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Plant distribution-altitude and landform relationships in karstic sinkholes of Mediterranean region of Turkey

Kürsad Özkan*[1], Serkan Gulsoy[1], Ahmet Mert[2], Munir Ozturk[3] and Bart Muys[4]

[1]Department of Soil and Ecology, [2]Faculty of Forestry, Suleyman Demirel University - 32260, Isparta, Turkey
[3]Department of Botany, Ege University, Bornova-Izmir - 35030, Turkey
[4]Division Forest, Nature and Landscape, Katholieke Universiteit Leuven, 3001, Belgium

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Abstract: *The purpose of this study was to investigate the relationships between the plant distribution and the altitude-shape-size characteristics of sinkholes, and the landform characteristics inside sinkholes in the Mediterranean region of Turkey. Block kriging, Factor analysis, Cluster Analysis and Detrended Correspondence Analysis were performed. The sinkhole type and altitudinal zone were found to be the significant factors affecting the plant distribution. However, the sinkhole type was more important than the altitudinal zone. Hence, the sinkholes were first subdivided into groups according to types and then the groups were divided into subgroups according to the altitudinal zones. Consequently, 4 groups were defined; A-type sinkholes [1400-1550 m (A_1), 1550-1700 m (A_2)] and B-type sinkholes [1400-1550 (B_1), 1550-1700 m (B_2)]. The B-type was wider vertically and shorter horizontally than A-type sinkholes. Significant differences were found between the plant distribution and slope position inside the sinkholes. Plant distribution in the lower slopes was different from that in the flats and ridges in the B_1 sub-type of B-type. Plant distribution in B_2 sub-type was different among the slope positions (ridge, middle slope, lower slope, and flat). Although distribution of plants is different in different parts (ridges, upper slope, middle slope, lower slope and basal flats) of A sinkhole, the differences between the parts of intermediate slope position are not significant. A high plant variability along short distances in the sinkholes was observed in the study area. That is why the site of sinkholes have a big potential for the distribution of many species. Hence, the area must be separated as strictly protected zone.*

Key words: *Altitudinal zone, Cluster analysis, Plant distributions, Sinkholes*
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* **Corresponding author:** kursadozkan@gmail.com

Introduction

The Mediterranean region has faced an intense human activity for thousands of year (Vanhaverbeke and Waelkens, 2003). This interference has resulted in a significant reduction of forest cover. The area occupied by *Cedrus libani* A. Rich has got reduced to over half million hectares in Turkey. Presently *Pinus brutia* Ten. and *Pinus nigra* Arnold. subsp. *pallasiana* (Lamb.) Holmboe are the major timber species in the country (Boydak, 2004; Fontaine *et al.,* 2007). Actually the area covered by this forest is highly degraded, ecologically unstable and economically unproductive (Boydak, 2004; Fontaine *et al.,* 2007). Efforts are being made for the restoration of these degraded forests**.** Mediterranean ecosystems have very important position not only because of their species diversity and high endemism ratio but also because of their composition, complex structure and successional stages. For this purpose site classification studies have been carried out and several investigators have tried to model site index (Kantarci, 1991; Ozkan, 2003; Fontaine *et al.,* 2007). The use of natural plant cover as an indicator for forest site quality has provided better results (Berge's *et al.,* 2005; Waring *et al.,* 2006). But, the site characteristics and plant cover are also affected by the tree species (Tarrega *et al.,* 2006), as well as naturally growing plant species (Fontaine *et al.,* 2007). In addition to this, in local forest ecosystems, the forms of the land such as flat surface, rough surface, erosion pavement surface and sinkholes influence the composition and patterns of occurrence of the biota as well as their other functions within ecosystems. The two key elements of specific landforms are their shape and their parent material. Shape, in particular, influences the reception and disposition of radiation, soil water and nutrients and hence the repetitive patterns of biota of an area (Barnes *et al.,* 1998).

Turkey has complex and rich terrains from shape and landform characteristics point of view. One of the typical representative sites in this connection is Beysehir (Konya) watershed area situated in the Mediterranean region of Turkey. This watershed area is characterized by the following landforms: flat surface, rough surface, erosion pavement surface, surface covered with glacier material, surface covered with colluviums and sink-holes. A preliminary study undertaken by Ozkan (2003) revealed that plant distribution in these land forms differs. Present study was thus undertaken to enlighten our knowledge on the plant distribution within the sinkholes and increase our understanding and document the relationships between plant distribution and the slope position within sinkholes on one hand and altitude-shape-size features between sinkholes on the other hand.

Materials and Methods

Study area: The study area is situated between 37° 34' and 37° 38'N latitudes and 31° 21' and 31° 25' E longitudes in the southeast of the Beysehir (Konya) watershed (Fig. 1). The sinkholes located in this area have developed on limestone during Paleozoic and Mesozoic era due to the dissolution of chemicals and crack intensity (Biricik, 1982; Atalay, 1987). The sinkholes in Uctepeler site are located in the faulted area and have developed on hard, recrystalized Mesozoic limestone. A sinkhole is defined as a karstic depression with a ridge, a slope and a flat area. The sinkholes in the study area vary in shape and size. The climate and soil characteristics also vary within a sinkhole and among sinkholes. The limestone located on the slopes of the sinkholes has duct and hole lapies (Biricik, 1982). The soil characteristics also vary at short distances. Ozkan (2003) has reported that the soils of the slopes are drier, shallower, with low soil skeleton, calcium carbonate, clay, organic matter and total nitrogen contents as compared to the soils of the flats of the same sinkholes in Cicekli mountain, Beysehir watershed. Additionally, the soils belonging to the slope of a sinkhole have only Cv horizon but the soils belonging to the flat of the same sinkhole have Ah and Cv horizons and are covered by litter (Ozkan, 2003). The soil features can differ in the same slope positions of the sinkholes if the sinkholes differ in size and shape. For instance, the soil profiles taken from two sinkholes differ from each other in the size and shape. Moreover, in comparison with the soils of the lower slope of the narrow and small sinkhole, the soils of the lower slope of the wide and big sinkhole are deeper, with less soil skeleton and a lower calcium carbonate content (Ozkan, 2003). The soil profiles in the lower slope of two sinkholes are different in size and shape in the Uctepeler site. These soils were middle to shallow in depth, rich to poor in skeleton, sandy-clayey-loam to loamy-clayey in texture, rich to moderate in calcium carbonate content and neutral to slightly alkaline (Ozkan, 2003).

