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Coenotic differentiation of the infraspecific taxa of *Cardamine amara* (Brassicaceae) in Central Europe and the Balkan Peninsula.

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ABSTRACT: Recent taxonomic studies revealed considerable morphological and karyological variation within *Cardamine amara*. In Central Europe and the Balkan Peninsula this species is represented by *C. amara* subsp. *amara*, *C. amara* subsp. *opicii*, *C. amara* subsp. *balcanica* (all diploid), and by the tetraploid *C. amara* subsp. *austriaca*. The present paper shows general pattern of vegetation types characterised by *C. amara* subspecies, using 247 relevés from the area studied, evaluated by the TWINSPAN program. Although (mostly) spring communities with different subspecies of *C. amara* are physiognomically similar, constant differences among communities in which different subspecies occur, where shown. Analysis of the phytocoenological data from the Bulgarian mountains lead to the description of new association.

KEYWORDS: Brassicaceae, Balkan Peninsula, *Cardamine*, Central Europe, Cruciferae, Phytocoenology

Introduction

Recent taxonomic studies revealed considerable morphological and karyological variation within *Cardamine amara* L. Apart from already known diploid (2n=16) *C. amara* subsp. *amara* distributed for most of the area of the species, mainly in the lower and middle altitudes, and *C. amara* subsp. *opicii* (J.

PRESL & C. PRESL) ČELAK., restricted to the upper montane to subalpine belt of the Sudeten Mts and Carpathians (MARHOLD 1992, 1995, HROUDA & MARHOLD 1993), diploid *C. amara* subsp. *balcanica* MARHOLD, ANČEV et KIT TAN was recently described from the mountains of SW Bulgaria and NE Greece (MARHOLD et al. 1996, MARHOLD 1998). On the tetraploid level (2n=32) two additional taxa should be recognised. Populations occupying the Eastern Alps and neighbouring areas should be classified as separate subspecies, *C. amara* subsp. *austriaca* MARHOLD (MARHOLD 1999), while endemic tetraploid populations occurring in Catalania are already known as *C. amara* subsp. *olotensis* O. BOLÒS (RICO 1993, MARHOLD, in prep.). These taxa represent an example of geographic and vertical vicariancy on the diploid and tetraploid level and we were interested to see how this vicariancy is reflected in their coenotic relations (Fig. 1).

The main aim of our paper is to show general pattern of vegetation types characterised by *Cardamine amara* subspecies. Rather than the detailed syntaxonomic analysis, the objective of the present study was a comparison of coenological behaviour of different subspecies of *Cardamine amara* in Central European and Balkan part of the distribution area of the species.

More detailed attention was paid to the Bulgarian populations of *C. amara* subsp. *balcanica* for which no phytocoenological data were available before.

Methods

247 relevés of the non-forest vegetation in which the abundance of *Cardamine amara* subspecies was higher than 5% (=2a) were selected from the TURBOVEG database (HENNEKENS 1995). Among them, data from Slovakia, Czech Republic, Austria, Germany, France, Belgium, Poland, Ukraine, and Romania were found. In addition, 20 relevés from the Bulgarian mountains were obtained using the Zürich-Montpellier approach (WESTHOFF & VAN DER MAAREL 1978) in 1994 and 1995 during the field research by the first author (see Appendix 2).

TWINSPAN program (HILL 1979) was used for the classification of the above-mentioned data set. Relevés were transformed before processing into ordinal scale. Analysis of the phytocoenological material from the Bulgarian mountains lead to the description of new association.

Nomenclature of taxa follows MARHOLD & HINDÁK (1998) and ANDREEV et al. (1992) unless otherwise stated.

Coenotic differentiation

Generally, the spring plant communities with *Cardamine amara* show on the first look conspicuous similarities in their structure, ecological requirements and overall habit. However, taking into account the new knowledge about taxonomic diversity and occurrence of the subspecies of *Cardamine amara* more fine classification of these communities should be considered.

For the present study available published and unpublished relevés of non-forest vegetation with significant abundance of *Cardamine amara* subspecies

were compared by divisive polythetic classification using the program TWINSPAN. After classification the logical clusters were formed, organised more or less according dominant *Cardamine amara* subspecies. The final synoptic table (Tab. 1) was made as a combination of the result of classification and subjective rearrangement of some relevés, taking into consideration the altitude, ecological features, and phytogeographic origin of the data. Especially the placement of the relevés with low number of species had to be corrected (compare Fig. 1 and Tab. 1).

Resulting clusters did not follow the origin of relevés. They were not strictly arranged according to the original publications or the classification by the original authors. More important than the origin from the certain source were the total floristic composition, and ecological features of localities, e.g. altitude.

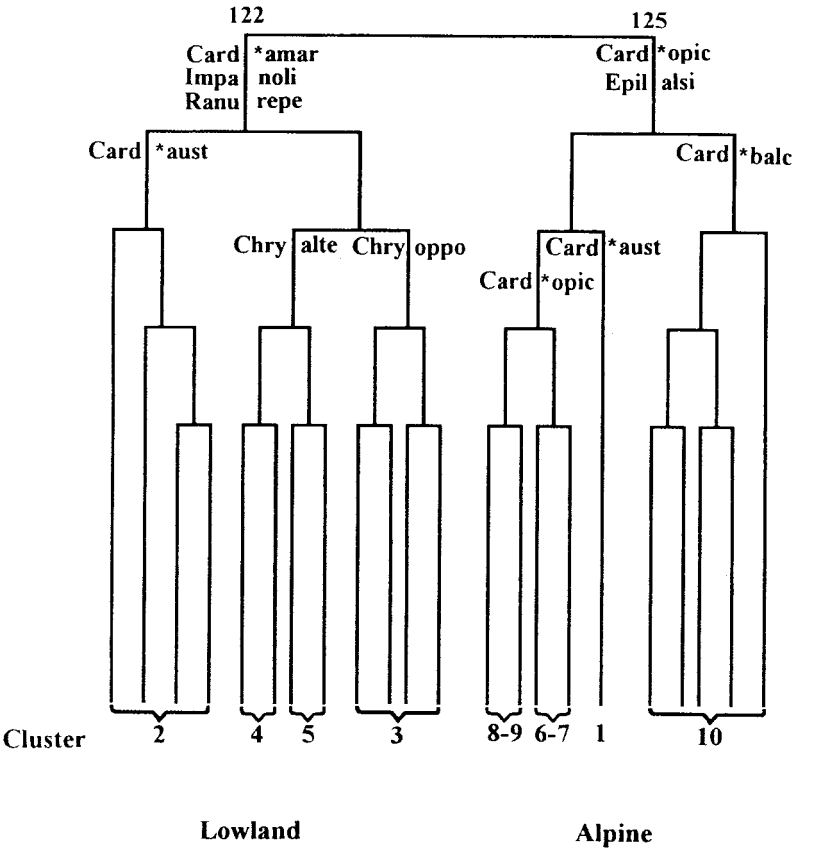

Fig. 1. Classification of the total 247 relevés using TWINSPAN with main indicator species for clusters 1-10 (the numbers of clusters correspond with Tab. 1).

