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Revision of three Astragalus taxa (Leguminosae) and their cenological relations

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Abstract — Author found the lecto- or probably the holotype of the *Astragalus exscapus* L. var. *caulifer* BORB. emend. SzL in the Budapest Herbarium. *Astragalus exscapus*, *A. e.* var. *caulifer* and *A. dasyanthus* had been revised by qualitative and quantitative taxonomical methods. The *Astragalus exscapus* and the variety of it had been found in different—in relatively tall grass—communities. Similarity of the community samples are low in binary date using the method of SOKAL and MICHENER, and also the coverege values by HUMMON. The development of the pedunculate variety of *A. exscapus* may be in connection more with the structure than with the floristical composition of communities. With 5 tables and 5 figures.

Among the Hungarian *Astragalus* taxa there are three with egg-yellow corolla and short, thick, semi-bilocilare legume, i.e. *Astragalus exscapus*, *Astragalus exscapus* "forma *caulifer*" and *Astragalus dasyanthus*. This group makes difficulties for taxonomists and cenologist (BORBÁS 1885a, b; CHARTER 1968) up-today because the *Astragalus exscapus* and the "f. *caulifer*" sometimes appear and soon disappear from the *Astragalo-Festucetum rupicolae danubiale* community in Hungary, together with the characteristic species composition of this association. In the series of the communities succession in calciphilous sandy soil this community is the third in our country, and usually developed on deep soil rich in humus. This type of soil is very suitable for the afforestation and for the agricultural fields, too (MAGYAR 1933, 1961). Disappearance of the community—including the *Astragalus* species—is in connection with these human effects.

I have found a new locality of the *Astragalo-Festucetum rupicolae danubiale* community at Dunavarsány "Varsány hegy" with five *Astragalus* taxa in it, and I decided do clarify the taxonomical problems and the cenological relations of three *Astragalus* taxa—two occur at Dunavarsány—because complete cenological list of this association s. str. (cf. BRAUN-BLANQUET 1964) has not been published up-today.

First I studied the original descriptions of these taxa and I went on with the morphotaxonomical investigations of the *A. exscapus*, *A. e.* "f. *caulifer*" and *A. dasyanthus* in the Herbarium sheets of the Botany Department of the Hungarian Natural History Museum, Budapest (BP).

Beside this, the *A. exscapus* and *A. e.* "f. *caulifer*" were collected at Dunavarsány on Varsány hegy = "Varsány hill" (Hungary) in calciferous sandy soil and in basalt rocks in Bohemian Central Mountain (Czechoslovakia). To clarify the cenological affinity of these two taxa to other species in different communities, it was recorded in both localities all of the species occur together with. *A. exscapus* and *A. e.* "f. *caulifer*" according to BRAUN-BLANQUET (l. c.).

Material and methods

The length of petiole and length and width of leaf blade in the herbarium sheets were measured; length of calix and corolla. Here the corolla means the length of the standard or banner from the base to apex in those flowers which are fully opened but the style not yet reached the length of the apex of the standard.

The length of petiole/leaf blade, the width/length ratio of leaf blade, the length of calix/corolla ratio has been calculated from these characters. These data together with the mm^3 of seeds were used for the cluster analysis, applied the CZEKANOWSKI (1909) and HUMMON (1974) similarity indices, programmed by M. RAJCZY.

The length of pedicel of the axillary or sessile inflorescence flowers and the length of pedicel of the solitary flower has also been calculated when it was possible to measure. All of these characters were measured in 15 specimens/species in mm. Fifteen seeds/taxon were taken from different legume

and the length and width of seed were measured by microscopic ocular micrometer under stereomicroscope, and thickness of the seed by the slide-thick measuring instrument. The mm- of seeds were counted by $\frac{4}{3}$. abc modell, where

$$a = \frac{\text{length of seed}}{2}; \quad b = \frac{\text{width of seed}}{2}; \quad c = \frac{\text{thickness of seed}}{2}.$$

The analysis of variance were made according to SVÁB (1973). The qualitative investigation also was made from the root to the seed of the three taxa (Table 1). The colour of seeds was identified according to MAERZ & REA PAUL (1950).

Besides the taxonomical revision of the three *Astragalus* taxa I investigated also the communities in Hungary and in Czechoslovakia in which the *Astragalus exscapus* and the variety of it occur together. According to BRAUN-BLANQUET (l. c.) the "community" is mean here in s. str. as plant assotiation. The name of community is accepted after SOÓ (1973) in Hungary. Species nomenclature agrees with SOÓ in: JÁVORKA & CSAPODY (1975).

The sample size is 5×10 m in both localities. The covering value of each species/sample was estimated in percentage value. The affinity of the two taxa to the communities was studied indirectly*, by used the similarity function of SOKAL and MICHENER (1958) for binary date (floristical composition of samples) and that of the HUMMON (1974) for coverage values and the WPGMA fusion technique (SNEATH & SOKAL 1973). The BP program package of the Botanical Department of the Hungarian Natural History Museum was run on the CDC-3300 computer of the Hungarian Academy of Sciences. The BP program package was constructed by L. HAJDU and M. RAJCZY. This program was applied here by M. RAJCZY.

The floristical diversity of samples was counted by SHANNON (1948) and the evenness by PIELOU (1975). The sample was made by the help of J. HOLUB and M. HUSOVA in Czechoslovakia.

RESULTS AND DISCUSSION

The genera *Astragalus* was described by LINNÉ (1737, p. 215.):
"Cal. Perianthium monophyllum, tubulatum, quinquedentatum, acutum, denticulis inferioribus, gradatim minoribus. Cor: Papillionacea
Vexillum longis reliquis, lateribus reflexis, emarginatum, obtusum, rectum.
Ale oblongae, vexillo brevioris.
Carina longitudine alarum, emarginate.
Stam: Filamenta didelphe (simplex et novemfidum), fere recta. Anthere subrotundae.
Pist: Germen teretiusculum. Stylus sabulatus, ascendens. Stigma obtusu.
Per: Legumen biloculare: loculus et alterum latus magis flexis.
Sem: reniformia.
Observatio: Tragacantha summa cum Astragalus habet affinitatem Astragalus Riv. Siliqua quad et oblonga polisperma Glaux riv. Siliculam gerit cordatam."

