

The transition zone between *Anthoxanthum alpinum* and *A. odoratum* in the Krkonoše Mts

Zóna překryvu druhů *Anthoxanthum odoratum* a *A. alpinum* v Krkonoších

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The distributions of the tetraploid *Anthoxanthum odoratum* and diploid *A. alpinum* were first studied in the Krkonoše Mts (part of the Sudetes Mts) to find the transition zone where both species occur together and then their ecological requirements in this zone were determined. The distribution was studied at two spatial scales, geographic and local; the latter included detailed distribution at a locality level, where the relationships of both species to plant communities were investigated. The zone where the overlap occurs is between 800–1290 m a.s.l. *Anthoxanthum alpinum* is able to descend to even lower altitudes, where it grows in vegetation dominated by *Nardus stricta*. The species commonly occur in a fine mosaic of plant communities of *Polygono-Trisetion* (*A. odoratum*), *Nardion* (*A. alpinum*) or *Nardo-Agrostion tenuis* (both species). *Anthoxanthum alpinum* also occurs in areas that are currently not in direct contact with either alpine or subalpine vegetation (the Rýchory ridge, Černá hora Mt).

Key words: *Anthoxanthum odoratum*, *Anthoxanthum alpinum*, the Krkonoše Mts, the Rýchory ridge, distribution, vicariants, nutrients

Introduction

In 1942, Östergren identified two different cytotypes within the variable species *Anthoxanthum odoratum* L. (Östergren 1942). The diploid was later described as a new species, *A. alpinum*, by Löve & Löve (1949). Because of changeable and overlapping morphological characters some authors (e.g. Böcher 1961) evaluated it as a subspecies. Jones & Melderis (1964) published a new nomenclatoric combination *Anthoxanthum odoratum* subsp. *alpinum* (Á. Löve et D. Löve) B. M. G. Jones et Melderis. The possible synonymy of *A. alpinum* with *A. nipponicum* Honda, described in Japan in 1926 (Tateoka 1966), remains unresolved. For a detailed review of the taxonomy of the *A. odoratum* complex see Conert (1988).

In some regions of Europe (e.g. Scandinavia) *A. odoratum* and *A. alpinum* cannot be distinguished only by morphological characters (Hedberg 1967). The first reports from the Krkonoše Mts were published by Rozmus (1958) and more detailed data by Mađalski & Serwatka (1963). Rostański (1977) reported *A. alpinum* from many localities above 1250 m a.s.l.; he also found *A. odoratum* in many places, especially ruderal sites and along touristic paths at altitudes above 1000 m. The situation is different in the Czech Republic.

From the 1950s there were a few attempts to find the diploid in Czechoslovakia (Hadač & Hašková 1956) and the first report of *A. alpinum* in this country was published by Holub

(1960), who considered the size of the caryopsis (*A. odoratum* 2.0–2.2 mm, *A. alpinum* less than 2.0 mm) to be the most useful character for discriminating these species. Mayová (1982) suggested that these taxa can be reliably differentiated only by the presence (*A. alpinum*) or absence (*A. odoratum*) of unicellular hooked hairs on the lemma and palea of fertile florets. For the determination of living plants the colour of leaves can be used: both sides of a leaf blade of *A. odoratum* are dull grey-green, and in *A. alpinum* the upper side is dull grey-green and lower bright yellow-green (Rothmaler 1995).

Mayová (1982) was also the first to report the diploid chromosome number (10) in the *A. odoratum* complex from the Czechoslovakia. She also pointed out the differences in the ecology of the two species: *A. alpinum* grows at high altitudes above the timber-line, whereas *A. odoratum* occurs from lowland to mountains. However, both species can occur at some localities. In her unpublished thesis she mentions localities of *A. alpinum* in the Krkonoše Mts, Králický Sněžník Mt, Hrubý Jeseník Mts and Šumava Mts (Mayová 1982).

Anthoxanthum alpinum is presumably more common on the Czech-Polish border; it is reported from Poland from the surroundings of Jívina Mt (1076 m) and Kunčický hřbet (the Góry Bialskie Mts) by Szeląg (2000), and the southern fringe of the Rychlebské hory Mts and the top of Smrk Mt in the Czech Republic (1125 m a.s.l.; leg. L. Filipová 2005).

The karyology of *A. alpinum* was studied by Krahulcová (1990) who confirmed that the karyotype of the plants from Krkonoše, Králický Sněžník and Hrubý Jeseník corresponds with that of “diploid of the boreal type” (sensu Hedberg 1986) from Scandinavia. Relations in the *A. odoratum* complex and cryptic polyploidy are discussed by Krahulcová & Krahulec (1996).

There is no agreement on the distribution of both species. According to some authors the borders of the distribution areas are sharp (Rozmus 1958, Bogenrieder et al. 1993), whereas others assume distinct distributions in the past, which are currently extending (Hedberg 1967). Data from the Polish side of the Krkonoše Mts show that *A. alpinum* descends to lower altitudes (Mađalski & Serwatka 1963). The fundamental criterion is the scale on which the authors work. Considering large geographic complexes, the lowest limit of distribution of *A. alpinum* is reported from Poland from the forest zone (estimate from a map published by Mađalski & Serwatka 1963), from Steiermark at 1200 m (Teppner 1969) and Schwarzwald about 1300 m (Bogenrieder et al. 1993). In the Czech Republic the lowest reported altitude is 1000 m a.s.l. (Mayová 1982).

Ecological experiments were carried out at a local scale in the Krkonoše Mts to find out what maintains the relatively sharp boundary between the distributions of these two taxa (Flégrová & Krahulec 1999). These authors showed that there are differences in the growth of both species after transplantation to the locality of the other, but these differences cannot explain the absence of *A. odoratum* from higher altitudes. They also suggest that *A. odoratum* may have been prevented from expanding into the area of *A. alpinum* by its inability to reproduce effectively by seeds and that *A. alpinum* can find favourable microsites if strong competitors are absent (Flégrová & Krahulec 1999). A reciprocal sowing experiment was performed at the same localities as studied by Flégrová & Krahulec (1999) to find out if generative reproduction limits the expansion of each species into the distribution area of the other. Survival of both species did not differ between localities; the results suggest that *A. odoratum* should grow at both localities, especially at the native locality for *A. alpinum* and vice versa. Laboratory tests show that for germination caryopses of *A. alpinum* need to be stratified (K. Vincencová, unpublished data).