The meteorological station in the study area is located in Yenisarbademli district near Kurucuova, east of Beysehir lake. It lies between 37° 43'N latitude, 31° 23'E longitudes. The altitude of the meteorological station is 1150 m above sea level. According to the data of last 14 yr, mean annual temperature of the study area is 11.04 °C, mean annual precipitation over 800 mm, number of snow cover days 37.6, number of foggy days 6.7 and number of frozen days 1.3 (Utku, 1990). The dominant wind direction in the area is south and northeast. The southern winds coming from Emerdin mountain-Helvaova depression are warm and humid. The northeast winds come from Beysehir lake and are cold and humid (Ozkan, 2003). According to Thornthwaite's Method (Erinc, 1984), Yenisarbademli has a humid climate, mesothermal with slight marine influence but with strong water deficit in summer. A transitional climate between the Mediterranean and Continental climates prevails in the district (Table 1).

Field sampling: Sampling was carried out in Uctepeler site during summer of 2006. In all 20 sinkholes(s) were surveyed and in each sinkhole 5 sample plots were sampled (Fig. 1). We sampled the vascular plant species as presence/absence data (Table 2). At first,

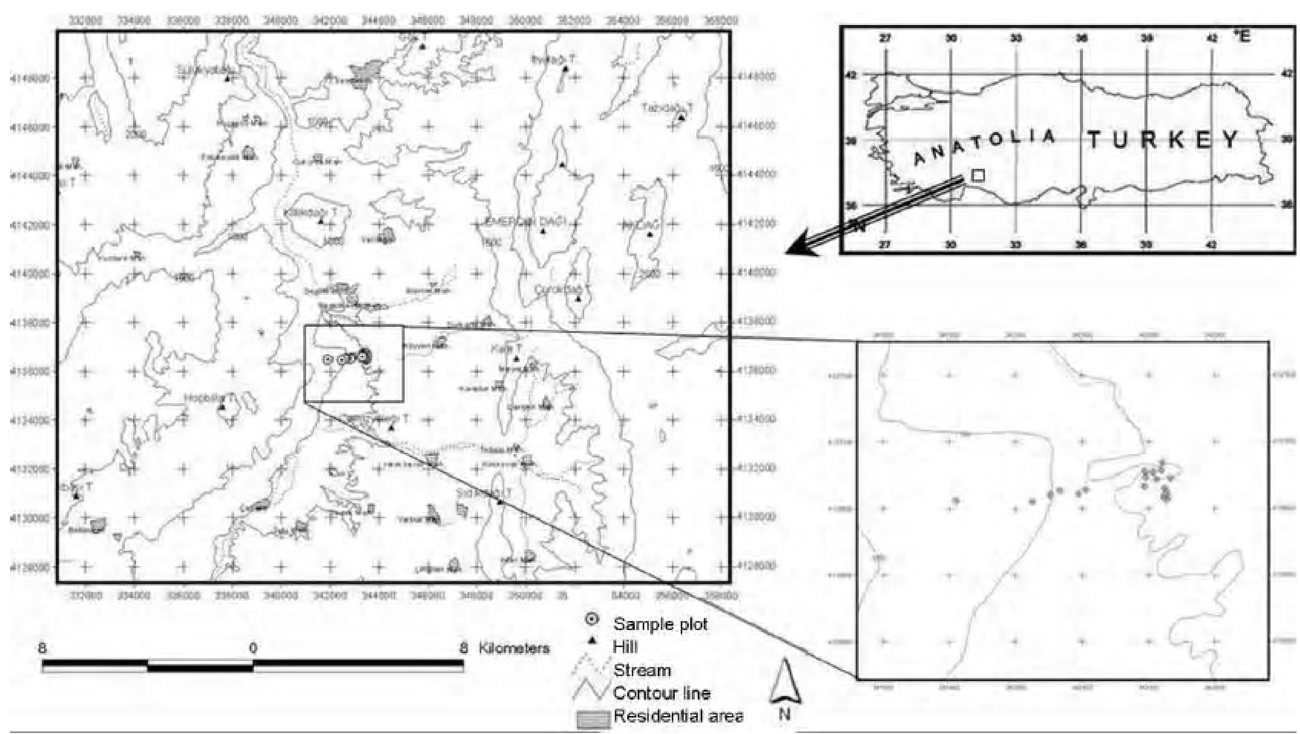

Fig. 1: Location of sample plots in the Uctepeler site from the Mediterranean region of Turkey

Table - 1: Water balance data of Yenisharbademli-Isparta (Turkey) according to the Thornwaite method (symbols explained in appendix table)

MD/M	1	2	3	4	5	6	7	8	9	10	11	12	Annual
TE	1.5	1.5	5.4	10.5	14.4	18.1	21.3	20.9	17.7	11.6	6.9	2.7	11.04
TEI	0.16	0.16	1.1	3.07	4.96	7.01	8.97	8.72	6.78	3.58	1.63	0.39	46.56
PETb	3.6	3.6	17.7	40.5	59.9	79.5	97.3	95.0	77.3	45.8	24.0	7.5	
PETa	*3.1*	*3.0*	*18.3*	*44.6*	*73.4*	*98.2*	*121.9*	*111.4*	*80.1*	*44.1*	*20.2*	*6.2*	624.6
P	134.9	96.9	83.1	75.9	48.4	35.9	8.4	7.5	18.4	58.0	101.3	139.5	808.2
MVSR	0.0	0.0	0.0	0.0	25.0	62.3	12.6	0.0	0.0	13.9	81.1	5.1	
SM	100.0	100.0	100.0	100.0	75.0	12.6	0.0	0.0	0.0	13.9	94.9	100.0	
GET	3.1	3.0	18.3	44.6	73.4	98.2	21.0	7.5	18.4	44.1	20.2	6.2	358.1
WD	0.0	0.0	0.0	0.0	0.0	0.0	100.8	103.9	61.7	0.0	0.0	0.0	266.4
WS	131.8	93.9	64.8	31.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	128.2	450.1

