

SOME DATA ABOUT THE COMPOSITION OF FLORA IN KARST DOLINES

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The intensity of corrosion processes in karst dolines changes as a function of oecological characteristics of doline soils. By regulating the circumstances of soil temperature and humidity — the microclimate, and by changing the content of soil air — the micro — and macroenvironment have influence on the degree and effectivity of corrosion processes which go through the soil. It has been proved on samples taken from Hungarian karst areas that special changes in soil temperature and humidity will cause differentiation in the development of bacteria population. (BÁRÁNY — G. MEZŐSI 1977).

Microflora and fauna in tight connection with macroflora can change the oecological circumstances of soil. Because of the above mentioned biogene i.e., soil transformations the intensity of the process of karsts is higher on the majority of Hungarian karsts than on the relatively smaller bare surfaces. It seems to be reasonable to extend our investigations on to the composition of doline macroflora besides that of microclimate and microflora.

The vertical arrangement of doline flore is the opposite of that of the high mountains as a consequence of microclimate circumstances. The above inversion was shown in Jugoslavian dolines by J. HORVÁTH (1953) and later by I. GAMS, (1972). R. GEIGER, (1961) referring to W. SCHMIDT's investigations in Lower—Austria (Gstettneralm doline) mentions the inversion of flora in dolines. The inversion is expressed in the changing of the type of growth which is indicated ve clearly in the map of the doline he called mrazisca (I. GAMS, 1972).

From among the Hungarian associational experiments the analysis carried out in the Bükk Mountains by N. BACSÓ and¹B. ZÓLYOMI, (1934) can be considered as a pioneering work. They report of *Nardetum montanum festucetosum ovinae* at the bottom of the Nagymező doline and of the drought-resistant *Festucetosum sulcatae* on the southern slope.

According to P. JAKUCS (1961) the characteristic associational types of Hungarian dolines are those of lower alpine *Nardo-Festucetosum ovinae* and *Nardetum strictae*. This type of association consists mainly of grasses, has fibrous root-system and covers the ground thickly. Because of its acid-producing rootlets it can transform the rock surface of mountains even through the direct corrosion of limestone. (P. JAKUCS, 1956).

A. LEHMANN (1974) analysed the relationship of climate and flora in the Mecsek Mountains. He also pointed out the inversion of the flora on the example of a doline in Abaliget and explained all that as a consequence of microclimatic inversion. He described a Fagion type of associaton.

The aim of the present study is to try to give a comparative analysis of the flora of the differently exposed slopes in the dolines of the Bükk Mountains with special emphasis on the species composition, covering up percentage (domination %) and oecological indication.

Our investigations were carried out in 5 similarly situated unwooded dolines (2 in Kurtabérc and 3 in Nagymező) in July and August of 1979 in the form of taking 1×1 m quadrat-samples and determining the species of plants. During the course of sample-taking we noted the degree of domination i.e., its corresponding covering up percentage on the basis of the AD scale used in botanical practise (A. SCAMONI, 1963).

The evaluation of mass-relations was not considered necessary since our aim was to show the expositional differences as it was done in our earlier study on micro-climate, soil humidity and bacteria. Also in this case the analysis of flora, as an important oecological factor, serves as an indirect proof of asymmetrical doline development.

The majority of the retraceable species belong to the class of Festuco-Brometea from coenosystematical point of view. But in the dolines there are a number of species of the Arrhenatheretea class. Within this class some of the representatives of the Festucetalia valesiaceae and those of Arrhenatheretalia series were also found among the members of the doline association.

Near the beeches (on the edge of the dolines) species characteristic of the Fagetalia series of Querco—Fagetetea class, e.g.: *Aegopodium podagraria*, *Daphne mesereum*, etc., were also found.

The class of Nardo—Callunetea constitutes an important component of the doline flora and so does the Nardo—Agrostion tenuis group of the Nardetalia series, the most important of which are *Nardus stricta* and *Agrostis tenuis* in the association of *Festuca ovinae*-Nardetum.

So according to the coenosystematic arrangement the majority of the species belong to the characteristic plants of steppe, rock-grass covered slopes, short-grass grounds, mountains and hay-fields (Tables 1., 2.).

