Vascular plant diversity in Solaklı watershed in Northeastern Turkey

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Abstract. This study was carried out on the flora and vegetation of the Solaklı watershed in Northeastern Turkey, situated in the Euxine province of the Euro-Siberian floristic region. The vegetation of the area was investigated following the Braun-Blanquet phytosociological approach. During a two-year study period, 223 relevés have been established and 13 plant associations were described. The floristic compositions and abundance patterns of all plant associations were also determined to evaluate the species diversity and richness of the study area. The richness of vascular plant species (α diversity) and the species turnover (β diversity) were calculated by different categories of measures often used to quantify biodiversity within habitats. A total of 1024 vascular plant taxa, including 73 endemics and 105 threatened plant species, were recorded from the whole area (80 436 ha). A new association, *Anemono narcissiflorae–Betuletum litwinowii*, was described for the first time and supplied with a vegetation table. This association belongs to the alliance *Lilio pontici–Anemonion narcissiflorae*. The alliance is represented by two associations and the new association is described. The similarity between these associations, based on the Sorensen Index, was 32.3%. In terms of diversity of the study area, some significant differences were found among the 13 associations, and the species richness varied between 13.64 (min.) and 28.88 (max.). Our results indicate that the study area has a remarkable diversity of vascular plants.

Key words: Anatolia, biodiversity, Braun-Blanquet, α and β indices, phytosociology

Introduction

The mountainous landscapes of Turkey have been attracting many botanists for over 150 years with the great diversity of high-mountain vegetation types (Parolly 2004). The first published reports on the vegetation of the region belonged to Handel-Mazetti (1908), followed by Krause (1932), Louis (1939), Maleev (1940), Zohary (1973), and Düzenli (1988), while the subalpine and alpine vegetation was reported in detail by Vural (1996). In addition to these studies, Acar & al. (2004) described the floristic composition and diversity of the ground cover vegetation in the study area and the region. As part of the successive surveys of the flora, vegetation and vascular plant diversity in the region, this study was carried out in the northeastern part of Turkey (Fig. 1) located in the Euxine province of the Euro-Siberian floristic region. This province extends throughout most of the Caucasus, and mountainous parts of the Crimea and Dobroudzha. In the eastern part of the province, known as Colchis province, the number of Caucasian and endemic species increases. The climate of this region is generally cloudy, humid and sheltered and supports the growth of many relict species (Davis 1971). Because of the humid conditions, the region hosts lots of alien species

