Acta Bot. Croat. 77 (1), 18–27, 2018
DOI: 10.1515/botcro-2017-0016

CODEN: ABCRA 25
ISSN 0365-0588
eISSN 1847-8476

Diversity and gradients of vegetation of Sivrihisar Mountains (Eskişehir-Turkey)

Neslihan Balpinar[1]*, Ali Kavgaci[2], M. Ümit Bingöl[3], Osman Ketenoğlu[3]

[1] Mehmet Akif Ersoy University, Faculty of Arts and Science, Department of Biology, 15030, Burdur, Türkiye
[2] Southwest Anatolia Forest Research Institute, 07022 Antalya, Türkiye
[3] Ankara University, Faculty of Science, Department of Biology, 06100, Ankara, Türkiye

Abstract – This study was carried out to determine the plant communities and understand the main topographical driving factors of floristic differentiation in the Sivrihisar Mountains (Eskişehir Province). Vegetation samplings were carried out according to the Braun-Blanquet approach. The relevés were stored in the TURBOVEG database management program. Hierarchical classification was carried out in PC-ORD program with Ward's method and Euclidean distance as a resemblance measure. The diagnostic species were identified by a fidelity measure in the JUICE program. The results of the classification were visualized by ordination techniques in the CANOCO package by using principal component analysis. In conclusion, except for the degraded forest community, all the 7 steppe and 1 scrub plant communities studied were identified and described as new associations. Also, a syntaxonomical scheme for the vegetation of Sivrihisar Mountains was suggested.

Keywords: classification, numeric analysis, ordination, phytosociology, steppe vegetation

Introduction

Steppes, which face habitat loss, fragmentation and degradation, are among the most endangered biomes of the world. Treeless vegetation dominated by perennial xerophilous grass and herbs is typical of these types of formation (Török et al. 2016). The Central Anatolian Plateau has a distinctive plant cover on the account of its isolation, due in turn to the high surrounding mountains and special nature (Aksoy and Hamzaoğlu 2006). Steppe vegetation is the main vegetation type, as it is in East and parts of South Anatolia, as a result of precipitation insufficient for the growth of trees under arid and semi-arid variants of Mediterranean climate (Atalay and Efe 2010). Numerous genera such as *Acantholimon*, *Astragalus*, *Centaurea, Cousinia* or *Verbascum* have their evolutionary origin and main centre of diversity in this region (Kürschner and Parolly 2012). The Central Anatolian steppe is generally typically surrounded by steppic woods and forest formations (Hamzaoğlu and Duran 2004). Although the floristic richness in the Central Anatolian steppe vegetation is very high, showing high levels of endemism, it is threatened by overgrazing pressure, intensive farming, and other management practices (Aydoğdu et al. 2004, Kurt et al. 2006, Kaya et al. 2011). Even though this steppe, forming the Central Anatolian Province of Irano-Turanian Region, has long been studied by many botanists (Louis 1939, Krause 1940, Walter 1956, Birand 1961, 1970; Çetik 1985, Akman et al. 1985, Ketenoğlu et al. 1983, 2000; Hamzaoğlu and Duran 2004), much of its ecological diversity is understudied and more studies are needed.

This study was carried out in this context, to determine plant communities and their structural components, to define ecological and geographical gradients and to examine the floral diversity in the Sivrihisar Mountains in Turkey. We expect that this classification will guide future phytosociological studies and will serve as a base for various prospective studies.

Materials and methods

Study area

Sivrihisar Mountains is a mountain chain extending from the Sakarya arc in the southeast corner of Eskişehir Province, in the SE-NW direction towards Kaymaz district, located between 39° 28' 00" latitude and 31° 34' 60" longitude (Fig. 1). The study area is mainly covered by steppe vegeta-

* Corresponding author, e-mail: nerdogan@mehmetakif.edu.tr

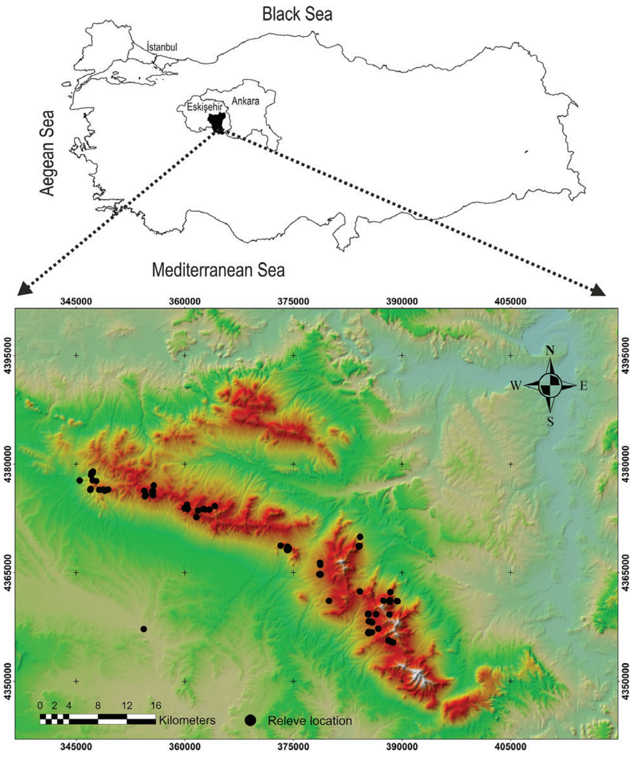

Fig. 1. The geographical position of the Sivrihisar Mountains in Turkey. Dots show the places of the relevés.

tion but also by degraded shrub and forest vegetation. The vegetation in the study area was intensely affected by overgrazing, agricultural activities and the expansion of stone and marble quarrying.

The altitude ranges from 1000 m a.s.l. to 1415 m a.s.l. The study area, within the Irano-Turanian phytogeographical region and placed in the B3 square according to the grid system of Davis (1965–1985), is represented by the "East-Mediterranean Precipitation Regime Type II" according to Emberger's classification (Akman 1990) (see On-line Suppl. Tab. 1). The area does not have any protection status. Largely the Paleozoic rocks are exposed in Sivrihisar Mountains in Eskişehir, while Mesozoic and Tertiary outcrops are also encountered.

Vegetation samplings and data analysis

The field work was carried out between 2003 and 2005. Homogenous sampling plots with an area of 50 m^2 were selected for steppe vegetation, the dominant vegetation type in the area, 100 m^2 for scrub vegetation and 150 m^2 for the degraded forest vegetation. The protocol for each plot included general, topographic and other data of individual plots, such as altitude, inclination, aspect, vegetation cover (total and of individual layers) and a list of all vascular plants, in which a cover value was assigned to each species according to the nine degree Braun-Blanquet scale (Braun-Blanquet 1964, Westhoff and Van Der Maarel 1973).

The samples (hereinafter relevés) were stored in the TURBOVEG database management program (Hennekens and Schaminée 2001). Hierarchical classification of the data set was carried out in the computer program PC-ORD (Mc Cune and Meffords 2006). The Euclidean distance was used as a resemblance measure for analysis and Ward's Method for dendrogram construction. Various levels of division were accepted in the dendrogram, resulting in nine clusters interpretable in terms of ecology. Additionally, the diagnostic species of the accepted clusters were identified by a fidelity measure in the JUICE program (Tichý 2002). The threshold of the phi value was subjectively selected at 0.50 for a species to be considered as diagnostic (Chytrý et al. 2002). Besides, the constant and dominant species of the clusters were defined in JUICE. Species that had a more than 50% occurrence frequency for a given community were defined as constant species, while species attaining a cover higher than 30% in more than 70% of the relevés were accepted as dominant species.

The results of the classification were visualized by ordination techniques in the CANOCO 4.5 package (Ter Braak and Šmilauer 2002). Principal component analysis (PCA), which is an indirect ordination method assuming a unimodal response of species to the environment, was run due to the high heterogeneity in the matrix of species (Lepš and Šmilauer 2003). Topographical variables were passively projected on the ordination plane. We also calculated the spectra of geo-elements according to Davis (1965–1985) and Davis et al. (1988) and life forms in accordance with Raunkiaer (1934) and they were also passively projected on the ordination diagram. Correlations between PCA releve scores and topographical variables, geoelement and growth form were calculated by using the non-parametric Kendall coefficient in STATISTICA (Anonymous 2007). The nomenclature of plant species follows Flora of Turkey (Davis 1965–1985, Davis et al. 1988) and new syntaxa were described in accordance with the International Code of Phytosociological Nomenclature (Weber et al. 2000). Syntaxonomical interpretations of taxa for the forest vegetation were made according to Quézel (1973), Akman et al. (1978a, b, 1979), and Quézel et al. (1978, 1980). Classification of the taxa belonging to the steppe communities was made according to the studies carried out by Akman et al. (1984, 1985), Ketenoğlu et al. (1983), and Quézel et al. (1992).

