

## MULTIVARIATE ANALYSIS OF THE *SENECIO NEMORENSIS* GROUP (*COMPOSITAE*) IN THE CARPATHIANS WITH A NEW SPECIES FROM THE EAST CARPATHIANS

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**Abstract:** Six species and subspecies of the *S. nemorensis* group from the Carpathians are recognized here, based on morphometric analyses (cluster and discriminant analyses). A new species *S. ucranicus* HODÁLOVÁ and a new hybrid *S. xdominii* HODÁLOVÁ = *S. germanicus* WALLR. × *S. ucranicus* HODÁLOVÁ, occurring in the East Carpathians and the eastern part of the South Carpathians, are described. The vicarious nature of *S. hercynicus* HERBORG subsp. *hercynicus*, *S. dacicus* HODÁLOVÁ et MARHOLD and *S. ucranicus* HODÁLOVÁ in the Carpathians is documented. A key to the *S. nemorensis* group in the Carpathians as well as to *S. nemorensis* L. s. str. is presented.

### INTRODUCTION

The *Senecio nemorensis* group is a taxonomically complex assembly of taxa widely distributed throughout the Carpathians. Great variation within each taxon and intergradation in morphology between the members of this group has promoted considerable taxonomic confusion. The taxa considered in the current study include all species and subspecies recognized by the present author in the Carpathians: *S. dacicus* HODÁLOVÁ & MARHOLD, *S. germanicus* WALLR. subsp. *germanicus*, *S. hercynicus* HERBORG subsp. *hercynicus*, *S. ovatus* (P. GAERTN. et al.) WILLD. subsp. *ovatus*, and the specimens treated by the present author as *S. ucranicus* and *S. xdominii* = *S. germanicus* × *S. ucranicus* (holotype representing hybrid *S. germanicus* subsp. *germanicus* × *S. ucranicus*).

This study is part of a series of articles presenting a taxonomic revision of the *Senecio nemorensis* group in the Carpathians (HODÁLOVÁ & MARHOLD 1996, 1998). The purposes of this paper are (1) to examine the overall morphological variation of the *S. nemorensis* group in the Carpathians, (2) to evaluate the morphological variation in *S. ucranicus* and its hybrid *S. xdominii* in the East Carpathians and the eastern part of the South Carpathians, and (3) to determine the set of morphological characters by which *S. ucranicus* and *S. xdominii* can be separated (in order to find the relationships of *S. ucranicus* and *S. nemorensis* L. s. str. the study focused on the latter taxon as well).

### MATERIAL AND METHODS

Morphometric analyses were based on 492 individuals from the Carpathians and eastern Siberia. The material studied consisted of 28 population samples, and an additional 11 individual specimens from different localities from the herbaria BP, BRNM, BRNU, W and

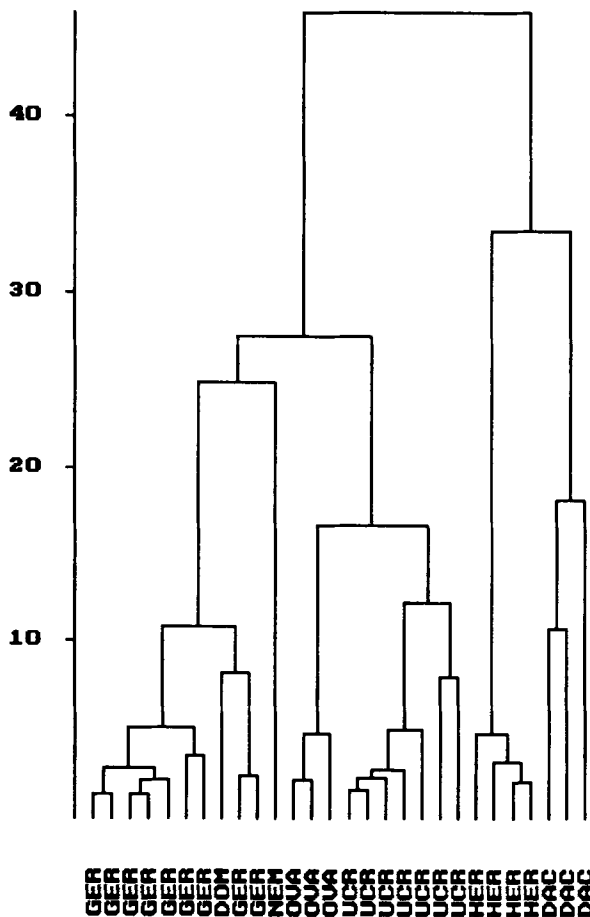


Fig. 1. Cluster analysis – UPGMA (CA1) (based on quantitative and qualitative characters) of *S. dacicus* (DAC), *S. germanicus* subsp. *germanicus* (GER), *S. hercynicus* subsp. *hercynicus* (HER), *S. nemorensis* (NEM), *S. ovatus* subsp. *ovatus* (OVA), *S. ucranicus* (UCR) and *S. xdominii* (DOM)

measured using an image analyzer ASBA (WILD, Heerbrugg, Switzerland). Leaves were measured in the middle part of the stem.

The multivariate numerical analyses were conducted using the following steps:

(1) Cluster analyses (CA) – UPGMA (average clustering) (EVERITT 1986) were based on populations as operational taxonomic units (OTU's), using the squared Euclidean distance coefficient, and performed on two different data sets: (a) a set of both quantitative and qualitative variables and (b) a set of quantitative variables only.

WU (for localities see Appendix 2). Hybrid populations (except hybrids of *S. ucranicus*) were not included in the present study. Their pattern has been presented (or will be) in other studies (HODÁLOVÁ & MARHOLD 1996, HODÁLOVÁ in prep.) and the selection of “pure” populations was based on their results. The following 10 quantitative and 3 qualitative characters were measured or scored for each plant: length of stem leaves (LL); width of stem leaves (WL); width of base of stem leaves (WBL); length of supplementary bracts (LSB); length of involucral bracts (LB); number of involucral bracts (NB); length of ligules (LLG); number of ligules (NL); length of tubular florets (LF); number of tubular florets (NF); indumentum of supplementary bracts (IB): short articulate hairs present or absent (“Gliederhaare” in the sense of OBERPRIELER 1994: 12–13); long articulate hairs present or absent (“Flaumhaare” in the sense of OBERPRIELER 1994: 13); glandular hairs present or absent (“Drüsenhaare” in the sense of OBERPRIELER 1994: 12). Quantitative characters LL, WL, LSB, LB were

Table 1. Total canonical structure (correlation of the characters with canonical axes) obtained in the canonical discriminant analysis of *S. dacicus*, *S. germanicus* subsp. *germanicus*, *S. hercynicus* subsp. *hercynicus*, *S. nemorensis*, *S. ovatus* subsp. *ovatus*, *S. ucranicus* and *S. xdominii*.

