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MONITORING OF CLIMATIC CHANGE IMPACTS ON ALPINE VEGETATION IN THE TATRY MTS – FIRST APPROACH

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Abstract

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Our contribution brings together the most relevant results of the research, which was a part of the all-European project GLORIA (The European dimension of the Global Observation Research Initiative in Alpine Environments). The fieldwork, data input and evaluation of data took 3 years (2001-2003). The establishing of the monitoring plots was the main aim of this project (reinvestigation intervals of 5 to 10 years, or even longer). The alpine belt of the Vysoké Tatry Mts and Liptovské kopy Mts was the objective area of our research. Here were recorded 67 species of vascular plants, 30 species of bryophytes and 27 species of lichens. For determination of the samples distribution along ecological gradients the DCA and PCA analysis were used.

Key words: monitoring, alpine vegetation, Tatry Mts, climatic change, GLORIA

Introduction

The purpose of research initiative GLORIA (Global Observation Research Initiative in Alpine Environments) is to establish a long-term observation network for the comparative study of climate change impacts on mountain biota (Grabherr et al., 2000). A crucial precondition to keep such a large-scale network effective in terms of comparability is a standardized sampling design such as Gloria's Multi-Summit approach. The main objectives of Gloria Multi-Summit approach are (Pauli et al., 2001):

1. To quantify the changes of vascular plant biodiversity patterns along the altitudinal gradient and their relation to environmental gradients.
2. To assess the potential risks for biodiversity losses due to climate change by comparing the current distribution patterns of species, vegetation, and environmental factors along vertical and horizontal gradients.

3. To quantify the changes of biodiversity patterns in the temporal dimension by using monitoring data from Multi-Summit sites.
4. To provide a risk assessment by comparing the monitoring data.

Material and methods

Two groups of methods were used for our research purpose (see more detailed classification in Pauli et al., 2001). In the first group there are the criteria for summit selection (hierarchy of site along the altitudinal gradient, human disturbance pressure, geomorphologic shape and bedrock of the summit area); sampling design represents the second one. The multi-summit sampling design for each summit consists of two different plot types (Fig. 1):

1. 1x1 m permanent quadrats.
2. Summit area sections (5 m and 10 m summit area).

In each of the 16 1x1 m quadrats, distributed in four 3x3 m clusters, the top cover of surface types and species cover of each vascular plant were sampled. The frequency counts were made for particular species by using a gridframe with 100 cells (10x10 cm) In addition; impacts caused by grazing mammals were recorded. Sampling in the summit area sections was made by 3 different ways:

1. Visual estimation of vegetation top cover – total vegetation cover as well as total vascular plant cover.
2. Step-pointing with 200-recorded step-points per section.
3. Abundance estimation with quantitative abundance classes (d – dominant: very abundant, the cover of species must be more than 50%; c – common: occurring frequently and widespread within the section, the cover is always less than 50%; c – scattered: widespread within the section, species cannot be overlooked, but the presence is not obvious at first glance; r – rare: some individuals at several locations; r! – very rare: one or few individuals; l – locally: at one or a few locations within the section.

Temperature was measured by using miniature data loggers buried in the substrate (10 cm below substrate). For the accurate reassignment of the plots and for documenting the whole visual situation of the quadrate the comprehensive photo documentation was used.

The complete data input was made by GDIT – Gloria Data Input Tool (Gottfried, 2001, 2002), which was written under Microsoft ACCESS using Visual Basic for Applications. Similar tool was written for recording of photo documentation GPDT – Gloria Photo Documentation Tool (Gottfried, 2003).

The species names are in compliance with Marhold, Hindák (1998) checklist, names of syntaxons with list of the Slovak vegetation units Mucina, Maglocký (1985). The software JUICE 6.2 (Tichý, 2004) was used for tabular synthesis and for the calculation of fidelity. Fidelity is the concentration of species occurrence in vegetation units. In fidelity calculations, we count each relevé in which the species is present as an occurrence of the species, disregarding any information about its abundance or density. For DCA and PCA analysis CANOCO 3.0 (ter Braak, 1988) was used. DCA and PCA belong both to the indirect ordination methods, i.e. ordination is calculated from the species data only. It shows the major patterns in the species data, irrespective of any environment data. Environment data, if available, are subsequently used to interpret the ordination and the ordination axes are theoretical gradients that best explain the species data. DCA (detrended correspondence analysis) represent unimodal and PCA (principal components analysis) linear unconstrained ordination methods.