Objectives of this study were (i) a detailed mapping of the distribution of both species in the Krkonoše Mts; (ii) to detect the zone where the distributions overlap and determine the differences in ecological requirements of both species within this zone; (iii) to determine if there are isolated populations.

The Krkonoše Mts are the most appropriate region for such a study, because of the presence of large meadow complexes that connect the subalpine area with grasslands in the foothills and enable a bidirectional migration and the common occurrence of both taxa (Krahulec et al. 1997).

Methods

Field data collection

During June and July 2000–2002 the inflorescences of *A. odoratum* and *A. alpinum* were collected from meadows, downhill runs and along the roads in the whole Krkonoše National Park, especially where both species were expected to co-occur. At each microlocality at least 10 inflorescences from various plants were collected for precise determination by means of a binocular magnifying glass (magnification 20–40×). From each inflorescence at least two caryopses were taken and their lemma and palea examined.

The altitudes and orientation of the slopes of the localities were extracted from the maps Krkonoše, atlas 1: 25 000 (Geodézie Česká Lípa 1998) and Krkonoše Západ, Krkonoše Východ (Rosy and Klub českých turistů 1997), the exact geographic coordinates taken from the Geobáze 2.5 software (Geodezie ČS 1997). Plant communities were characterized using 25–30 plots (0.5 × 0.5 m) per locality on which all plant species were recorded and all inflorescences of *Anthoxanthum* species (10–155 per plot) inspected and precisely determined.

The following localities were studied in detail: 1. Pěnkavčí vrch hill (50°41'49"N, 15°47'21"E, 990 m); 2. Vysoký svah-Barborka (50°40'40"N, 15°43'38"E, 1005 m); 3. Modrý důl valley (50°42'40"N, 15°42'54"E, 1100 m); 4. Richterovy Boudy settlement (50°42'36"N, 15°41'57"E, 1142 m).

Nomenclature of plant species follows Kubát et al. (2002).

Statistical analyses

Characteristics of the localities and floristic composition were analyzed using CANOCO 4.5 package and graphical outputs created by CANODRAW 4.0 (ter Braak & Šmilauer 2002). The correlation between species composition and ordination axes was tested using GLM and Akaike information criterion (AIC; Crawley 2002). The relationship between the occurrence of both species and the orientation of slope (with respect to the altitude and type of locality – meadows, downhill runs, road margins) was analysed using the Rayleigh test of uniformity of distribution and multiple comparisons by χ^2 test in Oriana 2.0 (Kovatch Computing Service 2003).

Ellenberg's indicator values (Ellenberg et al. 2001) were taken from program JUICE 6.1 (Tichý 2002). The divisive classification of the species was carried out using TWINSpan (Hill 1979), with floristic data on presence/absence; pseudospecies cut level of 3; values of cut levels of 0, 5, 25; minimum group size of 5; maximum level of division of 2. Calculations were made in JUICE 6.1 (Tichý 2002).

The separate and common occurrences of both species in the relevés of plant communities, as indicated by TWINSpan analysis (with *Anthoxanthum* species not included) were checked using χ^2 tests.

Results

Transition zone

In total, 170 localities with only *A. odoratum*, 109 with only *A. alpinum* and 72 with both species occurring together (Fig. 1 and Appendix 1) were recorded in the Krkonoše Mts at altitudes between 560–1500 m. The recording was done in two steps: in the first, relatively rough step the zone where the distribution of both species overlap (“transition zone”) was detected. In the second step, the transition zone and its vicinity was explored in detail. *Anthoxanthum odoratum* occurs abundantly in meadows and along roads in the Krkonoše Mts up to an altitude of approximately 1290 m, while *A. alpinum* is distributed continuously above the timber-line, where it grows mostly in swards dominated by *Nardus stricta*, in dwarf pine stands and sometimes also in spruce forests with a sparse canopy. In meadows connected with the tops of the mountains, the latter species descends to an altitude of 900 m or, in favourable habitats, even to 750 m a.s.l. *Anthoxanthum alpinum* is not restricted to the main ridge of the Krkonoše Mts, but is also present in locally isolated populations on the Rýchory ridge and Černá hora Mt.

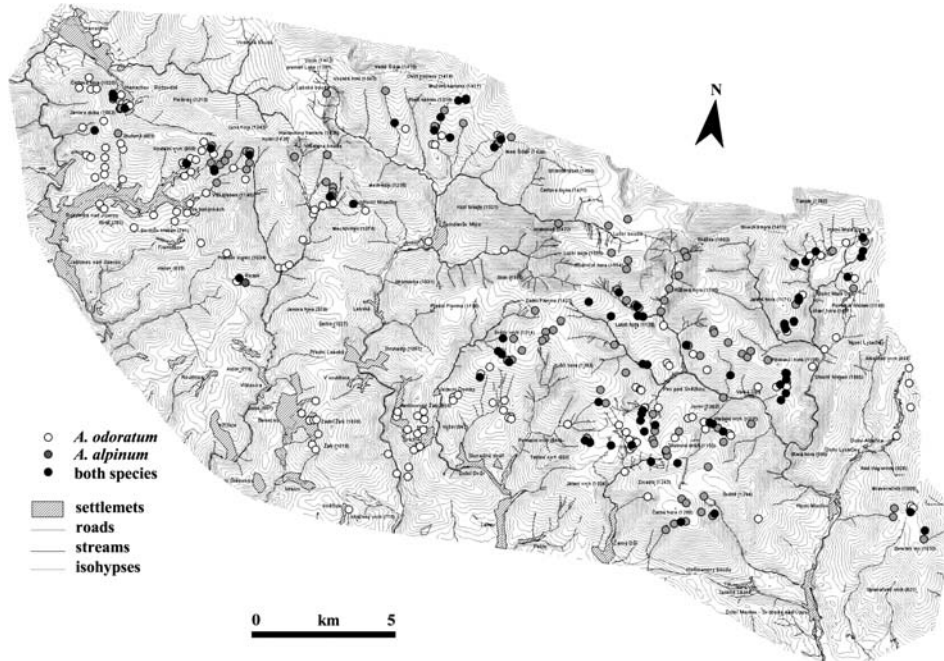


Fig. 1. – Distribution of *Anthoxanthum* species in the vicinity of the transition zone in the Krkonoše Mts.