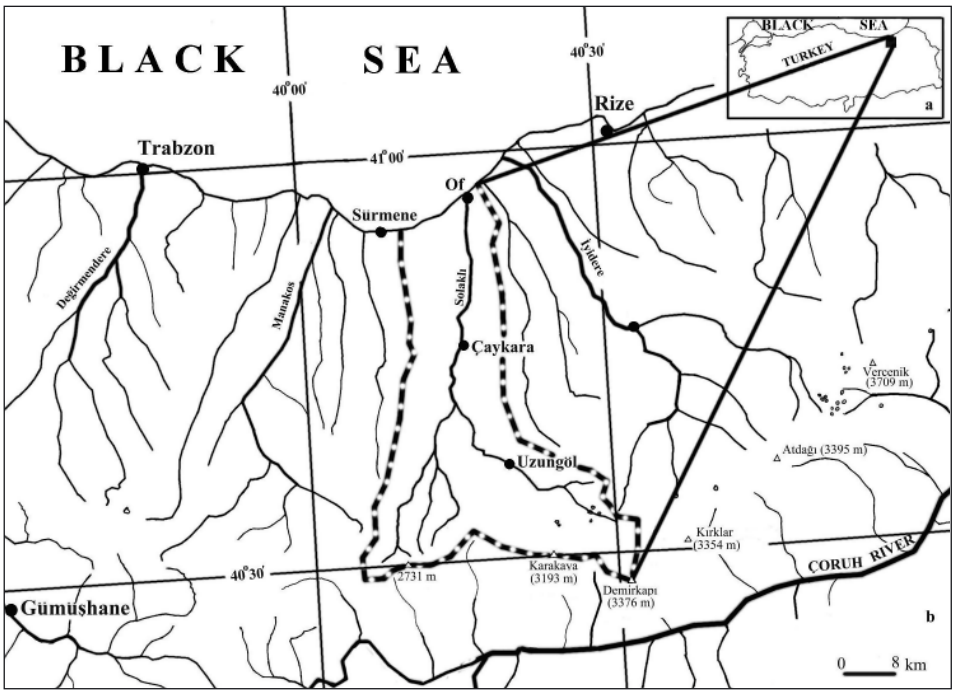

Fig. 1. Map of the study area: **a** – location in Turkey; **b** – regional setting and location of the Solaklı watershed, showing main streams and border (dotted line).

(Terzioğlu & Anşin 2001). The study area is included within the Conservation International's 25 World Biodiversity Hotspots (biologically richest and most endangered terrestrial ecoregions) and is one of the 200 priority ecoregions on the Earth (classified as temperate forests of the Caucasus) (WWF and IUCN 1994).

The first objective of this study was to determine the flora and vegetation of the study area. The second objective was to calculate and compare α and β diversity indices of the associations described in the study area. The third objective was to assess the phytosociological structure of the new association *Anemono narcissiflorae–Betuletum litwinowii*.

Methods

Brief description of the area

The study area is located in the northeastern part of Turkey. It extends from Of county (at the sea level) to Demirkapı summit (3376 m) (Fig. 1) and has a rugged terrain. The number of taxa, mean altitude, growing period, mean temperature, and precipitation for each plant association were calculated and presented, together with the formation types. There is no dry season in the area. During the summer period the study area is often shrouded by fog. The high humidity here favours hydrophytic vegetation (Atalay 1994). Volcanic and plutonic rocks dominate the geological structure of the region. The main soil type of the study area is well-aerated podzols. pH values of these soils are low, owing to leaching by high precipitation of the basic cations from the soil profile (Bulut & Tarhan 1991).

Vegetation inventory and field sampling

During the field work carried out following the Braun-Blanquet phytosociological approach (Braun-Blanquet 1964), a total of 138 relevés have been established. This method was chosen as suitable for providing data on the abundance, dominance and sociability of taxa (Ketenoğlu & al. 2000), used both in the determination of syntaxonomic categories and in calculating α and β diversity indices. Fifteen relevés have been established for determining the new association. Ecological data were placed at the top of each relevés-forming phytosociological table. All plant associations were named and classified according to the Syntaxonomic Nomenclatural Rules (Weber & al. 2000). Totally, 138 relevés have been established and studied in order to determine all associations of different vegetation types. The materials of study consisted of plant specimens collected during the period 1994-1998, with the vouchers stored at the herbarium of Karadeniz Technical University, Faculty of Forestry (KATO). The "*Threatened*" category has been suggested for some endemic and rare taxa in line with the

IUCN risk categories (Ekim & al. 2000; IUCN 2001). The following abbreviations are used: EX: Extinct; EW: Extinct in the wild; CR: Critically endangered; EN: Endangered; VU: Vulnerable; LC: Least concern; NT: Near threatened; DD: Data deficient.

Data analysis

In order to evaluate the degree of floristic resemblance between the associations of the alliance *Lilio pontici–Anemonion narcissiflorae,* Sorensen's Similarity Index (Sorensen 1948) was calculated as $[2C/(A+B)] \times 100$, where A and B are the total species content (herbs and/or shrubs) in the type association (A) and in the newly described association (B) respectively, while C is the number of species common to both associations.