Character	Total canonical structure		
	CAN1	CAN2	CAN3
NF	0.888	0.084	-0.018
NL	0.770	0.578	-0.195
LSB	0.735	-0.356	0.475
NB	0.687	0.134	-0.291
WBL	0.462	-0.621	0.391
WL	0.454	-0.499	0.121
LB	0.309	-0.014	0.414
LL	-0.308	0.440	0.292
LF	0.226	-0.133	0.495
LLG	0.040	0.066	0.668

were transformed to their logarithms; the distribution of NL was not improved by any transformation. In the case of classificatory discriminant analysis, a discrimination power was determined by crossvalidation.

(4) Exploratory data analysis (TUKEY 1977).

The numerical analyses were computed using procedures UNIVARIATE, CORR, CANDISC and DISCRIM of the SAS statistical package (SAS INSTITUTE 1990a,b) on the mainframe computer of the University of Vienna, Austria and the SYNTAX package (PODANI 1993).

## RESULTS

### Cluster analyses

A cluster analysis of the complete data set (CA1), and quantitative characters only (CA2) indicated that all 28 populations studied could be divided into six clusters corresponding to the following species: *S. dacicus*, *S. germanicus* subsp. *germanicus*, *S. hercynicus* subsp. *hercynicus*, *S. ovatus* subsp. *ovatus*, *S. ucranicus* and *S. nemorensis*. The intermediate population (no. 22) which was treated as *S. xdominii* was either grouped within the cluster of *S. germanicus* subsp. *germanicus* (CA1, Fig. 1) or that of *S. ucranicus* (CA2, not presented). In regards to the quantitative characters the population of *S. xdominii* (no. 22) closely resembles *S. ucranicus*, however, in regards to the qualitative characters it is closely related to *S. germanicus* subsp. *germanicus*; the indument of the supplementary bracts is probably responsible for its inclusion into the cluster of *S. germanicus* subsp. *germanicus* in CA1.

### Pearson and Spearman correlation coefficients

In the treatment of all material, the arbitrary level of 0.6 was exceeded among the following characters: IS, IB, NB, NL and NF. In the case of the individual groups, the correlation coefficients between the couples of characters LL-LB in *S. dacicus*, LL-WL in *S. nemorensis*, and LL-WL, LB-LLG, LB-NF, NB-LLG and NB-LF in *S. xdominii* exceeded the 0.6 value. None of the characters were very highly correlated (exceeding value 0.90), so they were all

(2) Pearson and non-parametric Spearman correlation coefficients were calculated on the matrix of the whole material and on the individual matrices of all groups of populations (representing different taxa).

(3) A method of CA was performed in order to generate a hypothesis suggesting a possible grouping of the populations studied. Canonical discriminant (CaDA) and non-parametric classificatory discriminant (CDA) analyses (KLECKA 1980, KRZANOWSKI 1990) were used as methods for hypotheses testing (they classified individuals *a posteriori* into groups defined *a priori* on the basis of CA). CaDA a CDA were based on quantitative characters only. To meet the assumptions of multivariate normality in canonical discriminant analysis, the characters LL, WL, WBL, LSB, LB, NB, LLG, LF, NF

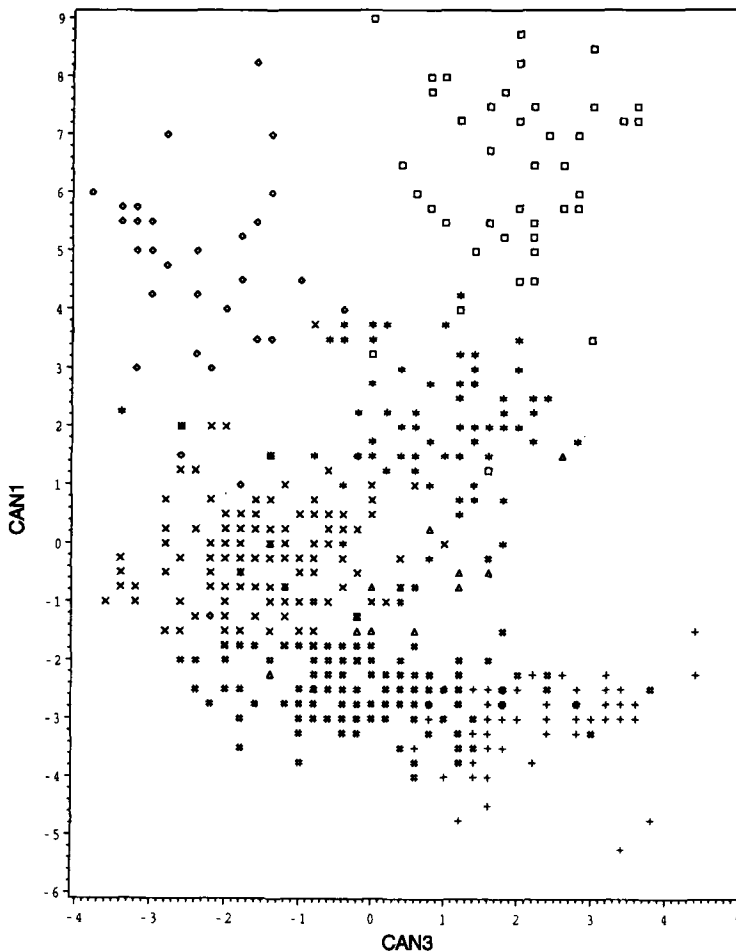


Fig. 2. Canonical discriminant analysis of *S. dacicus* (□), *S. germanicus* subsp. *germanicus* (x), *S. hercynicus* subsp. *hercynicus* (\*), *S. nemorensis* (◇), *S. ovatus* subsp. *ovatus* (+), *S. ucranicus* (#) and *S. xdominii* (Δ).

used in further analyses. A higher correlation indicates the importance of the corresponding characters for the delimitation of particular taxa.

### Discriminant analyses

The first canonical discriminant analysis included all individuals from the population samples and individual plants from the herbarium specimens (see Methods section). The scatterplot affirms the phenetic distinctness of the taxa studied, although they partly overlap morphologically (Fig. 2). The best phenetic groupings were found in a plot of the first and third canonical variates; thus, only the ordination based on these two axes is presented. The first three canonical variates explained 89% of the total variation encountered among the groups. The variables strongly contributing to the separation of these groups along axes CV1 and CV3 include NF, NL, LSB, NB and LLG, LF, LSB. The plants, regarded as hybrid *S. xdominii*, are located in an intermediate position between the *S. germanicus* subsp. *germanicus* and *S. ucranicus*. The values of the total canonical structure are presented in Tab. 1.

