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# Morphological Evaluation of *Picris hieracioides* L. (*Compositae-Lactuceae*) in Slovakia.

By

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With 5 Figures

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Summary

SLOVÁK M. & MARHOLD K. 2007. Morphological evaluation of *Picris hieracioides* L. (*Compositae-Lactuceae*) in Slovakia. – Phyton (Horn, Austria) 47 (1–2): 73–102, 5 figures. – English with German summary.

Infraspecific taxonomy of *Picris hieracioides* L. (*Compositae*) has been regarded as questionable and unresolved until now. This taxonomic complexity is most greatly influenced by the huge morphological variation, wide distribution area and ecological amplitude. Five morphologically uncertain subspecies have been recorded from Slovakia. Our study, particularly the morphometric analysis, aimed to evaluate morphological entities within this species occurring in Slovakia. Results of morphometric analyses (principal component analysis, cluster analysis, classificatory and canonical discriminant analysis) showed only two well separated morphotypes of *P. hieracioides*: "lower altitude morphotype" and "higher altitude morphotype". These two morphotypes differ by several morphological characters (pale indumentum on involucral bracts, usually with red stripes on the outermost ligules, heads along the whole branches in the former, dark indumentum, red stripes rare and heads in the upper part of branches in the latter). Their distribution patterns are influenced by specific ecological requirements. We suppose that both could be treated

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as separate taxa on the species level; however, it is necessary to confirm this treatment by studies on a larger geographical scale and by molecular analysis, as well as to clarify nomenclature.


## Zusammenfassung

Slovák M. & Marhold K. 2007. Morphologische Evaluation von *Picris hieracioides* L. (*Compositae-Lactuceae*) in der Slowakei. – Phyton (Horn, Austria) 47(1–2): 73–102, 5 Abbildungen. – Englisch mit deutscher Zusammenfassung.

Die infraspezifische Taxonomie von *Picris hieracioides* L. (*Compositae*) wurde bisher als zweifelhaft und ungelöst angesehen. Die taxonomische Komplexität ist besonders durch beträchtliche morphologische Variation, großes Areal und weite ökologische Amplitude beeinflußt. Fünf morphologisch unsicher begrenzte Subspezies wurden innerhalb der Slowakei unterschieden. Unsere Studien, vor allem die morphometrische Analyse, versuchten, diese morphologischen Einheiten innerhalb der Art auf dem Gebiete der Slowakei zu evaluieren. Als Resultat von Hauptkomponentenanalyse, Clusteranalyse, klassifikatorischer und kanonischer Diskriminanzanalyse sind jedoch nur zwei Morphotypen von *P. hieracioides* gut unterscheidbar: ein "Tieflagen-Morphotyp" und ein "Hochlagen-Morphotyp". Diese beiden Morphotypen sind durch einige morphologische Merkmale verschieden (blasses Indument der Hüllblätter, üblicherweise mit roten Streifen auf den äußersten Zungen, Körbchen entlang der ganzen Zweige bei ersterem, dunkles Indument, rote Streifen selten und Körbchen im oberen Teil der Zweige bei letzterem). Die Verbreitungsmuster werden durch spezifische ökologische Ansprüche beeinflußt. Wir glauben, daß beide als separate Taxa auf Artniveau geführt werden können; es ist aber noch notwendig, die Ergebnisse durch Studien über ein größeres Areal und durch molekulare Befunde abzusichern, sowie die Nomenklatur zu klären.


## 1. Introduction

The polymorphic species *Picris hieracioides* L., one of the most common representatives of the genus *Picris*, is widely distributed in Europe and has also been introduced into the North America (McMullen 2001), New Zealand and Australia (Lack 1974, Holzapfel & Lack 1993). Its European distribution extends from the Iberian and Apennine Peninsulas to Central and northern Europe, to the Balkan region, and continues to eastern Europe and into the Near East. In Siberia and Eastern Asia, the morphologically and possibly also phylogenetically closely related *Picris nuristanica* Boiss. and *Picris japonica* Thunb. occur.

The taxonomic complexity of *P. hieracioides* is influenced especially by the extreme morphological variation in most of the vegetative characters and large degree of phenotype plasticity. The most conspicuous variability is notable in such characters as colour of indumentum, branching of stems, morphology of leaves and involucral bracts. The morphological variability within this complex, wide distribution area and ecological amplitude have lead to the description of many taxa both on the infraspecific and species level. The complex is currently usually treated as

a single species. Nevertheless, the critical evaluation of its variation using more advanced taxonomic methods is still missing and in local floras often contradicting taxonomic concepts can be found.

There seems to be no karyological variation in *P. hieracioides*, as there has been only the diploid level with 2n = 10 (LACK 1974) reported. As for the reproductive mode, there is a single report of agamospermy for this species (BERGMAN 1935). However, no other study exists, which would either confirm or reject this report.

In the literature relevant to the area of Slovakia, several often controversial taxonomic concepts are found and various infraspecific taxa have been recorded. The first known record of the presence of *P. hieracioides* in Slovakia dates back to the end of 18th century (LUMNITZER 1791). No infraspecific taxa were recognised in this area for the next hundred years, and only records of *P. hieracioides* can be found in literature (REUSS 1853, HAZSLINSZKY 1872, BERDAU 1890). In 1891, a new infraspecific taxon, *P. hieraciodes* var. *crepoides* SAUT. (originally described from the Alps, near Kitzbühel) with larger capitulas and dark indumentum on bracts was reported from the settlement of Tatranská Kotlina in the Belianske Tatry Mts. (SAGORSKI & SCHNEIDER 1891). Only eleven years later, BORBÁS 1902 described a new taxon of *Picris* from the mountain area of northern Slovakia (Chočské vrchy and Belianske Tatry Mts.), this time on the species level, namely *P. tatrae*. According to the BORBÁS's description (BORBÁS 1902) it differs from the typical *P. hieraciodes* in the same characters as the above-mentioned variety of *P. hieracioides* reported by SAGORSKI & SCHNEIDER 1891.

At the end of the 1920s, the first widely accepted taxonomic concept for Central European *P. hieracioides* appeared. HAYEK 1929 recognised five subspecies within this area: *Picris hieracioides* L. subsp. *hieracioides* (with 5 varieties), *P. hieracioides* subsp. *auriculata* (SCH.BIP.) HAYEK, *P. hieracioides* subsp. *paleacea* (VEST) DOMIN & PODP., *P. hieracioides* subsp. *sonchoides* (VEST) THELL., and *P. hieracioides* subsp. *spinulosa* (BERTOL.) ARCANG. This concept was accepted by DOSTÁL 1948–1950 for the area of the former Czechoslovakia).

PADALÍKOVÁ 1972 studied *P. hieracioides* in the area of former Czechoslovakia as part of her diploma thesis. She accepted HAYEK's concept of subspecies, but pointed out the existence of intermediate morphological types. Together with M. SMEJKAL she proposed and described, but never validly published a new subspecies, *P. hieracioides* subsp. *cymosa* PADALÍKOVÁ & SMEJKAL. According to them, this subspecies should be morphologically related to *P. hieracioides* subsp. *spinulosa*, which occurs in southern Europe. Considering the fact that the greater part of her study was based only on herbarium material, her results have only indicative value.

The classification, which is currently more or less widely accepted, was published in the 4th volume of Flora Europaea (SELL 1976), accompanied by comments published in Notulae systematicae ad Floram Europaeam spectantes (SELL 1975). SELL recognized also five, but different subspecies, namely *Picris hieracioides* subsp. *hieracioides, P. hieracioides* subsp. *grandiflora* (TEN.) ARCANG. [including as synonyms *P. auriculata* SCH.BIP., *P. paleacea* VEST, and *P. tatrae* BORBÁS], *P. hieracioides* subsp. *longifolia* (BOISS. & REUT.) SELL, *P. hieracioides* subsp. *spinulosa* (BERTOL.) ARCANG. and *P. hieracioides* subsp. *villarsii* (JORD.) NYMAN [which he considers to be synonymous with *P. crepoides* SAUT., *P. pyrenaica* sensu COSTE non L., and *P. sonchoides* VEST]. Except for *P. hieracioides* subsp. *longifolia* (BOISS. & REUT.) SELL, an endemic subspecies of the Iberian Peninsula, and the southern European *P. hieracioides* subsp. *spinulosa*, the other three above-mentioned subspecies were implicitly reported also for Slovakia. This concept with some modifications was accepted by DOSTÁL & ČERVENKA 1992.

The authors of the Checklist of non-vascular and vascular plants of Slovakia (MARHOLD & HINDÁK 1998) pointed out the unresolved taxonomic problems of this species. The list of taxa occurring in Slovakia is based on SELL's concept, but in addition, *P. hieracioides* subsp. *paleacea* was recognised.

In our study, we have focused on the evaluation of morphological variability of populations of *P. hieracioides* occurring in Slovakia. The results of multivariate morphometric analyses of the population samples along with the study of all available herbarium material from this area should be considered as the first step to broadly dealing with the variation of this species in its European area.

## 2. Material and Methods

Five hundred and thirty-one specimens of *Picris hieracioides* from 27 population samples originating from Slovakia were collected for morphometric analyses. Each population sample comprises 10 to 30 plants, collected from natural habitats. For the detailed survey of geographical distribution of *P. hieracioides* morphotypes in Slovakia, herbarium specimens from the following herbaria were revised: BRA, BRNM, BRNU, PRC, PR, SAV, SLO.

The selection of characters used in multivariate morphometric analyses was based on those characters traditionally used for the identification of the infraspecific taxa of *P. hieracioides* in literature, most of those used in the study published by HOLZAPFEL & LACK 1993 and finally on a survey of collected specimens.

For morphometric analyses, 25 morphological characters (17 ones measured on the interval scale, 2 ones on the ordinal scale and 6 binary characters) were measured or scored for each herbarium specimen:

(1) number of stem branches; (2) number of stem leaves; (3) length of the longest stem branch (cm); (4) maximum number of capitulas per stem branch; (5) distribution of capitulas on stem branches (capitulas from 1/2 to 1/3 of length of branch vs. ca-

Table 1. Canonical discriminant analysis of individual plants of *Picris hieracioides*. Total canonical structure expressing the correlation of morphological characters and canonical axis. Values higher than 0.6 are set in bold.

| Characters | **CDA** |
|---|---|
| | **axis 1** |
| NBr – Number of stem branches | –0.506017 |
| NL – Number of stem leaves | –0.445041 |
| LBr – Length of the longest stem branch | 0.048160 |
| NCBr – Maximum number of capitulas per stem branch | 0.069252 |
| DC – Distribution of capitulas on stem branches – 1/2 to 1/3 | **0.908115** |
| RSL – Presence or absence of red longitudinal strip on outer ligules | –0.513258 |
| BML – Presence or absence of brown marks on upper part of ligules | –0.151868 |
| LL – Length of ligule | **0.730357** |
| LCT – Length of corolla tubes | 0.501529 |
| WL – Width of ligules | –0.189256 |
| LTL – Length of teeth on ligule | 0.351751 |
| LP – Length of the longest peduncle | 0.511071 |
| NCP – Maximum number of capitulas per peduncle | –0.163110 |
| NBP – Maximum number of bracts per peduncle | 0.579370 |
| NoB – Average number of all outer bracts from three randomly chosen capitula | –0.444808 |
| NiB – Average number of all of inner bracts from three randomly chosen capitula | –0.032618 |
| LoB – Length of outer bracts | 0.242454 |
| WoB – Width of outer bracts | 0.178982 |
| LiB – Length of inner bracts | **0.714070** |
| WiB – Width of inner bracts | 0.453289 |
| DH – Presence of dark hairs on involucrum | **0.782960** |
| PH – Presence of pale hairs on involucrum | **–0.715674** |
| IH – Presence of intermediate hairs on involucrum | 0.018251 |
| DHI – Distribution of hairs on involucrum | –0.266156 |
| DHP – Distribution of hairs on peduncle | –0.433149 |

pitulas along the whole branch); (6) length of the longest peduncle (cm); (7) maximum number of capitulas per peduncle; (8) maximum number of bracts per peduncle; (9) average number of all outer bracts from three randomly chosen capitula; (10) average number of all inner bracts from three randomly chosen capitula; (11) presence or absence of dark hairs on involucrum (brown-black, red-black or black coloured hairs); (12) presence or absence of intermediate hairs (in respect to colour) on involucrum (green-brown, light brown, bi- or multi-coloured hairs); (13) presence or absence of pale hairs on involucrum (white- or pale-coloured hairs); (14) distribution of hairs on involucrum (1 – no hairs, 2 – one row of hairs on the midribs of bracts, 3 – two or several rows of hairs on surface of bracts); (15) distribution of hairs on peduncle (1 – no hairs on peduncle, 2 – sparse hairs on peduncle, 3 – dense hairs on peduncle). Considering the fact that floral parts needed proper conservation before measuring, those (three pieces of each measured item) of one randomly chosen capi-

tulum were attached by lucid adhesive tape to paper, dried and scanned on the Microtec ScanMaker 9800XL. After this all floral characters were measured and recorded using program Carnoy (Schols & al. 2002). Following floral characters were measured and scored: (16) presence or absence of red longitudinal stripe on outer ligules; (17) presence or absence of brown marks on upper part of ligules; (18) length of ligules (mm); (19) length of corolla tubes (mm), (20) width of ligules (mm); (21) length of teeth on ligules (mm); (22) length of outer bracts (mm); (22) width of outer bracts (mm); (24) length of inner bracts (mm); (25) length of inner bracts (mm).