In the characterization of genera *Astragalus* is not included the semi-bilocular legume, though it is a common character of more species, including the investigated taxa by us. Really, the *A. exscapus* was printed only in 1771 also by LINNÉ. According to CHATER (1.c.) Subgen *Astragalus* (Subgen *Caprinus* BUNGE) "This subgenus contains many species of narrow geographical range, differing from each other in a combination of minor, often overlapping characters. Most of them have here been aggregated into 3 groups." Consequently, he speaks about *A. dasyanthus* group and also *A. exscapus* group. But the original description or in many times the icones BUNGE (1869), PALLAS (1800) BURGE Iv. BOISSER (1872) etc. had given the differences for the species. Moreover, here in Table 1 there are the similarities and dissimilarities qualitatively, referring to the represents of the two "groups".

* For studiums of the similarity, dissimilarity, distance and correlation between and among the samples, per see, the topic was discussed methodically in detail (e. g. by PODANI 1980).

Astragalus exscapus L.

"acaulis exscapus, leguminibus lanatis, foliis villosis"
Mant II. p. 275.
Syn: A. leiocarpus Shuttlew. Mag. Zool. u. Bot. II. 520 (1838) A. acaulis Scop. Insubr. 2. p. 112. n. 59.
A. acaulis exscapus Linn. Mant. II. p. 275. Jacq. Icon. Rar. III. p. 13. Tab. 561; Roth. Germ. I. p. 312. I. v. 2. p. 195.

Here LINNÉ (1.c.) rely particulary on MORISON (1715) p. 111. "8. Astragalus luteus, perennis procumbens vulgaris, nobis", but this description may correspond to more species. Particularly to Halt. Helv. n. 45 (cf. DECANDOLLE 1802).

The first icon was published by JAQUIN (1876 ad 1973), but it shows a transitional form more precisely was given by PALLAS (1.c.); as *Astragalus* f. typica by BECK (1903). The *Astragalus exscapus* by this character: "*acaulis*" or "*exscapus*" is characterized well, many taxonomists agree with this opinion.

Contrary with this, experts' opinion differ in the taxonomical range of *Astragalus exscapus* "f. *caulifer* BORB.". According to SOÓ (1968) it is the "*Astragalus exscapus* f. *culescens* A. MAYER in CELAK 1874, (f. *caulifer* BORB.)".

The original herbarium sheet collected by BORBÁS in 11. Jul. 1888. can be found in the BP with "*Astragalus exscapus* var. *caulifer* BORB.; in arenosis campi Rákos ad Budapestinum 11. Jul. 1888.; Dr. Vince de Borbás; 2454" on the label. The BP numero 455214 (Fig. 1). The original "Herbarium of Borbás" did not contain the "type specimens" to-day, or he signed on the label later (1888) than described it. He had collected this variety at first on 14. June 1871 in "Rákos" meadow beside Budapest, and in 1891 and 1893 at "Zugliget" beside Budapest. But this specimens may be a lectotype for this variety.

BORBÁS described this taxon as a var. *caulifer* and not as a form on the herbarium label and also in 1885 in German language "*Astragalus exscapus* var. *caulifer* m., mit 15 cm langem Stengel und ganz von der Tracht des *A. dasyanthus*, von dem jedoch die var. *caulifer* durch die kahle Fahne und eine mehr lockere Inflorescenz verschieden ist. Diese Apostasis des Strengels kann man hier für eine Accomodation ansehen, denn *A. exscapus* wächst auf diese Weise den Sand durch, wenn er durch den Wind in demselbe begraben wurde." Ö.B.Z. 35:232–233. In the same year he described it in Hungarian language in: Erdészeti Lapok 3: 302–304 almost with the same text, though he had not given a description of this variety in Latin language.

According to this:
Astragalus exscapus L. var. *caulifer* BORB. emend SzL.
Syn. nov.: f. *caulescent* MAYER in CELAK (cf. SOÓ 1973)
f. *scaposus* REICHENBACH (1903) "fil. pedunculis conspicuis". Non f. *scaposus* BECK and non f. *caulifer* BORB. (cf. SOÓ 1973).
BECK (l. c.) had given the good drawing from the *Astragalus exscapus* f. typica and f. *scaposus* on Table 156 (MMCCVII), too.
Diagn. nova: Acaulis, Flores terminales, capitati peduncus elongatus, ortus ex caude. Flora laxa. Legumina semi-locularia. Semen lucidum, fuscum usque ad violaceum.

(In genera *Astragalus* this phenomenon, i.e. the "caulifer" arise in *Astragalus pubiflorus* species, too.) Both occur in the same locality BORBÁS (1.c.) refers to the fact that the variety of "*caulifer*" came into beeing in high gras steppe. Consequently the *Astragalus exscapus* and *A. exscapus* var. *caulifer* grown together in both localities studied by me, in *Astragalo-Festucetum rupicolae* in Hungary and *Festuca valesiaca — Erysismum crepidifolium* community KLIKA (1933) in Bohemian Central Mountain. But the *Astragalus exscapus* often occurs without its variety.

The ecological factor complex, which cause the *caulifer* variety, is the structure of grasses associations. The "acaulon" form of the plant frequently occurs among the dicotyledonous

Fig. 1. Lecto- or holotype of the *Astragalus exscapus* L. var. *caulifer* BORB. em. SzL.

species of high mountains and in the Mediterranean area independent from the taxonomical status. The heigth of the *Astragalus* species decreased from the small shrub to annual species (cf. CHATER 1.c.) and we suppose that the acaules character of the perennials is young in the evolution process as a consequence of the variability of this character.

Astragalus dasyanthus PALL.

Syn.: A. eryocephalus W. et K. Plant. Rar. Hung. I. Table 46 (1800)
A. pannonicus Schult. (1814)
A. Stolzenburgensis In Schur (1853): Über J. Lerchenfeld p. 94.

Besides the description of species PALLAS (1778) published a good drawing also from *A. dasyanthus* but showing a young plant. PALLAS (1800) In: "Species Astragalorum" the picture is good, except the legumen of species. "Icones..." of WALDSTEIN & KITAIBEL (l. c.) was given an exact drawing on Table 46, as *A. eriocephalus*. In the "Icones..." of BECK (1903) the drawing is not suitable.

(BORBÁS, 1886, described the *A. dasyanthus* var. *monocephalus* but according to the Hungarian text it seems to be an aberration. I could not find it among the herbarium sheets.)

The sum total of the investigated morphological characters is 28 (Table 1), out of these four was quantitative ones. The three taxa have 9 similar characters (1, 2, 5, 6, 16, 19, 20, 23 and 25).

Astragalus exscapus and *A. e.* var. *caulifer* has similarites by the No. 4, 7, 14, 18 and 21.

A. exscapus and *A. dasyanthus* are similar in character No. 12. Between taxa pairs i.e. *A. exscapus* var. *caulifer* and *A. dasyanthus* there are no common characters.

