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Biogeography of the Carpathians:
Evolution of Biodiversity in a Spatiotemporal Context

September 26–28, 2013 • Kraków, Poland

Polish Academy of Sciences – Cracow Branch
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ACTA BIOLOGICA CRACOVIENSIA
Series Botanica

CONTENTS

Volume 55, suppl. 1, 2013

Keynotes

Oral presentations

Posters

KEYNOTES

Patterns of genetic variation in Carpathian forest trees

Dušan Gömöry[1], Ladislav Paule[1], Roman Longauer[2]

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Carpathian forests harbour populations of almost all important tree species of the European boreal and temperate zones. However, their history is generally quite short, restricted to the Holocene. Genetic structures of Carpathian forest trees have thus been shaped mainly by postglacial colonization, gene flow and adaptation. The presentation illustrates these processes by several examples.

Common beech (*Fagus sylvatica*) colonized most of its present range from a single refugium located in eastern Pre-Alps, as evidenced by a combination of paleobotanical data and chloroplast DNA and allozyme data. The colonization process is reflected in a gradual decrease of allelic richness towards range margins. In the Carpathians, beech appeared quite late (~5 ky BP). Nevertheless, detailed kriging of allelic richness revealed a hotspot in the Romanian Apuseni Mts., indicating the presence of a secondary refugium in southern Romania.

A parallel analysis of fossil pollen/macrofossil record and genetic data indicates a similarly late arrival in the Carpathians of silver fir (*Abies alba*), another dominant forest tree. Distribution patterns of maternally inherited mitochondrial *nad5-4* markers revealed a very sharp boundary between migration streams arriving from different refugia in the Ukrainian Carpathians. Contrasting widths of allele frequency clines of mitochondrial and nuclear markers signalize a distinct difference of the efficiency of gene flow by seeds and pollen, respectively, in an anemochorous and anemophilous tree species.

Common-garden experiments (provenance trials) with forest trees revealed adaptive differentiation across Europe both in the growth and survival responses of populations to transfer and in significant adaptive traits such as vegetative phenology. This can be demonstrated both on a large scale by an international provenance experiment with common beech and on a small scale by a local provenance experiment with Norway spruce (*Picea abies*), where clear geographical and climatic clines were found. However, the basis of this clinal variation is unknown, a nursery experiment with Norway spruce indicated that altitudinal and climate-related trends may rely on epigenetic variation rather than on genetic adaptation.

ACKNOWLEDGMENTS: The support of the grant VEGA 1/0218/12 is appreciated.

Connecting Carpathian vegetation history with phylogeography during the last glacial cycle

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This presentation will take you through the quaternary vegetation history of the Carpathian Mountains using pollen, plant macrofossil and paleogenetic evidences/ records obtained from last glacial, lateglacial and Holocene sedimentary archives in the Carpathians and adjacent lowlands. In the last decades paleobotanical and paleoecological research have intensified in these fields and several high resolution /multi-proxy records were published that 1) refined the timing of vegetation change during the lateglacial/Holocene; 2) allowed for more exact inference of the last glacial and Holocene treeline changes and vegetation zonation in the Carpathians; and not at least, 3) provided valuable new insights into the location and nature of the last glacial tree refugia in the mountains.

We will use the division of the Carpathian Mountains by major genetic lineages and endemism and show what differences can be seen in the last glacial, lateglacial and Holocene vegetation histories of these areas with particular emphasis on the Western Carpathians, the southern region of the Eastern Carpathians and the eastern region of the Southern Carpathians.

The last glacial maximum (LGM: 26.5-19-ka cal yr BP) vegetation of these mountains is only recorded by one continuous pollen record in the East Carpathians (Lake St Ana) and several fragmentary pollen and macrofossil records in the N Carpathians. These records provide evidence for the LGM persistence of boreal trees in both parts of the Carpathians, but with a more diverse woody assemblage in the W Carpathians, where *Picea abies*, *Pinus cembra*, *Larix decidua*, *Pinus sylvestris*, *Pinus mugo* and *Juniperus communis* persisted even during the coldest/driest interval. The Lake St Ana record, on the other hand, attests that in the most continental part of the Carpathians boreal type meadow steppes, dry steppes and mesic grasslands were in direct contact with the subalpine Juniperus scrubs, and the vegetation zonation likely resembled the Central Asian Mountains with conspicuous difference between windward and leeward slope vegetation. The pollen records furthermore attest periodic increases in mesic temperate deciduous taxa (*Quercus*, *Ulmus*, *Corylus*, *Carpinus*, *Fagus*) that likely suggest LGM persistence of these taxa in the low mountain regions or in lowland river valleys adjacent to the E Carpathians.

Holocene pollen records from the Carpathians are numerous and show that the main difference between the N and E Carpathians is in the histories of *Abies alba* and *Picea abies* that show different Holocene expansion times. The histories of both species correlate well with the population genetic records from the Carpathians.

The presentation will finally summarize Holocene changes in the forest belts of the genetically distinct areas of the Carpathians and raise critical question to be answered by future paleobotanical and paleoecological research and discuss the possibility to connect plant population genetic research with paleogenetics and paleoecology.

Outline of faunal history of Southeastern Central Europe: a synthesis of palaeoecology and phylogeography

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During the last glaciation a transition (*macro-ecotone*) of the cold-continental "mammoth steppe" and boreal forest was formed in the Carpathian Basin, with scarce survival of Mediterranean (s.l.) species and with high diversity of continental and mountain species (Schmitt and Varga, 2009, 2012; Varga, 2010). Recent palaeoecological surveys (e.g. Willis et al., 2000, 2004; Stewart et al., 2010) have shown that the "peri-Pannonian" hilly areas but even the northern-north-eastern Carpathians, and especially the southern slopes of the southern Carpathians were of special importance, as important retreat areas for a high diversity of biogeographical groups.

During the postglacial, Carpathian Basin was populated by multiple waves of expansions. The Mediterranean species from the Balkans represent the most important influence reaching the Carpathian Basin on three main routes: (i) a western one from the Illyrian region along the foothills of the Eastern Alps and via the Transdanubian Middle Range, (ii) a south-eastern one from the Moesian and Black Sea region via the Iron Gate to the foothills of the Apuseni Mts. and (iii) a southern one via the valley system of the Vardar and Southern Morava. The first main expansion route was often separated from the eastern one by the marshy-swampy floodplains of the Tisza valley. Therefore, some southern species or pairs of sibling species often show an "Illyrian-Dacian pincer" in their distribution pattern. Different types of long distance disjunctions have been also observed (i) the Mediterranean-Manchurian bicentric faunal elements and (ii) different continental faunal types, e.g. in the relict-like steppe and semi-desert species. The Balkan Peninsula was closely connected with the Carpathian Basin by numerous biogeographical links, e.g. by connecting glacial distributions as in some continental and mountain (Alpine and Balkanic-oreal) species or by postglacial expansions of Mediterranean species.

ACKNOWLEDGMENTS: Author is especially grateful to Prof. Thomas Schmitt for the close cooperation and fruitful discussions during the last, nearly 20 years. The long-year support of the staff of the Evolutionary Zoology Department of my home university is also highly appreciated. Last not least, I am the most grateful to my wife Julianna who acquainted me in several expeditions and continuously encouraged me.

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Climate change and range shifts in mountain plants of the European Alps and Carpathians

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Plants and animals have started to respond to climate change. Significant range changes can be expected for European mountain plants in response to projected climate change. These range shifts will likely be associated with considerable species turnover, which will alter the vegetation structure at large landscapes, associated with shifts in biomes and functional vegetation structure that accompany these changes. While we have a somewhat good knowledge on the degree of expected range shifts, we do not know whether all species will actually be able to cope with the rapid shifts. And for those who likely can make it, we still have considerable uncertainty as to how fast these plant species can migrate to those areas that become suitable in the future.

I will summarize expected range shifts for some plant species across Europe and the European Alps. These results originate from four European projects. All results indicate partly large range shifts for many European plant species. I will further present three analyses that indicate the difficulties plants face in tracking climate change at the pace it currently occurs. First, the alpine treeline is clearly lagging (partly > 100 m in some regions) behind its thermal potential since the 1960-ies, and only very slowly responds to increasing summer temperatures. Second, the projected discrepancy between the potential range changes of alpine plant species as calculated from a statistical species distribution model and the likely migration of these plants as calculated from dynamic population models that simulate the migration of these species indicate two interesting results. On the one hand, considerable time lags in tracking suitable habitats were observed. On the other hand, the ranges seem to adjust asymmetrically, with the front edge responding more rapidly than the rear edge, which may result in considerable extinction debts once the rear edges start to collapse. Such events may happen as an effect of future climatic extremes. Third, the Carpathian mountain plants, similar to those of the Pyrenees and of the eastern-most part of the Alps are likely more affected by climate change than are mountain plants from other European mountain systems. This is likely due to the comparably low environmental heterogeneity of the Carpathians as compared to e.g. the European Alps.

ORAL PRESENTATIONS

Lichen diversity response to human impact in Rodnei Mountain National Park (Romania)

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Studies that measure the influence of human impact on lichen diversity in various habitat types underline the negative effect it has on these communities. Only in few cases does it create new niches for some species, thus increasing species richness.

Rodnei Mts. are situated in the northern part of the Eastern Carpathians with their highest peak reaching 2303 m. Most of the area is protected in the form of a national park and a UNESCO Biosphere Reserve. Considering that the main objectives of the national park are to preserve the biodiversity and that lichens are sensitive to various changes in the environmental conditions, our study aims to highlight the impact had by human activities on lichen communities here. We therefore investigated three representative habitat types (mixed forests, coniferous forests and alpine vegetation) encompassing two levels of conservation: conserved and managed. We also made a comparison between the three habitat types by considering the species richness, abundance, and composition. All substrates from each habitat type were investigated, in order to find epiphytic, lignicolous, terricolous, and saxicolous communities. The analyses are based on $0.2m^2$ releves and 1 ha plots, respectively. Species richness and abundance were analyzed using analysis of variance, whereas the differences in species composition were assessed using the nestedness within and between each category considered.

We found a higher number of species in all conserved habitats compared to the managed ones, the highest species richness being found in the conserved mixed forests with 142 species. Indicator species for ecological continuity, such as: *Arthonia caesia, Chaenotheca brachypoda, Heterodermia speciosa, Lecanora cinereofusca, Lobaria pulmonaria, Loxospora cismonica* and *Megalospora tuberculosa*, are restricted to conserved habitats.

Lichen communities in the three habitat types are affected differently by the human impact. The analyses of nestedness show different patterns in releves vs. plots, but the main conclusion is that the conserved habitats are more stable and harbor a higher diversity.

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At the Central European – Balkan transition: forest land snail faunas of the Banat contrasted with those of the Carpathian chain

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Although forest snail faunas in the Carpathians include a number of species endemic to the region, the composition of site faunas relate far more to those of regions to the north and west than to those in countries to the south (Cameron et al., 2011). Endemic radiations within Romania are found more often in more open subalpine habitats. The Banat region lies at the junction of the Carpathians with the mountains of Serbia, where tightly restricted endemic species with Balkan affinities increase. Our study of forest snail faunas in the Banat reveals a set of distinctive faunas with some Balkan and even Mediterranean elements. There is some geographical differentiation even within this small area, reflecting patterns of endemism characteristic of southern Europe, and collectively, they show a greater affinity to faunas further south. Only on acid soils at high altitudes are there faunas with distinctive northern affinities. Despite much limestone, site faunas are not especially rich (a feature of southern European site faunas generally), and contain species associated with more open habitats further north. Endemic species are not exclusive to forests.

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Alpine-Carpathian postglacial migration and glacial survival of temperate shrubs in Central Europe: examples from *Rosa pendulina* and *Lonicera nigra*

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Quaternary climatic fluctuations strongly influenced current distribution of plant species in Europe. Traditional concept assumes that during cold periods the species migrated to the south and survived unfavourable conditions in southern refugia (at the Balkan, Iberian and Apennine Peninsulas). The possibility of full-glacial survival in areas farther north (in so-called northern refugia) for some species was assumed based on subfossil data. However, the molecular evidence for the existence of such northern refugia situated in Central Europe or in the Western Carpathians is still very scarce. Using molecular (cpDNA sequences, AFLP) and palaeoecological data from two European temperate shrubs (*Lonicera nigra* and *Rosa pendulina*) we detected: (1) Possible full-glacial survival is supported by both molecular and palaeoecological data. Rarity index based on population AFLP was higher than average in at least some of the populations outside the traditional refugia. Palaeoecological data (available only for *L. nigra*) showed pollen presence in Western Carpathians in Late Glacial. (2) Colonization of Central Europe was realised from at least two refugia (based on differentiation in both cpDNA and AFLP data). First might be located at the edge of the Alps, northern Apennines or in Dinaric Alps, the other might be in the Balkan Peninsula or in Southern Carpathians. (3) Contact zone between these two lineages was the Danube valley north of the Alps or the area slightly southward.

The relevance of palaeoecological data in understanding the biogeography of a few tree taxa in the Carpathians, Romania

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Palaeoecological investigations provide a way to identify historical and ecological processes involved in range shifts, habitat fragmentation, and species resilience in relation to climate change and human disturbance; and are therefore of relevance for biogeography and conservation.

Here, we review a number of palaeoecological records from the Carpathian region, Romania and address the following key questions: i) glacial refugia: identifying species that persisted in the region and the implication for their postglacial range shifts; ii) the temporal and spatial variability in the range distribution and abundance of a few economically valuable tree taxa in Eastern Europe (*Pinus diploxylon* type – e.g., *P. sylvestris* and *P. mugo – Pinus cembra, Picea abies*, and *Quercus*), during the Holocene; iii) the relationship between diversity change and major land use strategies of prehistoric societies. We found that *Pinus* dominance in the early Holocene was the legacy of its local glacial refugia and high stress tolerance, but *Pinus* exhibited poor competitive abilities against *Picea abies* and temperate deciduous taxa after 10,500 cal yr BP. *P. abies* has persisted in large abundances at higher elevations (above 1000 m) and *Quercus spp*. (mainly *Q. robur* and *Q. petreae*) at lower elevations until the present day, as a result of good competitive abilities and resilience to climate change and disturbances. Consequently, these are the only two tree taxa to show continuity during the whole postglacial. There is also a strong link between diversity change and major land use strategies of prehistoric societies; with most distinct episodes of enhanced floristic richness during the Roman Period (2000 cal. yr BP), and between 500–100 cal. yr BP in the mountain zone. We argue that long-term palaeoecological records from this region provided a wealth of data in understanding contemporary and likely plant dynamics.

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Predictive spatial distribution model for Mediterranean and Atlantic saxicolous lichens *Solenopsora cesatii* and *S. candicans* in the Western Carpathians

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Geographical position of the Western Carpathians in Europe is particular, reflected in structure of biota, including lichens. This territory lies on the border of several regions and on the crossroads of migration routes – a prerequisite of high diversity. Landscape diversity is high too, due to geology and relief. Further important factor is local climate, influenced by terrain and overall position between colder north and warmer south, "oceanic" west and "continentalish" east. The species of the lichen genus *Solenopsora* (Catillariaceae) are an example of the Circum-Mediterranean-Atlantic elements, with in case of *S. candicans*, range extensions, and in case of *S. cesatii* outlying, isolated populations, into the Western Carpathians. They are saxicolous, free from competition with vascular plants, directly responding to climate. They grow on sedimentary (limestone, dolomite, conglomerate) or extrusive igneous (basalt) rocks, occasionally overgrowing bryophyte thalli. They differ by their ecological preferences, inhabiting different micro-niches, even on the same rock. *Solenopsora candicans* is a helio-sciophyte, meso-xerophyte, confined to plane rock faces. *Solenopsora cesatii* is an ombrophyte, mesophyte, and chasmophyte. First findings of *Solenopsora* populations in the Carpathians were opportunistic. Predictive potential spatial distribution models are tools for efficient delineation of explicit occurrence hotspots of these species in the study area. The predictive models for *Solenopsora* species in the Western Carpathians were prepared using geographical information system (GIS). The models are based on the analysis of the relationship between the various types of quantitatively defined geo-bio-ecological fields (e.g. air temperature, vertical atmospheric precipitation, solar energy, vegetation) and recent data of presence. For searching the potential we have used our application in GRASS GIS, as the script written in the Bin/Bash programming language. The models suggest that the two species may have spread from the distribution centre through a pathway which worked as a filter. *Solenopsora cesatii* prefers montaneous areas with cool or moderately cool climate, whereas *S. candicans* occurs in moderately warm to warm areas.

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Unique calcareous fens in the Western Carpathians: how the millennial-scale age and history affects recent species richness and composition

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Understanding species distribution and species richness patterns is one of the essential questions of ecology and biogeography. While the effects of contemporaneous local environment have been repeatedly documented, much less is known about historical effects, especially over large temporal scales. We studied the patterns in fen initiation and history in calcareous fens in the Western Carpathians. We selected 50 well-preserved fens differing in location and species compositions for radiocarbon dating of their basal layers and have compiled species data from the same plots for three taxa groups with contrasting dispersal modes: vascular plants, bryophytes and molluscs. We found fen ages spanning from Late Glacial to modern times (16,975-270 cal years). Using the species co-occurrences in large data sets, we identified calcareous fen specialists and compared their recent distribution patterns against a null model that controlled for the effect of fen area. We found that two land snail species, eleven vascular plant species and no bryophyte species have statistically significant affinities with old fens of Late Glacial and Early Holocene age, independent of the effect of recent fen area. Further, using path analysis we tested the relationships between species richness and habitat age, area, isolation, and altitude for these groups. When only matrix-derived taxa were considered, no significant positive relation was noted between species richness and habitat size or age. When only calcareous-fen specialists were considered, however, habitat age was found to significantly affect vascular plant richness and, marginally, also bryophyte richness, whereas mollusc richness was significantly affected by habitat area. Our results demonstrate that not only recent ecological conditions, but also historical-biogeographical effects could significantly shape species composition of island-like habitats and they may contribute to the explanation of ecological-biogeographical differences among vegetation types. In other words, the species-composition differences between particular Western-Carpathian regions can be explained not only by local ecological conditions, but also by site history. We further explored Holocene development of selected fens in detail, tracing survivals, extinctions and persistence of the species, which are currently endangered across Europe.

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Centres of endemism, spatial barriers and biogeography of the South-Eastern Carpathians inferred from multivariate analysis of endemic plant species distribution

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The current distribution of plants is a consequence of both evolutionary phenomena and ecological processes. The highest level of historical and ecological pattern imprint is found in the distribution of endemics. They comprise spatially restricted species that are confined to one or few biogeographic units. Endemic taxa distribution has been widely used as a model for studying biogeographic regionalisation (Pawłowski, 1970) or factors affecting the current spread of species (López-Pujol et al., 2011). Here we aim at analysing the different biogeographic relations existing between mountain units, outlining the centres of endemism and spatial barriers in the South-Eastern Carpathians (Poland, Ukraine, Romania and Serbia).

Our dataset comprises georeferenced field samples, herbarium and literature data for endemic plant taxa from the studied area. We choose an integrative approach by using several spatial/multivariate analyses to identify patterns and centres of endemism (krigging interpolation), biogeographic regions (NMDS ordination, hierarchical clustering), biotic elements and break zones in the distribution of endemic species from the South-Eastern Carpathians. The dataset, as well as preliminary results for the Romanian Carpathians were already presented in a couple of papers published recently (Hurdu et al., 2012a,b).

Our present study revealed several high richness centres located in areas with extensive alpine environments, characterised also by locally restricted species. Secondly, we outlined the differences between the Eastern and Western part of the Southern Carpathians, thus only partly sustaining their inclusion into one biogeographic unit. Our results partly support the previous regionalisation of the South-Eastern Carpathians based on the distribution of endemics.

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The whole Holocene development of vegetation of the Inner West Carpathians – Pannonian borderland: spreading of mesophilous trees, continuity of open grasslands and human impact

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The geographical position of the study site at the southern margin of the Inner West Carpathians (middle-Nitra Basin; Slovakia) at the contact with Pannonian lowland provides great opportunity to enlarge palaeoecological knowledge about the northern refugia of mesophilous trees and continuity of grasslands throughout the climatic optimum.

In the Pannonian lowland, evidence of mesophilous trees presence during the Full Glacial was recently provided and some indirect evidence suggests these refugia even more to the north, close to or directly within the West Carpathians. Therefore, the appearance of mesophilous tree pollen in the profile located at the Pannonian-Carpathian interface could shed more light to this question. The continuity of temperate grasslands throughout the entire Holocene is the second still unresolved problem. In the middle Holocene the closed-canopy forests started to spread retreating open grassland vegetation. The spread of agriculture that started in Central European lowlands ca 7500 BP had counteracting effect which supported spread of heliophilous species. The study site occurs in the early-colonized region with archaeological records since early Neolithic periods and continual existence of treeless vegetation throughout the whole Holocene can be therefore supposed.

We analysed the whole-Holocene profiles by multi-proxy approach (pollen, macroremains of plants and molluscs), which allow us to confirm (i) the early expansion of mesophilous trees (*Ulmus, Fraxinus, Tilia, Quercus*) at northern part of the Carpathian-Pannonian boundary from the beginning of Holocene (ca 11 500 cal. yr BP), (ii) the whole-Holocene persistence of open steppe and/or dry grasslands and open wetlands in this region, and iii) we found coincidences between the history of human settlement, local development of the fen and regional changes in the representation of particular habitats including managed mesic and semi-dry grasslands.

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Are Goosanders good indicators of Carpathian's submontane river valleys naturalness and biodiversity?

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The European range of the Goosander *Mergus merganser* stretches across northern Europe. Outside this area, breeding populations exist in the Alps, the Balkans and since the end of XX. century this species settled in the Carpathians. Expanding Goosanders breed mostly in submontane river valleys of the Carpathians. The main aim of this work was to assess if Goosanders could be used as good indicators of naturalness of Carpathian's river valleys, the level of anthropopressure, and distribution of other cryptic riparian animals.

Data from submontane Raba river drainage (southern Poland) were used for statistical analyses considering differences between 1-km valley fragments occupied (22 with 33 pairs in 2007 year) and un-occupied (30) by breeding Goosanders. Several predictors related with hydrogeomorphology, water and riparian habitat quality, fish, bird and mammals richness, and urbanization were used for testing usefulness of Goosnaders as indicators of valley naturalness.