Results

Classification

The classification analysis resulted in nine main clusters representing clear floristic and ecological differences of vegetation in the Sivrihisar Mountains (Fig. 2). While seven of these clusters represent steppe vegetation, the other two clusters represent the scrub and forest vegetation in the study area. Diagnostic, constant and dominant species of these clusters are as follows:

Cluster 1: *Artemisia scoparia*-dominated steppe

Diagnostic species: *Agrostemma gracilis*, *Artemisia scoparia*, *Astrodaucus orientalis*, *Bupleurum gerardii*, *Campanula argaea*, *Coronilla varia* ssp. *varia*, *Hordeum bulbosum*,

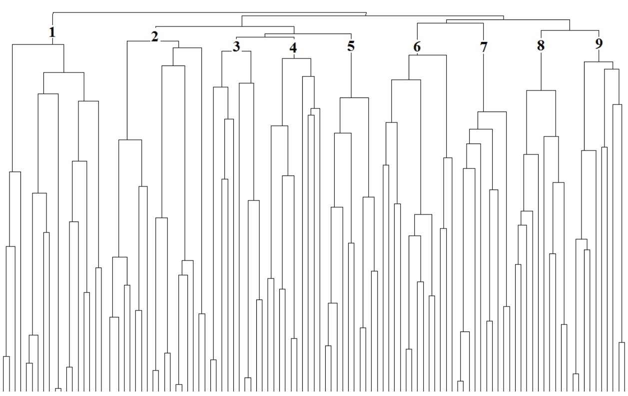

Fig. 2. Hierarchical classification diagram of relevés from Sivrihisar Mountains: 1. *Artemisia scoparia*-dominated steppe, 2. *Thymus leucostomus* var. *argillaceus*-dominated steppe, 3. *Astragalus microcephalus*-dominated steppe, 4. *Astragalus angustifolius* ssp. *angustifolius* var. *angustifolius*-dominated steppe, 5. *Artemisia santonicum*-dominated steppe, 6. *Astragalus condensatus*-dominated steppe, 7. *Astragalus plumosus*-dominated steppe, 8. *Cistus laurifolius*-dominated scrubland, 9. *Quercus pubescens*-dominated forest.

Melica ciliata ssp. *ciliata*, *Parietaria judaica*, *Pimpinella tragium* ssp. *polyclada*, *Rubus sanctus*, *Silene squamigera* ssp. *squamigera*, *Thymus sipyleus* ssp. *sipyleus* var. *sipyleus*, *Trifolium arvense* var. *arvense*. Constant species: *Astragalus angustifolius* ssp. *angustifolius* var. *angustifolius*, *Convolvulus holosericeus* ssp. *holosericeus*, *Galium verum* ssp. *verum*, *Koeleria cristata*, *Poa bulbosa*. Dominant species: *Artemisia scoparia*

Cluster 2: *Thymus leucostomus* var. *argillaceus*-dominated steppe

Diagnostic species: *Alyssum strigosum* ssp. *strigosum*, *Bromus japonicus* ssp. *japonicus*, *B. squarrosus*, *Ebenus hirsuta*, *Hypericum aviculariifolium* ssp. *depilatum* var. *bourgaei*, *Ornithogalum oligophyllum*, *Scandix iberica*, *Silene dichotoma* ssp. *dichotoma*, *Thymus leucostomus* var. *argillaceus*. Constant species: *Androsace maxima*, *Anthemis cretica* ssp. *anatolica*, *Astragalus vulnerariae*, *Eryngium campestre* var. *virens*. Dominant species: *Thymus leucostomus* var. *argillaceus.*

Cluster 3: *Astragalus microcephalus*-dominated steppe

Diagnostic species: *Astragalus microcephalus*, *Chrysopogon gryllus* ssp. *gryllus*, *Cichorium intybus*, *Cirsium arvense* ssp. *vestitum*, *Daucus broteri*, *Echium angustifolium*, *Elymus hispidus* ssp. *hispidus*, *Helianthemum nummularium* ssp. *ovatum*, *Inula montbretiana*, *Lolium perenne*, *Teucrium orientale* var. *orientale*, *Thymelaea passerina*, *Thymus longicaulis* ssp. *longicaulis* var. *subisophyllus*. Constant species: *Acantholimon acerosum* var. *acerosum*, *Astragalus condensatus*, *Centaurea virgata*, *Dianthus zonatus* var. *zonatus*, *Eryngium campestre* var. *virens*, *Euphorbia anacampseros* var. *anacampseros*, *Festuca valesiaca*, *Filago pyramidata*, *Marrubium parviflorum* ssp. *oligodon*, *Scabiosa argentea*, *Teucrium polium*, *Xeranthemum annuum*. Dominant species: *Astragalus microcephalus*

Cluster 4: *Astragalus angustifolius* ssp. *angustifolius* var. *angustifolius*-dominated steppe

Diagnostic species: *Alkanna orientalis* var. *orientalis*, *Alyssum murale* var. *murale*, *Anthemis tinctoria* var. *pallida*, *Arabis nova*, *Astragalus angustifolius* ssp. *angustifolius* var. *angustifolius*, *Ceratocephalus falcatus*, *Erodium hoefftianum*, *Erophila verna* ssp. *verna*, *Geranium lucidum, Hypecoum procumbens, Lamium amplexicaule, Lamium garganicum* ssp. *reniforme*, *Lathyrus cicera*, *Medicago minima* var. *minima*, *M. sativa* ssp. *sativa*, *Moenchia mantica* ssp. *caerulea*, *Ranunculus isthmicus* ssp. *stepporum*, *R. reuterianus*, *Rumex acetosella*, *Valerianella costata, V. pumila, Veronica triphyllos, Vicia lathyroides, Viola parvula*, *Crataegus monogyna* ssp. *azarelle*, Constant species: *Anthemis tinctoria* var. *tinctoria*, *Artemisia santonicum.* Dominant species: *Astragalus angustifolius* ssp. *angustifolius* var. *angustifolius*

Cluster 5: *Artemisia santonicum*-dominated steppe

Diagnostic species: *Allium flavum* ssp. *tauricum* var. *tauricum*, *Allium sieheanum*, *Alyssum sibiricum*, *Artemisia santonicum*, *Asperula stricta* ssp. *latibracteata*, *Bothriochloa ischaemum*, *Consolida thirkeana*, *Erysimum crassipes*, *Phlomis pungens* var. *laxiflora*, *Sideritis lanata*, *S. montana* ssp. *montana*, *Verbascum uschakense*, *Centaurea solstitialis* ssp. *solstitialis*. Constant species: *Achillea coarctata*, *Astragalus lydius*, *Bromus tomentellus*, *Centaurea virgata*, *Cruciata taurica*, *Eryngium campestre* var. *virens*, *Festuca valesiaca*, *Marrubium parviflorum* ssp. *oligodon*, *Minuartia anatolica* var. *arachnoidea*, *Onobrychis armena*, *Paronychia kurdica* ssp. *kurdica* var. *kurdica*, *Scabiosa argentea*, *Stachys lavandulifolia* var. *lavandulifolia*, *Stipa holosericea*. Dominant species: *Artemisia santonicum*, *Sideritis montana* ssp. *montana*

Cluster 6: *Astragalus condensatus*-dominated steppe

Diagnostic species: *Astragalus condensatus*, *Fumana arabica* var. *arabica*, *Globularia orientalis*, *Linum nodiflorum*, *Medicago rigidula* var. *rigidula*, *Muscari neglectum*, *Phleum subulatum* ssp. *subulatum*, *Polygala anatolica*, *Scorzonera eriophora*, *Silene lydia*, *Stachys cretica* ssp. *anatolica*, *Thymus argaeus*, *Valerianella coronata*, *Veronica pectinata* var. *Glandulosa*, *Paronychia condenseta*, *Poa timoleontis*, *Silene macrodanta*. Constant species: *Hypericum origanifolium*, *Ornithogalum alpigenum*, *Phlomis armeniaca*, *Scutellaria orientalis* ssp. *pectinata*. Dominant species: *Astragalus condensatus*