The own qualitative character is only one of the *A. exscapus*, two of the *A. e.* var. *caulifer* and 6 of the *A. dasyanthus*. The seeds of *A. exscapus* show some nuance of brown colour, less variable from this point of view the *A. dasyanthus* with its brown seeds, and more variable the *A. exscapus* var. *caulifer* because it has seeds from light-yellow to dark lilac, including brown too.

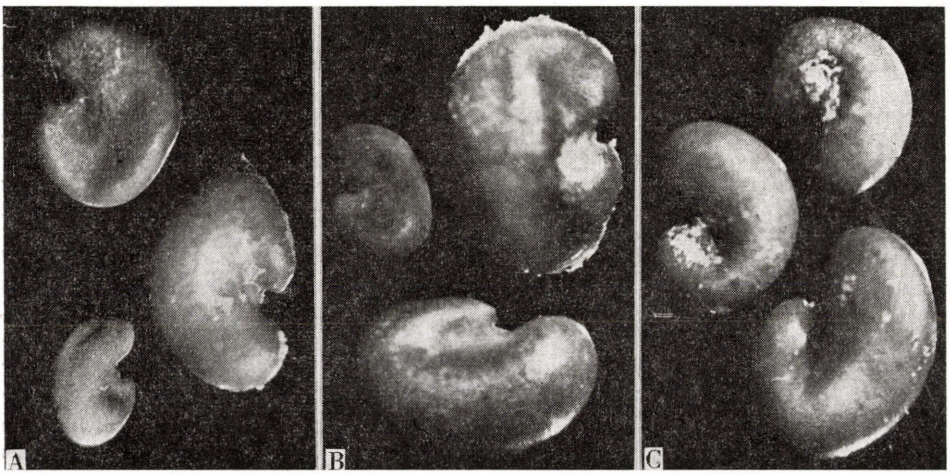

Fig. 2A–C. A = *Astragalus excapus* seeds. — B = *A. e.* var. *caulifer* seeds. — C. = *A. dasyanthus* seeds

The size of the seed/species in mean value in mm^3 may be classified in an increasing sort. The less $\bar{x}$ value has the *A. exscapus* 1.161 mm^3, from this the minimum value is 0.587 and the maximum one is 1.950 mm^3. The *A. e.* var. *caulifer* is standing in the middle of the two other taxon. The $\bar{x}$ is 1.591, the minimum is 0.760 and the maximum is 4.459 mm^3. In *A. dasyanthus* $\bar{x}$ = 1.715 mm^3, the minimum is 0.794 and the maximum is 3.511 mm^3. More variable in size the *A. e.* var. *caulifer* see in Table 2 and Fig 2.

The variance analysis of the quantitative characters resulted the next: The arithmetic mean of characters with their P = 95% confidence interval (Table 2, Fig. 3a) shows the length of petiole per leaf lamina (Char. 1) significantly differ in the *Astragalus dasyanthus* from the *A. exscapus* and the variety of it. But, in the date of the *A. exscapus* and *A. e.* var. *caulifer* are scattered in a large amplitude.

In character No. 2 (width of leaf lamina per length of it) the *A. dasyanthus* is significantly higher that of the *A. e.* var. *caulifer* (Fig. 3b); in character No. 3 (length of calix per corolla) has no significant differences among the three taxa (Fig. 3c); in character No 4 (size of seed in mm^3) the *A. exscapus* and *A. dasyanthus* differ significantly from each other but the size of seeds of the *A. e.* var. *caulifer* overlap both other species (Fig. 3d).

Out of the investigated four characters some has large variability refering to the three taxa. Consequently, the clusters of the attributes —characters—grouped the species I can not interpret.

After to the taxonomical revision of the three *Astragalus* taxa, in the following steps I decided to calrify the fidelity or affinity of the *A. exscapus* and *A. e.* var. *caulifer* to the other species and communities in Hungary and in Czechoslovakia. Moreover, by this indirect way I cast light on the role of this community or communities in the micro-evolution process in the formation of a pedunculate variety of the *Astragalus exscapus*.

Astragalo-Festucetum rupicolae danubiale

According to the literature Soó (1973) this "community" in sensu lato meaning was first metioned by MAGYAR (1933) as *Festuca sulcata* ass. and later on in 1950 as *Festuca pseudovina* and *Festuca sulcata* ass. In this "community" description there are not reported any *Astragalus* species until 1961 when MAGYAR (l. c.) reported the next list: *Astragalus exscapus*, *A. asper*, *Festuca stricta* var. *hungarica*, *Pulsatilla nigricans*, *A. austriacus*, *Daphne cnoerum* (?), *Seseli hipomaratum*, *Centaurea sadleriana*, *Onosma arenaria*, *Inula salicina* var. *denticulata*, *Achillea kitaibeliana*, *Gypsophyla arenaria*, *Secale silvestre*, etc.. — HARGITAI (1940) reported two *Astragalus* species, *A. glyciphyllos* and *A. cicer* in the open patches of the *Quercetum roboris festucetosum*. Out of these two the *A. cicer* is frequent among grassex.—A detailed cenological checklist and characterization of this community was given by ZSOLT (1943) from Island Szentendre.—TÖLGYESI (1979) had drawn a popular picture from this community by the report of the flowering species in bloss seasonally.—MAGYAR (1961) described the soil characters of those localities where the *Astragalus exscapus* and *A. asper* occur, as a good type for afforestation and for agricultural field also in the Great Hungarian Plain.

Consequently, the localities of this community decrease rapidly. Publication of this community with a near complete list of the species is not issued in Hungary until today. This publication from Dunavarsány "Varsány hegy" is the first. But the excellent soil characters due to the fact, that if we found a locality of this community, it would be more or less disturbed. It is true for our second sample, too (Table 3).

The 1st sample contains most of the species of the *Astragalo-Festucetum rupicolae* the 2nd sample is laying near to the wet meadow and the 3rd had been ploughed three years ago and after followed this place. Consequently, the 3rd sample has some pioner characters by the resuccession from the *Festucetum vaginatae* to the *Astragalo-Festucetum* assotiation.