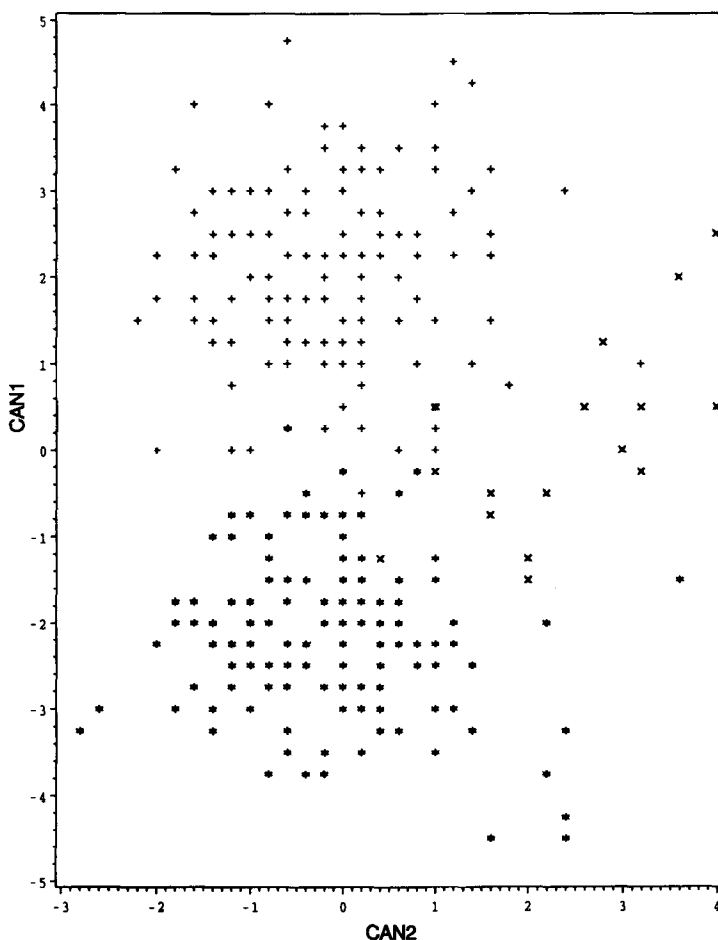


Fig. 3. Canonical discriminant analysis of *S. germanicus* subsp. *germanicus* (+), *S. ucranicus* (\*) and *S. xdominii* (x).

In an effort to portray the separation of *S. xdominii*, *S. germanicus* subsp. *germanicus* and *S. ucranicus*, a second CaDA, based on subsets of these three taxa, was carried out (Fig. 3). In spite of the fact that no clear disjunction between groups was presented by the first and second canonical variate, general trends in the patterning did occur. Axis CV1, is related primarily to LSB, NF and WBL and accounts for 90% of the total variation. Axis CV2 is related to LB and LF and accounts for 45% of total variation.

Finally, a series of five canonical discriminant analyses (graphs are presented only in the case of sympatric taxa *S. ucranicus*, *S. germanicus* subsp. *germanicus* and *S. ovatus* subsp. *ovatus*), based on subsets of *S. ucranicus* and individual species and subspecies of the *S. nemorensis* group studied in the Carpathians (as well as *S. nemorensis* L. s. str.), was performed to reveal the morphological differences among *S. ucranicus* and the other taxa. The characters NL, NF, LSB, NB, LB and LF were determined to be the best key characters for distinguishing *S. ucranicus* and *S. dacicus*; LSB, NF, and WBL for distinguishing *S. ucranicus* and *S. germanicus* subsp. *germanicus* (Fig. 4a); LSB, NF, LB, LF and WL for

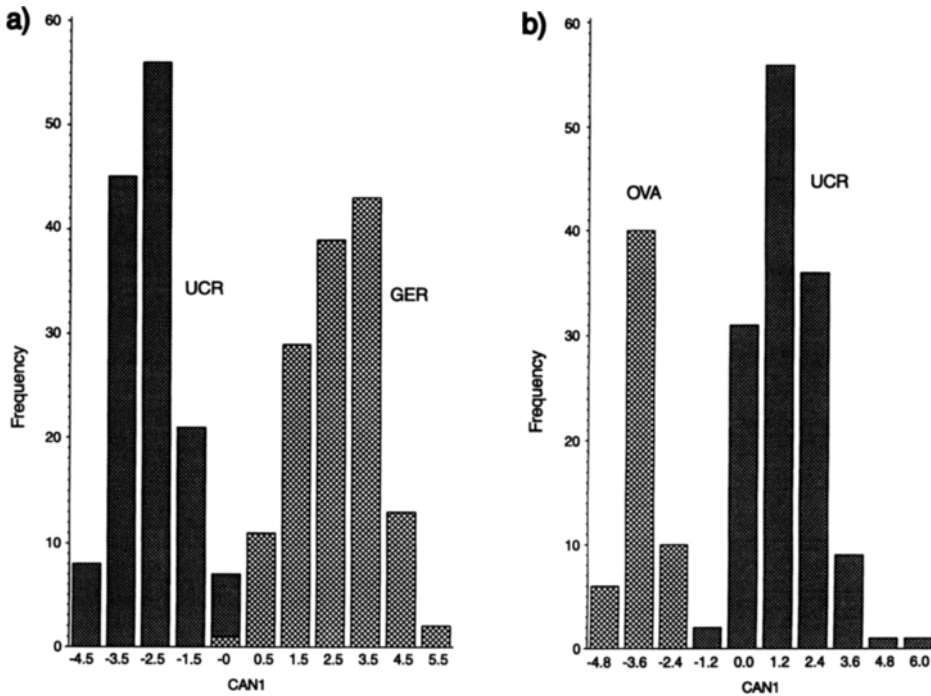


Fig. 4. Canonical discriminant analysis of a – *S. ucranicus* and *S. germanicus* subsp. *germanicus*; b – *S. ucranicus* and *S. ovatus* subsp. *ovatus*.

distinguishing *S. ucranicus* and *S. hercynicus* subsp. *hercynicus*; NL, NF, NB and LSB for distinguishing *S. ucranicus* and *S. nemorensis*; and WBL, NB, WL and LSB for distinguishing *S. ucranicus* and *S. ovatus* subsp. *ovatus* (Fig. 4b).

Non-parametric classificatory discriminant analysis performed on the seven *a priori* groups (*S. dacicus*, *S. germanicus* subsp. *germanicus*, *S. hercynicus* subsp. *hercynicus*, *S. nemorensis*, *S. ovatus* subsp. *ovatus*, *S. ucranicus* and *S. xdominii*) indicated that discrimination between the groups was possible and *a posteriori* placement of individuals into the “correct” groups was high (Tab. 2).

