Importance under the Natura 2000 system.

(9) Žebračka NNR (49°28.3'N, 17°28.0′E; area 234 ha; 204–2014 m a.s.l.). The main subject of protection in this NNR is the complex of predominantly forested ecosystems (alluvial forests around the Strhanec stream and their transformation into other types of mixed deciduous forests). These forests are bound to the relief and the geological substrates of the Bečva river terrace and contain wild plant and animal communities with high diversity and endangered species. Žebračka NNR is included in the proposed Bečva–Žebračka Site of Community Importance under the Natura 2000 system.

Sampling methods

Terrestrial species of molluscs were collected by the direct hand picking method (Lozek, 1956). Clearly recognizable species were only counted and left at the site. Species that required a more precise determination were killed in carbonated water, preserved in ethanol, and analyzed in laboratory. During sampling, we tried to cover all types of habitats within the site with special attention to shady and moist sites, rocks, and dead wood. In addition to hand collecting, from each habitat represented at the individual localities, samples of leaves, litter, and thin topsoil layer were collected (ca. 20 l bag) using a special entomological sieve with mesh size of 1 cm^2. The collected material was completely dried and shells were collected by hand under a magnifying glass in laboratory.

The collection and determination of aquatic species was based on Beran (2002). Aquatic specimens were collected using a metal sieve 25 cm in diameter (mesh size 0.5 × 0.5 mm) by washing out a bottom substrate and also the submerged and other aquatic vegetation. In addition, some direct collections from objects submerged in water (litter, rocks, wood) were performed.

Data evaluation

To compare similarity and diversity of the sample sets, Jaccard and Sörensen indices were computed by the software EstimateS for MS Windows (Version 9.10.) with 50 randomizations without replacement (Colwell, 2013). The principal component analysis (PCA) based on known ecological parameters was performed using XLSTAT software (Addinsoft, 2012).

The molluscs were classified following the determination keys in Lozek (1956) and Horsak et al. (2010, 2013). By the division into ecological groups based on Lisicky (1991) the obtained molluscs were divided into 22 ecological groups, namely:

SI – strictly forest species; SIth – forest species living also outside the forest or on shrubby biotopes; SI(MS) – mesohygrophilous forest species; PDt – wetland species; SG – species of standing waters; MS – euryvalent species; SIi – species of floodplain and wetland forests; 9 PD – strongly hydrophilic species living in wetlands; 10 PD – species of overgrown swamps and marshes; HG – hygrophilous species; ST – herbaceous formations in dry and sunny habitats; ST(SI) – species of open dry habitats and forest steppe; MSp – species living on rocky habitats with hard rocks; XC – thermophilic and xerotolerant species; SS – species of bushy xerothermic habitats even in the sparse forest; STp – species living on rocky habitats with limestone rocks; SIp – petrophilous forest species; SIh – strongly hygrophilous forest species; PT – silviphobic species of open habitats in general;

RV – species of running waters; PT(SI) – species of sparse forest; and SI(HG) – hygrophilous forest species.

RESULTS

Altogether 10 450 individuals belonging to 107 mollusc species were collected during a three-year period (2012–2015) in nine selected small scale landscape areas. During the study we observed 81 terrestrial and 26 aquatic mollusc species. In total 15 species (14.0%) are included on the Red List of invertebrates for the Czech Republic; moreover, 23 species (21.5%) are classified in 'near threatened' category (Beran et al., 2005). In terms of the species number, the locality of Třesín NNM (Loc5) seems to be the most favourable for a wide range of mollusc species (54) (Table 1). On the other hand, the locality of Chopyně Fishpond (Loc2) was assessed as a poor locality in terms of molluscan diversity. The collection contained only 14 species with the dominance of terrestrial, however ubiquitous and very common species (*H. pomatia* and *C. hortensis*).