Results and discussion

Complying with Gloria methodology four summits were chosen

1. Summit – Krížna peak (1918.6 m a.s.l.) is situated in Liptovské kopy Mts (eastern part of the Západné Tatry Mts). It is occurred on the westward crest, about 900 m from main Krížna peak (2038 m a.s.l.). This summit represents higher subalpine level. The summit is

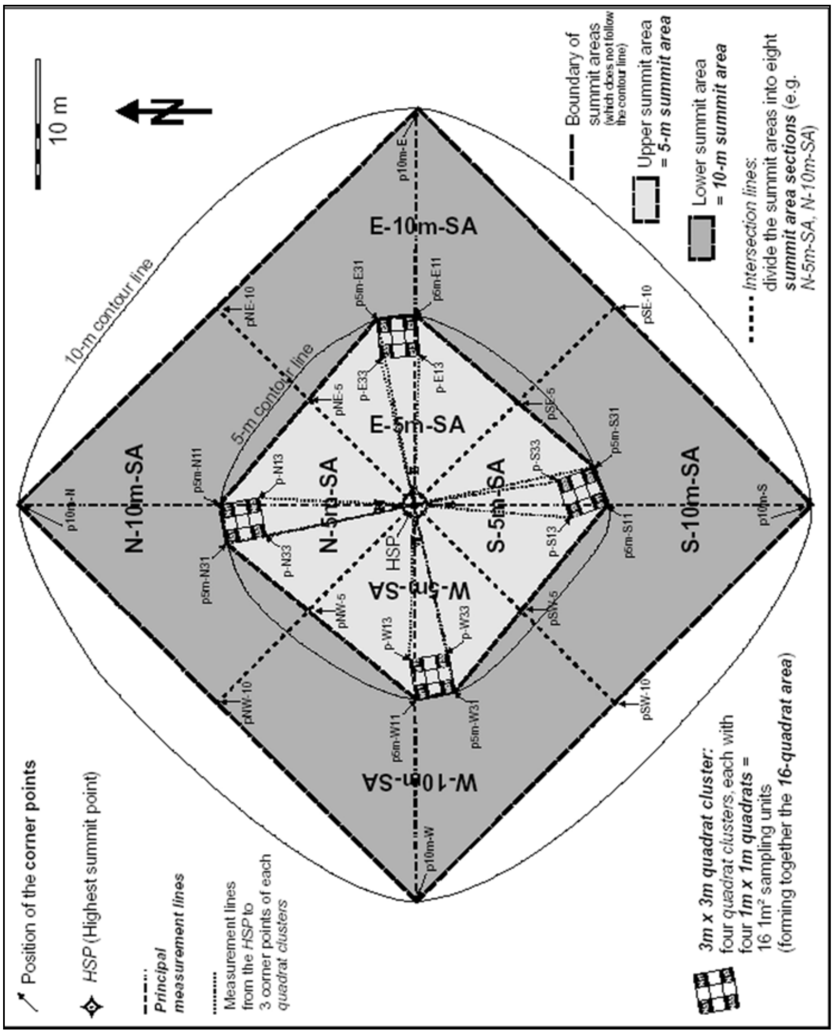

Fig.1. Scheme of the Multi-Summit sampling design (Pauli et al., 2001).

The 8 lower corner points of the 3x3 m quadrat clusters at the 5-m level: p5m-N11, p5m-N31, p5m-E31, p5m-E11, p5m-S11, p5m-S31, p5m-W31, p5m-W11

The 8 upper corner points of the quadrat clusters, they determine the position of the quadrat clusters and the lower limit of the 5-m summit area: p-N13, p-E13, p-S13, p-W13, pN33, p-E33, p-S33, p-W33m

The 4 corner points at the 10-m level they determine the lower limit of the 10-m summit area: p10m-N, p10m-E, p10m-S, p10m-W

The principal measurement line for each main direction starts at the HSP, runs through one of the points at the 5-m level (e.g. p5m-N11 or p5m-N31) and ends at the points at the 10-m level

The 8 corner points at the intersection lines (three points usually lie above the 5-level and the 10-m level, respectively. These points, by the HSP, and the points at the 5-m and 10-m levels delimit the summit area sections: pNE-5, pNE-10, pSE-5, pSE-10, pSW-5, pSW-10, pNW-5, pNW-10.