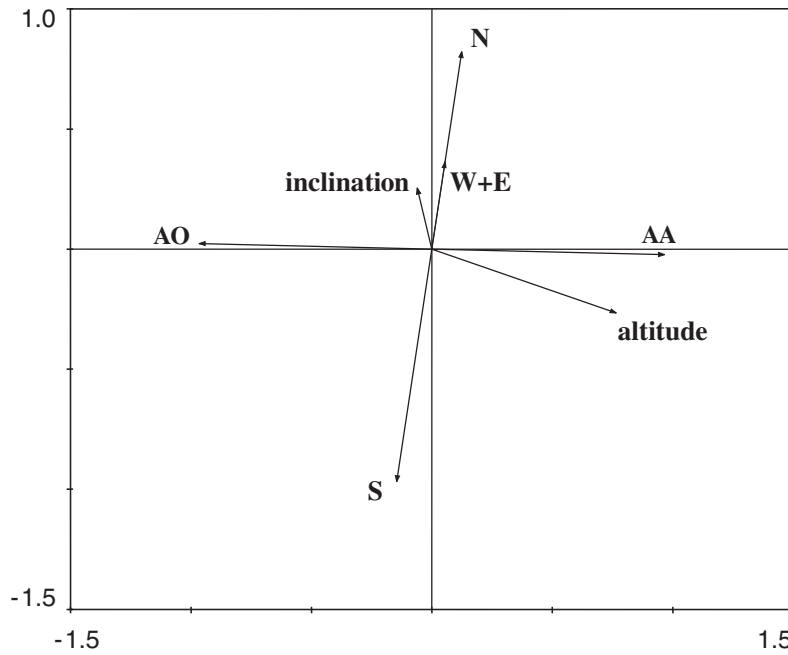


Fig. 2. – PCA of the characteristics of the localities of both species including common localities: altitude, orientation (N –north, S – south, W+E – west+east), inclination, presence of AO – *Anthoxanthum odoratum*, AA – *A. alpinum*. Data were centered and standardized.

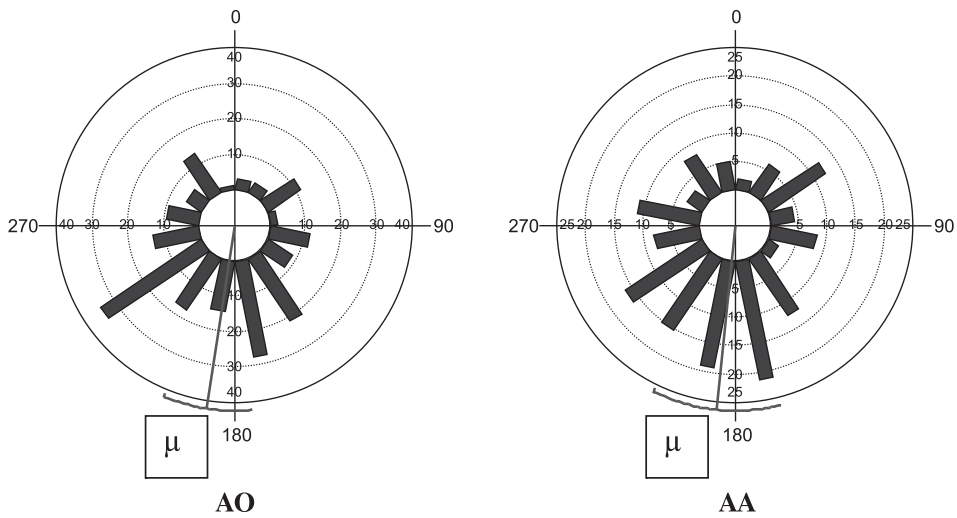


Fig. 3. – Distribution of the localities of both species relative to the orientation of the slope. AO – *Anthoxanthum odoratum*; AA – *A. alpinum*, the mean vector (μ) and standard deviation. Data were not transformed.

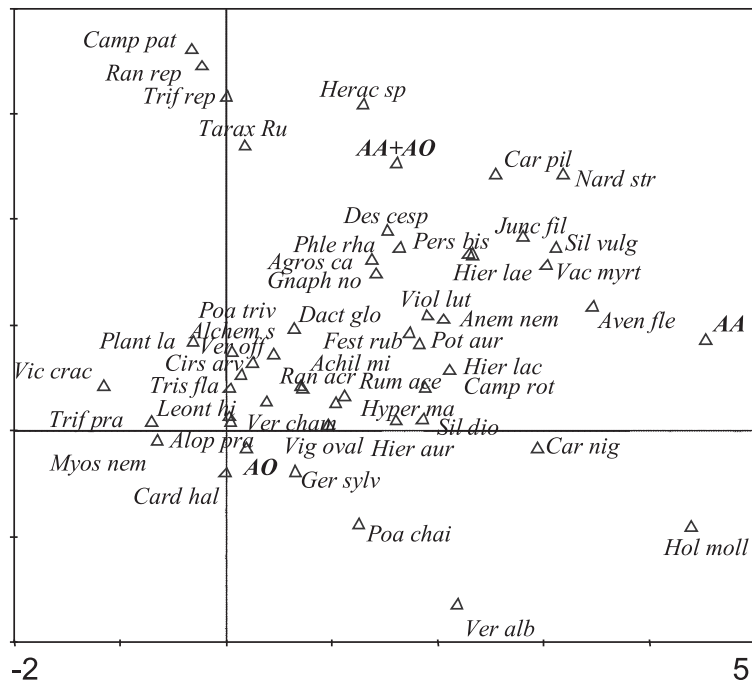


Fig. 4. – Ordination of the species. DCA of all relevés from all localities. Localities are considered as covariates. The abbreviations of the species are given in Fig. 6.