Overall, across locations, *H. pomatia* and the genus *Vallonia* species were the most frequent representatives of terrestrial species; among aquatic species *P. planorbis* and *P. casertanum* dominated (Table 1).

Similarity indices and analyses

To evaluate similarity between the nine localities, the Jaccard and Sörensen indices were calculated using EstimateS software (Table 2). The highest similarity was found between Loc6 and Loc9 (indices values *Ja* = 61.5%; *Sö* = 58.5%). Contrarily, the lowest index value was found between Loc3 and Loc7 (*Ja* = 4.4%; *Sö* = 11.3%). As shown in Fig. 1 in more detail, the PCA analysis described the relationships between the species ecological groups and the studied localities. Regarding the particular ecological groups, the analysis explained over 48% variability (axes F1 and F2); it clearly separated localities 4, 6, 7, and 8. While Loc4 seems to be favourable for thermophilic and xerotolerant (XC) together with euryvalent (MS) species, Loc6 is favourable for wetland species (PDt) and species of standing (SG) and running (RV) water. Loc7 is a typical forest habitat with open-forest (SS) and hygrophilous forest species (HG, SIh). Finally, Loc8 has attracted namely species living on rocky habitats with hard (MSp) and limestone rocks (STp).

DISCUSSION

Although the Třesín NNM (Loc5) covers only 143 ha area, several various biotopes favourable for molluscs have been noticed there and it was found the site with the largest diversity in our study. The forested limestone hill with fragments of natural forest stands in the centre of the locality provides favourable conditions for forest species the most abundant being *Alinda biplicata, Arianta arbustorum,* and *Vallonia costata*; and on the other side wetlands provide very good conditions for water and strongly hygrophilous species as *Planorbis planorbis* or *Perforatella bidentata*. The research realized in 2003 (Manas, 2004) documented altogether 88 molluscs species (50 species collected by the author himself and

Fig. 1. Ordination biplot showing the effect of the locality on the distribution of particular ecological groups of molluscs (48.09% of variability explained by F1 and F2 canonical axes). For abrevations see the Material and Methods part.

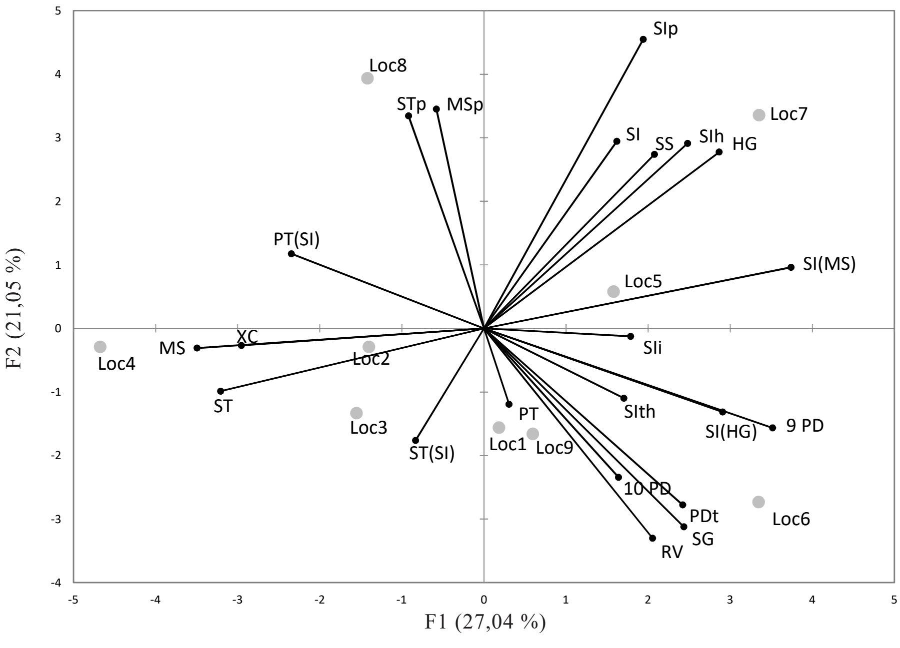

Table 1: The abundance data and the summary of obtained specimens per locality- Patt 1