Goosanders breeding in the Carpathians significantly avoid river fragments severely regulated and deforested banks. Interestingly, we found that type of river hydrogeomorphology and fish biomass had only minor impact on Goosanders distribution. Occurrence of these birds were positively related with presence of beavers, otters and riparian bird richness.

Presented results show that Goosander generally prefer to breed in valley fragments characterized by natural channels, forested banks whereas fish biomass and river depth and width are of much less importance. We found that the Goosander can act as reliable indicator of presence of several other, more cryptic and difficult to detect birds and mammals inhabiting river valleys. Relatively high detectability of the Goosanders due to their behavior, large size and colorful plumage, make this species potentially useful as indicator of submontane river valleys naturalness and species richness. As river valleys are centers of biodiversity and important migration routes and simultaneously are seriously threatened due to human activity (e.g. regulations, deforestations, water pollution, urbanizations, etc.), result of this work could be valuable for conservation planning (e.g. in Natura 2000), monitoring of habitat quality and riparian biodiversity of submontane valleys. As Goosanders are still expanding, they could be used as indicators also in all Carpathian's countries and possibly also in other submountane areas of Europe.

Diversity and distribution of the micro endemic *Pedicia staryi* group (Insecta, Diptera) reveal complex evolutionary history in the Carpathian Area

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The Carpathian Area is recognized as one of the most important hotspots for aquatic biodiversity in Europe. In the present study linear morphomentry and mitochondrial sequence data (COI) were used to study morphological variability and phylogeographic patterns of a range-restricted endemic dipteran group in the Carpathians. Morphometry based on DA analyses are highly congruent with molecular data and confirm the taxon status of *P. apusenica, P. staryi* and *P. lobifera* with limited distribution in small enclaves the Carpathian Area. However in the case of the most widespread *Pedicia staryi* both morphometry and molecular data revealed further divergent structurers between allopatric populations from Rodnei and Bucegi Mountains. This pattern is most likely the result of long term isolation in multiple microrefugia in the South-Eastern Carpathians, probably due to its specific habitat requirements to headwater springs and long term evolutionary history dating back to Miocene-Pliocen periods. Contrastingly, the genetic and morphological divergences between the two allopatric populations of *P. staryi* show more recent speciation events and should be related with the presence of important micro refugia in the Carpathians during the Pleistocene climate change. The present study brings important new evidences on the complex autochthonous evolution of springs habitats in the Carpathians leading finally to a high genetic complexity of these particular aquatic ecosystems from here.

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The evolutionary history of *Cochlearia* in Central European mountains – Population genomics of a cold relic in a warming world

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The genus *Cochlearia* L. is one of the numerous young polyploid complexes in the Central European flora (Koch, 2012). Pleistocenic speciation processes resulted in several lineages with numerous taxa representing different ploidy levels and base chromosome numbers, different adaptations to coastal and inland environmental conditions, distribution ranges in lowland and alpine/arctic regions, or auto- and allopolyploids. *Cochlearia* belongs to the tribe Cochlearieae, which can be divided into two major groups: (i) a western Mediterranean clade comprising all *Ionopsidium* species, and (ii) a central European *Cochlearia* clade extending its distribution far into northern and arctic regions. The deep split between the two clades dates back to the middle Miocene, approximately 13.8 million years ago (Koch, 2012). The *Ionopsidium* lineage fully adapted to arid conditions but showed low rate of speciation. Contrary, *Cochlearia* radiated very late during the Pleistocene into almost exclusively cold characterized habitats. Among these species there are ecologically vicariant taxa in the Tatra mountains (*Cochlearia tatrae*) and Eastern Austrian Alps (*C. excelsa*), geographically closely associated with mountaineous/lowland species (e.g. *C. polonica* and *C. pyrenaica*). Although a series of past investigations focused on different aspects of the evolution in the genus, only a schematic scenario of speciation processes could be formulated based on traditionally used molecular markers. Here we introduce next-generation-sequencing data from all three plant genomes to present some first results on the spatio-temporal speciation and distribution pattern. We discuss a genome-skimming-approach to utilize fully assembled whole chloroplast genomes, CDS of mitochondrial DNA and some first insights to the nuclear genome to unravel short periods of time during Pleistocene glaciation and deglaciation cycles and test the hypothesis of parallel evolution of the two ecologically vicariant high alpine *Cochlearia* species from the High Tatras and Eastern Austria.

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Vegetation-human-climate interplays during the Middle Holocene in the Dniestr-Łomnica valley (western Ukraine) recorded in ox-bow lake deposits

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The area of Prykarpattia (western Ukraine) is poorly covered by palynological data. One of the main causes is the predominance of sites characteristic of poor preservation of sporomorphs. Our research was conducted on a profile in which most pollen grains were well-preserved, and which was retrieved from the former ox-bow lake in the Dniestr valley. Archaeological investigations revealed occupation of this area by the Neolithic and Early Bronze humans during the Middle Holocene. Our studies were focused on pollen, non-pollen palynomorps (NPPs), plant macrofossils and aDNA of symbiotic bacteria which live in human digestive system. Palynological analyses revealed four main phases of development of the depositional basin. An initial ox-bow lake functioned between ca. 5530±80 and 4060±150 cal. yr BC. During that time at least three periods of increasing human activity were marked. In that phase *Alnus, Fraxinus, Ulmus, Quercus* and *Corylus* were probably dominants in the then woodlands. The subsequent phase (4060±150-3250±90 yr cal. BC) registered the probable occurrence of alder carr in the area of the former ox-bow lake. The first traces of *Plantago lanceolata* appeared ca. 3920±160 cal. yr BC i.e., at least 1000 years after first cultivation fields. This fact may indicate the beginning of the spread of this species in anthropogenically disturbed habitats in that area. The period between ca. 3250±90 and 2950±40 yr cal. BC showed another intensification of human activity, which was simultaneous with the increase in the water table. Between ca. 2950±40 and 1520±530 yr cal. BC the water table on the rich fen strongly fluctuated which is demonstrated by weak pollen preservation and dramatic falls in their concentration. However, during ca. 2190±80-1990±100 yr cal. BC water table rose and this event was synchronous with an increase in agricultural activity.

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Long-term land use and land cover changes in the Carpathians

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Since the mid-19th century, the Carpathians have undergone several political and socio-economic transformations that influenced the land use patterns and land cover. The most important ones were liberation of peasantry in 1848, collectivization after World War II, transition to market-oriented economy and re-privatization of land after 1990 (Kozak, 2010). Among the most pronounced changes were those related to forest transition: reversal from the shrinking to expanding forest cover (Mather, 1992).

We document the forest expansion process for the Polish Carpathians, using series of vectorized historical topographic maps (1860s, 1930s, 1970s) and contemporary satellite data for all the area. In addition, we map forest succession patterns with high resolution aerial data for a sample of communes. The preliminary results show that in the Polish Carpathians the forest cover was relatively stable till 1930s and increased after World War II. Results of local scale analysis prove that forest succession on abandoned agricultural land adds to the forest or tree covered area especially since 1990s. Referring to the meta-analysis of land use and land cover change case studies carried out for the whole Carpathian range (Munteanu et al., Forest and agricultural land change in the Carpathian region – a meta-analysis of long-term patterns and drivers of change. *Land Use Policy* [submitted]), we note the analogy of land use and land cover change processes in the Polish Carpathians and other parts of the range.

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Impact of the Carpathians on the genetic structure of the spruce bark beetle *Ips typographus*

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The Carpathians are a range of mountains forming an arc roughly 1,500 km long across Central and Eastern Europe. They are an important area for biodiversity and belong to one of the major refuges of the last ice ages for many organisms. The forests of the Carpathians are dominated by spruce, which have suffered continuous outbreaks of the eight spined spruce bark beetle, *Ips typographus*, in recent decades. The phylogeography of this spruce pest is well documented, however, little is known on small scale, i.e., the Carpathians. Here we applied a mitochondrial marker and studied the genetic variation and structure of Carpathian populations and compared data with published one from other European populations. Twelve haplotypes were characterized and 42% of those were not detected in other European populations. Despite a slight genetic structure, differences were observed in the haplotype distribution and diversity between the Western/Southern Carpathians and the Eastern Carpathians reflecting at least two potential refugial areas for *I. typographus* within the Carpathian mountain system. Further data show that the Eastern Beskidian Mountains of the Carpathians could act as barrier for several European haplotypes. This small-scale analysis reveals that the Carpathians have been an important glacial and postglacial refuge for *I. typographus*. This information is important for a preventive and reactive forest management.

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Chloroplast and nuclear microsatellites reveal shallow genetic structure and introduced individuals in scattered *Pinus cembra* populations from the Carpathians

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The high-mountain tree species *Pinus cembra* occurs in forests near the timberline or as solitary individuals in alpine pastures or dwarf pine stands. *Pinus cembra* is present in all major parts of the Carpathian Mountains, although its occurrences are restricted to the highest mountain ranges. As a consequence, large geographic distances separate the often small populations. While the species was more widespread under past colder climates, remnant Carpathian populations of *P. cembra* are considered to be relicts.

To better understand the historical dynamics of the species, we analyzed genetic variation of eleven disjunct *P. cembra* populations from of the Carpathian Mountains at four chloroplast and eleven nuclear microsatellite loci. Population genetic analysis of altogether 175 genotyped trees gave similar results with the two marker types. The highest genetic diversity was observed in the populations from the northernmost Tatra Mountains and the southernmost Retezat Mountains. Indications of bottleneck effects and inbreeding found in several populations suggest recent population decline and currently small effective population sizes.

Only one population from the Parâng Mts. (Southern Carpathians) showed pronounced genetic differentiation from the others. The lack of geographic separation of genetic groups and no isolation by distance among the remaining populations imply that the majority of *P. cembra* populations may represent remnants of a formerly larger and contiguous occurrence. Moreover, a comparative analysis further indicates a close genetic relationship of the Carpathian *P. cembra* populations with those from the Eastern Alps, suggesting historical contact through gene flow.

Assignment analysis identified individuals in two populations of the Rodnei Mts. (Eastern Carpathians) that were genetically differentiated from any other studied specimens. Comparison with East-Alpine *P. cembra* and Siberian *P. sibirica* populations has led to the assumption that these specimens are indeed non-native *P. sibirica*. This analysis demonstrates the power of our molecular markers to identify allochthonous individuals, which may be crucial for the characterization of stands for seed harvesting or conservation purposes.

Genetic characteristics of the Carpathian endemic *Syringa josikaea*: regional structuring of small and isolated populations

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Syringa josikaea is a narrowly distributed endemic species of the Carpathian Mountains. Continent far from its closest relatives that are native to Eastern-Asia (sect. Villosae), this species is distributed in two restricted small areas, the Romanian Apuseni Mountains and the Ukrainian Carpathians. The individuals inhabit mostly remote, moist valley bottoms. Six out of eight populations from the Apuseni Mountains are extremely small with only a few individuals. In contrast, the majority of the seventeen populations from the Ukrainian Carpathians are formed by dense, clonally propagating individuals.

We studied the genetic variability of all known populations of the species. Specimens were sampled and DNA sequence variation was tested in 14 chloroplast, two low-copy nuclear and three nuclear ribosomal loci. In addition, nuclear microsatellite primers were designed for *S. josikaea*, and samples were screened with four highly variable microsatellite markers.

Sequence variation was found only in the nuclear ribosomal external and internal transcribed spacers, while all other loci were invariable. The three variable nucleotide positions gave four ribotypes with low geographic structuring. All ribotypes were present in the Ukrainian Carpathians, often mixed within populations. Three ribotypes were found in the Apuseni Mountains, but in most of the individuals just a single ribotype was present.

The microsatellite loci showed clear geographic structuring with pronounced differentiation between the two mountain ranges and strong isolation by distance across the range. Altogether five genetic groups were identified. Three of these were found only in the Ukrainian Carpathians with high admixture among populations. The other two genetic groups were present in the Apuseni Mountains, where each population contained mainly a single genetic group.

Plant usage and environment conditions during the Bronze Age in the Carpathian Foothills

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Recent archaeological excavations conducted in the central part of the Dunajec river valley within the framework of a joint project between the Institute of Archaeology, the Jagiellonian University in Kraków (Prof. Dr. hab. Paweł W. Valde-Nowak) and the Institute of Archaeological Science at the University of Bochum (Prof. Dr. Tobias L. Kienlin, now University of Cologne), have constituted a great opportunity for carrying out the first systematic archaeobotanical study of the Carpathian Foothills. Six archaeological sites dated to the Bronze Age (Brzozowa, sites 107-65/83 and 107-65/104, Janowice, site 106-65/61, Tworkowa, site 107-63/80, Wróblowice, site 106-65/57; Zakliczyn, site 107-64/8) have provided macroscopic plant remains, which mostly consist of seeds, fruits and wood. The study of cultivated and gathered plants has provided valuable palaeoeconomical data concerning the ancient plant diet of the inhabitants of settlements belonging to the Lusatian culture. It has been confirmed that common millet *Panicum miliaceum* was the most widespread cereal among cultivated species, and this new data corroborates its early and common use in south Poland. The analysis of remains of wild plants, especially weeds, indicate emergence of synanthropic plant communities associated with fields and ruderal habitats that developed nearby the settlements. The study of the remnants of firewood showed the composition of local forests. During the final stages of the Subboreal period, these communities were already dominated by *Carpinus betulus* and *Fagus sylvatica*. New data has permitted evaluating the degree of interaction between people and their environment since archaeobotanical materials represent different phases of Bronze Age occupation.

In addition, the results have been contrasted with the analysis conducted by means of Geographical Information Systems (GIS) with Site Catchment Analysis. These methods were employed to prepare a model showing the possible environments used for subsistence strategies and study their correlation with the archaeobotanical data.

Patterns of vascular plant endemism in the Western Carpathians in relation to geography, environmental factors and taxon traits

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The Western Carpathians covering the area of ca 66,000 km^2 on the territory of Slovakia, Poland, Hungary, the Czech Republic and Austria are the highest European mountain range north of the Alps. They have long been considered to be an important center of endemism of vascular plants in Central Europe though overall evaluation of endemism in the whole range is still uknown. The aim of this study is to localize the areas of endemism in the Western Carpathians and to assess their distribution pattern in relation to environmental factors and species traits. Analyses were based on 84 Western Carpathains or Pan-Carpathians (sub)endemic species and subspecies (excluding apomictic groups) and related traits (bedrock, elevation and vegetation affinities; elevation niche breadth; life form; ploidy level). The occurrences of endemic taxa were scored in 121 operational geomorphological units (OGUs, moutain ranges and intermountain basins), each of them characterized by several environmental variables.

The highest number of endemic taxa were recorded in the OGUs with high altitude (above 2000 m) and at the same time with calcareous or geologically variable bedrock: Západné/Zachodnie Tatry, Belianske Tatry and Dumbierske Nízke Tatry. Statistical analyses revealed strong positive associations beetween endemic richness and mean altitude and altitudinal range of OGUs, but only weak with the OGUs' area. Almost 60% of the taxa preferentially occur in lower – and upper – montane zones, mostly due to the Western Carpathian (sub)endemic taxa. On the contrary, the Pan-Carpathian taxa are confined predominantly to the alpine and subalpine belt. Majority of endemic taxa are calciphilous (65%) and occurring mostly in the rocky and other unforested habitats (alpine and subalpine meadows, calcareous steppes; 77%). High proportion of polyploids (52%) suggests that polyploidization had played an important role in evolution of endemic taxa, though no siginificant associations between polyploidy and elevation, bedrock affinities, elevation niche breadth or life form were found.

Lateglacial and Holocene paleolimnological localites of Slovakia

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Western Carpathians do not have lot of natural lakes. Only exceptions are Tatra mts. which were covered by ice during last Glacial period. We were focused for localities which represent environmental and geomorfological diversity of Western Carpathians.

Hybkana – It is 11,5 depth vanished lake on the north slope of Vihorlat mts. in 1000 m.a.s.l. Paleoecological record shows Lateglacial environment with cold-tolerance water communities with surrounding pinebirch forest. Holocene transition is recorded by expansion of broadleaf trees. Lake was vanished during late Holocene at the same time with *Fagus* expansion. Viničky – Locality is on Zemplínské vrchy mts. (Tokai region) on eastern Slovakia. It is shallow depression on basalt hill slope surrounded by oak forest. Locality has periodical water level. Pollen record contains late Holocene forest history and human impact. Interesting is occurring of ruderal vegetation and *Sphagnum* communities. Santovka – Locality is situated on near Ipel river, southwestern Slovakia. Researched were secondary infilling (peat and lake chalk) of valley in Pleistocene travertine mud, when Holocene travertine sedimentation dammed small stream. Sedimentary record shows environment of early Holocene forest and arrival of the first farmers by pottery directly found in the sediment. Locality is important of rich prehistoric settlement. Hanšpilje – large shallow lake on the western foothill of Malé Karpaty mts. dammed of sand dunes dated to Lateglacial interstadial. Sedimental sequences show basal peat covered by gyttja and lake chalk. Pollen record shows dominance of *Pinus* without broadleaf trees. Holocene layers are destroyed by peat exploitations.

Mentioned localities are situated on south part of Western Carpathians arch; therefore recorded vegetation development is more close to Hungarian sites than localities situated in northern part like Spiš region or other Carpathians basins. Vegetation of Lateglacial is created by pine forest with occurrence of broadleaf trees. *Corylus, Quercus, Tilia* a *Fraxinus* are spread on beginning of Holocene. *Fagus* is presented on early Holocene, but expansion is dated about 4 500 BP together with *Carpinus*. Anthropogenic indicators are recorded in the same time, linking of human activities and *Fagus* expansion is ambiguous.

Recent changes in plant species composition on the summits of Rodna Mountains (Eastern Carpathians, Romania)

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The cold adapted alpine ecosystems are expected to be particularly sensitive to climate change, whose impact on them is thus pronounced and detectable at an early stage. Nevertheless, there are only very few empirical studies showing the influence of climate change on local diversity. Here we analyse the short-term variation in plant species composition with respect to climate, in a re-survey study of four summits above the treeline ecotone in Rodna Mountains (Eastern Carpathians, Romania). The target area is part of GLORIA network (Global Observation Research Initiative in Alpine Environments). Therefore, the summit areas were comprehensively sampled following a standardized protocol, from the highest point down to the 10 m contour line (The GLORIA Multi-Summit Approach, www.gloria.ac.at).

During the period 2001-2008, an increase in species richness was recorded at the whole four summits area, from 45 to 58 species (+33.3%). The highest peak of the target region (Rebra, 2268 m - alpine belt) had the biggest increase in species richness (+54%), whereas in the lower alpine zone and treeline ecotone (Gropile, 2063 m, and Golgota, 2010 m) that trend was less important (+26% new species compared to 2001). Out of the 15 vascular plant taxa newly found in 2008, 80% are mountainous, treeline or treeline-low-alpine species. Meteorological data showed an increase in temperature for the study area in the course of the seven years of field surveys (+ 0.8°C more than the previously recorded Tmean). The thermophilization trend (i.e. higher abundance of thermophilic species in 2008, compared to 2001) and the changes in plant species richness found in the alpine vegetation of Rodna Mountains were consistent with other results reported by similar studies in the major high mountains of Europe (Gottfried et al., 2012; Pauli et al., 2012). The transformation of alpine plant communities within less than a decade may suggest a rapid ecosystem response to local climate changes.

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Diversity and distribution of macrofungi (Basidiomycota, Agaricomycetes) in the isolated high-mountain habitats of the Carpathians on the background of their arctic-alpine ranges

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Macrofungi (Basidiomycota, Agaricomycetes) are ecologically interrelated with plants by mycorrhizal symbiosis or specific saprotrophic links and thus they belong to important elements of various terrestrial ecosystems. Although majority of species are confined to forests, there is an ecological group of macrofungi inhabiting arctic and alpine environments.

Here, we will present the results of eleven years of field studies on diversity and distribution of fungi in the island-like, isolated alpine zone areas of the Carpathians. Our survey encompasses most of the representative parts of the range in the Western, Eastern and Southern Carpathians and includes sites of varying alpine plant communities as well as siliceous and calcareous habitats (Tatry, Nízke Tatry, Ceahlău, Rodnei, Bucegi, Piatra Craiului, Iezer-Papușa, Făgăraș, Builă-Vănturarița, Cindrel, Latoriței, Lotru, Parâng, Retezat). Our Carpathian data are analysed on the background of other European mountains and the results of a worldwide distribution assessment of arctic-alpine fungi based on more than 500 published articles. Based on these data we will attempt to define main distribution patterns, present global ranges of several most important arctic-alpine fungi, and present maps of their distribution in the Carpathians. Additionally, we will present first attempts towards a phylogeographical survey of selected arctic-alpine fungi in the Carpathians.

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High-mountain flora of the Carpathians: a multispecies comparative phylogeography

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The Carpathians belong to major ranges forming the European mountain system. They extend over ca. 1400 km in Central Europe. As large parts of the range are within altitudinal belts currently covered by mountain forests, habitats for high-mountain vegetation (alpine zone) form a discontinuous island system determined by the distribution of highest massifs. Due to such topography, the Carpathians were not extensively glaciated during the Quaternary glacial periods; lower massifs remained ice-free, potentially enabling range expansion for high-mountain plants (e.g., Ronikier, 2011). To assess the impact of such physiographical context on biodiversity patterns of the high-mountain flora, we monitored the intraspecific genetic structure of 17 species distributed in alpine habitats across the Carpathians. AFLP fingerprinting was applied to a population sampling based on a regular grid system (Gugerli et al., 2008) in a way to (i) infer phylogeographies of individual species, (ii) estimate the congruence in genetic structure of the investigated species, (iii) elaborate a synthetic, multispecies analysis to identify main genetic breaks/long-term barriers to gene flow, areas of phylogeographical congruence and centres of intraspecific diversification across the Carpathians. Most species were characterized by a clear-cut phylogeographical structure revealing several well-supported, geographically coherent genetic groups. The comparative analysis of all analyzed species evidenced a major genetic break discriminating the populations from Western and South-Eastern Carpathians and supporting the well-known phytogeographical boundary concurring with the largest discontinuity of alpine habitats. Further genetically diverging groups were found in the SE Carpathians; the most significant of them was identified in the south-westernmost part of the range, west of the Olt valley (Parâng-Retezat-Țarcu mountains). In general, the boundaries and extension of phylogeographical groups were geographically coherent but not always clearly correlated with spatial distance among populations or large habitat disjunctions.