In the less disturbed 1st sample (Table 3) there are eightyfive species, among others four *Astragalus* ones and one variety of *Astragalus exscapus*. The number of the short life-

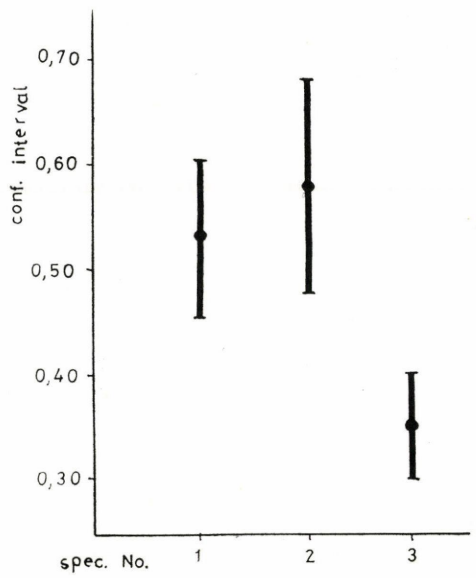

Fig. 3a

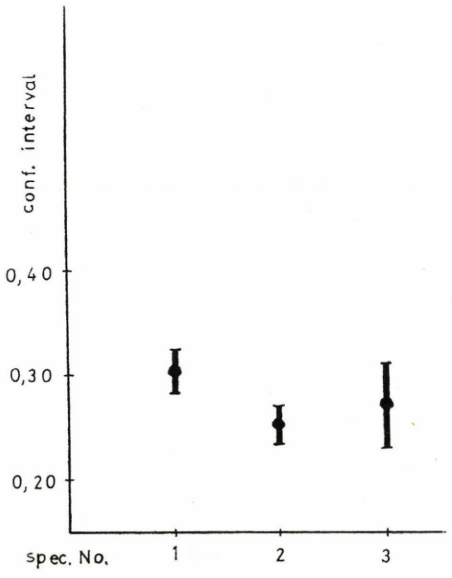

Fig. 3b

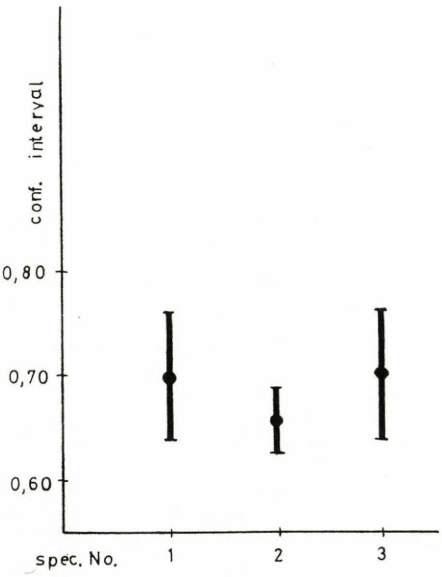

Fig. 3c

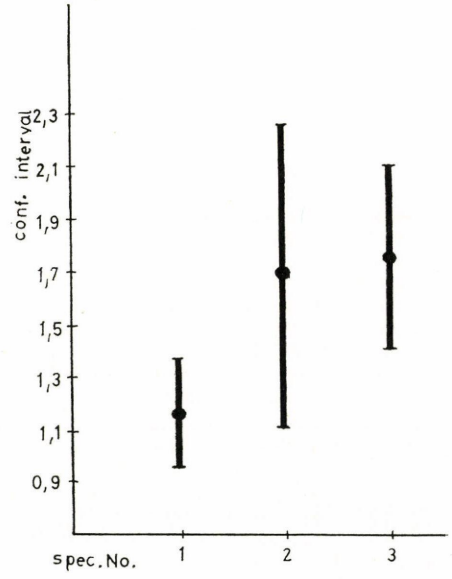

Fig. 3d

Fig. 3a. Mean value of the length of petiole per leaf lamina of the *Astragalus exscapus* (spec. No. 1), *A. e.* var. *caulifer* (spec. No. 2) and *A. dasyanthus* (spec. No. 3). — Fig. 3b. Mean value of the width of leaf lamina per length of it in the spec. No. 1, 2, 3. — Fig. 3c. Mean value of the length of calix per corolla in spec No. 1, 2, 3. — Fig. 3d. Mean value of the size of seed in mm^3 in spec No. 1, 2, 3.

spann or in other word belong to the Th life-form (RAUNKIAER 1907) 18 species are present but among the perennial species the annual *Arenaria serpillifolia*, *Bromus mollis*, *B. ramosus*, *Cerastium semidecandrum*, *Erysimum diffusum*, *E. pannonicum*, *Minuartia verna* ssp. *pannonica*, *Poa bulbosa* var. *vivipara*, *Saxifraga tridactylites*, *Syrenia cana* are always characteristic on the calcifilous sandy soil. Only the remained seven plants seem to be ruderale.

The 2nd sample has fortythree species. The species composition shows here that of the perennials and annuals are growing here but they are tallgrasses species in a deeper deposition at the margin of "Varsány hegy". This sandy hill subsequently losses the hillic character and begins the narrow transitional zone to the wet marshy land beside the river Duna.

The 3rd sample has the less species, only forty. Consequently the species have the largest covering values in this sample: *Artemisia campestris* 10%, *Carex liparicarpos* 5%, *Cynodon dactylon* 15%, the two *Festuca* species 10–10%, *Koeleria glauca* 35%, *Sedum acre* 5%, and *S. sexangulare* 40%! and the 50% of the surface is covered by the two *Thymus* species. In June the yellow and lilac colours of the *Sedum* and *Thymus* species are predominant in this sample plot.

The following species are present in the three samples (Table 3): *Astragalus onobrychis*, *Festuca rupicola* var. *sulcata*, *Galium verum*, *Eryngium campestre*, *Thymus praecox*. In the 1st and 3rd samples occur together twenty-one species. The 1st and 2nd samples are similar by seven species, the 2nd and 3rd samples contain only four common species.

Nine species had already been over the flowering at that time—phenophase 41, 42—or just had finished in the first flower or in the blossoming—phenophase 34—twenty species. Only seven species had been in the vegetative developmental phenophase (24). But the forty-eight species were in blossoming time.

Festuca vallesiaca — Erysimum crepidifolium ass.

The number of species/sample alter from 29–38 in Bohemia (Table 4). Only in Mont. Radobyl (sample 1, 2) grown at that time; *Astragalus exscapus*, *A. e.* var. *caulifer*, *Carex supina*, *Centaurea rhenana*, *Dianthus carthusianorum*, *Elytrigia intermedia*, *Eryngium campestre*, *Lithospermum arvense*, *Muscari tenuiflorum*, *Stachys recta*, *Stipa pennata* (but it may occur in Mont. Oblik too, out of the sample). There are present only in Mont. Oblik: *Adonis vernalis*, *Agrimonia eupatoria*, *Brachypodium pinnatum*, *Crategus monogyna*, *Fragaria viridis*, *Oxytropis pilosa*, *Pilosella cymosa*, *Taraxacum* sp.