The morphological characters considered (Lack 1974, Holzapfel & Lack 1993) as highly influenced by ecological factors (length, width and shape of leaves, height of plants, colour of bracket leaves, etc.) were excluded from analyses. Several characters on stem leaves (ratio of width and length of leaves, width of leaves, and width of bases of leaves) were measured for preliminary analyses, however, no conspicuous differences in respect to these characters were found. Therefore, characters on stem leaves were excluded from all morphological analyses. As rosette leaves shrivelled at anthesis, it was not possible to obtain sufficient material for morphometric analyses. Similarly, due to logistic reasons, it was not possible to obtain achenes from all collected population samples. Therefore, we decided to evaluate morphological variation of achenes (three achenes with pappus per plant) in a separate multivariate analysis. Width and length of achenes (mm) and length of pappus (mm) from chosen populations were measured and evaluated.

Three data matrices were used for the analysis. The first matrix (Matrix 1) comprised population samples characterised by mean values of all characters (27 populations $\times$ 25 characters). This includes also populations referred to further in the paper as "uncertain". The second one comprises individual plants from 25 populations based on all characters except those of achenes (531 plants $\times$ 25 characters); the third one represents a selection of individuals from 16 populations characterised by achene characters (226 plants $\times$ 3 characters).

The morphometric analyses were done with either individual specimens or populations as OTUs: PCA – principal component analyses (PCA, Sneath & Sokal 1973, Krzanowski 1990), and cluster analyses (Everit 1986) were performed as hypothesis-generating methods, while canonical discriminant as well as non-parametric classificatory discriminant analyses were used as hypotheses-testing methods (Klecka 1980, Krzanowski 1990). Pearson and Spearman correlation coefficients were computed to detect pairs of highly correlated characters in the primary matrix of all examined specimens. The analyses were performed in the following order:

1. For cluster analyses (average linkage – UPGMA, complete linkage and Ward's methods), Euclidean distance as a coefficient of distance was used. Populations were characterised by mean values of character states, and characters of the primary matrix were standardised to zero means and unit standard deviations.

2. PCA, based on populations and the correlation matrix between characters, was performed to generate a concept of the morphological relationships. Results of the cluster analyses, based on populations, were used as an aid in the interpretation of PCA.

3. Canonical (CDA) and k nearest neighbours non-parametric classificatory discriminant analyses, based on plant individuals and results of cluster and PCA analyses (for the group definitions), were performed in order to test the possibility of the division of collected material into discrete morphologically defined groups. The

Table 2. List of population samples of *Picris hieracioides* used in the study. All populations were collected in Slovakia. Abbreviations for morphotypes (second column): L – "lower altitude morphotype", H – "higher altitude morphotype", U – morphologically 'ùncertain populations" from southwest Slovakia. PC – population code, NI – number of individuals per population sample used in morphometric analyses. NIS – number of individuals per population sample used in morphometric analyses of achenes.

| PC | Morphotype | Locality (Slovakia) | NI | NIS |
|---|---|---|---|---|
| CHLA | L | Burda (Kováčovské kopce hills), ruderal xerotherm slopes and field behind the village of Chl'aba, calcareous bedrock, 142 m a. s. l., 47° 50.071' N, 18° 49.053' E, 22. 7. 2003, coll. Slovák & Perný | 20 | – |
| HAJ | L | Ipel'sko-rimavská brázda, Cerová vrchovina hills, village of Hajnáčka, dry field on the slopes of Hájnačka hill, 212 m a. s. l., 48° 14.956' N, 19° 57.939' E, 27. 7. 2003, coll. Slovák & Lihová | 20 | 15 |
| SOR | L | Slovenský kras karst, Soroška pass, dry meadow with shrubs (*Juniperus comunis*) and trees, 544 m a. s. l., 48° 37.053' N, 20° 37.805' E, 27. 7. 2003, coll. Slovák & Lihová | 20 | – |
| LAM | L | Podunajská nížina lowlands, city of Bratislava, Lamač, abandoned ruderal areas between the city quarter Lamač and crematory, 202 m a. s. l., 48° 11.951' N, 17° 02.672' E, 15. 7. 2003, coll. Slovák | 15 | – |
| ČUN | L | Podunajská nížina lowlands, city of Bratislava, Čunovo, nature reserve Ostrovné lúčky, ruderal margins of the road along Malé and Vel'ké Čunovo lakes, 119 m a. s. l., 48° 02.388' N, 17° 10.692' E, 16. 7. 2003, coll. Slovák | 19 | – |
| BANBE | L | Podunajská nížina lowlands, town of Bánovce nad Bebravou, mown ruderal outfield near the road, 162 m a. s. l., 48° 58.660' N, 18° 15.348' E, 3. 8. 2003, coll. Slovák | 20 | – |
| KOM | L | Podunajská nížina lowlands, town of Komárno, close to the village of Kava, inundation area of the river Váh, mown grassy areas near the river, 275m a. s. l., 47° 46.652' N, 18° 8.735' E, 26. 6. 2003, coll. Slovák, Hodálová & Perný | 20 | 9 |
| VRT | L | Podunajská nížina lowlands, village of Kamenín, below natural reserve Vršok hill, ruderal xerotherm slopes near gardens under protected area Vršok hill, calcareous bedrock, 221 m a. s. l., 47° 49.351' N, 18° 39.169' E, 22. 7. 2003, coll. Slovák & Perný | 20 | – |

| PC | Morphotype | Locality (Slovakia) | NI | NIS |
|---|---|---|---|---|
| VAP | L | Podunajská nížina lowlands, village of Želiezovce, Vápnik hill, abandoned travertine quarry, ruderal xerotherm margins of the path, calcareous bedrock, 260 m a. s. l., 48° 11.022' N, 18° 38.639' E, 19. 7. 2003, coll. SLOVÁK | 20 | 15 |
| LOP | L | Biele Karpaty Mts., village of Nová Bošáca, Lopeníček, ruderal margins of the road near old abandoned orchards, calcareous bedrock, 337 m a. s. l., 48° 52.938' N, 17° 47.592' E, 23. 7. 2003, coll. SLOVÁK & PERNÝ | 20 | – |
| KOL | L | Tríbeč Mts., village of Kolíňany, stone quarry on dry slopes of Kolíňanský vrch hill, calcareous bedrock, 212 m a. s. l., 48° 20.465' N, 18° 10.460' E, 27. 7. 2003, coll. SLOVÁK & LIHOVÁ | – | 10 |
| VAC | L | Strážovská Hornatina Mts., slopes of Mt. Vápeč, dry meadows and margins of shrubberies, calcareous bedrock, 543 m a. s. l., 48° 56.475' N, 18° 18.916' E, 23 .7. 2003, coll. SLOVÁK & PERNÝ | 19 | 19 |
| PlL | L | Pohronský Inovec Mts., village of Píla, mown meadow near the road, 470 m a. s. l., 48° 32.175' N, 18° 39.246' E, 3. 8. 2003, coll. SLOVÁK | – | 18 |
| DEM | L | Nízke Tatry Mts., Demänovská dolina valley, in the grassy areas on parking place N of the village of Pavčiná Lehota, 677 m a. s. l., 49° 02.192' N, 19° 34.611' E, 25. 7. 2003, coll. SLOVÁK & LIHOVÁ | 29 | 21 |
| LPT | L | Popradská kotlina basin, between the village of Liptovský Trnovec and the reservoir Liptovská Mara, ruderal margins of the fields, 588 m a. s. l., 49° 06.926' N, 20° 20.932' E, 22. 8. 2003, coll. SLOVÁK & LIHOVÁ | 20 | 8 |
| VRS | L | Biele Karpaty Mts. (severná časť), slopes of Mt. Vršatec, ruderal margins of meadows near cottages, calcareous bedrock, 730 m a. s. l., 49° 04.172' N, 18° 09.089' E, 23. 7. 2003, coll. SLOVÁK & PERNÝ | 20 | – |
| SCHB | H | Slovenský Raj Mts., above the Suchá Belá gorge, Glacká cesta, semiruderal meadow, calcareous bedrock, 942 m a. s. l., 48° 56.081' N, 20° 22.853' E, 25. 7. 2003, coll. SLOVÁK & LIHOVÁ | 20 | 12 |
| GER | H | Slovenský Raj Mts., below the cable car to Geravy, calcareous bedrock, 860 m a. s. l., 48° 52.194' N, 20° 23.476' E, 26. 7. 2003, coll. SLOVÁK & LIHOVÁ | 19 | – |

| PC | Morphotype | Locality (Slovakia) | NI | NIS |
|---|---|---|---|---|
| FAC | H | Lúčanská Malá Fatra Mts., Fačkovské sedlo saddle, meadows under cable car and margins of the road, calcareous bedrock, 1220 m a. s. l., 737 m a. s. l., 48° 57.296' N, 18° 37.441' E, 3. 8. 2003, coll. Slovák | 20 | – |
| VLK | H | Vel'ká Fatra Mts., village of Vlkolínec, mountain meadows below the village, calcareous bedrock, 586 m a. s. l., 49° 01.921' N, 19° 16.501' E, 25. 7. 2003, coll. Slovák & Lihová | 20 | 8 |
| LUC | H | Chočské vrchy Mts., between the villages of Lúčky and Osádka, calcareous bedrock, 643 m a. s. l., 49° 8.514' N, 19° 23.055' E, 26. 8. 2003, coll. Slovák & Lihová | 20 | 7 |
| DON | H | Nízke Tatry Mts., Donovaly mountain pass, ruderal margin of the road, calcareous bedrock, 867 m a. s. l., 48° 52.624' N, 19° 12.156' E, 2. 8. 2003, coll. Slovák | 19 | – |
| JAN | H | Nízke Tatry Mts., Jánska dolina valley, along the road through the valley, calcareous bedrock, 771 m a. s. l., 49° 048' N, 19° 40.505' E, 25. 8. 2003, coll. Slovák & Lihová | 20 | 16 |
| MAD | H | Západné Tatry Mts., Mačie diery, ruderal margins of the road between Zverovka and open-air museum, 900 m a. s. l., 49° 15.525' N, 19° 40.234' E, 21. 8. 2003, coll. Slovák & Lihová | 20 | 18 |
| ZDI | H | Belianske Tatry Mts., Ždiarska dolina valley mountain meadows and margins of the mountain road, near hotel Magura, calcareous bedrock, 890 m a. s. l., 49° 16.099' N, 20° 14.991' E, 24. 8. 2003, coll. Slovák & Lihová | 20 | 8 |
| CEK | H | Pieniny Mts., village of Červený Kláštor, wet meadows near the Dunajec river, ruderal biotopes, calcareous bedrock, 468 m a. s. l., 49° 23.341' N, 20° 25.325' E, 23. 8. 2003, coll. Slovák & Lihová | 20 | 16 |
| SPH | H | Spišské vrchy hills, Spišské Hanušovce village, in the interface of semiruderal field margins and shrubberies near the road, 616 m a. s. l., 49° 19.524' N, 20° 20.937' E, 23. 8. 2003, coll. Slovák & Lihová | 20 | 18 |
| STU | U | Malé Karpaty Mts., village of Stupava, on the left side of the village park, road to Červený Domček, 224 m a. s. l.,48° 16.894' N, 17° 03.594' E, 11. 10. 2005, coll. Slovák | 18 | – |

| PC | Morphotype | Locality (Slovakia) | NI | NIS |
|---|---|---|---|---|
| MAR | U | Malé Karpaty Mts., city of Bratislava, Záhorská Bystrica, orchards and gardens, 220 m a. s. l., 48° 14.086' N, 17° 03.231' E, 11. 10. 2005, coll. SLOVÁK | 13 | – |

correlation of particular characters with canonical axes was expressed as the total canonical structure.

4. In order to summarise morphological differences between the morphologically defined groups resulting from multivariate analyses, the exploratory data analyses were performed.

All multivariate analyses were carried out using the SAS 8.2 software (SAS INSTITUTE 2000), except for the cluster analyses and PCA, which were computed using SYNTAX 2000 (PODANI 2001).