Ecogroup*	Species	Treat**	1	2	3	4	5	6	7	8	9
SI	*Acanthinula aculeata* (O. F. Müller, 1774)	NT	0	0	0	0	7	0	0	0	0
SIth	*Aegopinella minor* (Stabile, 1864)	LC	0	0	0	20	36	0	0	0	0
SI	*Aegopinella nitens* (Michaud, 1831)	LC	0	0	0	0	0	16	0	0	5
SI	*Aegopinella nitidula* (Draparnaud 1805)	VU	2	8	50	0	0	59	23	0	0
SI	*Aegopinella pura* (Alder, 1830)	LC	0	0	0	5	26	0	0	0	0
SI(MS)	Aegopis verticillus (Lamarck, 1822)	VU	0	0	1	0	0	0	0	5	0
SI(MS)	*Alinda* (*Balea*) *biplicata* (Montagu, 1803)	LC	0	0	0	3	173	33	102	32	15
RV	*Ancylus fluviatilis* O. F. Müller, 1774	LC	0	0	0	0	0	9	0	0	0
PDt	*Anisus leucostoma* (Millet, 1813)	LC	0	0	0	0	6	51	0	0	0
PDt	*Anisus spirorbis* (Linnaeus, 1758)	VU	0	0	0	0	0	10	0	0	0
SG	*Anisus vortex* (Linnaeus, 1758)	LC	0	0	0	0	3	50	0	0	23
RV	*Anodonta anatina* (Linnaeus, 1758)	LC	6	0	0	0	0	12	2	0	2
RV	*Anodonta cygnea* (Linnaeus, 1758)	VU	4	2	0	0	0	0	0	0	0
PDt	*Aplexa hypnorum* (Linnaeus, 1758)	NT	0	0	0	0	0	3	0	0	25
SI(MS)	*Arianta arbustorum* (Linnaeus, 1758)	LC	0	0	0	0	128	219	98	0	0
SI	*Arion circumscriptus* Johnston, 1828	NT	0	1	0	0	0	0	0	0	0
MS	*Arion distinctus* Mabille, 1867	LC	0	3	0	0	0	0	0	0	0
MS	*Arion lusitanicus* Mabille, 1863	LC	0	14	0	1	0	6	3	0	19
SIi	*Arion rufus* (Linnaeus, 1758)	LC	0	0	0	0	2	14	8	0	50
SI	*Arion silvaticus* Lohmander, 1933	LC	48	0	0	0	0	0	0	3	3
SI(MS)	*Arion subfuscus* (Draparnaud, 1805)	LC	61	0	0	6	0	0	0	0	100
MS	*Boettgerilla pallens* Simroth, 1912	LC	0	0	0	0	1	0	0	0	0
9 PD	*Carychium minimum* O. F. Müller, 1774	LC	0	0	0	0	46	41	0	0	0
HG	*Carychium tridentatum* (Risso, 1826)	LC	0	0	0	0	47	69	50	0	0
ST	*Cecilioides acicula* (O. F. Müller, 1774)	LC	0	0	7	3	1	0	0	0	0
SI(MS)	Cepaea hortensis (O. F. Müller, 1774)	LC	0	83	0	0	76	79	253	4	50

Table 1: The abundance data and the summary of obtained specimens per locality-Part 2