#### Exploratory data analysis

Summary statistics obtained in the exploratory data analysis are given in Tabs. 3 and 4. The ranges of quantitative characters overlap at least among some of the taxa studied. The taxa cannot be perfectly distinguished by any single character but can be quite well separated by combinations of the quantitative characters. The indument of supplementary bracts is strongly group-dependent in *S. germanicus* subsp. *germanicus*, *S. hercynicus* subsp. *hercynicus*, *S. nemorensis* and *S. ovatus* subsp. *ovatus*. The presence of morphological differentiation within this character in *S. dacicus* and *S. ucranicus* has been found (see Discussion). The population of *S. xdominii* possesses an indument of supplementary bracts typical of *S. germanicus* subsp. *germanicus*. Morphological variation in the indument of the lower part of stem was also observed. *S. ovatus* subsp. *ovatus* and *S. ucranicus* are usually glabrous, while *S. germanicus* subsp. *germanicus* and *S. nemorensis* are usually hairy.

Table 2. Results of non-parametric classificatory discriminant analysis of *S. dacicus*, *S. germanicus* subsp. *germanicus*, *S. hercynicus* subsp. *hercynicus*, *S. nemorensis*, *S. ovatus* subsp. *ovatus*, *S. ucranicus* and *S. xdominii*. Species are abbreviated by the first three letters of the specific name.

Actual group	DAC	Predicted group membership (number of observations/percentage classified into groups)					DOM
		GER	HER	NEM	OVA	UCR	
DAC	40/93.0	0/0.00	2/4.65	0/0.00	0/0.00	0/0.00	1/2.33
GER	0/0.00	113/81.88	5/3.62	2/1.45	0/0.00	6/4.35	12/8.70
HER	0/0.00	2/2.82	68/95.77	0/0.00	0/0.00	0/0.00	1/1.41
NEM	0/0.00	2/6.25	0/0.00	30/93.75	0/0.00	0/0.00	0/0.00
OVA	0/0.00	0/0.00	0/0.00	0/0.00	56/100.00	0/0.00	0/0.00
UCR	0/0.00	0/0.00	0/0.00	0/0.00	2/1.47	129/94.85	5/3.68
DOM	1/6.25	2/12.50	0/0.00	0/0.00	0/0.00	1/6.25	12/75.00

*S. dacicus* and *S. hercynicus* subsp. *hercynicus*, *S. xdominii* are glabrous or rarely hairy in the lower part of stem.

## DISCUSSION

Based on the results of this study, it is apparent that the morphological differences between *S. dacicus*, *S. germanicus* subsp. *germanicus*, *S. hercynicus* subsp. *hercynicus*, *S. nemorensis*, *S. ovatus* subsp. *ovatus* and *S. ucranicus* are sufficient to justify separation into distinct taxa. Hybrids of *S. germanicus* and *S. ucranicus* – *S. xdominii* – are much more difficult to distinguish from the parental taxa. Usually the supplementary bracts tend to be longer in *S. xdominii* than in *S. ucranicus*, and shorter than in *S. germanicus* subsp. *germanicus*. Among the other characters considered, *S. xdominii* differs from *S. ucranicus* in the number of tubular florets and in the width of the base of stem leaves, and from *S. germanicus* subsp. *germanicus* mainly by the length of involucre bracts and the length of tubular florets.

In the Carpathians *S. ucranicus*, *S. dacicus* and *S. hercynicus* subsp. *hercynicus* often possess glandulous supplementary bracts, although plants with an almost complete lack of glandular hairs were found as well. Similar to the case of *S. dacicus* (cf. HODÁLOVÁ & MARHOLD 1998), the indument of supplementary bracts varies a great deal within *S. ucranicus*. There are plants with completely glandulous supplementary bracts, or rarely only sparsely hairy plants with short or long articulate hairs without glandular ones. Plants collected at higher altitudes (subalpine belt) and phenologically earlier (June or in the first half of July) are densely glandulous. In the supramontane and montane belts, plants with short or rarely long articulate hairs (sometimes together with glandular hairs on the same plants) were found. This pattern of morphological differentiation of *S. ucranicus* could be explained in the following ways: (1) this variation is caused by continuous morphological variation within this taxon; or (2) mainly in the lower altitudes the variation of *S. ucranicus* might be partly influenced by introgressive hybridization with *S. germanicus* subsp. *germanicus* or *S. ovatus* subsp. *ovatus*. However, in respect to other morphological characters populations of “nontypical” *S. ucranicus* are much more similar to *S. ucranicus* than any other members of the *S. nemorensis* group. The major problem with “typical” and “nontypical” groups of *S. ucranicus* was that it was not possible to find any other character which would allow

Table 3. Summary statistics for quantitative characters of *S. dacicus* (n=43), *S. germanicus* subsp. *germanicus* (n=138), *S. hercynicus* subsp. *hercynicus* (n=71), *S. nemorensis* (n=32), *S. ovatus* subsp. *ovatus* (n=56), *S. ucranicus* (n=136) and *S. xdominii* (n=16). Upper line: mean  $\pm$  standard deviation, lower line 5% and 95% percentiles.

	DAC	GER	HER	Taxa NEM	OVA	UCR	DOM
Characters (mm)							
LL	181.13 $\pm$ 37.58 126.4–244.8	147.80 $\pm$ 28.55 106.4–201.6	141.56 $\pm$ 21.46 104.8–170.0	142.23 $\pm$ 27.35 97.6–187.2	214.38 $\pm$ 27.61 175.2–268	172.20 $\pm$ 32.71 130.53–242.8	159.95 $\pm$ 23.88 118.4–210.4
WL	70.22 $\pm$ 5.95 53.52–89.48	60.16 $\pm$ 4.87 44.42–77.8	72.72 $\pm$ 6.15 55.02–92.52	50.40 $\pm$ 6.65 30.08–70.6	38.68 $\pm$ 3.64 28–55.08	55.70 $\pm$ 5.35 40.96–77.24	56.48 $\pm$ 5.38 43.82–75.24
WBL	6.72 $\pm$ 2.64 3.5–10	6.41 $\pm$ 2.33 4–10	6.28 $\pm$ 2.71 3–11	3.16 $\pm$ 1.79 1.5–7	1.29 $\pm$ 0.35 1–2	3.91 $\pm$ 1.13 2.5–6	6.78 $\pm$ 3.77 3.5–10
LSB	9.01 $\pm$ 1.79 6.6–12.34	6.37 $\pm$ 1.60 3.76–9.47	10.52 $\pm$ 1.75 7.44–13.71	5.84 $\pm$ 1.66 4.08–8.4	4.46 $\pm$ 0.79 3.16–5.8	3.06 $\pm$ 0.94 1.61–4.44	4.51 $\pm$ 1.22 2.78–6.38
LB	8.80 $\pm$ 1.78 5.75–11.64	5.33 $\pm$ 0.80 4.16–6.81	7.58 $\pm$ 1.05 6.68–8.87	4.94 $\pm$ 0.61 4.15–6.57	5.95 $\pm$ 0.53 4.92–6.94	5.92 $\pm$ 0.99 4.64–7.86	5.17 $\pm$ 0.99 5.41–7.25
NB	12.40 $\pm$ 1.18 10–14	9.67 $\pm$ 1.23 8–12	10.32 $\pm$ 1.49 9–13	12.63 $\pm$ 1.88 10–18	8.04 $\pm$ 0.19 8–8	9.54 $\pm$ 0.76 9–11	9.38 $\pm$ 1.20 9–11
LLG	20.23 $\pm$ 2.91 15–25	14.92 $\pm$ 2.45 11–19	20.42 $\pm$ 2.66 17–25	13.84 $\pm$ 2.23 10–18	20.05 $\pm$ 2.89 16–26	16.89 $\pm$ 2.61 13–22	15.56 $\pm$ 3.37 12–25
NL	7.67 $\pm$ 0.71 6–8	5.09 $\pm$ 0.42 5–6	5.00 $\pm$ 0.00 5–5	7.47 $\pm$ 0.84 6–8	4.80 $\pm$ 0.44 4–5	5.01 $\pm$ 0.19 5–5	5.19 $\pm$ 0.40 5–6
LF	9.29 $\pm$ 0.96 8–11	7.52 $\pm$ 0.69 6–9	8.71 $\pm$ 0.71 7.5–10	6.55 $\pm$ 0.74 6–8	7.95 $\pm$ 0.81 6.5–9	7.67 $\pm$ 0.63 6.5–8.5	7.51 $\pm$ 1.03 7–9
NF	23.40 $\pm$ 3.94 17–30	14.59 $\pm$ 2.18 11–19	16.42 $\pm$ 3.29 12–22	23.78 $\pm$ 5.01 17–32	10.73 $\pm$ 1.53 8–14	10.76 $\pm$ 1.69 8–14	14 $\pm$ 3.01 10–20