A detailed distribution map was created based on the herbarium specimens as well as our own population samples. The phytogeographical division of the Slovak Republic (FUTÁK 1966) was used for an arrangement of particular localities.

## 3. Results

### 3.1. Morphometric Analysis

Results of all cluster analyses based on populations and mean values of measured characters except those on achenes (Matrix 1) showed two clusters representing two separated morphotypes (out of three analyses performed, only the result of the UPGMA method is presented on Fig. 1). The first group of populations represents a morphotype, which in Slovakia usually occurs in higher altitudes, predominantly on the calcareous bedrock (in further text referred to as "higher altitude morphotype"). Another group comprises plants collected mostly in ruderal biotopes at lower altitudes (in further text referred to as "lower altitude morphotype"). Two samples from populations collected from ruderal biotopes in lower altitudes at the interface of the Záhorská nížina lowlands and the Malé Karpaty Mts. are clustered together with populations of "higher altitude morphotype". However, although they occur in an ecological niche much more typical for the "lower altitude morphotype", they morphologically appeared to be intermediate or even closer to the "higher altitude morphotype". In the cluster of the "lower altitude morphotype" some subdivisions can be observed, however, they most likely do not reflect either ecological or geographical structure.

The ordination diagram of PCA (Fig. 2, two morphotypes resulting from cluster analyses are shown by different symbols) based on populations and all characters, except of those on achenes (Matrix 2), is in accordance with the results of the cluster analysis of population samples. A division visible along the first ordination axis delimits two fairly-well separated morphological groups of *P. hieracioides*. Two previously men-

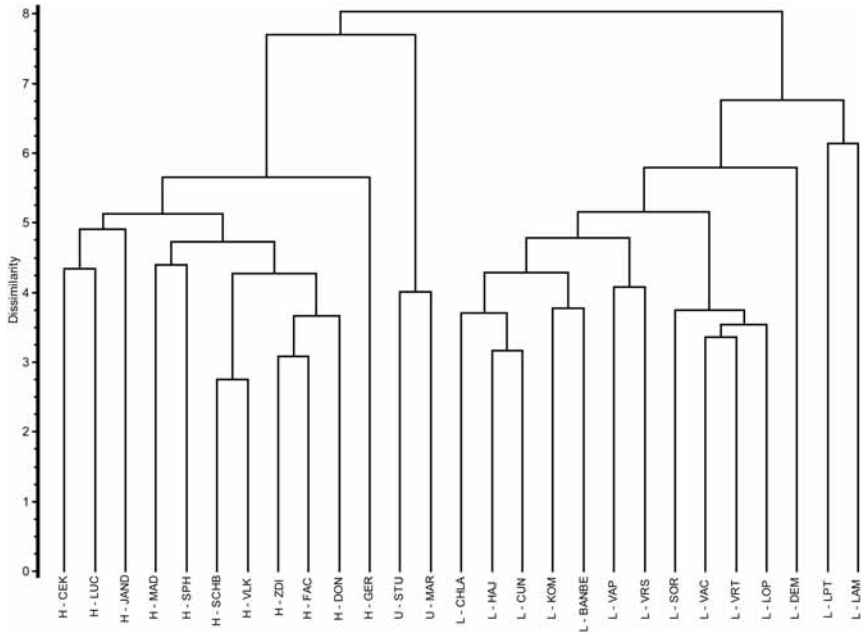


Fig. 1. Dendrogram of the average linkage (UPGMA) cluster analysis of population samples of *Picris hieracioides* from Slovakia. Clusters of the "higher altitude morphotype" (H) as well as two populations of morphologically "uncertain morphotype" (U) of *P. hieracioides* are situated on the left part of dendrogram, whereas the cluster on the reight corresponds to "lower altitude morphotype" (L). For population codes see Table 2.

tioned morphologically "uncertain" populations have outlying positions as was the case in the cluster analysis. The first two ordination axes explain 42.18% and 16.59% of the total variation of the morphological characters. The following characters were strongly correlated with the first component axis and, thus, have the highest influence on the delimitation of the two above mentioned morphotypes: distribution of capitula on stem branches, presence or absence of red longitudinal stripe on outer ligules, length of ligules, and length of inner bracts as well as colour of indumentum on involucrum. With the second ordination axis, length of the longest branch, and number of capitula per branch, were most strongly correlated and, therefore they play an important role in division along the second axis, separating two "uncertain" populations. In general, individuals representing the "higher altitude morphotype" compared to the lower altitude one are characterised by longer and narrower ligules, longer inner bracts as well as by presence of capitula on upper part of stem branches only; dark coloured involucral hairs are typical for the higher altitude morphotype.

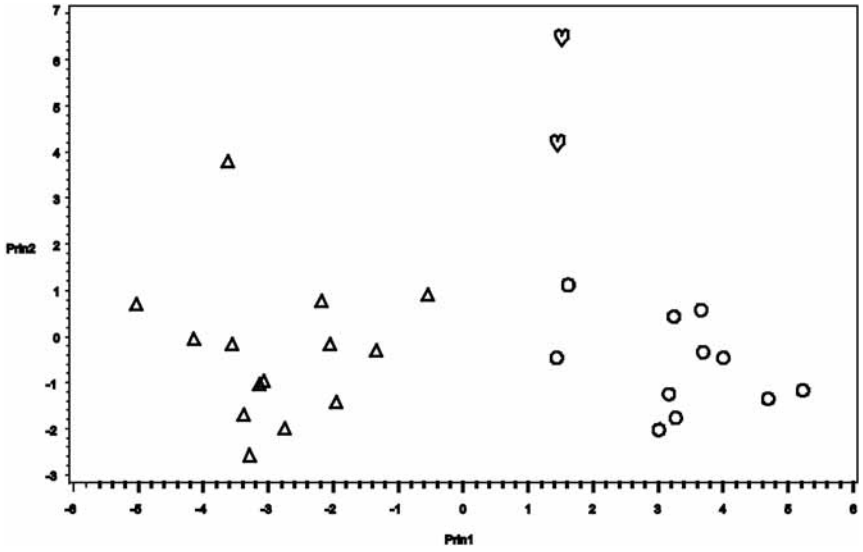


Fig. 2. Ordination diagram of the principal component analysis of 27 populations (531 individuals) of *Picris hieracioides* from Slovakia. Grouping on the left side of the diagram represents populations of the "lower altitude morphotype" of *P. hieracioides* (triangles), whereas the second grouping on the right corresponds to the "higher altitude morphotype" (circles). Two morphologically "uncertain" populations are marked with hearths. The first two ordination axes explain 42.18% and 16.59% of the total variation of morphological characters.

To test the results obtained in PCA, canonical discriminant and classificatory discriminant analyses were performed on individual plants using Matrix 2, excepting two "uncertain" populations. Very good separation of both morphotypes with minor overlaps appeared on the histogram of CDA (black and crosshatched column in Fig. 3). This division is influenced by many of the same characters as those in the PCA. Correlation coefficients of particular characters with the canonical axis are presented in Table 1. In the non-parametric k nearest neighbours classificatory discriminant analyses, with k = 30 (not shown), more than 99 % of individuals from both tested groups were classified correctly.

In the following step, to detect the objective position of the plants from the two "uncertain" populations in morphological space, the discriminant function from the previous analysis was applied to the individuals of these two populations, and their position was depicted on the resulting histogram according to their canonical scores, together with plants from typical populations. The result shows a morphological affinity of the "uncertain" plants to the "higher altitude morphotype". Only a minority of individuals from "uncertain" populations were integrated to

Table 3. Principal component analysis of individual plants of *Picris hieracioides*. Correlation coefficients expressing the correlation of morphological characters and the first two principal components. Values higher than 0.6 are high lighted in bold.

| Characters | PCA | |
|---|---|---|
| | **axis 1** | **axis 2** |
| NBr – Number of stem branches | **0.790** | 0.153 |
| NL – Number of stem leaves | **0.711** | –0.190 |
| LBr – Length of the longest stem branch | –0.193 | **0.846** |
| NCBr – Maximum number of capitulas per stem branch | –0.140 | **0.816** |
| DC – Distribution of capitulas on stem branches - 1/2 to 1/3 | **–0.944** | 0.147 |
| RSL – Presence or absence of red longitudinal stripe on outer ligules | **0.806** | 0.297 |
| BML – Presence or absence of brown marks on upper part of ligules | 0.169 | **0.623** |
| LL – Length of ligule | **–0.876** | 0.329 |
| LCT – Length of corolla tubes | **–0.777** | 0.076 |
| WL – Width of ligules | 0.245 | **0.622** |
| LTL – Length of teeth on ligule | **–0.773** | 0.160 |
| LP – Length of the longest peduncle | **–0.661** | **0.623** |
| NCP – Maximum number of capitulas per peduncle | 0.386 | 0.460 |
| NBP – Maximum number of bracts per peduncle | **–0.787** | 0.147 |
| NoB – Average number of all outer bracts from three randomly chosen capitula | 0.566 | 0.129 |
| NiB – Average number of all of inner bracts from three randomly chosen capitula | 0.102 | **0.647** |
| LoB – Length of outer bracts | –0.566 | 0.019 |
| WoB – Width of outer bracts | –0.570 | –0.093 |
| LiB – Length of inner bracts | **–0.935** | –0.038 |
| WiB – Width of inner bracts | **–0.665** | –0.549 |
| DH – Presence of dark hair on involucrum | **–0.868** | –0.247 |
| PH – Presence of pale hair on involucrum | **0.876** | –0.108 |
| IH – Presence of intermediate hair on involucrum | –0.219 | 0.454 |
| DHI – Distribution of hairs on involucrum | 0.441 | 0.091 |
| DHP – Distribution of hairs on peduncle | **0.706** | 0.162 |

the group of the "lower altitude morphotype". These atypical populations are differentiated from the "higher altitude morphotype" predominantly by narrower inner bracts, longer stem branches and more often the presence of a red stripe on outer ligules; from the "lower altitude morphotype" they predominantly differ in length of ligule, length of peduncle, and by the distribution of capitula on branch.

Because of the fact that it was not possible to obtain achenes for all measured plants included in the above-mentioned analyses, we prepared a separate matrix (Matrix 3), based on achene characters from selected populations only (Table 2). On the PCA ordination diagram (Fig. 4) some

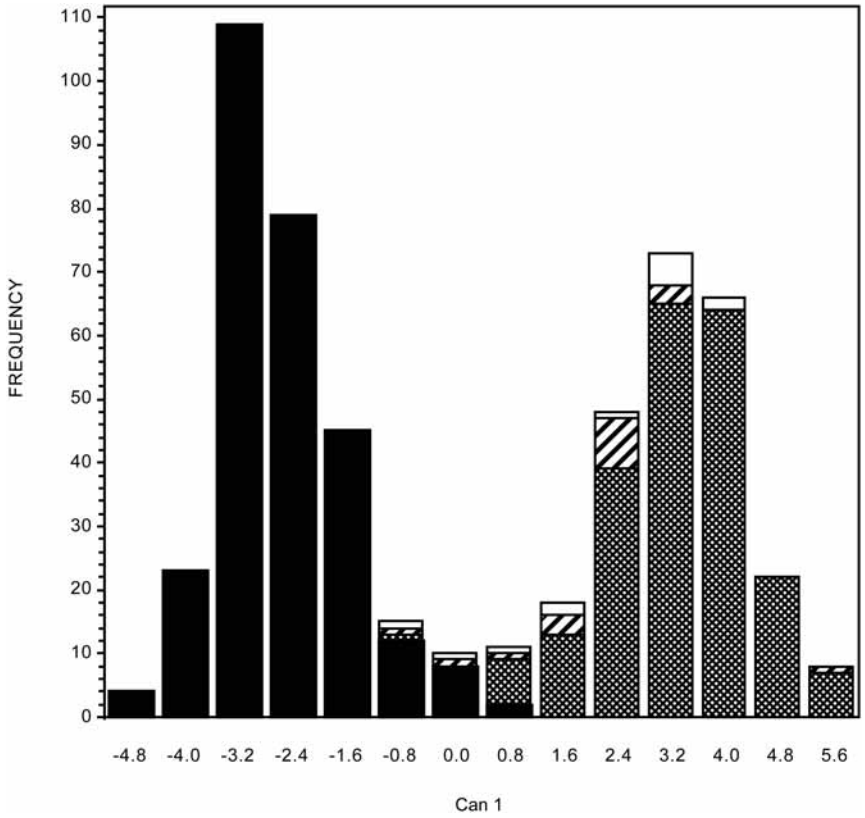


Fig. 3. Histogram of the canonical discriminant analysis based on individual plants of *Picris hieracioides* as OTU's. "higher altitude morphotype" of *P. hieracioides* (crosshatched), "lower altitude morphotype" (black). Morphologically "uncertain" populations from the village of Stupava (hatched) and from the village of Mariánka (white) are depicted on resulting diagram according to their scores computed from the discriminant function based on higher and lower altitude morphotypes

tendency in placement of the "lower altitude morphotype" achenes to the right part of the diagram along the first axis and "higher altitude morphotype" ones to the left one, is visible. However, no clearly separated groups can be delimited. Ordination axes explain 56.00%, 28.10% and 1.57% of variation among measured characters of achenes. The histogram of the canonical discriminant analysis (not shown), based on characters of achenes with lower and higher altitude morphotypes as groups shows almost the same large overlap of achenes of examined groups.