Ecogroup*	Species	Treat**	1	2	3	4	5	6	7	8	9
SI(MS)	*Cepaea nemoralis* (Linnaeus, 1758)	LC	0	0	50	0	0	0	0	0	0
ST(SI)	*Cepaea vindobonensis* (Férussac, 1821)	NT	8	0	120	0	0	0	0	0	50
MSp	*Clausilia parvula* de Férussac, 1807	NT	0	0	0	0	10	0	0	30	0
Sih	*Clausilia pumila* C. Pfeiffer, 1828	LC	0	0	0	0	3	0	0	0	0
MS	*Cochlicopa lubrica* (O. F. Müller, 1774)	LC	4	0	7	131	19	9	0	0	0
XC	Cochlicopa lubricella (Rossmässler, 1835)	LC	5	0	8	120	28	0	0	0	0
SI	*Cochlodina laminata* (Montagu, 1803)	LC	0	0	0	0	22	5	0	0	17
SI	*Cochlodina orthostoma* (Menke, 1828)	NT	0	0	0	0	5	0	0	19	0
HG	*Columella edentula* (Draparnaud, 1805)	LC	0	0	5	0	10	0	0	0	5
SI	*Daudebardia rufa* (Draparnaud, 1805)	NT	0	0	0	0	2	0	0	3	0
PT	*Deroceras agreste* (Linnaeus, 1758)	LC	0	0	0	2	0	0	0	0	0
SI	*Discus perspectivus* (Megerle von Mühlfeld, 1816)	VU	0	0	0	0	17	0	0	5	0
SI(MS)	*Discus rotundatus* (O. F. Müller, 1774)	LC	0	12	0	0	14	28	68	3	163
SI	*Ena montana* (Draparnaud, 1801)	NT	0	0	5	0	6	0	0	12	0
SI(HG)	*Eucobresia diaphana* (Draparnaud, 1805)	NT	0	0	0	0	1	0	0	0	0
MS	*Euconulus fulvus* (O. F. Müller, 1774)	LC	0	0	6	13	5	0	0	0	0
9 PD	*Euconulus praticola* (Reinhardt, 1883)	VU	9	0	0	0	0	0	0	3	0
SS	*Euomphalia strigella* (Draparnaud, 1801)	LC	10	0	0	14	12	4	100	0	0
SI	*Faustina faustina* (Rossmässler, 1835)	NT	0	0	0	0	19	0	50	5	0
SI(MS)	*Fruticicola fruticum* (O. F. Müller, 1774)	LC	0	0	0	0	9	0	0	0	0
SG	*Galba truncatula* (O. F. Müller, 1774)	LC	0	0	6	0	0	73	0	0	0
ST	*Granaria frumentum* (Draparnaud, 1801)	NT	0	0	4	0	0	0	0	0	0
SG	*Gyraulus albus* (O. F. Müller, 1774)	LC	50	0	0	0	0	49	0	0	6
SG	*Gyraulus crista* (Linnaeus, 1758)	LC	18	0	0	0	0	0	0	0	0
10 SG	*Gyraulus parvus* (Say, 1817)	NE	0	0	0	0	0	0	0	0	1
SIth	*Helix pomatia* Linnaeus, 1744	LC	188	76	173	2	150	53	139	4	100

Table 1: The abundance data and the summary of obtained specimens per locality-Part 3