Table 4. Frequencies of the character of indument of supplementary bracts: in *S. dacicus*, *S. germanicus* subsp. *germanicus*, *S. hercynicus* subsp. *hercynicus*, *S. nemorensis*, *S. ovatus* subsp. *ovatus*, *S. ucranicus* and *S. xdominii* (SAH – short articulate hairs, LAH – long articulate hairs, GLH – glandular hairs).

Character	Frequency in the group						
	DAC	GER	HER	NEM	OVA	UCR	DOM
SAH	0	0	0	0	56	29	0
LAH	17	138	0	32	0	13	16
GLH	26	0	71	0	0	94	0

unambiguous separation of these two groups of *S. ucranicus*. Thus, on the basis of the results of multivariate analyses, both these groups were assigned to *S. ucranicus*.

The distribution of *S. ucranicus* supports its taxonomic recognition. In the Carpathians, all three “glandulous” taxa (= *S. ucranicus*, *S. dacicus* and *S. hercynicus* subsp. *hercynicus*) are allopatric, and their geographical ranges do not overlap (Fig. 5). *S. hercynicus* subsp. *hercynicus* occurs in the West Carpathians; *S. dacicus* occurs in the southern South Carpathians and western part of Romania (Apuseni). *S. ucranicus* alternates both of these taxa in the whole of the East Carpathians and in the eastern part of the South Carpathians. It ranges from Slovakia (Bukovské vrchy), Poland (Bieszczady), the Ukraine (ranging from Prikarpatija and Schidni Beskydy j Nyz’ki Polonyny to Chyvchyno-Grynyavs’ki Gory and Marmaros’ki Al’py) to Romania (ranging from Munții Rodna and Maramureș to the South-Carpathian mountains



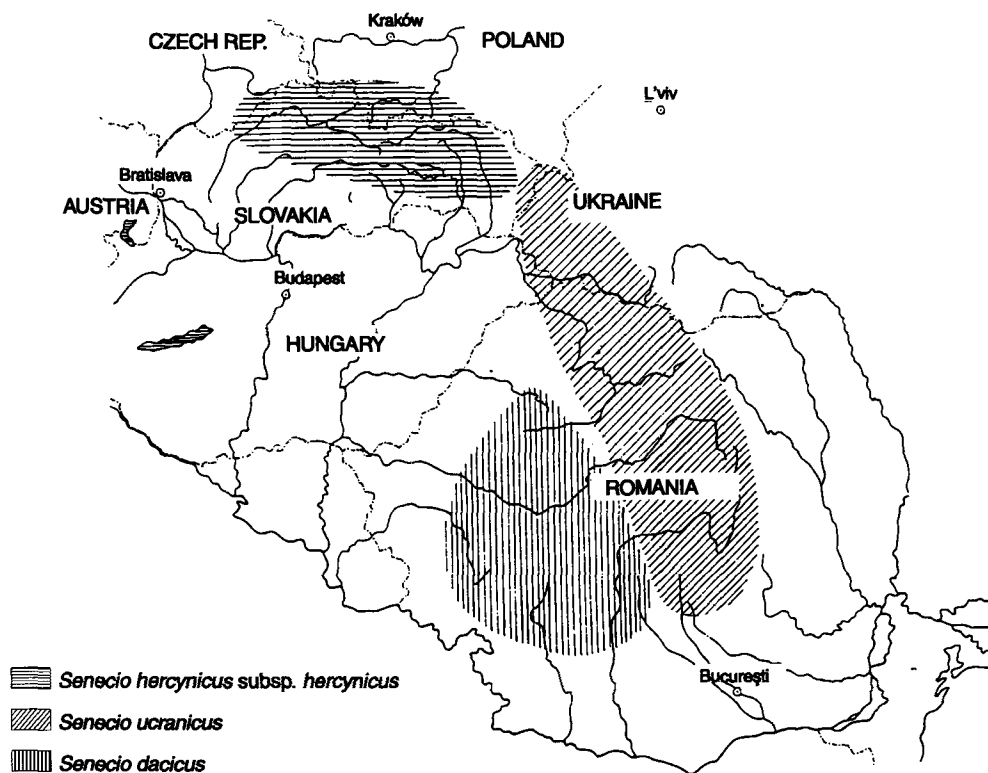


Fig. 5. The distribution of *S. hercynicus* subsp. *hercynicus*, *S. ucranicus* and *S. dacicus* in the Carpathians.

Bucegi and Făgăraş). In the West Carpathians, it was found only in the Vihorlat Mts. All three taxa are mostly distributed in tall-herb and grass communities and in communities with *Pinus mugo* or *Alnus viridis* in the subalpine belt; in forest communities, forest glades and clearings, on sufficiently moist and humus-rich soils in communities surrounding springs in montane, supramontane and subalpine belts.

“Eglandulose” Carpathian members of the *S. nemorensis* group – *S. germanicus* subsp. *germanicus* and *S. ovatus* subsp. *ovatus* (they never possess glandulous supplementary bracts) are distributed in colline, submontane, and montane belts. *S. germanicus* subsp. *germanicus* was confirmed in the whole of the Carpathians, *S. ovatus* subsp. *ovatus* mainly in its western part. The distribution areas of *S. ucranicus* and *S. germanicus* subsp. *germanicus* partly overlap. In the area of their sympatry, mixed populations occur, sometimes including intermediate specimens. These intermediates are probably the result of hybridization and introgression.