Clusters 1-2 determined by *Cardamine amara* subsp. *austriaca*

As it is shown by MARHOLD (1999) the Eastern Alps and closely neighbouring areas are occupied by tetraploid populations of *Cardamine amara* subsp. *austriaca* MARHOLD, ranging from the altitudes at the level of the Danube river up to the 2500 m. Such broad altitudinal span indicates that they are more ecologically plastic than any other taxon of this species. Although in the Eastern Alps authors often does not make difference between the spring communities from alpine belt and those from submontane altitudes (e. g. HINTERLANG 1992: tab. 5.2.1.), the relevés from the areas entirely occupied by the tetraploid populations are in our dendrogram divided according to the altitude.

The cluster 1 represents the alpine type of the communities in the Eastern Alps. We have found only few published relevés of this kind (HARTL 1963, HAUPT 1985). These were classified as *Cratoneuro-Philonotidetum seriatae* GEISSLER 1976 or as the broadly conceived association *Cardaminetum amarae* BR.-BL. 1926, what undoubtedly requires further study.

The data from the Lower Austrian Alpenvorland from 500-700 m a. s. l., forming the cluster 2 are more closely related to the other lowland communities with *Cardamine amara* subsp. *amara* than to the high-mountain relevés with *C. amara* subsp. *austriaca*. Relevés by RAUSCHER (1992) were made in the species poor stands and classified as "*Cardamine amara*-Kleinstandorte". ZECHMEISTER & STEINER (1995) published similar communities with higher abundance of *Cardamine amara* using for them the name *Cardamino-Chrysosplenietum alternifolii* MAAS 1959 em. ZECHMEISTER 1993 and *Trichocoleo-Sphagnetum* MAAS 1959. In hierarchical system these communities belong to the alliance *Caricion remotae* KÄSTNER 1941.

Clusters 3-5 determined by *Cardamine amara* subsp. *amara*

This taxon is a typical element of spring communities in lowlands and submontane belt in most of Europe except more southern parts of the Balkan Peninsula (SW Bulgaria and NE Greece), the Eastern Alps and Pyrenees. Relevés with *C. amara* subsp. *amara* were separated into 3 clusters.

The cluster 3 contains predominantly data from Central and western part of Europe (Germany, Belgium, France, Czech Republic) represented mainly by the association *Chrysosplenietum oppositifoliae* subass. *cardaminetosum amarae* OBERDORFER et PHILIPPI 1977 (HINTERLANG 1992). More frequent subatlantic taxa such as *Chrysosplenium oppositifolium* L., *Stelaria alsine*, *Lysimachia nemorum* (KRAUSCH 1985) play the role of differential species.

In the Western Carpathians (cluster 4) *C. amara* subsp. *amara* is dominant or subdominant taxon in springs of lowland and hills, where *Cardamino-Chrysosplenietum alternifolii* MAAS 1959 is more frequent community. Beside this, subspecies is present in other spring associations of the alliance *Caricion remotae*. The lowland *Magnocaricetalia* march species, such as *Galium uliginosum, Glechoma hederacea, Juncus effusus, Iris pseudacorus*, are present here and they are putting together often geographically distant relevés. Relevés from forest springs were considered as more or less typical association

Caricetum remotae (KÄSTNER 1941) SCHWICKERATH 1944. They ecologically prefer oligotrophic springs and rivulet banks on sandy soils with relatively low content of silt.

Especially the cluster 5 represents some features typical for the flysch zone of the Carpathians. The stands from higher altitudes (450-1000 m) were very often ascribed as *Cardamino-Chrysosplenietum alterniifolii* MAAS 1959 *calthetosum laetae* HADAČ et SOLDÁN 1989. As differential moment there are not only East-Carpathian species such as *Symphytum cordatum*, but also high presence of *Petasites albus, Chaerophyllum hirsutum* so much typical for flysh zone of the Carpathians.

In spite of these differences, all relevés of lowland and middle altitude spring communities in our material (clusters 3-5) are to large extent similar and according to the dominance of some species can be classified into one alliance, namely *Caricion remotae* - see group of diagnostic species in Tab. 1.

Clusters 6-9 determined by *Cardamine amara* subsp. *opicii*

Cardamine amara subsp. *opicii* builds in the higher altitudes in the upper montane and subalpine belts of the Sudety Mts, W and E Carpathians and partly also S Carpathians the association *Brachythecio rivularis-Cardaminetum opicii* (KRAJINA 1933) HADAČ 1983. In *Caltho-Dicranelletum squarrosae* HADAČ 1956 and *Calthetum laetae* KRAJINA 1933 it occurs as the accompanying element.

All these vegetation types are known also from the Eastern and Southern Carpathians (here with differential taxa such as *Saxifraga stellaris* subsp. *alpigena*, *Aconitum tauricum* WULFEN - see cluster 6 with relevés from the Rodna Mts (COLDEA 1990), Făgăraş Mts (VOIK 1976) and from Ukraine (Mt. Pop Ivan) by DEYL (1940)).

Clusters 7 and 8 represent typical situation of vegetation cover on open springs in the Western Carpathians. The division into two blocks follow some ecological and floristical aspects, which are hard to express syntaxonomically. Relevés by KRAJINA (1933), UNAR et al. (1984), MIADOK (1995), and some unpublished data from the Západné and Vysoké Tatry Mts were dispersed into both clusters. All these relevés can be classified generally as typical *Brachythecio rivularis-Cardaminetum opicii.* Beside this, *C. amara* subsp. *opicii* is present in the *Cratoneuro decipiens-Cardamine opicii* community, known from the Západné Tatry and Vysoké Tatry Mts, mainly on the border between Poland and Slovakia (PAWŁOWSKI et al. 1928). Community recorded by KORNAŚ & MEDWECKA-KORNAŚ (1967) from the Gorce Mts was at that time described as *Cardamino-Cratoneuretum,* and here confirmed as possible separate cluster 9. The geological substrate does not play important role, nevertheless calciphilous species such as *Swertia perennis, Arabis soyeri, Philonotis calcarea* direct some relevés of the cluster 9 to *Cratoneurion commutati* W. KOCH 1928.