sharply divided into the warmer SW, S, SE and E expositions and colder and moister W, NW, N, NE expositions. Particularly broken relief conditions cause variability of vegetation here. In the SW, S, SE and E direction the communities of the alliances *Juncion trifidi* K r a j. 1933 and *Nardion* B r.-B l. 1926, L u q u e t 1926 are dominant here; in the N and W directions communities of alliance *Loiseleurio-Vaccinion* B r.-B l. in B r.-B l. et J e n n y ex K r a j. 1933, which alternate with communities of *Salicetea herbaceae* B r.-B l. 1948 class.

2. Summit – Veľká kopa peak (2052.4 m a.s.l.) is situated in Liptovské kopy Mts (eastern part of the Západné Tatry Mts). It is occurred 4 m (altitudinal) from the top of Veľká kopa peak itself. This summit was classified as lower alpine level. The communities of alliance *Juncion trifidi* K r a j. 1933 are widespread in W, S and E expositions. Some transitional communities sporadically dislocate the homogeneity of vegetation. However, typical herb species of alpine zone are missing. Northern exposition is characteristic by evenly backdown of grass species. They are substituted by herb species here, in consequence of this vegetation is getting a character of the class *Salicetea herbaceae* B r.-B l. 1948 communities – alliances *Salicion herbaceae* B r.-B l. in B r.-B l. et J e n n y 1926 and *Festucion pictae* K r a j. 1933 or the class *Thlaspietea rotundifolii* B r.-B l. 1948 – alliance *Androsacion alpinae* B r.-B l. in B r.-B l. et J e n n y 1926.

3. Summit – Sedielková kopa peak (2061.3 m a.s.l.) is situated in Vysoké Tatry Mts. This summit represents higher alpine level. The altitudinal divergence between previous and this summit is certainly small (Veľká kopa peak 2052.4 m a.s.l.), but we can see here some differences according to species composition. Mosses and lichens typical for a higher alpine zone often occur here. On the southern slope, communities of alliances *Juncion trifidi* K r a j. 1933 and *Festucion pictae* K r a j. 1933 dominate; communities of alliance *Loiseleurio-Vaccinion* B r.-B l. in B r.-B l. et J e n n y ex K r a j. 1933 characterize the eastern one. The northern slope is covered by mosaic of *Juncion trifidi* K r a j. 1933 and *Salicion herbaceae* B r.-B l. 1948 alliances. Western slope is mostly covered by vegetation of alliance *Loiseleurio-Vaccinion* B r.-B l. in B r.-B l. et J e n n y ex K r a j. 1933 with a higher abundance of mosses and lichens.

4. Summit – Krátka peak (2374.5 m a.s.l.) is situated in the Vysoké Tatry Mts. This summit was classified as subnival level and is the highest one within the target region Tatry. It occurs eastwards from the main summit. Particular expositions are characterized by the habituated temperature differences (SW, S, SE, E compare to NW, N, NE). Grassy communities of alliance *Juncion trifidi* K r a j. 1933 mostly cover S slopes. Vegetation of terraces and stone holes was classified to order *Androsacetalia vandellii* B r.-B l. in M e i e r et B r.-B l. 1934. Northwards is obvious by the occurrence of the communities of *Salicion herbaceae* B r.-B l. in B r.-B l. et J e n n y 1926 and *Hypno-Polypodion* M u c i n a ms. alliances, which are typical by low abundance of grasses and domination of mosses (even with lichens).

In 32 relevés, which were made in the particular summit area sections, 67 species were found. *Oreochloa disticha, Campanula alpina, Juncus trifidus, Festuca supina, Primula minima, Agrostis rupestris* and *Luzula alpinopilosa* ssp. *obscura, Avenula versicolor, Hieracium alpinum, Homogyne alpina* belong to the most wide-spread species with

T a b l e 1. Diagnostic species for 5 and 10 m summit areas (SA) with fidelity value (phi-coefficient)

Krátka peak - 5 m SA
1. *Campanula alpina* (77.46)
2. *Primula minima* (57.74)
3. *Avenula versicolor* (37.80)
4. *Hieracium alpinum* (37.80)
5. *Huperzia selago* (37.80)
6. *Juniperus sibirica* (37.80)
7. *Minuartia sedoides* (37.80)