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Carpathian phylogeography in a Eurasian context

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The Carpathians are situated at the crossroads of important plant migration corridors in Europe. My presentation aims to summarize available literature as well as recent, partly unpublished studies in order to get a first overview of the position of the Carpathians in the roadmap of Eurasian plant migrations. I will first focus on the well-investigated relationships between Eastern Alps and Carpathians and then present some new data on the rarely explored connections to the mountains of the Balkan Peninsula. My second focus is to explore the role of the Carpathians in the context of larger-scale Eurasian plant migrations, for instance as first recipients of westward range expansions from (central) Asia.

Forest inventory data in conservation planning: Predicting rare woodpeckers habitat quality on regional scale

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In this study, we present results of predictive habitat mapping for two rare woodpecker species – three-toed woodpecker (TTW) and white-backed woodpecker (WBW) – in the Polish Carpathians, based on recent bird surveys and the environmental data extracted from a forest inventory database. Models for both species proved useful for the identification of suitable habitats with high conservation value. The data used for preparing and testing of habitat prediction models for TTW and WBW was based on the Maxent algorithm (Phillips et al., 2006; Phillips and Dudík, 2008), which computes the predicted habitat suitability as a function of corresponding environmental variables. Based on this model we were able to predict not only the probable woodpecker locations, but also potential migration trails for studied Carpathians populations.

Moreover, we tested the performance of the model for TTW while applying it to design a monitoring scheme for the species' population in Polish Carpathians. The monitoring scheme includes 130 sample plots (2 x 2 km), each plot containing at least one 25 ha habitat patch with the TTW occurrence probability (P) equal to or greater than 0,5. First inventory in 2011 revealed that 74 out of 80 in the Polish Carpathians contained breeding TTW pairs, therefore providing a good validation of the model in the field and confirming its practical applicability.

Our results suggest the need for a holistic approach to forest management in order to reconcile woodpecker habitat requirements with regular forestry practices.

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Phylogeography of the alpine violet (*Cyclamen purpurascens* Mill.) – northernmost glacial refugia and an endemic subspecies in the Western Carpathians?

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We analysed the Pleistocene history of *Cyclamen purpurascens*, a mountainous calcicolous geophyte, to test hypotheses regarding its glacial survival and postglacial colonisation routes, and to explore how they are congruent with the histories inferred for temperate trees. We also studied overall genetic, morphological and karyological variation of this species with special focus on the Western Carpathian populations considered represents a narrow endemic taxon *C. fatrense*, which, however, has not been generally accepted as a separate species because of its uncertain morphological distinction from *C. purpurascens*.

Genetic (AFLP and chloroplast DNA *trn*D-*trn*T sequences), multivariate morphometic and karyological analyses of 68 populations spanning the entire distribution range of both species (the Jura Mts., Alps, Western Carpathians, Dinarides) were investigated. Genetic markers revealed two main lineages in *C. purpurascens*, but additionally, AFLP data detected a more detailed structure of five lineages: two widespread, showing east-west geographical separation, and three local ones, restricted to somewhat disjunct, marginal regions of the species' range. We suggest that the alpine violet survived the last glaciation predominantly at the foothills of the Southern Limestone Alps and in the Karst area of the Northwestern Dinarides, but most likely also in microrefugia in the Western Carpathians. The glacial persistence and colonisation routes of this woodland herb are highly concordant with those inferred for several temperate trees. Although all analysed populations are karyologically invariable, the Western Carpathian populations are genetically and morphologically separate from those of *C. purpurascens*, and they should be considered a separate endemic subspecies (*C. purpurascens* subsp. *immaculatum*). The most important diagnostic characters discriminating it from the nominate subspecies include the absence of ornamentation on their upper leaf surface, the shape of the leaves and sepals, and the width of the petals.

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Spatial and temporal changes in vegetation composition and distribution of the Dolina Siedmich pramenov Valley (Belianske Tatry Mts, Slovakia)

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The Dolina Siedmich prameňov Valley (Belianske Tatry Mts) attracts people for centuries because of its rich calcareous flora differs from mostly acidophilous High Tatras vegetation. This valley with surrounding mountains has charmed not only shepherds and hunters but also hikers and botanists. First scientific papers focusing on the flora and vegetation of this locality revealed spectacular diversity already in 20-ies of 20th century. Later the most comprehensive monograph about vegetation, ecology and soil and snow conditions was compiled by Hadač et al. (1969). We decided to compare historical data from this book about distribution, variability and quality of plant communities with our recent data.

The most important changes have been detected in the range of altitudes between 1200 to 1500 m asl, where the plant communities of the class *Molinio-Arrhenatherea* predominantly occurred in the past as a result of intensive grazing or logging. These communities are usually dependent on certain type of management so, after the grazing or logging was ended, the succession started immediately and the different plant communities have been developed. We can observe increase of the species poor communities dominated by *Chamerion angustifolium, Urtica dioica* and *Rubus idaeus*, thus the species biodiversity have decreased distinctively.

Our results show, that natural (sub)alpine communities are relatively stable and even after long time of abandoning of traditional grazing in the mountains, the communities of the gullies and meadows (*Mulgedio-Aconitetea*), grasslands (*Elyno-Seslerietea*) and initial communities and vegetation of rocky slopes (*Thlaspietea rotundifolii*, *Asplenietea trichomanis*) are almost of the same quality as 50 years ago. Some small differences such as increasing of acidophilous species in some types occur, but generally, this change hasn't been of any statistical significance. We can conclude that traditional management has impact on plant communities in the Carpathians Mountains, but in the areas where no overgrazing happen, the natural regeneration is very smooth and successful. The major changes have been detected only in distribution and variability of secondary communities that have been conditioned by traditional human activities such as grazing.

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Patterns of floristic diversity in forest openings of the Trascău Mountains (Southeastern Carpathians)

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Forest openings (clearings) are particular ecological settings harbouring various plant species groups, i.e. grassland, forest, and edge species. In the low-elevated regions of the Southeastern Carpathians, patches of grassy vegetation enclosed within woodlands have been maintained by an extensive grazing regime, which has been exerted once trees have been artificially cleared. Since these openings are rich in species and display high floristical turnover, we considered them as appropriate models to test the behaviour of various diversity measures proposed in the literature. Our sampling was conducted in 40 openings of different sizes, ranging between 15 and 50 m in width, and using transects with four 1-m^2 plots. We measured canopy openness using hemispherical photos (for each 1-m2 plot), heat load index, altitude, and recorded tree litter cover and bedrock type. Species richness at 1 m2 was modelled as a function of these variables using generalized linear mixed models (GLMMs). β-diversity, as calculated with five distinct measures, was modelled against the means and ranges of the variables along each transect, using multiple linear regressions. Species richness at 1 m2 was explained mostly by canopy openness and tree litter cover. The additive and multiplicative measures of β-diversity behaved differently when it came to their relationships with the predictors, as the first was explained by canopy openness range and the second by altitude. The multiplicative β-diversity was similar to the Sørensen-based multiple-site dissimilarity. Neither β-diversity expressed by the slope of distance decay nor Simpson-based multiple-site dissimilarity did have significant relationships with the variables. Our discussion is based on possible ecological explanations for these contrasting relationships, while taking into account also the mathematical constraints of the diversity measures used. We articulate the necessity of simultaneously considering multiple diversity measures when seeking underlying causes of variation in community structure.

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Possible refugia for *Liophloeus* Germar, 1817 and *Bryodaemon* Podlussany, 1998 weevils (Coleoptera:Curculionidae) near Carpathian Mountains

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Distribution of European biota was largely influenced by climatic oscillations during the Quaternary. Because of recurrent cooling and warming periods, ranges of many species expanded or contracted. Many populations survived in refugia with more stable conditions (Taberlet et al., 1998). It was also connected with processes of speciation (as a result of ranges division and isolation of populations in refugia) and extinction (for species that did not manage to survive suboptimal conditions). The Carpathian Mountains and nearby areas (for example Pannonian Basin or Subcarpathia) had good conditions to be considered as glacial and interglacial refugia. Indeed, there is much evidence inferred from paleontological, ecological, molecular and geographical data, that many populations survived there during decline of conditions (Provan and Bennet, 2008; Litvinchuk et al., 2013).

Also weevils (Coleoptera: Curculionidae) were vulnerable to climate changes, thus many of their populations stayed in refugia during harsh conditions (Stenberg and Lundmark, 2004). The possible refugia for weevils from two genera: two species of *Liophloeus*, which are Carpathian subendemits, and four Carpathian species of *Bryodaemon* will be proposed, basing on phylogenetic trees constructed using molecular data (three markers: one mitochondrial and two nuclear) with support from morphological and geographical data. An attempt will be also made to reconstruct their phylogeography in order to get an insight into possible paths of migrations, and events that caused division of ranges.

The proposed Carpathian refugia will be compared with refugia known from literature. Some of proposed areas represent new possible refugia for weevils.

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Genetic structure of the Carpathian newt suggests multiple Pleistocene refugia within the Carpathians

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The Carpathians are increasingly recognized as an important refugial area. Analyses of genetic structure of species which ranges are currently restricted to the Carpathians provide important insights into the Pleistocene history of the area. Here we present the analysis of genetic structure and species distribution modeling (SDM) for the Carpathian newt (*Lissotriton montandoni*), a species confined almost exclusively to the Carpathians.

Nuclear dataset comprising 15 microsatelites and 139 nuclear SNPs revealed a clear separation between populations from the northern part of the Carpathians and the rest of the range. Microsatellites suggested a further division between the Eastern Carpathians and the southern part of the Carpathain belt. These groups of populations were probably derived from separate glacial refugia, located in the northern, eastern and southern part of the Carpathians. In situ survival and range fragmentation of *L. montandoni* are supported by SDM, corroborating the role of the Carpathians as a major refugial area. All mitochondrial DNA (mtDNA) lineages present in *L. montandoni* are the result of hybridization with the smooth newt (*L. vulgaris*). We inferred multiple, spatially and temporally distinct introgression events which resulted in complete mtDNA replacement in L. montandoni. In contrast, there has been little evidence of recent interspecific nuclear gene flow, except several populations at the margins of the range, which exhibited some nuclear admixture. Our results, in combination with previous reports of extensive introgression of the major histocompatibility complex (MHC) genes, emphasize the complexity of historical gene exchange between *L. montandoni* and *L. vulgaris*, which has been likely affected by the range changes during the Pleistocene climatic oscillations.

POSTERS

Carpathians as major geographic barriers shaping the phylogeographic history of *Erythronium dens-canis* (Liliaceae) in Europe: insights from plastid DNA sequences

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The impact of Quaternary climate events on intraspecific history of deciduous forest herbs remains poorly understood when compared with the arctic-alpine plant species which have been extensively studied in the last decade.

Erythronium dens-canis L. is disjunctly distributed from the Iberian Peninsula to Ukraine without extending above the Alps. It is a typical deciduous forest geophyte inhabiting also mesophytic meadows in the subalpine belt. It remains thus challenging to test its past presence in regions which have been hypothesised to be characterised by cold and dry steppe vegetation during Quaternary climate fluctuations.

We studied the plastid *rpl*32-*trn*L IGS sequence variation in an initial sample set of *E. dens-canis* originating from different parts of the species range, using *E. caucasicum* and *E. sibiricum* samples as outgroups. Although based only on a modest dataset (12 sequences from 12 populations), parsimony network and phylogenetic tree analyses uncovered a striking phylogeographic pattern and recognition of a 'Transylvanian', and a 'non-Transylvanian' lineage suggesting the long standing isolation of species within the Transylvanian basin. Genetic distances (in terms of number of mutations) between the Transylvanian, non-Transylvanian samples and *E. caucasicum*, are broadly equal suggesting an early split probably in the late Tertiary. Samples from the Iron Gates and Oltenia region of Romania, south-western Hungary and the Iberian Peninsula shared one single haplotype, whereas the five samples sequenced from Transylvania are clustered to four haplotypes. The haplotype richness from Transylvania is suggestive for the past existence of several local refugia. Moreover, the Transylvanian populations are confidently subdivided according to the tepal colour: white flowered populations (*E. dens-canis* var. *niveum*) from Apuseni Mts. are grouped together as compared with the pink flowered populations from different parts of Transylvania.

Ongoing denser sampling of the species and endeavours aiming to study a nuclear DNA region will hopefully reveal the species' complete phylogeographic history.

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Festuca pseudodalmatica Krajina consideration: the Volcanic Carpathians or European steppe zone?

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While revising genus *Festuca* L. (Poaceae) within the flora of Ukraine and conducting comparative analysis of obtained data from neighboring territories, it was revealed that consideration (conception) of *F. pseudodalmatica* species in different parts of Europe varies significantly.

According to Russian school (Alexeev, 1975; Tzvelev, 1976), *F. pseudodalmatica* traditionally is considered as cerulea fescue with higher stems, longer leaves, bigger spikelet than of *F. valesiaca* and also with possible fusion of sclerenchyma strands. The distribution area is considerably wide: European steppe zone until Ural, Western Siberia, Caucasus, Asia Minor, Mediterranean.

At the same time, according to the protologue and the traditions of Western European schools, *F. pseudodalmatica* additionaly differs by the longer inflorescences and the confluence of sclerenchyma strands is not described anywhere. However, distribution of the species is limited to a small territory along the inner side of the Carpathians (Krajina, 1930; Májovský, 1955; Beldie, 1972; David and Záchenská, 2010; Dúbravková, 2010).

We studied more than 100 populations of *F. valesiaca* agg. in Ukraine. The typical specimens of *F. pseudodalmatica* (according to protologue) occurred exclusively in the region of the Volcanic Carpathians [Lovachka Mt. and Chorna Gora (Black Mountain)] in the rocky xerothermic meadows, considered to be relict by many authors. The remaining blue-gray "large" populations appear to be morphologically a very heterogeneous material.

To authors' consideration, East European *F. pseudodalmatica* tends to be a fake aggregated taxon. Perhaps, it is confused with similar "small" species not described yet and possibly of hybrid origin. However, it is also possible that data about the species in Western Europe lacks and its peculiarities in the eastern part of distribution area are not considered. Yet, we prefer first hypothesis.

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The role of small woodlands in the flora diversity in the landscape of the Carpathian Foothills

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The vast primeval forests of the Carpathian Foothills in Poland have been reduced to small areas of forest islands as a result of human activity. The fragmentation led to a change of habitat conditions, loss of their tangency and it increased a distance between them. However, even small forest islands could serve as important refuges for plants and animals in agricultural landscape (Dzwonko and Loster, 1988; Orczewska, 2001). The Rożnów Foothills represent a typical landscape for the Carpathian Foothills with most of the area covered by cultivated hills, meadows and abandoned fields. Group of rare and interesting plant species was found in the forests during the floristic investigation in this area (Budzik and Stachurska-Swakoń, 2011).

The aim of the presented study is to determine the occurrence of indicator species of old forests of forest islands in the Rożnów Foothills. Their presence indicates the primary origin of the forest and its long and continuous existence in the place of forest habitat (Dzwonko and Loster, 2001). The floristic investigation was conducted during 2011–2013.

The results have shown the presence, of 90 species considered to be indicative of old forests e.g. *Cephalanthera damasonium*, *C. longifolia*, *Epipactis purpurata*, *Mellitis mellisophyllum*, *Scilla bifolia*. The number of species varies within individual forest complexes. The highest number of indicator species concerns large forest complexes. It is connected with diverse habitat conditions e.g.: varied terrain and micro-climate conditions. Despite significant transformations of forest complexes in the Rożnów Foothills they maintain a high degree of naturalness and constitute refuge for typical forest flora.

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Phylogenetic analysis confirms the status of *Saxifraga wahlenbergii* Ball (Saxifragaceae) as a distinct endemic of the Western Carpathians

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Saxifraga wahlenbergii is considered one of the most distinct endemic plants of the Carpathians. It occurs in the Tatra Mountains (the highest Carpathian range) and in a few neighbouring massifs within the Western Carpathians. According to a widely accepted taxonomic treatment, it belongs to a separate, monotypic series *Perdurantes* within sect. *Saxifraga* (Pawłowska, 1966), characterized by exclusive presence of pluricellular glandular hairs with peculiar worm-shaped (instead of typical short and wide) endings. Recently, a new species, *S. styriaca* Köckinger, was described from the Eastern Alps and a close affinity to *S. wahlenbergii* was hypothesized based on presence of similar glandular hairs (Köckinger, 2003). This hypothesis stimulated us to test the genetic divergence of *S. wahlenbergii* and *S. styriaca*, because confirmation of close relationship of the Alpine taxon with the species considered a distinct Carpathian endemic would have important floristic and biogeographical implications. We sampled populations covering the distribution of the two taxa and applied AFLP fingerprinting as well as sequencing of non-coding plastid DNA regions and the ITS nuclear ribosomal region. Using available GenBank resources, we also placed our ITS sequences in a wider phylogenetic context within sect. *Saxifraga* (Vargas, 2000). Our analysis showed a strong divergence of the Western Carpathian and Eastern Alpine taxa. A wider-scale ITS phylogenetic reconstruction confirmed a separate evolutionary position of *S. wahlenbergii* within sect. *Saxifraga*, while *S. styriaca* appears to be closely related with *S. depressa* and *S. androsacea*. These results support the status of *S. wahlenbergii* as a Western Carpathian endemic with a distinct phylogenetic position, which may be an isolated relict of the Tertiary flora (Pawłowska, 1966). In turn, shared presence of characteristic glandular hairs in the two taxa indicates that this character is not unique for ser. *Perdurantes*, as it was previously assumed.

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Taxonomy, diversity and distribution of bryophytes in Polish Carpathians: *Cephaloziella spinigera* (Lindb.) Warnst.

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Cephaloziella spinigera is one of the rarest species of liverworts in Poland and is listed in Red Data Book of European Bryophytes as least concern species (LC category; ECCB, 1995), and in Poland as indeterminate (I) species (Klama, 2006). Until now, *C. spinigera* was considered as a typical lowland species known from scattered localities mainly on bogs, but not reported from there for over 70 years (Szweykowski, 2006). Recently, the species was discovered on twelve new localities in the Polish Tatra Mountains and one on the Babia Góra Mt where it grows on a very interesting type of substrate – on the *Sphagnum-Polytrichum* hummocks above tree line (Cykowska, 2011). It is in very good condition there and regularly reproduces. *Cephaloziella spinigera* is nearly systematically distributed on the area of the Polish part of the Tatra Mts and it is very likely that it can be most frequent in the Slovak part of these mountains. For now, it seems that the Tatra Mts are a centre of occurrence of *C. spinigera* in Poland and in the Carpathians and that the species has a lowland-montane type of distribution. During works on 'Catalogue of Bryophytes of the Polish Carpathians' historical herbarium materials was revised and one historical place in the Polish Tatra Mountains was confirmed in the field. New data about the species from Poland throw some new light on its distribution, altitude range and ecology.

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Adaptation of Carpathian and other mountain floristic elements to a warmer and drier habitat. Preliminary results

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Alpine and arctic vegetation occupies 7% of the Earth's surface and contains different ecosystems. These ecosystems are inherently fragile, due in part to the simplicity of their systems and to the fact that many of the organisms present are existing close to the limits of their survival. These characteristics suggest that the alpine species will reflect more sensitively and rapidly to the global climate change. The current consensus is that global warming will affect the vegetation patterns, phenological characteristics and the ecological processes of plant systems. Thus, it has been noted that plants of sub-alpine and alpine areas seem to be especially sensitive to global warming. It is likely that such effects are more intense in mountain systems under limiting conditions, as in many alpine areas of Carpathians. The present analysis of climatic data suggests that this is not the only effect, and underline the importance of specific studies linking adaptation mechanism to phenological traits and ecological processes than indications of climatic variables.

In 2012 all mountain species of the Botanical Garden of Szent István University (Gödöllõ, 220 m a.s.l.) have been counted, mapped and catalogued, including the Carpathian floristic elements. The climate of the region is temperate continental, the mean annual precipitation is lower (560 mm), while the mean annual temperature is warmer (10.5°C), than in alpine and subalpine areas, thus the site is suitable for studying the forecasted climatic effects on different taxa. The phenological phases and population dynamics of selected mountain taxa will be monitorized in the future in order to enable more accurate predictions of responses to future climatic conditions. Botanical gardens can offer continuity for phenological recording in observers, protocols and plant specimens that may not be achievable from other sources (Schulman and Lehvävirta, 2011). *Cardamine glanduligera* represents the largest population of Carpathian elements with more than 150 shoots covering a 10 m2 patch, however *Scopolia carniolica, Allium victorialis* and *Telekia speciosa* also have viable populations.

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Pollen and macrofossil evidence of Holocene vegetation changes in a former small lake in the Malé Karpaty Mts (SW Slovakia)

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Mires are ecosystems accumulating high amount of organic matter with preserved micro- and macrofossils. Thus they can serve as natural archives allowing reconstruction of local vegetation and landscape development. Main aim of our study was to bring evidence of the whole Holocene history of mire birch woodland located on the ridge of the Malé Karpaty Mts (SW Slovakia) using multi-proxy approach (pollen, macrofossils, C^{14} dating). We sampled two peat cores, one from the middle part containing the whole Holocene sequence and one from mire margin containing fossil record of the Late Holocene with higher resolution. The local development of study site started with small lake in a terrain depression, which arose at the end of the Late Glacial (Younger Dryas). The macrophyte vegetation was dominated by *Batrachium trichophyllum* and *Potamogeton pusillus*, whereas litoral vegetation was represented by *Carex rostrata* and *Menyanthes trifoliata*. After infilling of former lake by sediments in early Holocene, minerotrophic fen and later acidic mire vegetation with *Eriophorum vaginatum* and *Betula* sp. developed. Middle and Late Holocene record is not well represented because of frequent fires and high rate of decomposition. The recent vegetation established only several hundreds years ago (ca 500 cal. BP), when birch started dominate. The Late Glacial landscape was mosaic of birch-pine forests on suitable places and *Artemisia* steppes. Early Holocene is characterized by steep decline of pine and increase of *Corylus* and other mesophilous trees (*Quercus, Tilia, Ulmus, Fraxinus*). *Fagus* started to dominate in middle Holocene (about 6000 cal BP).

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Niche shifts in lichens: are they real or the result of cryptic speciation? A case study in the boreal lichen *Cladonia botrytes*

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In the face of climate change in the next decades, considerable research effort is being invested in understanding the ecological behaviour of lichens in different parts of their range. With lichens, little work has been directed to studying niche shifts, and currently ecological variability is difficult to parse from unknown patterns of cryptic speciation, widespread in fungi. Our study focuses on the genetic structure of European populations of red-listed *C. botrytes*, which is extremely rare in Western Carpathians nowadays. It is a boreal species thought to be obligately associated with dead wood in forests, especially in central Europe and southern Scandinavia. However, in the northern parts of its range in Scandinavia it can also occur on other substrates, such as soil. We ask whether substrate switches in *C. botrytes* are bona fide niche shifts or the manifestation of hidden genetic differences.