Table - 2: Vascular plant species recorded from the sinkholes

Aa	*Artemisia absinthium* L.	p	*Polygonatum* spp.
Ac	*Abies cilicica* Carr.	pe	*Pyrus elaeagnifolia* Pallas
Acm	*Achillea millefolium* L.	phn	*Phlomis nissolii* L.
alp	*Alcea pallida* (Willd.) Waldst. & Kit.	pm	*Paeonia mascula* Miller
am	*Acer monspessulanum* L.	pn	*Pinus nigra* Arnold.
Ap	*Acer platanoides* L.	pt	*Populus tremula* L.
Cl	*Cedrus libani* A. Rich.	qc	*Quercus cerris* L.
Co	*Crataegus orientalis* Pallas ex Bieb.	qt	*Quercus trojana* P. B. Webb
Dfm	*Dryopteris filix-mas* (L.) Schott.	qv	*Quercus vulcanica* Boiss.
Dl	*Digitalis lanata* Ehrh.	rc	*Rhus coriaria* L.
E	*Euphorbia* spp.	ro	*Rumex obtusifolius* L.
El	*Euonymus latifolius* (L.) Miller.	roc	*Rosa canina* L.
Fo	*Fraxinus ornus* L.	s	*Sedum* spp.
Hc	*Helichrysum compactum* Boiss.	se	*Sambucus ebulus* L.
Ja	*Juncus acutus* L.	sg	*Sideritis germanicopolitana* Bornm.
Je	*Juniperus excelsa* Bieb.	tp	*Tilia platyphyllos* Scop.
Ln	*Lonicera nummulariifolia* Jaub & Spach	ud	*Urtica diocia* L.
Ms	*Malus silvestris* Miller	ug	*Ulmus glabra* Hudson
Oi	*Onopordum illyricum* L.	v	*Verbascum* spp.
Om	*Origanum munitiflorum* O. Schwarz &. P. H. Davis	vv	*Vicia villosa* Roth ssp. *eriocarpa* (Hausskn.) P.Ball

a sinkhole was separated as flat, lower slope, middle slope, upper slope and ridge. The other parts of a sinkhole except ridge and the flat were separated as upper slope, middle slope and lower slope equally as according to the slope distances. The plant species were recorded for each part of a sinkhole as presence-absence along north-south and east-west directions in a sinkhole. Cover values of plants are not a reliable data. Because the human effects or animal grazing have probably effected on the cover values of plant species. In especially, in Beysehir watershed, the forests have been subjected to human effects for a long time (Özkan, 2003). Hence, presence-absence data was preferred and these are the most reliable data for the purpose of our investigation.

The size and shape of the sinkholes was measured and altitudinal zones determined. In each sinkhole presence/absence estimates were made for trees, shrubs and herbs as a function of landscape position [ridge, slope (upper slope, middle slope, lower slope) and flat] of the sample plots. Altitude, latitude and longitude were estimated with Global Positioning System (GPS). For the classification of the sinkholes the distance of north-south direction and east-west direction of the flats and slopes of the sinkholes was measured in accordance with their shape and size. In each sinkhole, elevation differences from the flat to the ridge were recorded while measuring the distance.

Statistical analysis: Block kriging was applied to interpolate elevation measurements in order to draw the contour line maps of the sinkholes to elevation and distance measurements of north-south direction and east-west direction of the sinkholes by using the program SURFER. Block kriging is an effective spatial interpolation technique to simulate landscape pattern. Hence, this technique is generally preferred more than any geostatistical method by different researchers (Robertson and Huston, 1988; Redd *et al.*, 1993; Ortas and Berkman, 1997; Zhenquan *et al.*, 1997; Wang *et al.*, 2002). Q type factor analysis, rotated in accordance with Varimax method was applied to the maximum and minimum length, the maximum and minimum flat length and the maximum and minimum altitude of the sinkholes to define how many groups are created and their presence in the sinkhole by using program SPSS (Kalipsiz, 1981; Ozdamar, 1999).

Cluster analysis based on Sorensen similarity index was applied to distinguish and pool these up in to different groups according to the data obtained from plants in each sinkhole. In each

Table - 3: The results of factor analysis belonging to the first 5 factors

Factor	Eigenvalue	% of Variance	Cumulative %
1	16.823	84.111	84.111
2	2.300	11.499	95.614
3	0.478	2.391	99.671
4	0.333	1.667	100
5	0.066	0.329	100

Table - 4: The results of factor analysis according to the Varimax method (symbols explained in appendix table)

S	CA	CB	S	CA	CB
S1	0.668	0.693*	S11	0.561	0.790*
S2	0.747*	0.635	S12	0.146	0.974*
S3	0.866*	0.488	S13	0.658	0.749*
S4	0.961*	0.275	S14	0.551	0.766*
S5	0.975*	0.140	S15	0.208	0.946*
S6	0.836*	0.494	S16	0.215	0.941*
S7	0.703*	0.640	S17	0.591	0.805*
S8	0.628	0.770*	S18	0.255	0.947*
S9	0.314	0.946*	S19	0.544	0.794*
S10	0.601	0.769*	S20	0.791*	0.602

Table - 5: The average values of the groups discriminated on the basis of factor analysis (symbols explained in appendix table)

S	Mean type A	Mean type B
MALS	43	69.2
MILM	27.1	43.6
MAFLS	9.1	34.3
MIFLS	5.2	18.8
MAS	22.9	17.9
MIAS	7.3	6.4

Table - 6: 2x2 tables between the groups of cluster analysis and the groups of altitudinal zones (symbols explained in appendix table)

	1550-1700 m (S_1-S_9, S_{13})	1400-1550 m (S_{10}-S_{12}, S_{14}-S_{20})	Total
Cluster group I (S_2-S_7, S_{11})	6	1	10
Cluster group II (S_1, S_8-S_{10}-S_{12}-S_{20})	3	10	10
Total	9	11	20

Table - 7: 2x 2 tables between the groups of cluster analysis and the groups of factor analysis (symbols explained in appendix table)

	A type sinkholes (S_2-S_7, S_{20})	B type sinkholes (S_1-S_8, S_{19})	Total
Cluster group I (S_2-S_7, S_{11})	5	1	6
Cluster group II (S_1, S_8-S_{10}-S_{12}-S_{20})	1	13	14
Total	6	14	20

Table - 8: The groups on the basis of sinkhole types and altitudinal zones (symbols explained in appendix table)

Sinkhole types	Altitudinal zones	The number of sinkholes	The codes of the groups
A	1400-1550 m	S_{20}	A_1
	1550-1700 m	S_2-S_7	A_2
B	1400-1550 m	S_{10}-S_{12}, S_{14}-S_{19}	B_1
	1550-1700 m	S_1, S_8, S_9, S_{13}	B_2

sinkhole, the frequencies according to presence situation of the plants for the different parts of a sinkhole were taken into consideration and recorded as numerical value. For instance, if one species is present both on lower slope and middle slope in a sinkhole, we recorded the species as 2 in the same sinkhole. Thus, data matrix was prepared to evaluate. The analysis was performed by using community analysis program (CAP) (Pritchard and Anderson, 1971).