In the area of the Carpathians and Sudeten around altitude 1000 m there is a zone where both *C. amara* subsp. *opicii* and *C. amara* subsp. *amara* sometimes occur side by side. However, mostly the first of them is restricted to the upper montane to alpine belts while the second one to the lower and middle altitudes.

Transitional character between associations of the alliance *Cratoneuro filicini-Calthion laetae* HADAČ 1983 and *Caricion remotae*, depicted by presence of dealpine species such as *Epilobium alsinifolium*, *Viola biflora*, with combination of *Equisetum palustre* or *Poa trivialis* is more or less proved.

Column 10 determined by *Cardamine amara* subsp. *balcanica*

Cardamine amara subsp. *balcanica* forms in the Balkan mountains communities very similar to *Brachythecio rivularis-Cardaminetum opicii*, known from the Sudeten Mts and Carpathians. However, results of our study show that these Balkan communities are enough different to be described as a vicariant association occurring in the Pirin, Rila, Rhodops and Vitosha Mts (see Appendix 1). Apart from these areas the distribution of this association probably extends to the Belasica Mts. in Bulgaria and Rhodopi and Vrondous Mts in Greece, from where *Cardamine amara* subsp. *balcanica* was also confirmed (MARHOLD et al. 1996).

***Brachythecio rivularis-Cardaminetum balcanicae* ass. nova. hoc loco**

Nomenclatural type: Tab. 2, rel. 9 (holotypus)
Characteristic species combination: *Cardamine amara* subsp. *balcanica* (char., dom.), *Cirsium appendiculatum* (dif.), *Myosotis orbelica* (dif), *Brachythecium rivulare* (const.)

The stands of this community are situated under timberline, only exceptionally in the subalpine belt. They occur nearly in the same altitudes as *C. amara* subsp. *opicii*, but because of the Balkan mountains are situated more southerly (in comparison with the West Carpathians), there is a clear shift of belts upwards. In other words, while the timberline in the West Carpathians lies at about 1500 m, in the Balkan mountains it is situated nearly at the altitude of 2000 m. Thus *Brachythecio rivularis-Cardaminetum balcanicae* occupies a transitional position between typical oligotrophic mountain and alpine spring vegetation - see presence of differential species of both Carpathian alliances, namely *Caricion remotae* and *Cratoneuro filicini-Calthion laetae*. Unlike in the case of *C. amara* subsp. *opicii* there are no vicariant populations of *C. amara* subsp. *amara* in the lower altitudes of the Balkan mountains. *Cardamine amara* subsp. *balcanica* is the only representative of the species in this region (Fig. 2).

Cardamine amara subsp. *balcanica* grows mostly on granite substrate and in the community manifests as significant dominant. Like communities with *C. amara* subsp. *opicii* it occupies springs, rivulet banks and meanders. The community is either permanently flooded or grows on the soil with very high content of water. Some species, like *Rumex alpinus* or *Fontinalis antipyretica* most probably indicate the fertilisation due to the intensive pasture. Balkan elements in the species composition which contribute to the differentiation of this community from *Brachythecio rivularis-Cardaminetum opicii* are represented by *Cirsium appendiculatum, Cardamine raphanifolia* subsp. *acris, C. rivularis, Geum*

coccineum, Soldanella chrysostricta, Myosotis orbelica (ŠTEPÁNKOVÁ & MARKOVA 1991).

The floristic comparison with the other spring plant communities is presented also in the Tab. 1, where the new association represents the last column.

Conclusions

Our selected relevés represent non-forest spring vegetation only. Although high abundance of *Cardamine amara* was regularly recorded in floodplain forests and other forest communities, these are not included here. The descriptions of higher syntaxa according to cryptogams only is certainly artificial. Similarly, we consider the woody associations such as *Cardamino amarae-Alnetum* PASSARGE et HOFMANN 1968, *Chrysosplenio oppositifoliae-Alnetum glutinosae* MÖLLER 1979, or *Carici remotae-Fraxinetum* KOCH ex FABER 1936 as a mosaic of moist patches (springs, rivulets, depressions) situated in the interior of the forest. The close relation of *Cardamine amara* subspecies to running water or to permanent flooding is evident. Therefore, for definition of ecological behaviour of *Cardamine amara* subspecies we selected the non-forest vegetation.

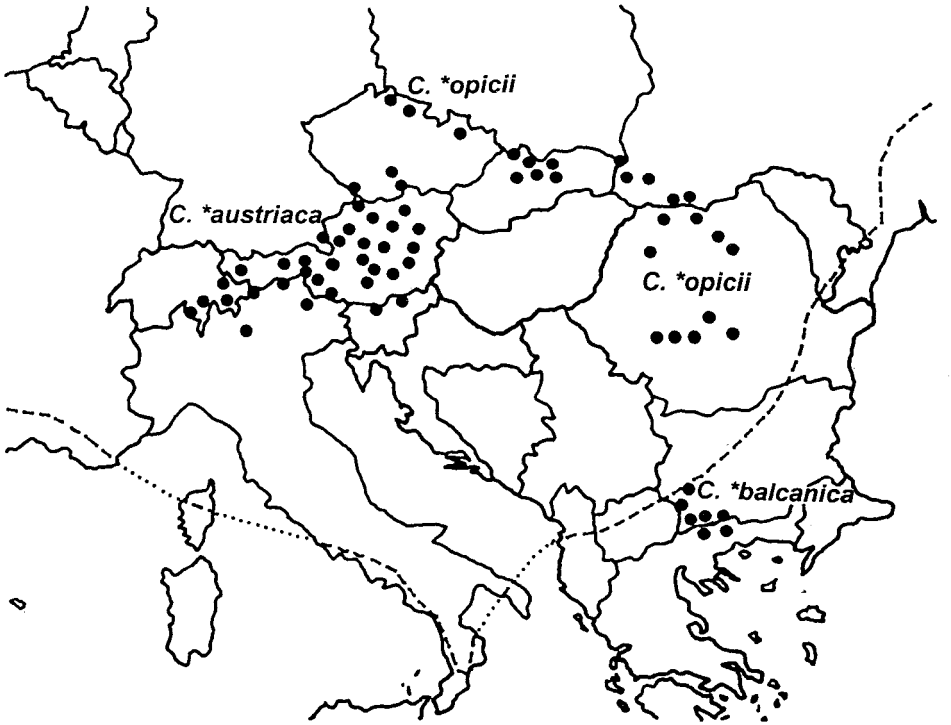

Fig. 2. Distribution map of four subspecies of *Cardamine amara* (for *C. amara* subsp. *amara* the southeastern limit of its area is marked by the broken line).