Having done the domination investigations we have come to the conclusion that *Arrhenatherum elatius* (5—75%) and *Nardus stricta* (5—50%) have the highest covering up percentage as they could be found on each slope. The covering up percentage was also high in the case of *Galium mollugo*, *Molinia coerulea*, but *Centaurea scabiosa* could be found on all the four slopes with the covering up percentage of 5—25% (in one case this species had 75% on the western slope) and *Fragaria vesca* had about 5% covering up percentage on every slope.

Achillea millefolium, *Ranunculus polyanthemos*, *Briza media*, *Carlina acaulis*, *Veronica prostrata*, *Valeriana officinalis*, *Pimpinella saxifraga*, *Phleum phleoides*, *Plantago media*, *Asperula cynanchica*, *Viola hirta*, *Euphorbia salicicola*, *Thymus glaberrimus*, *Filipendula vulgaris*, *Serratula tinctorica*, *Rumex acetosa* could be met with 5% or even lesser covering percentage on all the four slopes.

Galium verum (5—25 covering up %), *Geranium sanguineum*, *Trifolium alpestre* and *Sanguisorba minor* could be found on all the slopes except the southern one. The other species appeared on 3, 2 or 1 places depending on the type of the slope-association.

The number of species found on every slope is not sufficient for demonstrating

Table 1.

Species	Locality	Nagymező/1				Nagymező/2				Nagymező/3				Kurtabérc/1				Kurtabérc/2			
	Slope S	S	W	E	N	S	W	E	N	S	W	E	N	S	W	E	N	S	W	E	N
Salvia pratensis		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	+
Iris sibirica		2	1—2	+	—	—	2	—	+	—	—	—	—	—	—	—	—	—	—	+	—
Potentilla recta		—2	+	2	—	—	—	+	—	—	—	1	—	—	—	—	—	—	—	+	—
Arrhenatherum elatius		1	1	1—2	—	1	1	1—2	+	1	—	2—3	2	4	2	3	3	4	3—2	—3	2—
Centaurea scabiosa		1	1	+	1	—	+	1	1	—	4	—	—	—	—	—	—	—	—	—	—
Molinia corulea		—1	—	1—2	—	—	—	+	—	2	—	2—	1	1	—	—	3	—	—	—	—
Nardus stricta		—1	—	2	2	—1	1	2	2	—	2	—	—	1	+	3	3	—	—	—	—
Dactylis glomerata		—	—	—	—	—	—	—	—	—	—	—	+	—	+	+	—	—	—	—	—
Origanum vulgare		—	—	—	1	—	—	—	—	—	—	—	—	—	+	—	—	—	+	+	—
Galium mollugo		—	—	—	—1	+	—	—	—	—	1	—	—	1—	2	—	3—	—2	1	3	—
Achillea millefolium		+	+	+	1	+	—	+	+	—	—	—	—	—	—	+	+	+	+	+	—
Fragaria vesca		—	+	—	—1	+	+	+	—1	—1	+	—1	1	—	—	+	—	+	1	1—	—1
Coronilla varia		—	—	—	—	—	+	—	—	—	—	—	2—3	—	—	—	+	—	—	—	—
Colchicum autumnale		—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1	—	—
Gentiana crutiata		+	+	—	—	—	+	—	—	—	—	—	+	—	—	—	—	+	+	—	—
Luzula albida		+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ranunculus polyanthemus		+	+	—	+	+	—	+	—	+	—1	+	+	+	—	—	—	—	+	+	—
Betonica officinalis		+	—	+	—	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—
Briza media		+	—	+	—	—	—	—	—	+	—	+	+	—	—	—	—	—	+	—	+
Carlina acaulis		+	—	—1	—	+	1	+	—	—	—	1	+	—	—	+	—	—	—	—	—
Succisa pratensis		+	+	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—
Cerastium vulgatum		+	+	+	+	—	—	—	—	+	—	+	—	—	—	—	—	+	—	+	—
Verbascum ausztriacum		—	+	—	+	—	+	—	+	—	+	—	+	—	—	—	—	—	—	—	—
Silene vulgaris		—	+	—	—	—	+	—	—	—	+	—	—	—	—	—	—	—	—	—	—
Veronica dentata		—	—	+	+	—	—	—	+	+	—	—	+	+	—	+	+	+	+	+	—
Valeriana collina		—	+	—	+	—	—	—	—	—	+	+	+	—	—	+	—	+	—1	+	—
Geranium sanguineum		—	1	+	+	—	+	+	1—	—	—	—	—	—	—	—	—	—	—	—	—
Dianthus deltoides		—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+
Teucrium chamaedrys		—	—	—	+	—	—	—	—	—	+	—	—	—	—	1—2	1	—	—	—	—
Pimpinella saxifraga		—	—	—	+	—	+	—	+	+	+	+	+	—	—	—	—	—	—	—	—
Lathyrus pratensis		—	—	—	+	+	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—
Phleum phleoides		—	—	+	+	+	+	+	—	—	—	—	—	—	—	—	—	+	+	1	+
Galium verum		—	+	++	+	—	1	+	—	—	—	+	1—2	—	1—2	—	—	—	—11	—2	+
Aconitum moldavicum		—	1	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Plantago media		—	+	—	—	+	+	+	+	+	—	+	—	—	—	—	—	—	+	—	—
Asperula cynnanchica		—	—	—	—	+	—	—	—	—	—1	—	+	—	+	+	+	—	+	+	—
Filipendula vulgaris		—	—	—	—	+	+	+	+	—	—	—	+	—	—	—	—	—	—	—	—
Viola hirta		—	—	+	—	+	+	+	+	—	—	—	—	—	+	—	—	—	+	—	—1
Serratula tinctorica		—	—	—	—	2—3	+	1—	+	—	—	—	—	—	—	—	—	—	—	—	—
Potentilla erecta		—	—	—	—	+	—1	—	—	—	—	—	—	—	—	—	—	—	—	—	—