Uctepeler site was subdivided into two altitudinal zones, 1400-1550 m and 1550-1700 m (Ozkan, 2003). An 'accuracy assessment' and 'Kappa statistics' was applied to evaluate suitability between the sinkholes grouped in accordance with altitudinal zones and the groups distinguished by cluster analysis and between the groups distinguished by Q- type factor analysis and the groups distinguished by cluster analysis (Ozdamar, 1999).

DCA (Detrended Correspondence Analysis) was applied to portray the plant distribution in accordance with the location inside the sinkholes by using the program CAP. DCA has been especially effective in detrending the 'arch effect', which may occur when ordination procedures are applied to data sets that encompass too much variability (Hill, 1980; Beauty, 1984; Chang and Gauch, 1986; Jeglum, 1991)

Results and Discussion

Group of sinkholes in accordance with distance values: The Q type factor analysis results of the sinkholes were given 5 factors (Table 3), but only 2 factors; first and second; were taken into consideration, because both of these factors have eigenvalues more than 1 and % variance more than 10 (Kalipsiz 1981). Therefore, we accepted 2 factors. In other words, it is possible that the sinkholes in Uctepeler site can be separated into two groups in accordance with the distance values. S_2-S_7, S_{20} have maximum correlation to component A. CA is component A, the coefficients of the sinkholes belonging to CA (Table 4). S_1, S_8-S_{19} has maximum correlation to component B (Table 4). The Type A sinkholes are those which have the biggest values in component A compared to component B. The situation of the sinkholes in both type A and type B was interpreted according to the average size and shape values of different types.

In comparison with type A sinkholes, Type B have wider flat and cover. However, type A of sinkholes is deeper than type B (Table 5, Fig. 2,3).

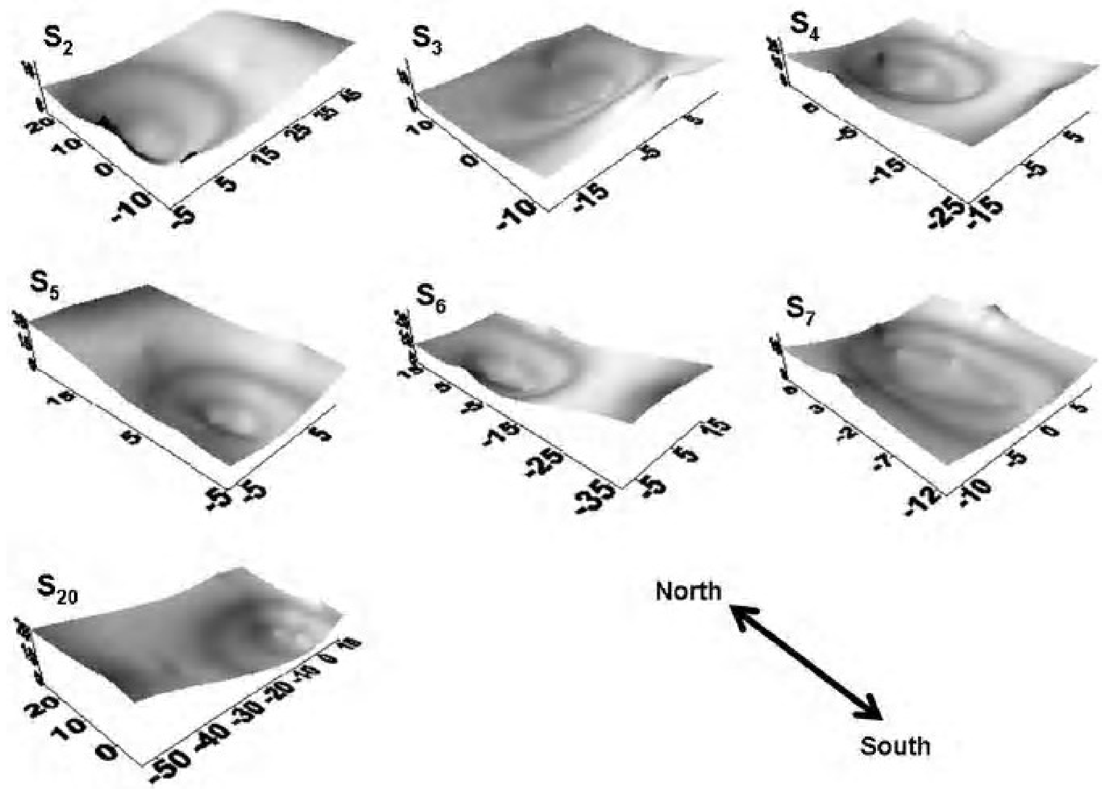

Fig. 2: Digital elevation view of A type sinkholes(s)