As regards to the selection of the relevés another fact is also important. While in the older syntheses of spring vegetation from the Central-Europe (HINTERLANG 1992), or in the Europe (ZECHMEISTER & MUCINA 1994) the relevés from E and SE Europe were nearly ignored, in our choice is the ratio between the data from the different areas more balanced. The data set of 247 relevés from 10 countries is evenly divided. Although the majority of them come from Slovakia (133 rels), 70 rels are from the other parts of Central Europe, and from W Europe, including the Sudeten Mts and 44 rels are from E Europe and the Balkan Peninsula.

Although (mostly) spring communities with different subspecies of *C. amara* are physiognomically similar it was shown that there are constant differences among the communities in which different subspecies occur. This is partly because of the different ecological conditions (lowland vs high mountain stands) and partly because of the occurrence in different phytogeographical regions which result in differences in species composition.

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References

ALTMANOVÁ M. (1983): Subalpínska a alpínska vegetácia Nízkych Tatier a jej hodnotenie pre potreby LANDEP. - PhD Thesis, Depon. in ÚKE SAV, Nitra.

ANDREEV N., ANCHEV M., KOZHUKHAROV S., MARKOVA M., PEEV D. & PETROVA A. (1992): Opredelitel na visshite rasteniya v Balgariya. - Sofiya.

COLDEA G. (1978): Vegetaţia fontinală şi palustră din Munţii Plopiş. - Stud. Cercet. Biol. 30: 125-134.

COLDEA G. (1990): Munţii Rodnei. Studiul geobotanic. - Bucureşti.

DEYL K. (1940): Plants, soil and climate of Pop Ivan. Synecological study of Carpathian Ukraine. - Opera Bot. Čech. 2: 1-290.

DÚBRAVCOVÁ Z. (1996): Nové lokality Epilobium nutans F. W. SCHMIDT na Slovensku. - Bull. Slov. Bot. Spoločn. 18: 141-144.

FAJMONOVÁ E. (1991): Fytocenózy zväzu Cardaminion amarae MAAS 1959 v Javorníkoch. - Biológia (Bratislava) 46: 57-61.

FOLTÍNOVÁ J. (1974): Rastlinné spoločenstvá prameníšť v TANAP-e a Slovenskom raji. - Thesis, Depon. in Prírodovedecká fakulta UK, Bratislava.

HÁBEROVÁ I. (1978): Rastlinné spoločenstvá rašelinných lúk Slovenska. - Habil. Thesis, Depon. in Prírodovedecká fakulta UK, Bratislava.

HADAČ E. (1956): Rostlinná společenstva Temnosmrečinové doliny ve Vysokých Tatrách. - Biol. Práce Slov. Akad. Vied 2/1: 1-78.

HADAČ E. & SOLDÁN Z. (1989): Rostlinná společenstva prameništ a horských potoků v Bukovských vrších na severovýchodním Slovensku. - Preslia 61: 343-353.

HARTL H. (1963): Die Vegetation des Eisenhutes im Kärtner Nockgebiet. - Carinthia II 153 (73): 293-336.
HAUPT W. (1985): Die aktuelle Vegetation der östlichen Lechtaler Alpen: II. Strauch-, Fels-, Schneeboden- und Feuchtbiotopgesellschaften. - Veröff. Tirol. Landesmus. Ferdinandeum. 65: 13-57.
HENNEKENS S.M. (1995): TURBO(VEG). Software package for input, processing, and presentation of phytosociological data. User's guide. 1. draft. - Lancaster.
HILL M.O. (1979): TWINSPAN - a FORTRAN program for arranging multivariate data in an order two way table by classification of the individuals and the attributes. - Ithaca.
HINTERLANG D. (1992): Vegetationsökologie der Weichwasserquellgesellschaften zentraleuropäischer Mittelgebirge. - Crunoecia 1: 1-117.
HRABOVCOVÁ J. (1976): Vegetácia subalpínskeho a alpínskeho stupňa Jamnickej doliny. - Thesis. Depon. in Prírodovedecká fakulta UK, Bratislava.
HROUDA L. & MARHOLD K. (1993): The distribution of Cardamine amara subsp. opicii (Cruciferae) in the Sudeten mountains. - Preslia 65: 27-32.
KOPECKÝ K. (1985): Brachythecio rivularis-Cardaminetum opizii (KRAJINA 1933) HADAČ 1983 a Calthetum laetae KRAJINA 1933 na Roháčském potoce v západních Liptovských Tatrách. - Zprávy Československ. Bot. Společn. 20: 217-222.
KOMÁRKOVÁ V. (1964): Alpinská vegetace Roháčů. - Dipl. Thesis, Depon. in Katedra botaniky, PřF KU, Praha.
KORNAŚ J. & MEDWECKA-KORNAŚ A. (1967): Zespoły roślinne Gorców. I. Naturalne i na wpol naturalne nieleśne. - Fragm. Florist. Geobot. 13: 197-203.
KRAJINA V. (1933): Die Pflanzengesellschaften des Mlynica-Tales in den Vysoké Tatry (Hohe Tatra). - Beih. Bot. Centrbl. 50: 774-957.
KRAUSCH H.-D. (1985): Ozeanische Florenelemente in aquatischen Pflanzengesellschaften der D.D.R. - Vegetatio 59: 193-198.
MARHOLD K. (1992): A multivariate morphometric study of the Cardamine amara group (Cruciferae) in the Carpathian and Sudeten mountains. - Bot. J. Linn. Soc. 110: 121-135.
MARHOLD K. (1995): Taxonomy of the genus Cardamine L. (Cruciferae) in the Carpathians and Pannonia. II. Cardamine amara L. - Folia Geobot. Phytotax. 30: 63-80.
MARHOLD K. (1998): Morphometric comparison of diploid populations of Cardamine amara (Brassicaceae) from Central Europe and the Balkan Peninsula. - Thaiszia J. Bot. 8: 19-32.
MARHOLD K. (1999): Taxonomic evaluation of the tetraploid populations of Cardamine amara (Brassicaceae) from the Eastern Alps and adjacent areas. - Bot. Helv. 109, in press.
MARHOLD K., ANČEV M.E., KIT TAN (1996): A new subspecies of Cardamine amara (Brassicaceae) from Bulgaria and Greece. - Ann. Bot. Fenn. 33: 199-204.
MARHOLD K. & HINDÁK F., eds., (1998): Zoznam nižších a vyšších rastlín Slovenska - Checklist of non-vascular and vascular plants of Slovakia. - Bratislava.
MIADOK D. (1995): Vegetácia ŠPR Ďumbier. - Bratislava.
PASSARGE H. (1979): Das Impatientetum noli-tangere Tx. 1975, seine Gliederung und Kontaktgesellschaften im Zipser Bergland. - Doc. Phytosociol. N.S. 4: 783-793.
PAWŁOWSKI B., SOKOŁOWSKI M. & WALLISCH K. (1928): Die Pflanzenassoziationen des Tatra-Gebirges. VII. Die Pflanzenassoziationen und die Flora des Morskie Oko-Tales. - Bull. Int. Acad. Polon. Sci. Cl. Math.-Natur. (1927): 205-272.
RAUSCHER I. (1992): Saumgesellschaften im Flußbereich des niederösterreichischen Alpenvorlandes. - Verh. Zool.-Bot. Ges. Österreich 129: 105-141.