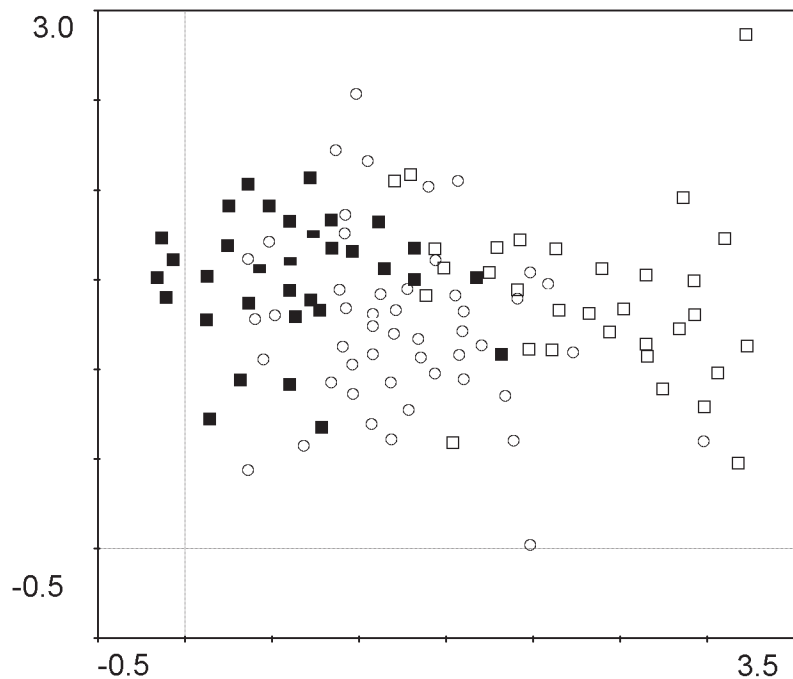


Fig. 5. – Ordination of the relevés. DCA of all relevés from all localities. Localities are considered as covariates. □ relevés with *A. alpinum*, ■ relevés with *A. odoratum*, ○ relevés with both species.

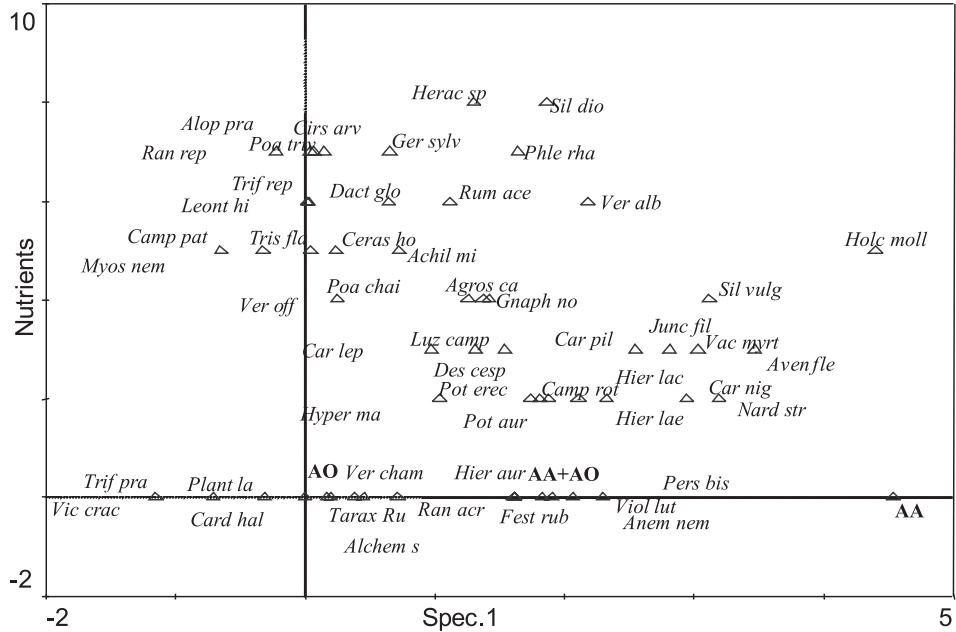


Fig. 6. – The relationship of the Ellenberg's values for nutrients and scores of species on the 1st axis. AA – *Anthoxanthum alpinum*, AO – *Anthoxanthum odoratum*, AA+AO – both species, Achill mill – *Achillea millefolium* agg., Agros cap – *Agrostis capillaris*, Alchem sp – *Alchemilla* sp., Alop prat – *Alopecurus pratensis*, Anem nem – *Anemone nemorosa*, Anth nit – *Anthriscus nitida*, Aven flex – *Avenella flexuosa*, Calam vill – *Calamagrostis villosa*, Camp pat – *Campanula patula*, Camp rot a – *Campanula rotundifolia* and *C. bohemica*, Card prat – *Cardamine pratensis* agg., Card hal – *Cardaminopsis halleri*, Cardus sp. – *Cardus* sp., Car lep – *Carex ovalis*, Car nig – *Carex nigra* agg., Car pal – *Carex pallescens*, Car pil – *Carex pilulifera*, Ceras hol – *Cerastium holosteoides*, Cirs arv – *Cirsium arvense*, Cirs heter – *Cirsium heterophyllum*, Cirs pal – *Cirsium palustre*, Crep moll – *Crepis mollis* subsp. *hieracioides*, Dact glom – *Dactylis glomerata* agg., Dact long – *Dactylorhiza fuchsii*, Des cesp – *Deschampsia cespitosa*, Epil alp – *Epilobium alpestre*, Epil cil – *Epilobium ciliatum*, Epil mont – *Epilobium montanum*, Epil sp – *Epilobium* sp., Fest rub – *Festuca rubra* agg., Galeop tetr – *Galeopsis tetrahit* agg., Ger sylv – *Geranium sylvaticum*, Gnaph norv – *Gnaphalium norvegicum*, Gnaph sylv – *Gnaphalium sylvaticum*, Herac sph – *Heracleum sphondylium*, Hier aur – *Hieracium aurantiacum*+*H. rubrum*, Hier iser – *Hieracium iseranum*, Hier lach – *Hieracium lachenali*, Hier laev – *Hieracium laevigatum*, Hier sp – *Hieracium* sp., Holc mol – *Holcus mollis*, Hyper mac – *Hypericum maculatum* agg., Chaer hirs – *Chaerophyllum hirsutum* agg., Junc cong – *Juncus conglomeratus*, Junc filif – *Juncus filiformis*, Junc squ – *Juncus squarrosus*, Lath prat – *Lathyrus pratensis*, Leont hisp – *Leontodon hispidus*, Luz camp – *Luzula campestris* a *L. multiflora*, Maianth bif – *Maianthemum bifolium*, Myos nem – *Myosotis nemorosa* s. lat, Nard str – *Nardus stricta*, Pers bis – *Bistorta major*, Phle rhaet – *Phleum rhaeticum*, Phle prat – *Phleum pratense* agg., Phyt spic – *Phyteuma spicatum*, Pilos of – *Hieracium pilosella*, Plant lanc – *Plantago lanceolata*, Plant maj – *Plantago major*, Poa chaix – *Poa chaixii*, Poa pal – *Poa palustris*, Poa prat – *Poa pratensis* agg., Poa triv – *Poa trivialis*, Pot aur – *Potentilla aurea*, Pot erect – *Potentilla erecta*, Ran acr – *Ranunculus acris*, Ran plat – *Ranunculus platanifolius*, Ran rep – *Ranunculus repens*, Rum ace – *Rumex acetosa* and *R. alpestris*, Rum asel – *Rumex acetosella*, Sen fuch – *Senecio ovatus*, Sil dio – *Silene dioica*, Sil vulg – *Silene vulgaris*, Solid virg – *Solidago virgaurea*, Tarax Rud – *Taraxacum* sect. *Ruderalia*, Trif prat – *Trifolium pratense*, Trif rep – *Trifolium repens*, Tris flav – *Trisetum flavescens* agg., Tuss farf – *Tussilago farfara*, Urt dio – *Urtica dioica*, Vac myrt – *Vaccinium myrtilus*, Ver alb – *Veratrum album* subsp. *lobelianum*, Ver cham – *Veronica chamaedrys*, Ver off – *Veronica officinalis*, Ver ser – *Veronica serpyllifolia*, Vic crac – *Vicia cracca*, Vic sep – *Vicia sepium*, Viol lut – *Viola lutea* subsp. *sudetica*, Viol pal – *Viola palustris*.