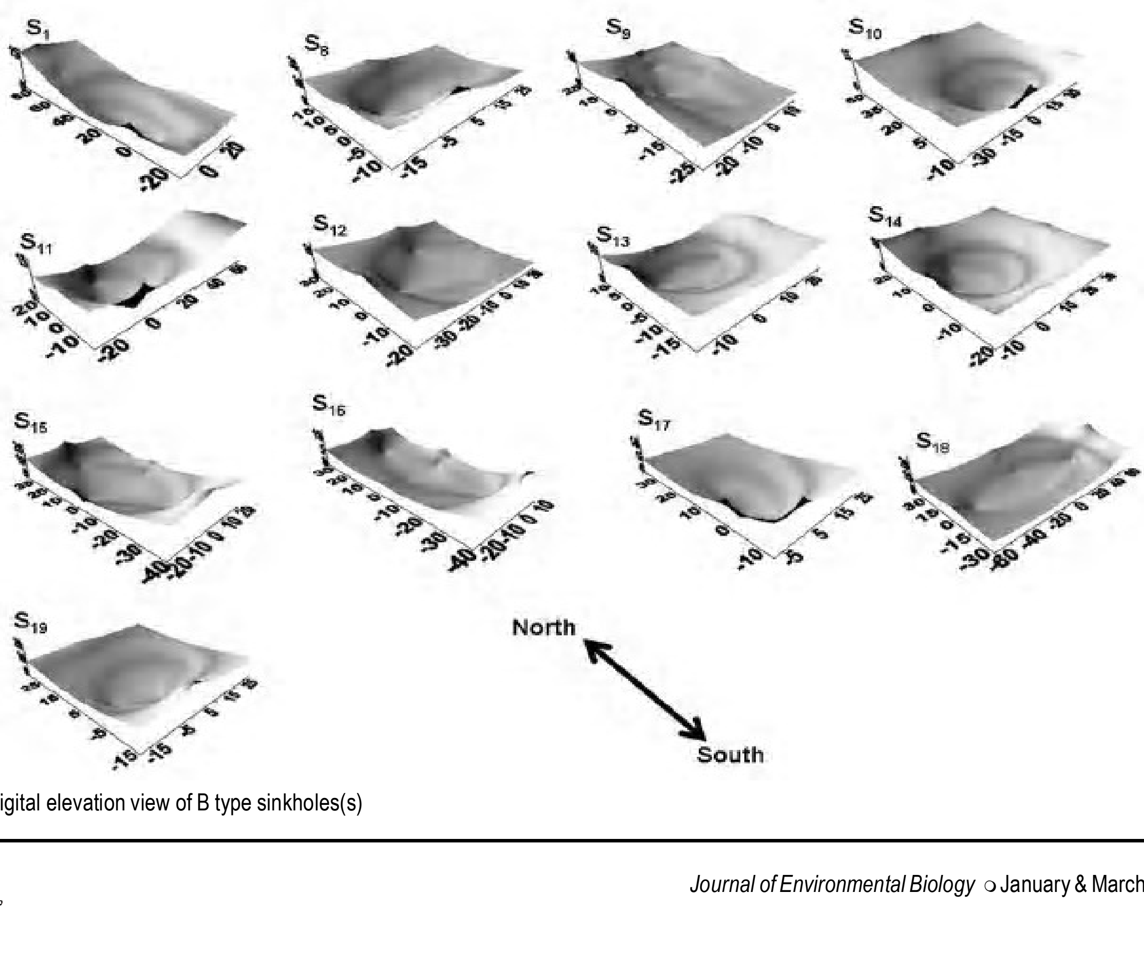

Fig. 3: Digital elevation view of B type sinkholes(s)

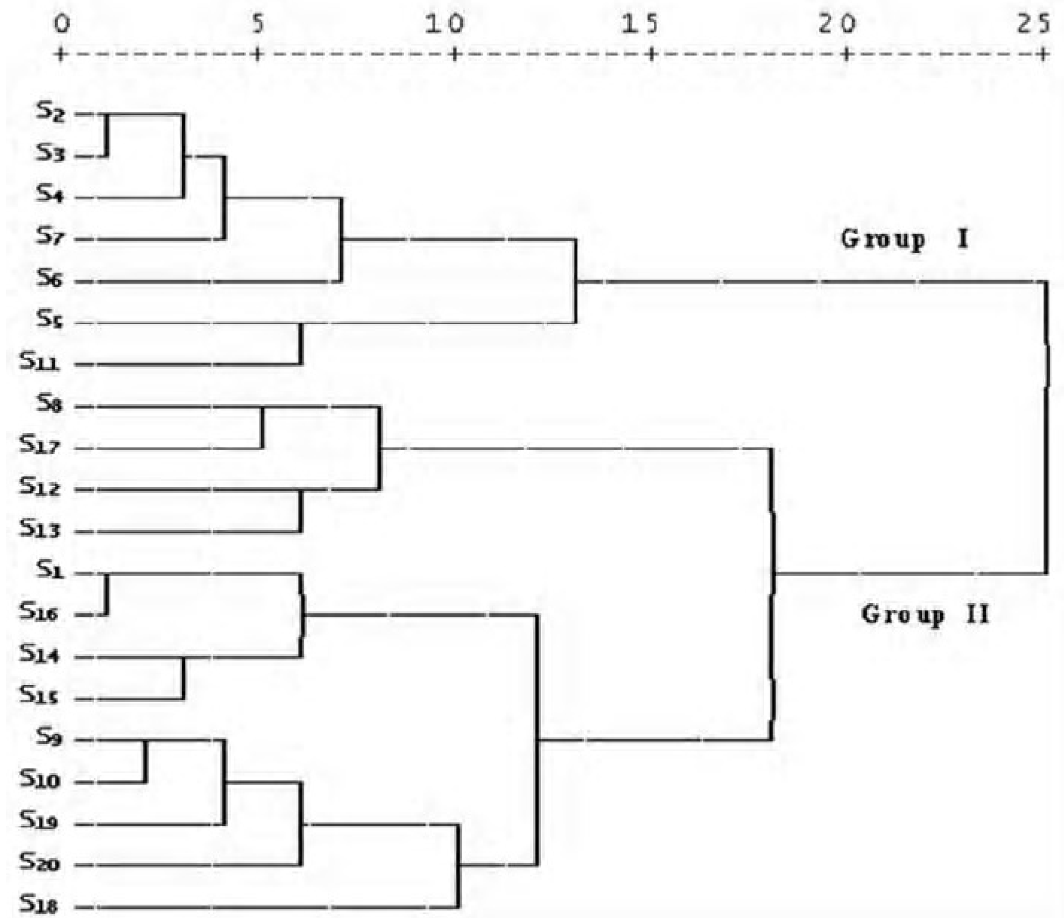

Fig. 4: Dendrogram of the sinkholes on the basis of plant distribution

Group of sinkholes in accordance with species' distribution: Two groups at maximum level were distinguished by cluster analysis applied in accordance with the distribution of plant species among the sinkholes. These are S_2-S_7, S_{11} in group I, and S_1, S_8-S_{10}, S_{12}-S_{20} in the group II (Fig. 4).