The results of exploratory data analyses of "higher" and "lower altitude morphotype" (Table 4) also show differences between them. They differ in several quantitative characters with only slight overlap in ex-

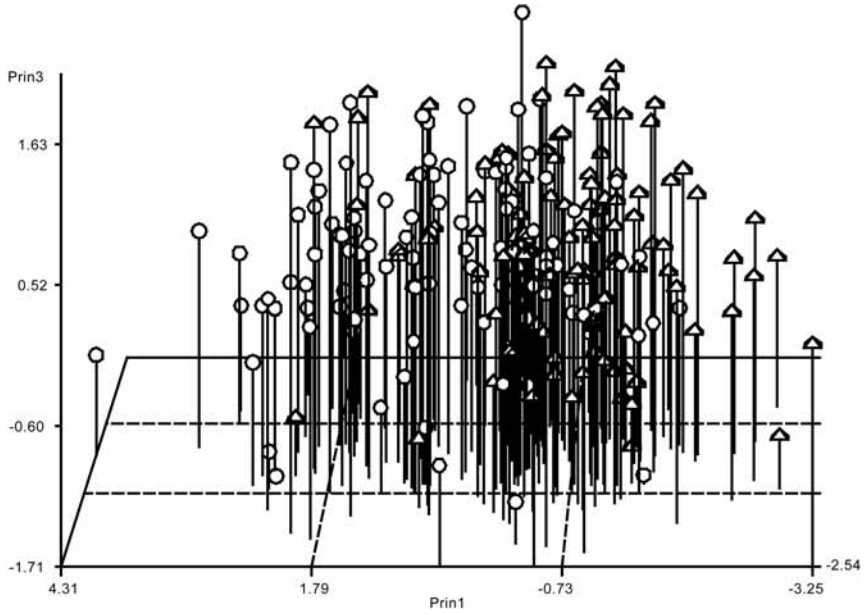


Fig. 4. Ordination diagram of the principal component analysis of individuals of *Picris hieracioides* from Slovakia based on Matrix 3. Circles represent achenes from the populations of "higher altitude morphotype", triangles correspond to achenes from the populations of "lower altitude morphotype".

treme values. Most conspicuous discriminating characters are length of ligules, length of teeth of ligule, length of inner bracts and width of inner bracts.

### 3.2. Geographical Distribution and Ecological Requirements

On the basis of 442 herbarium specimens from seven herbaria (see Material and Methods) and 27 population samples collected during the course of the present study, a detailed distribution map of both *P. hieracioides* morphotypes in Slovakia was prepared. As is apparent from the map (Fig. 5), the morphotypes are to large extent geographically separated.

In general, the "lower altitude morphotype" inhabits lowlands and lower altitude biotopes throughout Slovakia. Usually it occurs in altitudes from 100 to 500 m a. s. l., and only very rarely inhabits biotopes in the mountain belt (Mt. Vršatec, 926 m, FAJMONOVÁ 1963, BRA); however, in such cases, it occupies strongly disturbed anthropogenic areas. From our field observations as well as herbarium specimens, it can be concluded that the "lower altitude morphotype" usually occurs on xerotherm biotopes strongly influenced by anthropic activities. Predominantly, it occupies ruderal biotopes like urban outfields, along the highways or another

Table 4. Results of the exploratory data analysis of "lower altitude morphotype", "higher altitude morphotype" and morphologically "uncertain populations" (SW Slovakia) of *Picris hieracioides* from Slovakia. For the explanation of acronyms of morphological characters see Table 1. St dev. – standard deviation, perc. – percentile.

| Char. | "Lower altitude morphotype" | | | "Higher altitude morphotype" | | | Morphologically "uncertain morphotype" | | |
|---|---|---|---|---|---|---|---|---|---|
| | mean | st. dev. | perc. (1) 5 - 95 (99) | mean | st. dev. | perc. (1) 5 - 95 (99) | mean | st. dev. | perc. (1) 5 - 95 (99) |
| NBr | 10.7 | 5.81 | (1-) 1-21(-28) | 5.6 | 2.50 | (1-) 5-9 (-13) | 6.5 | 2.73 | (3-) 3-12 (-15) |
| NL | 19.4 | 5.75 | (7-) 8-34 (-29) | 14.8 | 3.35 | (8-) 15-20 (-23) | 12.4 | 3.45 | (8-) 8-19 (-21) |
| LBr | 10.1 | 10.97 | (0.2-) 0.6- 29.5 (-49.2) | 11.0 | 6.76 | (1.8-) 9.3-22.6 (-33.2) | 21.8 | 10.32 | (5.0-) 5.1- 40.3 (-43.3) |
| NCBr | 5.0 | 2.59 | (1-) 1-10 (-15) | 5.3 | 2.67 | (2-) 5-10 (-14) | 7.0 | 3.62 | (2-) 2-15 (-16) |
| LL | 9.7 | 1.02 | (6.7-) 7.1-11.3 (-12.2) | 12.4 | 1.83 | (9.0-) 12.3-16.3 (-17.6) | 13.7 | 1.78 | (11.0-) 11.0-16.7 (-16.9) |
| LCT | 4.4 | 0.68 | (2.8-) 3.0-5.6 (-6.3) | 5.3 | 0.99 | (3.4-) 5.2- 6.9 (-8.0) | 5.0 | 0.94 | (3.4-) 3.4-6.9 (-7.2) |
| WL | 2.5 | 0.32 | (1.7-) 1.8-3.0 (-3.2) | 2.4 | 0.33 | (1.8-) 2.4-2.9 (-3.2) | 2.9 | 0.42 | (2.4-) 2.4-3.5 (-4.0) |
| LTL | 0.7 | 0.33 | (0.3-) 0.3-1.0 (-2.3) | 0.9 | 0.43 | (0.4-) 0.9-1.7 (-2.7) | 0.9 | 0.39 | (0.4-) 0.4-1.6 (-2.1) |
| LP | 2.2 | 1.09 | (0.4-) 0.4-4.2 (-5.6) | 3.6 | 1.56 | (1.0-) 3.5-6.2 (-7.3) | 5.8 | 2.27 | (2.2-) 2.2-9.5 (-9.9) |
| NCP | 2.7 | 0.78 | (1-) 2-4 (-5) | 2.4 | 0.67 | (1-) 2-3 (-4) | 2.5 | 0.85 | (1-) 1-4 (-5) |
| NBP | 2.4 | 0.86 | (0-) 1-4 (-5) | 4.0 | 1.58 | (2-) 4-7 (-9) | 3.8 | 1.49 | (2-) 2-7 (-8) |
| NoB | 15.8 | 1.85 | (11-) 11-19 (-20) | 14.1 | 1.91 | (10-) 14-17 (-18) | 14.3 | 1.50 | (12-) 12-17 (-18) |
| NiB | 12.7 | 0.81 | (9-) 11-14 (-14) | 12.7 | 0.84 | (11-) 13-14 (-16) | 13.2 | 1.04 | (9-) 10-15 (-15) |
| LoB | 4.6 | 0.63 | (3.0-) 3.1-5.6 (-5.9) | 4.9 | 0.72 | (3.5-) 4.8-6.2 (-6.7) | 4.9 | 0.70 | (3.2-) 3.3-5.7 (-6.4) |
| WoB | 1.1 | 0.20 | (0.7-) 0.7-1.4 (-1.6) | 1.2 | 0.19 | (0.7-) 1.1-1.5 (-1.6) | 1.0 | 0.19 | (0.6-) 0.6-1.2 (-1.5) |
| LiB | 9.2 | 0.84 | (7.0-) 7.2-10.7 (-11.3) | 11.0 | 1.12 | (8.5-) 10.9-12.8 (-14.1) | 10.3 | 1.06 | (8.3-) 8.3-12.1 (-12.3) |
| WiB | 1.3 | 0.18 | (0.9-) 0.9-1.6 (-1.8) | 1.5 | 0.21 | (1.1-) 1.5-1.8 (-2.0) | 1.1 | 0.16 | (0.8-) 0.8-1.4 (-1.5) |

strongly disturbed ecosystems, while in seminatural plant communities (mowed meadows) it is scattered or grows only ephemerally. Only a slight overlap with the distribution of the "higher altitude morphotype" can be observed in the southernmost parts of mountain ranges or lower altitude localities with a colder and more humid climate. Such areas of overlap of distribution of these two morphotypes are in the north-east Slovakia, in the Slovenské rudohorie Mts., Muránska planina plateau and in the southern part of the Nízke Tatry Mts.

Unlike the previous morphotype, the distribution of the "higher altitude morphotype" seems to be restricted in Slovakia to the high mountain ranges; it has also a conspicuous affinity to calcareous bedrock. The most abundant occurrence of this morphotype is recorded from the Vel'ká Fatra and Malá Fatra Mts., Nízke Tatry and Belianske Tatry Mts., Pieniny and Slovenský Raj Mts. Here, it occupies biotopes situated in altitudes above 500 m a. s. l., often exceeding 1000 m a. s. l., with a local maximum in the Vel'ká Fatra Mts. (Vel'ká Ramižiná, below Mt. Krížna, 1490 m a. s. l., Kliment 1988, BRA). According to our field observations and a revision of the herbarium specimens there are only a few records from the Západné and Vysoké Tatry Mts. and no records from higher altitudes of the Kremnické vrchy or Štiavnické vrchy Mts. These observations support our hy-

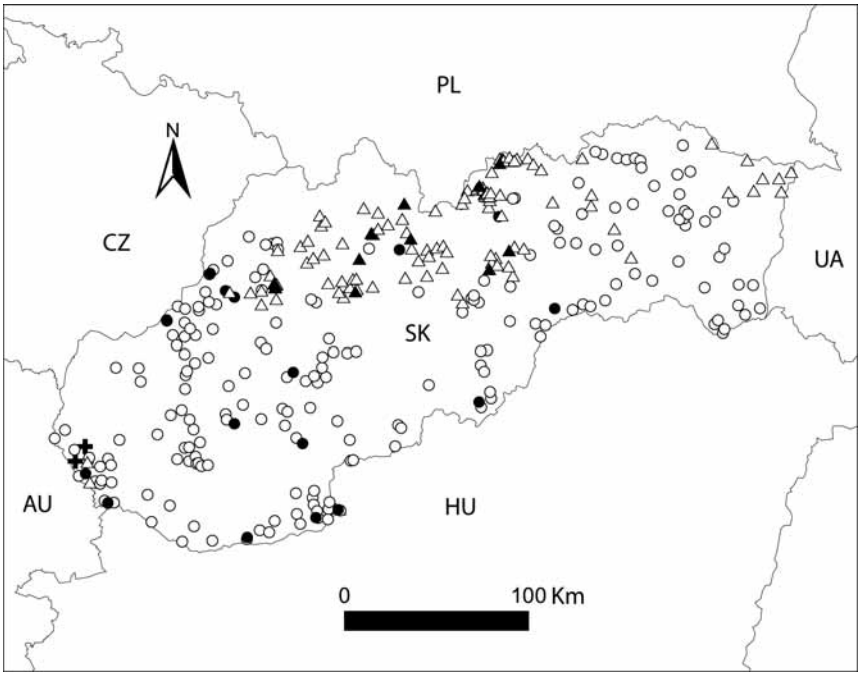


Fig. 5. Distribution map of *Picris hieracioides* morphotypes in Slovakia, herbarium specimens of "lower altitude morphotype" (empty circles) and "higher altitude morphotype" (empty triangles), author collections of "lower altitude morphotype" (filled circles), "higher altitude morphotype" (filled triangles) and morphologically "uncertain" populations from southwest Slovakia (filled crosses)

pothesis about the calcareous bedrock preference of mountain populations. In the eastern part of Slovakia, the "higher altitude morphotype" was found also in lower altitudes (e.g., village of Adidovce, 250 m, Soják 1957 PR 562524, 562525), but these are probably localities with colder and more humid conditions.

The origin of the isolated localities of the atypical "higher altitude morphotype" near Bratislava city (Mariánka village, Záhorská Bystrica village) is uncertain.

## 4. Locality Lists

The lists of localities of *Picris hieracioides* morphotypes in Slovakia are based on revised herbarium specimens. Localities from Table 2. are not included here.