Krátka peak - 10 m SA
1. *Oreogeum montanum* (57.74)
2. *Saxifraga moschata* var. *kotulae* (57.74)
3. *Leucanthemopsis alpina* (50.00)
4. *Anthoxanthum alpinum* (37.80)
5. *Bartsia alpina* (37.80)
6. *Bistorta major* (37.80)
7. *Botrychium lunaria* (37.80)
8. *Cystopteris fragilis* (37.80)
9. *Lloydia serotina* (37.80)
10. *Omalotheca supina* (37.80)
11. *Pulsatilla alba* (37.80)
12. *Thymus alpestris* (37.80)
13. *Viola biflora* (37.80)

Veľká kopa peak - 5 m SA
1. *Salix herbacea* (57.74)
2. *Festuca picturata* (37.80)
3. *Ligusticum mutellina* (37.80)
4. *Primula minima* (37.80)
5. *Ranunculus alpestris* (37.80)
6. *Vaccinium vitis-idaea* (37.80)

Veľká kopa peak - 10 m SA
1. *Gentiana punctata* (57.74)
2. Doronicum stiriacum (50.00)
3. *Sempervivum w.* ssp. *wettsteinii* (37.80)
4. *Vaccinium uliginosum* (37.80)

Krížna peak - 5 m SA
1. *Carex nigra* (77.46)
2. *Hieracium alpinum* (37.80)
3. *Pinus cembra* (37.80)

Krížna peak - 10 m SA
1. *Bistorta major* (77.46)
2. *Rhodiola rosea* (57.74)
3. *Silene acaulis* (57.74)
4. *Empetrum hermaphroditum* (57.74)
5. *Calamagrostis villosa* (50.00)
6. *Hieracium species* (37.80)
7. *Homogyne alpina* (37.80)
8. *Juncus trifidus* (37.80)
9. *Picea abies* (37.80)
10. *Pulsatilla alba* (37.80)

Sedielková kopa peak - 5 m SA
1. *Carex atrata* (37.80)
2. *Pinus mugo* (37.80)
3. *Soldanella carpatica* (37.80)
4. *Vaccinium uliginosum* (37.80)

Sedielková kopa peak - 10 m SA
1. *Gentiana punctata* (77.46)
2. *Potentilla aurea* (77.46)
3. *Solidago virgaurea* (77.46)
4. *Sempervivum w.* ssp. *wettsteinii* (57.74)
5. *Oreogeum montanum* (50.00)
6. *Calamagrostis villosa* (50.00)
7. *Trommsdorffia uniflora* (50.00)
8. *Agrostis rupestris* (37.80)
9. *Avenula versicolor* (37.80)
10. *Bistorta vivipara* (37.80)
11. *Euphrasia tatrae* (37.80)
12. *Ranunculus oreophilus* (37.80)

the highest frequencies. The monitoring and comparison of the species migration from 10 m summit area up to 5 m area is one of the main GLORIA aims. The phi-coefficient for this purpose was used. It goes out from the theory of fidelity (Bruelheide, 2000) and expresses the concentration of species occurrence in vegetation units. If some changes occur, it will be good visible in changes of the fidelity coefficient (Table 1). The species with the highest fidelity are presented here. The fidelity threshold 37.8 was chosen for the better transparency purpose. Species richness among the summits was not markedly different, although the altitudinal range from the lowest (upper treeline ecotone) and the highest summit (alpine-nival ecotone) was more than 450 m. From PCA chart (Fig. 2) are the differences among particular summit areas (5 and 10 m) very good visible. The X-axis represents the temperature gradient, the soil reaction we can suppose as the Y-axis gradient. A DCA (Fig. 3) showed, as expected, the greatest difference in species composition (in the m² quadrats) between the highest and the lowest summit; though, strikingly, the difference between the north and west sides among the attitudinally contrasting summits was particularly low. This suggests that exposition effects can override elevation effects even when comparing treeline and subnival habitats.