The floristic relationship between α and β diversity indices was used to assess the species diversity on the basis of floristic data for each association. The following indices were used:

- The species richness was described as the number of species encountered in each relevé. In this process, the abundance-dominance data were transformed using a five-point scale: 1 = 1–10 %; 2 = 11–25 %; 3 = 26–50 %; 4 = 51–75 %, 5 = 76–100 % (Acar & al. 2004);
- The Shannon-Wiener index ($H' = -\Sigma\, Pi$ In Pi), where $pi = ni/N$ (ni is the number of individuals of species, i and N is the total number of individuals) (Magurran 1988).
- Pielou's evenness index ($J' = H'/\log S$), where S is the number of species) was calculated (Magurran 1988);
- The dominance indices of Berger-Parker ($d = N_{max}/N_T$), (N_{max} is total dominant species in a habitat type and N_T is the proportion of the total species) (CAP 1999);
- Whittaker (βw = S/α – 1), Cody (βc = [g(H) + l(H)]/2) and Wilson-Shmida (βT = [g(H) + l(H)]/2α), where α is the average species richness of paired habitats, g(H) is the number of species present in habitat 2 but not in habitat 1 and l(H) is the number of species present in habitat 1 but not habitat 2 (Wilson & Shmida 1984; Magurran 1988).

Kruskal-Wallis one-way analysis of variance (ANOVA) was performed using the program package SPSS 7.5 for Windows to detect any significant differences in the species diversity among plant associations. Also, with the help of the Community Analysis Package (CAP) Version 1.41 program, a Principal Component Analysis (PCA) was performed to explore and ordinate the relationship of the species composition of each association.

Results and discussion

Flora of the area

A total of 724 plant taxa were recorded from the relevés. The remaining 300 taxa were recorded from outside of the relevés in the study area. Thus a total of 1024 taxa (157 on subspecies level, 96 on variety level) belonging to 435 genera in 117 families was recorded from the whole area (unpubl. data). The families representing the highest number of taxa were *Compositae* (136), *Leguminosae* (64), *Rosaceae* (59), *Gramineae* (54), *Caryophyllaceae* (48), *Labiatae* (47), *Scrophulariaceae* (43), *Cruciferae* (37), *Liliaceae* (28), *Ranunculaceae* (27), and *Boraginaceae* (24). The taxa categorized by phytogeographic region could be listed as follows: Euro-Siberian elements, 209 (20.4 %), Euxine elements, 180 (17.6 %), Hyrcano-Euxine elements, 31 (3.0 %), Hyricanian element, 1 (0.1 %), Irano-Turanian elements, 47 (4.6 %), Mediterranean elements, 20 (1.9 %); the remaining 536 (52.4 %) were multi-regional or of unknown phytogeographic origin. The vast number of Euro-Siberian and Euxine elements could be explained by the fact that the study area lies wholly within the Euxine province of the Euro-Siberian floristic region. The number of Mediterranean elements was the least common and these taxa were mainly located in the dune vegetation of the study area. That vegetation type was found in a very restricted part of the study area. According to Davis (1971), the Mediterranean elements migrated to the north through the Anatolian Diagonal in the Ice Age of the Pleistocene. The Irano-Turanian elements were mainly observed in the high northern parts of the study area. These areas were close to the Irano-Turanian floristic region of Turkey. The number of Hyrcano-Euxine elements showed a close relation between the study area and the Hyricanian province, a fact pointed out by Davis (1971).

The main reason for the high number of multi-regional or uncertain phytogeographic regional taxa in the study area could be due to inadequate or missing information on the distribution of some taxa. The second reason could be the appropriate climatic condi-

tions of the study area suitable for a large number of taxa to grow. In a regional study, a total of 32 naturalized taxa (all of the *Angiospermae*) were recorded from the Eastern Black Sea region. Eighteen of these taxa have transferred to the study area mostly from North America (the relatively humid, coastal and mountainous regions), Japan and China (Terzioğlu & Anşin 2001). Four of the naturalized woody taxa – *Albizzia julibrissin* Durazz., *Robinia pseudoacacia* L., *Acer negundo* L. and *Ailanthus altissima* (Mill.) Swingle – have been used as wood for heating or timber in the region. Furthermore, *Robinia pseudoacacia* has been planted for the purposes of erosion control and honey production in the study area. Mention deserves the fact that most naturalized taxa belong to the *Compositae*, due to the easily scattered achenes.