### 4.1.1. Lower Altitude Morphotype

PANNONICUM. Burda (Kováčovské kopce): Basalt rocks (Nábělek 1936 SAV). – village of Kováčov (Langr 1947 BRNM 0523656, Domin 1929 PRC). – village of Lel'a,

slopes above the village (Bertová 1989 SAV). – village of Kováčov, road between the villages of Kováčov and Chl'aba, margin of the forest (Smejkal & Marvan 1960 BRNU 408536).

Ipel'sko-rimavská brázda: village of Pukanec (Bakabánya), Stopnica (Kupčok 1894 PRC 103886). – area Skaly, above railway station of the village of Kamenica nad Hronom, 120 m, 130 m, 160 m, 250 m, (Soják 1956 PR 561757, Soják 1956 PR 272655, Soják 1956 PR 561756, Smejkal 1968 BRNU 439446, Vicherek 1972 BRNU). – village of Kamenica nad Hronom, on the pasture, 164 m (Weber 1930 PR 235996, Weber 1932 BRA 236012, Weber 1936 BRA, Deyl & Soják 1964 PR). – village of Bajtava, hills near the village (Weber 1935 BRA). – village of Salka, in the vineyards (Májovský 1963 SLO). – "Magas hegy" near the town of Šahy (Weber 1933 PR 236011). – Šípka near the village of Plášťovce (Weber 1935 PR 235997, Májovský 1963 SLO). – village of Tešmák near Šahy, on the hill, 130–170 m (ex herb. Hlavaček 1938 BRA). – Ďarmotské kopce Hills, southern slopes among vineyards (Klika 1937 PR). – Ďarmotské kopce Hills, xerotherm slopes of Vel'ký kopec ("Nagy Hegy") hill, 170–200 m (Hejny 1954 PR). – Ďarmotské kopce Hills (Májovský 1958 SLO). – town of Velký Krtíš, near the hospital (Slabá 1973 PR 2229). – village of Malý Krtíš (Májovský 1956 SLO). – Tomášovce – Rimavská Sobota (Vrťová 1973 SLO). – Hájnačka hill near the village of Hájnačka (Futák 1946 SLO). – Vyšná Pokoradz near town of Rimavská Sobota, dry slope (Vrťová 1973 SLO). – town of Rimavská Sobota ("Rimaszombát") (Freyer 1867 BRA, Fábry 1869, 1879 BRA, ex herb. Blatný 1941, 1947, 1951 BRA). – town of Rimavská Sobota, Šibeničný vrch hill (Vrťová 1973 SLO). – village of Gemerské Dechtáre ("Détér") near the village of Jesenské ("Feledince", "Feled"), 250 m (Klášterský 1938 PR). – Pusta Vereš ("Verös puszta") village, near the village of Jesenské ("Feledince", "Feled"), 250 m (Klášterský 1938 PR). – village of Drienčany, dry meadow near the river Blh (Vrťová 1974 SLO).

Slovenský kras: village of Jelšavská Teplica, pasture, 250 m (Michalko, Džatko 1957 SAV). – village of Gombasek, 250–500 m (Vašák 1978 BRA). – village of Kečovo, calcareous rocks (Dostál 1970 PR 301493). – village of Silica, trail in the field near Hungarian border, 350 m (BRNU 631760). – village of Silica, NW, fields (Chrtek, Žertová 1956 PRC). – among the villages of Bôrka, Hrhov and Dvorníky, along the road (Dočolomanský 1962 BRA). – village of Zádiel (Brym 1919 PRC). – Zádielska dolina valley, 300 m (250–800 m) (Dočolomanský 1962 BRA, Dostál 1927 PRC). – village of Turňa nad Bodvou, 250 m (Dostál 1927 PRC). – village of Turňa nad Bodvou, slopes of the Turniansky hrad castle, 350 m (Dočolomanský 1962 BRA).

Záhorská nížina: village of Zohor, near potato field (Slavoňovský 1958 BRNU). – village of Záhorská Ves, sands near the village (Valenta 1938 BRA). – village of Jakubov, on sands, 160 m (Ptačovský 1924 SAV). – town of Senica, near the railway station, 200 m (Dvořák, Grüll 1976 BRNU 473787).

Devínska Kobyla: Devínska Kobyla hill, buiding site of Faculty of Natural Sciences of the Comenius University, Mlynská dolina valley (Dráboová 1983 SLO). – Devínska Kobyla hill, 514 m (Kaleta 1961, 1963 BRA, Feráková 1975 SLO, Pecníková 1968 BRA, Májovský 1936, 1980 SLO). – Devínska Kobyla hill, stone quarry (Opluštilová 1947 SLO).

Podunajská nížina: city of Bratislava, Rača, railway station (Kothajová, Feráková 1976 SLO). – city of Bratislava, Rača, Krasňany (Hodovál 1968, 1981 BRA). – city of Bratislava, Petržalka, Dostihová dráha (Hodovál 1983 BRA). – city of Bratislava, Petržalka, Botevova street (Feráková, Dráboová, Halada 1984 SLO). – city of

Bratislava, Petržalka, Starý Háj (Šípošová 1986 SAV). – city of Bratislava, fields between the city quarters of Rusovce and Jarovce (Votavová & Májovský 1971 SLO). – city of Bratislava, ostrov Kopáč island, Danube barrage (Kothajová 1985 SLO, Svobodová 1985 SLO, Hodovál 1975 BRA). – city of Bratislava, Rača, 164 m (Dočolomanský 1963 BRA). – city of Bratislava, Dynamitka factory [factory of the company Istrochem], 140 m (Ptačovský 1926 SAV, Dočolomanský 1963, 1964 BRA, Feráková 1976 SLO). – city of Bratislava, student residence Mladá Garda, 164 m (Dočolomanský 1963 BRA). – city of Bratislava, – Ostredky (Feráková 1968 SLO). – Bratislava, Zlaté Piesky (Hodovál 1978 BRA). – city of Bratislava, Pálenisko, gravel pits (Májovský 1968 SLO). – city of Bratislava, Čunovo, Ostrovné lúčky, along the lake (Hodovál 1978 BRA, Májovský 1983 SLO). – Topol'ové Hony, near Podunajské Biskupice in Bratislava (Bertová, Pakozdyová, Rácová 1987 SAV). – village of Jur pri Bratislave ("Svätý Jur"), vineyeards Káspikel and Frangle, 250 m (Dočolomanský 1962 BRA). – nature reserve Šúr, near the village of Svätý Jur (Buta 1955 SLO, Hodovál 1968 BRA). – town of Modra ("Modor") (Mergl 1894 SAV). – village of Lehnice, meadows northwest of "Kerites majcia", 122 m (Jasičová 1957 SAV). – village of Bodíky, meadows near gamekeeper house Dekán (Bertová 1986 SAV). – village of Zeleneč (Juriš 1951 SLO). – town of Dunajská Streda, 115 m (Valenta 1938 BRA). – between the villages of Medved'ov and Palkovičovo, in flood-plain forest, 114 m (Lizoň 1964 BRA). – village of Bučany (Frantová 1942 SLO). – town of Galanta, on the bank of river, direction to Ulčany (Slavoňovský 1959 BRNU 493813). – village of Vel'ky Meder ("Čalovo"), near Dobos Derka, 112 m, 109 m (Krist 1938 BRNU 299626, 299627). – village of Váhovce, in flood-plain forest, near of dam Král'ová priehrada (Niková 1973 SLO, Schwarzová 1975 SLO). – village of Kajal ("Únovce") "Kajal", gravel pit (Niková 1973 SLO). – town of Hlohovec (Maglocký 1970 SAV). – village of Šoporňa, in forest (Niková 1973 SLO). – village of Štrkovec, Malá Sihot' (Niková 1973 SLO). – village of Král'ová nad Váhom (Niková 1973 SLO, Schwarzová 1975 SLO). – village of Sasinkovo (ex herb., Ješko 1960 BRA, ex herb. Ješko 1967 BRA). – village of Sasinkovo, field trail, grove Vagaš (ex herb. Ješko 1967 BRA). – village of Moravany nad Váhom (Marhold 1992 SAV). – village of Dlhá nad Váhom, in flood-plain forest near the river Váh (Niková 1973 SLO). – village of Dlhá nad Váhom (Feráková 1975 SLO). – village of Rumanová, in the glade (Ješko 1963 BRA). – town of Šal'a, left bank of the river Váh (Niková 1973 SLO). – village of Okánikovo (Májovský 1964 SLO). – village of Mladý Háj (Ješko s.d. BRA). – village of Trnovec nad Váhom, on the pasture (Weber 1929 PR). – village of Sokolníky ("Salakuzy"), village 200 m (Krist 1938 BRNU 288413). – town of Komárno, in the meadows (Deyl 1959 PR 515366). – village of Chotín, dry sands, 120 m (Májovský 1958 SLO, Dostál 1947 PRC). – village of Marcelová, near the river Žitava (Štěpánek 1984 PR). – village of Modrany (Májovský 1958 SLO). – Arboretum Mlyňany near the village of Tesárske Mlyňany (Náběl ek 1953 SAV). – Drieňová hora Hill, near the village of Gbelce (Májovský 1959 SLO). – village of Čenkov, gamekeeper house (Májovský 1963 SLO, Weber 1933 PR 235999). – village of Jurský Chlm, near the village of Mužla (Májovský 1980 SLO). – village of Tekovské Nemce (Lányi 1962 BRA). – town of Tlmače (Valenta 1938 BRA). – between the towns of Levice and Tlmače, 200 m (Krist 1938 BRNU 299628). – village of Bíňa (Weber 1935 BRA). – village of Bíňa, Avarský hrink (Weber 1929 PR 235998). – village of Kamenín, on the saline "Alsó rétek", in the field, 110 m (Šourek 1954 PR 272653). – between the villages of Čata and Pastovce (Weber 1960 BRA). – Jankov vŕšok ("Hegyfarok") hill, near the town of

Štúrovo (Weber 1932 PR 236009). – Kamenný Most ("Kamenný Most nad Hronom", "Kamenné Ďarmoty"), 115 m (Smejkal 1959 BRNU 404082, 404083, 404085). – town of Štúrovo, SW slope of hill Boží Kopec, above the river Danube, 130 m (Vicherek 1972 BRNU). – town of Štúrovo, 120 m (Krist 1934 BRNU 262103, Deyl 1952 PR, Hodovál 1976 BRA). – town of Štúrovo, SW slope of the hill Modrý Vrch, 210 m. (Vicherek 1972 BRNU). – near the village of Močany, on the pasture (Šmarda 1951 BRNM 70161).

Košická kotlina: village of Moldava nad Bodvou, along the railway station, 205 m (Jehlík 1964 PR). – city of Košice, – Hradová hill, ruderal area, 300 m, 360 m (Dostál 1952 PR, Hlavaček 1954 SAV). – Holica hill, nearby the village of Nižná Hutka, 200 m (Michalko 1960 SAV).

Východoslovenská nížina: village of Malý Kamenec, natural reserve Tarbucka (Pospíšil 1958 BRNM 0551602, 0551600). – village of Vel'ký Kamenec, slope above the road near village (Pospíšil 1958 BRNM 0551598). – village of Viničky, side chanell of the river Bodrog (Májovský 1964 SLO). – Szomoš hill, 10 km west of the village of Ladmovce, on the pasture, 150–200 m (Sutorý 1986 BRNM). – between the village of Bol' and the town of Král'ovský Chlmec, meadow near the oxbow lake Tica (Pospíšil 1958 SAV). – village of Čierna nad Tisou, along the railway, 103 m (Jehlík 1964 PR). – Bol', on the meadow near the oxbow lake Tica (Pospíšil 1958 BRNM 0551601). – Bol', on the bank of the river Latorica in *Betula pendula* forest (Májovský & Kytka 1980 SLO). – village of Vojany, near road to the electric power station (Hajdúk 1972 BRA). – village of Vel'ké Kapušany, along the railway 110 m (Jehlík 1964 PR). – village of Zemplínske Hradište, vineyards (Holuby 1887 BRA). – village of Krásnovce, road to Michalovce, trail under orchards (Králik 1974 SLO). – village of Drahov, 300 m (Dostál 1947 PRC). – town of Michalovce (Pöllerbauer 1937 PRC, Pospíšil 1958 SAV, Pospíšil 1958 BRNM 0551599). – village of Vranou nad Topl'ou, pasture on the SE margin of the town (Pospíšil 1961 BRNM 0551591). – village of Brekov, below Brekov castle, 270 m (s. colL. 1969 BRA).

CARPATICUM OCCIDENTALE. Biele Karpaty (južná časť): village of Nová Bošáca, along the road to the village of Grúň (Perný 1997 SAV). – village of Chocholná-Velčice, Machnáč settlement, Chocholanská dolina valley (Perný 1997 SAV). – village of Dolné Srnie, in the area of Vojnové (Hargašová 1962 BRA). – village of Adamovské Kochanovce (Jurákovec), Kurinov vrch hill, 400 m (Perný 1997 SAV). – village of Drietomá, E slope of Žlab hill, 290 m (Černá 1985 BRNU 525367).