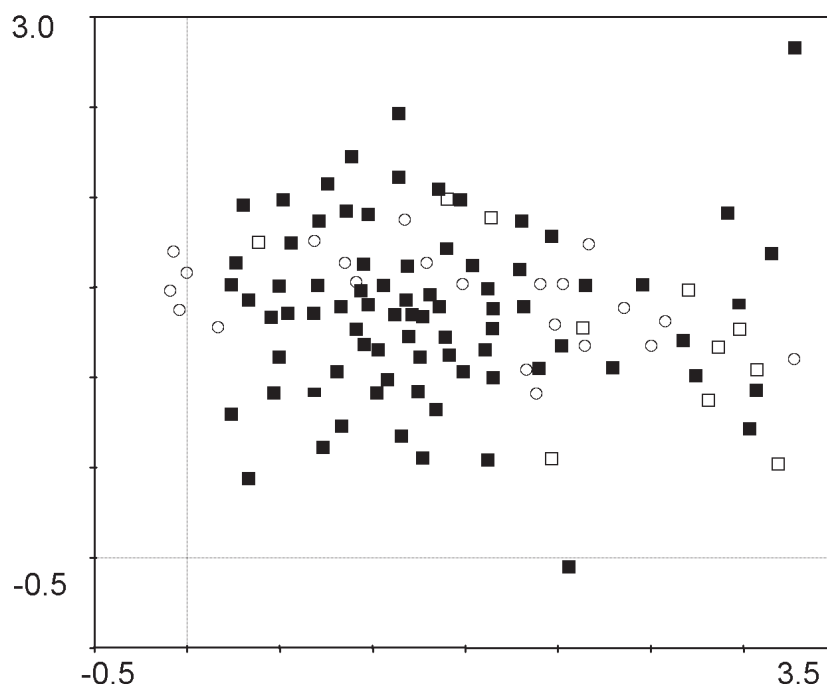


Fig. 7. – Ordination of the relevés with projection of the groups of relevés selected by Twinspan. □ *Nardion*, ■ *Polygono-Trisetion*, ○ *Nardo-Agrostion tenuis* (*Sileno vulgaris-Nardetum*).

The occurrence of *A. alpinum* correlated with altitude, that of *A. odoratum* weakly with orientation. The presence of both species was independent of slope inclination (Fig. 2).

The occurrence of both species on downhill runs and along roads was independent of the orientation of the slopes. Between-species comparisons did not reveal any differences in preference for slopes of a certain orientation in the transition zone (Fig. 3).

Floristic composition of vegetation at localities where both species occur

The results of detrended correspondence analysis indicate that both species occur in different plant communities (1st ordination axis explained 6.8%, 2nd axis 4.1% of the variability) (Figs 4, 5).

A strong correlation was found between *A. odoratum* and both ordination axes (GLM, Poisson distribution, 1st axis: $F = 39.39$, $P < 0.0001$, $AIC = 59.99$; 2nd axis: $F = 29.17$, $P < 0.0001$, $AIC = 67.72$) and between *A. alpinum* and the 1st axis ($F = 67.48$, $P < 0.0001$, $AIC = 50.526$).

The positions of species were interpreted by using Ellenberg indicator values for light, temperature, moisture, nutrients and soil reaction. The only significant models (GLM, normal distribution) were for nutrients ($F = 4.36$, $p = 0.0397$, $AIC = 682.92$) (Fig. 6) and soil reaction ($F = 4.35$, $p = 0.0398$, $AIC = 700.78$).

The divisive classification of the relevés formed three groups, that are discussed below (Fig. 7). The χ^2 test indicated that the occurrence of both species and common occurrence

in communities of the alliances *Nardion* ($\chi^2 = 10.4$, $df = 2$, $P < 0.01$) and *Polygono-
Trisetion* ($\chi^2 = 10.7$, $df = 2$, $P < 0.01$) is not random. For *Nardo-Agrostion tenuis* the frequencies were too low to be tested statistically.

Discussion

Distribution of Anthoxanthum alpinum and A. odoratum

The occurrence of *A. alpinum* in locally isolated populations, currently without direct contact with alpine and subalpine vegetation, supports the hypothesis that *A. alpinum* is a glacial relict (Bogenrieder et al. 1993). In the Krkonoše Mts, there are two such regions isolated from the main ridge: the massif of Rýchory and Černá hora Mt.