In respect to flowering time and ecological relationships, the absence of significant differences among *S. dacicus*, *S. hercynicus* subsp. *hercynicus* and *S. ucranicus* was recorded. However, all three taxa differ from the “eglandulous” taxa of the *S. nemorensis* group (*S. germanicus* subsp. *germanicus* and *S. ovatus* subsp. *ovatus*) by an apparent phenological shift. In the same altitudes (e.g. montane belt), *S. germanicus* subsp. *germanicus* and *S. ovatus* subsp. *ovatus* flower 2–3 weeks later than the “glandulous” taxa of this group. *S. dacicus*,

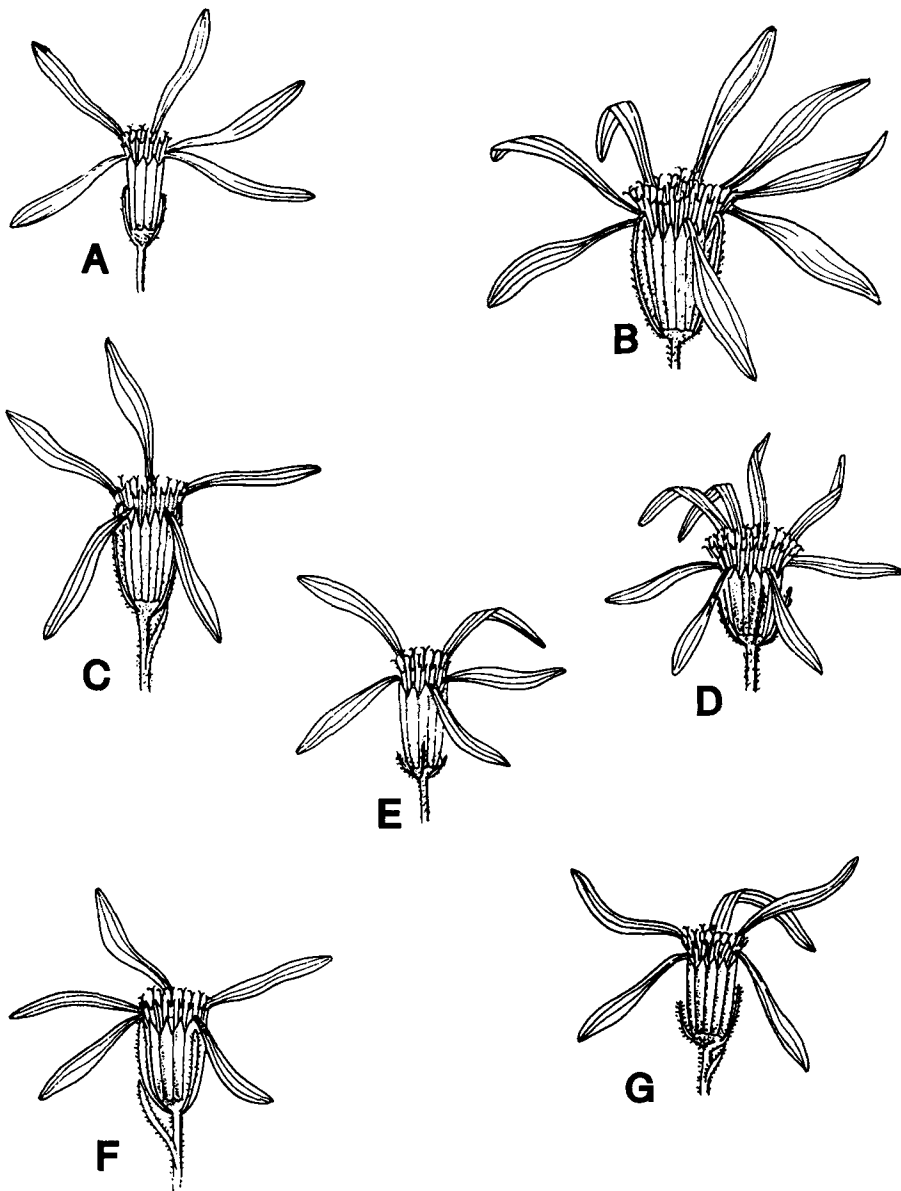


Fig. 6. Anthodium. A – *Senecio ovatus* subsp. *ovatus*; B – *S. dacicus*; C – *S. hercynicus* subsp. *hercynicus*; D – *S. nemorensis*; E – *S. ucranicus*; F – *S. germanicus* subsp. *germanicus*; G – *Senecio* × *dominii*.

*S. hercynicus* subsp. *hercynicus* and *S. ucranicus* start to bloom in June or in the first half of July (in montane and supramontane belts) and they bloom until the end of August. *S. germanicus* subsp. *germanicus* and *S. ovatus* subsp. *ovatus* bloom from the second half of July or the first half of August (in submontane and montane belts) until the end of September.

In the herbaria, *S. ucranicus* has been often identified as *S. ovatus* subsp. *ovatus*. The results of this study showed significant morphological differences between them (see above, results of canonical discriminant analyses of *S. ucranicus* and *S. ovatus* subsp. *ovatus*). Besides

morphological differences, there are differences in flowering time and in the distribution of both taxa in the Carpathians.

The authors of some Floras and keys treated the taxa of the *S. nemorensis* group at a subspecific level (e.g. CHATER & WALTERS (1976) in Flora europaea treated *S. ovatus* as *S. nemorensis* subsp. *fuchsii* (C.C. GMEL.) ČELAK.). Between the taxa of the *S. nemorensis* group (*S. germanicus*, *S. hercynicus*, *S. ovatus*, *S. ucranicus* and *S. dacicus*) visible morphological, ecological, geographical and phenological differences were observed (cf. HODÁLOVÁ & MARHOLD 1996, 1998, HODÁLOVÁ & VALACHOVIČ 1996). However, taxonomic evaluation of this group is complicated by the presence of a great number intermediate populations probably of hybridogenous origin (cf. KUCOWA 1976, HERBORG 1987, OBERPRIELER 1994, HODÁLOVÁ & MARHOLD 1996). In spite of the fact that genetic barriers between the taxa studied seem to be very weak and natural hybrids occur very frequently, hybridization has probably been accelerated mainly by anthropological influences. Thus, this study supports those of KONECHNAYA (1979), HERBORG (1987), OBERPRIELER (1994) in that the taxa of this group should be separated at the specific level.