The following species are common in the four samples in both investigated localities of the Bohemian Central Mountain: *Achillea pannonica*, *Euphorbia cyparissias*, *Thymus* cf. *glabrescens* and no more. In all the three samples are present: *Astragalus exscapus*, *Erysium crepidifolium*, *Festuca valesiaca* (in the sample 4th grow the *F. rupicola*), *Koeleria gracilis*, *Sanguisorba minor*, *Teucrium chamaedrys*, *Verbascum lychnitis*.

The Mont. Radobyl and in the Bohemian Central Mountain the Oblik appears as an isolated basaltic cone. The bigger part of the Oblik is covered by a mixed forest. (In Mont. Radobyl the patches of forest is much smaller.) The 4th sample in Oblik was taken from near to the forest margin. But the 3rd sample has also shown the same calciphilous oak-forest steppe characters by the species *Adonis vernalis*, *Brachypodium pinnatum*, *Carex humilis*, the two *Helictotrichon* species, *Oxytropis pilosa*, *Pilosella cymosa*.

Phenologically, thirty-nine species—more of them are shrubs—was only in the vegetative phenophases (22–24), three finished or standing near to the blossoming phases (phenophase 34), the *Pulsatilla nigricans* was in the seed ripening stage or over this, and the remaining forty-seven species were in the blossoming phenophases. Though the difference in days are only 26 between the recording time in the two localities in Hungary and Bohemien Central Mountain, much more species were only in the vegetative developmental phases in Czechoslovakia than in Hungary.

Making a comparison between the samples of the Great Hungarian Plain (i.e. at Dunavarsány) and of the Bohemian Central Mountain, we can conclude: the former is more luxuriant in species than the latter.

This difference among the seven samples is reflected in Fig. 4 apllied the SOKAL-MICHENER (1.c.) similarity method. At the lower first quartile of the dendrogram the samples are in four groups. Similarity among the six samples reach only a little more than half size of dendrogram, but the sample No. 1 remained isolated. The samples No. 2–3 and 4–5 and 6–7 are similar (Fig. 4) due to the applied method considering the presence (Table 5) and absence of common species, too. Regarding the coverage values of the samples species are less similar according to HUMMON index (Fig. 5). Because the number of common species in sample pairs is low (Table 5) and the similarity (Figs. 4–5), we can conclude that the *Astragalus exscapus* and *A. e.* var. *caulifer* do not have close affinity to each or to other communities studied by us. These assotiations are together in a higher unit *(Festucetea)* cenosystematically. Almost independent from the diversity of samples floristical point of view (Tables 3–4). They must two common characters: one or other *Festuca* taxa should be and the relative tallgrasses (steppe) species occur together in dry circumstance.

According to the results it may be supposed that the community structure—refering to the tallgras — and the development of the pedicellate variety of the *Astragalus exscapus* are in connection with each other.

Summary — The lecto- or more probable the holotype of the *Astragalus exscapus* L. var. *caulifer* BORB. emend. SZL. had been found in the herbarium of Botany Department BP. The three *Astragalus* taxa differ from each other in different number of qualitative and quantitative characters (attributes). Affinity of *Astragalus exscapus* and *A. e.* var. *caulifer* to the relative tallgrasses communities is higher than considering the floristical composition and coverage values (Figs. 4–5) than it was believed earlier. But the structure of these communities and the pedicellate variety of the *Astragalus exscapus* may be in some connection with each other.

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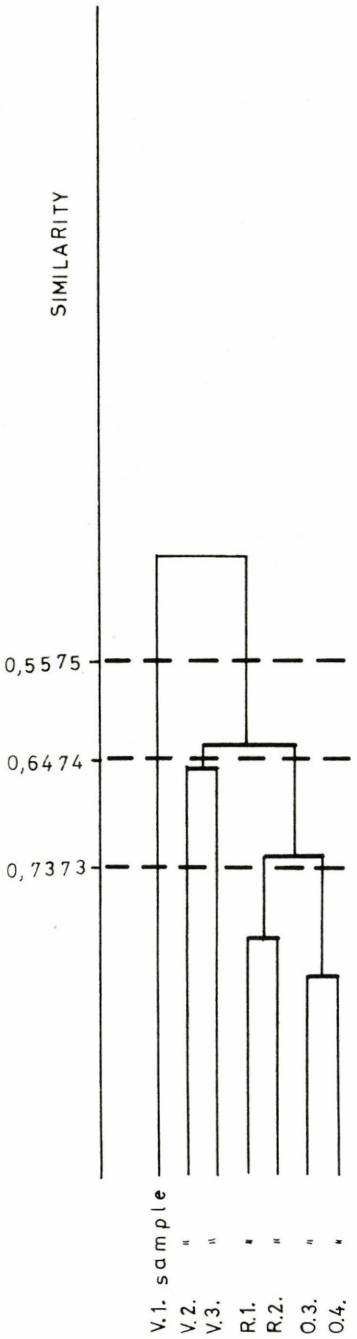
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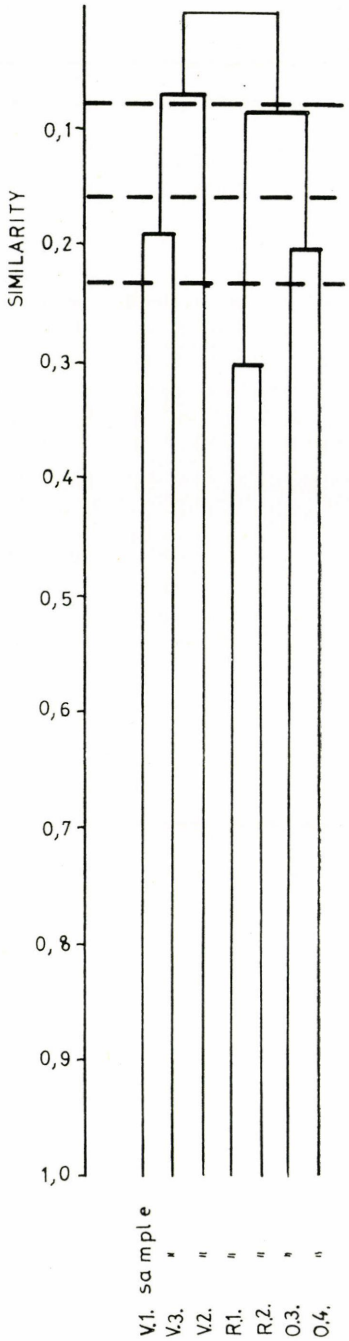
0,6474
0,7373
V.1. sample
V.2.
V.3.
R.1.
R.2.
0.3.
0.4.