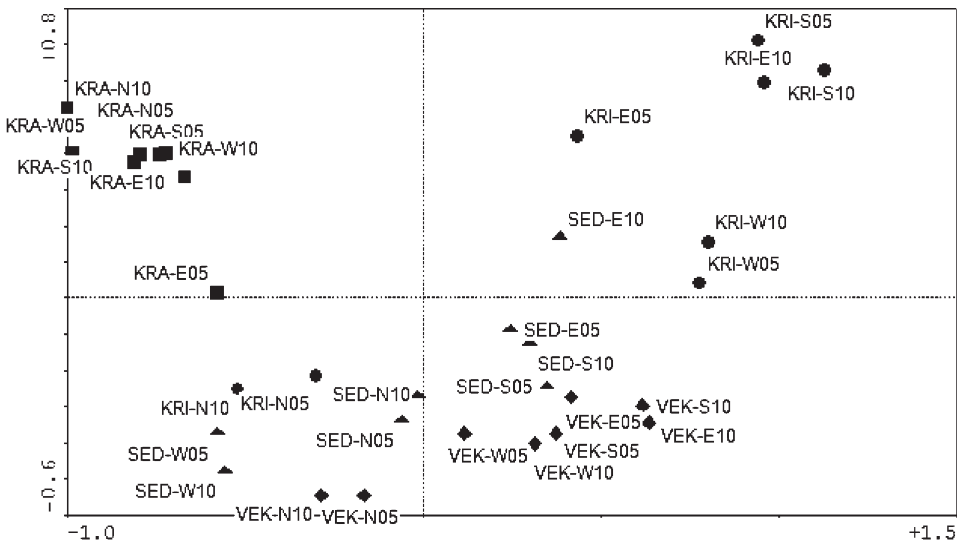

Fig. 2. Principal components analysis (PCA). 5 and 10 m summit area sections: KRI – Krížna peak, KRA – Krátka peak, SED – Sedielková kopa peak, VEK – Veľká kopa peak; W – west, N – north, S – south, E – east direction.

Conclusion

Slovakia was integrated in the project GLORIA by the establishing of the four summits in the Tatry Mts (Krížna, Veľká kopa peak, Sedielková kopa peak and Krátka peak) and by the completed field research connected with the creating of robust and complex database.

The data from the Tatry Mts will be progressively evaluating included with the all 18 target regions. Nowadays, the first data packet (288 records from the 18 regions – pooled 4x1 m^2 plots) was evaluated and first paper is in press.

The standardized high quality data of the network are getting increasingly attractive as baseline for re-investigations and model evaluations in the short- mid and the longer-term future.

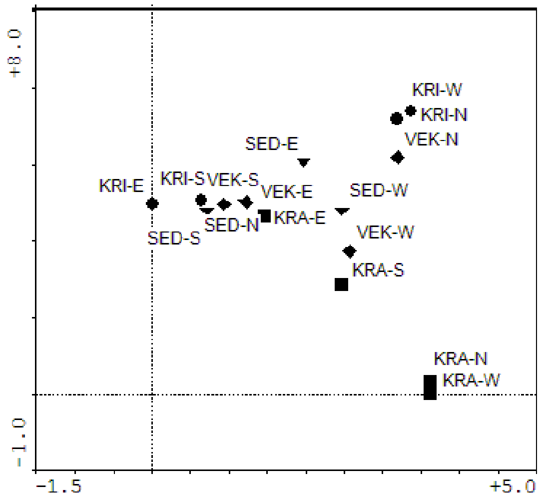

Fig. 3. Detrended correspondence analysis (DCA). 1 m^2 permanent quadrats: the merger of four m^2 quadrats generates species composition for each direction.
KRI – Krížna peak, KRA – Krátka peak, SED – Sedielková kopa peak, VEK – Veľká kopa peak; W – west, N – north, S – south, E – east direction.

Translated by R. Kanka

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Kanka R., Kollár J., Barančok P.: **Monitorovanie vplyvov klimatických zmien na alpínsku vegetáciu Tatier – prvé priblíženie.**

V príspevku prezentujeme najdôležitejšie výsledky výskumu, ktorý bol časťou celoeurópskeho projektu GLORIA (Európsky rozmer globálnej observačno-výskumnej iniciatívy v alpskom prostredí). Terénne práce, tvorba databázy a vyhodnotenie dát trvali 3 roky (2001-2003). Založenie monitorovacích plôch bolo hlavným cieľom tohto projektu (predpokladajú sa intervaly od 5 do 10 rokov, prípadne viac). Ako predmetné územie projektu boli vybrané Vysoké Tatry a Liptovské kopy, kde sme zaznamenali 67 druhov vyšších rastlín, 30 druhov machorastov a 27 druhov lišajníkov.