RICO E. (1993): 22. Cardamine L. - In: CASTROVIEJO S. et al. (eds.): Flora Iberica 4, p. 119-133. - Madrid.
SANDA V., POPESCU A. & DOLTU M. (1977): Vegetaţia masivului Piatra Craiului. - Stud. Şt. Nat. Muzeul Brukenthal 21: 115-212.
SILLINGER P. (1933): Monografická studie o vegetaci Nízkych Tater. - Praha.
SÝKORA T. (1970): Lesní společenstva jihozápadní části Hradčanské plošiny. - In: SLAVÍK B. (ed.): Některé fytogeografické a fytocenologické problémy Československa. - Studie ČSAV 7: 9-43.
ŠOLTÉS R. (1989): Ekologicko-syntaxonomické hodnotenie bryocenóz Vysokých a Belianských Tatier. - Biol. Práce 35: 1-148.
ŠOMŠÁK L. (1993): Cardamine amara L. v spoločenstvách zväzu Alnion glutinosae na Záhorskej nížine. Biológia (Bratislava) 48: 417-420.
ŠTĚPÁNKOVÁ, J., MARKOVA, M.L. (1991): A note on distribution of Myosotis orbelica. - Preslia 63: 329-331.
UNAR, J., UNAROVÁ, M., ŠMARDA, J. (1984): Vegetační poměry Tomanovy doliny a Žlebu spod Diery v Západních Tatrách. - Folia. Fac. Sci. Natur. Univ. Purkyn. Brun. 25: 1-101.
VOIK W. (1976): Vegetaţia alpină din valea Şerbotei (Munţii Făgăraşului). - Stud. Şt. Nat. Muzeul Brukenthal 20: 47-64.
WESTHOFF V., VAN DER MAAREL E. (1978): The Braun-Blanquet approach. - In: WHITTAKER R.H. (ed.): Classification of plant communities, p. 289-399. - The Hague.
ZECHMEISTER H., MUCINA L. (1994): Vegetation of European springs: High-rank syntaxa of the Montio-Cardaminetea. - J. Veg. Sci. 5: 385-402.
ZECHMEISTER G.H., STEINER M.G. (1995): Quellfluren und Quellmoore des Waldviertels, Österreich. - Tuexenia 15: 161-197.

Tab. 1: Synoptic table of spring plant communities with *Cardamine amara* group (diagnostic taxa = characteristic taxa - bold; differential taxa (d); and constant species)

Cluster number	1	2	3	4	5	6	7	8	9	10
Number of relevés	5	15	46	36	24	13	58	22	8	20
Altitude from m:	1580	510	380	160	450	1260	930	900	855	1500
to m:	2250	±700	1440	750	1000	1850	1840	1800	1720	2100
communities with *Cardamine *austriaca*										
Cardamine *austriaca	**100**	**100**	.	.	.	.	.	.	.	.
Saxifraga stellaris	**60**	.	.	.	.	**69**	.	.	.	20
Bryum schleicheri (d)	**60**	.	.	.	.	.	.	9	13	.
Chrysosplenietum oppositifoliae cardaminetosum amarae										
Chrysosplenium oppositifolium	.	.	**98**	3	.	8	.	.	.	.
Cardamino amarae-Chrysosplenietum alternifoliae										
Cardamine *amara	.	.	**100**	**100**	**100**	.	3	.	25	.
Petasites albus (d)	.	.	.	.	**54**	.	2	.	.	15
Symphytum cordatum (d)	.	.	.	.	**29**	.	.	.	.	.
***Cratoneuron decipiens-Cardamine opicii*-Ass.**										
Palustriella decipiens	80	.	.	.	.	.	**52**	5	.	15
Brachythecio rivularis-Cardaminetum opicii										
Cardamine *opicii	.	.	.	.	.	**100**	**97**	**100**	**75**	.
*Aconitum *firmum* (d)	.	.	.	.	.	62	32	.	63	.
Aconitum tauricum (d)	20	.	.	.	.	31	.	.	.	.