Cluster 7: *Astragalus plumosus*-dominated steppe

Diagnostic species: *Adonis aestivalis* ssp. *aestivalis*, *Alyssum thymops*, *Anchusa undulata* ssp. *hybrida*, *Astragalus plumosus* var. *plumosus*, *Bromus cappadocicus* ssp. *cappadocicus*, *Bungea trifida*, *Centaurea triumfettii*, *Erodium cicutarium* ssp. *cicutarium*, *Hedysarum varium*, *Moltkia coerulea*, *Salvia cryptantha*, *Scandix australis* ssp. *grandiflora*, *Scorzo-*

nera suberosa ssp. *suberosa*, *Sisymbrium altissimum*, *Tragopogon coloratus*. Constant species: *Adonis flammea*, *Astragalus lydius*, *Eryngium campestre* var. *virens*, *Hypericum origanifolium*, *Scutellaria orientalis* ssp. *pectinata*, *Teucrium polium*. Dominant species: *Astragalus plumosus* var. *plumosus*, *Salvia cryptantha*

Cluster 8: *Cistus laurifolius*-dominated scrubland

Diagnostic species: *Alyssum murale* var. *murale*, *Berberis crataegina*, *Campanula lyrata* ssp. *lyrata*, *Cistus laurifolius*, *Colutea cilicica*, *Cotoneaster nummularia*, *Daphne oleoides* ssp. *oleoides*, *Fritillaria armena*, *Globularia trichosantha* ssp. *trichosantha*, *Helichrysum plicatum* ssp. *plicatum*, *Hypericum linarioides*, *H. scabrum*, *Juniperus oxycedrus* ssp. *oxycedrus*, *Lathyrus digitatus*, *Minuartia juniperina*, *Plantago lanceolata*, *Prunella laciniata*, *Prunus spinosa* ssp. *dasyphylla*, *Pyracantha coccinea*, *Pyrus elaeagnifolia* ssp. *elaeagnifolia*, *Ranunculus illyricus* ssp. *illyricus*, *Rosa canina*, *Sanguisorba minor* ssp. *muricata*, *Silene italica*, *Sorbus umbellata* var. *umbellata*, *Trifolium physodes* var. *physodes*, *Trigonella spruneriana* var. *spruneriana*, *Ziziphora taurica* ssp. *taurica*. Constant species: *Koeleria cristata*. Dominant species: *Cistus laurifolius*

Cluster 9: *Quercus pubescens*-dominated forest

Diagnostic species: *Aegilops umbellulata* ssp. *umbellulata*, *Alkanna pseudotinctoria*, *Alyssum minus* var. *micranthum*, *Briza humilis*, *Bupleurum odontites*, *Centaurea pichleri* ssp. *pichleri*, *Ceratocephalus testiculatus*, *Conringia perfoliata*, *Ephedra major*, *Erysimum sintenisianum*, *Geranium tuberosum* ssp. *tuberosum*, *Holosteum umbellatum* var. *umbellatum*, *Jasminum fruticans*, *Juniperus excelsa*, *J. oxycedrus* ssp. *oxycedrus*, *Lamium garganicum* ssp. *reniforme*, *Linum cariense*, *Matthiola longipetala* ssp. *bicornis*, *Poa timoleontis*, *Quercus pubescens*, *Ranunculus gracilis*, *Rhamnus rhodopeus* ssp. *anatolicus*, *Rhamnus thymifolius*, *Salvia cadmica*, *S. syriaca*, *Trifolium pannonicum* ssp. *elongatum*, *Veronica grisebachii*, *Vinca herbacea*, *Viola kitaibeliana*. Constant species: *Astragalus lydius*, *Cruciata taurica*, *Eryngium campestre* var. *virens*, *Hypericum origanifolium*, *Ornithogalum alpigenum*, *Sedum acre*, *Teucrium polium*. Dominant species: *Quercus pubescens*

Ordination

The PCA ordination of relevés for the nine clusters (Fig. 3) shows that there is a clear gradient along the both axes of the ordination. These gradients show the ecological differences among the communities in the study area. The gradient of the ordination mainly results from the differentiation of *Juniperus oxycedrus-Cistus laurifolius* and *Quercus pubescens* forest. These clusters are characterized by the high appearance of phanerophytic species (Fig. 3) which has a strong positive correlation with both of the ordination axes and the altitude (Tab. 1). These two clusters are also formed on the highest elevation zones of the study area (Fig. 3 and Tab. 1).

All topographical variables used in the study have strong effects on the floristic differentiation of the vegetation. However, altitude has the highest effect (Tab. 2). Due to the strong differentiation of *J. oxycedrus-C. laurifolius* and *Q. pubescens* forest, representing the higher vegetation types (scrub and forest) in the study area, these two communities were excluded from further ordination analysis to show clearly the differentiation between the others. For the lower vegetation types

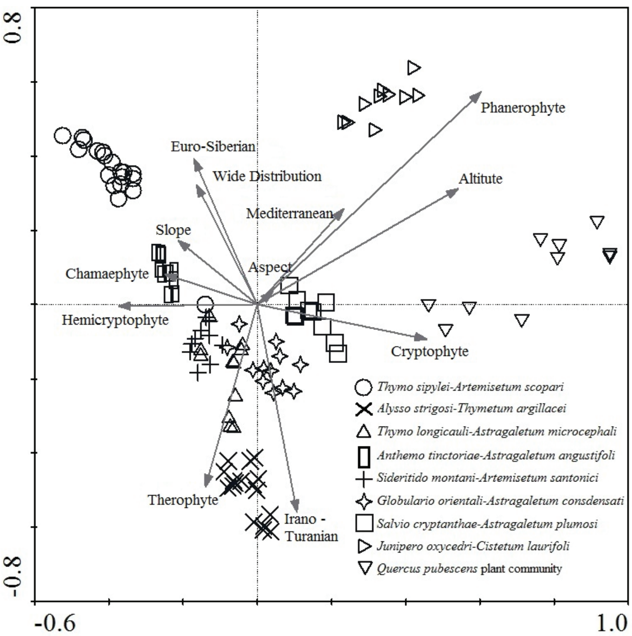

Fig. 3. Indirect ordination of the vegetation relevés from the Sivrihisar Mountains carried out by principal component analysis.

Tab. 1. Kendal correlation coefficients (weighted correlation) between first two principal component analysis axes and topographical variables, geo-element and life form properties for the nine plant communities in the Sivrihisar Mountains. Legend: *** means p<0.001, ** means p<0.01, * means p<0.05.

	Altitude	Aspect	Inclination	Irano-Turanian	Mediterranean	Euro-Siberian	Wide distribution	Therophyte	Cryptophyte	Hemicryptophyte	Chamaphyte	Phanerophyte
Axis 1	0.321***	0.110	–0.162*	0.154*	0.112	–0.174**	–0.133*	–0.059	0.249***	–0.255***	–0.160*	0.254***
Axis 2	0.199**	0.002	0.131*	–0.407***	0.176*	0.269***	0.245***	–0.311***	–0.026	–0.018	0.000	0.423***

Tab. 2. Conditional effects of topographical variables on species composition for nine plant communities in the Sivrihisar Mountains, carried out by canonical correspondence analysis. The table is with the additional variances that each variable explains (Lambda A) and the significance of the variables (P-value) together with their test statistics (F-value).

Variable	Var. N	LambdaA	P	F
Altitude	1	0.43	0.002	4.62
Slope	3	0.32	0.002	3.41
Aspect	2	0.31	0.002	3.42

Tab. 3. Conditional effects of topographical variables on species composition for seven steppe communities carried out by canonical correspondence analysis. The table is with the additional variances that each variable explains (Lambda A) and the significance of the variables (P-value) together with their test statistics (F-value).

Variable	Var. N	LambdaA	P	F
Altitude	1	0.21	0.002	2.42
Slope	3	0.33	0.002	3.62
Aspect	2	0.34	0.002	3.73

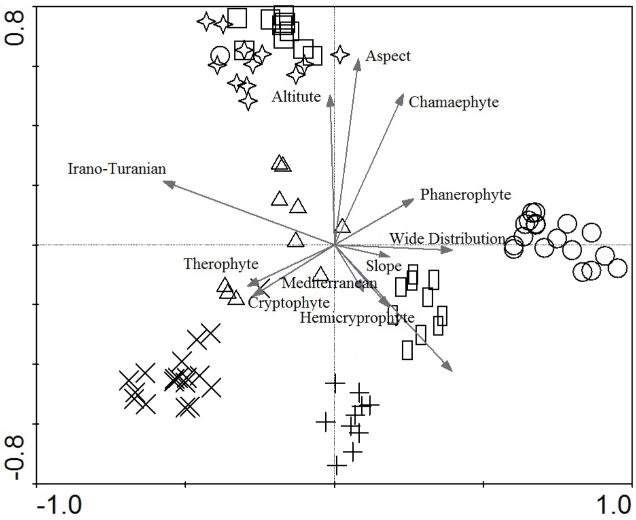

Fig. 4. Indirect ordination of the relevés from steppe vegetation in the Sivrihisar Mountains. See Fig. 3 for the explanations of the symbols.