Anthoxanthum alpinum can be considered as native, because it can grow at high altitudes in spruce and mixed forests, which are the same as those occurring on tops of both mountain ranges. The analysis of the orientation of slopes indicates that *A. odoratum* prefers slopes with a S or SW orientation. Its occurrence by the roads, independent of orientation, is most likely a consequence of diaspores transported along the roads by people when moving cattle or transporting hay or other products (Rostański 1977, Štursová & Štursa 1982, Krahulec et al. 1997). *Anthoxanthum alpinum* seems to be less fastidious than *A. odoratum* in terms of the slope orientation, but occurs more often on south-oriented slopes. This differs from the situation on Mt Feldberg in Schwarzwald (Black Forest, Germany), where the altitudinal boundary on the south-western slope occurs at higher altitudes than on the northern slope where snow remains for long periods. The lowest localities for *A. alpinum* on the northern slope are at approx. 1200 m (Bogenrieder et al. 1993). In our study sampling was concentrated in the area of the potential common occurrence of both species. Slopes of southern orientation are more represented in our sample because of the geography of the Krkonoše Mts, which makes the comparison with results from Mt Feldberg difficult.

Floristic composition of communities

A number of studies refer to the phytosociology of both species at a larger spatial scale. In Italian mountain regions, where both species grow in close vicinity, *A. odoratum* occurs only in mown and manured meadows (*Trisetetum*), *A. alpinum* in meadows of *Nardetum* (Pignatti 1982). In Sweden, *A. odoratum* occurs continuously southward from the 64° parallel in various vegetation types (meadows, pastures, road margins etc.), especially in anthropogenically affected areas. Only a minority of the localities are natural (coastal heaths and rock outcrops). Northward of the 64° parallel and in the mountains in the south, *A. alpinum* dominates, especially in *Deschampsio-Anthoxanthion* Du Rietz 1942. However, no differences in ecological requirements in the transition zone were found; isolated populations of the tetraploids grow in anthropogenic habitats (road margins, parking places), those of diploids in seminatural and natural habitats (subalpine wet meadows and forests fringes) (Hedberg 1967).

In Germany, the common occurrence of both species was studied at a finer spatial scale on Mt Feldberg in Schwarzwald. *Anthoxanthum alpinum* grows with a high constancy in *Leontodonto-Nardetum*. The vegetation of the transition zone, which is 50–70 m wide on

northern and eastern slopes but much narrower on the southern and south-western slopes, consists of a fine mosaic of plant communities. Vegetation relevés indicate that characteristic species of *Leontodonto-Nardetum* decrease and those *Festuco-Genistetum* increase along the transition from vegetation with *A. alpinum* to that with *A. odoratum*. *Anthoxanthum alpinum* is found at higher altitudes in some swards of *Bartsio-Caricetum fuscae*, but the species that usually occurs in these communities is *A. odoratum*. This species is able to thrive in this high-altitude community and penetrate far into the continuous distribution of *A. alpinum* up to altitudes above 1320 m a.s.l. (Bogenrieder et al. 1993).

The characteristics of the common localities in the Krkonoše Mts are analogous with those reported from Schwarzwald. There is also a mosaic of communities and the gradient in the data can be explained by using Ellenberg indicator values for soil reaction and nutrients; the soil reaction ranges from neutral to acid and does not differ in stands of *A. alpinum* and *A. odoratum* at one locality (D. Pimentel 2003, pers. comm.). The pattern may be explained by soil nutrients. *Anthoxanthum odoratum* occurs together with CSR-strategists, which demand a high supply of nutrients (e.g. *Rumex acetosa*, *Achillea millefolium*, *Ranunculus acris*, *Alchemilla* sp., *Agrostis capillaris*; Grime et al. 1988), and *A. alpinum* with S-strategists (e.g. *Bistorta major*, *Silene dioica*, *Avenella flexuosa*, *Nardus stricta*, *Potentilla aurea*; Grime et al. 1988).

Similarly, Felber-Girard et al. (1996) analyzed in detail the vegetation along transects in several contact zones between diploid and tetraploid cytotypes of *A. alpinum* in the Swiss Prealps. They observed a similar ecological segregation in the hybrid zone of cytotypes of *A. alpinum* to that between diploid *A. alpinum* and tetraploid *A. odoratum*. Although outside this zone these cytotypes are not confined to certain vegetation types, within it they occur in different plant communities and thus exhibit distinct ecological requirements, which contribute to the preservation of the hybrid zone (Felber-Girard et al. 1996). It seems that in the Krkonoše Mts *A. odoratum* and *A. alpinum* are bound to specific types of vegetation outside the transition zone as well.

The divisive classification, which reveals the largest discontinuities within the data set (Jongman et al. 1987), indicates that in the area of common occurrence *A. odoratum* is associated with species-rich meadows of the alliance *Polygono-Trisetion* Braun-Blanquet et Tüxen ex Marschall 1947, and *A. alpinum* with oligotrophic communities of the alliance *Nardion* Braun-Blanquet 1926. This accords with the results of Bogenrieder et al. (1993). They co-occur in stands classified as the alliance *Nardo-Agrostion tenuis* Sillinger 1933, association *Sileno vulgaris-Nardetum* Krahulec 1990, i.e. species rich meadows with a low nutrient supply, which allows the coexistence of *Nardion* species with those of mesotrophic meadows (Krahulec et al. 1997).

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Souhrn

V Krkonoších bylo studováno rozšíření tetraploidního druhu *Anthoxanthum odoratum* a diploidního *A. alpinum* s cílem nalézt zónu překryvu výskytů obou druhů a jejich ekologické nároky v této oblasti, a to na dvou prostorových škálách: krajinné a na úrovni lokalit s ohledem na detailní rozšíření obou druhů a vazbu na rostlinná společenstva. Oblast společného výskytu leží v nadmořské výšce od 800 do 1290 m, *A. alpinum* sestupuje ojedinelé i do nižších poloh, kde se vyskytuje v trávnicích s dominantní *Nardus stricta*. Společné lokality jsou jemnou mozaikou společenstev svazů *Polygono-Trisetion* (s *A. odoratum*), *Nardion* (s *A. alpinum*) a *Nardo-Agrostion tenuis* (s oběma druhy). *A. alpinum* se též vyskytuje v oblastech, které v současnosti nemají přímý kontakt s alpinskou a subalpinskou vegetací (Rýchorský hřeben, Černá hora.).