Suitability between cluster analysis groups and altitudinal zones: 2x2 tables were arranged to determine the successful ratio of the classification between the groups based on the plant distribution and the groups based on altitudinal zones (Table 6). According to accuracy assessment, the successful ratio of the classification was 75%. According to Kappa statistics, the successful ratio was 50%.

Suitability between cluster analysis groups and factor analysis groups: 2x2 tables were arranged to determine the successful ratio of the classification between the groups based on the plant distribution and the groups based on the distance values of the sinkholes (Table 7). According to the accuracy assessment, the successful ratio of the classification was 85%. According to Kappa statistics, the successful ratio of the classification was 66%.

Definition of groups to investigate species' distribution inside sinkholes: The results of the statistical analysis showed that altitudinal zones and sinkhole types play important role in terms of the plant distribution. In order to explain the relationships between the distribution of plant species and the landform features of the location inside the sinkholes the variability originating from altitude and sinkholes types has to be reduced. Besides, accuracy assessment and Kappa statistics showed that sinkhole type is more effective than the altitude in terms of distribution of plant species. Therefore, it was decided to constitute the groups in accordance with sinkhole types at first and then in accordance with altitudinal zones in each sinkhole type (Table 8).

In each group, except for A_1 group which had only one sinkhole, the plant distribution in accordance with landform features inside the sinkholes was investigated. A group was divided into A_1 and A_2 according to altitudinal zones. A_1 group including one sinkhole is located at 1400-1550 m. A_2 group (S_2-S_7) is located at 1550-1700 m (Table 8). The statistical analysis could not be applied to A_1 because of being one sinkhole in A_1 group as explained above.

Distribution of plant species in A_2 group: Eigenvalue of the first through fourth axes are 0.3776, 0.1065, 0.0454 and 0.0073.

The first two axes explain 70.52% and 19.77%, which comes to a total of 90.29% joint variation.

In A_2 group, the ordination distinguished a gradient from ridge to the intermediate slope unit (upper slope, middle slope and lower slope), and flat along the first axes (Fig. 5). Furthermore, lower slope and flat were differentiated from the rest on the second axes (Fig. 5). Species affiliated with ridge, upper slope and middle slope were *Pinus nigra, Cedrus libani,* while *Abies cilicica* occurred on middle slope, lower slope, flat, and *Rhus coriaria, Tilia platyphyllos* occurred on upper slope, middle slope, and lower slope. The species like *Ulmus glabra, Quercus trojana, Lonicera nummulariifolia, Acer platanoides, Sambucus ebulus, Quercus vulcanica, Helichrysum compactum, Polygonum* spp., *Dryopteris filix-mas* and *Euonymus latifolius* were present in the flat, (Axes 1 and Axes 2; Fig. 5).

Distribution of plant species in B_1 group: Eigenvalue of the first through fourth axes are 0.418, 0.072, 0.023, and 0.002. The first two axes explain 81.16% and 13.77%, the total being 94.93% of the joint variation.

The landform patterns identified among plant species were clearly related to the slope position unit including ridge, upper slope, middle slope, lower slope–flat, with *Pinus nigra, Acer monspessulanum, Cedrus libani, Verbascum* spp. occurring from lower slope to ridge, *Populus tremula, Crataegus orientalis, Rosa canina, Sambucus ebulus, Euonymus latifolius, Digitalis lanata, Origanum munitiflorum, Poygonum* spp., *Paeonia mascula, Artemisia absinthium, Achillea millefolium, Juncus acutus, Malus sylvestris, Onopordum illyricum* and *Rumex obtusifolius* occurring in the flat along the first axes. However, second axes could not be interpreted (Fig. 6).

Distribution of plant species in B_2 group: Eigenvalue of the first through fourth axes are 0.533, 0.124, 0.034, and 0.015. The first two axes explain 76.17% and 17.07%, total being 93.24% of the joint variation.

In B_2 group ordination, the gradient was similar to B_1 group, *i.e.* ridge, upper slope, middle slope and lower slope were opposite to the flat along the first axis (Fig. 7). Furthermore, lower slope and flat were differentiated from the rest on the second axes (Fig. 7). Species affiliated with ridge, upper slope and middle slope were *Pinus nigra, Cedrus libani, Rhus coriaria, Sideritis germanicopolitana*, while, *Sambucus ebulus, Helichrysume compactum, Euphorbia* spp., *Ulmus glabra, Acer monspessulanum* near lower slopes, and *Populus tremula, Phlomis nissoli, Crataegus orientalis, Digitalis lanata, Paeonia mascula, Achillea millefolium, Vicia villosa* ssp. *eriocarpa* close by flats (Axis 1 and Axis 2; Fig. 7).

Many papers have been published in Turkey on the relationships between the altitude and plant species distribution (Unaldi, 1999; Altun *et al.,* 2002; Ozkan, 2003). But none of these report the relationships between plant distribution and shape, size of sinkholes and slope position inside sinkholes. The only information