From the most southern part of Romania (Danube Carpathians – “Banat”) NYÁRÁDY (1964) reported the presence of *S. cacaliaster* LAM. In spite of the fact that in the Carpathians this taxon was not confirmed by the present author (nor by HERBORG (1987), who reported the presence of this species only from France, Austria, Italy and former Yugoslavia), its occurrence in the area studied is not completely excluded. However, no specimens identified as such by Nyárády and belonging to this taxon were found in Romanian herbaria.

**Key to the species and subspecies of *S. nemorensis* group occurring in the Carpathians, including *S. nemorensis* L. s. str.**

- 1a. Supplementary bracts glandulous . . . . . 2
- b. Supplementary bracts hairy with short or long articulate hairs (not glandulous) . . . . . 3
  
- 2a. Involucral bracts 6–12 mm; supplementary bracts 7–14 mm, longer, or as long as involucre; tubular florets 12–30, 8–11 mm; West Carpathians, southern part of the South Carpathians and Apuseni Mts. . . . . 4
- b. Involucral bracts 5–8 mm; supplementary bracts 2–4 mm, much shorter than involucre; tubular florets 8–14, 7–9 mm; East Carpathians and eastern part of the South Carpathians . . . . . *S. ucranicus*
  
- 3a. Ligules regularly 5; tubular florets 12–22; West Carpathians . . . . . *S. hercynicus* subsp. *hercynicus*
- b. Ligules 6–8; tubular florets 17–30; southern part of the South Carpathians and Apuseni Mts. . . . . *S. dacicus*
  
- 4a. The middle and upper leaves narrow or petiolate; supplementary bracts sparsely hairy with short articulate hairs . . . . . 5
- b. The middle and upper leaves sessile or semiamplexicaul (not petiolate); supplementary bracts usually densely hairy with long articulate hairs . . . . . 6
  
- 5a. Stem leaves at base 1–2 mm wide; involucral bracts regularly 8; supplementary bracts 3–6 mm . . . . . *S. ovatus* subsp. *ovatus*

- b. Stem leaves at base 3–6 mm wide; involucre bracts (8)9–11; supplementary bracts 2–4 mm ..... *S. ucranicus*
- 6a. Involucre bracts 8–12; ligules regularly 5 (only rarely up to 8); tubular florets 8–19 .  
..... 7
- b. Involucre bracts 10–18; ligules 6–8; tubular florets 17–32 ..... 8
- 7a. Stems in lower part usually hairy; supplementary bracts 4–10 mm, longer or as long as involucre; tubular florets 11–19 ..... *S. germanicus* subsp. *germanicus*
- b. Stems in lower part usually glabrous; supplementary bracts 2–4 mm, much shorter than involucre; tubular florets 8–14 ..... *S. ucranicus*
- 8a. Stem leaves at base 4–10 mm wide; involucre bracts 6–12 mm; supplementary bracts 7–12 mm; tubular florets 8–11 mm ..... *S. dacicus*
- b. Stem leaves at base (1.5–) 2–7 mm wide; involucre bracts 4–7 mm; supplementary bracts 4–8 mm; tubular florets 6–8 mm ..... *S. nemorensis*

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## APPENDIX 1

[in descriptions the 5% and 95% percentiles are accompanied with 1% and 99% percentiles in brackets]

***Senecio ucranicus* HODÁLOVÁ, sp. nov.**

Planta perennis; caulis florifer erectus, (50–)70–150 cm altus, viridis vel rubescens, glaber vel raro sparsim pilosus. Folia anguste-ovata vel lanceolata, (12.3–)13.1–24.3(–25.4) × (3.5–)4.1–7.7(–8.0) cm, ad basin angustata vel sessilia, semiamplexicaulia, (2.0–)2.5–6.0(–8.0) mm lata. Inflorescentia polycephala, pedunculi sparsim aut moderatim glandulosi, raro subglabri aut sparsim pilosi. Phylla involucralia interiora (8–)9–11(–12), (4.2–)4.6–7.9(–8.9) mm longa, phylla involucri exteriora (1.4–)1.6–4.4(–5.7) mm longa, plerumque glandulosa, raro sparsim pilosa (pilis articulatis). Ligulae plerumque 5, (12–)13–22(–23) mm longae, flosculi 8–14, (6.0–)6.5–8.5(–9.0) mm longi.

Habitat in sylvis et nemoribus montanis et subalpinis.

Floret VI–VIII, c. 2–3 hebdomades ante *S. germanicus* subsp. *germanicus* et *S. ovatus* subsp. *ovatus*.

Type: Ukraine, Chornogora, Mt. Breskul, N, ca. 1300 m, 8. VIII. 1990, leg. I. HODÁLOVÁ (HT: SAV, IT: W).

Perennial. Stems erect (50–)70–150 cm, green or purplish, in the lower part of stem usually glabrous or rarely sparsely hairy. Leaves anguste-ovate or lanceolate, (12.3–)13.1–24.3(–25.4) × (3.5–)4.1–7.7(–8.0) cm, narrowed, sessile or semiamplexicaul at the base, the base of stem leaves (2.0–)2.5–6.0(–8.0) mm wide. Inflorescence many flower-headed, corymbs, peduncles sparsely or densely glandulous, subglabrous or sparsely hairy. Involucral bracts (8–)9–11(–12), (4.2–)4.6–7.9(–8.9) mm long, supplementary bracts (1.4–)1.6–4.4(–5.7) mm long, usually glandulous or sparsely hairy (with short or rarely long articulate hairs often together with glandular hairs on the same plants). Ligules regularly 5, (12–)13–22(23) mm, tubular florets 8–14, (6.0–)6.5–8.5(–9.0) mm long.

Flowering time VI–VIII, ca. 2–3 weeks earlier than *S. germanicus* subsp. *germanicus* and *S. ovatus* subsp. *ovatus*.

***Senecio xdominii* HODÁLOVÁ hybr. nov.  
= *S. germanicus* x *S. ucranicus***

Planta inter *S. germanicus* et *S. ucranicus* intermedia. Caulis florifer erectus, (50–)70–150 cm altus, viridis aut rubiginosus, glaber, subglaber vel pilosus. Folia ovata aut anguste-ovata vel lanceolata, 11.8–21.1 × 4.4–7.5 cm lata, ad basin angustata vel sessilia, semiamplexicaulia 3.5–10.0 mm lata. Pedunculi sparsim aut moderatim pilosi. Phylla involucri interiora (8–)9–11, 5.4–9.3 mm longa, phylla involucri exteriora 2.8–6.4 mm longa, dense, raro sparsim pilosa (pilis articulatis). Ligulae plerumque 5(–6), 12–25 mm longae, flosculi 10–20, 7–9 mm longi.

Floret VII–IX.

Type: Romania, Munții Făgăraș, Bîlea Lac, ca. 1800 m, 17. VII. 1993, leg. I. HODÁLOVÁ (HT: SAV, IT: W).

Holotype representing hybrid *S. germanicus* subsp. *germanicus* × *S. ucranicus*.