(steppe communities), ordination also shows clear gradients along two axes (Fig. 4) and there are significant topographical differences between steppe communities (Tabs. 3, 4).

Discussion

Ecological differences

The effects of topographical variables on species richness and diversity, like the other ecological components affecting the biological mechanisms, were clearly shown (Burke et al. 1989, Sebastiá 2004). In our case, it was also seen that topographical variables (altitude, aspect, inclination) have explicit driving effects on community differentiation of steppe vegetation. These kinds of effects of topography were also shown for different vegetation types in Turkey before like forests, scrublands and grasslands (Fontaine et al. 2007, Kavgacı et al. 2010a, b; Özkan 2009, Özkan et al. 2009, 2010). The clear gradients of these topographical factors also correspond to the geo-elemental structure. The communities at higher altitudes have a higher proportion of Euro-Siberian plant species in comparison with the other communities. The communities at lower altitudes are clearly represented by Irano-Turanian plants. As is known, higher elevations are associated with higher precipitation (Basist and Bell 1994) and the phytogeographical differences in the study area can be a result of these local climatic differences.

Plant communities show clear growth form differences at local, regional and global scales by depending on the changing environmental and ecological conditions (Rowe and Speck 2005). In this context, clear growth form differences among the communities in the study area were also observed. The communities at lower altitudes and with northern aspects are mostly represented by the Therophytes and Cryptophytes. The high proportion of Therophytes may indicate the dry site conditions at these areas. Chamaephytes are more common and characteristic for higher zones and southern slopes, which is probably the result of the human pressure at these sites.

Syntaxonomy

There are nine different plant communities in the study area. Two of them are *Cistus laurifolius*-dominated scrub

Tab. 4. Kendal correlation coefficients (weighted correlation) between first two two principal component analysis axes and topographical variables, geo-element and life form properties for the seven steppe communities in the Sivrihisar Mountains. Legend: *** means p<0.001, ** means p<0.01, * means p<0.05.

	Altitude	Aspect	Inclination	Irano-Turanian	Mediterranean	Euro-Siberian	Wide distribution	Therophyte	Cryptophyte	Hemicryptophyte	Chamaphyte	Phanerophyte
Axis 1	−0.016	0.019	0.161*	−0.339***	0.104	0.300***	0.198**	−0.224**	−0.164*	0.119	0.162*	0.225**
Axis 2	0.375***	0.394***	0.036	0.081	−0.129	−0.301***	0.027	−0.100	−0.144*	−0.096	0.359***	0.160*

and *Quercus pubescens*-dominated degraded forest while the rest are lower steppe communities. From the phytosociological point of view, the central part of the Anatolian steppe has lowland steppe characteristics and is included in the order *Onobrychido armenae-Thymetalia leucostomi* of the *Astragalo-Brometea* class (Akman et al. 1985). All of the steppe communities which were identified in the research area were classified under the alliance *Phlomido armeniacae-Astragalion microcephali* since this alliance represents the communities on radiolarite, flysch, marly and serpentine rocks at altitudes ranging from 750 m to 1350 m a.s.l. (Akman et al. 1984).

Artemisia scoparia-dominated community occurs at approximately the middle elevation zone of the study area. It is mostly seen on inclined slopes. The phanerophytic species, *Rubus sanctus* and *Amygdalus orientalis* join to the floristic composition of this community locally. The dominance of Euro-Siberian plants is very clear in this community and it is also characterized by the more frequent appearance of widely distributed plants. The diagnostic species of the community are clearly differentiated from the previously described *A. scoparia*-dominated communities from central Anatolia (Akman et al. 1991, Kurt 2002). Due to this fact, it is classified as *Thymo sipylei-Artemisetum scopari* ass. nova hoc loco. The nomenclatural type is relevé number 16 in On-line Suppl. Tab. 2 (holotypus hoc loco: On-line Suppl. Tab. 2/16).

The *Thymus leucostomus* var. *argillaceus*-dominated community is distributed on the lower elevation belts with northern aspects. It is represented by the highest occurrences of therophytic and cryptophytic species. The high occurrence of therophytes, generally indicating a typically desert spectrum vegetation, may be a result of over-grazing in this community (Jankju et al. 2011). None of the geo-elements shows clear dominance in this community. The previously described *T. leucostomus* var. *argillaceus*-dominated communities in Central Anatolia are found on gypsum bedrock (Akman 1990, Kurt et al. 1999) and classified under the alliance *Astragalo karamasici-Gypsophylion eriocalycis* which is clearly different from our case. Due to this fact, the *Thymus leucostomus* var. *argillaceus*-dominated community is classified as *Alysso strigosi-Thymetum argillacei* ass. nova hoc loco. The nomenclatural type is relevé number 65 in On-line Suppl. Tab. 2 (holotypus hoc loco: On-line Suppl. Tab. 2/65).

The *Astragalus microcephalus*-dominated community is placed on the lower vegetation belts with northern aspects. The site of this community is highly inclined. The community can be characterized by the relatively high proportion of chamaephytes and low proportion of therophytes. Due to the wide distribution of *A. microcephalus,* many *A. microcephalus* communities are described in Anatolia (Çetik 1963, Akman 1974, 1976; Akman and Ketenoğlu 1976, Düzenli 1976, Akman et al. 1983, Kılınç 1985, Akman 1990, Akman et al. 1991, Ocakverdi and Ünal 1991, Ocakverdi and Oflas 1999, Aydoğdu et al. 1994, Tatli et al. 1994, Hamzaoğlu 1999, Kurt et al. 1999, Kurt 2000, 2002). However, our community shows clear differences from these communities because of the different diagnostic species, and it is classified as *Thymo longicauli-Astragaletum microcephali* ass. nova hoc loco. The nomenclatural type is relevé number 129 in On-line Suppl. Tab. 2 (holotypus hoc loco: On-line Suppl. Tab. 2/129).

The *Astragalus angustifolius* ssp. *angustifolius* var. *angustifolius*-dominated community is placed on a very narrow vegetation belt at the lower elevation zone. The site of this community is formed on gentle slopes. The number of Irano-Turanian plants and chamaephytes is the highest in this community. There are several *A. angustifolius* dominated communities described from the different parts of Anatolia which were classified under different alliances (Schwarz 1936, Quézel 1973, Akman 1974, 1976; Akman and Ketenoğlu 1976, Düzenli 1976, Kılınç 1985, Akman 1990, Akman et al. 1991, Ocakverdi and Ünal 1991, Hamzaoğlu 2000, Şanda et al. 2000). But in our case, there is a clear floristic difference and the *A. angustifolius* ssp. *angustifolius* var. *angustifolius*-dominated community is classified as *Anthemo tinctoriae-Astragaletum angustifoli* ass. nova hoc loco. The nomenclatural type is relevé number 11 in On-line Suppl. Tab. 2 (holotypus hoc loco: On-line Suppl. Tab. 2/11).

The lowest distribution zone of the study area is formed by the *Artemisia santonicum*-dominated community. These sites have mostly northern oriented slopes with relatively high inclinations. This community can also be characterized by the relatively higher appearance of Euro-Siberian plants than the other communities. The number of Hemicryptophytes, Cryptophytes and Therophytes is also high in this community. *A. santonicum*-dominated communities are described by Ocakverdi and Ünal (1991), Aydoğdu et al. (2001), Aydoğdu et al. (1994), Kurt (2002) and grouped under different alliances. The *A. santonicum*-dominated community in Sivrihisar Mountains represents a different floristic composition from the previous studies, and it is classified as *Sideritido montani-Artemisetum santonici* ass. nova hoc loco. The nomenclatural type is relevé number 26 in On-line Suppl. Tab. 2 (holotypus hoc loco: On-line Suppl. Tab. 2/26).