Malé Karpaty: village of Borinka (Májovský 1964 SLO). – Dobrá Voda (Ladovičová 1971 SLO). – Bradlo hill, near the village of Brezová pod Bradlom (Schwarzová 1969 SLO). – Brezovské kopce hills, near the village of Brezová pod Bradlom, 400 m (Kmeťová 1968 SAV). – town of Nové mesto nad Váhom, Turecko hill, dry slopes, 160 m, 230 m (Michalko 1950 SAV, Futák 1960 SAV). – village of Višnové, hill of Čachtický hrad castle (Futák & Peniašteková 1973 SAV, Deyl & Soják 1967 PR 260317, 260318, 260319, 260320).

Považský Inovec: between the villages of Hubina and Skalka (Maglocký 1968 SAV). – village of Sokolovce, dry slopes above village (Michalko 1959 SAV). – village of Stará Lehota (Marhold 1992 SAV). – village of Podhradie (Maglocký 1970 SAV). – Drieňový vrch hill (Hrušovská 1982 SLO). – Tematínske kopce hills, on the slope near the stream Kolište, 240 m (Michalko 1956 SAV). – village of Selec-Hradisko (Hrušovská 1982 SLO, Schidlay 1953 SAV). – village of Beckov (Maglocký 1966,

1967 SAV, Hrušovská 1982 SLO ). – village of Trenčianske Jastrabie, Mitická slatina (Perný 1997 SAV). – village of Krivosúd-Bodovka, stone-quarry (Hrušovská 1982 SLO).

Tríbeč: Zobor hill, S slopes in vineyards, near the town of Nitra (Pulchart & Souček 1933 SLO). – Vel'ký Lysec hill, near the village of Ladice (Kováčiková 1972 SLO). – Hrdovická hill (Kováčiková 1972 SLO). – village of Klátová Nova Ves, southern slope of Kostrín hill (Kováčiková 1972 SLO).

Strážovské a Súl'ovské vrchy: gamekeeperhouse Chalmová near the village of Chalmová (Michalko 1958 SAV). – town of Bojnice, area of Kalvária (Novacký 1938 BRA). – town of Trenčín (Brancsik 1900 PRC, Brancsik 1948 BRA, Schidlay 1954 SAV, Perný 1997 SAV). – village of Trenčianske Teplice, near the top of Král'ovce hill (Podpěra 1932 BRNU 231906, Náběl ek 1949 SAV, Džatko 1957 SAV). – between the town of Trenčianske Teplice and the village of Trenčianska Teplá (Náběl ek 1949 SAV). – Čičmanský hrad castle, area around the castle (Králik 1972 SLO). – village of Pružina (Marhold 1992 SAV). – village of Domaniža (Marhold 1992 SAV). – village of Babkov, Babkovská Brána (Hallonová 1978 SAV). – Dolina Strinianka valley, road to Lietavský hrad castle (Hallonová 1977 SLO). – Lietavské sedlo saddle, between of Drieňovec hill and Lietavský hrad castle (Hallonová 1978 SLO). – Súl'ovské skaly, between the villages of Súl'ov and Hradná (Skalický 1973 PRC).

Pohronský Inovec: village of Žarnovica, area of Kalvária, along the trail, 270 m (Lányi 1962 BRA). – village of Píla, 210–219 m (Lányi 1963 BRA, Lányi 1963 BRA).

Kremnické vrchy: village of Budča, in the meadow 320 m (Deyl & Soják 1967 PR 260321, 260322, 260323, 260324, 2603250). – village of Trnavá Hora, in shrubs, 320 m (Lányi 1962 BRA). – village of Nevol'né, railway station, 620 m (Lányi 1962 BRA). – village of Čremošné, near the road (Dvořák 1963 BRNU 422082).

Pol'ana: town of Zvolen, 500 m (Petrášová 1963 BRA, Freyn 1869 BRNM).

Štiavnické vrchy: village of Ladzany, near Tlstý vrch hill (Blažková 1964 SAV). — village of Hronský Beňadik (Lányi 1962 BRA). – Hampoch hill near the village of Pukanec, 555 m (Hlavaček 1976 BRA). – above the village of Banská Hodruša "Hodrua – Hámre", near the town of Banská Štiavnica, forest (ex herb. Hlavaček 1937 BRA). – Mt. Sitno, near the town of Banská Štiavnica (Cserey 1890 BRA). – village of Vyhne, on S slopes, fields, 420–425 m (Lányi 1962 BRA, Valenta 1990 BRA). – village of Sklené Teplice (Marhold 1992 SAV). – between the villages of Ladomer and Ladomerská Vieska, left bank of the river Hron, on the basalt bedrock, 210 m (Lányi 1962 BRA).

Slovenské rudohorie: town of Tisovec (Vraný 1922 BRA). – village of Lukovištia (Vrťová 1973 SLO). – road between the villages of Muráň and Muránska Dlhá Lúka (Opluštilová 1952 SLO). – Radzim hill, near the town of Revúca (Hajdúk 1956 SAV). – near the village of Olcnava, Galmus hill (Hajdúk 1959 SAV). – town of Krompachy, oak forest on the slope oposite of Kovobrus factory, 300 m (Hajdúk 1970 BRA).

Muránska planina: Hradová, natureal reserve, near the town of Tisovec, 600 m (Černoch 1956 BRNM 400105). – Hrdzavá dolina valley, 400 m (Dočolomanský 1963 BRA). – along the road from village of Muráň to the town of Tisovec, pastures near the road, 430 m (Dočolomanský 1963 BRA). – village of Muráň, calcareous rocks in the forest, 394 m (Deyl 1937 PR, Dočolomanský 1963 BRA). – from the village of Muráň to the Muránsky hrad castle (Dočolomanský 1963 BRA). – village of Muráň, direction to Suchá valley, under Osiská, 400 m (Hendrych 1949 PR).

Slovenský raj: Šulerloch hill ("Schullerloch", "Kleine Rittenberg"), southern slopes (MÁJOVSKÝ 1956 SLO).

Stredné Pohornádie: village of Vel'ká Lodina, 350 m (DOSTÁL 1928 PRC). – between the villages of Jaklovce and Margecany, near Kurtova skala rock, calcareous bedrock, 800 m (MĚSÍČEK 1961 PR).

Slanské vrchy: village of Kapušany, 320 m (POSPÍŠIL 1961 BRNM 0551593).

Vihorlat: village of Dlhé nad Cirochou, Biely vrch, above the river Cirocha, 300 m (TÖRÖKOVÁ 1998 SLO).

Lúčanská Malá Fatra: village of Rajecké Teplice, on the calcareous rocks (DOMIN 1919 PRC).

Nízke Tatry: town of Brezno ("Brezno nad Hronom"), in grassland near turistic trail to Skalka hill, 520–560 m (ŠTĚPÁNEK 1990 PR).

Turčianska kotlina: town of Turčianske Teplice, weed in gardens, less than 500 m, calcareous bedrock (MALOCH 1922 BRNU 182272).

Liptovská kotlina: village of Štiavnička, near the town of Ružomberok, on the meadows in the park (MÁJOVSKÝ 1970 SLO).

Spišská kotlina: village of Spišské Podhradie, ruderal area, 450 m (DOSTÁL 1946 PRC). – area of Dreveník hill, near beech forest (MARCIOVÁ 1997 SAV). – Dreveník hill, near the village of Spišské Podhradie, in grassland (CHRTEK & DEYLOVÁ 1987 PR). – village of Krížová Ves (ZECHENTER s. d. BRA). – town of Spišská Belá (DOMIN 1925 PRC).

Biele Karpaty (severná časť): Vlársky priesmyk pass, 280 m (DOČOLOMANSKÝ 1963 BRA). – Mt. Vršatec, 926 m (FAJMONOVÁ 1963 BRA). – village of Červený Kameň, meadow (SCHIDLAY 1930 BRA).

Javorníky: town of Púchov, Hrabovka, calcareous rocks near the village, 350 m (POSPÍŠIL 1963 BRNM 0523579).

Spišské vrchy: village of Jablonov, 600 m (DEYL PR 1934 103884).

Šarišská vrchovina: village of Lipovce, Hurka (POSPÍŠIL 1959 SAV, BRNM 0551605). – Šariš ("Šarišská hora") hill, near of the village of Vel'ký Šariš (KLÁŠTERSKÝ & MĚSÍČEK 1961 PR). – village of Kamenica, slopes above the village (MÁJOVSKÝ 1962 SLO).

Čergov: town of Bardejov, area of the river Topl'a, 360 m (BERGANSKÝ 1929 BRA, POSPÍŠIL 1961 BRNM 0551609). – town of Bardejov, Vimbark, on the pasture Čolo, 350 m (POSPÍŠIL 1955 BRNM 0551596, POSPÍŠIL 1958 BRNM 0551612). – town of Bardejov, on the pasture Blichy (POSPÍŠIL 1958 BRNM 0551609). – Rokytov, slope SE of the village, 350 m (POSPÍŠIL 1962 BRNM 0551609). – Kurov, near the village, 360 m (POSPÍŠIL 1961 BRNM 0551594).

Nízke Beskydy: village of Komárov, left bank of the river Topl'a, on the slope above road (POSPÍŠIL 1959 BRNM 0551604). – Brezovka, near the road W of the village, 350 m (POSPÍŠIL 1961 BRNM 0551597). – Dubinné, slope N of the village, 230–250 m (POSPÍŠIL 1958 BRNM 0551603, POSPÍŠIL 1961 BRNM 0551595). – Nemcovce, NW of the village, 300 m (POSPÍŠIL 1960 BRNM 0551611). – village of Giraltovce, 200 m, 200–220 m (DOSTÁL 1947 PRC, POSPÍŠIL 1961 BRNM 0551592). – village of Vyšny Žipov, meadows along the trail to Jastrabie (KRÁLIK 1975 SLO). – birch forest between the villages of Ruský ("Vyšný") Kazimír and Benkovce, (KRÁLIK 1973 SLO). – village of Komárany, Lipová (KRÁLIK 1974 SLO). – water reservoir between the villages of Vel'ká Domaša and Nová Kelča, 250 m (HLAVAČEK 1975 BRA). – water reservoir Domaša, margins of forest above the dam (KRÁLIK 1972 SLO). – village of

Brusnica, in grassland near the elevation pointcote 190 m, near Lišná hora hill, 190–210 m (Hejný 1957 PR). – village of Slovenská Kajňa, Domačky, pasture above Domaša dam (Králik 1973 SLO). – village of Benkovce, Zadné paseky (Králik 1973 SLO). – Lysá hora hill, meadow below the hill, 1 km of the village of Čičava (Králik 1974 SLO). – settlement of Kopanica near the village of Ruská Poruba, in the pasture, 430 m (Hejný 1957 PR). – town of Humenné, alluvium of the rivers Cirocha and Latorica, (Töröková 1997 SAV).

4.1.2. Higher Altitude Morphotype

CARPATICUM OCCIDENTALE. Strážovské a Súl'ovské vrchy: village of Biela Voda (ex herb. 1950 Kmeť BRA). – village of Tužina, Priečna lúka meadow (Schidlay 1930 BRA). – road below spring of the Nitra river, direction to Mt. Homôlka, 1360 m (Dočolomanský 1963 BRA). – between the villages of Zliechov and Čičmany, Mt. Zakluka, in the forest, 800 m (Schidlay 1946 BRA). – Súl'ovské skaly (Domin 1920 PRC).

Slovenské rudohorie: town of Tisovec, in the area of Mt. Ostrica (Soják 1962 PR 565887). – village of Dobšiná, forest on the margin of the river Dobšiná, 500 m (Švestka 1932 SLO, Švestka 1932 BRNM 0523660, 0858/40, 08598/32, Švestka 1932 BRNU 403123, Švestka 1932 PR 103888, Švestka 1932 PRC).

Muránska planina: Mt. Vel'ká Stožka, subalpine meadow, 1400 m (Sillinger 1937 PRC). – road from the Vernár bus station to the Dobšinská l'adová jaskyňa cave, 910 m (Hendrych 1948 PR). – between the villages of Dobšiná and Stratená, 800 m (Klášterský 1947, 1957 PR). – village of Stratená, Tiesňavy valley, calcareous bedrock (Dvořák 1965 BRNU 422036). – village of Stratená, údolie Stratená valley, on the meadow near bridge over the river Hornád, 850 m (Dvořák 1976 BRNU 495065, 495081).

Slovenský raj: above the Horný Kysel' valley and historical settlement Kláštorisko (Soják 1958 PR 289651, 289652). – village of Čingov, in the valley of the river Hornád (Soják 1976 PR).