Plants intermediate between *S. germanicus* and *S. ucranicus*. Stems erect (50–)70–150 cm, green or purplish, in the lower part stem glabrous, subglabrous or hairy. Leaves ovate to anguste-ovate or lanceolate, 11.8–21.1 × 4.4–7.5 cm, narrowed, sessile or semiamplexicaul at the base, the base of stem leaves 3.5–10.0 mm wide. Peduncles sparsely or densely hairy. Involucral bracts (8–)9–11, 5.4–9.3 mm, supplementary bracts 2.8–6.4 mm long, usually densely hairy with long articulate hairs. Ligules regularly 5(–6), 12–25 mm, tubular florets 10–20, 7–9 mm long.

Flowering time VII–IX.

## APPENDIX 2

List of the localities of the population samples and herbarium specimens used for the morphometric study (number of specimens in square brackets, abbreviations of herbaria according to HOLMGREN et al. 1990):

### *Senecio germanicus* subsp. *germanicus*

**Slovakia:** Strážovské vrchy, between the villages of Zliechov and Čičmany, 700 m (1991 HODÁLOVÁ SAV) [20]; Veľká Fatra, near the road between the villages of Harmanec and Dolný Harmanec, 420 m (1989 HODÁLOVÁ SAV) [9]; Veľká Fatra, Ružomberok, part Hrabovo, 550 m (1990 HODÁLOVÁ SAV) [19]; Bukovské vrchy, Nová Sedlica, 550 m (1989 HODÁLOVÁ SAV) [14]. **Ukraine:** Prikarpattya, Knyazh Dvor, 440 m (1990 HODÁLOVÁ & KAGALO SAV) [12]; Gorgany, near the road to the village of Kremenci, 700 m (1990 HODÁLOVÁ & KAGALO SAV) [20]; Zakarpats'ke peredgir'ya, Uglya, 600 m (1990 HODÁLOVÁ & KAGALO SAV) [13]. **Romania:** Munții Cindrel, the touristic resort Paltiniș, Poiana Muacelului, 1300 m (1992 HODÁLOVÁ SAV) [12]; Munții Cindrel, the touristic resort Paltiniș, Poiana Muacelului, 1400 m (1994 HODÁLOVÁ SAV) [19].

### *Senecio ovatus* subsp. *ovatus*

**Slovakia:** Turčianska kotlina, Valča, Valčiansky potok Stream, 450 m (1993 HODÁLOVÁ SAV) [20]; Slovenské rudohorie, Rožňava, Rožňavský potok Stream, 500 m (1993 HODÁLOVÁ SAV) [18]; Bukovské vrchy, Nová Sedlica, near the stream Stužica, 650 m (1989 HODÁLOVÁ SAV) [18].

### *Senecio hercynicus* subsp. *hercynicus*

**Slovakia:** Západné Beskydy, Suchá Hora, peat-bog, 760 m (1990 HODÁLOVÁ SAV) [19]; Nízke Tatry, Mt. Chopok, 1400 m (1990 HODÁLOVÁ SAV) [24]. **Poland:** Tatry, valley Dolina Kondratowa, Piekło, 1600 m (1990 HODÁLOVÁ & VALACHOVIČ SAV) [18]; Tatry, Wlk. Świstowka, 1300 m (1990 HODÁLOVÁ & VALACHOVIČ SAV) [10].

### *Senecio ucranicus*

**Slovakia:** Bukovské vrchy, Mt. Kremenec, 1200 m (1992 HODÁLOVÁ SAV) [18]. **Ukraine:** Chornogora, Mt. Maryshevs'ka (1990 HODÁLOVÁ & KAGALO SAV) [22]; Chornogora, Mt. Dancher, S (1990 HODÁLOVÁ & KAGALO SAV) [19]; Ukraine, Chornogora, Mt. Breskul, N, 1300 m (1990 HODÁLOVÁ SAV) [18]; Chornogora, Mt. Goverla, N, 1900 m (1990 HODÁLOVÁ & KAGALO SAV) [18]; Chornogora, Mt. Chorna Gora, 1600 m (1990 HODÁLOVÁ & KAGALO SAV) [23]; Chyvchyno-Grynyavs'ki gory, Mt. Chyvchyn, 1700 m (1990 GINDA SAV) [18].

### *Senecio dacicus*

**Romania:** Munții Cindrel, the touristic resort Paltiniș, Poiana Muacelului, 1600 m (1992 HODÁLOVÁ SAV) [13]; Munții Cindrel ("Transsilvania, in fagetis et pinetis montium Cibinensium abunde") (1883 ORWAY BP) [1]; Munții Retezat, Cimpu lui Neag, foot of the Mt. Piatra Iorgovanului, N, 1200 m (1993 HODÁLOVÁ & VALACHOVIČ SAV) [17]; Noul near the town of Sibiu ("Siebenbürgen, in silvis Transsilvaniae pr. Neudorf" (s.d. FUSS WU) [1]; Munții Retezat ("Retyezat") (1857 HAYNALD BP) [1]; Munții Retezat ("Transsilvaniae alpes Retyezát, secum rivulum Zsugyele in alpinis") (1874 SIMONKAI BP) [1]; Munții Retezat, Valereasca ("Transsilvaniae, montes Retyezát, in mughetis supra locum Valeriaszka dictum") (1907 LENGYEL BP) [1]; Apuseni, Muntele Mare, near the chalet Baișoara, N, 1300 m (1993 VALACHOVIČ SAV) [8].

### *Senecio nemorensis*

**Russia:** Lake Baikal, Barguzinskii rajon, village Maksimiha, S, 464 m (1994 HODÁLOVÁ, VALACHOVIČ & ANENHONOV SAV) [26]; Barguzinskii khrebet, mouth of the Bol'shaya Cheremshana river into Lake Baikal, 460 m (1992 DANIHELKA BRNM) [1]; Barguzinskii khrebet, valley of the river Bol'shaya Cheremshana, 800 m (1992 CHALOUPOKOVÁ BRNM) [1]; Barguzinskii khrebet, valley of the river Bol'shaya Cheremshana, stream Pryamoi, 1700 m (1992 DANIHELKA BRNM) [1]; Barguzinskii khrebet, mouth of the Bol'shoi Chivyrkui river into Lake Baikal, 460 m (1993 DANIHELKA & CHYTRÝ BRNM) [1]; Barguzinskii khrebet, valley of the river Bol'shoi Chivyrkui into Lake Baikal, 460 m (1993 DANIHELKA & CHYTRÝ BRNM) [1]; Bassejn Tyrma, top of the mountain ridge, near the river Iauryn [Bureinskii Khrebet] (1909 DOCTUROWSKY BRNU) [1].

### *Senecio xdominii*

**Romania:** Munții Făgăraș, Bîlea Lac, W, 1800 m (1993 HODÁLOVÁ SAV) [16].