Seventy-three of all taxa are endemic to Turkey and the endemism rate is 7%. Distribution of the "*Threatened*" category of endemic and rare taxa according to IUCN is as follows: CR – 1, EN – 1, VU – 15, NT – 3, LC – 6, and DD – 2 (not any taxa in EX and EW categories).

Vegetation and syntaxa of the area

Vegetation of the study area was classified according to the International Vegetation Classification System (UNESCO 1973). All associations, along with the formation types, were presented with some ecological data (Table 1).

Coastal dune vegetation is partly distributed along the Karadeniz (Black Sea) coast and mostly consists of the Mediterranean elements recorded from the area. The study area includes a very small part of coastal dune vegetation from which it was possible to evaluate only three relevés in this study. Of this vegetation, the association *Otantho maritimi–Euphorbietum paraliadis* Karaer & al. 1997 was described by Karaer & al. (1997). This association should be included in *Ammophiletea arenariae* Br.-Bl. & R. Tx. 1943 class, *Ammophiletalia arundinaceae* (Br.-Bl. 1993) R. Tx. & Oberdf. 1958 order, and the *Ammophilion arundinaceae* (Br.-Bl. 1993) R. Tx. & Oberdf. 1958 alliance.

The distribution of *Pinus sylvestris* L. community at low altitudes, starting from sea level in Çamburnu

Table 1. Plant associations and formation types of the study area, together with the total number of taxa per association, mean altitudes (m), growing periods (day/year), mean temperatures (°C), and mean precipitations (mm).

Plant associations*	Formation types**	Total number of taxa	Mean altitude (m)	Growing period (day/year)***	Mean temperature (°C)	Mean precipitation (mm)
Otanthi maritimi–Euphorbietum paraliadis	Medium tall grassland consisting mainly of sod grasses (coastal dune)	26	1	278	14.1	1685.1
Epimedio colchici–Pinetum sylvestris	Temperate evergreen needle-leaved forest with rounded crowns	66	128	270	14.0	1627.5
Oplismeno undilatifolii–Alnetum barbatae	Regularly flooded cold-deciduous alluvial forest	77	416	253	12.5	1502.4
Fago orientalis–Castaneetum sativae	Temperate lowland and submontane broad-leaved cold-deciduous forest	80	458	251	12.3	1483.5
Equiseto fluviatili–Lythretum salicariae	Wet or flooded most of the year (swamps)	44	1050	217	7.8	941.5
Piceo orientalis–Fagetum orientalis	Cold-deciduous broad-leaved forest with evergreen needle-leaved trees	76	1405	196	7.0	1101.3
Sedo stoloniferi–Piceetum orientalis	Evergreen needle-leaved forest with conical crowns	93	1468	192	6.7	1129.6
Anemono narcissiflorae–Betuletum litwinowii	Broad-leaved deciduous woodland	107	2143	154	3.6	1433.4
Vaccinio myrtilli–Rhododendretum caucasici	Alpine and subalpine meadows of higher latitudes, rich in dwarf shrubs	124	2434	136	2.1	1564.3
Stachyo macranthae–Polygonetum carnei	Alpine and subalpine meadows of higher latitudes, rich in forbs	121	2434	136	2.1	1564.3
Gentiano pyrenaicae–Nardetum strictae		84	2469	135	1.9	1580.1
Agrostio lazicae–Sibbaldietum parviflorae		140	2290	145	2.8	1499.5
Anthemido creticae–Centaureetum appendicigerae		44	2942	108	–0.6	1792.9