The majority of the study area, covered by lower communities, is formed by an *Astragalus condensatus*-dominated community and an *Astragalus plumosus var. plumosus*-dominated community. These communities, showing similar environmental characteristics, are distributed mostly on southern slopes. They are dominated by Chamaephytes differently from the other communities and characterized by the highest appearances of Irano-Turanian plants, which indicate a higher steppic character (Kurt et al. 2006) in comparison with the other steppe communities. Akman et al. (1984) describes an *Astragalus condensatus*-dominated community under the alliance *Salvio tchihatcheffii-Hedysarion varii*. But the *A. condensatus*-dominated community in the Sivrihisar Mountains represents a very different floristic composition from this community, and it is classified as *Globulario lumose-Astragaletum condensati* ass. nova hoc loco. The nomenclatural type is relevé number 58 in On-line Suppl. Tab. 2 (holotypus hoc loco: On-line Suppl. Tab. 2/58). The communities dominated by the spiny taxon *Astragalus plumosus* var. *plumosus* are described by Akman (1976), Akman and Ketenoğlu (1976), Akman (1990) and Yurdakulol et al. (1990). However, the community at Sivrihisar Mountains is formed by different floristic composition than those communities and is classified as *Salvio cryptanthae-Astragaletum plumosi* ass. nova hoc loco. The nomenclatural type is relevé number 90 in On-line Suppl. Tab. 2 (holotypus hoc loco: On-line Suppl. Tab. 2/90).

The dominant components of the peripheral vegetation around Central Anatolia have been included in the class *Quercetea pubescentis* (Akman et al. 1984). *Cistus laurifolius* is an important element of this vegetation type and appears intensively especially in the transitional zone between inner Anatolia and the Mediterranean, Aegean and Marmara Regions. It mostly occurs as the remnants of *Pinus nigra* forests as a result of a regressive succession process. In the initial phase of the succession, it is often found as mixed communities with oak species. The *C. laurifolius*-dominated shrub community in the study area is named *Junipero oxycedri Cistetum laurifoli* ass. nova hoc loco. The nomenclatural type is relevé number 21 in On-line Suppl. Tab. 2 (holotypus hoc loco: On-line Suppl. Tab. 2 /21). It is grouped under *Quercion anatolicae* alliance belonging to *Querco-Carpinetalia orientalis* order due to lack of congruence with *Pino-Cistion laurifolii* alliance characteristics which is accepted as the alliance of *C. laurifolius* dominated communities in the other parts of Anatolia (Akman and Ketenoğlu 1976, Çetik and Vural 1979, Hamzaoğlu and Duran 2004). The high frequency of characteristic species of *Astragalo-Brometea* and *Onobrychido-Thymetalia* in this community may indicate a conversion through steppe vegetation. The steppe vegetation of Central Anatolia has resulted from the reduction or extinction of former primary forest vegetation, which has disappeared due to biotic factors (Kılınç 1979, Kurt et al. 2006). The higher scrub and wood communities in Central Anatolia represent their degraded forms (Kurt et al. 2006), and these communities are under high anthropogenic pressure today. *Quercus pubescens* dominated forests in the study area are one of the remnants of those forests. Although forest species such as *Trifolium pannonicum* ssp. *elongatum*, *Vicia cracca* ssp. *stenophylla*, *Coronilla varia* ssp. *varia*, *Pyrus elaeagnifolia*, *Juniperus oxycedrus* ssp. o*xycedrus* are found as accompanying plants in the degraded *Q. pubescens* forests in the area, the high coverage by steppic species may indicate that the formation is a transitional phase. Although several *Q. pubescens* forest communities are described from Anatolia (Akman and Ketenoğlu 1976, Ketenoğlu and Akman 1982, Akman et al. 1983, Akman and Aydoğdu 1986), the *Q. pubescens* forest community in theSivrihisar Mountains is not identified at association level due to its highly degraded structure.

In conclusion, in addition to the *Q. pubescens* forest community, 7 steppe and 1 scrub associations are identified and described as new associations in this study. The degraded structure of forest and scrub vegetation indicates the severe anthropogenic effects in the region. However, the presence of various plant associations in such a small area reflects the high floristic and ecological diversity. This emphasizes the importance of the region in terms of nature conservation. So, the richness and diversity of the region should be taken into consideration during the preparation of a management plan for the region, especially from the restoration point of view.

In accordance with these assessments, the syntaxonomical scheme of communities and nomenclature type relevés of the newly described syntaxa can be suggested as follows:

Class: Astragalo microcephali-Brometea tomentelli Quézel 1973

Order: Onobrychido armenae-Thymetalia leucostomi Akman, Ketenoğlu, Quézel 1985

Alliance: Phlomido armeniacae-Astragalion microcephali Akman, Ketenoğlu, Quézel et Demirörs 1984

Association: *Thymo sipylei-Artemisetum scopari* ass. nova

Association: *Alysso strigosi-Thymetum argillacei* ass. nova

Association: *Thymo longicauli-Astragaletum microcephali* ass. nova

Association: *Anthemo tinctoriae-Astragaletum angustifoli* ass. nova

Association: *Sideritido montani-Artemisetum santonici* ass. nova

Association: *Globulario lumose-Astragaletum condensati* ass. nova

Association: *Salvio cryptanthae-Astragaletum plumosi* ass. nova

Class: *Quercetea pubescentis* (Oberd. 1948) Doing Kraft 1955

Order: *Querco cerridis-Carpinetalia orientalis* Quézel, Barbéro et Akman 1980

Alliance: *Quercion anatolicae* Akman, Barbéro et Quézel 1979

Association: *Junipero oxycedri-Cistetum laurifoli* ass. nova

Quercus pubescens community

1. The nomenclature type of the association *Thymo sipylei-Artemisetum scopari* **ass. nov. holotypus hoc. loco:** N. Balpınar (10.06.2003). Plot size: 50 m^2, Altitude:1275 m, Slope: 40%, SW: 39°22.504´ N, 031°40.130´ E, Cover herb layer: 80%.

Herb layer: *Thymus sipyleus* ssp. *sipyleus* var. *sipyleus*: 2, *Artemisia scoparia*: 3, *Astragalus angustifolius* ssp. *angustifolius* var. *angustifolius*: +, *Alyssum murale* var. *murale*: +, *Alyssum sibiricum*: 1, *Paronychia condensata*: +, *Helianthemum canum*: +, *Convolvulus holosericeus* ssp. *holosericeus*: 2, *Centaurea urvillei* ssp. *stepposa*: +, *Astragalus vulnerariae*: +, *Onobrychis hypargyrea*: 1, *Carduus nutans* ssp. *trojanus*: +, *Poa bulbosa*: +, *Minuartia hirsuta* ssp. *falcata*: +.

2. The nomenclature type of the association *Alysso strigosi-Thymetum argillacei* **ass. nov. holotypus hoc. loco:** N. Balpınar (12.06.2004). Plot size: 50 m^2, Altitude:1240 m, Slope: 25%, NW: 39°31.030´ N, 031°18.442´ E, Cover herb layer: 80%.

Herb layer: *Alyssum strigosum* ssp. *strigosum*: +, *Bromus japonicus* ssp. *japonicus*: +, *Ornithogalum oligophyllum*: +, *Scandix iberica*: +, *Thymus leucostomus* var. *argillaceus*: 3, *Hypericum aviculariifolium* ssp. *depilatum*: +, *Bromus squarrosus*: +, *Lolium perenne*: +, *Astragalus condensatus*: +, Stachys cretica ssp. anatolica: +, *Centaurea triumfettii*: +, *Briza humilis*: +, *Astragalus lydius*: +, *Phlomis armeniaca*: 2, *Centaurea virgata*: 1, *Onobrychis armena*: +, *Ziziphora tenuior*: +, *Onobrychis hypargyrea*: +, *Eryngium campestre* var. *vi-*

rens: +, *Cruciata taurica*: +, *Bromus tectorum*: +, *Minuartia anatolica* var. *arachnoidea*: 1, *Festuca valesiaca*: +, *Androsace maxima*: +, *Alyssum minus* var. *micranthum*: +, *Adonis flammea*: +, *Filago pyramidata*: +, *Ajuga chamaepitys* ssp. *chia* var. *chia*: +, *Bromus tomentellus*: 1, *Globularia trichosantha* ssp. *trichosantha*: +, *Chardinia orientalis*: +, *Centaurea depressa*: +, *Scleranthus annuus* ssp. *annuus*: +, *Allium paniculatum* ssp. *paniculatum*: +, *Thlaspi perfoliatum*: +, *Elymus lazicus* ssp. *divaricatus*: +, *Crupina crupinastrum*: +, *Erysimum kotschyanum*: +.