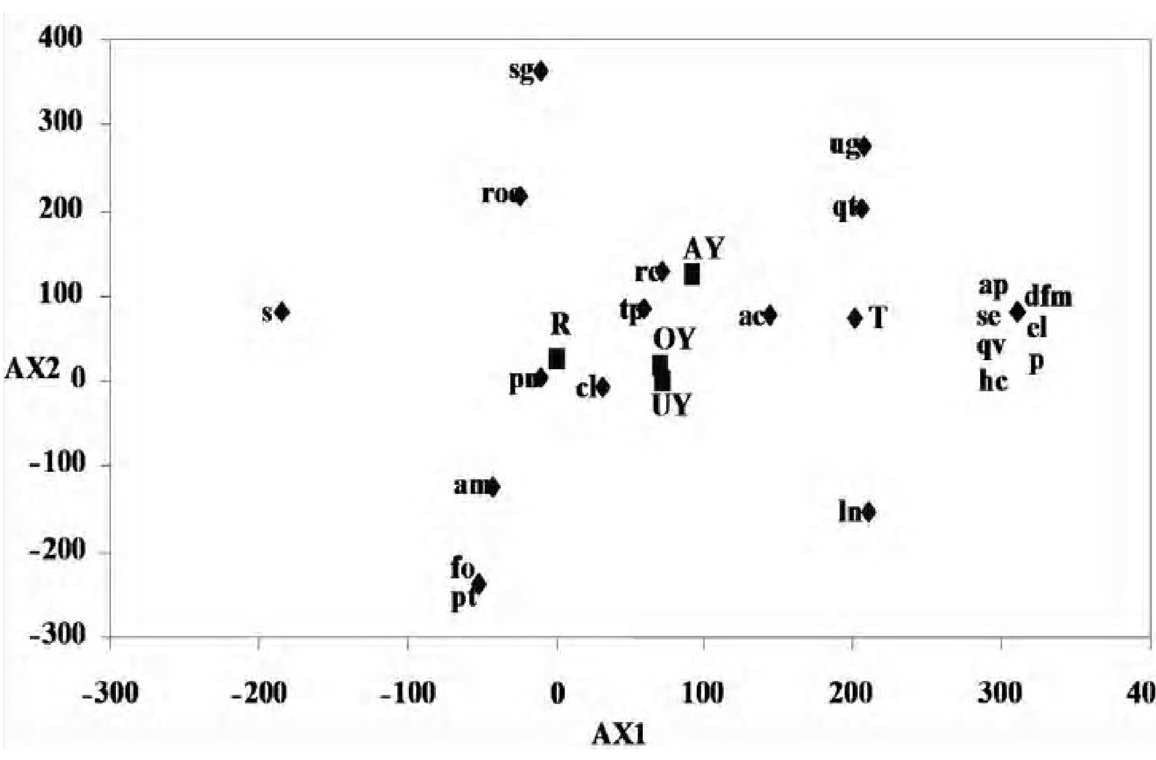

Fig. 5: DCA ordination for A_2 group (symbols explained in appendix table)

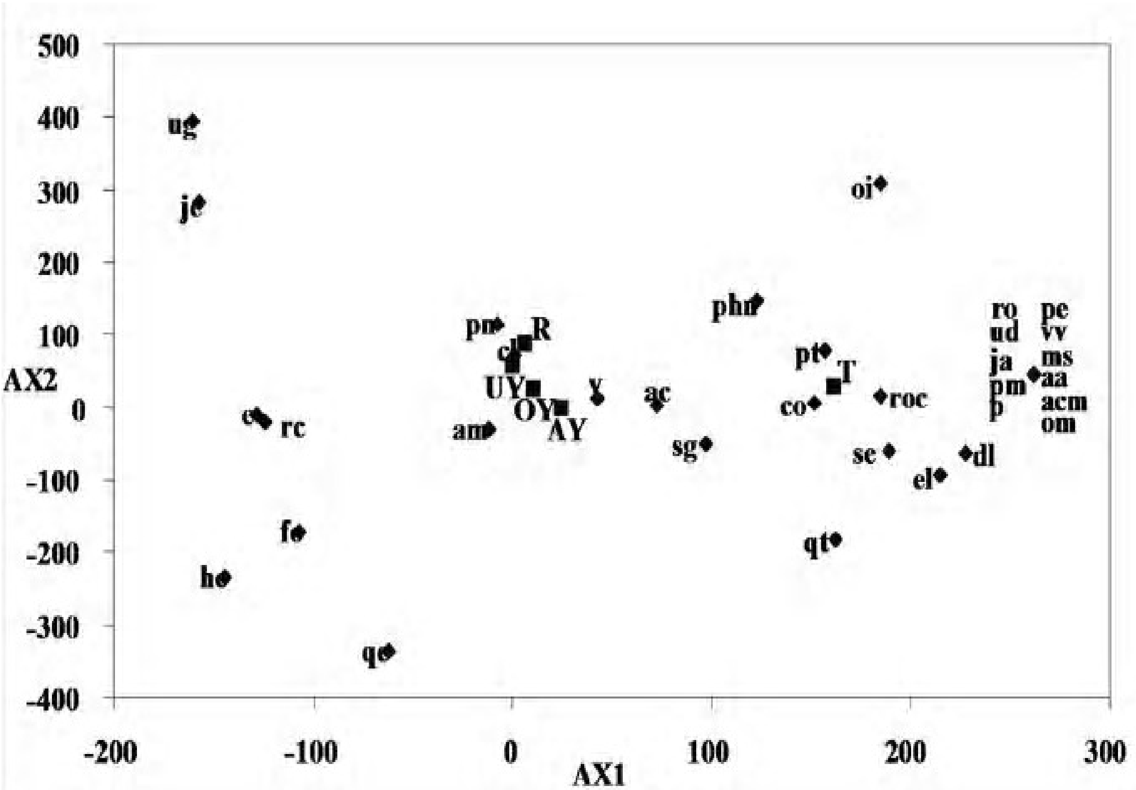

Fig. 6: DCA ordination for B_1 group (symbols explained in appendix table)