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Appendix 1. – List of localities studied in the Krkonoše Mts. where *Anthoxanthum alpinum* and *A. odoratum* occur together. Localities are arranged according to phytogeographical districts of the Czech Republic.

93a: Krkonoše Mts. – woody. **1.** Rokytnice n. J., Hledšebe, the meadow above the cottage no. 14, 50°44'54"N, 15°26'02"E, 800 m a.s.l., 18. 6. 2001, **2.** Rýžoviště, under the forest between the blue and the red ski slope from the Čertova hora Mt, 50°45'34"N, 15°26'28"E, 810 m, 18. 6. 2001, **3.** Rýžoviště, in the middle of the slope under the chalet ŽOS Praha, 50°45'38"N, 15°26'26"E, 800 m, 18. 6. 2001, **4.** Rýžoviště, a meadow at the end of the ski-tow Na Stráni, 50°45'23"N, 15°26'51"E, 780 m, 18. 6. 2001, **5.** Hrušov, at the cottage no. 365, 50°44'29"N, 15°28'53"E, 750 m, 21. 6. 2001, **6.** Hoření Domky, the ski-tow Slalomový svah, under the road to the chalet Lovčanka, 50°44'50"N, 15°29'32"E, 895 m, 16. 6. 2001, **7.** Horní Rokytnice, Zákoutí, the boarding house Světlanka, the meadow above the house along the road, 50°44'27"N, 15°29'42"E, 880 m, 20. 6. 2001, **8.** Horní Rokytnice, Zákoutí, the meadow opposite to the boarding house Světlanka, 50°44'25"N, 15°29'43"E, 880 m, 20. 6. 2001, **9.** the meadow under the chalet Dvoračky, 50°44'48"N, 15°30'42"E, 1130 m, 17. 6. 2001, **10.** Rezek, the meadow at the hotel Rezek at the forest, 50°42'28"N, 15°30'51"E, 885 m, 17. 6. 2001, **11.** Dolní Mísečky, at the beginning of the ski-tow Novákova louka, 50°44'12"N, 15°33'14"E, 920 m, 20. 6. 2001, **12.** Horní Mísečky, the meadow under the chalet Horské zátíší, 50°44'07"N, 15°33'57"E, 1025 m, 3. 8. 2000, **13.** Vysoké Kolo Mt, along the road from the Martinova bouda chalet to the Medvědí bouda chalet, 50°45'44"N, 15°34'52"E, 1150 m, 3. 8. 2000, **14.** the meadow under the chalet Sedmidolí across the road, 50°45'41"N, 15°36'04"E, 1100 m, 11. 7. 2001, **15.** SW of the Petrova bouda chalet, the green plot at the crossroad at the Novopacká bouda chalet, 50°45'57"N, 15°36'13"E, 1192 m, 11. 7. 2001, **16.** along the blue tourist path from the Davidovy Boudy settlement to the Špindlerova bouda chalet, 50°45'35"N, 15°36'34"E, 1000 m, 11. 7. 2001, **17.** the meadow at the crossroad of the blue and the yellow tourist path at the Petrova bouda chalet, 50°46'18"N, 15°36'41"E, 1290 m, 11. 7. 2001, **18.** the meadow above the crossroad of the blue and the red tourist path at the Petrova bouda chalet, 50°46'21"N, 15°36'54"E, 1270 m, 11. 7. 2001, **19.** E margin of the meadow under the Petrova bouda chalet, 50°46'20"N, 15°36'54"E, 1255 m, 11. 7. 2001, **20.** the meadow under the road under the recovering house Malý Šišák, 50°45'30"N, 15°37'54"E, 1150 m, 11. 7. 2001, **21.** the meadow under the Špindlerova bouda chalet, 50°45'40"N, 15°38'04"E, 1190 m, 11. 7. 2001, **22.** the Lahrový Boudy settlement, at the tourist path to Adolfska about 30 m from the Huculská bouda chalet, 50°41'10"N, 15°38'18"E, 1030 m, 26. 6. 2001, **23.** at the pole road from the Lahrový Boudy settlement to the Friesovy Boudy settlement, 50°41'42"N, 15°38'44"E, 1140 m, 26. 6. 2001, **24.** the Friesovy Boudy settlement, at the road, 1200 m, 26. 6. 2001, **25.** the Friesovy Boudy settlement, under the ski-tow at the chalet SKI SK Praha, 50°41'57"N, 15°38'50"E, 1140 m, 26. 6. 2001, **26.** the Přední Rennerovský settlement, the meadow under the chalet Rozhled, 50°41'31"N, 15°39'06"E, 1180 m, 26. 6. 2001, **27.** the Tetřeví Boudy settlement, the meadow on the N end at the forest, 50°40'13"N, 15°41'37"E, 1035 m, 24. 6. 2002, **28.** the Tetřeví Boudy settlement, at the green and the yellow tourist path, 50°40'11"N, 15°41'46"E, 1035 m, 24. 6. 2002, **29.** the Richterovy Boudy settlement, the meadow, 50°42'36"N, 15°41'57"E, 1142 m, 13. 7. 2001, **30.** Liščí louka, the meadow at the hotel Prvosenska, 50°40'58"N, 15°41'53"E, 1207 m, 31. 7. 2001, **31.** the Modrý Důl valley, the meadow under the chalet Hořec, 50°43'04"N, 15°42'06"E, 1060 m, 25. 6. 2001, **32.** along the green tourist path from the chalet Mír to the Tetřeví Boudy settlement, 50°40'11"N, 15°42'24"E, 1055 m, 24. 6. 2002, **33.** the Modrý důl valley, the meadow above the Bouda V Modrém Dole chalet, 50°42'51"N, 15°42'41"E, 1040 m, 25. 6. 2001, **34.** at the red tourist path from the Richterovy Boudy settlement to the Modrý Důl valley, 50°42'40"N, 15°42'44"E, 1117 m, 13. 7. 2001, **35.** the Modrý Důl valley, the meadow at the SE end, 50°42'40"N, 15°42'54"E, 1100 m, 25. 6. 2001, **36.** Chaloupky, Amor, the meadow at the ski-tow above the chalet Chemie at the forest, 50°41'47"N, 15°43'03"E, 900 m, 8. 7. 2001, **37.** the Hrnčířské Boudy settlement, the meadow NW from the chalet Mír, 50°40'14"N, 15°43'01"E, 1060 m, 24. 6. 2002, **38.** Chaloupky, the meadow above the path above the chalet Amor, 50°41'47"N, 15°43'11"E, 880 m, 8. 7. 2001, **39.** Pec p. S., the ski-tow Zahrádky, the meadow above the Čapkova bouda chalet, under the ski-tow, 50°40'51"N, 15°43'12"E, 985 m, 24. 6. 2002, **40.** Pec p. S., the ski-tow Zahrádky, the meadow at the beginning of the ski-tow under the chalet Purkyně, 50°40'43"N, 15°43'11"E, 1020 m, 24. 6. 2002, **41.** Pec p. S., the ski-tow Zahrádky, the meadow at the beginning of the ski-tow Klondike, 50°40'31"N, 15°43'20"E, 1025 m, 24. 6. 2002, **42.** Pec p. S., Vysoký svah, the meadow at the chalet Lokomotiva, 50°40'55"N, 15°43'13"E, 940 m, 9. 7. 2000, **43.** the meadow opposite to the Žižkova bouda chalet across the road, 50°40'40"N, 15°43'38"E, 1005 m, 9. 7. 2000, **44.** at the blue tourist path from Zrcadlolovky to the Kolínská bouda chalet, 50°39'58"N, 15°43'39"E, 1125 m, 10. 6. 2002, **45.** Větrník, the lower meadow, 50°42'14"N, 15°44'16"E, 950 m, 8. 7. 2000, **46.** the crossroad Pod Kolínskou boudou, at the road, 50°40'00"N, 15°44'26"E, 1100 m, 11. 7. 2000, **47.** the meadow under the Sokolská bouda chalet at the forest, 50°38'54"N, 15°44'44"E, 1255 m, 10. 6. 2002, **48.** the Malé Típpeltovy Boudy settlement, the lower part of the slope, above the road, 50°40'50"N, 15°45'14"E, 870 m, 9. 7. 2000, **49.** the Malé Típpeltovy Boudy settlement, in the middle of the slope, 50°40'49"N, 15°45'20"E, 960 m, 9. 7. 2000, **50.** Pec p. S., at the road Konvalinka, behind the Žlebský potok brook, 50°41'46"N,