We use samples from Scandinavia and Central Europe, and data from the nuclear ribosomal internal transcribed spacer (ITS1-5.8s-ITS2) region to study genetic variability in relation to substrate switches. Possible cryptic specialisation in different habitats is discussed.

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Quantification of biotic homogenization in the Eastern Carpathian beech forests

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Biotic homogenization is defined as a gradual increase in compositional similarity. Although a lot of attention has been paid to this process, methods used to quantify homogenization are still poorly developed. An increase in compositional similarity is equivalent to a decrease in β diversity quantified with a dissimilarity measure. In recent years it has been noted that techniques used in traditional classical dissimilarity indices (e.g. Sørensen, Jaccard) in reality quantify two components of variation in species composition: spatial turnover (Simpson, Lennon) and nestedness. In this study, taxonomic homogenization of the beech forest was analyzed by two methods: the traditional method, and one differentiating between turnover and nestedness.

The layer of herbaceous vegetation of beech forests in the Sanocko-Turczańskie Mountains was examined at sampling plots in the 1970s and then again in the 2000s. The total number of species identified on sampling plots was 133, with 86 of these species recorded for both sampling periods. The number of species unique to the 1970-data and 2000-data sampling periods was similar, amounting to 25 and 22 species respectively. The average species richness per plot showed no significant changes, at 24 species in the 1970s and 25 in the 2000s. On the other hand, the nature of changes in species richness on the compared plots does suggest changes in species richness: an increase in the plots with low species richness in the past and a decrease in those with high species richness. Species with the greatest increase in frequency include *Anemone nemorasa, Lysimachia nemorum* and *Veronica montana*. The greatest decline was observed for *Geranium robertianum, Chrysosplenium alternifoloum* and *Sanicula europaea*. Over the past 30 years, the average dissimilarity index values changed significantly. The mean Sørensen and Simpson dissimilarity indexes decreased. In contrast, the nestedness dissimilarity index increased. The resulting pattern of taxonomic homogenization indicates that environmental changes differentiating the beech forest vegetation had lead to a decrease in turnover (changes resulting from the replacement of some species by others) and an increase in nestedness, which suggests that plots with fewer species becoming subsets of plots with higher species richness. Nonetheless, in both periods, most of the β diversity was caused by turnover.

Woody vegetation in abandoned subalpine meadows of the Western Bieszczady Mts

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In many mountain ranges, the areas of subalpine grasslands have been artificially increased and the upper limit of trees has decreased as a result of human activity. However, the declining use of mountain meadows during the 20th century has resulted in these meadows being overgrown again by trees. In the Polish part of the Eastern Carpathians (Western Bieszczady Mts) a complete cessation of agricultural use of alpine meadows occurred in the 1940s. This study involved woody thickets overgrowing alpine meadows in two mountain ranges (the Wielka and Mała Rawka (R), 1304 m a.s.l.; and the Bukowe Berdo (BB), 1238 m a.s.l.; parts of the "Eastern Carpathian" International Biosphere Reserve). Based on data collected from sampling plots at the nodes of the regular grid, relationship between the structure of rowan bushes and the altitude was analyzed.

Rowan (*Sorbus aucuparia*) is the main species in the local thickets and occupies large parts of the subalpine grasslands. The individuals of rowan had a multi-stem form. The oldest rowans reached the age of 79 (R) and 75 years (BB), the highest reached 9 (R) and 17.5 m (BB), the thickest 25 (R) and 26 cm (BB) and the greatest number of stems was 67 (R) and 52 (BB). In the Rawka range, the age of the oldest rowan on the plot (settlement date), height, total basal area and stem density decreased significanlty with increasing altitude. The density of individuals also decreased. In the Rawka range, thickets spread gradually from the edge of the forest towards mountain tops. In the Bukowe Berdo range, the increase in altitude above sea level was not accompanied by any changes in the age of the oldest rowans, total basal area and the density in individuals but there was a decrease in the height of the rowans. It suggests that the thickets in the Bukowe Berdo grasslands appeared almost simultaneously in the large area from the edge of the forest to mountain tops in Bukowe Berdo range.

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Phylogeography and taxonomy of *Arabidopsis halleri* in the Carpathians

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Arabidopsis halleri comprises about five subspecies and represents one evolutionary lineage of the genus, well known for the model species *Arabidopsis thaliana*. It is an important model species for the study of phytoremediation and a number of studies about its features were already published. Only a few of them, however, were focused on the correct intraspecific identity and intraspecific variation of the material studied.

Arabidopsis halleri is a perennial, clonal and self-incompatible plant. Four subspecies tentatively recognised (*A. halleri* subsp. *halleri, A. halleri* subsp. *dacica*, *A. halleri* subsp. *ovirensis*, *A. halleri* subsp. *tatrica*) are centred in Central Europe, while the last one, *A. halleri* subsp. *gemmifera* occurs in Japan and the Far East. Despite representatives of *A. halleri* are purely diploid (2n=16), a high morphological variation combined with geographic differentiation stand behind complex and still unresolved taxonomy of the group.

Using seven microsatellite loci and AFLPs we aimed to reveal phylogeographic structure of this lineage and to find correlations with the results of previous karyological and morphological analyses. Our sampling includes populations used in previous studies that lead to the current subspecies' circumscriptions. We collected samples from 50 populations in the Carpathian Mountains (Poland, Slovakia, Ukraine, Romania, Hungary), the Dinaric and Balkan mountains (Croatia, Serbia, Bosnia and Herzegovina), the Czech Massive (Czech Republic), the Alps (Austria, Italy, Slovenia) and comparative material of *A. halleri* subsp. *gemmifera* from Japan.

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Assessing the sensitivity of the high mountain region in Northern Romanian Carpathians to climate- and land use changes through multi-proxy analysis

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A multi-proxy analysis (pollen, spores, stomata, micro- and macro-charcoal, plant macrofossil, loss on ignition, mineral magnetic properties and AMS 14C dating) of a lacustrine sequence in Rodna Mountains (Northern Romania), covering more than 5000 years, was employed to determine the sensitivity of high mountain habitats to climate, fire and land use.

The pollen, stomata and plant macrofossil records revealed regional forests dominated by *Pinus sylvestris* in the lower part of the sequence that probably belongs to the Preboreal phase and a possible hiatus until ca. 4200 cal yr BP. The *Pinus* stomata found in this bottom section of the sequence could indicate a higher position of the treeline reaching the catchment of the lake. After 4200 cal yrs BP, these regional forests were composed of *Picea, Abies* and *Fagus*. In the lake proximity sub-alpine shrubs (*Alnus viridis, Betula nana*), alpine herbaceous comunities (Poaceae, Cyperaceae, Apiaceae, Asteroideae, Cichorioideae, *Thalictrum*) and ruderal species (*Artemisia*, *Rumex*, Chenopodiaceae) appear as dominant during Subboreal and Subatlantic (4200 years). The treeline and timberline position and composition appear to be rather stable over the late Holocene. Upward shifts in the timberline were recorded around 3900, 3000 and 2000 cal yrs BP, whereas a descent of the timberline (decline in the percentages of tree taxa – *Picea* and *Pinus*, increase in sub-alpine shrubs – *A. viridis* and herbs – Poaceae, Cyperaceae, Apiaceae) is evident around 1700 and 2500 cal yrs BP.

Anthropogenic impact in the area increases in the last 2000 years. Peaks in macro-charcoal concentration and magnetic susceptibility are correlated with elevated percentages of NAP pointing to the possibility of local human-induced fires, while prior to that it is more likely they are linked to naturally occurring fires.

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The Late-Glacial and Holocene history of vegetation in the Slovakian West Carpathians: introducing ongoing multi-proxy project and first results

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The knowledge of the long-term, millennial-scale dynamics of particular vegetation types is crucial for deeper understanding of vegetation changes under the ongoing global change. Only a low number of palaeoecological studies, which would use modern multi-proxy analyses accompanied by radiocarbon dating have been conducted in the Slovakian West Carpathians. It holds especially for middle altitudes on limestone and volcanic rocks, the landscape which is important biodiversity hot-spot in the West Carpathians whose history was explored only based on fossil molluscs so far. Thus, we attempt to fill an important gap in our knowledge using modern methods and multi-proxy approaches (pollen, testate amoebae, diatoms and macrofossils of molluscs, vascular plants, bryophytes, and chironomids, geochemical analyses, AMS dating). A variety of sedimentary environments are investigated (mires of different mineral richness including travertine fens, lakes and palaeo-meanders), which will contribute to a more complete image of vegetation development of the entire Slovak West Carpathians as well as habitat development of particular types of wetlands. The main aims of our project are: 1) to study Holocene development of vegetation along climatic and altitudinal gradients and among contrasting bedrock that differ with respect to acidity and sensitivity to cation leaching; 2) to study spreading of mesophilous trees from the Late Glacial up to present and the role of southern margin of the West Carpathians in the tree migration during the early Holocene; 3) to study influence of human activities from Neolithic up to present times on the vegetation in different regions and importance of continuity of treeless landscape for present diversity patterns and 4) to study relic fen species (molluscs, bryophytes and vascular plants), their surviving and extinctions through the Holocene. So far, we sampled more than 20 palaeoecological profiles, published some local partial studies dealing e.g. continuity of treeless landscape (Bílé Karpaty Mts., Hornonitrianska Basin), history of calcareous fen vegetation in Slovakia, history of former lake environment in South Slovakia and influence of human impact in the last thousand years in eastern flysh Carpathians.

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Fungi of the Carpathians – contributions of Czech mycologists with emphasis on newly described taxa

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Although the Czech Republic is not a "core" Carpathian country, the contributions of Czech mycologists to the study of Carpathians macrofungi are very important. Czech mycologists studied above all the Western Carpathians (in eastern Moravia and Slovakia) and Eastern Carpathians (Ukraine). The reasons why so many of them were involved in the Carpathian research are emotional (beauty and well-preserved state of local nature), scientific (biodiversity hot-spot, especially the alpine belt and virgin forests) and historical (Eastern Carpathians were part of former Czechoslovakia in the period 1918-1939, Western Carpathians till 1992).

The most important contributions were published by Josef Velenovský (Discomycetes), Albert Pilát (pioneer works on almost all groups of Basidiomycota, including large taxonomic monographs based on the Carpathian material), Mirko Svrček (Ascomycota, Agaricales), František Kotlaba (Polyporales, Agaricales), Zdeněk Pouzar (Aphyllophorales, Agaricales), Jirí Kubička (Agaricales), Zdeněk Schaefer (Lactarius), Jan Kuthan (Aphyllophorales, Agaricales), Alois Černý (Polyporales), Jiří Lazebníček (Aphyllophorales, Agaricales), Jiří Moravec (Discomycetes), and Rostislav Fellner with Jaroslav Landa (Agaricales). Their collections including type specimens are deposited mostly in the National Museum, Prague (herbarium PRM), partly also in the Moravian Museum, Brno (BRNM). High percentage of contributions has been published in Česká Mykologie/Czech Mycology journal. Recently, the Slovak Carpathians are often visited by Petr Vampola, Josef Vlasák (Polyporales), Vladimír Antonín (Agaricales) and Jan Holec (Agaricales).

Due to the complexity and long-termed character of their studies, the following authors can be considered "fathers" of the modern mycological research in the Carpathians: A. Pilát (virgin forests of the Eastern Carpathians), F. Kotlaba and Z. Pouzar (Slovak virgin forests).

Hundreds of new taxa have been described by the aforementioned authors from the Carpathians, mostly discomycetes, polypores, corticioid fungi and agarics. Tens of them proved to be good species. The most important ones are e.g. *Haasiella splendidissima* Kotl. et Pouzar, a new genus and species of agarics, *Frantisekia mentschulensis* (Pilát ex Pilát) Spirin, *Hymenochaete carpatica* Pilát, *Crepidotus carpaticus* Pilát, *Kubickia tatrensis* Svrcek.

Larger mycobiota studies were published by Pilát (Eastern Carpathians, Vysoké Tatry Mts.), Kotlaba and Pouzar (Dobročský virgin forest), Svrček (Nízke Tatry Mts., Vysoké Tatry Mts.), Kubička (Belanské Tatry Mts., Vysoké Tatry Mts.), Kuthan and Antonín with Slovak co-authors (Poloniny National Park) and Holec (Eastern Carpathians).

Relations between subalpine flora of West-Carpathian and Sudeten Mountains

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From the phytogeographical point of view there are many influences between Carpathian and Sudeten subalpine and alpine flora. In Sudeten mountains (Krkonoše Mts., Králický Sněžník Mts., Hrubý Jeseník Mts.) we can see species of Carpathian migration flow, both acidophilous and calciphilous. Typical plants, which migrated from West-Carpathians to the all Sudeten mountains, are for example *Veratrum lobelianum, Crepis conyzifolia, Delphinium elatum, Hedysarum hedysaroides, Scabiosa lucida, Anemone narcissiflora* or *Allium schoenoprasum* subsp. *alpinum*. Some of Carpathian species have western limit of its area in Králický Sněžník Mts.: *Avenula planiculmis, Scrophularia scopolii, Conioselinum vaginatum*. The third group of subalpine species has their limit of Carpathian migration in Hrubý Jeseník Mts., especially in the kar Velká kotlina: *Laserpitium archangelica, Crepis sibirica, Hieracium villosum, Gentiana punctata* and others. Some of the Carpathian migrants occur in the Sudeten only in Krkonoše Mts. – the representatives are *Poa laxa, Primula minima, Geum montanum, Primula minima* and *Festuca versicolor*, generally the plants of open grassland places. Distributional maps and ecological consequences are discussed.

Carpathian-Pannonian Species in the Collections of the Botanical Garden of the Faculty of Science, Charles University in Prague, Czech Republic

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The tradition of cultivation of the Pannonian and Carpathian species in the outdoor expositions of the Botanical garden of the Charles University in Prague has begun by collecting tours of the university by prof. Karel Domin, the author of the Czechoslovak Flora prof. Josef Dostál in 30's of the 20th century and others. Completing of the collections had been running till 80's of the 20th century through the regular autumn collecting tours of the garden staff dedicated first of all/mainly to collecting seeds. The Pannonian and Carpathian species of the middle elevations are grown mainly in the greatest exterior exposition of the garden, "The Flora of the Central Europe".

Phytogeographically, higher number of species with the centre of occurrence in the area of South-Slovakian and North-Hungarian mountain ranges of Matricum (e.g. *Lathyrus transsilvanicus, L. laevigatus, Silene viridiflora*) and species with the frequency centre of the occurence in the middle (especially calcareous) locations of the western Carpathians (*Aconitum moldavicum, Adenophora liliiflora*) is interesting. The populations of endemic species, both to the West-Carpathians (e.g. *Dianthus nitidus, Pulsatilla slavica*) and Pannonia (e.g. *Dianthus serotinus, D. lumnitzeri, Festuca vaginata*) are especially valuable. Quite high number of taxa described from the Pannonian area by Waldstein and Kitaibel at the beginning of the 19th century is also remarkable; it includes both endemics (already mentioned *Dianthus serotinus*) and species with the centre of occurrence in the Carpathian-Pannonian region (*Iris arenaria, Euphorbia villosa*) or even overlapping it (*Euphorbia lucida*).

All cultivated plants come from the registered original localities; they thus represent the genofond collection of the region quite distant from Prague showing how great attention was devoted to the Pannonian-Carpathian region both at the Department of Botany and in the Botanical Garden of the Charles University, Faculty of Science in Prague.

Chromosome numbers in *Pulmonaria mollis* Wulfen ex Kern. in relation to geographic distribution in Poland

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Pulmonaria mollis Wulfen ex Kern. (Boraginaceae) is a relatively young taxon with chromosome number 2n=18. Its range is limited to Central Europe. In Poland, populations of *P. mollis* are dispersed in south-western part of the country; some of them are isolated. *Pulmonaria mollis* is known as species characteristic to order *Quercetalia pubescenti-petraeae*. In last decade many new localities and habitats of this species were found due to the "Distribution Atlas of Vascular Plants in Poland" project.

The aim of our study was to find out if there are differences in chromosome number in populations from different habitats in Poland.

All phytosociological relevés studied, from the years 1929-2013, were made using Braun-Blanquet method. Information about localities and habitats from floristic papers were used as well.

Analysis of archival and new phytosociological data from Poland shows that *P. mollis* occurs in many different habitats: grasslands (*Origano-Brachypodietum*), meadows (classes *Molinio-Arrhenatheretea* and *Scheuchzerio-Caricetea* nigrae), forb fringes (classes *Trifiolio-Geranietea* and B*etulo-Adenostyletea*) and in forests (classes *Querco-Fagetea* and *Vaccinio-Piceetea*). In the Polish Carpathians it could be found in fresh and boggy meadows, forb fringes and forests. Chromosome analyzes show that there are no differences in chromosome number in populations from grasslands, xerothermophilous forb fringes and forests.

The studies provide evidence that *P. mollis* is characterized by relatively wide ecological amplitude. Results of investigations on isolated population from Bieszczady Mountains could be interesting. To explain contemporary dispersed range molecular studies are needed.

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Diversity of nivicolous myxomycetes (Protozoa, Amebozoa) of the Tatra Mountains along an altitudinal gradient of habitats – presentation of a new project

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Nivicolous myxomycetes form a distinct ecological group of species characterized by a seasonal occurrence in early spring and obligatory affinity to ecological conditions present at the edge of melting snowfields. They were traditionally considered as alpine organisms, i.e., restricted to the alpine regions of the mountains. Recent analyses of published data showed that nivicolous myxomycetes have more often been recorded in the forest (montane) and subalpine belts than in the alpine belt. The main aim of the presented project is to conduct a comparative analysis of myxomycete diversity from habitats located along an altitudinal gradient – from low mountain, through subalpine to alpine sites. Myxomycete species will be surveyed at three transects situated within the Tatra Mountains, which are the highest mountain range in the Carpathians and the only one characterized by altitudinal zonation spanning habitats from deciduous forests up to subnival areas. Specimens will be collected between April and June, in meadows (open vegetations) as well as inside adjacent forest, during at least two or three following seasons. It is expected that this study will reveal whether some myxomycete species have a preference for the specific ecological condition existing at different elevations and whether the diversity of nivicolous myxomycetes is correlated with their altitudinal occurrence.

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Niche differentiation in *Tephroseris longifolia* agg.

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The complex of *Tephroseris longifolia* agg. includes several subspecies with separate distribution in the Eastern and Central Alps reaching also Apennines, Pannonia and Western Carpathians. One of the subspecies, *T. longifolia* subsp. *moravica*, is considered as endemic of Western Carpathians and is treated as endangered taxon of European importance (NATURA 2000). In our study, we evaluated ecological and coenological interspecific differentiation within *Tephroseris longifolia* agg. We also ask, whether the indicated differences correspond to the newest taxonomical concept, according which the Pannonian morphotype originally ordered within *T. longifolia* subsp. *longifolia* is more closely related to *T. longifolia* subsp. *moravica* than to the Alpine morphotype of *T. longifolia* subsp. *longifolia*.

The quantification of the realized niche of the subspecies/morphotypes was based on 134 circular plots of 0.5 m^2. For each plot, a set of environmental variables was measured or calculated including topographic, edaphic, bioclimatic and biological habitat characteristics and all co-occurring species of vascular plants and bryophytes were recorded. Differences among the taxa were tested by Kruskal-Wallis ANOVA and multiple comparisons of the mean ranks. Coenological relationships were analyzed by the detrended correspondence analysis based on presence-absence data of co-occurring species while the occurrences of TL subspecies/morphotypes were used as nominal environmental variables. Post-hoc correlation with the measured environmental variables was used to interpret the relationships among the sample plots. Vascular plants and bryophytes with the highest fidelity to plant communities containing the respected *T. longifolia* subspecies/morphotypes were indicated by *phi* coefficient in JUICE program.

According to our results, the subspecies/morphotypes differ significantly in their ecological niches and their niche width. For most of the recorded environmental variables, the variance was lower for taxa with narrow distribution (*T. longifolia* subsp. *moravica*, *T. longifolia* subsp. *brachychaeta, T. longifolia* Pannonian morphotype) than for the widely distributed taxa (*T. longifolia* Alpine morphotype, *T. longifolia* subsp. *gaudinii*, *T. longifolia* subsp. *pseudocrispa*). Although the subspecies do not overlap much in their geographic distribution, they are well separated along the altitudinal gradient. Similarly to the results of morphometric study, we indicated high similarity of *T. longifolia* subsp. *moravica* and the Pannonian morphotype in their coenological and ecological characteristics.

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Vegetation development in the West Carpathians during the Last Glacial Period (palaeobotanical results)

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The long time efforts to obtain palaeobotanically relevant sediments of Last Glacial Period age in the territory of previous Czechoslovakia have not been successful nearly till recently. We had relatively enough information about the vegetation and landscape character in Late Glacial in the past, but any information about the vegetation conditions in older parts of Weichselian period.

As a success, therefore should be appreciated the findings of some localities with the Weichselian sediment.

The most valuable sources of new information are the sediment profiles from Šafárka (NE Slovakia), Jablůnka (NE Moravia), one peat sample from Týn nad Bečvou (NE Moravia) and one peat-wood sample from Chlebovice (NE Moravia). These localities provided data on the landscape character from the period of MIS 3, MIS 2 and partly also MIS 4. The oldest radiocarbon data from the Šafárka have a higher value than 52.000 BP. These data and data between 16.500 – 48.000 uncal. BP confirm the Middle and Upper Pleniglacial age. Sediments from the Jablůnka with 39.000 – 45.000 uncal. BP and Týn nad Bečvou with 44.200 ± 1.400 uncal. BP are both also of Middle Pleniglacial age. Peat sample from Chlebovice around *Picea* wood showed the age 53.230 ± 490 ^{14}C BP (out of calibration set).

Results of pollen analyses from the Šafárka, Jablůnka and Týn n. Bečvou have brought the evidence that both *Larix* and *Pinus cembra* were the forest forming species in the Pleniglacial period of Carpathians. The profile Šafárka contained in addition a great amount of seeds, cones and other remains of larch, stone pine and spruce subsequently used in radiocarbon dating. Very interesting was result of pollen-analysis of the sample from Chlebovice (53.230 ± 490 ^{14}C BP). Pollen grains of *Picea* prevailed, but also pollen of *Abies* were found. Perhaps it reflects warmer climatic event in this time (?).