***According to Braun-Blanquet (1964).**

****According to UNESCO classification (1973).**

*****According to Wiersma (1963).**

county (mean altitude is 128 m) in the study area, is extreme for this species. The shrub layer of this community contains many evergreen-hygrophilous taxa, contrary to the composition of optimum communities in optimum conditions for this species. Owing to this extreme distribution, individuals of this community were named *Pinus sylvestris* L. f. *lazica* (Quezel & al. 1980). Forests of *Fagus orientalis* Lipsky and *Picea orientalis* (L.) Link, with underbrush of *Rhododendron ponticum* L., were characteristic in the study area, as in the other parts of the Colchis sector. Furthermore, there were mixed forests in the study area composed of various combinations of *Fagus orientalis* and *Picea orientalis*: *Fagus orientalis, Picea orientalis* and *Alnus glutinosa* (L.) Gaertn. subsp. *barbata* (C.A. Mey.) Yalt. dominated along the Solaklı stream on the alluvial soil; *Fagus orientalis* and *Castanea sativa* Mill.; *C. sativa, Carpinus betulus* L., and *Quercus* spp. and *Acer* spp.; *P. orientalis* and *Abies nordmanniana* (Stev.) Spach. subsp. *nordmanniana.* This vegetation had three vertical canopy layers of vascular plants; tree, shrub and herb. The forest vegetation of the study area had five associations and they belonged to *Rhododendro–Fagetalia orientalis* Akman & al. 1980 and *Pino–Piceetalia orientalis* Quezel & al. 1980, of the *Querco–Fagetea* Quezel & al. 1980 class. These orders were endemic to the Euxine province (Akman 1995). Especially *Alnion barbatae* Akman & al. 1980 and *Castaneo–Carpinion* Akman & al. 1980 alliances of the *Rhododendro–Fagetalia orientalis* order were frequently observed in the study area.

Aquatic vegetation occurred along the edge of lake Uzungöl and was under the heavy pressure of intense tourist activities in the study area. This vegetation type generally consisted of commonly distributed taxa. The association of this vegetation was included in *Phragmitetea* R. Tx. & Preising 1942 class. *Molinio–Arrhenatheretea* R. Tx. 1937 and *Molinio–Juncetea* Br.-Bl. 1947 classes were also represented in the study area.

Betula litwinowii Doluch scrub could be seen in three close vicinities in the subalpine areas, adjacent to *Picea orientalis* and *Abies nordmanniana* subsp. *nordmanniana* timberline of the study area. In these communities the new association *Anemono narcissiflorae–Betuletum litwinowii* Terzioğlu (**Holotype:** Table 2, relevé no. 3) was described. It had two vertical layers of vascular plants: shrub (with layer coverage of about 85 %) and herb (with layer coverage of about 56 %). Some inadequately growing individuals of tree species (e.g. *Picea orientalis*, *Abies nordmanniana* subsp. *nordmanniana*, *Acer trautvetteri*, *Sorbus aucuparia*, *and Populus tremula*) were remarkable in this association. *Betula litwinowii* was the dominant species of the shrub layer and *Anemone narcissiflora* L. subsp. *narcissiflora* was the dominant taxon of the herb layer. These were the only species occurring in all relevés (Table 2). The birch communities started from the timberline at about 2000 m and ascended to about 2300 m into the alpine vegetation dominated by herbs and *Rhododendron caucasicum* Pallas. and *Vaccinium myrtillus* L. scrub. In this part of the study area six associations were present (Table 1).

All alpine and sub-alpine vegetation was represented by *Alchemillo retinervis–Sibbaldietea parviflorae* Vural 1987 class consisting of two orders: *Swertio ibericae – Nardetalia strictae* Vural 1987 and *Alchemillo retinervis–Sibbaldietalia parviflorae* Vural 1987. The *Agrostio lazicae–Sibbaldion parviflorae* Vural 1987, *Lilio pontici–Anemonion narcissiflorae* Vural 1987, *Centaureo appendicigerae–Senecion taraxacifolii* Vural 1987, and *Vaccinio myrtilli–Rhododendrion caucasici* Vural 1987 alliances represented the subalpine and alpine vegetation of the study area and belonged to the *Alchemillo retinervis –Sibbaldietalia parviflorae* order.