15°45'41"E, 900 m, 8. 7. 2001, **51.** the meadow at the crossroad Nad Vlašskými Boudami, 50°40'42"N, 15°45'40"E, 1000 m, 9. 7. 2000, **52.** the Malé Pardubické Boudy settlement, the meadow between the chalets Tunel and Větrník, 50°39'08"N, 15°45'42"E, 1035 m, 11. 7. 2000, **53.** the Šímovy Chalupy settlement, the upper meadow, 50°42'50"N, 15°47'06"E, 1050 m, 11. 6. 2002, **54.** the Šímovy Chalupy settlement, along the small brook in the upper part, 50°42'46"N, 15°47'09"E, 1115 m, 11. 6. 2002, **55.** the Žacléřské Boudy settlement, the meadow under the chalet ČD HK, 50°44'01"N, 15°47'12"E, 985 m, 11. 6. 2002, **56.** Velká Úpa, Končiny, the meadow at the upper end, 50°41'42"N, 15°47'11"E, 975 m, 11. 6. 2002, **57.** Pěnkavčí vrch, above the end of the ski-tow under the forest, 50°41'56"N, 15°47'20"E, 1051 m, 12. 7. 2000, **58.** the Janovy Boudy settlement, the meadow at the chalet Junák, 50°41'25"N, 15°47'16"E, 900 m, 12. 7. 2000, **59.** at the road from the Šímovy Chalupy settlement to Niklův vrch, 50°42'55"N, 15°47'22"E, 1050 m, 11. 6. 2002, **60.** Niklův vrch, the meadow of the S part, under the cottage, 50°43'19"N, 15°47'26"E, 1000 m, 11. 6. 2002, **61.** Pěnkavčí vrch, the meadow at the chalet ČD HK, 50°41'49"N, 15°47'21"E, 990 m, 12. 7. 2000, **62.** Niklův vrch, under the cottage, in the middle of the slope, 50°43'22"N, 15°47'26"E, 955 m, 11. 6. 2002, **63.** the Janovy Boudy settlement, the meadow above the chalet Jana, 50°41'33"N, 15°47'23"E, 920 m, 12. 7. 2000, **64.** the meadow above the yellow tourist path from the Žacléřské Boudy settlement, at the chalet Juta, 50°44'04"N, 15°47'30"E, 950 m, 11. 6. 2002, **65.** Za větrem, above the chalet Hedvika, under the forest, 50°44'16"N, 15°47'46"E, 975 m, 11. 6. 2002, **66.** the Rottrovy Boudy settlement, the meadow at the yellow tourist path, 50°43'52"N, 15°48'48"E, 1005 m, 11. 6. 2002, **67.** the Pomezní Boudy settlement, the meadow at the chalet ČSAD Jičín, 50°44'38"N, 15°49'07"E, 1040 m, 8. 7. 2000, **68.** Černá Voda, the meadow at the chalet Rubena, 50°44'16"N, 15°49'08"E, 990 m, 11. 6. 2002, **69.** Horní Malá Úpa, the meadow at the chalet Blesk, 50°44'23"N, 15°49'10"E, 1000 m, 11. 6. 2002. 93b: Krkonoše Mts – subalpine. **70.** at the road from the chalet Výrovka to the Richterovy Boudy settlement, 50°42'49"N, 15°41'14"E, 1250 m, 13. 7. 2000 **93c:** Krkonoše Mts – Rýchory. **71.** the margin of the meadow above the fold across the road from Kutná to Rýchorský kříž, 50°39'36"N, 15°51'29"E, 970 m, 10. 7. 2000, **72.** Sněžné Domky, the meadow on the N part, 50°39'17"N, 15°51'58"E, 970 m, 10. 7. 2000.