Tab. 1 - continued

Brachythecio rivularis-Cardaminetum balcanicae											
Cardamine *balcanica	.	.	.	.	.	.	.	.	.	.	**100**
Cirsium appendiculatum (d)	.	.	.	.	.	.	.	.	.	.	70
Rumex alpinus (d)	.	.	.	3	.	.	2	14	13	60	
Angelica sylvestris (d)	.	.	2	11	.	.	.	.	.	.	60
Fontinalis antipyretica (d)	.	.	.	.	.	.	.	.	.	.	45
Myosotis orbelica (d)	.	.	.	.	.	.	.	.	.	.	30
Cardamine rivularis (d)	.	.	.	.	.	.	.	.	.	.	25
Caricion remotae, Cardamino-Chrysosplenietalia											
Carex remota	.	.	**24**	**61**	**33**	.	.	.	.	.	.
Veronica montana	.	.	**9**	**6**	**4**	.	.	.	.	.	.
Pellia epiphylla	.	**27**	**15**	**3**	**4**	.	.	.	.	.	.
Impatiens noli-tangere	.	.	39	69	54	.	.	.	.	.	.
Urtica dioica	.	33	20	61	63	.	.	.	.	.	.
Ranunculus repens	.	.	63	47	42	.	.	9	.	40	
Athyrium filix-femina	.	27	20	31	42	.	2	.	.	25	
Dryopteris dilatata	.	7	2	3	13	.	2	.	.	.	
Oxalis acetosella	.	20	28	14	33	.	2	.	.	15	
Veronica beccabunga	.	7	7	36	29	.	.	9	.	20	
Galium palustre agg.	.	20	46	11	4	.	.	9	.	20	
Tephroseris crispa	.	27	2	3	8	.	.	.	.	.	
Equisetum sylvaticum	.	33	13	3	4	.	.	.	.	.	
Plagiomnium undulatum	.	7	28	6	46	.	.	.	.	25	
Filipendula ulmaria	.	13	9	11	.	.	.	.	.	.	
Cirsium palustre	.	13	9	3	.	.	.	.	.	.	
Scirpus sylvaticus	.	13	.	8	8	.	.	.	.	5	
Carex sylvatica	.	.	2	19	25	.	.	.	.	.	
Senecio ovatus	.	.	11	19	21	.	.	.	.	.	
Galium uliginosum	.	.	2	3	21	.	2	.	.	.	
Juncus effusus	.	.	11	3	21	.	.	.	.	5	
Lysimachia nemorum	.	.	28	3	13	.	.	.	.	.	
Epilobium montanum	.	.	2	14	13	.	.	.	.	.	
Epilobium roseum	.	.	2	14	8	.	.	.	.	.	
Milium effusus	.	.	4	14	4	.	.	.	.	.	
Geranium robertianum	.	.	9	6	21	.	.	.	.	.	
Ajuga reptans	.	.	2	8	25	.	.	.	.	.	
Glyceria fluitans	.	.	28	3	.	.	.	.	.	.	
Equisetum arvense	.	.	7	25	.	.	.	.	.	.	
Circaea lutetiana	.	.	4	31	.	.	.	.	.	.	
Rumex obtusifolius	.	.	7	19	.	.	.	.	.	.	
Montio-Cardaminetalia											
Bryum pseudotriquetrum	.	7	4	.	4	**8**	**40**	**41**	**50**	**30**	
Epilobium alsinifolium	60	.	.	.	.	**31**	**76**	**64**	**75**	**45**	
Philonotis seriata	60	.	.	.	.	**69**	**28**	**55**	.	**15**	
Philonotis fontana	.	.	2	.	.	.	**38**	**14**	.	**5**	
Silene pusilla	.	.	.	.	.	**39**	**19**	**14**	.	.	
Swertia perennis	.	.	.	.	.	.	**2**	**5**	**38**	.	
Epilobium nutans	.	.	.	.	.	**15**	**10**	.	.	.	
Epilobium anagallidifolium	.	.	.	.	.	.	**10**	**5**	.	.	
Tozzia *carpathica	.	.	.	.	.	.	.	.	.	**30**	
Saxifraga rotundifolia	.	.	.	.	.	.	.	.	.	**30**	
Arabis soyeri	20	.	.	.	.	.	.	.	**25**	.	

Tab. 1 - continued

Viola biflora	.	.	.	.	4	23	45	9	63	15
Ligusticum mutellina	.	.	.	.	.	8	31	5	13	5
Luzula alpinopilosa	.	.	.	.	.	15	7	9	25	5
Senecio subalpinus	.	.	2	.	.	.	12	9	13	.
Arabis alpina	.	.	.	.	.	.	26	9	.	5
Poa alpina	.	.	.	.	.	.	36	14	25	.
Montio-Cardaminetea										
Caltha *laeta	**100**	**53**	**4**	**42**	**63**	**69**	**55**	**50**	**88**	**60**
Chrysosplenium alternifolium	**.**	**47**	**33**	**56**	**75**	**.**	**29**	**18**	**13**	**30**
Brachythecium rivulare	**20**	**40**	**70**	**33**	**29**	**39**	**45**	**59**	**.**	**85**
Palustriella commutata	**40**	**.**	**.**	**.**	**17**	**8**	**10**	**59**	**100**	**15**
Cratoneuron filicinum	**.**	**.**	**.**	**8**	**4**	**.**	**5**	**5**	**.**	**5**
Pohlia wahlenbergii	**.**	**.**	**2**	**.**	**4**	**.**	**33**	**5**	**.**	**.**
Dicranella palustris	**20**	**.**	**7**	**.**	**.**	**.**	**14**	**.**	**.**	**.**
Scapania undulata	**.**	**.**	**13**	**.**	**4**	**.**	**19**	**9**	**.**	**5**
Scapania uliginosa	.	.	.	.	.	.	.	**5**	**.**	**5**
Bryum weigelii	**.**	**.**	**.**	**.**	**.**	**.**	**17**	**9**	**.**	**.**
Pellia endiviifolia	.	.	.	**3**	.	.	.	.	.	**5**
Jungermannia obovata	**.**	**.**	**.**	**.**	**.**	**.**	**9**	**9**	**.**	**.**
Aneura pinguis	**.**	**.**	**2**	**.**	**.**	**.**	**.**	**.**	**13**	**.**
Blindia acuta	**.**	**.**	**.**	**.**	**.**	**.**	**2**	**.**	**.**	**.**
Stellaria nemorum	.	20	20	22	79	39	88	41	75	55
Chaerophyllum hirsutum	.	53	11	6	46	15	26	18	50	40
Deschampsia cespitosa	80	7	22	6	21	.	41	41	75	60
Myosotis palustris agg.	.	62	22	28	58	23	3	.	13	.
Rhizomnium punctatum	.	47	41	.	50	23	21	27	13	.
Equisetum palustre	.	7	2	1	8	.	.	9	25	5
Poa trivialis	.	.	48	8	4	.	2	9	25	20
Crepis paludosa	.	.	20	6	17	.	3	.	13	.
Epilobium palustre	.	7	9	.	.	8	.	.	.	15
Stellaria alsine	.	.	46	8	4	.	3	23	13	.
Myosotis nemorosa	.	.	15	.	17	.	9	.	.	60
More frequent species										
Veratrum album	20	.	.	3	.	.	2	5	.	10
Doronicum austriacum	.	.	.	6	4	.	3	.	.	15
Geum rivale	.	.	.	3	8	.	10	.	.	15
Agrostis stolonifera	20	.	17	8	4	.	3	.	25	.
Plagiomnium affine	.	53	4	6	.	.	2	.	.	15
Plagiochila asplenioides	.	27	2	6	4	.	9	.	.	.
Chiloscyphus polyanthos	.	.	11	.	.	.	7	.	.	25
Philonotis calcarea	.	.	.	.	.	.	2	.	25	.
Conocephalum conicum	.	.	.	.	33	8	.	.	.	5
Marchantia polymorpha	.	40	.	.	8	.	12	.	.	5
Mentha longifolia	.	13	.	11	.	.	.	.	.	10
Rumex alpestris	.	.	2	.	4	.	10	5	.	.
Plagiomnium rostratum	.	.	2	.	3	.	4	5	.	10
Plagiomnium medium	.	.	2	.	.	.	3	9	.	5
Plagiomnium elatum	.	.	7	.	.	.	3	.	.	5
Other species	8	30	66	114	51	13	86	38	17	65

Tab. 2. The *Brachythecio rivularis-Cardaminetum balcanicae* MARHOLD et VALACHOVIČ ass. nova (diferential taxa (d); Balkan endemic taxa - b)