3. The nomenclature type of the association *Thymo longicauli-Astragaletum microcephali* **ass. nov. holotypus hoc. loco:** N. Balpınar (14.07.2004). Plot size: 50 m^2, Altitude:1175 m, Slope: 45%, NW: 39°27.548´ N, 031°39.139´ E, Cover herb layer: 80%.

Herb layer: *Thymus leucostomus* var. *argillaceus*: 1, *Hypericum aviculariifolium* ssp. *depilatum*: +, *Thymelaea passerina*: +, *Teucrium orientale* var. *orientale*: 1, *Astragalus microcephalus*: 4, *Elymus hispidus* ssp. *hispidus*: +, *Helianthemum nummularium* ssp. *ovatum*: 1, *Inula montbretiana*: +, *Daucus broteri*: +, *Lolium perenne*: +, *Thymus longicaulis* ssp. *longicaulis* var. *longicaulis*: 3, *Phlomis armeniaca*: 1, *Centaurea virgata*: 1, *Dianthus zonatus* var. *zonatus*: 2, *Hypericum origanifolium*: +, *Centaurea urvillei* ssp. *stepposa*: +, *Scabiosa argentea*: 2, *Euphorbia macroclada*: 2, *Acantholimon acerosum* var. *acerosum*: 1, *Teucrium polium*: +, *Festuca valesiaca*: 2, *Xeranthemum annuum*: 1, *Euphorbia anacampseros* var. *anacampseros*: +, *Ornithogalum alpigenum*: +, *Chardinia orientalis*: +, *Achillea setacea*: +, *Stipa pontica*: 2, *Acanthus hirsutus*: +.

4. The nomenclature type of the association *Anthemo tinctoriae-Astragaletum angustifoli* **ass. nov. holotypus hoc. loco:** N. Balpınar (09.06.2003). Plot size: 50 m^2, Altitude:1190 m, Slope: 30%, N: 39°27.346´ N, 031°32.387´ E, Cover herb layer: 80%.

Herb layer: *Artemisia scoparia*: +, *Astragalus microcephalus*: +, *Viola parvula*: +, *Geranium lucidum*: +, *Alkanna orientalis* var. *orientalis*: 2, Astragalus angustifolius ssp. angustifolius: 3, *Erophila verna* ssp. *verna*: +, *Lamium garganicum* ssp. *reniforme*: +, *Crataegus monogyna* ssp. *azarelle*: +, *Ranunculus reuterianus*: +, *Moenchia mantica* ssp. *caerulea*: +, *Vicia lathyroides*: +, *Arabis nova*: +, *Rumex acetosella*: +, *Veronica triphyllos*: +, *Anthemis tinctoria* var. *pallida*: +, *Lamium amplexicaule*: +, *Lathyrus cicera*: +, *Erodium hoefftianum*: +, *Alyssum murale* var. *murale*: +, *Artemisia santonicum*: 1, *Minuartia juniperina*: +, *Veronica grisebachii*: +, *Centaurea pichleri* ssp. *pichleri*: +, *Potentilla recta*: +, *Paronychia kurdica* ssp. *kurdica* var. *kurdica*: +, *Onobrychis armena*: 1, *Eryngium campestre* var. *virens*: +, *Cruciata taurica*: +, *Alyssum minus* var. *micranthum*: +, *Euphorbia anacampseros* var. *anacampseros*: +, *Koeleria cristata*: +, *Anthemis cretica* ssp. *anatolica*: +, *Anthemis tinctoria* var. *tinctoria*: 3, *Thlaspi perfoliatum*: +, *Stipa pontica*: +, *Holosteum umbellatum* var. *umbellatum*: +, *Myosotis ramosissima* ssp. *ramosissima*: +, *Lotus aegaeus*: +.

5. The nomenclature type of the association *Sideritido montani-Artemisetum santonici* **ass. nov. holotypus hoc. loco:** N. Balpınar (26.06.2003). Plot size: 50 m^2, Altitude:1120 m, Slope: 45%, N: 39°32.168´ N, 031°13.365´ E, Cover herb layer: 80%.

Herb layer: *Thymus leucostomus* var. *argillaceus*: +, *Consolida thirkeana*: +, *Asperula stricta* ssp. *latibracteata*: +, *Allium sieheanum*: +, *Phlomis pungens* var. *laxiflora*: +, *Sideritis montana* ssp. *montana*: 3, *Verbascum uschakense*: 1, *Artemisia santonicum*: 4, *Erysimum crassipes*: +, *Alyssum sibiricum*: +, *Bromus cappadocicus* ssp. *cappadocicus*: +, *Dianthus zonatus* var. *zonatus*: +, *Marrubium parviflorum* ssp. oligodon: +, *Paronychia kurdica* ssp. *kurdica* var. *kurdica*: +, *Onobrychis armena*: +, *Convolvulus holosericeus* ssp. *holosericeus*: +, *Centaurea urvillei* ssp. *stepposa*: +, *Scabiosa argentea*: +, *Cruciata taurica*: +, *Teucrium polium*: +, *Minuartia anatolica* var. *arachnoidea*: +, *Carduus nutans* ssp. *trojanus*: +, *Stipa holosericea*: 3, *Stachys lavandulifolia* var. *lavandulifolia*: +, *Anthemis tinctoria* var. *tinctoria*: +, *Pistacia terebinthus* ssp. *palaestina*: 1.

6. The nomenclature type of the association *Globulario lumose-Astragaletum condensati* **ass. nov. holotypus hoc. loco:** N. Balpınar (29.05.2004). Plot size: 50 m^2, Altitude:1360 m, Slope: 45%, SE: 39°20.559´ N, 031°42.122´ E, Cover herb layer: 80%.

Herb layer: *Thymus longicaulis* ssp. *longicaulis* var. *longicaulis*: +, *Erysimum crassipes*: +, *Phleum subulatum* ssp. *subulatum*: +, *Poa timoleontis*: +, *Medicago rigidula* var. *rigidula*: +, *Fumana arabica* var. *arabica*: +, *Thymus argaeus*: +, *Scorzonera eriophora*: +, *Astragalus condensatus*: 5, *Paronychia condensata*: +, *Stachys cretica* ssp. *anatolica*: +, *Veronica pectinata* var. *glandulosa*: +, *Silene macrodanta*: +, *Silene lydia*: +, *Linum nodiflorum*: +, *Globularia orientalis*: 3, *Polygala anatolica*: +, *Juniperus oxycedrus* ssp. *oxycedrus*: 1, *Salvia cadmica*: +, *Phlomis armeniaca*: +, *Teucrium chamaedrys* ssp. *syspirense*: +, *Hypericum origanifolium*: +, *Acantholimon acerosum* var. *acerosum*: 1, *Cruciata taurica*: +, *Bromus tectorum*: +, *Androsace maxima*: +, *Euphorbia anacampseros* var. *anacampseros*: +, *Adonis flammea*: +, *Anthemis cretica* ssp. *anatolica*: +.

7. The nomenclature type of the association *Salvio cryptanthae-Astragaletum plumosi* **ass. nov. holotypus hoc. loco:** N. Balpınar (09.06.2003). Plot size: 50 m^2, Altitude:1190 m, Slope: 35%, W: 39°31.466´ N, 031°14.444´ E, Cover herb layer: 80%.

Herb layer: *Astragalus microcephalus*: 1, *Hypecoum procumbens*: +, *Asperula stricta* ssp. *latibracteata*: +, *Globularia orientalis*: 1, *Tragopogon coloratus*: +, *Scorzonera suberosa* ssp. *suberosa*: +, *Sisymbrium altissimum*: +, *Alyssum thymops*: +, *Anchusa undulata* ssp. *hybrida*: +, *Erodium cicutarium* ssp. *cicutarium*: +, *Astragalus plumosus* var. *plumosus*: 4, *Bungea trifida*: +, *Salvia cryptantha*: 3, *Moltkia coerulea*: +, *Hedysarum varium*: +, *Astragalus lydius*: +, *Potentilla recta*: +, *Paronychia kurdica* ssp. *kurdica* var. *kurdica*: +, *Lappula barbata*: +, *Aubrieta anamasica*: +, *Eryngium campestre* var. *virens*: +, *Poa bulbosa*: +, *Adonis flammea*: +, *Ajuga chamaepitys* ssp. *chia* var. *chia*: +, *Anthemis tinctoria* var. *tinctoria*: +, *Iris schachtii*: +, *Anchusa leptophylla* ssp. *incana*: +, *Orobanche cilicica*: +, *Alyssum hirsutum* var. *hirsutum*: +.