Fig. 4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0,2
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0,6
0,7
0,8
0,9
1,0
V.1. sample
V.3.
V.2.
R.1.
R.2.
0.3.
0.4.

Fig. 5

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Fig. 4. Dendrogram of the seven samples by SOKAL & MICHENER function + WPGMA fusion technique based on binary date
— Sign: V 1, 2, 3 = samples from Varsány-hegy at Dunavarsány in Hungary; R. 1, 2 = samples from Radobyl at Litomeritz and O. 1, 2 = samples from Oblik at Louny in Czehoslovakia

Fig. 5. Dendrogram of the seven samples by Hummon index + WPGMA fusion technique based on coverage values

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Table 1. Similarities and dissimilarities among the three taxon qualitatively
(Sign of the taxon: *Astragalus exscapus* = a; *A. e.* var. *caulifera* = b; *A. dasyanthus* = c)

Characters Species:	a, b, c,	a, b,	a, c,	b, c,	a	b	c
Perennial with taproot	+						
Caudex ramified	+						
Steam erect							+
Steam decumbent		+					
Node stipulaceous	+						
Leaf petiolate, imparipinnate	+						
Lamina is more wide in the middle of leaf blade or above		+					
Lamina is more wide under the middle of leaf blade							+
Pedicel of inflorescence shorten from the fisrt to the apical one							+
Pedicel of inflorescence differ in length irregularly						+	
Pedicel absent					+		
Flowers crowded into head			+				
Flowers arranged in loose head						+	
Flower pedicellate		+					
Pedicel of flower immesurable							+
Bract surface hairy	+						
Base of flower bract breit, leaf-like							+
Base of flower bract narrow, stipule-like		+					
Calix bilaterally symmetric	+						
Corolla markedly bilaterally, symmetr. papillionaceous	+						
Standard or banner hairy							+
Standard or banner naked		+					
Flowers egg-yellow in colour	+						
Legume short, thick, semi-bilocular in double rows of seeds in it	+						
Colour of seeds					P_{13}, G–11 P_{14}, A–12	P_{13}, G–10 P_{14}, G–11 P_{55}, J–12	P_{14}, A–12

Table 2. The arithmetic means of characters with P = 95% confidence intervals

	A. exscapus	*A. e.* var. *caulifer*	*A. dasyanthus*
Char. 1	0.53±0,07	0.58±0,10	0.35±0.05
Char. 2	0.30±0.02	0.25±0.02	0.27±0.04
Char. 3	0.70±0.06	0.66±0.03	0.70±0.06
Char. 4	1.16±0.20	1.68±0.57	1.75±0.35

Date of samples: "Varsány hegy" 115 m above see level at Dunavarsány, county Pest in Hungary, 18. June 1980. The estimated covering value of each species was recorded in percentage. The phenophase(s) of species was sign according to SZUJKÓ–LACZA and FEKETE (1973). The species are arrange in abc order.

Table 3. Astragalo-Festucetum rupicolae (sulcatae) danubiale

Species list	Ser. No of sample			Phenophases		
	1	2	3	1	2	3
Achillea orchroleuca	1		2	24, 33		24, 32
Achillea pannonica	.	2	.	.	24, 32	.
Achillea setacea	2	.	.	24, 32	.	.
Acinos arvensis	.	.	01	.	.	24, 32
Ajuga chamaephytis	.	.	01	.	.	24, 32
Alkanna tinctoria	1	.	2	24, 34	.	24, 34
Allium rotundum var. waldsteinii	05	.	.	24, 32	.	.
Allium scorodoprasum	01	.	.	24, 31	.	.
Alyssum alyssoides	01	.	.	24, 32, 34	.	.
Alyssum desertorum	01	.	.	34	.	.
Anchusa officinalis	1	01	.	24, 32	24, 32	.
Anthemis ruthenica	1	01	.	24, 32	.	24, 32
Anthyllis vulneraria ssp. polyphylla	2	.	.	24, 32, 34	.	.
Arenaria serpyllifolia	1	.	.	42	.	.
Artemisia campestris	1	.	10	24, 31	.	24, 31
Asparagus officinalis	05	.	.	24, 31	.	.
Asperula cynanchyca	1	.	.	24, 32	.	.
Astragalus austriacus	5	2	.	24, 34	24, 34	.
Astragalus cicer	15	.	.	24, 32, 33	.	.
Astragalus exscapus	5	.	.	24, 34	.	.
Astragalus exscapus var. caulifera	15	.	.	24, 34	.	.
Astragalus onobrychis	15	05	2	24, 32	24, 32	24, 32
Bromus mollis	3	.	1	24, 34	.	24, 34
Bromus ramosus	1	.	.	24, 33	.	.
Carduus nutans	05	.	01	24, 32	.	24, 31
Carex liparicarpos	1	.	5	24, 34	.	24, 34
Centaurea arenaria	1	.	01	24	.	24, 31
Centaurea sadleriana	1	01	.	24, 32	24, 31, 32	.
Cerastium smidecandrum var. glandulosum	10	.	2	34	.	42
Coronilla varia	2	2	.	24, 32	24, 32	.
Crepis nicaensis	.	1	.	.	34	.
Crepis tectorum	.	.	1	.	.	24, 33
Chrysopogon gryllus	.	05	1	.	24, 32;	24, 32
Coronilla varia f. albiflora	05	.	.	24, 32	.	.
Crataegus monogyna	.	.	05	.	.	24
Cynodon dactylon	5	.	15	24	.	24, 32
Dactylis glomerata var. ciliata	1	1	2	24, 34;	24, 32, 34;	24, 32, 33
Daucus carotta	.	05	.	.	23	.
Echium vulgàre	05	.	1		23	
Elytrigia intermedium	2	.	.	24, 32	.	.
Elytrigia intermedium var. villiferum	.	10	.	.	24, 32	.
Equisetum aevense		(1)	.	.	24, 32	.
Equisetum ramosu m	2	.	.	24, 32	.	.
Erodium cicutarium	05	.	05	24, 34	.	24, 34
Erysimum diffusum	1	.	.	24, 32, 33	.	.
Erysimum pannonicum	1	.	.	24, 32	.	.
Eryngium campestre	1	1	1	24	24	24
Euphorbia cyparissias	1	.	1	24, 34	.	24, 34
Euphorbia palustris	.	(1)	.	.	24, 32	.
Euphorbia seguieriana	1	.	2	24, 32	.	24, 32