Table 2.

Species	Locality		Nagymező/1				Nagymező/2				Nagymező/3				Kurtabérc/1				Kurtabérc/2			
	Slope		S	W	E	N	S	W	E	N	S	W	E	N	S	W	E	N	S	W	E	N
Rumex acetosa	—	—	—	—	—	+	—	—	—	—	+	—	+	+	—	—	—	+	—	+	—	—
Scabiosa ochroleuca	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—
Senecio jakobaea	—	—	—	—	—	—	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—
Euphorbia salicifolia	—	—	+	—	—	—	+	+	+	—	—	—	—	—	+	+	—	—	—	+	—	—
Polygala vulgaris	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+
Digitalis ambigua	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—
Prunella laciniata	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—
Alchemilla monticola	—	—	—	—	—	—	—	+	—	3	—	—	1	—	—	—	—	—	—	—	—	—
Thymus glabrescens	—	—	—	—	—	—	—	+	—	+	—	+	—	—	—	—	—	—	+	+	+	—
Ranunculus auricomus	—	—	+	—	—	—	+	+	—	+	—	—	—	—	—	—	—	—	—	—	—	—
Taraxacum officinale	—	—	—	—	—	—	—	—	—	+	—	+	—	—	—	—	—	—	—	—	—	—
Rumex acetosella	—	—	+	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	+	—	—	—
Trifolium alpestre	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	+	—	—	+	+	—	—
Hypericum perforatum	—	—	—	—	—	—	—	—	—	—	+	—	—	+	—	—	—	—	—	—	—	—
Gentiana ciliata	—	—	—	—	—	—	—	—	—	—	—	+	—	+	—	—	—	1	—	—	—	2—3
Carex panicea	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	+	+	—	—	+
Aegopodium podagraria	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—
Scrophularia nodosa	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	+	—	—	—	—	—	—
Campanula persicifolia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—
Polygonum convolvulus	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	+	+	—	—
Vicia sepium	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—
Calamintha clinopodium	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—
Lysimachia vulgaris	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—
Anthriscus silvestris	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—
Carduus nutans	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—
Viola mirabilis	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—
Ribes alpinum	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	+	+	1	—
Sanguisorba minor	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	+
Festuca ovinae	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	+	—	—	—	—	—	1
Helianthemum ovatum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	3	+
Viscaria vulgaris	—	—	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	+
Thalictum lucidum	—	—	—	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Parnassia palustris	—	—	—	—	—	—	—	—	—	—	+	+	—	—	—	—	—	—	—	—	—	—
Gentiana cruciata	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Sedum maximum	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Thesium linophyllum	—	+	—	—	—	—	—	+	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Allium montanum	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—

the expositional differencies, so they were excluded from the further investigations inspite of their considerable up percentage.

Species with differential appearance were of much greater help from the point of view of oecological arrangement. In the following the species found only on one slope were examined according to oecological demands.