The stone pine – larch stands formed the vegetation cover of Slovak Carpathians from the inner Carpathians basins up to the alpine forest limits in the nearly all Pleniglacial and even during the whole Late Glacial.

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Phylogeographic patterns of boreal-mountain orchid *Malaxis monophyllos* in Eurasia

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The rare orchid *Malaxis monophyllos* is distributed both in the boreal and mountain ecosystems from Eurasia to the eastern areas of North America. It grows both in the natural and anthropogenic habitats, but with marked tendency to decrease of population size and abundance in natural habitats. Here, we investigated the phylogeography of this orchid species in sixty-eight populations over the whole Eurasian distribution range using four cpDNA markers (*trnL* (UAA), *trnL* (UAA)3'-*trn*F (GAA)5', *rps*16, *acc*D-*psa*I). Our cpDNA data showed high intraspecies genetic diversity but shallow phylogeographic structure along its European range. The high haplotype diversity was found both in boreal and mountains populations, e.g. in the North and East Europe, Western Alps and Silesian Highland in Poland. Surprisingly low level of haplotype diversity we recorded in the Carpathian populations. More than half of haplotypes were rare (haplotype restricted only to one population). Bayesian analyzes distinguished two haplotype groups (only one group with high bootstrap support – 100%), which co-occurred in Eurasia. The cpDNA network indicated also H7 as putative ancestral haplotype, which is widespread across whole distribution area, but it is most common in Asian populations. The present data did not reveal the refugia, but we suspect more than two sources of postglacial colonization in Eurasia, with particular emphasis on Western Alps and Central Asia. That hypothesis is worth pursuing in future work extending our analysis to the Asian populations and with application of AFLP markers.

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Two millennia of environmental changes on ombrotrophic peat bogs in the Orawa-Nowy Targ Depression (southern Poland) inferred from palaeobotanical proxies

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Two ombrotrophic peat bogs, Puścizna Mała (PM) and Puścizna Krauszowska (PK), located in the biggest north Carpathian complex of mires were examined in terms of environmental changes in the last 2 kyr. This period was characteristic of dramatic changes induced by human activity which influenced the bogs in the Orawa-Nowy Targ Depression. Since the Middle Ages the area was successively deforested and mires has been exploited with different intensity, which is recorded as several disturbances in peat sedimentation. Our studies included analyses of pollen, non-pollen palynomorphs, macrofossils combined with ^{14}C and ^{210}Pb dating. Final results revealed three major phases of peat bog succession: 1. Period ca. 0-1300 AD (ca. 0-700 AD in PK and ca. 300-1300 AD in PM) showed low human impact and domination of *Picea-Abies-Fagus* forest. Both profiles registered dry period during ca. 4th-5th century. The subsequent wet phase during ca. 5th-6th century was detected in the PM profile. 2. Layers dated at ca. 700-1850 AD in PK and ca. 1300-1850 AD in PM recorded disturbances induced by exploitation of bogs which was triggered in the second part of the 18th century. The most characteristic features of this phase are significant inversions of radiocarbon dates occurring in both profiles. In the case of the PM profile, dramatic deforestations simultaneous with a rapid decline of the water table were identified then and the topmost layer was probably later removed. On the other hand, pollen, NPP and plant macrofossil analyses failed to discover so evident disturbances in the PK profile, which point to different cause of their presence. 3. The topmost layer (ca. 1850-2009 AD) recorded regeneration of the acrothelm in both profiles. *Ambrosia* ssp. expansion in Southern and Central Europe was regularly registered in pollen spectra. These results seem to be a promising tool for validation of absolute chronologies of topmost deposits' sections in palaeoecological research from the Carpathian area in the future.

Diversity of the genus *Clavaria* (Basidiomycetes, Clavariaceae) in Western Carpathians

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Representatives of the genus *Clavaria* L. (Clavariaceae, Agaricales, Basidiomycota) are characterized by very simple structure of basidiomata which are annual, cylindrical or narrowly club-shaped, mostly unbranched and simple. *Clavaria* has a worldwide distribution probably with maximum diversity in the tropics. In Central Europe *Clavaria* representatives are mostly found in semi-natural grasslands (meadows and pastures), or in forest edges and shrubs. In grasslands, they are often treated as valuable indicators of well preserved, diversity rich, traditionally managed meadows and pastures and are given high scores in several evaluating systems of such habitats.

Overview of the West-Carpathian (WC) representatives of *Clavaria* is presented, based on taxonomic and nomenclatural revision of the genus and extensive collecting in Central and Western Europe. Species concepts are based on macro- and micromorphological characters and DNA analyses of nrLSU region. Molecular analyses resulted in a phylogenetic tree with nine well defined clades and thirteen *Clavaria* species occurring in WC region. Dark coloured *Clavaria* species were analyzed separately (Kautmanová et al., 2012). Of the seven recognized brown and black *Clavaria* species *C. fumosa, C. greletii* and *C. pullei* were found in WC. Of the resulting species *C. argillacea, C. flavipes, C. incarnata, C. rosea* and *C. zollingeri* were well delimited requiring only additional type studies to stabilize their species concept and nomenclature. *Clavaria amoenoides* showed relatively high infraspecific variability of LSU sequences and it deserves closer attention. Sequences determined morphologically as white coloured *C. falcata, C. fragilis* and *C. tenuipes* or with affinity to these species showed clear polyphyly but no morphological pattern for recognizing more species of these complexes has been revealed. Further research in this field is needed. Part of collections with yellow basidiomata belonged to a new species *C. xantha* (Olariaga I, Salcedo I, Daniëls PP, and Kautmanová I. Taxonomy and phylogeny of yellow *Clavaria* species with clamped basidia – *Clavaria xantha* sp. nov. and typifications of *C. argillacea, C. flavipes* and *C. sphagnophila*. *Persoonia* [submitted]).

The genus Clavaria in West Carpathians is much more diverse than it has been assumed and further research may reveal even higher species diversity and ecological significance of these interesting fungi.

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Separate polyploid lineages or allopatric segregation? Possible relationships of high Sudeten and Alpine-Carpathian populations of *Galium pusillum* complex

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Species complex of *Galium pusillum* includes approx. 27 polymorphic taxa encompassing up to five cytotypes distributed from lowland grasslands and rocky sites up to subalpine habitats. Subalpine species *G. anisophyllon* is the most common member of this complex in central European mountains (both the Alps and the Carpathians) spreading up to the mountains of Balkan Peninsula and the Apennines. Fragmented areas and cytotype heterogeneity (di-, tetra-, hexa- and octoploid cytotypes are known) probably reflecting the glacial oscillations, give rise to many questions about relationships of different isolated diploid lineages and origins of the polyploids.

An interesting, but still unclear position with respect to *G. anisophyllon* takes up its Sudeten-Hercynian parallel, *G. sudeticum*. This endangered endemic of the Czech Republic and Poland shows a remarkable disjunct distribution in high Sudeten mountains (Krkonoše, Jeseníky) and serpentine outcrops in western Czech Republic (Slavkovský les). There is extensive controversy among existing morphological, chorological and caryological studies about the unity of this taxon (possible polytopic origin of serpentine and mountain populations) and about evolutionary mechanisms of its origin. Existing hypotheses consider *G. sudeticum* as (i) a result of independent polyploidization or (ii) an allopatric segregate from morphologically and ecologically close mountain species *Galium anisophyllon* (either its Carpathian or Alpine arelle) or (iii) a polyphyletic taxon with relationships to different lowland and subalpine taxa from *G. pusillum* agg. By combination of morphological analyses (both on wild and cultivated plants), cytological examination and a wide range of molecular methods (chloroplast DNA, low-copy nuclear genes, AFLP) we want to test these hypotheses and reveal evolutionary processes that took part in the origin of this taxon. Collectively, the data will help us to understand the role of serpentine sites as a post-glacial refugia; to reveal evolutionary mechanisms involved in development of the mountain flora (relationship among the Sudeten and Alpine/Carpathian flora), and will also contribute to effective protection of this endangered species.

Our preliminary flow cytometric (different homoploid genome size) and chloroplast haplotype data indicate distinct origin of the subalpine vs. serpentine *G. sudeticum* populations and probably closer relations of the former ones to tetraploid *G. anisophyllon* from the Alps/Carpathians.

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Recent changes in distribution of rare plant species in the Ukrainian Carpathians

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The vast majority (157) of 214 occurring in the Ukrainian Carpathians species of vascular plants included into "The Red Data Book of Ukraine" (Chervona Knyha..., 2009) are presented at the limits of their geographical ranges in the region. Some of their populations are peripheral not only geographically but also ecologically, i.e. are confined to the habitats with atypical conditions that makes them vulnerable. Analysis of the past literature and herbarium data on rare species and comparison with their current occurrence, as well as long-term monitoring of populations revealed significant altitudinal changes in their distribution. These shifts are related mostly to global warming, especially decrease or extinction of cold-tolerant high-mountain species (e.g. *Saxifraga carpatica* Sternb., *S. oppositifolia* L., *Trifolium badium* Schreb., *Veronica belliodioides* L.).

However, other mountainous species – *Rumex scutatus* L., *Swertia punctata* Baumg. – demonstrate latitudinal extension of their ranges that can be explained by their current northeastward migration along the Carpathian arch.

The main cause of changes in abundance and distribution of rare species is massive abandonment of traditional land use – grazing and mowing. It results in reduction of vast grassland areas all over the Ukrainian Carpathians that endangers many low-growing herbaceous plants and concerns peripheral populations of narrow-range *Minuartia oxypetala* (Woł.) Kulcz., *Thlaspi dacicum* Heuf., *Th. kovatsii* Heuf.

Populations of some petrophilous species (e.g. *Erigeron atticus* Vill., *Sempervivum marmoreum* Griseb., *Erysimum witmannii* Zawadzki) also decrease at the edge of their ranges due to forestation.

Nevertheless, such vegetation succession is favorable for some rare forbs – *Achillea lingulata* Waldst. & Kit., *Campanula serrata* (Kit.) Hendrych, *Delphinium elatum* L. subsp. nacladense (Zapał.) Holub, *Gentiana punctata* L. Their abundance increased significantly during last decades and new populations of these species appeared at the edge of their geographical ranges.

Short-lived species (e.g. *Arabis hornungiana* Schur, *Cardaminopsis neglecta* (Schult.) Hayek, *Pedicularis oederi* Vahl, *P. verticillata* L., *Thlaspi kovatsii*) are most vulnerable to climate change and land use shifts. The size of their populations is very unstable and they are prone to extinction due to changes of conditions in their habitats.

Further extinction of the above-mentioned groups of rare species at the limits of their ranges should be expected in the mid-term perspective.

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Cytological variation of *Arabidopsis arenosa* in its Carpathian diversity centre

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Despite vast amount of knowledge available for the plant model species No. 1, *Arabidopsis thaliana*, the distribution, ecology, cytological and genetic variation of its closest relatives (formerly treated in the genus *Cardaminopsis*) still remain highly fragmentary. The group of *Arabidopsis arenosa* represents the most intricate member of the whole genus as it encompasses up to ten taxa (species and subspecies, partly still undescribed) inhabiting a wide range of habitats from lowland steppes to alpine rocks throughout the temperate Europe.

A necessary prerequisite for a detailed molecular study of such complex ploidy-heterogeneous plant systems is knowledge of the geographic distribution of cytotypes. The cytogeographic data serve as a foundation for addressing questions of evolutionary history, frequency of polyploid formation, ecological differentiation of cytotypes and the evolution of interploidy reproductive barriers. Using a high-throughput method of flow cytometry, we investigate the cytotype distribution and cytological composition of populations of the *A. arenosa* complex throughout its range.

Our preliminary results show largely parapatric distribution of the diploid (SE Europe) and tetraploid cytotype (NW Europe) with two contact zones – narrow one in Slovenia and a wide mosaic-like contact zone in Eastern and Western Carpathians. Particularly in Slovakia, the diploid and tetraploid populations are largely intermingled and both cytotypes are spread along the whole lowland-alpine habitat gradient. In contrast with the complexity at the landscape scale, the within-population cytological homogeneity and extremely rare occurrence of triploids indicate a rather stabilized character of the contact zone. Collectively, Western Carpathians emerge as the cytological and probably also ecological and taxonomical hotspot of the whole *A. arenosa* complex.

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Variability of population traits of tall herb species *Doronicum austriacum* in different site conditions

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Doronicum austriacum (Asteraceae) belongs to the Central-European species with the centre of its distribution in the mountains of Europe. It occurs in the Alps, Apennines, Balkans, Carpathians, Eastern Pyrenees, Eastern Sudetes. It could be found in the tall-herb communities of the *Adenostylion alliariae* Br.-Bl. order, it is believed to be the subalpine species. However, it has rather wide amplitude of its occurrence, it could grow in the mountain piedmont. In Poland, the species even has few localities beyond the Carpathians: in Świętokrzyskie Mts, Silesian Upland, Kraków-Częstochowa Upland. These localities are regarded as glacial relicts originated form the Carpathians.

Austrian leopard's bane is a perennial rhizome species. It produces stem up to 120 cm with numbers of leaves of variable shapes (different according to its place on the stem). One to ten capitulas, 5–7 cm in diameter, sit on long peduncles. The female flowers are yellow, and ligulate, and bisexual flowers are disc florets.

During our studies we tested hypothesis that site conditions (e.g. moisture, temperature, light) modify population traits of the species such as: number of generative and vegetative stems, height of the stems, number of leaves and their characteristics, number and diameter of capitulas. Secondly, we tested whether the habitat stress leads an increase of allocation in generative reproduction.

We used six localities [three of them also used in the study of Stachurska-Swakoń and Kuź (2011)], where three are mountain localities but represent different mountain ranges, site conditions, and different associations and three localities are beyond the Carpathians: in Silesia Upland and Świętokrzyskie Mts. We could conclude that site conditions regarding Austrian leopard's bane affect the populations traits. The statistically significant difference is evident for the generative traits as the number of capitulas, number of generative shoots and height of the stem.

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A revision of the endemic species *Centaurea carpatica*

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Centaurea carpatica Porc. (subgenus *Centaurea*, section *Jacea*) is considered an endemic species of the East Carpathians. It was described from the Rodna Mts., Romania, and reported also from several other mountain groups in Romania and Ukraine. It occurs mainly in tall-herb subalpine communities, although there are several records also from lower altitudes. In general, the species is poorly known and detailed information on morphological variation, chromosome count and distribution were missing. A revision of herbarium material has shown that the species is extremely rare, probably an endemic of the Rodna Mts. documented from only about 5 localities. The other records are erroneous (most of the material belong to *C. phrygia* s. str.). A morphometric study of the whole *C. phrygia* complex confirmed that the populations from the Rodna Mts. are unique and should be recognized as an autonomous taxon. One population was analysed using flow cytometry and is diploid. Surprisingly, morphologically somewhat similar plants were identified in the subalpine belt in several mountains in Slovakia, but they differ in ploidy level (tetraploid) and are probably a subalpine variant of *C. erdneri*, which is frequent in the West Carpathians. Concerning nomenclature, the widely used name *C. carpatica* Porc., 1885 is illegitimate, as it is a younger homonym of *C. carpatica* Genersich, 1798. The latter name belongs to some taxon from the subgen. *Cyanus* (probably from the *C. triumfettii* complex). The correct name for the taxon from the Rodna Mts. is *C. rodnensis* Simonk., 1886.

Centaurea rodnensis is a narrow endemic species of the Rodna Mts. and is known from a few localities only. It thus deserves an attention from nature protection agencies in Romania.

Freshwater lichens in the Bieszczady Mts, the Polish Eastern Carpathians

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Most lichens occur in terrestrial habitats, but some species are present also in aquatic environments, in both maritime and freshwater habitats. In mountain regions freshwater lichens are amphibious organisms, most of them being submerged during only a part of the year when the water level is raised in the streams (in spring or after a heavy rain). The freshwater lichen flora seems to be very homogeneous worldwide (for example *Verrucaria margacea* is a common species in Europe, Asia, North America, Australia) and corresponds to relatively few taxonomic groups (e.g. genera *Aspicilia, Bacidia, Ionaspis, Porina, Staurothele, Thelidium, Verrucaria*).

The lichen flora of the Bieszczady Mts was an object of intensive studies over several decades and, therefore, it is relatively well know. The freshwater lichens, however, remain the least recognized ecological group that needs investigations.

In 2011 a field work was carried out in the following streams in the Bieszczady Mts: Smerek, Solinka, Roztoka, Osława. The aim of the study was to provide complex data on freshwater lichens in the area. Along with lichen diversity, physical and chemical parameters of water (pH, conductivity, oxygen, nitrate, phosphate, Mg, Ca, K, Na and Cl contents) were examined. The ecological factors such as substrate type, shading, water speed, sediment organic matter content were studied as well.

In total c. 30 species were found in examined sites representing various genera, for instance *Verrucaria* and *Thelidium* (7 and 5 species, respectively) and *Bacidia, Gyalidea, Hydropunctaria, Ionaspis, Polyblastia, Porina, Porpidia, Staurothele* (single species). Distribution of lichens was noted as slightly differentiated in various streams. Species diversity and abundance changed distinctly depending on the distance from river source and reflected anthropogenic changes in the catchment area.

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Where to find rare species of relict mires? The experience with the habitat analysis of *Pholiota henningsii* (Fungi, Strophariaceae) in Central Europe

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There are many and complex ways in which species responded to climatic and environmental changes during the Holocene, including the habitat succession from lakes through the fens, transitional mires up the particularly forested bogs. Just the temporal and spatial forest-treeless mire mosaic seems to be the most important conditional factor for the long-term persistence of relict species. The occurrence of *Pholiota henningsii* in areas of old lakes, both near the inland fresh-waters and mountain or northern glacial lakes shows the probable relict character of its distribution. *Pholiota henningsii* is known from localities which are mostly concentrated together in some geographic areas, e.g. in the western (seaside) part of the Netherlands, in the Parisian and Aquitanian basins, Massif Central and foothills of the Pyrénées in France, Jurassic valleys in France and Switzerland, northern foothills of the Alps in France, Switzerland and Austria, alpine valleys in Austria, southern Bohemia in the Czech Republic (Tertiary basins, with numerous mires and fishponds), Mazury lakes region in Poland, northern part of the Sjaelland island in Denmark and coastal/island region close to Stockholm in Sweden. In several European countries it is included in Red Lists of endangered fungi and/or species protected by law. The fungus occurs in spring fens, transitional mires and raised bogs at the altitude of 25–1930 m (Alps), both nutrient-rich and oligotrophic. It is confined to localities with a long-term mire continuity (thousands of years, based on palynological data). Most of localities are in the vicinity of the open water bodies up to present. If not, the high air humidity is ensured by (sub-)atlantic climate combined with cover of shrubs and trees. The species resists quite well to disturbances, when the water balance is stable. In the Czech Republic, three historical sites were supplemented by two new localities in 2012 with exactly same habitat conditions as the previous ones. The distance to the closest site to the east is approximately 650 km, between the Mazury lakes (Poland) and Dokesko (CR). The proper perspective localities are in lake landscapes of northern Poland: Biebrza and Rospuda, Lake Sejny, Augustow Forest, and the Kashubian Lake District. The occurrence of *Pholiota henningsii* has not been recorded in the Carpathian region yet, but we suppose probable sites in northern foothills of Carpathians. The detail survey search should be realised in the old fens and mires that are covered by Natura 2000 habitats 7140 Transition mires and quaking bogs, 7150 Depressions on peat substrates of the Rhynchosporion and 7230 Alkaline fens. In Slovakia potential localities are near Liptovská Mara and some other localities in the valleys of Western Carpathians.

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Enhanced key to Geoglossum-like fungi in Slovakia

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Geoglossum-like fungi are considered as rare fungi in most of European countries. Our extensive field research on these fungi both in non-forest and forest biotopes in Carpathians started in 2000 and resulted not only in discovery of ten new species for the region and solving some taxonomical problems but also in gathering of data on their distribution and ecology. According to our records common habitats for Geoglossum-like fungi are not peat-bogs and wet meadows (as frequently mentioned in publications) but grasslands; irregularly maintained meadows and pastures and their bushy margins seem to have the highest diversity of these fungi. Annual fruit-body production was even from the location of a collecting site and was influenced especially by rainfall. Geoglossum-like fungi are endangered mainly by changes in traditional farming of pastures and meadows and drainage of countryside.

Eighteen species were identified in Slovakia until now: *Trichoglossum hirsutum* (26 localities), *T. walteri* (2 localities), *T. variabile* (2 localities), *T. octopartitum* (4 localities), *Geoglossum umbratile* (7 localities), *G. glutinosum* (5 localities), *G. glabrum* (4 localities), *G. fallax* (6 localities), *G. montanum* (1 locality), *G. cookeianum* (2 localities), *G. alveolatum* (1 locality), *G. uliginosum* (1 locality), *Thuemenidium atropurpureum* (2 localities), *Microglossum viride* (7 localities), *M. olivaceum* (4 localities), *M. fuscorubens* (1 locality), *M. rufescens* (1 locality) and *M. nudipes* (1 locality).

The preliminary key for Geoglossum-like fungi introduces our taxonomic concept and assumed distribution in the Western Carpathians.

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What do classical taxonomy and molecular data reveal about diversity of *Pediastrum* taxa in the Western Carpathians? Preliminary results

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Extensive taxonomic studies on microscopic green algae *Pediastrum* (Chlorophyceae, Sphaeropleales, Hydrodictyaceae) in the years 2008–2010 revealed that 32 taxa from 19 species occur in Poland, in the littoral mainly of coastal lakes and fish ponds. The present study focused on morphological and molecular variability of *Pediastrum* taxa in the Polish Western Carpathians. Samples were collected in the Dolina Gąsienicowa valley (High Tatra Mountains) in summer 2011. Only eight *Pediastrum* taxa were found, in four of eight lakes investigated. Most taxa were observed in Litworowy Staw and Wyżni Czerwony Stawek, which are small shallow lakes having slightly higher conductivity values than the others. In order to better understand the relationships between the mountain and lowland *Pediastrum* taxa, 18S, 26S and ITS rDNA sequences from three isolates from Wyżni Czerwony Stawek, 12 from other Polish regions and two from GenBank database were used to build a phylogenetic tree. All *Pediastrum* taxa from the field and cultured materials were documented using light and/or scanning electron microscopes. The three mountain strains, identified as *P. boryanum* var. *longicorne*, *P.* cf. *boryanum* var. *cornutum* and *P. boryanum*/*integrum*, grouped together with lowland *P. boryanum* strains in the tree. However, the two former strains did not show the closest relationships to *P. boryanum* var. *longicorne* and *P. boryanum* var. *cornutum* from the lowland regions. In these two cases small differences in the length of processes and the characteristics of surface elements were reflected in molecular variability of *Pediastrum*. Due to the fact that phylogenetic distances in the *P. boryanum* group were quite short, analysis of additional DNA regions is planned for a more accurate assessment of the mountain isolates. A higher number of strains is also necessary for better recognition of diversity of *Pediastrum* taxa in the High Tatra Mountains.