Stredné Pohornádie: village of Kostol'any nad Hornádom, Mt. Biela skala, 650 m (Dostál 1932 PRC).

Lúčanská Malá Fatra: Fačkovské sedlo saddle, near the village of Fačkov (Marhold 1992 SAV). – Fačkovské sedlo saddle, between the chalet Energetik and that of the Institutte of Chemistry, 550 m, 900 m, 1000 m, 1050 m (Dočolomanský 1963 BRA). – Mt. Reváň (Holuby 1900 BRA, Novacký 1940, 1946 BRA, Pospíšil 1952 BRNM 75901, Dočolomanský 1963 BRA, Černoch 1965 14430 BRNM 400094). – Mt. Kl'ak (Novacký 1936 BRA). – between Mts. of Kl'ak and Reváň, 900 m (Brancsik 1900 BRA, Klika 1949 PR, Dočolomanský 1963 BRA). – Mt. Horná Reváň, alpine meadow (Skřivánek 1959 BRNM 0523655, 0523661). – above the village of Predvalašská, near the village of Bystrička, Lázky, granitic bedrock (Horváthová 1978 BRA). – town of Martin ("Turčiansky Svätý Martin") (Kmeť 1906 BRA). – below Mt. Úplaz (Grebenščikov 1953 SAV). – village of Rajecké Teplice, near springs, 460 m (Dočolomanský 1963 BRA). – trail between Mts. of Malý Kl'ak and Kl'ak, 1360 m (Dočolomanský 1963 BRA).

Krivánska Malá Fatra: between the town of Vrútky and the village of Strečno, in the shrubs near the river Váh, 360 m (Dostál & Novák 1937 PRC). – village of Terchová, below Mt.Vel'ký Kriváň, 800 m (Domin 1919 PRC). – rocky slopes at the

acces to the Vrátna dolina valley, near the village of Terchová, calcareous bedrock, 550–600 m (Soják 1959 PR 564173). – Vrátna dolina valley (Skřivánek 1957 BRNM 0523657). – village of Štefanová, trail to Mt. Vel'ký Rozsutec (Májovský 1983 SLO).

Vel'ká Fatra: Mt. Majerova skala, 1200 m (Schidlay 1941 BRA). – Vel'ká Ramižiná valley, below Mt. Krížna, 1490 m (Kliment 1988 BRA). – Mt. Zvolen, margin of the forest (Futák & Zahradníková 1964 SAV). – Gaderská dolina valley, area Pustalovčia, 1100 m (Horváthová 1975 BRA). – Folkušovský žl'ab, Gaderská dolina valley (Marhold 1992 SAV). – Gaderská dolina valley, 800 m (Horváthová 1984 BRA). – Mt. Ploská, subalpine meadow, in shrubs, 1000 m (Margittai 1912 PR 103881). – Sútecká dolina valley, in the forest near the village of Liptovské Revúce, 800 m (Černoch 1959 10805 BRNM 400095). – Dedošova dolina valley (Marhold 1992 SAV). – Suchá dolina valley, 1490 m (Kliment 1988 BRA). – eastern slope of Mt. Čierny Kameň, 1300 m, 1000 m (Černý 1959 BRNM 0518638, Margittai 1912 PR 103879). – Jasenská dolina valley, near chalet Lysec (Horváthová 1977 BRA). – village of L'ubochňa, L'ubochnianska dolina valley, below Mt. Kútnikov kopec (Horváthová 1975 BRA). – village of L'ubochňa ("Fenyöháza"), in the forest (Borbás 1900 BRA). – village of Vyšná Revúca, meadow Vyšná (Schidlay 1931 BRA.).

Chočské vrchy: village of Lúčky (Borbás BRA 190, Roubal 1971 PRC).

Nízke Tatry: village of Korytnica (bath) (Richter 1898 PRC). – between Mts. Demänovská hora and Magura, 800 m (Sillinger 1930 PRC). – Mt. Baba, near the village of Korytnica (baths), 1050 m (Zavřel 1934 BRNM 46647). – Mt. Demänovská hora, 900 m (Sillinger 1930 PRC). – natureal reserve Ohnište, xerotherm slope near rocks at E margin of Nižný Príslop (Dráboová & Hrouda 1986 SAV). – Mt. Smrekovica, Jánska dolina valley, spruce forest, calcareous bedrock, 900 m (Fott 1928 PRC). – village of Malužiná, 800 m (Sillinger 1930 PRC). – near the village of Svarín, in the area with *Calamagrostis varia*, 850 m (Futák 1957 SAV). – Mt. Zapol'ná, forest above railway near the village of Čierny Váh, 720 m (Vartíková 1972 SLO). – village of Nižný Chmelienec (near Svarín), on the right side of the river Čierny Váh, 700 m (Vartíková 1972 SLO). – village of Vyšný Chmelienec, in the valley, 850 m (Sillinger 1931 PRC). – Mt. Popová near the village of Vernár, 1000 m (Hrubý 1911 BRNU 63141, 63147, Černoch 1965 14431 BRNM). – in the valley of the river Hnilec, direction to Mt. Človečia hlava, 2–3 km NW of the village of Vernár, 900–950 m (Štěpánek 1991 PR). – in the valley of the river Hnilec, 0–2 km to the settlement Pusté Pole, near the railway station of village Vernár, 900–950–1050 m (Štěpánek 1991, 1992 PR).

Západné Tatry: Mt. Sokol, 1100 m (Dostál 1930 PRC). – Mts. Liptovské Hole Mts., (Svoboda 1933 PR).

Vysoké Tatry: Bielovodská dolina valley, near the gamekeeper house Biela Voda, (Součková 1953 BRNM 65803). – settlement Tatranská Lomnica (Pospíšil 1947 BRNM 75900). – near the road between the villages of Kežmarské Žlaby and Tatranská Kotlina (Chrtek 1989 PR23b). – village of Vel'ká Lomnica (Vraný 1887 BRA).

Belianske Tatry: village of Javorina, trail from bus stop to mountains, 900 m (Dočolomanský 1962 BRA). – valley of the rivulet Biela near the village of Ždiar, 875 m, 900 m (Domin & Krajina 1925 PRC, Domin 1937 PRC, Černoch 1954 BRNM 400097). – Červená hlina (Domin & Krajina 1925 PRC). – meadows near the rivulet Biela between the villages of Ždiar and Ždiarske Turne ("Plošové Turne"), 920 m (Černoch 1954 7075 BRNM 400093). – Červená hlina, southernmost slope of Mt. Bujačí, above trail between chalet Plesnivec and Predné Med'odoly valley, 1360 m, 850–1000m (Šmarda 1958 401390 BRNU, Dočolomanský 1962 BRA). – meadows on the

SE margin the village of Ždiar, 900 m (Dvořák 1978 494863 BRNU). – slopes of Mt. Tokáreň, 1300 m (DVORÁK 1951 BRNM 4790). – near chalet Plesnivec ("Protěž"), 1200, 1250 m, 1300 m (Dostál 1936 PRC, Šourek 1949, 1948 PR 272649, 272651, Černoch 1954 BRNM 0523662, Černoch 1954 BRNM 400092, Vartíková 1970 SLO). – settlement of Tatranská Kotlina, near Skalné Vráta rocks (Futák 1962 SAV). – dolina Siedmych prameňov valley, glade (Hadač 1956 PR). – dolina Siedmych prameňov valley, along the rivulet Čierna Voda (Domin 1932 BRA). – Čierna dolina valley (Domin & Krajina 1925 PRC). – settlement of Tatranská Kotlina, Suchá dolina valley (Futák 1953 SLO). – Šumivý prameň spring above the settlement of Taranská Kotlina, 800 m (Šmarda 1962 BRNM). – settlement of Tatranská Kotlina, Faixova lúka meadow (Futák 1953 SAV). – between the settlement of Tatranská Kotlina and dolina Siedmych prameňov valley ("Holubyho důl") (Weber 1933 PR 236001). – near Hučivá Diera (Domin 1925 PRC). – near the settlement of Tatranská Kotlina, 850 m (Suza 1925 BRNU 58247). – settlement of Tatranská Kotlina, alpine meadows, 1217 m, 800 m, 850 m (Skřivánek 1947 BRNM 0523658, Černoch 1954, 7074 BRNM 400096, Futák 1954 SLO, Domin & Krajina 1925 PRC, Domin 1925 PRC). – settlement of Tatranská Kotlina, above Rusalka house, 700 m (Šourek 1951 PR 272650). – settlement of Tatranská Kotlina, Vel'ký les (Domin 1928 PRC). – settlement of Tatranská Kotlina, Drabina, 780 m (Domin 1933, 1937 PRC). – settlement of Tatranská Kotlina, trail to Mt. Šarpanec, 750 m, 740 m (Domin & Krajina 1920, 1925 PRC, Dočolomanský 1953, 1963 BRA). – Mt. Javorinka, 1210–1220 m (Domin 1935 PRC).

Pieniny: Mt. Holica (Michalko 1953 SAV, Májovský 1953 SLO). – near the village of Červeny Kláštor, 470 m (Domin 1932 PRC). – Lipník, Mt. Suchý vrch, Mt. Rabštýn, Mt. Šafránovka, near the village of Lesnica (Domin 1932 PRC). – Mt. Kláštorská hora (Májovský 1953 SLO). – village of Červený Kláštor, road from Červený Kláštor to the village of Lechnice (Májovský 1968 SLO). – Aksamitka cave, Haligovské skaly rocks (Michalko 1953 SAV). – Haligovské skaly rocks, between the villages of Haligovce and Vel'ký Lipník, calcareous bedrock (Chrtek 1983 PR). – Mt. Vysoké Skalky, near the village of Stráňany, (Michalko 1953 SAV, Futák 1954 SLO). – in the valley of the river Dunajec, calcareous bedrock (Deyl 1953 PR). – Pieniny Mts. (Náběl ek 1936 BRA).

Liptovská kotlina: between Prosiecka dolina and Kvačianska dolina valleys, in beech forest, 900 m (Futák 1958 SAV). – below Mt. Babky, above the village of Vel'ký Bobrovec (Domin 1919 PRC). – village of Smrečany (Botlíková 1969 BRA).

Západné Beskydy: Oravský podzámok castle, meadow below castle (Schidlay s.d BRA). – SW margin of the village of Chlebince, in grassland and in shrubs, 600 m (Chrtek & Chrtková 1971 PR).

Spišské vrchy: village of Spišské Hanušovce, near the road (Michalko 1983 SAV). – village of Stará L'ubovňa, rocks near of the settlement of Folvark, calcareous bedrock (Deyl 1953 PR). – N margin of the village of Litmanová, on calcareous rocks (Chrtek & Deylová 1984 PR). – in grassland near road between the villages of Jarabiná and Litmanová (Chrtek & Deylová 1984 PR). – village of Podsadek, near the town of Stará L'ubovňa, in the valley of the river Maslienka (Chrtek & Skočdopolová 1985 PR).

Šarišská vrchovina: village of Uzovské Pekl'any, in shrubs on S slope of Mt. Volčenská hora, calcareous bedrock, 600 m (Dostál 1953 PR 39424). – village of Pečovská Nová Ves, near Mt. Kohút, calcareous bedrock, 650 m (Dostál 1953 PR 39423). – village of Bzenov, 350 m (s. coll. 1959 PR 564968).

Čergov: village of Lenartov, valley of the Večný potok stream (Pospíšil 1958 BRNM 0551607).

Nízke Beskydy: village of Palota, near Lupkovský priesmyk pass, 684–657 m (Domin, Deyl, Jirásek 1937 PRC). – village of Adidovce, margins of forest and wet meadows in the Ilovnica valley, 250 m (Soják 1957 PR 562524, 562525).

CARPATICUM ORIENTALE. Bukovské vrchy: village of Osadné, margin of the forest of Čereniny (Májovský 1975 SLO). – village of Stakčín, near the village of Vel'ké Pole (Májovský 1970 SLO). – village of Stakčín, above Kováčikov (Soják 1957 PR 562527). – village of Dara, grassy, sunny slopes below altitude 647 m (Soják 1957 PR 562526). – village of Ruský Potok, fields around the village (Májovský 1970 SLO). – valley of the river Ulička near the village of Ulič (Michalko 1954 SAV). – village of Ulič (Michalko 1954 SAV). – village of Nová Sedlica, Mt. Rozdiel, trail along the country border (Májovský, Peciar, Murín 1970 SLO).

4.1.3. Morphologically "uncertain populations" from Southwest Slovakia

PANNONICUM. Podunajská nížina: Bratislava, area of the Zoological garden, in forest above the garden (Dočolomanský 1962 BRA).

CARPATICUM OCCIDENTALE. Malé Karpaty: village of Mariánka, gravel pit (Nábělek 1941 SLO).