B. ZÓLYOMI (1964, 1966) worked out on evaluation system for plant species with the help of oecological indicators taking Hungarian examples. The species found in the dolines were given appropriate indicator numbers applying ZÓLYOMI's differentiation method where (T) indicated heat balance, (W) water balance, (R) soil reaction and (N) nitrogen demand; then oecological average numbers were calculated for species found on the same places with the help of the following formula:

$$T\bar{a} = \frac{x_i y_i}{n_i} \text{ where}$$

$T\bar{a}$ = the number of the average heat balance value for the found species

x_i = oecological value

y_i = the species number of the given oecological number

n = the number of the found species

The same formula was used for calculating the water balance, soil reaction and nitrogen-indication index numbers as well (Table 3.).

Table 3.

Species occurrence on the N slope:	T	W	R	N
<i>Salvia pratensis</i>	6	3	0	2
<i>Coronilla varia</i>	5a	3	4	—
<i>Diantus pontederiae</i>	6	2	4	1—2
<i>Scabiosa ochroleuca</i>	6k	2	4	1—2
<i>Polygala vulgaris</i>	5a	5	3	1
<i>Yigitalis ambigua</i>	5a	4	3	2—3
<i>Prunella grandiflora</i>	5a	4	5	2
<i>Campanula persicifolia</i>	5k	4	3	2
<i>Calamintha acinos</i>	6a	1	4	1
Mean value index:	5,45	3,12	3,34	1,88
Species occurrence on the S slope:				
<i>Molinia coerulea</i>	5a	7	0	1
<i>Astrantia major</i>	5a	6	4	2—3
<i>Aegopodium podagraria</i>	5	7	3	4
<i>Lysimachia vulgaris</i>	5	9	0	0
<i>Anthriscus silvestris</i>	5	5	4	4—5
<i>Carduus nutans</i>	5a	2	3	3—4
<i>Viola mirabilis</i>	5a	5	4	0
Mean values index:	5,00	5,86	2,58	2,15

The number of species which did not appear anywhere else only here, was greater on the southern and northern slopes. One or two species could be found on the western and eastern slopes which could not be met elsewhere but their number was sufficient enough to make a comparison with their help.

The value of the average heat balance ($T\bar{a}$) was 5,45 on the northern slope (southern exposition) and 5,00 on the southern slope (northern exposition). Their difference in value is significant because of the microenvironment they refer to. The greater value found in the case of the northern slope refers to a bigger extent of aridation which has a decisive effect on the other oecological factors resulting from the exposition.

Characteristically, the average value of water balance ($W\bar{a}$) shows the expositional effect. Its value is 3,12 on the northern slope and 5,86 on the southern one. The difference in their value definitely proves the differences in soil humidity (2,74), the data of which have already been shown in details earlier (I. BÁRÁNY, 1981.).

Soil reaction is also a function of temperature and water metabolism since they determine the composition of species in micro- and macroflora and thus, have an effect on the quality of the soil reaction. The average value of soil reaction is somewhat higher (3,34) on the northern slope than on the southern one (2,58).