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Morphological differences between *Rhododendron myrtifolium* Schott et Kotschy and *R. ferrugineum* L. based on the leaf characteristics

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The closely related *Rhododendron myrtifolium* and *R. ferrugineum* occur in the mountain massifs of Central Europe, the first in the Carpathians and mountain systems of the Balkan Peninsula, the latter in the Alps and Pyrenees. The contemporary geographic ranges of the species are disjunctive, but during cold periods of Pleistocene the contact between them was possible.

I hypothesize that isolation, which started at least with the beginning of Holocene, might have led to formation of differences in the leaf characteristics among populations occurring in distant mountain massifs of the Carpathians, and between *R. myrtifolium* and *R. ferrugineum*. The leaf characters allow distinguishing between these two species and are important in the taxonomy of the genus.

Material for the study was sampled in seven populations of *R. myrtifolium* and two of *R. ferrugineum*. Every population was represented by 30 individuals and every individual by 10 leaves. Collected samples were dried as herbarium specimens and conserved in this state to the study. I analyzed 16 traits of leaves, 10 of them were measured on the scanned leaves using digiShape 1.9.177 software, the remaining six were calculated. Totally 1940 leaves from 195 individuals of *R. myrtifolium* and 600 leaves from 60 individuals of *R. ferrugineum* were compared.

The received data were tested for the normality of distribution and homoscedasticity of variance. The minima and maxima were found, the mathematic means, standard deviations and variation coefficients were calculated for every population and species. The dependence between average values of particular characters was tested using Pearson's correlation coefficient, to eliminate possible the most redundant of them. The differences between populations, regions and species were tested using Tukey's test, analysis of discrimination and agglomeration on the shortest Euclidean distances. The STATISTICA 10 (StatSoft Poland) software was used in the calculations.

The higher level of variation of leaf characters of *R. ferrugineum*, when compared to *R. myrtifolium*, was found. The average values of characters were generally consistent with data reported in the floras. The samples of *R. myrtifolium* from East and South Carpathian differed significantly, while within these regions they were more similar. The last result can be due to the long lasting isolation between population of the species, or to different environmental conditions.

Distribution of *Taraxacum* sect. *Palustria* species in the Polish Carpathians

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Section *Palustria* of the genus *Taraxacum* is an European taxon with 125 low dispersal species (Kirschner and Štěpánek, 1998; Marciniuk, 2012). All its species are regarded as endangered because of the disappearance of their habitats (Kirschner and Štěpánek, 1998).

The greatest species diversity of the dandelions belonging to section *Palustria* can be found in the wet and damp mountain habitats of Central and Southern Europe (Kirschner and Štěpánek, 1998). In the Polish Carpathians 15 species of dandelions representing this section have been observed (Marciniuk, 2012; Marciniuk et al., 2012). They are as follows: *Taraxacum bavaricum* Soest, *T. dentatum* Kirschner & Štěpánek, *T. hollandicum* Soest, *T. madidum* Kirschner & Štěpánek, *T. mendax* Kirschner & Štěpánek, *T. paucilobum* Hudziok, *T. polonicum* Małecka & Soest, *T. portentosum* Kirschner & Štěpánek, *T. skalinskanum* Małecka & Soest, *T. subdolum* Kirschner & Štěpánek, *T. subpolonicum* Kirschner & Štěpánek, *T. trilobifolium* Hudziok, *T. turfosum* (Schultz Bip.) Soest, *T. vindobonense* Soest and *T. zajacii* J. & P. Marciniuk.

Only *T. paucilobum*, *T. vindobonense* and *T. mendax* occur more frequently in the Polish Carpathians, while the others were found rarely or very rarely, showing some regional dependencies in their distribution. Complete mapping of these species distribution will be possible after intense field research.

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First palaeohydrological reconstructions based on testate amoebae (Protists) from Polish Carpathians

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Among microbes, testate amoebae (Protists) are the best tool to quantitatively estimate past wetness of peatlands. Testate amoebae are (1) very abundant in peatlands, (2) very sensitive to water table changes and (3) form the test that can be preserved in sediments, therefore they are good indicators of past hydrological changes. Using this group of protists we reconstructed palaeohydrological changes in Orawa-Nowy Targ peatlands in the last two millennia. This is the first quantitative reconstruction with the use of testate amoebae carried out in the Polish Carpathians. The analysis was based on peat profiles sampled from two sites – Puścizna Mała (PM) and Puścizna Krauszowska (PK). Together with testate amoebae, profiles were supplemented by high resolution depth-age models based on ^{14}C and ^{210}Pb dating. Due to the fact that peatlands in the study area were disturbed by human in the last centuries, the most crucial problem was to separate climatic drivers of the past hydrological changes from the anthropogenic ones. We recorded three phases of peatland development. Layers dated at ca. 0–1300 AD (ca. 0–700 AD in PK and ca. 300–1300 AD in PM) showed low human impact. For both peatlands it was rather wet period with registered dry period during ca. 4th–5th century and subsequent wet phase in PM during ca. 5th–6th century. In the period ca. 700–1850 AD in PK and ca. 1300–1850 AD in PM we recorded disturbances due to the bog exploitation in the second part of the 18th century. This was demonstrated with the shift of fossil testate amoebae from hydrophilous taxa (e.g. *Hyalosphenia papilio, Archerella flavum*) to strong domination of xerophilous taxa (*Assulina muscorum, Euglypha rotunda type, Trinema lineare, Nebela militaris* and *Nebela tincta*). Furthermore, we observed *Arcella discoides* (taxon representing wet but unstable habitats) together with xerophilous taxa in PM. Top layers (ca. 1850–2009 AD) recorded a shift in testate amebae assemblage from dry to wetter conditions, showing the regeneration of the peatlands in the study area.

Morphological diversity of selected arctic-alpine species against biogeography of the Carpathians

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Results of research into arctic-alpine species conducted with molecular methods proved their internal variability to be a consequence of postglacial migrations, and the spatial structure of this variability in the mountain ranges is often consistent with traditional bio-geographical divisions. Research on morphological variability of these species is scarce. This work is the first attempt to run a partial summary of my research on the morphological diversity of selected arctic-alpine species. The aim of the study was to examine how the spatial distribution of this diversity in Europe can be explained. Therefore, the number of Carpathian samples is not large enough to draw generalized conclusions. In spite of this, you might see some common patterns of variation in the species tested, which were *Polygonum viviparum* L. (3 samples), *Dryas octopetala* L. (10 samples), *Salix reticulata* L. (3 samples) and *Salix herbacea* L. (5 samples).

Average values of leaf traits of particular species showed a common trend. The leaves had the greatest: perimeter, area, length and width, petiole length – in the Western Carpathians, and they got smaller in the Eastern Carpathians and further in the Southern. A similar spatial structure was shown by the average values of the leaf length-width ratio, and in two species with toothed leaf edge (*Dryas octopetala, Salix herbacea*), also two ratios: number of teeth – the leaf perimeter, and the leaf area – the leaf perimeter. I did not find this feature only in the case of teeth number and the petiole length – leaf length ratio. At the same time, the results of my analysis from across Europe showed the dependence of certain leaf characteristics on the general climatic conditions. However, the climate impacts were largely species-specific, as they often depended on the location of the samples.

Nevertheless, multivariate statistical analyses showed clustering according to the allocation to the Western, Eastern and Southern Carpathians for *Polygonum viviparum*, *Dryas octopetala* and *Salix reticulata*. This structure was not visible only in the case of *Salix herbacea*. Although the hypothesis about a possible effect of postglacial migration on the intraspecific morphological variation of species does not seem too likely, the spatial analysis of this variation, in case of the Carpathians, in general is consistent with the biogeographic division of the massif.

Distribution and conservation of subalpine dwarf pine shrubs in the Parâng Mountains of the Southern Carpathians, Romania

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In the Romanian Carpathians, dwarf pine shrubs have a special status at national and Community level. At the EU level they are included in Natural Habitats of Community Interest (bushes with *Pinus mugo* and *Rhododendron hirsutum* – priority habitat type – code 4070*). Dwarf pine shrubs in the Carpathians are well known for its protective, scientific and landscape role. Nevertheless, the total area of the Romanian Carpathian dwarf pine shrubs and current state of preservation are not well known. The total area of habitat was estimated at more than 50,000 ha (Doniţă et al., 2005). After 2008, about 20,000 ha of pine dwarf shrubs were included in the national forest), fact that will hopefully be beneficial for conservation. The current state of conservation of these habitats is often estimated only by the perception of institutions and organizations involved in conservation. The conservation status varies from massif to massif, but it is generally accepted that outside habitats included in Retezat National Park, subalpine shrubs in the Romanian Carpathians are still destroyed (Blada, 2008). Almost all dwarf pine in Romania is included in the Natura 2000 network, conservation efficiency within the network is still questionable. Due to morphographical and morphometric characteristics, the Parâng Mountains hold the largest share of the Southern Carpathian dwarf pine although the largest anthropogenic pressure on forest is here (Marinescu et al., 2013). This study evaluates the areas occupied by dwarf pine shrubs and explains the influence of environmental factors by analyzing the patterns of distibution. Using topographic 1:25,000 maps, 1:5000 orthophotoplans, and field measurements, spatial distribution pattern dwarf pine shrubs was obtained. The paper aims to be a reference point for future conservation status evaluation and habitat monitoring in this area.

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Evolutionary links between the Sudeten and Western Carpathian *Aconitum* sect. *Aconitum*

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Aconitum sect. *Aconitum* in the Sudetes and Western Carpathians is represented by two tetraploid (2n = 4x = 32), endemic species: *A. plicatum* Rchb. (*A. p.*) and *A. firmum* Rchb. (*A. f.*), respectively. However, two subspecies from the neighbouring mountain ranges: *A. p.* subsp. *sudeticum* Mitka and *A. f.* subsp. *maninense* (Skalický) Starmühler (Mitka, 2003) share unusual in the section glandular indumentum. This fact enables the hypothesis on the evolutionary links between the Sudetic and Carpathian genomes to be put forward. To test the hypothesis the PCR-ISSRs (Mitka et al., 2007), AFLPs and karyological analyses were carried out. In the effect a part of the Sudetic genome within the Carpathian genetic stock (AFLPs) and close genetic relationships (ISSR) between the two subspecies taxa were found. Based on the distribution of heterochromatin and rDNA in the 1st chromosome type of the karyotype of *A. firmum* its hybrid origin was shown (Mitka et al., 2007; Ilnicki and Mitka, 2009). It was also found that *A. sudeticum* and *A. maninense* had the highest and statistically significant ($p<0.05$) values of the genetic diversity indices, pointing to their relict character. These facts create a new prospect in seeking the evolutionary pathways of *Aconitum* in Central Europe.

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Ectomycorrhizal communities of an arctic-alpine plant species, *Dryas octopetala* L. in alpine and relict low-elevation populations

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Dryas octopetala is one of key arctic-alpine vascular plants. Its circumpolar distribution encompasses – apart from wide extent of the (sub)arctic tundra of the Northern hemisphere – the discontinuous areas of the alpine zone (alpine tundra) in the temperate mountains, including the Carpathians. In the Carpathians several isolated populations are also known to occur at lower elevations within the forest zone; they are considered post-glacial relicts. *Dryas octopetala* is one of few arctic-alpine plants that form ectomycorrhizal symbiosis. The aim of the present project is to make a step towards understanding drivers of distribution of arctic-alpine ectomycorrhizal fungi and test potential influence of climate and of host plant presence, by studying *D. octopetala* ectomycorrhizal assemblages as a model system. We apply morphotype analysis and molecular barcoding to compare communities of ectomycorrhizae of *D. octopetala* at three climatic-vegetation belts: (1) alpine belt – typical area of the species occurrence, (2) subalpine belt – the area to which the species descends naturally, (3) forest belt – the area of the relict populations occurrence. Here, we present preliminary results based on morphological segregation of ectomycorrizal tips. The material was collected from 30 samples (five per locality) from six localities (two at each vegetation belt) localized in the Tatra Mts., Maľa Fatra Mts., Chočské Vrchy Mts., Pieniny Mts. and Slovenský Raj Mts. We identified in total 55 mycorrhizal morphotypes of which 35 were recorded only in single localities. No significant differences in number of morphotypes, either per sample or per locality, were found. Only four morphotypes were found across all climatic-vegetation belts. One of them, *Cenococcum geophilum*, was recorded in almost all samples but its abundance (measured as number of mycorrhizal tips pooled from all samples per climatic-vegetation belt) showed a decrease with elevation (alpine zone – 366 tips, subalpine zone – 289 tips, forest zone – 223 tips).

Based on morphology of ectomycorrhizae, we can assume that the communities of ectomycorrhizae of *Dryas octopetala* are not impoverished either in subalpine or in relict localities of the species. In the next step of the project, the identification of ectomycorrhizal fungal symbionts will be attempted using sequencing of DNA barcoding markers in order to estimate the taxonomic composition of fungal symbionts connected with the host plant at different climatic-vegetation zones. This will allow to check whether the arctic-alpine fungi follow their mycorrhizal partner at the low-altitude relict localities or their potential co-migration is hampered by the climatic constraints.

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Radiocarbon dated paleoecological reconstruction on the loess-paleosol section of Villánykövesd, Hungary: long term environmental and climatic changes

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It can be said that the loess-paleosol section of Villánykövesd is one of the most interesting in the South Transdanubia region in Hungary. The almost eight meters high section was sampled in every 12 centimetres, from where about five kilograms of samples were taken. The samples were analysed by various methods. Malacological, sedimentological, magnetic susceptibility and LOI examinations were made on every sample. These high resolution multi-proxy analyses can show the environmental and climatic changes in the area of Villánykövesd.

Results of the examinations prove that the investigated area was a refuge of the warmth-loving (thermophilous) mollusc species during the stadial periods of the Middle and Late Pleistocene. And owing to the high resolution investigations and the radiocarbon age data, the environmental and climatic changes between the stadial and interstadial periods can be well examined. An age-depth model was made of Villánykövesd section using the multi-proxy results combined some geostatistical methods, which can show the environmental and climatic changes of an about 100 kyr long term from the Middle Pleistocene to the Holocene.

Microfungi of the Tatry Mountains and surroundings (PL, SK) – 155 years of investigations

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The Tatry Mountains are the highest range within the Carpathians and the only to have the subnival vegetation zone. Its high geobotanical diversity arouses botanists' and mycologists' interest.

The first reports of microfungi originate from the mid-19th century. In 1859, F. Hazslinszky reported *Endococcus propinquus* on *Ophioparma ventosa* thalli (Lichens) from Slovakian Tatras. The first fungi in the Polish Tatras were also collected on lichens (Rehman, 1879). By 2014, mycological investigations on microfungi in Tatry Mts will have been carried out for 155 years.

After 100 years, the first summary was published (Starmachowa, 1963), and the list of 450 was reported. In the late 20th century, a list of fungi from the Slovakian Tatras (Bacigálová, 1999) and next a Polish report (Mułenko et al., 2004) were published consecutively. Both papers included ca. 650 microfungal species.

In 1998, Polish-Slovakian mycological research started aimed at detailed floristic and ecological investigations and summary of hitherto results, which has finished this year. The literature comprises over 350 publications, showing 1 635 microfungal species from the Tatry Mts and surroundings. The most numerous groups are Ascomycota (820 species), anamorphic fungi (388), and Basidiomycota (288).

The fungi were collected primarily on living organs of vascular plants and less frequently on mosses, algae, lichens, insects, litter, and soil.

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Migration of *Fagus sylvatica* in the West Carpathians based on percentage pollen distribution in the light of isopollen maps

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Isopollen are lines joining points of identical pollen percentages. The isopollen method was first proposed by Szafer (1935). The development of dating methods allowed Szafer's isopollen maps to be turned into a precise tool to study the vegetation dynamics and make syntheses of historical plant geography. A map is needed for each time interval presenting the pollen percentages for that dated period. The methods was taken up by several authors (e.g.: Huntley and Birks, 1983; Ralska-Jasiewiczowa et al., 2004). Now, the palynological knowledge was used to summarize the Holocene history of important trees in the Western Carpathians (Obidowicz et al., 2013).

Comparison among isopollen maps for *Fagus sylvatica* constructed on the Western Carpathians and Polish territory (till 1939 and after 1945) is an example of using this technique to reconstruct migration routes of plants in the past. Beech pollen appeared in the West Carpathians ca. 8500 years ago, its expansion is dated since 3500 to 3000 years ago, the maximal spread took place in the interval between 2000 and 500 years ago, and the regression has started after 500 years ago.

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Vascular anatomy of the flower of rare Eastern Carpathian endemic *Aconitum lasiocarpum* (Rchb.) Gáyer subsp. *lasiocarpum*

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Floral anatomy has been well studied for a lot of Ranunculaceae species, but there are no special investigations on the vascular anatomy in the genus *Aconitum*. Therefore I would like to present the results of such investigations for *A. lasiocarpum* subsp. *lasiocarpum* – a rare endemic of Eastern Carpathians.

Pedicel is innervated at the base by 4 collateral vascular bundles which produce 3 independent traces of a bract and two bracteoles. Farther the basic 4 bundles divide on 7–11. In the receptacle this bundles merge together and form inseparable vascular cylinder. This cylinder produces five tri-traced trilacunar vascular groups on the radiuses of sepals, and two unilacunar traces of nectaries. At the base of each nectary its trace divides into 3 bundles which go independently up to the nectariferous body where produce the web. In the same time the cylinder disintegrates and continued producing of numerous separated vascular traces of the stamens. Finally it forms 6 bundles, 3 of which become the dorsal carpelar ribs, and next 3 – split into the 6 ventral ribs of the carpels. In summary, the vascular system of the flower in *A. lasiocarpum* shows similar organization with other Ranunculaceae representatives (Worsdell, 1908; Tobe, 1980). But interesting is that the sepals have trilacunar 3-traced innervation similar to vegetative leaves (Novikoff, 2011) while the nectaries have unique innervation by single traces what confirms its petiolar origin [W2-organs by Jabbour and Renner (2012)]. These investigations confirm that nectary of *Consolida* arose as a result of fusion of two W2-organs because it is innervated by pair of vascular bundles which correspond to the traces of nectaries in *Aconitum* (Novikoff, unpublished).

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Palaeobotanical researches of the Late Glacial and Holocene in the Orawa-Nowy Targ Basin (south Poland)

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Palynological investigations have been carried out in the Orawa-Nowy Targ Basin – the subsidence depression between Tatra Mts. to the south and the Outher Carpathians to the north – since twenties of 20th century (e.g. Dyakowska, 1928; Koperowa, 1962). The exhausting information on palaeoecological investigations was summarized by Obidowicz (1989, 1992). He followed previous palaeobotanical studies on these peat bogs conducted mainly by W. Koperowa as well as several new ones.

The peat bog Puścizna Rękowiańska was selected as the reference site (project IGCP 188A) to Orawa-Nowy Targ Basin (Obidowicz, 1989, 1990). This research shows the development of plant cover in this area since 12 600 cal BP till recent times. Since the XXI century next palaeobotanical investigations have been started, as a part of multi-proxy analyses. The main goals of them are connected with the Holocene local changes, induced by anthropopressure (Kołaczek et al., 2012) or related to hydrological changes. Recently that question has been developed by K. Korzeń, PhD student (in prep.).

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The distribution of native hawthorn (*Crataegus*) species in the Polish Carpathians according to new and old taxonomy

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The genus *Crataegus* is a critical taxon. Since the mid-20th century the differentiation criteria and status of this particular species changed a few times. For a long time five species were distinguished, whereas Kobendza (1955) distinguished seven species: *C. oxyacantha, C. palmstruchii, C. ucrainica, C. monogyna, C. curvisepala, C. calycina* and *C. pentagyna*.

In the 1970s and 1980s hawthorn taxonomy was studied by Gostyńska-Jakuszewska (e.g., 1973). Apart from the above mentioned taxa she found two more (of hybrid origin): *C. ×macrocarpa* and *C. ×media*. Moreover, Zarzycki (1981) reported three more taxa from the Pieniny Mountains: *C. ×kyrtostyla, C. ×fallacina, C. dunensis* and *C. ×pseudo-oxyacantha*.

The overall hawthorn systematics of European hawthorns was created by Christensen (1992). In Poland there are six species, according to his approach.

In Polish floristic and phytosociological works mainly *C. monogyna* is reported, the other species only occasionally. In the atlas of the distribution of vascular plants in Poland (Zając and Zając, 2001), maps for only two species were included due to the difficulties in proper taxa identification.

Our studies in the Polish Carpathians confirmed the presence of all the hawthorn species distinguished by Christensen. *Crataegus rhipidophylla* is the most common species. *C. monogyna, C. ×subsphaericea* and *C. ×macrocarpa* have a similar number of localities, although they are not so abundant as *C. rhipidophylla.* The other taxa are rarer.

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Characterization of ultrastructure of the leaf surface *Luzula luzuloides* (Lam.) Dandy et Wilmott

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Luzula luzuloides (Lam.) Dandy & E.Willm. is native in Central Europe, introduced to North Europe, East Europe and North America. This species is common in Carpathians. There are two subspecies: *L. luzuloides* subsp. *luzuloides* (*L. albida* (Hoffm.) Bonnier & Layens) and *L. luzuloides* subsp. *rubella* (Hoppe ex Mert. & W.D.J.Koch) Holub. At the same time, researchers attach importance to features of the ultrastructure of leaf surface as a diagnostic criterion for distinguishing between taxons, identifying ecological characteristics of species.