Ecogroup*	Species	Treat**	1	2	3	4	5	6	7	8	9
STp	*Chondrina clienta* (Westerlund, 1883)	VU	0	0	0	0	0	0	0	9	0
ST	*Chondrula tridens* (O. F. Müller, 1774)	VU	0	0	0	0	0	0	0	0	1
SIp	*Laciniaria plicata* (Draparnaud, 1801)	NT	0	0	0	0	50	0	93	55	0
SIp	*Lehmannia marginata* (O. F. Müller, 1774)	LC	0	0	0	0	1	0	0	0	0
SI(MS)	*Limax cinereoniger* Wolf, 1800	LC	0	0	0	0	4	14	6	0	100
SIp	Limax maximus Linnaeus , 1758	LC	0	3	0	0	0	2	0	0	0
SG	*Lymnaea stagnalis* (Linnaeus, 1758)	LC	3	6	0	0	0	149	0	0	0
SI	*Macrogastra plicatula* (Draparnaud, 1801)	NT	0	0	0	0	0	0	0	0	5
SIh	*Macrogastra ventricosa* (Draparnaud, 1801)	NT	0	0	5	0	19	0	0	0	0
SI(MS)	*Monachoides incarnatus* (O. F. Müller, 1774)	LC	0	0	13	0	21	17	229	0	50
SIh	*Monachoides vicinus* (Rossmässler, 1842)	LC	0	0	0	0	6	3	0	1	1
10 PD	*Musculium lacustre* (O. F. Müller, 1774)	NT	0	0	0	0	0	0	3	0	0
SIp	*Orcula dolium* (Draparnaud, 1801)	VU	0	0	0	0	0	0	0	4	0
MS	*Oxychilus Cellarius* (O. F. Müller, 1774)	LC	0	9	56	50	0	0	0	0	0
SI(MS)	*Oxychilus glaber* (Rossmässler, 1835)	NT	0	0	0	0	15	0	0	1	0
9 PD	*Oxyloma elegans* (Risso, 1826)	NT	0	0	0	0	4	3	0	0	0
SIi	*Perforatella bidentata* (Gmelin, 1791)	NT	0	0	0	0	102	0	6	0	1
MS	*Perpolita hammonis* (Ström, 1765)	LC	0	0	6	0	6	8	0	0	5
SI	*Petasina unidentata* (Draparnaud, 1805)	NT	0	0	0	0	0	0	0	4	0
RV	*Pisidium casertanum* (Poli, 1791)	LC	23	0	133	0	10	203	0	0	50
RV	*Pisidium nitidum* Jenyns, 1832	LC	0	0	0	0	3	0	0	0	0
SG	*Pisidium subtruncatum* Malm, 1855	LC	0	0	0	0	0	1	25	0	0
SG	*Planorbarius corneus* (Linnaeus, 1758)	LC	71	13	0	0	0	61	0	0	183
10 PD	*Planorbis planorbis* (Linnaeus, 1758)	LC	220	0	0	0	141	80	0	0	131
10 RV	*Potamopyrgus antipodarum* (Gray, 1843)	NE	0	0	0	0	0	0	20	0	0
9 PD	Pseudotrichia rubiginosa (Rossmässler, 1838)	VU	0	0	0	0	0	0	77	0	0

Table 1: The abundance data and the summary of obtained specimens per locality-Part 4