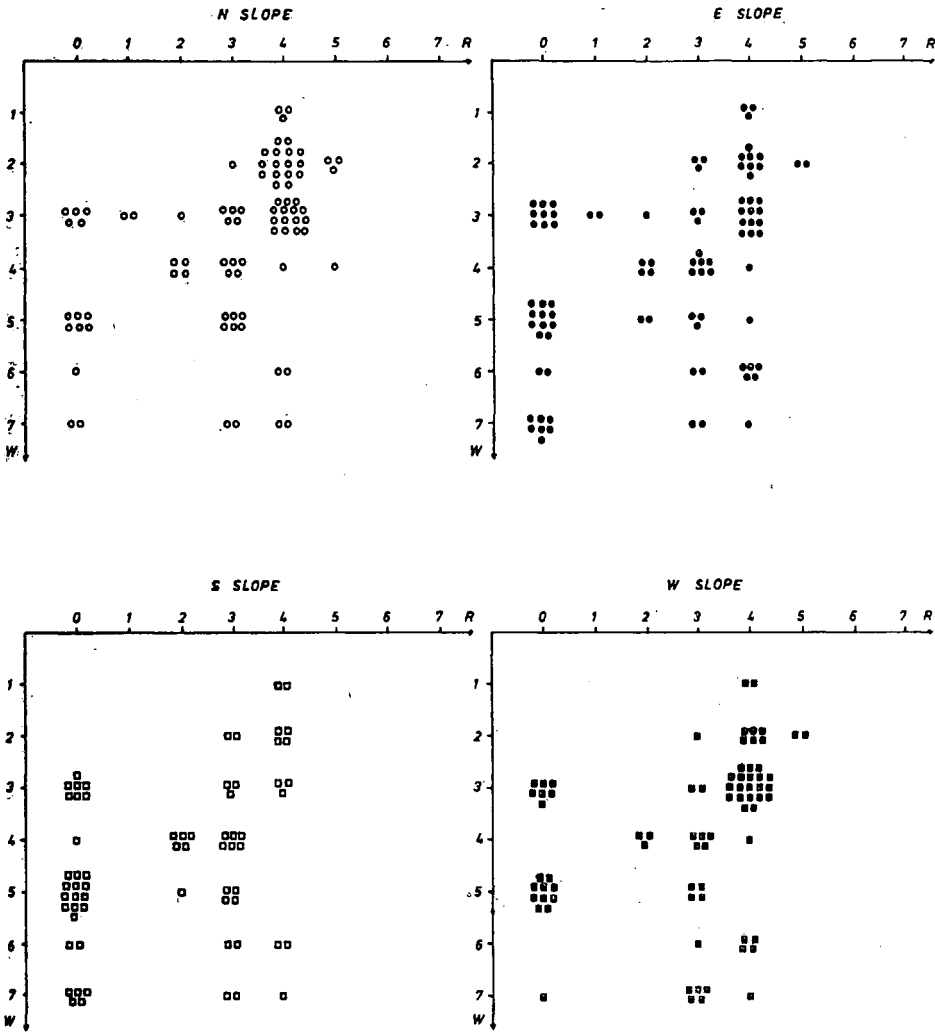
In respect of the nitrogen indication there is no considerable expositional difference. Generally, however it should be noted that the nitrogen demand of species found in the dolines is not too high and its average value is between 1,00—2,50. (Our information about the soil reaction and nitrogen correspond well with A. LEHMANN's results on the basis of his findings in the Mecsek Mountains in 1974.)

The appearance only on slope may be accidental in certain cases. So for the further verification of the tendencies only the species which were found on every slope except one were analyzed. (In the majority of the cases either on the northern or the southern slope was the place where certain species could not be found. (Table 4.).

In this comparison the difference in the value of the average water balance on the northern slopes (W, N, E slopes) and the southern (W, S, E slopes) doline halves

Table 4.

Species occurrence on the W, S and E slope	T	W	R	N
<i>Potentilla erecta</i>	5	7	0	1—2
<i>Succisa pratensis</i>	5a	7	4	2
<i>Ranunculus auricomus</i>	5	6	3	3
<i>Rumex acetosa</i>	5	5	0	2—3
<i>Ribes alpinum</i>	5a	6	4	2
Mean value index:	5,00	6,20	2,20	2,20
Species occurrence on the W, N E slopes:				
<i>Dactylis glomerata</i>	5k	3	4	1—2
<i>Origanum vulgare</i>	5	3	4	2
<i>Geranium sanguineum</i>	5a	2	5	1—2
<i>Teucrium chamaedrys</i>	6a	2	4	1—2
<i>Galium verum</i>	5k	3	4	1—2
<i>Trifolium alpestre</i>	5a	3	1	2
<i>Polygonum convolvulus</i>	5	4	4	3
Mean value index:	5,15	2,86	3,72	1,88



1. Figure DIAGRAMS INDICATING W-R VALUE OF SPECIES OCCURRING ON DIFFERENT SLOPE DOLINES

is rather striking. The difference in value is 3,40 which is significantly higher than that of the northern and southern slopes. Conclusions must be more carefully drawn in case of further differentiation of the slopes. The number of the species found only on two slopes is smaller, thus, their accidental number may distort the results of the investigation. However, even these data may have some relevance for the demonstration of slope tendencies. The comparison of the northern and eastern slopes with the

southern and western ones is of particular interest for us. The same refers to the comparison of the northern and western slopes with the southern and eastern ones. (It is important to compare two slopes opposite each other because in the Bükk Mountains the extension of the dolines in NW—SE and NE—SW directions is often experienced.)