Table 3., continuation

Species list	Ser. No. of samples			Phenophases		
	1	2	3	1	2	3
Festuca rupicola var. sulcata	60	30	10	24, 34;	24, 33;	24, 33
Festuca vaginata	.	.	10	.	.	24, 32
Festuca wagneri	.	5	.	.	24, 32	.
Filipendula vulgaris	.	05	.	.	24, 32, 34;	.
Fragaria moschata	1	.	.	24	.	.
Galium verum	1	15	1	24, 31;	24, 31;	24, 32
Hieracium caespitosum	1	.	.	24, 31 (32)	.	.
Hieracium pilosella	1	.	.	24, 31 (32)	.	.
Hypericum perforatum	1	.	.	24, 32	.	.
Knautia arvensis	05	01	.	24, 32	24, 32	.
Koeleria glauca	5	.	35	24, 34	.	24, 34
Lappula redowski ssp. patula	01	.	.	24, 32, 33	.	.
Lepidium draba	1	.	.	24, 42	.	.
Linum austriacum	1	01	.	24, 32	24, 32	.
Lotus corniculatus	1	1	.	24, 31, 32;	24, 32	.
Lotus c. ssp. tenuifolius	.	1	.	.	24, 32	.
Medicago falcata	1	.	1	24, 32	.	24, 31
Melandrium album	1	.	.	24, 34	.	.
Minuartia verna ssp. montana	1	.	2	24, 32	.	24, 32, 33
Muscari comosum	1	.	01	24, 33, 34;	.	24, 34
Muscari racemosum	1	(01)	01	42	24, 34;	34
Nonnea pulla	1	.	.	24, 34	.	.
Ononis spinosa	05	(05)	.	24, 31	24	.
Ornithogalum umbellatum	(1)	.	.	24, 32	.	.
Papaver rhoeas	1	.	.	24, 32	.	.
Pastinaca sativa	.	05	.	.	24, 32	.
Pimpinella major	.	05	.	.	23	.
Plantago lanceolata var. eriophylla	1	.	01	24, 32	.	24, 32
Plantago media	.	1	.	.	24, 32	.
Poa bulbosa ssp. vivipara	2	.	3	24, 42	.	24, 42
Poa pratensis ssp. angustifolia	1	.	.	24, 32	.	.
Polygala comosa ssp. podolica	.	05	.	.	24, 32	.
Polygonum patulum ssp. kitaibelianum	.	1	.	.	24, 32	.
Potentilla arenaria	1	.	.	24, 42	.	.
Potentilla argentea	2	.	.	24, 42	.	.
Potentilla heptaphylla	.	01	.	.	24	.
Potentilla pentaphylla	.	01	.	.	24	.
Reseda lutea	1	.	.	24, 32, 33	.	.
Salvia nemorosa	1	1	.	24, 32	24, 32	.
Salvia nem. var. submollis	1	.	.	24, 32	.	.
Salsola kali	1	.	.	23	.	.
Saxifraga tridactylites	2	.	.	34, 42	.	.
Scabiosa ochroleuca	.	.	01	.	.	24, 31
Sedum acre	.	.	5	.	.	24, 32
Sedum sexangulare	1	.	.	24, 32	.	.
Seseli annuum	1	.	.	24, 32, 33	.	.
Silene cucubalus var. leaceae	1	.	.	24, 32	.	.
Silene otites	1	.	1	24, 31	.	24, 31
Sonchus arvensis	01	.	01	24, 31	.	24, 32
Stachys recta	1	.	.	24, 32	.	.
Stipa eriocaulis	1	.	.	24	.	.
Syrenia cana	1	.	1	24, 32	.	24, 32
Taraxacum serotinum	1	.	.	24, 32	.	.
Tetragonolobus siliquosus	.	05	.	.	24, 32, 34	.
Teucrium chamaedrys	.	05	.	.	24	.
Thalictrum minus	.	2	.	.	24, 31.	.

Table 3., continuation

Species list	Ser. No. of sample			Phenophases		
	1	2	3	1	2	3
Thesium ramosum	.	.	02	.	.	24, 32
Thymus pannonicus	3	01	20	24, 32;	24, 32;	24, 32, 33;
Thymus praecox	1	01	30	24, 31, 32;	24, 32;	24, 31, 32;
Tragopogon dubius	1	(01)	.	24, 32, 34;	24, 32;	.
Trifolium alpestre	.	(01)	.	.	24, 32	.
Verbascum phoeniceaum	.	1	2	.	24, 34;	24, 34, 42;
Veronica prostrata	.	(01)	.	.	24, 33	.
Veronica spicata var. hybrida	1	.	.	24, 32	.	.
Veronica verna	1	.	.	24, 32	.	.
Zerna inermis var. aristata	(10)	.	.	24, 32, 34;	.	.
Zerna inerm. var. villosus	.	50	.	.	24, 32	.
Number of species = S	83	35	40			
H' =	4.77	2.90	3.85			
J =	0.75	0.56	0.72			

Note: Near to the sample plots there are: Agropyron pectinatum, Andropogon ischaemum, Ballota nigra, Berteroa incana, Bromus tectorum, Buglossoides arvense, Capsella bursa-pastoris, Carlina vulgaris ssp. intermedia, Centaurea jacea ssp. pannonica, Cychorium intybus, Conyza canadensis, Hordeum murinum, Nigella arvensis, Odontites (rubra) vulgaris, Polygala comosa, Raphanus raphanistrum, Rapistrum perenne, Rinanthus borbásii, Rumex ambiguus, Salvia austriaca, Scleranthus polycarpa, Sedum hillebrandtii, Sysimbrium orientale, Spartium junceum, Taraxacum (laevigatum) erythrospermum, Vicia angustifolia, Vinca minor, Viola tricolor ssp. arvensis, Xeranthemum annuum.

Table 4. Mont. Radobyl at Litomeritz, SW slope 30–35°, sample 1–2; Mont. Oblik at Louny, SW slope 40° sample 3–4 in: Bohemian Central Mountain, Czehoslovakia, at 23.05.1980. Size of sample plot 5 × 10 m.