Ecogroup*	Species	Treat**	1	2	3	4	5	6	7	8	9
MS	*Punctum pygmaeum* (Draparnaud, 1801)	LC	0	0	0	0	14	0	0	50	6
PT	*Pupilla muscorum* (Linnaeus, 1758)	NT	0	0	9	0	0	0	0	0	0
9 PD	*Pupilla pratensis* (Clessin 1871)	NE	30	0	0	0	0	0	0	0	0
STp	*Pyramidula pusilla* (Vallot, 1801)	VU	1	0	0	0	2	0	0	100	0
SG	*Radix auricularia* (Linnaeus, 1758)	LC	0	0	0	0	0	6	0	0	0
SG	Radix peregra (O. F. Müller, 1774) s. str.	LC	65	0	0	0	0	183	0	0	0
HG	*Semilimax semilimax* (J. Férussac, 1802)	LC	0	0	0	0	4	15	11	0	0
SG	*Sphaerium corneum* (Linnaeus, 1758) s. lat.	LC	0	0	0	0	0	2	0	0	0
SG	*Stagnicola palustris* O. F. Müller, 1774 s. str.	DD	0	0	0	0	0	0	0	0	19
9 PD	*Succinea putris* (Linnaeus, 1758)	LC	6	9	81	0	50	19	0	0	50
HG	*Succinella oblonga* (Draparnaud, 1801)	LC	11	0	70	0	0	13	73	3	3
MS	*Trochulus hispidus* (Linnaeus, 1758)	LC	0	0	0	0	5	8	0	0	3
HG	*Trochulus villosulus* (Rossmässler, 1838)	VU	0	0	0	0	0	14	50	0	0
PT	*Truncatellina cylindrica* (A. Férussac, 1807)	LC	0	0	4	0	50	0	0	0	0
RV	*Unio crassus* Philipsson, 1788	EN	0	0	0	0	0	0	0	0	2
RV	*Unio pictorum* (Linnaeus, 1758)	LC	13	0	0	0	0	13	4	0	25
SIh	*Urticicola umbrosus* (C. Pfeiffer, 1828)	LC	0	0	0	0	0	0	130	0	0
PT(SI)	*Vallonia costata* (O. F. Müller, 1774)	LC	0	0	111	149	161	0	0	100	0
PT	*Vallonia excentrica* Sterki, 1892	LC	0	0	4	0	0	0	0	0	0
PT	*Vallonia pulchella* (O. F. Müller, 1774)	LC	182	0	106	0	128	0	0	0	0
SI	*Vertigo pusilla* O. F. Müller, 1774	NT	0	0	0	0	0	0	0	100	0
HG	*Vertigo substriata* (Jeffreys, 1833)	NT	0	0	0	0	0	0	0	100	0
SI(HG)	*Vitrea crystallina* (O. F. Müller, 1774)	LC	0	0	0	3	37	59	12	0	0
SI	*Vitrea diaphana* (Studer, 1820)	NT	0	0	0	0	0	0	0	0	1
SI	*Vitrea subrimata* (Reinhardt, 1871)	VU	0	0	0	0	0	0	0	8	0
MS	Vitrina pellucida (O. F. Müller, 1774)	LC	0	0	48	50	20	3	0	18	3

Table 1: The abundance data and the summary of obtained specimens per locality-Part 5

Ecogroup*	Species	Treat**	1	2	3	4	5	6	7	8	9
SG	*Viviparus contectus* (Millet, 1813)	VU	0	7	0	0	0	122	0	0	0
ST	*Xerolenta obvia* (Menke, 1828)	LC	0	0	98	123	0	0	0	0	0
9 PD	*Zonitoides nitidus* (O. F. Müller, 1774)	LC	8	0	0	0	13	48	0	0	0

*… Ecogroup based on Lisický (1991), for abrevations see Materials and Methods

**… Treatment based on Beran et al. (2005): LC = least concern; NT = nearly threatened; VU = vulnerable; EN = endangered; NE = not evaluated; DD = data deficient.

other 38 species collected within several studies in the past). Our research confirms the occurrence of some newly found species listed in the study.

The sample analysis indicated the Loc2 (Chropyně Fishpond) as a poor locality with only 14 species. We attribute the low number of (especially water) species as well as individuals to the fact that the Fishpond is distinguished bird nesting habitat and thus the predation pressure on molluscs is very significant.

Based on the total number of occurring species and the number of species shared between pairs of localities the similarity indices were evaluated (Table 2). Both indices revealed a relatively high similarity by localities Loc6 (NNP Ramena řeky Moravy) and Loc9 (NNR Žebračka). The similarity of molluscan populations is given by the character of localities; both are wet forest habitats situated close to a rich water source. Also the majority of common species is strongly linked to wet forest and water habitats. On the other hand, unsurprisingly, low similarities were recognized between a grassland locality with thermophilous hair grass vegetation – NNM Křéby (Loc3) and a forested alluvial plain – Zástudánčí (Loc7). However, in the overall assessment and comparison, very common and ubiquitous species with a wide range of tolerance to ecological conditions in habitats could distort results and the comparison may mislead and may not fully account the nature of the site. A better view and analysis of the site character provides the PCA analysis of molluscan ecological groups. We may state that based on the analysis of molluscs' ecological demands we are able to indicate the key functional parts of the ecosystems; and at the same time, the analysis could indirectly point to a bad condition of particular natural components within the studied habitat. This procedure is applicable to a wide spectrum of terrestrial and aquatic invertebrate populations and could be useful, for example, for assessing the habitat status over time and/or the development of the studied communities.