For the first time the surface ultrastructure of the leaf of species of *L. luzuloides* in the flora of Ukrainian Carpathians was studied using scanning electron microscopy (SEM). Research was based on herbarium material collected during expeditions, samples from herbaria of the M.G. Kholodny Institute of Botany (KW) and Komarov Botanical Institute of the Russian Academy of Sciences (LE). Leaf ultrastructure was described using the terminology proposed by Barthlott et al. (1998), Chakrabarty and Mukherjee (1980), etc.

We have identified common features of leaf surface for the studied subspecies (types of leaves, stomata parasitic regularly located, well-developed cuticle, a common type of relief) and specific subspecies studied were found. Subspecies have similar type of leave surface wrinkled (on the costal zone) and ossiform-ridges (in between the costal zone). Subspecies differ in the types of wax: wax crusts (*L. luzuloides* subsp. *luzuloides*), granules (*L. luzuloides* subsp. *rubella*).

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Genetic diversity of the *Streptopus amplexifolius* (L.) DC. populations from the Polish Western Carpathians

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Streptopus amplexifolius is a mountain plant. In Poland it occurs mainly in the Carpathians and Sudetes and occasionally in lowland. We studied the allozyme variation of 12 populations and subpopulations from the Tatra Mts., Babia Góra Mt., Gorce Mts., Pilsko Mt., Barania Góra Mt. and Beskid Mały Mts.

Genetic variation of the examined populations was low, only 10 of 21 studied loci were polymorphic. Only 76 multilocus genotypes (MLGs) were detected among 124 studied plants, so the proportion of distinguishable genotypes (G/N) was 0.80 and ranged from 0.63 to 1.00. It is suggested that some of the examined plants are clones. Fifty-one MLGs (67%) were restricted to single plants.

The mean percentage of polymorphic loci (P) within populations was 57.14%. The highest percentage was in Barania Góra and Gorce populations (61.90%), while the lowest was in Tatra and Babia Góra populations (52.38%). The mean number of alleles per locus (A) per population was 1.61. The greatest number of alleles (35) were found in Barania Góra Mt. and the Gorce Mts., whereas the smallest (32) was detected in Babia Góra population. Observed heterozygosity ranged from 0.367 (Babia Góra Mt.) to 0.536 (the Gorce Mts.) with average Ho = 0.445. Genetic differentiation (FST), calculated over polymorphic loci among 12 studied populations was 0.314 and gene flow (Nm) between populations was low and amounted 0.547 individual per generation.

Analysis of molecular variance (AMOVA) showed that the genetic differentiation between *S. amplexifolius* populations (FPT) was 0.314 (P 0.01). Most of genetic variation (69%) resulted from variation within populations.

Nei's genetic distance between populations ranged from 0.0 to 0.078 (average DN = 0.023). Dendrogram, constructed by UPGMA method, showed that examined populations formed two subsets: first includes populations from the Tatra Mts. and Barania Góra Mt., second – populations from the Babia Góra Mt. and Beskid Mały Mts., and Pilsko and Gorce Mt.

Results indicate that there are no evident correlations between genetic structure and geographic distances of the examined populations.

Reconstruction of palaeo-environmental conditions of the locality Šúr during late-glacial and Holocene through the knowledge of recent vegetation

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Macrofossil analyses were carried out on the late-glacial and Holocene sediments of two cores at extinct lake Šúr, western Slovakia. The emphasis has been on development of the lake, aquatic vegetation changes and reconstruction of past environmental conditions. We used Ellenberg values and knowledge of the requirements of the current vegetation to estimate temporal changes in temperature, nutrients, pH, lake level, etc. During late-glacial the lake was colonized by *Myriophyllum spicatum, Potamogeton filiformis* and fish and at the beginning of early-Holocene also by *Zannichellia palustris, Najas marina* and *Ceratophyllum* sp. About 8900 cal. yr BP started the phase dominated by *Potamogeton* spp., *Myriophyllum spicatum* and *Trapa natans*. The lake was still lowering and ca. 5200 cal. yr BP was replaced by fen with shallow ponds with *Chara* sp., *Zannichellia palustris, Najas marina*, sedges and other herbs around. Formation of alder forest with occasional fire events and creation of temporary pools was next step in the succession. Presence of identified species indicates that water in the lake was slightly salty, calcareous and nutrient rich, which is primarily due to the bedrock from the marine sediment. Changes in the macrophyte flora and extinction of lake during middle Holocene was caused by several processes such as infilling, eutrophication and lake level fluctuations, which is seen elsewhere.

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Biomorphological features of *Lloydia serotina* – a bulbous plant with wide ecological and geographical amplitude

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Bulbous plants from the Carpathian high mountains are polycarpic grasses, geophytes (Prokopiv, 2010), and the study of vegetative sphere of *Lloydia serotina* (L.) Rchb. is interesting due to its exceptionally wide range and diverse growth conditions compared to all other bulbous plants of the family Liliaceae. At the natural localities, *L. serotina* develops relatively tightly thickened shoots with numerous remains of the last year's leaves located on a thin horizontal nonbranched rhizome with a terminal cone-shaped bulb. The tunicate bulb is made up of three closed scales: a sappy storing lower scale and thin axils of two ground leaves.

Life-span of the short shoot's leaves is 14–16 months from the initiation to the axils' drying, the one of the elongated flower-bearing part – 13–14 months. Monocarpic shoot functions for 26–28 months. However, after drying out of the shoot's above-ground parts, its basal part with root system stays alive for at least 2–3 years. Consequently, the small life cycle of the *L. serotina* shoot is no less than 4–5 years (Baranova, 1999). The above-ground vegetation lasts no more than two months and the main part of the shoot's life takes place inside the bulb.

The short part of the *L. serotina* shoot is represented by a three-metameric bulb, and the flower-bearing part is elongated and contains a few leaves. It indicates the monocarpic shoot to be semi-rosellate. Such a few-metameric shoot is featured in all organs to be initiated inside the bulb over a short vegetation period as well as in the formation of a short stolon-like shoot. Due to development acceleration caused by severe high-mountain conditions and shortened vegetation period, a rapid formation of the few-metameric shoots takes place together with rapid dying back of the above-ground parts. These structural features of the *L. serotina* shoot system may be considered to be evolutionary advanced.

The conclusion is that *L. serotina* is a polycarpic semi-rosellate grass with tunicate annual bulb on a plagiotropic sympodial nonbranched stolon-forming rhizome.

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The new steps in the description of the habitats (biotops) in the Ukrainian context

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The habitat concept of the nature conservation is a promising method in Ukraine. Currently, in Ukraine there are first steps in this direction, based on the Habitats Directive (1992) principles.

In the frame of the project entitled "Introduction of the European Standards and Methods for the Habitat Identification and Classification in Ukraine" (the pilot project in the Ukrainian Carpathians) appeared many important issues, there are theoretical grounds for the introduction and implementation of the habitat concept for biodiversity conservation in Ukraine, including specificity of the Ukrainian legislation and different traditions of the nature conservation in Ukraine and other parts of Europe; the methodic aspects of this work; the formation of the databases, etc.

One of the most important basic questions is a method of the description of the biotopes for subsequent classification of habitat types (biotopes). As one of members of the research team, I elaborated the method of the description. My part of this work was concerned with phytosociological characteristics of the habitats (biotopes), because plants communities and their characteristics are faces (physiognomies) of the habitats. We made several variants of the forms or blanks with account of different types of the basic vegetation in plots for work during nature investigation. There are five types of blanks: 1. Plots of rocky substrate (rock, stone deposits, placers, exits the parent rock); 2. Plots of water and coastal water area (open water; coastal areas overgrown coastal water plants); 3. Plots of wood and shrub groups (leaf pins (pine) and mixed forests, floodplain forests, plantations, areas with shrubs, planting shrubs on the slopes); 4. Plots of river valleys (areas that are regularly flooded by river water: floodplain areas covered with trees and shrubs, gallery forests along streams, willow thickets); 5. Plots of herbal groups (typical lowland meadows, alpine meadows, steppes, pastures, grassy areas ruderal; grassy marshes). The main idea of this Plots range is to cover the different faces of biotopes, not types of the vegetation, but using vegetation as a most recognizable part of the habitat (biotopes).

The results of this work will be presented as a "Catalogue of types of habitats Ukrainian Carpathians and Transcarpathian Lowland", which is under preparation.

Arbuscular mycorrhizal fungi at petroleum-impacted sites in the Polish Carpathians

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Petroleum exploitation in the Polish Carpathians started in 1852 and is declining presently. However, long-term operation and presence of wells, infrastructure and tanks led to development of heavily-polluted sites. In this work, arbuscular mycorrhizal fungi (AMF) in roots of plants colonizing such places were investigated. Rhizosphere samples were collected in the Beskid Niski Mts and in the Bieszczady Mts. Mycorrhizal fungal colonization and diversity were analysed using both microscopic and molecular methods. AMF were present in most samples, even at the highest petroleum levels. Members of different genera were identified. Their adaptation to extreme habitats and importance for vascular plants is discussed.

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Mollusc-based biogeographical data for refugee model of the Pannonian forest steppe

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This work presents details of a Mollusc-based paleoecological and Quaternary biogeographical study on the sedimentary sequence of brickyard profile at Cservenka (Vojvodina, Serbia) reserve situated in the southern parts of the Great Hungarian Plain in Central Europe. The principal aim was to test some biogeographical hypotheses on the Pannonian forest steppe origin based on malacological data. The first emergence of the Pannonian forest steppe, corresponding to the westernmost isolated part of the Eastern European forest-steppe belt, is generally dated to the opening of the Holocene (bw. ca. 10–8.5 kys cal BP); i.e. the Boreal in the literature. According to this concept, the emergence of an extremely dry climate during the referred period must have triggered the opening of the mixed taiga hosted by the area of the Great Hungarian Plains due to specific edaphic factors enhancing the invasion of heliophyl steppe and Pontic elements into the initial clearings and the retreat of pine to the higher, cooler areas and cold-spots of the basin.

This hypothesis considers the opening of a mixed taiga as the main trigger in the formation of a temperate forest steppe during the initial part of the Holocene. Our data suggest another origin and development of the Pannonian forest steppe vegetation in the Carpathian Basin. The presence of steppe/forest-steppe vegetation hosting the marker taxon *Granaria frumentum* could have been attested in the area of the Great Hungarian Plains and the marginal part of the Carpathians as early as 110–130 kys. An increase in dry grassland areas was accompanied by the spread of xerophylous, grassland mollusc taxa. It was this zone, where the representatives of the character species of modern Pannonian steppe/forest-steppe areas *Granaria frumentum* first turn up in the southern parts of the basin. Accordingly, the warmer periods of the terminal Pleistocene must have created ideal conditions for the spread of this type of mollusc fauna in the southern parts of the Carpathian Basin. On the basis of the paleodistribution of the mollusc species *Granaria frumentum*, the area of the Pannonian steppe/forest-steppe belt must have expanded as far north as the heart of the basin during the interstadials.

Investigation of interactions among the soil, its seed bank and vegetation in an Inner Carpathian site (presentation of preliminary results)

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Research of soil seed banks is an important field of ecology. However, many aspects of seed banks buried in soil are poorly sought. The soil, as a reservoir of propagules has many characteristics that can affect the formation of seed bank buried in it. For instance, certain physical features, like compacted microstructure or structure can influence their spatial pattern and vertical distribution, and the moisture of soil can determine the survival of seeds. Research of the latter is particularly important during the time of climate change.

For the purpose of revealing interactions between the soil seed bank and soil properties – especially moisture – we conduct pedological, seed bank and vegetation examinations at a slope of Tardona Hills in North Hungarian Mountains (NE Hungary) belonging to Inner Carpathians.

Surveys were performed in 30 study plots (size of 2x2 m) designated in three parallel transects in direction of the slope. The pedological studies were carried out in the summer of 2012. Sampling was made by Pürckhauer soil sampling auger and soil hand (shell) auger. Besides, defining genetic soil-type, a detailed morphological database was made and laboratory testing was carried out. In the fall of 2012, soil moisture was measured. The soil seed bank studies (taking soil seed samples, examining viability of seeds by germinating in greenhouse) and the vegetation monitoring (Braun-Blanquet) are in progress.

The pedological results show the soil classification of a catena on the slope. From bottom to top of the slope we found peaty meadow (Endogleyic Regosol) and colluvium (Colluvic Regosol) soil sequences (according to the Hungarian Genetic Soil Classification System and the World Reference Base for Soil Resources 2006). Moisture content of the soil varied from 37 to 66 m/m %, which is also shown by the change of vegetation. Results of these pedological background studies with the ongoing seed bank and vegetation investigation can serve as a basis for answering concerns about soil and seed bank interactions.

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The significance of the Carpathians for the genetic diversity of European subalpine tall-herb species

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Tall-herb communities constitute important elements of vegetation within the subalpine zone of the European mountain ranges. The flora of tall-herb communities consists of different geographical elements, e.g., the alpine-Central-European species, the arctic-alpine species, the Carpathian-Balkan species; therefore, there is a question about its origin in different parts of the mountains and potential migration routes during the Quaternary (Stachurska-Swakoń, 2009, 2011). In the framework of our project, several key tall-herb species were selected to examine their genetic structure and infer their distribution history: *Adenostyles alliariae, Cicerbita alpina, Ranunculus platanifolius* (Stachurska-Swakoń et al., 2011, 2012, 2013).

Genetic diversity and distribution of lineages within the contemporary populations unravel a general pattern pointing at existence of two main genetic clades within the European mountains. The main phylogeographical break runs across the Carpathians (between the Western and South-East Carpathians). Some differences in the otherwise weak phylogeographical structure of the examined species may reflect different biological traits of every studied species (e.g. pollination, seed dispersal and ecological requirements). The presented results underline the role of the Carpathians for shaping the diversity of the contemporary European mountain flora.

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Modeling the niche and distribution of rare and endangered plants in the Romanian Carpathians

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The Carpathians have been projected as a potential area for excessive species loss in the following century, as a result of the warming climate and human impact (Thuiller et al., 2005). A series of studies show that alpine and subalpine plant species ("High Mountain Taxa", HMT) are some of the most affected by climate change (Bellard et al., 2012). Therefore gathering knowledge and distribution data is of particular importance for these species.

In the spring of 2013 a postdoctoral project has been approved for financing by the Romanian Ministry of Education and Research, with the goal of creating a geo-referenced database with distribution data for selected rare and endangered HMT of the Romanian Carpathians. The presentation will be focused on the description of the objectives of this project, as well as a short summary of the work done in the first few months.

The project builds on the results of an FP6 project (IntraBioDiv, FP6-GOCE-CT-2003-505376), trying to improve the resolution of the distribution data for certain rare high mountain taxa (HMT) in the Romanian Carpathians, to model the niche and distribution of selected rare HMT, and also to model the distribution of richness patterns of HMT (rarity hotspots), and relate it to environmental variables, as well as current conservation areas, similar to the work of Parviainen et al. (2008) in Finland, and Dubuis et al. (2011) in the Swiss Alps.

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Identifying landscape factors influencing spatial genetic structure of a mountain plant – a comparative approach across four European mountain massifs

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It is commonly accepted that mountain landscape poses substantial difficulties for plant dispersal. Generally, harsh topography and inhospitable climate present a significant barrier for migration, establishment in new areas, and gene exchange between existing populations. On the other hand, restricted gene flow can lead to local adaptation or allopatric speciation events (Slatkin, 1987). Indeed, in the mountainous environment we often observe patterns of disjunctive species ranges or local endemism (Kruckeberg & Rabinowitz, 1985). Understanding how landscape structure affects gene flow, and factors influencing it, is thus one of the keys to understand mountain biodiversity. Despite this, empirical data on the relation between topography and genetic structure of mountain plants remain scarce.

The aim of the presented study is to assess the role of topographical factors in shaping the genetic structure of a mountain-boreal plant species – the European globeflower *Trollius europaeus* (Ranunculaceae). More specifically, we assess how the barriers for migration, such as mountains, valleys, and terrain ruggedness affect the genetic structure of the plant. For this, we analyse genetic distances, based on AFLP markers, among individuals collected in several European mountain areas. We then correlate these genetic distances among individuals with different spatial distance metrics, based on Euclidean distances and topography. By sampling seven different areas, located in four mountain massifs characterized by different altitudes and topography, i.e. the Carpathians, Sudetes, Alps, and Jura, we spatially replicate our study, control for the possible geographic variability in the studied system and test for existence of correlations repeatable across different areas.

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Floristic diversity of bryophyte-fern communities of shady acid and neutral rocks of the Beskid Sądecki, Beskid Wyspowy and their foothills (the West Carpathians, Poland)

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Either rocks or rock plant communities are not very common in the Polish Carpathians. Large outcrops occur only occasionally and most often they are hidden in the surrounding forest. These rocks are usually engulfed by the forest and covered with the plants from the forest phytocoenoses. In recent years, rock plant communities were examined more thoroughly and some new entities were identified. Neither their distribution, nor variability, nor dependence from specific kinds of rocks have been sufficiently explored. This is particularly the problem of the plant communities of the Carpathian flysch sandstones for which almost no data is available. The newly described rock phytocoenoses usually are located on Carpathian limestone rocks or in Sudetes where geological structure is completely different.

Exploration of the areas of Beskid Sądecki, Beskid Wyspowy and their foothills revealed the most significant outcrops with their plant communities. We performed evaluation of floristic composition and plant diversity of these communities. Among bryophyte-fern communities of shady Carpathian flysch sandstone rocks, rare communities with *Androsacetalia vandellii* could be found. Each time when the species composition indicated such community, we took a phytosociological record to confirm the assumption. In the data analysis we focused on identification of rare, valuable or protected plant communities. Development of the data obtained during the field investigation included analyses of the habitat groups of vascular plants growing on the rocks and assignment of the phytosociological records to the proper phytosociological communities.

Based on the field observations, it was possible to characterize the habitat of rock plant communities of Beskid Sądecki, Beskid Wyspowy and their foothills and to show the diversity and poor species composition of the rock vascular flora of these communities in comparison with the plant communities of the Sudetes or Tatra Mountains. They belong to the bryophyte-fern communities of shady acid and neutral rocks. Most of them occupy small areas on large rock walls with a shallow layer of initial soil. Species of mosses and lichens form an important part of these communities. They are different depending on the age of the exposed rocks, shading by the surrounding forest and the type of sandstone rock. Many of the communities described above are located in nature reserves, the Natura 2000 areas or are preserved as nature monuments.

Species richness of lichens in relation to land use intensity – the Polish Tatra Mts case study

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Six different land-use types were investigated concerning lichen diversity in the Polish Tatra Mts to collect data for the EU LACOPE (Landscape Development, Biodiversity and Co-operative Livestock Systems in Europe) project. These were: (i) previously pastured, now abandoned land; present (ii) extensive and (iii) intensive pastures; (iv) mown grasslands; (v) conservation-relevant habitats (mostly wet open ones, as fens and bogs); (vi) forest. The research focused on 30 sampling plots selected according to floristic and land management data. Biodiversity assessment tools were applied (according to the instructions and protocols elaborated by C. Scheidegger, C. Keller and S. Stofer – Swiss Federal Institute for Forest, Snow and Lanscape Research – WSL) and soil, rock and tree relevés were done on 12 collecting sites at each plot to estimate lichen species diversity and frequency.

The preliminary results of the study indicate that the various modes of land use have resulted in diverse lichen biota both in terms of species richness and composition. In previously pastured and now abandoned land 133 species were recorded, in present extensive pastures – 124 species, in present intensive pastures – 163 species, in mown grasslands – 113 species, in conservation-relevant habitats (as described above) – 44 species, and in forest – 82 species. The data obtained will be statistically analyzed. The investigations have supplied also important information of local and regional meaning. In total, there were 301 lichen taxa recorded on the investigated Tatra plots. Forty six species were reported for the first time from the area (including 12 sterile crustose lichens, 11 pyrenocarpous lichens and 23 other lichen species or allied fungi), three from the Polish Carpathians (*Candelariella efflorescens*, *Pertusaria pulillaris* and *Thelidium athellinum*) and one from Poland (*Calicium pinastri*). The new records contribute to distribution patterns of individual lichen species in Central Europe.

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Exploring patterns of variation within *Tephroseris longifolia* agg. (Asteraceae)

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Tephroseris longifolia agg. is an intricate complex of perennial outcrossing herbs distributed in the Eastern and Central Alps reaching also Apennines, Pannonia and Western Carpathians. Recently, five subspecies with rather separate distribution and different geographic pattern are distinguished within the aggregate. While *T. longifolia* ssp. *brachychaeta* (TLB) and ssp. *moravica* (TLM) are endemic taxa with narrow ranges, *T. longifolia* ssp. *gaudinii* (TLG), ssp. *pseudocrispa* (TLP) and ssp. *longifolia* (TLL) are more widely distributed. The only Carpathian taxon TLM is known just from nine localities in Slovak and Czech Republic and it is treated as endangered taxon of European importance (NATURA 2000).

As the taxonomy of the aggregate was not comprehensively elaborated so far, in our study we aim to detect genuine variability and evolutionary relationships within the *Tephroseris longifolia* agg. using methods of plant systematics (multivariate morphometrics of 509 individuals/32 populations, flow cytometry of 96 individuals/33 populations, pollination experiments). This represents the first step to identify factors underlying the rarity of endemic taxa and to explain importance of geographically and ecologically marginal populations in the evolution of (neo)endemics.

The DNA content at the homoploid level (2n=6x=48) determined by DAPI flow cytometry varied by 23.9% and significant taxa-specific differences in DNA content may be used as a supportive taxonomic marker for distinguishing four groups: TLB, TLP, TLG and TLL+TLM. In accordance, morphometric study indicated five morphotypes roughly corresponding to previously distinguished subspecies. Detected differentiation fits classification at species level for TLB, while differences among other taxa respond to subspecific level. Suprisingly, Pannonian populations of TLL are morphologically closer to populations of Carpathian endemic TLM than to Alpine populations of TLL. Based on this, the taxonomic position of Pannonian populations and subsequently endemic status of TLM require further study. Experimental hybridizations showed that all taxa hybridize easily and produce viable progeny, what suggests that divergences among taxa are maintained mainly by geographical isolation.