8. The nomenclature type of the association *Junipero oxycedri-Cistetum laurifoli* **ass. nov. holotypus hoc. loco:** N. Balpınar (10.06.2003). Plot size: 100 m^2, Altitude:1350 m, Slope: 45%, NE: 39°23.453´ N, 031°42.182´ E, Cover shrub layer: 75%, Cover herb layer: 80%.

Shrub layer: *Cistus laurifolius*: 5, *Daphne oleoides* ssp. *oleoides*: 1, *Prunus spinosa* ssp. *dasyphylla*: 1, *Cotoneaster nummularia*: 1, *Berberis crataegina*: 1, *Juniperus oxycedrus* ssp. *oxycedrus*: 2, *Amelanchier parviflora* var. *parviflora*: 2.

Herb layer: *Hypericum linarioides*: 1, *Lathyrus digitatus*: 1, *Prunella laciniata*: 1, *Silene italica*: 1, *Pyracantha coccinea*: 1, *Sanguisorba minor* ssp. *muricata*: 1, *Globularia trichosantha* ssp. *trichosantha*: 1, *Trigonella spruneriana* var. *spruneriana*: 1, *Trifolium physodes* var. *physodes*: 1, *Alyssum murale* var. *murale*: 1, *Ranunculus illyricus* ssp. *illyricus*: 1, *Hypericum scabrum*: 1, *Plantago lanceolata*: 1, *Rosa canina*: 2, *Minuartia anatolica* var. *arachnoidea*: 1, *Koeleria cristata*: 1, *Crataegus orientalis* var. *orientalis*: 2, *Veronica multifida*: 1, *Achillea setacea*: 1.

Acknowledgements

Some data used in this study is obtained from corresponding author's Ph.D. thesis, which was partially financed by Research Fund of Ankara University (Project ID: 2004-07-05-085).

References

Akman, Y., 1974: Etude phyto-écologique de la région de Beypazarı-Karaşar et Nallıhan Communications 18, 51–113.

Akman, Y., 1976: Etude phytosociologique du massif d'Işık. Communications 20, 1–30.

Akman, Y., 1990: Etude de la végétation steppique des montagnes d'Aydos située au Nord Ouest d'Ankara. Ecologia Mediterranea 16, 223–230.

Akman, Y., Aydoğdu, M., 1986: A phytosociological study in the vicinities of Çamlıdere Çamkoru and Peçenek (Ankara). Communications 4, 9–24.

Akman, Y., Barbéro, M., Quézel, P., 1978a: Contribution a l'etude de la végétation forestiére d'Anatolie Méditerranéenne. Phytocoenologia 5, 1–79.

Akman, Y., Barbéro, M., Quézel, P., 1978b: Contribution a l'etude de la végétation forestiére d'Anatolie Méditerranéenne. Phytocoenologia 5, 189–276.

Akman, Y., Barbéro, M., Quézel, P., 1979: Contribution a l'etude de la végétation forestiére d'Anatolie Méditerranéenne. Phytocoenologia 5, 277–346.

Akman, Y., Ketenoğlu, O., 1976: The phytosociological and phytoecological investigation on the Ayaş Mountains. Communications 20, 1–43.

Akman, Y., Ketenoğlu, O., Quézel, P., 1985: A new syntaxon from Central Anatolia. Ecologia Mediterranea 11, 111–121.

Akman, Y., Ketenoğlu, O., Quézel, P., Demirörs, M., 1984: A syntaxonomic study of steppe vegetation in Central Anatolia. Phytocoenologia 12, 563–584.

Akman, Y., Quézel, P., Barbéro, M., Ketenoğlu, O., Aydoğdu, M., 1991: Le végétation des steppes, pelouses écorchées et à xérophytes épinex de l'Antitaurus dans la partie sud-ouest de l'Anatolie. Phytocoenologia 19, 391–428.

Akman, Y., Yurdakulol, E., Demirörs, M., 1983: The vegetation of the Ilgaz Mountains. Ecologia Mediterranea 9, 137–165.

Aksoy, A., Hamzaoğlu, E., 2006: Vegetation zones in the salty marshes of Central Anatolia and natural borders of agricultural usage (Turkey). In: Öztürk M., Waisel Y., Khan M.A., Görk G. (eds.), Biosaline agriculture and salinity tolerance in plants, 109–116. Birkhäuser, Basel.

Anonymous, 2007: Statistica (data analysis software system). Version 8.0. StatSoft, Inc. www.statsoft.com

Atalay, Ý., Efe, R., 2010: Structural and distributional evaluation of forest ecosystems in Turkey. Journal of Environmental Biology 31, 61–70.

Aydoğdu, M., Akman, Y., Quézel, P., Barbéro, M., Ketenoğlu, O., Kurt, L., 1994: Syntaxonomic analysis of gypsaceous vegetation of the surrounding area between Ayas-Polatlı and Beypazarı (Ankara, Turkey). Ecologia Mediterranea 20, 9–19.

Aydoğdu, M., Hamzaoğlu, E., Kurt, L., 2001: The study on the vegetation of Baran Mountain (Kırşehir-Türkiye). Gazi Üniversitesi Fen Bilimleri Enstitüsü Dergisi 14, 1375–1386.

Aydoğdu, M., Kurt, L., Hamzaoğlu, E., Ketenoğlu, O., Cansaran, A., 2004: Phytosociological studies on salty steppe communities of Central Anatolia, Turkey. Israel Journal of Plant Sciences 52, 72–79.

Basist, A., Bel, G. D., 1994: Statistical relationships between topography and precipitation pattern. Journal of Climate 7, 1305–1315.

Birand, H., 1961: Erste Ergebnisse vegetations-Untersuchungen in der Zentral Anatolischen steppe. I. Halopyten gesellschaften des Tuzgölü. Botanische Jahrbücher 79, 255–296.

Birand, H., 1970: Die verwüstüng der *Artemisia* steppe bei Karapınar in Zentral Anatolien. Vegetatio 20, 21–47.

Braun-Blanquet, J., 1964: Pflanzensoziologie. Grundzüge der Vegetationskunde 3rd ed. Springer Verlag, Wien-New York.

Burke, I. C., Reiners, W. A., Olson, R. K., 1989: Topographical control of vegetation in a mountain big sagebrush steppe. Vegetation 84, 77–86.

Chytrý, M., Tıchý, L., Holt, J., Botta-Dukát, Z., 2002: Determination of diagnostic species with statistical fidelity measures. Journal of Vegetation Science 13, 79–90.

Çetik, R., 1963: The vegetation of Çubuk Dam. İstanbul Üniversitesi Fen Fakültesi Mecmuası 28, 109–138.

Çetik, R., 1985: The vegetation of Turkey I: The vegetation and ecology of Central Anatolia. Selçuk Üniversitesi Basımevi, Konya (in Turkish).

Çetik, R., Vural, M., 1979: Ecological and sociological studies on the vegetation of Afyon, Bayat-Köroğlubeli and its environment. Communications 23, 1–44.

Davis, P. H., 1965-1985: Flora of Turkey and the East Aegean Islands. Vol. 1–9, Edinburgh University Press, Edinburgh.

Davis, P. H., Mill, R. R., Tan, K., 1988: Flora of Turkey and East Aegean Islands (Supplement). Vol. 10, Edinburgh University Press, Edinburgh.

Düzenli, A., 1976: Phytosociological and ecological investigation of Hasan Mountain. Ormancılık Araştırma Enstitüsü Dergisi 22, 51–70 (in Turkish).

Fontaine, M., Aerts, R., Özkan, K., Mert, A., Gülsoy, S., Suel, H., Waelkens, M., Muys, B., 2007: Elevation and exposition rather than soil types determine communities and site suitably in Mediterranean mountain forests of southern Anatolia, Turkey. Forest Ecology and Management 247, 18–25.

Hamzaoğlu, E., 1999: The steppe vegetation of Kervansaray Mountain (Kırşehir). Gazi Üniversitesi Fen Bilimleri Enstitüsü Dergisi 12, 1143–1167 (in Turkish).

Hamzaoğlu, E., 2000: The vegetation of Buzluk Mountain (Kırşehir). Gazi Üniversitesi Gazi Eğitim Fakültesi Dergisi 20, 79–89 (in Turkish).