Number of relevé	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Locality	R	ZR	R	V	P	R	P	P	R	R	R	R	ZR	ZR	ZR	V	R	P	R	R
Altitude (x 100 m)	16	17	15	18	16	15	19	19	21	18	17	19	16	16	16	18	15	19	18	17
Area (m2)	4	8	17	20	25	19	12	6	40	12	14	10	5	3	4	6	22	12	15	20
Slope (°)	15	5	10	10	10	5	5	20	10	15	15	15	5	5	3	10	30	5	15	5
Exposition	NE	NE	N	S	N	N	N	E	N	N	-	N	NW	S	S	S	N	NW	N	-
Cover total (%)	100	90	95	100	80	95	90	70	98	100	100	70	95	75	85	90	85	90	90	100
Cover E_1 (%)	95	80	95	100	80	95	90	70	95	100	100	65	90	70	80	90	80	90	90	100
Cover E_0 (%)	25	50	10	0	5	25	20	20	60	5	40	20	10	5	10	1	40	15	1	30
*Cardamine *balcanica*	4	3	3	5	5	2b	4	3	4	4	4	3	5	3	2b	2b	2b	2b	2a	2b
b *Cirsium appendiculatum*	(+)	2a	2a	.	1	2a	1	2a	3	2a	2a	.	.	.	+	.	2a	2a	1	1
Rumex alpinus (d)	.	.	2a	.	1	2a	.	1	2b	2b	2b	+	.	.	+	.	2a	.	2a	2b
Fontinalis antipyretica (d)	.	2b	+	.	1	2a	+	.	.	.	.	.	2a	1	1	.	2b	.	.	.
b *Myosotis orbelica* (d)	.	+	.	.	.	.	.	.	+	.	.	.	+	.	1	.	.	+	+	.
Cratoneuro-Calthion laetae																				
Palustriella decipiens	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	1
Philonotis seriata	.	.	.	.	.	.	.	.	2b	+	.	.	.	+	.	.	.	.	.	.
Epilobium alsinifolium	.	.	.	.	+	.	.	+	+	+	.	.	.	.	+	.	+	+	+	r
Saxifraga rotundifolia	.	.	+	.	.	.	+	1	.	.	2b	+	.	.	.	.	.	.	.	2b
*Tozzia *carpathica*	.	.	+	.	.	1	.	.	.	.	1	.	.	.	.	.	1	.	+	+
*Saxifraga *alpigena*	.	.	.	.	1	.	.	.	2a	.	.	.	.	.	.	.	2a	.	.	r
Viola biflora	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	r	.	.	r
b *Soldanella chrysostricta*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	r	r
Arabis alpina	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Caricion remotae and Cardamino-Chrysosplenietalia																				
Athyrium filix-femina	+	.	1	.	.	+	.	.	.	.	1	1	.	.	.	.	1	.	.	.
Veronica beccabunga	.	.	.	.	.	.	.	.	.	+	.	.	.	1	+	.	.	1	.	.
Plagiomnium undulatum	.	.	1	.	.	+	.	.	.	.	+	+	.	.	.	.	+	.	.	.
Ranunculus repens	r	+	1	.	.	.	.	.	.	1	+	.	+	2a	+	.	.	.	.	.
Galium palustre agg.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	r	.	.	r	.	.
Oxalis acetosella	r	.	+	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.
Montio-Cardaminetalia and Montio-Cardaminetea																				
Brachythecium rivulare	2a	2b	1	.	+	+	2b	2b	2b	+	2a	2a	.	+	.	r	1	1	+	1
Chrysosplenium alternifolium	2a	1	.	.	.	.	.	.	.	r	+	1	.	.	.	.	.	.	.	1
*Caltha *laeta*	.	+	1	2a	.	2b	.	.	.	2a	1	1	.	.	.	4	2a	4	4	4
Deschampsia cespitosa	.	1	.	+	1	.	.	.	2b	.	.	+	1	2b	2a	+	1	2a	3	.
Chaerophyllum hirsutum	.	.	.	.	+	.	1	1	.	2a	+	+	.	+	.	.	.	.	.	+
Rhizomnium punctatum	2a	+	+	.	.	.	+	.	.	+	+	1	.	.	.	r	1	.	.	2b
Stellaria nemorum	3	2b	+	.	.	1	2b	+	2b	+	2b	3	.	.	.	.	.	.	r	2b
Bryum pseudotriquetrum	.	+	+	.	+	+	.	.	+	.	.	.	.	.	.	.	.	1	.	.
Chiloscyphus pallescens	.	.	.	.	.	.	.	.	+	.	+	.	.	r	.	.	+	.	.	+
b *Cardamine rivularis*	.	+	.	.	.	.	.	.	.	.	.	+	.	1	2a	.	.	.	+	.
*Cardamine *acris*	.	.	.	.	.	.	2a	+	.	.	.	.	.	.	.	.	.	2b	.	.
Doronicum austriacum	2b	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.
Geum rivale	.	.	+	.	.	+	.	.	.	.	.	.	.	.	r	.	.	.	.	.
Poa trivialis	.	2a	.	.	.	.	.	.	.	.	.	.	+	1	1	.	.	.	.	.
Plagiomnium affine	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.
Palustriella commutata	.	+	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
Cratoneuron filicinum	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Philonotis fontana	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2a	.	.
Scapania undulata	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.

Tab. 2 - continued

Companions																						
Myosotis nemorosa	1		1		+	2a				2a	1	+	+	2a			1	1		2a		
Angelica sylvestris			2a	2a	+	2a	+				1	+			+	2a	1		1	1		
Heracleum sphondylium					1		2b	+	+		2b								1			
Poa sp.						+	+	1	+	1	+				r			1		+		
Pellia sp.						r		2a		+				r					r	r		
Poa nemoralis		2a			1										+		+					
Luzula sylvatica												+					+		+			
b *Geum coccineum*	(+)									+									1	+		
Epilobium sp.					+								+									
Epilobium palustre												r		+	+							
Petasites albus	2a		2a														2a					
Doronicum sp.																			+			
Senecio *germanicus	1																					
Senecio hercynicus			+			1																
Senecio nemorensis agg.							+					+										
Pulmonaria rubra	+						+															
Plagiomnium rostratum												+		r								
Picea abies juv.												+			r							
Sanionia uncinata											+	+										
Plagiochila porelloides											+	+										
Veronica serpyllifolia														+	+							
Mentha longifolia		3																	+			
Anthriscus sp.						2a											1					
Glyceria sp.		2a																	+			
Cicerbita alpina			+								1											
Hypericum maculatum			+																			r
Geranium sylvaticum								+			+											
Stellaria palustris										+					+							
Veratrum *lobelianum				+																		+
Drepanocladus revolvens					+		+															
Philonotis sp.									+											+		
Total number of species	17	21	25	6	20	21	17	14	19	18	30	26	10	20	30	7	28	18	22	26		