During the study several species of molluscs included on the Red List for the Czech Republic were detected. Specifically, of the total number of 107 species 15 species (14%) were included on the Red List – one as endangered, 14 species as vulnerable; and

Table 2: Similarity evaluation. Values of Jaccard and Sörensen indices. Lowest and highest values are bolted.

Jaccard	**Loc1**	**Loc2**	**Loc3**	**Loc4**	**Loc5**	**Loc6**	**Loc7**	**Loc8**	**Loc9**
Loc1	x	0.188	0.242	0.100	0.143	0.224	0.091	0.082	0.212
Loc2	0.316	x	0.079	0.073	0.059	0.139	0.075	0.060	0.105
Loc3	0.314	0.146	x	0.294	0.309	0.108	**0.043**	0.128	0.167
Loc4	0.195	0.194	0.455	x	0.200	0.079	0.075	0.082	0.068
Loc5	0.228	0.116	0.293	0.333	x	0.439	0.263	0.432	0.465
Loc6	0.429	0.333	0.219	0.190	0.495	x	0.385	0.152	**0.615**
Loc7	0.240	0.250	**0.113**	0.233	0.370	0.556	x	0.152	0.235
Loc8	0.157	0.146	0.222	0.182	0.390	0.192	0.264	x	0.167
Loc9	0.367	0.240	0.286	0.151	0.440	**0.585**	0.387	0.286	x
Sörensen	**Loc1**	**Loc2**	**Loc3**	**Loc4**	**Loc5**	**Loc6**	**Loc7**	**Loc8**	**Loc9**

other 23 species are classified as nearly threatened. Generally, these species were rarely found but at certain locations some vulnerable species accounted significant part of the community. For example, the vulnerable species of *Viviparus contectus* (Loc6 – 122 individuals) is a large snail living mostly in unpolluted rivers. The population has been declining in recent years due to eutrophication and intensive agriculture (Horsak et al., 2013). *Pyramidula pusilla* (Loc8 – 100 specimens) is an epilithic species associated with limestone and dolomite rocks. At Loc7 we found 77 individuals of the snail *Pseudotrichia rubiginosa* inhabiting shores and wet floodplain meadows, nowadays rapidly declining at most localities in the Czech Republic. The endangered *Unio crassus* is on the IUCN Red List of threatened species (Lopes-Lima et al., 2014). This species is a benthic, filter-feeding animal very susceptible to any changes of water chemistry (Mouthon, 1996), therefore it is most endangered by anthropogenic pollution.

Generally within the whole PLA, the landscape features significant for the molluscan fauna protection and development are the forest complex, opened xerothermic sites and, in particular, the wetland parts. We recommend paying attention to the flooded and periodically flooded areas and their protection zones. We also recommend to ensure protection of the forest complex with the support of the deciduous forest and fallow trees. More concretely, almost two-thirds of the Třesín NNM are covered with conifers that are unfavourable to molluscs. Acidification caused by coniferous trees may also result in the disruption of limestone sites many important species are bound to.

CONCLUSION

This study yielded new data on the molluscan fauna occurring in several parts of the Litovelské Pomoraví Protected Landscape Area in the eastern, Moravian part of the Czech Republic. The territory of the PLA is highly valuable in terms of natural habitats and species conservation on the European scale. For the purpose of comparing the localities and/or tracking population shifts, as well as habitat condition, the use of ecological groups and PCA analysis seems to be a suitable tool.

As already mentioned, publishing raw faunistic data is generally unpopular, but data stemming from faunistic surveys are of great value to other scientists; and are important for monitoring valuable sites in time or mapping invasive and introduced species.

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