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The Carpathians – a contact zone of different genetic lineages of *Melampyrum nemorosum* group

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Melampyrum nemorosum group is the most critical group in the genus *Melampyrum* (Orobanchaceae). Fifteen species with many intraspecific taxa have been distinguished in Europe. Whereas the highest species diversity is found in the Balkan Peninsula, a taxonomic complexity of group is thought to be reduced in the Central and Eastern Europe. However, our ongoing study of the group using modern biosystematic tools detected complex pattern of genetic diversity along the Carpathians. Several slightly morphologically differentiated lineages differ in genome size, in cpDNA haplotypes alike as in nuclear markers. An ancient hybridization of particular lineages on contact zones is supposed to be one of the reasons of difficult morphological identification and taxonomic evaluation of these lineages. A recent geographic distribution of particular genetic lineages reflects Holocene history and vegetation changes in the Carpathians. Therefore this region seems to be a key to an understanding of taxonomy and phylogeography of *Melampyrum nemorosum* group in the Central and Eastern Europe.

Primula leucophylla in South-Eastern Carpathians: a genetic and morphometric study within *Primula elatior* group

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Within the Carpathians, *Primula elatior* (L.) Hill exhibits a great deal of polymorphic varieties, some of them considered as subspecies, differentiated from each other based on leaf shape and development of indumentum. The variety with the best developed indumentum, grey-white tomentose beneath, is recognized as the South-Eastern Carpathians endemic *Primula leucophylla* Pax. (*P. elatior* subsp. *leucophylla* (Pax) Hesl.- Harr. f. ex W. W. Sm. & H. R. Fletcher). Its separation from *P. elatior* s. str. is sometimes difficult because of the continuous range of varieties between them, thus, its field identification and precise distribution are still uncertain.

This study based on genetic markers as well as on morphometry aims to cast a new light on the distribution, determination, and separation of *P. leucophylla* in contrast to *P. elatior* s. str.

The genetic tools used are Amplified Fragment Length Polymorphism (AFLP) and sequencing of chloroplastic regions such as *trnH-psbA, psbD-trnT* and *rpL16*. The morphometry refers to Principal Component Analysis (PCA), Nonmetric Multidimensional Scaling (NMDS) (using the Jaccard similarity index) and a K-means clustering method, all based on the thirteen most relevant morphological traits.

The results suggest that most of the populations a priori classified as *P. leucophylla* do not differentiate clearly from *P. elatior*, except for the populations originating from few Eastern Carpathian massifs (Ceahlău, Rarău and Giurgeu-Hăşmaş), which show a steady grouping and which can be considered the real core *Primula leucophylla*.

Endemism in the Ukrainian Carpathians

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Critical revision of the species composition based on polytypic species standard, application of unified taxonomy adopted in Flora Europaea as well as incorporation of data on recent floristic findings make it possible to suggest that natural vascular flora of the Ukrainian Carpathians comprises 2,020 species and subspecies. For comparison the entire flora of the Eastern Carpathians is composed of 2,790 species and subspecies.

Summing up all the previous data, including recent taxonomic treatments of certain groups aver that Ukrainian Carpathians' flora includes 120 endemic taxa of species and subspecies rank. Only a fraction – 16 taxa – are strict Ukrainian Carpathians' endemics, the status of many of them needs further clarification. Only two diploid species among them, described from the limestone outcrops – *Galium pawlowskii* Kucowa (Chywchyny Mts.) and *G. transcarpaticum* Stojko et Tasen. (Uholka in Polonyny ridge) – are considered as palaeoendemics. To this group of East-Carpathian endemics belong another 22 taxa, occurring also in the Romanian part of the East Carpathians. Among them *Armeria pocutica* had disappeared from its *locus classicus* in the Ukrainian part and *Saussurea porcii* – from its sites in the Romanian part of the East Carpathians.

The second largest group of East-South-Carpathian endemics, reflecting close florogenetic relationship between the East and South Carpathians, consists of 27 taxa. The group of West-East-South-Carpathian endemics, traditionally called pan-Carpathian endemics, comprises 22 taxa.

The group of West-East-Carpathian endemics, which until recently were not distinguished in the analysis of Carpathian endemism, proved rather numerous – 18 species and subspecies, although composed of mainly representatives of *Alchemilla* and *Hieracium* genera. Other endemic taxa belong to East-South-Carpathian-Apuşeni group (9 taxa), West- East-South-Carpathian-Apuşeni group (6 taxa).

The endemics' distribution among different parts is uneven in the Ukrainian Carpathians. They are mostly concentrated in the south-eastern part of mountains – the Svydovets, Chornohora, Marmarosh and Chyvchyny massifs with their developed subalpine and alpine belts to which endemics are mainly confined. On the west direction, to the border between the West and East Carpathians, the number of endemic species in the floras of separate massifs decreases.

Although the study of flora of the Ukrainian Carpathians, started by Baltazar Hacquet at the end of 1790th, was continued for over two centuries, it still remains the least studied, compared with other parts of the Carpathians. A number of taxonomic, phytogeographical, ecological and florogenetic problems remain to be solved.

Ptychoptera albimana Fabricius, 1787 (Diptera, Ptychopteridae), a complex with important lineage divergencies in the Carpathian Area

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The present biodiversity crisis gives new perspectives in biodiversity conservation and management. However a number of organisms are consequently neglected, due to their taxonomic impediment. Dipterans are organisms with a rather neglected taxonomy, but with a high potential in evolutionary ecology studies. *Ptychoptera albimana* is a widespread European aquatic dipteran which was considered monotypic in its range due to its conspicuous wing pattern and body design. However our recent morphometry investigations using linear and geometric morphometry on wing and male genital structures revealed highly divergent pattern between western and eastern population in contact in the Carpathian Basin Area and make questionable the taxon status of the species. The morphological differences on the male terminalia between the two allopatric structures are important which reflect long term isolation and most probably surviving Pleistocene glaciations in at least two distant refugia. The western morphotype were identified among populations from Luxembourg, Germany and Hungary and most probably represents a postglacial expansion from one or more western Mediterranean refugia. The eastern morphotype identified among populations from Romania and Bulgaria is conspicuously different in a series of details on wing ratio and genital structures from the previous form and the Carpathian-Balkan region is the most likely refugia and postglacial expansion centre for this lineage. Further phylogeography studies can reveal the population history of these two divergent structures identified in the case of *P. albimana* and the taxonomic importance of these evidences can be tested using an integrative approach.

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Morphological and molecular evaluation of native Scots pine (*Pinus sylvestris* L.) populations from South-Eastern Europe

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Native Scots pine (*Pinus sylvestris* L.) populations are scattered along the whole Carpathians mountain range and occur mainly in extreme environmental conditions as raised bogs or dry rocky outcrops. These stands are considered to be relict occurrences of Scots pine. Former studies already revealed that as being isolated these populations carry specific morphometric and genetic marks. The aim of our study was to find relations between the different morphological types, and to compare them with their genetic background. Populations from Tatra Mountains (4), Eastern Carpathians (3) were compared with Hungarian (2) and one Bulgarian population from the Rila Mountains. Cone traits of 13 sampled sites were analyzed, and four chloroplast microsatellite markers (cpSSR) were analysed. More than 325 cone samples were collected and 250 individuals were selected for the genetic comparison. The morphometric dataset was analyzed by correlation and discriminant analysis and a cluster analysis was also performed to evaluate cone traits. We found statistical differences in case of all morphological variables and by analyzing cpDNA fragment length we have found divergence between population genetic variability of different proveniences and habitat type. Generally low variation was found on samples inhabiting dry habitats. The high morphologic diversity and the high intra-population genetic variability of populations makes them valuable for further phylogenetic studies by involving new markers.

Population diversity of rare plant species at the Ukrainian Carpathians: distribution, structure, threats

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Ukrainian Carpathians (UC) are situated in the central part of the Carpathian mountain arc. According to our investigations, 408 species and subspecies of endangered rare, endemic, relict and edge-areal vascular plants were detected. They represent 200 genera of 62 families including 214 taxa listed in the Ukrainian Red Data book (2009). In 70-s the study of plant coenopopulations in UC phytocoenosyses begun under prof. K. Malinovsky supervision and since 90-s the peculiarities of plant population organization and functioning of rare, endemic, relict species have been investigated.

Low density and number, considerable spatial limits, incomplete age spectra, vegetative recruitment, group distribution of individuals and available fragments, appeared due to the area division under natural and anthropogenic causes, are the specific characters of rare species populations (some species of *Carex* L. and *Galium* L.). Primary and secondary types of population strategies determined. Transition to the secondary strategy is the way to survive in changing environmental conditions. Analysing population viability, inter- and within-population variability of endangered species we found out the indicative traits of population condition, as follows: individual life-history variability, type of recruitment, age and spatial pattern, density fluctuation or succession, division into fragments (*Pulmonaria filarszkiana* Jáv., etc.).

First, the human-induced factors (e.g., irregular recreation) and demutation processes, if the traditional land management at the high-mountain zone of UC changed, threatened significantly rare plant populations. Under the stress conditions, as a result of periodical collecting medicinal plants, populations of the most productive capacity and individuals of high viability lost the recruitment ability and extinct (*Rhodiola rosea* L.). Second, number of relict species populations gradually reduces because of natural extinction.

Populations of nearly 200 species are going to lose their viability and number of habitats occupied, particularly small populations (*Leontopodium alpinum* Cass., *Primula halleri* J. F. Gmel., *Ranunculus tatrae* Borb., *Saussurea alpina* (L.) DC.) Recommendations to preserve and renew a viability of depressive plant populations at high-mountain zone of UC are elaborated, especially for the populations of endangered and protected species of tall-grass and shrub communities of subalpine zone, rare small plant populations of alpine zone at the steep slope rocky habitats.

New consideration regarding the endemic *Centaurea ratezatensis* Prod. from Romanian Carpathians

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Centaurea ratezatensis Prod. [*C. phrygia* subsp. *ratezatensis* Prod. (Dostál)] is an enigmatic taxon from the Retezat Mountains, Romania. *Centaurea ratezatensis* is part of *Centaurea* subgenus and belong to *Lepteranthus* group. This group is known for easy hybridization giving rise to a huge polymorphism of individuals. In Romania, *C. ratezatensis* Prod. is treated as subspecies of *Centaurea phrygia* L., *Centaurea pseudophrygia* C. A. May or *Centaurea stenolepis* A. Kern. In the present study, was made morphological and cytogenetical observations on dried samples of Natural History Museum Herbarium from Sibiu (SIB), Botanical Garden Herbarium from Cluj-Napoca (CL) and field-collected samples from the native areas. The final matrix includes 26 morphological characters (17 quantitative characters, 3 qualitative characters and 6 ratios) that were measured on 232 individual plants of 6 taxa (*C. erdneri* J.Wagner, *C. phrygia* L., *C. indurata* Janka, *C. pseudophrygia* C. A. May, *C. stenolepis* A. Kern. and *C. ratezatensis* Prod.). The data were analyzed with multivariate ordination (CCA) and classification methods (K-means clustering). Multivariate morphometric analysis revealed close similarity of *C. ratezatensis* and *C. stenolepis*. Both taxa have the same ploidy level, diploid (2n=22), as revealed using flow cytometry. However, they are differentiated by several morphological characters (visibility of middle bracts appendages, width of leaves, number of fimbriae, and length of a steam between the last lowest brunch and the terminal capitulum). Discriminant analysis for *C. ratezatensis* Prod. and *C. stenolepis* A. Kern. shows that the taxa were correctly classified by 87.6%, but there is a partial overlap in the canonical score histogram.

In conclusion, *C. ratezatensis* Prod. is very similar to *C. stenolepis* A. Kern. and can be included into this taxon or treated as a variety of *C. stenolepis*.

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Bátorliget old and new paleoecological results and Late Quaternary biogeographical development of the Great Hungarian Plain

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In 1994 a comprehensive paleoecological research had started with the leadership of Prof. Kathy Willis, in Bátorliget, NE Hungary. This research produced astonishing results on the evolution of late Pleistocene flora and fauna in the Carpathian Basin. The examinations were continued working up new sections during 1998 and 2004.

This work presents details of a multidisciplinary paleoecological and geoarcheological study on the sedimentary sequences, including 11 core and open profiles, of the Bátorliget marshy natural reserve situated in the northeastern parts of the Great Hungarian Plain in Central Europe. The principal aim was on one hand to shed light onto how the former human societies and cultures shaped and altered their natural environment. Furthermore, to make a reconstruction of the one-time existing environmental conditions within the framework of the natural evolution of the vegetation, soil, fauna and the catchment basin for the times preceding the emergence of productive economy via the application of sedimentological, geochemical, isotope geochemical, palynological, seed, macrocharcoal, vertebrate, malacological analytical methods and approaches.

Occurrence of *Heracleum sosnowskyi* in plant communities of the Strzyżowskie Foothills

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Dispersal and introduction of alien plant species outside their natural occurrence range is difficult to predict. Some invasive species settle down and spread intensively, which strongly affects the local ecosystem. Currently, invasions of alien species, which pose a threat to biodiversity, are one of the major problems in nature protection. In Poland, over 300 alien species (kenophytes) have been reported, including ca. 30–40 species that are invasive plants spreading in natural and semi-natural plant communities. They are referred to as "transformers", i.e. species capable of transforming plant communities and forming new vegetation systems in which they dominate and hamper the development of native plant species. The most expansive species include *Impatiens glandulifera, Impatiens parviflora, Reynoutria japonica, Solidago gigantea, Solidago virgaurea, Robinia pseudoacacia, Padus serotina, Quercus rubra, Heracleum mantegazzianum*, and *Heracleum sosnowskyi.*

Heracleum sosnowskyi reaches a height of 2–5 m and its leaf rosette can be 3 m long. It is a biennial or perennial plant; it flowers in June and July and dies after seed production. It produces numerous compound umbel inflorescences. The plant produces up to 20 thousand seeds, which fall within the radius of 4 meters away from the parent plant. They are carried at longer distances by watercourses, particularly during high water and flooding periods.

Heracleum sosnowskyi spreads across the country, often in the vicinity of State Agricultural Farm, where it was cultivated. The greatest number of it localities have been reported from the southern part of the country, where it occurs abundantly in river valleys. Since there are no detailed reports, it is difficult to estimate the exact number of the localities and occurrence range of the species.

In the Strzyżowskie Foothills, *Heracleum sosnowskyi* has been observed in the Wielopolka River valley for many years. The species is most abundant in the upper river course in Nawsie and Wielopole Skrzyńskie, wherefrom it spreads along the river valley northwards, thus extending its range. The species inhabits diverse habitats, e.g. meadows, grasslands, field shrubs, crop fields, forest edges and roadsides. However, it is the most abundant on fallows and agricultural wasteland, where it is a dominant species.

The aim of the study was to determine the occurrence range of *Heracleum sosnowskyi* in the plant communities of the Strzyżowskie Foothills as well as the species composition and the structure of communities invaded by the species.

Characterization of ultrastructure of the leaf surface in species of the genus *Sedum* of the flora of Ukrainian Carpathians and Crimean mountains

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Genus *Sedum* L.(Crassulaceae) is critical and difficult in a systematic relation. One problem of identification species of this genus is a striking uniformity of their morphologic features (Goncharova, 2006). At the same time, researchers attach importance to features of the ultrastructure of leaf surface as a diagnostic criterion for distinguishing between taxons, identifying ecological characteristics of species, etc. (Juniper, 1959).

First time the surface ultrastructure of the leaf of species of genus *Sedum* in the flora of the Ukrainian Carpathians was studied using scanning electron microscopy (SEM). Research was based on herbarium material collected during expeditions, samples from herbaria of the M.G. Kholodny Institute of Botany (KW) and Taras Shevchenko National University of Kyiv (KWU). Leaf ultrastructure was described using the terminology proposed by Barthlott et al. (1998) and Goncharova (2006).

The common characters of the leaf surface of the studied species (amphistomatic type of leaves; regularly spaced unimmersed anizocytic stomata; well developed cuticle; general type of surface structure) and specific ones for studied species have been revealed. Species differ in (i) types of wax: wax crusts (*S. aethense, S. atratum, S. pallidum*), plates (*S. antiquum, S. hispanicum*), granules (*S. hispanicum, S. anuum, S. pallidum*), and in (ii) surface relief: rugose (wrinkled irregular elevations running in one direction; *S. aethense, S. antiquum, S. anuum*), ossiform-ridges (ridges with ends flaring like bones; *S. atratum*), reticulate-ossiform-ridges (*S. hispanicum, S. pallidum*).

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Distribution of *Agrimonia pilosa* in Polish Carpathians – state of knowledge

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Agrimonia pilosa Ledeb. (Rosaceae) is an Eurasian species that reaches its south-western border of range in the Carpathians. The first records from the Carpathians back to the nineteenth century, when the species was noted in the Eastern Carpathians, in the area of today's Ukraine (e.g. publications of different authors in *Sprawozdanie Komisji Fizjograficznej*, supported by herbarium specimens). The second half of the twentieth century brought new data for the Carpathians, when localities from Ukraine, Slovakia and Romania were published.

Agrimonia pilosa was recorded in the Polish Carpathians for the first time in 1994 in Bieszczady Mts (Eastern Carpathians) (leg. Wojciech Paul; Zemanek and Winnicki, 1999; Zarzyka-Ryszka et al., 2008) and in 1998 in the Beskid Niski Mts (Western Carpathians) (Zarzyka, 2001; Zarzyka-Ryszka, 2005). The following years brought information about new localities, both in the Bieszczady and Beskid Niski Mts, however most of them were obtained after 2005, when there was an increase in research in this area (Zarzyka-Ryszka et al., 2008).

This contribution summarizes 15 years of research on the distribution of *A. pilosa* in the Polish Carpathians (e.g. in valleys of Wisłoka river and its tributaries: Zawoja and Wilsznia, in Jasiołka river basin, in Wisłok river valley, and adjacent ranges in the Beskid Mts, as well as in Bieszczady Niskie and Bieszczady Wysokie Mts). Map of the current distribution on the basis of own records and data from the literature and herbaria is presented. Status of the species in the Carpathians, historical and contemporary factors influencing its occurrence and dispersal, and the possible migration routes in the Carpathians are also discussed.

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Arbuscular mycorrhizal fungi (Glomeromycota) species diversity in the Tatra Mountains

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Arbuscular mycorrhizal fungi (AMF; Glomeromycota) associated with selected rare and endemic plant species collected from 22 locations in the Polish Tatra Mts. (Western Carpathians) were studied. AMF spores were isolated either directly from soils or using the trap culture method (Błaszkowski 2012).

Twenty-nine AMF species were identified. This was the first record of AMF in the Tatra Mts. Spores of *Claroideoglomus claroideum* and *Septoglomus constrictum* were most frequently isolated, being found in 10 and 18 locations, respectively. In contrast, *Acaulospora alpina, Ac. mellea, Ac. scrobiculata, Ac. thomii, Diversispora trimulares, Glomus aggregatum, Gl. microcarpum* and *Pacispora robigina* were detected in single locations. Four species, namely *Ac. alpina, Ac. cavernata, Ac. excavata* and *Ac. scrobiculata*, were found only on non-calcareous bedrock (High Tatra Mts.), whereas 19 AMF species, e.g. *Ac. bireticulata, C. claroideum, Rhizophagus fasciculatus*, were isolated from calcareous bedrock (Western Tatra Mts.) (Zubek et al., 2008, 2009a,b). For *Ac. alpina* this is the second location in the world after the Alps (Oehl et al., 2006).

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Liverworts in a transformed montane environment (Beskid Wyspowy Range, Polish Western Carpathian Mts): factors shaping species diversity patterns.

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Results of research into the flora of liverworts in the central part of the Beskid Wyspowy Range (Polish Western Carpathian Mts) are presented. Over 3 000 floristic-ecological records were analyzed. Data were collected with the cartogram method (a grid of 195 squares, 1 x 1 km). The following parameters were identified for each research plot: (i) type of anthropogenic management (build-up site, arable field, meadow); (ii) forestation rate; (iii) occurrence and abundance of water courses. A three-degree scale of intensity/abundance was applied (1 – low, 2 – average, 3 – high). Basic diversity measures were used to describe the flora of liverworts: the number of species (n) and their localities (N), Shannon index (H), Simpson index (D) and Margalef index (dM). Species diversity was superimposed on the transformation rate within the squares (alpha diversity) and within three local montane groups (beta diversity) to investigate the local pattern of distribution and richness of the hepaticoflora.

While the occurrence frequency of taxa is not included in the Shannon index ($0.0 \leq H \leq 1.5$) or the Simpson index ($0.0 \leq D \leq 1.0$), they can be used to identify cartograms with a high total number of species. The value of both indices is zero for 1/4 cartograms. The mean values of H (0.6–0.8) were recorded for slightly over 36% of the plots and the highest ($H \geq 1.4$) were detected for 5% of all cartograms. The mean value of Simpson index (0.6–0.8) was observed for almost 20% of squares and its maximum value was recorded only for 4.5% of research plots. Margalef index of species richness ($0.0 \leq dM \leq 6.4$) describes both the species composition and the number of localities. The index was zero for individual occurrences of a taxon in a cartogram (ca 15% of all squares) even if a species was recorded a few times. The highest value of the index ($d \geq 4.5$) was recorded for 6.5% cartograms.

The spatial image of the local biodiversity seems to narrow down its general distribution when compared to the traditional approach. However, the richness of the hepaticoflora can be estimated more accurately based on these findings and its actual level, changeability and direction of the changes in man-transformed sites can be established.

Environmental history of the extinct lake Šúr (Western Carpathians, Slovakia) during the Late-glacial and Holocene: a multi-proxi approach

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Our project is aimed at paleoenvironmental reconstructions of local vegetation and landscape character of the Nature Reserve Šúr (Western Carpathians, Slovakia) during the Holocene and Late-glacial. Development and origin of the lake and changes of vegetation and landscape in the spatiotemporal context are reconstructed by using a multi-proxy approach: pollen, macrofossil, diatom analysis. These data are supported by radiocarbon dating, detailed sediment stratigraphy and micromorphology of samples taken from three cores in this area. The sedimentary record of the lake Šúr was chosen due to its exceptional position within the area of contact zones between the Pannonian basin and Western Carpathians. We test the hypothesis whether this type of reconstructed environment is able to reflect climatic changes during the Pleistocene/Holocene transition. Our aim is also to detect refugia of temperate trees in Late-glacial and to trace pollen indicators of agriculture in the middle Holocene. First results show the unique ecosystem of the Šúr Lake during the first half of the Holocene. Macrofossil record gives detailed evidence of shallow brackish lake with macroremains of aquatic plants *Zannichellia palustris* and *Chara* and littoral and swampy species *Typha* and *Cyperus fuscus*. The pollen record reflects trees refugia very close to this area. A pine forest was frequently admixed with broad-leaved trees (such as *Quercus, Ulmus, Tilia* and *Corylus*) during the Late-glacial.

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Index of Authors

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