One relevé only: 1: *Picea abies* E_2 2b; 2: *Conocephalum conicum* +; 3: *Veronica urticifolia* +; 4: *Salix caprea* 1; 5: *Silene roemeri* +, *Luzula* *velenovskyi* +; 6: *Sorbus aucuparia* E_2 2a, *Scirpus sylvaticus* 1, *Juncus effusus* +; 9: *Hygrohypnum diurusculum* +, *Luzula* *rubella* r; 10: *Marchantia polymorpha* +; 11: *Plagiomnium medium* 2b, *Hylocomium splendens* +, *Porella cordaeana* +, *Plagiothecium nemorale* +, *Pohlia cruda* +; 12: *Plagiothecium denticulatum* 1, *Plagiomnium elatum* +, *Polytrichum formosum* +; 13: *Carex vesicaria* 1; 14: *Epilobium obscurum* +, *Mnium hornum* r, *Scapania uliginosa* r; 15: *Campylium stellatum* 1, *Climacium dendroides* 1, *Alchemilla reniformis* +, *Cerastium holosteoides* +, *Equisetum palustre* +, *Luzula sudetica* +, *Prunella vulgaris* +, *Sagina* sp. +, *Tussilago farfara* +, *Rorippa thracica* r; 16: *Poa cenisia* +; 17: *Alchemilla xanthochlora* 1, *Calamagrostis arundinacea* +, *Carex canescens* agg. +, *C. lachenalii* +, *Warnstorfia exannulata* r; 18: *Barbarea bracteosa* +, *Equisetum* sp. +; 19: *Alchemilla straminea* +, *Ligusticum mutellina* +, *Taraxacum* sp. r; 20: *Alchemilla* cf. *impexa* +, *Crepis* sp. +.

Appendix 1: Relevés to the table 1.

Column 1: [3 rels HINTERLANG 1992 Tab. 5.2.1; 1 rel. HAUPT 1985 Tab. 19; 1 rel. HARTL 1963 Tab. X]
Column 2: [12 rels ZECHMEISTER & STEINER 1995 Tab. 1/II; 3 rels RAUSCHER 1992 p. 137.]
Column 3: [44 rels HINTERLANG 1992 Tabs. 5.2/7.2; 2 rels SÝKORA 1970 Tab. 2]
Column 4: [3 rels SANDA et al., 1977 Tab. 19; 1 rel. SÝKORA 1970 Tab. 2; 1 rel. ŠOMŠÁK 1993 p. 419; 21 rels VALACHOVIČ ined.; 7 rels KLIMENT ined; 3 rels HÁJEK ined.]
Column 5: [8 rels COLDEA 1978 Tab. 1; 5 rels FAJMONOVÁ 1991 Tab. 1; 3 rels HADAČ & SOLDÁN 1989 Tab. 2; 1 rel. SÝKORA 1970 Tab. 2; 1 rel. PASSARGE 1979 Tab. 3; 4 rels HÁBEROVÁ 1978; 2 rels HÁJEK ined.]
Column 6: [11 rels COLDEA 1990 Tabs. 13/14; 1 rel. VOIK 1976; 1 rel. DEYL 1940 Tab. 35]
Column 7: [4 rels PAWŁOWSKI et al. 1928 Tab. 14; 4 rels KOPECKÝ 1985 Tab. 1; 3 rels KRAJIŇA 1933 Tab. 23; 3 rels DÚBRAVCOVÁ 1996 Tab. 1; 2 rels SILLINGER 1933 p. 139; 2 rels MIADOK 1995 p 33; 2 rels HINTERLANG 1992 Tab. 5.2/6.2; 1 rel. UNAR et al. 1984 Tab. 22; 20 rels FOLTÍNOVÁ 1974; 6 rels VALACHOVIČ ined.; 4 rels HRABOVCOVÁ 1976; 2 rels ALTMANOVÁ 1983; 2 rels KOMÁRKOVÁ 1964; 2 rels ŠTRBA ined.; 1 rel. FAJMONOVÁ ms.]
Column 8: [5 rels ŠOLTÉS 1989 Tab. 1; 4 rels KRAJIŇA 1933 Tab. 23; 2 rels UNAR et al. 1984 Tab. 22; 1 rel. MIADOK 1995 p 33; 3 rel. FOLTÍNOVÁ 1974; 3 rels KOMÁRKOVÁ 1964; 2 rels VALACHOVIČ ined.; 2 rels ŠTRBA ined.]
Column 9: [4 rels UNAR et al. 1984 Tabs. 22/24; 2 rels KORNAŚ, MEDWECKA-KORNAŚ 1967 Tab.7; 2 rels HADAČ 1956 Tab. 25]
Column 10: (20 rels MARHOLD, ANCHEV & VASSILEV - see Appendix 2]

Appendix 2: Localities to the table 2.

1. Rila Mts, Borovets, on the way from the settlement Sintnyakovo to the village of Borovets - 16.6.1994
2. Zapadni Rodopi Mts, Beglika Nature Reservation, near the right side of the Semiza rivulet - 20.6.1994
3. Rila Mts, Kostenets, above the summer camp Yurukova Polyana, slope of Mt. Sokolovets - 22.6.1994
4. Vitosha Mts, spring near the Aleko chalet - 15.6.1994
5. Pirin Mts, Demyanitsa Valley, Demyanishka Polyana nearby the rivulet - 28.6.1995
6. Rila Mts, Kostenets, above the summer camp Yurukova Polyana, slope of Mt. Sokolovets - 22.6.1994
7-9. Pirin Mts, Demyanitsa Valley, bellow Demyanitsa chalet, nearby the rivulet - 29.6.1995
10. Rila Mts, Ionchevo ezero Lake, spring near the path - 4.7.1995
11-12. Rila Mts, Maliovitsa Complex, direction to Ovnarsko, rivulet near path - 4.7.1995
13-14. Zapadni Rodopi Mts, Beglika Nature Reserve, Toshkovo Dere Valley - 19.6.1994
15. Zapadni Rodopi Mts, Beglika Nature Reserve, near the Semiza rivulet, close to the Kolarova Polyana - 20.6.1994
16. Vitosha Mts, spring near the Aleko chalet - 15.6.1994
17. Rila Mts, Kostenets, above the summer camp Yurukova Polyana, slope of Mt. Sokolovets - 22.6.1994
18. Pirin Mts, Demyanitsa Valley, Demyanishka Polyana nearby the rivulet - 28.6.1995
19-20. Rila Mts, Maliovitsa chalet, rivulet near the bridge - 3.7.1995

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