Hamzaoğlu, E., Duran, A., 2004: A phytosociological research on the degraded forest vegetation of Dinek Mountain (Kırıkkale). Gazi Üniversitesi Fen Bilimleri Dergisi 17, 1–13.

Hennekens, S. M., Schaminée, J. H. J., 2001: TURBOVEG a comprehensive data base management system for vegetation data. Journal of Vegetation Science 12, 589–591.

Jankju, M., Mellati, F., Atashgahi, Z., 2011: Flora, life form and chorology of winter and rural range plants in the northern Khorasan province, Iran. Journal of Rangeland Science 1, 269–283.

Kavgacı, A., Başaran, S., Başaran, M. A., 2010b: Cedar forest communities in western Antalya (Taurus Mountains, Turkey). Plant Biosystems 144, 271–287.

Kavgacı, A., Čarni, A., Tecimen, B., Özalp, G., 2010a: Diversity and ecological differantiation of oak forests in NW Thrace (Turkey). Archives of Biological Sciences 62, 705–718.

Kaya, Ö. F., Ketenoğlu, O., Yetim, S., 2011: A synecological and syntaxonomical research of the secondary vegetation caused by overgrazing on Arat Mountain (Şanlıurfa, Turkey). Acta Botanica Gallica 158, 13–25.

Ketenoğlu, O., Akman, Y., 1982: The phytosociological investigation of *Quercus pubescens* formation in Kızılcahamam-Kargasekmez region in Central Anatolia. Communications 25, 1–9.

Ketenoğlu, O., Aydoğdu, M., Kurt, L., Akman, Y., Hamzaoğlu, E., 2000: Syntaxonomic research on the gypsicole vegetation in Cappadocia, Turkey. Israel Journal of Plant Sciences 48, 121–128.

Ketenoğlu, O., Quézel, P., Akman, Y., Aydoğdu, M., 1983: New syntaxa on the gypsaceus formations in the Central Anatolia. Ecologia Mediterranea 9, 211–221.

Kılınç, M., 1979: The flora of the serpentine formation between Kırıkkale-Kalecik and Elmadağ. Ormancılık Araştırma Enstitüsü Dergisi 25, 29–40 (in Turkish).

Kılınç, M., 1985: The vegetation of the area among Devrez stream and Kızılırmak River in Central Anatolia-Western Black Sea Region transition zone. Doğa Bilimleri Dergisi 9, 315–357 (in Turkish).

Krause, K., 1940: Plant formations of Western and Central Anatolia (Translation: A. Birand). Ziraat Vekaleti Yüksek Ziraat Enstitüsü Yayınları, Ankara (in Turkish).

Kurt, L., 2000: A study on the steppic vegetation between Aksaray-Nevşehir and Şereflikoçhisar from the phytoecological aspect. Fırat Üniv. Fen ve Mühendislik Dergisi 12, 51–59 (in Turkish).

Kurt, L., 2002: The steppe vegetation of Emirdag (Afyon/Turkey). Anadolu Üniversitesi Bilim ve Teknoloji Dergisi 3, 257–270.

Kurt, L., Kurt, F., Evren, H., Karakaya, A., 1999: Steppic vegetation of the Eldivan Mountain (Çankırı/Turkey). Fırat Üniversitesi Fen ve Mühendislik Bilimleri Dergisi 11, 49–57.

Kurt, L., Tuğ, G. N., Ketenoğlu, O., 2006: Synoptic view of the steppe vegetation of central Anatolia. Asian Journal of Plant Sciences 5, 733–739.

Kürschner, H., Parolly, G., 2012: The Central Anatolian steppe. In: Werger, M. J. A. and van Staalduinen, M. A. (eds.), Eurasian steppes. Ecological problems and livelihoods in a changing world, 149–171. Springer, Netherlands.

Lepš, J., Šmilauer, P., 2003: Multivariate analysis of ecological data using CANOCO. Cambridge University Press, Cambridge.

Louis, H., 1939: Das natürliche Pflanzenkleid Anatoliens, geographisch gesehen. Geographische Abhandlungen, Stuttgart.

Mc Cune, B., Mefford, M. J., 2006: PC-ORD 5, Multivariate analysis of ecological data. MjM Sofware Design. Gleneden Beach, Oregon.

Ocakverdi, H., Oflas, S., 1999: The plant sociology and ecology of Upper Göksu Basin (Hadim-Konya) and its environs. Turkish Journal of Botany 23, 195–210.

Ocakverdi, H., Ünal, A., 1991: Plant sociology and its ecology research of Karadağ (Karaman). Doğa, Turkish Journal of Botany 15, 79–100 (in Turkish).

Özkan, K., 2009: Environmental factors as influencing vegetation communities in Acipayam district of Turkey. Jornal of Environmental Biology 30, 741–746.

Özkan, K., Gülsoy, S., Mert, A., Öztürk, M., Muys, B., 2010: Plant distribution-altitude and landform relationships in karstic sinkholes of Mediterranean region of Turkey. Jornal of Environmental Biology 31, 51–60.

Özkan, K., Şenol, H., Gülsoy, S., Mert, A., Suel, H., Eser, Y., 2009: Vegetation-environment relationships in Mediterranean mountain forests on limeless bedrocks of southern Anatolia, Turkey. Journal of Environmental Engineering and Landscape Management 17, 154–163.

Quézel, P., 1973: Contribution á l'etude phytosociologique du masif du Taurus. Phytocoenologia 1, 131–222.

Quézel, P., Barbéro, M., Akman, Y., 1978: L'Interpretation phytosociologique des groupements forestiers dans le Bassin Mediterraneen Oriental. Documents Phytosociologiques 2, 329–352.

Quézel, P., Barbéro, M., Akman, Y., 1980: Contribution á l'etude de la végétation forestiére d'Anatolie Septentrionale. Phytocoenologia 8, 365–519.

Quézel, P., Barbéro, M., Akman, Y., 1992: Typification de syntaxa décrits en région Mediterranéenne Orientale. Ecologia Mediterranea 18, 81–87.

Raunkiaer, C., 1934: life forms of plants and statistical plant geography. Oxford University Press, London.

Rove, N., Speck, T., 2005: Plant growth forms: an ecological and evolutionary perspective. New Phytologist 166, 61–72.

Sebastiá, M. T., 2004: Role of topography and soils in grassland structuring at the landscape and community scales. Basic and Applied Ecology 5, 331–346.

Schwarz, O., 1936: Die vegetations verhältnisse Westanatoliens. Englers' Botanische Jahrbücher fur Systematik 67, 297–436.

Şanda, M. A., Küçüködük, M., Serin, M., 2000: The steppe vegetation of the area among Hadim (Konya), Ermenek and Bucakkışla (Karaman). Selçuk Üniversitesi Fen-Edebiyat Fakültesi Fen Dergisi 1, 21–35 (in Turkish).

Tatlı, A., Eyce, B., Serin, M., 1994: The vegetation of Kızılören, Çal and Loras Mountains (Konya). Turkish Journal of Botany 18, 267–288 (in Turkish).

Ter Braak, J. F. C., Šmilauer, P., 2002: CANOCO Reference Manual and CanoDraw for Windows User's Guide, Software for Canonical Community Ordination (version 4.5) Wageningen.

Tichý, L., 2002: JUICE, software for vegetation classification. Journal of Vegetation Science 13, 451–453.

Török, P., Ambarlı, D., Kamp, J., Wesche, K., Dengler, J., 2016: Step (pe) up! Raising the profile of the Palaearctic natural grasslands. Biodiversity and Conservation 25, 2187–2195.

Walter, H., 1956: Des problem der Zentralanatolischen stepe. Die Naturwissenschaften 43, 97–102.

Weber, H. E., Moravec, J., Theurillat, J. P., 2000: International code of phytosociological nomenclature 3rd edition. Journal of Vegetation Science 11, 739–768.

Westhoff, V., Van Der Maarel, E., 1973: The Braun-Blanquet approach. In: Whittaker, R. H. (ed.), Handbook of Vegetation Science 5, Ordination and classification of communities, 617–726. Junk, The Hague (in Dutch).

Yurdakulol, E., Aydoğdu, M., Çetin, B., 1990: A study of the steppe vegetation surrounding area of Kırıkkale-Kalecik-Kırşehir from the phytosociological aspect. Doğa, Turkish Journal of Botany 14, 215–234 (in Turkish).