## 5. Discussion

In the course of our morphometric analyses, we confirmed for the area of Slovakia two morphological entities of *Picris hieracioides*. These two morphotypes differ by several morphological characters as well as by their distribution patterns and ecological requirements. We conclude that both morphotypes can be treated as separate taxa, however, we would like to test this hypothesis also using molecular methods (this work is in progress) and to solve related nomenclature problems.

The results of our study do not correspond to the number of recognised taxa in the treatments of the infraspecific variation of *P. hieracioides* in floras and identification keys for the area of Slovakia (Dostál 1948–950, Dostál & Červenka 1992). When we compare morphological data from our study with the characters of the recognised taxa from literature, the "lower altitude morphotype" belongs to what was considered to be the typical subspecies *P. hieracioides* subsp. *hieracioides* (e.g. Sell 1975, 1976), while the higher altitude one seems to correspond with what was treated as *P. hieracioides* subsp. *grandiflora, P. hieracioides* subsp. *crepoides* or *P. hieracioides* subsp. *paleacea* (Dostál 1948–1950, Dostál & Červenka 1992). We hesitate for the time being to attach particular names to the two recognised morphotypes. The lectotype of the name *P. hieracioides* (and consequently also *P. hieracioides* subsp. *hieracioides*) was chosen by Lack 1975. The specimen deposited in BM (Hortus siccus Cliffortianus 387 no. 2, http://internt.nhm.ac.uk/jdsml/research-curation/projects/clifford-herbarium/) seems to correspond to the higher altitude populations from the

Alps rather than to the "lower altitude morphotype" of anthropogenically influenced habitats, which is traditionally classified as *P. hieracioides* subsp. *hieracioides* (e.g. SELL 1975, 1976). Depending on the solution of this nomenclatural controversy the appropriate name for the "higher altitude morphotype" should also be chosen. We have not found populations with very short branches and peduncles that could correspond to the south European populations classified as *P. hieracioides* subsp. *spinulosa*. Slovak populations, which were treated under this name belong to the "lower altitude morphotype".

As to the important discriminating characters among the above mentioned two morphotypes, the most conspicuous differences, visible at first glance, are the dark colour of indumentum on involucral bracts, the near absence of red stripe on outer part of ligules and the distribution of capitulas only in the upper part of branches of the "higher altitude morphotype", whereas the pale indumentum on involucral bracts, the red stripe very often presented on the most outer ligules and the distribution of capitulas along the whole branches are most typical for the "lower altitude morphotype". The colour of involucral bracts, recorded as one of the important characters among subspecies (DOSTÁL & ČERVENKA 1992, SELL 1975, 1976) is according to our field observations as well as cultivation experiments (SLOVÁK unpubl.) not confined to a particular morphological or ecological type; therefore, it was not included in our morphometric study. The length and width of flowers and involucral bracts are also appropriate for morphological differentiation between the two morphotypes. Length of bracts (but usually not specified as outer or inner ones) is widely used as a relevant discriminating character in identification keys (SELL 1975, 1976). Our analyses show that predominantly the length of inner bracts, is useful in this respect.

Characters of the stem and rosette leaves are sometimes incorporated into the identification keys (PADALÍKOVÁ 1972, ZÁNGHERI 1976), however LACK in his studies (LACK 1974, HOLZAPFEL & LACK 1993) pointed out that all characters related to leaves in the genus *Picris* are strongly influenced by ecological factors, and strongly varying already on population level. For this reason, he argues that they should not be used in taxonomic studies. Our field experience and observations in preliminary analyses generally confirm this opinion, although there are some tendencies in leaf shape differentiating the two morphotypes. The leaves of the "higher altitude morphotype" are usually wider, almost entire or shallowly toothed at margin and soft. The bases of the upper stem leaves are in some populations more-less cordate to auriculate, and in some cases amplexicaul. Plants of the "lower altitude morphotype" possess usually narrower, strongly toothed to almost pinnatisect, scabrous leaves with a base narrowed into petiole. There is, however, a considerable overlap in respect to these characters.

Achenes play an important role in differentiation among species in the genus *Picris*. HOLZAPFEL in his taxonomic revision of *Picris* in Australia, as well as LACK based on the material from tropical Africa, consider particularly the length and width of achenes as appropriate discriminating characters on the species level (LACK 1979, HOLZAPFEL & LACK 1993, HOLZAPFEL 1994). A systematic study of *Picris* species in Arabian Peninsula and Socotra (SMALLA 2000) also shows that fruits are essential for identification of individual species. Although this author confirmed significant differences in achenes length, shape and surface characters among the related species, only a slender distinction was found between two subspecies of *P. abyssinica* FORSK. Similarly, the results of our analyses show only a minor separation between both morphotypes in respect to the length and width of their achenes, and no differences in their surface characters were observed.

It is apparent from the distribution map that the distribution areas of both morphotypes in Slovakia only partly overlap. The distribution of the morphotypes is connected also with their ecological preferences. The first results of the coenological evaluation of the preferences of the two morphotypes suggest their differentiation also in this respect (SLOVÁK & ŠIBÍK, unpubl. data, JAROLÍMEK, pers. comm.).

The "higher altitude morphotype" naturally occurs in tall herb communities of montane to alpine belt of the class Mulgedio-Aconitetea HADAČ & KLIKA in KLIKA 1948 (alliances Calamagrostion arundinaceae (LUQUET 1926) JENÍK 1961, tall grass species rich communities on drier and warmer slopes of supramontane and subalpine belt; and Festucion carpaticae BĚLOHLÁVKOVÁ & FIŠEROVÁ 1989, tall grass chionophilous communities in the moist craggy glens on carbonates of higher montane to alpine belt) and in the subalpine communities of deciduous shrubs of the class Betulo carpaticae-Alnetea viridis REJMÁNEK in HUML & al. 1979 (alliance Salicion silesiacae REJMÁNEK & al. 1971, communities of subalpine shrubs with *Salix silesiaca*).

According to our field observations, populations of the "higher altitude morphotype" tend to spread also into non-forested synanthropic habitats in valleys, along the forest roads and into other mountain secondary habitats. Although these habitats can be regarded as synanthropic and anthropogenically influenced, they differ from those of the "lower altitude morphotype" (see below) predominantly because they do not belong to the xerothermous communities and always are fixed within mountain ranges.

The "lower altitude morphotype" prefers synanthropic habitats such as abandoned places along roads, railways, along margins of pastures, on lowland river terraces, and in orchards and vineyards on fluffy, airy, frequently gravelly skeleton-rich and drying soils. These habitats are occupied by typical heliophilous ruderal (semi-) xerothermophilous communities of the class Artemisietea vulgaris LOHMEYER & al. in R. TX. ex VON ROCHOW 1951 with a prevalence of biennial and hemicryptophyte herbs.

Within the class, the coenological optimum of this morphotype lies clearly in the alliance Dauco-Melilotion GÖRS 1966 and especially in the association Dauco-Picridetum GÖRS 1966 (see JAROLÍMEK & al. 1997: Tab. 15). In this community the "lower altitude morphotype" of *P. hieracioides* attains its highest values of abundance. From the point of view of succession, communities of Dauco-Melilotion represent usually the second step of secondary succession after the therophyte communities of the alliance Sisymbrion officinalis R. TX., LOHMEYER & PREISING in R. TX. 1950 on places deprived of vegetation that have been abandoned. Consequently, a higher number of therophytes participates in their floristic composition.

The occurrence of two morphologically "uncertain populations" (SW Slovakia) of *P. hieracioides*, which are morphologically closer to the higher altitude morphotype in respect to ecological requirements, but are settled in biotopes typical for "lower altitude morphotype", is still confusing and unresolved. In both cases, they occur in synanthropic niches such as margins of orchards, gardens and roads. As to their origin, we suppose that it is not autochthonous. The most plausible hypothesis for their origin seems to be their introduction by gardeners from the higher altitude biotopes of the Carpathians or Alps. This is supported also by the absence of the "higher altitude morphotype" in the other parts of the Malé Karpaty Mts. as well as in the Podunajská and Záhorská nížina lowlands.

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## 7. References

BERDAU F. 1890. Flora Tatr, Pienin i Beskidu Zachodniego. – J. Flipowicz, Warszawa.

BERGMAN B. 1935. Zytologische Studien über die Fortpflanzung bei den Gattungen *Leontodon* und *Picris*. – Svensk bot. Tidskr. 29: 155–301

BORBÁS V. 1902: Hazai botanikai dolgozatok ismertetése. – Magyar bot. Lapok. 1: 320.

DOSTÁL J. 1948-1950. Květena ČSR. – Československá botanická společnost, Praha.

— & ČERVENKA M. 1992.Vel'ký kl'úč na určovanie vyšších rastlín 2. – SPN, Bratislava.

EVERIT B. 1986. Cluster analysis ed. 2 (reprint 2). – Gower, Halsted Press, New York.

FUTÁK J. 1966. Flóra Slovenska 1. – VSVS, Bratislava.

HAYEK A. 1929. *Compositae* – In: HEGI G. (ed.), Illustrierte Flora von Mittel–Europa 4(2): 1036–1040. – Carl Hauser Verlag, München.

Hazslinszky F. 1872. Magyarhorn edényes növényeinek fűvészeti kézikönyuve. – Athenaeum, Budapest.

Holzapfel S. 1994. A revision of the genus *Picris* (*Asteraceae, Lactuceae*) s.l. in Australia. – Willdenowia 24: 97–217.

— & Lack H. W. 1993. New species of *Picris* (*Asteraceae, Lactuceae*) from Australia. – Willdenowia 23: 181–191.

Jarolímek I., Zaliberová M., Mucina L. & Mochnacký S. 1997. Rastlinné spoločenstvá Slovenska 2. Synantropná vegetácia. – Veda. Bratislava.

Klecka W. R. 1980. Discriminant analysis. – Sage University papers, Series: Quantitative Application in the Social Science. 19., – Beverly Hills.

Krzanowski W. J. 1990. Principles of multivariate analysis. – Clarendon Press, Oxford.

Lack H. W. 1974. Die Gattung *Picris* L. sensu lato im ostmediterran-westasiatischen Raum. – Dissertationen der Universität Wien. – Wien.

— 1975. Type specimens of the Linnaean species of *Picris* L. (*Compositae*). – Taxon 24: 113–116

— 1979. The genus *Picris* (*Asteraceae, Lactuceae*) in Tropical Africa. – Pl. Syst. Evol. 131: 35–52.

Lumnitzer S. 1791. Flora Posoniensis exhibens plantas circa Posonium sponte crescentes. – Impensis Siegfried Lebrecht crusii, Lipsiae.

Marhold K. & Hindák F. 1998. Zoznam nižších a vyšších rastlín Slovenska / Checklist of non-vascular and vascular plants of Slovakia. – Veda, Bratislava.

McMullen J. M. 2001. Bitterweed (*Picris hieracioides* L.) – an abundant but often overlooked species. – NYFA Newsleter 13 (1): 4–5.

Padalíková E. 1972. Variabilita a rozšíření *Picris hieracioides* L. na území Československa. Diplomová práce. – Katedra biologie rostlin Přírodovědecké fakulty ÚJEP. –, Brno.

Podani J. 2001. SYN-TAX 2000. Computer program for data analysis in ecology and systematics. User's manual. – Scientia Publishing, Budapest.

Reuss G. 1853. Květena čili opis všech Jevnosnubných na Slovensku divorostaucích a mnohých zahradních zrostlin podlé saustavy De Candelle–ovy, p. 258. – F. Lorber, Banská Štiavnica.

Sas Institute 2000. SAS OnlineDoc®, version 8 (available online). – SAS Institute, Cary.

Sagorski E. & Schneider G. 1891. Flora der Centralkarpathen mit specieller berücksichtigung der in der Hohen Tatra. – Eduart Kummer, Leipzig.

Schols P., Dessein S., D'hondt C., Huysmans S. & Smets. E. 2002. Carnoy: a new digital measurment tool for palynology. – Grana 41: 124–126.

Sell P. D. 1975. Flora Europaea notulae systematicae ad Floram Europaeam spectantes. – Bot. J. linn. Soc. 71: 235–274.

— 1976. *Picris* L. - In: Tutin T. G., Heywood V. H., Burges N. A., Moore D. M., Valentine D. A., Walters S. M. & Webb D. A. (eds.), Flora Europaea 4: 159–160. – Cambridge University Press, Cambridge.

Smala M. 2000. Studies in the *Compositae* of the Arabian Peninsula and Socotra. – 6. The *Hypochaeridinae (Lactuceae)* in the Arabian Peninsula. – Wildenowia 30: 315–339.

Sneath P. H. A & Sokal R. R. 1973. Numerical taxonomy. Principles and practice of numerical classification. – W. H. Freeman, San Francisco.

Zángheri P. 1976. Flora Italica 2. – Cedam – Casa Editioice Dott. Antonio Milani, Padova.