The species the locality of which can be found on the northern and western slopes have 5,25 as the value of the average heat balance and 4,00 as that of the water balance. On the southern and eastern slopes the value of the above species was 4,33 and 4,00. So, the conclusion can be drawn that in the opposite expositions a big difference is indicated as far as the heat balance is concerned. The identical values of water balance can be well explained by the fact that in the afternoon the southeastern doline quarter is exposed to longer and stronger sunshine than the others what results in the decrease of humidity. (In spite of this fact the index numbers cannot be taken in absolute value because of the small number of species.)

The difference is greater in the case of the north-eastern and south-western doline quarters where the average value of water balance for the species of the northern and eastern slopes is 2,50 and 5,34 in the opposite expositions.

According to the diagram (See Figure 1.) drawn on the basis of water balance (W) soil reaction (R) values the number of line-preferring species is quite considerable. Species resistant to the chemical reaction of the soil can be found mostly on the southern slope. The least number of the species requiring the neutral chemical reaction of the soil can be found on the northern and western slopes. The lime-preferring species are either on the dry or on the moderately dry slopes. Those species which prefer neutral chemical reaction are on the wet areas.

As far as the water balance and soil reaction is concerned the variety of the species is the highest on the eastern and western slopes.

Summarizing our results we can conclude that in bare dolines the grassy associations which are seemingly homogeneous in their habitat and rich in their number of species, act as indicators of the special oecological circumstances on the different slopes. In respect of the composition of species the northern and southern, i.e., the northern and southern halves of the dolines differ from each other. The vegetation experiments on the slopes in the direction of the cardinal side-points yet have to be analyzed, but it can already be noticed for the differences of species on the SW and NE slopes the water balance, for those on the NW and SE slopes the heat balance differences are responsible.

The composition of flora according to the above exposition verifies our previous statements in connection with the asymmetrical doline development.

REFERENCES

- BACSO, N.—ZÖLYÖMI, B. (1934): Mikroklima és növényzet a Bükk-fensíkon. (Microclimate and flora on the Bükk highland). *Időjárás*, 1934, 177—196. pp.
- BÁRÁNY, I. (1981): A dolinák fejlődésének ökológiai szabályozottsága. (Oecological regularities in the development of dolines.) Kandidátusi disszertáció. 156—169. pp.
- BÁRÁNY, I.—MEZŐSI, G. (1977): Interrelation of some factors of karstcorrosion in a doline in the Bükk Mountains, Hungary. *Proceedings of the 7th International Speleological Congress, Sheffield 1977*. 20—22. pp.

- GAMS, I. (1972): K ekologiji vrtac. IX. Kongres Geografa Jugoslavije S. R. Bosna i Hercegovina 24—30. Sept. 1972. Sarajevo. 1974. 151—159. pp.
- GEIGER, R. (1961): Das Klima der bodennahen Luftschicht. Braunschweig. 412—422. pp.
- HORVÁTH, I. (1953): Die Vegetation der Krstdolinen. Geografski Glasnik, Nos. 14—15. pp. Zagreb.
- JAKUCS, P. (1956): Karrosodás és növényzet. (The process of karring and flora.) Földrajzi Közlemények 3. 249—241. pp.
- JAKUCS, P. (1961): Az Északi-Középhegység keleti felének növényzete. (The flora of the eastern half of the Northern Mountains.) Földrajzi Értesítő 3. 357—377. pp.
- LEHMANN, A. (1974): Klima és növényzet a Mecsek és a Villányi hegység karsztos területein. (Climate and flora on the karstdolines of the Mecsek and Villányi Mountains.) Karszt és Klíma Konferencia, Pécs, 1974. szeptember 7.
- SCAMONI, A. (1963): Einführung in die praktische Vegetationskunde. VEB Gustav Fischer Verlag Jena. 20—38. pp.
- ZÓLYOMI, B. (1964): Methode zur ökologischen Charakterisierung der Vegetationseinheiten und zum Vergleich der Standorte. Acta Botanica Academiae Scientiarum Hungaricae. Tom. X. 377—416. pp.
- ZÓLYOMI, B. (1966): Einreichung von 1400 Arten der ungarischen Flora in ökologische Gruppen nach TWR—Zahlen. Fragmenta Botanica Musei Historico-Naturalis Hungarici. Tom. IV. Fasc. 1—4. 101—142. pp.