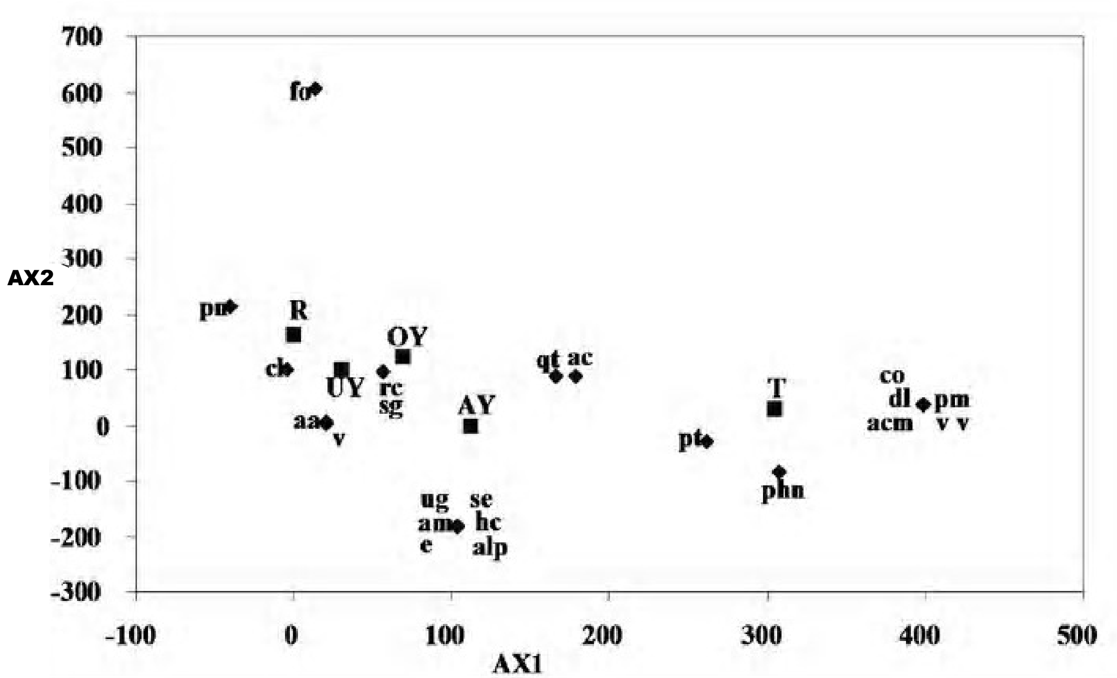

Fig. 7: DCA ordination for B_2 group (symbols explained in appendix table)

Appendix: Abbreviations and their full forms

Abbreviations	Full form
A	Altitude (m)
AY	Lower slope
CA	Component A
CB	Component B
GET	Actual evapotranspiration (mm)
M	Months
MAFLS	Maximum flat length of sinkholes (m)
MALS	Maximum length of sinkholes (m)
MAS	Maximum altitude of sinkholes (m)
MD	Meteorological data
MIAS	Minimum altitude of sinkholes (m)
MIFLS	Minimum flat length of sinkholes (m)
MILM	Minimum length of sinkholes (m)
MVSR	Monthly variation of soil moisture recharge (mm)
OY	Middle slope
P	Precipitation (mm)
PETa	Potential evapotranspiration after correction
PETb	Potential evapotranspiration before correction
R	Ridge
S	Sinkhole
T	Flat
TE	Temperature (^{o}C)
SM	Soil moisture recharge (mm)
TEI	Temperature efficiency index
UY	Upper slope
WD	Water deficiency (mm)
WS	Water surplus (mm)

in this connection is about some relict species belonging to Euro-Siberian communities and *Quercus vulcanica* Boiss. growing in the dolin areas of Davraz and Dedegul mountains because of more humidity than other sites located in the surrounding sinkhole sites (Atalay, 1994). The present study is the first detailed investigation carried out to determine relationships between the species distribution and sinkhole types and slope position inside sinkholes. Sinkhole types and altitudinal zones are effective on the plant distribution. However, in comparison with altitudinal zones, sinkholes types are more important in terms of the plant distribution. Therefore, at first, the sinkholes were subdivided into groups in accordance with sinkholes type and then the groups coming from sinkhole types were divided into subgroups in accordance with altitudinal zones which had been segregated by Ozkan (2003). Consequently, 4 groups were defined which include A type sinkholes [1400-1550 m (A_1), 1550-1700 m (A_2)] and B type sinkholes [1400-1550 (B_1), 1550-1700 m (B_2)]. The distribution of plants inside the sinkholes was investigated in accordance with the landform features.

In general, in A_2 group (1550-1700 m) which is more narrow vertically and deeper horizontally than B groups, *Abies cilicica, Acer platanoides, Sambucus ebulus, Quercus vulcanica, Ulmus glabra, Helichrysum compactum, Polygonum* spp.*, Dryopteris filix-mas* and *Euonymus latifolius* prefered the flat of the sinkholes due to their high moisture content. *Abies cilicica* was also located in lower slopes and middle slopes. *Rhus coriaria* and *Tilia platyphyllos* were associated with middle slope which are generally including middle depth soils, being more humid from the upper slope and the ridge but less humid from the lower slope and especially the flat. Although *Pinus nigra* and *Cedrus libani* occupied the area from middle slopes to ridges of the sinkholes, they showed better growth in the flat and the lower slope. The other species, especially *Abies cilicica* are lacking in this part of the sinkholes. In general, the differences in terms of plant distribution were observed among the ridge, intermediate slope unit including upper slope, middle slope and lower slope, and flat.

In B_1 group (1400-1500 m), *Populus tremula, Crataegus orientalis, Rosa canina, Sambucus ebulus, Euonymus latifolius, Digitalis lanata, Origanum munitiflorum, Polygonum* spp., *Paeonia mascula, Artemisia absinthium, Achillea millefolium, Juncus acutus, Malus sylvestris, Onopordum illyricum, Rumex obtusifolius* and *Abies cilicica* preferred the flats of the sinkholes. *Pinus nigra, Acer monspessulanum* and *Cedrus libani* occupied the area from ridges to lower slopes of the sinkholes. The differences in terms of species' distribution in B_1 group were apparent between the slope unit including ridge, upper slope, middle slope and lower slope, and flat.

In B_2 group (1500-1750 m), *Populus tremula, Phlomis nissoli, Crataegus orientalis, Digitalis lanata, Paeonia mascula, Achillea millefolium, Vicia villosa* ssp. *eriocarpa* preferred the flats, while *Sambucus ebulus, Helichrysum compactum, Euphorbia* spp.*, Ulmus glabra, Acer monspessulanum* were associated with lower slopes. In addition to *Pinus nigra, Cedrus libani, Rhus coriaria, Sideritis germanicopolitana* had widespread distribution from middle slopes to ridges. The differences in the plant distribution in B_2 group were among the slope unit from ridge to middle slope, lower slope and flat.

In conclusion, we observed that in comparison with A_2 type sinkholes, B type sinkholes have more homogeneous plant distribution. A similar situation is observed in the B_2 type sinkholes when compared to B_1 type sinkholes. A high plant variability along very short distances in the sinkholes site had been recorded together with many endemic species and these sites embody big potential distribution areas of many plants (Ozkan 2003).

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