The new association reported in this paper was naturally distributed in three close vicinities: two in Demirkapı village and one in Arpaözü village of the Uzungöl county in Northeastern Turkey. This association belongs to the *Lilio pontici–Anemonion narcissiflorae* alliance, with *Betula litwinowii* as a shrub taxon (up to 4 m) in dense population as the climax of subalpine shrub communities. However, in the forest vegetation of the region *Betula litwinowii* occurred with individual trees (up to 15 m). The *Lilio pontici–Anemonion narcissiflorae* alliance had 24 characteristic species altogether. It was poor in members of *Gramineae,* but rich in conspicuous flowering herbs (Vural 1996). Although the type association included 19 out of all 24 characteristic species of the alliance, the new association comprised 14 of them. This clearly shows that the new association belongs to this alliance. After the addition of the new association, the alliance was represented by two associations necessary for describing it (Weber & al. 2000). Similarity of the associations is 32.3 % according to Sorensen's Index. These associations located in the subalpine area and the locations showed similar ecological conditions.

Table 2. ***Anemono narcissiflorae–Betuletum litwinowii*** **Terzioğlu 2007, ass. nova.**

Relevé no.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	**F**	
Size of relevé (m²)	400	400	400	400	400	400	400	400	400	400	400	400	400	400	400	**R**	**P**
Altitude (m)	2140	2100	2120	2200	2200	2250	2300	2030	2080	2150	2080	2160	2100	2150	2080	**E**	**R**
Exposure (aspect)	NW	NW	N	N	NW	NW	N	NE	NE	E	E	E	E	N	NW	**Q**	**E**
Inclination (%) (slope)	90	90	80	70	40	60	70	75	90	80	80	85	70	80	70	**U**	**S**
Height of the shrub layer (m)	3	3	3.5	3	3.5	3.5	3	3.5	3.5	3.5	3.5	3.5	4	3.5	3.5	**E**	**E**
Coverage of the shrub layer (%)	100	90	80	90	90	85	90	90	80	90	70	70	80	80	80	**N**	**N**
Height of the herb layer (cm)	40	50	40	40	50	50	50	50	40	40	50	60	50	50	50	**C**	**C**
Coverage of the herb layer (%)	10	50	70	40	60	80	40	50	70	60	60	50	75	60	65	**Y**	**E**
Characteristic and differential species of the association *Anemono narcissiflorae–Betuletum litwinowii*																	
Betula litwinowii	4.4	4.4	4.4	4.5	5.5	4.4	5.5	4.4	4.5	5.5	4.4	4.4	4.4	3.4	3.3	100	v
Anemone narcissiflora subsp. *narcissiflora*	1.2	2.2	3.3	1.2	2.3	3.3	2.2	2.2	3.3	3.3	3.3	3.3	4.4	2.2	3.4	100	v
Aconitum nasutum	+1	+1	+1	1.1		1.1	+1				+1	+1	1.1			60	iv
Lilium carniolicum subsp. *ponticum*	+1	+1	+1	+1		+1	+1	+1	+1	+1						53	iii
Helianthemum nummularium		1.2	1.2					+1	1.2	1.2	2.2	1.2			1.2	53	iii
Euphorbia squamosa		+1	11											1.1	1.1	27	ii
Characteristic species of the alliance *Lilio pontici–Anemonion narcissiflorae*																	
Veratrum album	+1	+1	1.1		+1	1.1	1.1				+1	+1	+1	2.2	1.1	73	iv
Astrantia maxima subsp. *maxima*		+1	+1			1.1	+1	2.1		1.1	+1	1.1		+1	1.1	67	iv
Chaerophyllum aureum	+1		+1	+1	1.2						+1		+1			40	iii
Geranium psilostemon	+1	+1		1.1							+1			+1		33	ii
Cenaturea helenioides							+1				+1	+1				20	ii
Rhynchocorys stricta													+1		+1	13	i
Cephalaria gigantea			+1										1.1			13	i
Valeriana phu							+1								+1	13	i
Vicia balansae						1.1	+1									13	i
Thymus pseudopulegioides		+1														7	i
Carduus adpressus					+1											7	i
Knautia involucrata								1.1								7	i
Trifolium canescens												+1				7	i
Scabiosa caucasica													+1			7	i
Characteristic species of the alliance *Geranio–Pinion*																	
Hypericum bithynicum	+1			+1	+1								+1			27	ii
Saxifraga rotundifolia													+1			7	i
Aconitum orientale												+1				7	i
Alchemilla heterophylla													1.1			7	i
Characteristic species of the alliance *Swertio ibericae–Nardion strictae*																	
Heracleum apiifolium										+1				+1	1.1	20	ii
Swertia iberica				+1												7	i
Dactylorhiza euxina var. *euxina*					+1											7	i
Characteristic species of the alliance *Vaccinio myrtilli–Rhododendrion caucasici*																	
Rhododendron caucasicum			+1							+1	+1		+1	1.2	1.1	40	iii
Vaccinium myrtillus		1.2		+1				+1	+1	+1	+1					40	iii
Solidago virgaurea subsp. *alpestris*	+1	+1					+1		+1				+1	1.1		40	iii
Characteristic species of the alliance *Centaureo appendicigerae–Senecion taraxacifolii*																	
Anthemis marschalliana subsp. *pectinata*								+1	+1							13	i
Saxifraga sibirica subsp. *mollis*				+1												7	i
Characteristic species of the order *Alchemillo retinervis–Sibbaldietalia parviflorae*																	
Stachys macrantha			+1						+1	+1	+1					27	ii
Taraxacum crepidiforme subsp. *crepidiforme*											1.1			1.2	+1	20	ii
Gentianella caucasea								+1						+1	+1	20	ii
Rumex tuberosus subsp. *horizontalis*					+1									1.1		13	i
Polygonum bistorta subsp. *carneum*	+1	+1														13	i
Phleum alpinum													+1	+1		13	i
Silene saxatilis															+1	7	i
Thymus praecox subsp. *grossheimii*											+1					7	i
Sedum spurium			1.2													7	i
Sedum tenellum					+1											7	i
Minuartia circassica									+1							7	i
Characteristic species of the order *Pino–Piceetalia orientalis*																	
Gentiana asclepiadea	1.1	1.2	+1	1.1	2.2	2.2	+1									47	iii
Aquilegia olympica	+1	1.2	+1	1.1		1.1	1.1									40	iii