Species list	Serial No. of sample				Phenophase			
	1	2	3	4	1	2	3	4
Achillea pannonica	01	01	01	01	23,	24,	23,	23,
Achillea setacea	.	1	2	.	.	23,	23,	.
Adonis vernalis	.	.	5	3	.	.	24, 32	24, 32–34;
Agrimonia eupatoria	.	.	(1)	01	.	.	24, 31;	23,
Anchusa officinalis	01	.	.	.	24,	.	.	.
Arenaria serpillifolia	.	1	.	.	.	24, 34;	.	.
Armeniaca serpillifolia	01	.	.	.	24, 33;	.	.	.
Artemisia campestris	1	.	.	(1)	23,	.	.	23,
Asparagus officinalis	01	.	.	.	23, 31;	.	.	.
Astragalus exscapus	.	2	2	5	.	24, 32;	24, 32;	24, 32;
Astragalus exscapus var. caulifera	2	3	.	.	24, 32;	24, 32;	.	.
Brachypodium pinnatum	.	.	15	5	.	.	23,	24,
Carduus acanthoides	.	1	.	.	.	23,	.	.
Carex humilis	.	.	10	.	.	.	23,	.
Carex supina	10	(1)	.	.	24, 32:	23,	.	.
Carlina vulgaris	.	.	01	.	.	.	42	.
Centaurea rhenana	1	2	.	.	23,	23,	.	.
Chrysanthemum vulgare	.	.		2	.	.	.	23,
Cirsium eriophorum	.	.	01	.	.	.	23,	.
Convolvulus arvensis	1	.	.	.	23,	.	.	.
Cotoneaster integerrima	.	.	.	1	.	.	.	24, 31;
Crataegus monogyna	.	.	(1)	1	.	.	24,	.
Dianthus carthusianorum	01	01	.	.	24, 32;	24, 31,32;	.	.
Erodium cicutaria	01	.	.	.	24, 32	.	.	.
Elytrigia intermedia	5	10	.	.	23,	23,	.	.
Eryngium campestre	01	01	.	.	23,	23,	.	.
Erysimum crepidifolium	1	10	1	.	24, 32, 33;	24, 32, 33;	24, 32;	.
Euphorbia cyparissias	3	5	2	2	24, 32;	24, 32, 33;	24, 33;	24, 33;
Falcaria vulgaris	01	.	.	.	23,	.	.	.
Festuca rupicola	.	.	.	.	.	.	.	24, 32;
Festuca valesiaca	60	85	10	.	24, 32;	24, 32;	24, 31;	.
Filipendula vulgaris	.	.	(1)	.	.	.	23,	.
Fragaria viridis	.	.	1	2	.	.	24, 32;	24, 32;
Galium verum	.	.	.	1	.	.	.	23, 31;
Geranium sanguneum	.	.	.	5	.	.	.	23,
Helianthemum nummularium	.	.	.	1	.	.	.	24, 31, 32;
Helictotrichon adsurgens	.	.	10	.	.	.	24, 32;	.
H. desertorum ssp. basalticum	.	.	1	.	.	.	24, 32;	.
Hieracium pilosella	1	.	.	.	24, 32;	.	.	.
Hypericum perforatum	.	.	(1)	.	.	.	24, 31;	.
Isatis tinctoria	.	1	.	.	.	24, 32, 33;	.	.
Koeleria gracilis	3	10	1	'	24, 32;	23, 31;	23, 31;	.
Lamium amplexicaule	.	1	.	.	.	24, 32;	.	.
Lathyrus versicolor	.	.	.	(2)	.	.	.	24, 33;
Linum austriacum	.	.	.	1	.	.	.	24, 32;
Buglossoides arvense	01	2	.	.	24, 32;	24, 32;	.	.
Medicago falcata	.	01	.	.	.	23,	23,	.
Myosotis ramosissimum	(01)	.	.	.	24, 32;	.	.	.
Muscari tenuiflorum	1	1	.	.	24, 31;	24, 32;	.	.
Oxytropis pilosa	.	.	2	1	.	.	24, 31;	23,
Phleum bohmeri	3	.	.	.	23,	.	.	.
Pilosella cymosa	.	.	2	1	.	.	24, 31;	24, 32;

Table 4., continuation

Species list	Ser. No. of sample				Phenophase			
	1	2	3	4	1	2	3	4
Pimpinella saxifraga	01	.	.	.	24,	.	.	.
Plantago sp.	.	.	.	01	.	.	.	23,
Poa bulbosa	1	.	.	.	24, 32;	.	.	.
Potentilla arenaria	.	2	.	1	.	24, 33, 34;	.	24, 32;
Potentilla serpillifolia	2	.	.	.	24, 33, 34;	.	.	.
Primula veris	.	.	.	(1)	.	.	.	24, 33;
Prunus spinosa	10	.	.	.	24,	.	.	.
Pulsatilla nigricans	.	1	.	15	.	24, 34;	.	24, 34, 41;
Ribes uva-crispa	.	.	.	(1)	.	.	.	24,
Rosa canina	2	.	.	.	24,	.	.	.
Rosa pimpinellifolia	2	.	.	.	24,	.	.	.
Rosa sp.	.	.	.	.	.	.	24,	.
Salvia nemorosa	(1)	.	.	.	24, 32;	.	.	.
Salvia pratensis	.	.	.	2	.	.	.	24, 31, 32;
Sanguisorba minor	(01)	.	01	01	24,	.	23,	24,
Scabiosa ochroleuca	.	.	01	.	.	.	23,	.
Sedum acre	.	2	.	.	.	24, 31;	.	.
Sedum maximum	01	.	.	.	23,	.	.	.
Sedum sexangulare	02	.	.	.	23,	.	.	.
Seseli hyppomaratrum	.	1	.	.	.	22,	.	.
Silene otites	(01)	.	.	.	24, 31;	.	.	.
Sorbus danubialis	.	.	01	.	.	.	23,	.
Stachys recta	1	01	.	.	23,	23,	.	.
Stipa capillata	.	15	.	.	.	22,	.	.
Stipa pennata	2	5	.	2	24, 31;	24, 31, 32;	.	24, 32;
Taraxacum sp.	.	.	01	01	.	.	23,	24, 33;
Teucrium chamaedrys	5	.	5	10	23,	.	23,	23,
Thalictrum minus	.	.	.	2	.	.	.	24, 31;
Thymus cf. glabrescens	2	1	6	2	24, 32;	24, 32;	24, 32;	24, 32;
Valeriana officinalis	.	.	.	01	.	.	.	23, 31;
Verbascum lychnitis	1	.	1	01	23, 31;	.	23,	23,
Verbascum phoeniceaum	.	1	.	.	.	24, 32;	.	.
Veronica prostrata	.	01	.	.	.	24, 32;	.	.
Viburnum lantana	.	.	01	.	.	.	23,	.
Viola silvatica	.	.	(1)	.	.	.	24, 31;	.
Number of species = S =	35	29	25	23				
H' = 3.08	2.83	3.60	3.55					
J = 0.60	0.58	0.77	0.73					

Table 5. Number of common species in samples

Sample No.	1	2	3	4	5	6	7
1	83						
2	16	35					
3	30	9	40				
4	11	4	4	35			
5	10	3	5	15	29		
6	3	2	2	8	8	25	
7	5	5	3	6	7	13	29

In the diagonal there are the number of species per sample in the half matrice