Table 2. Continuation

Campanula lactiflora		+1				+1								+1	+1	27	II
Picea orientalis																7	I
Abies nordmanniana subsp. *nordmanniana.*																7	I
Saxifraga rotundifolia													+1			7	I
Ribes biebersteinii					+1											7	I
Characteristic species of the order *Rhododendro–Fagetalia orientalis*																	
Rhododendron luteum	1.2			2.2	1.1	1.2	+1	+1					+1			47	III
Acer trautvetteri	+1		+1	+1	+1					+1			+1			40	III
Lapsana communis subsp. *grandiflora*		+1			+1			1.1								20	II
Companions																	
Sorbus aucuparia	+1	+1	+1	1.1	1.1	2.2	+1				+1		2.2	1.2	1.1	73	IV
Valeriana alliariifolia	+1	1.1		1.1		1.1	+1		+1			+1	2.2	2.2	1.1	67	IV
Silene alba subsp. *eriocalycina*		+1		+1	+1		+1	+1	+1			+1	+1	+1		60	IV
Populus tremula	2.2	1.2				+1	+1	2.2	1.1	+1	1.1					53	III
Pedicularis condensata	+1		+1			1.1		+1	+1			+1		1.1	+1	53	III
Dactylis glomerata subsp. *glomerata*	+1				+1	+1	+1	+1			+1			+1		47	III
Lonicera caucasia subsp. *oientalis*	+1	+1	+1							+1		+1			+1	40	III
Achillea millefolium subsp. *millefolium*	+1		1.1										+1	+1	1.1	33	II
Festuca gigantea	+1			+1	+1					+1						27	II
Briza media								+1		+1	+1	+1				27	II
Trifolium pratense var. *pratense*							+1	1.2			+1		+1			27	II
Juniperus communis var. *saxatilis*	2.2						.	1.2	1.2			1.2				27	II
Silene vulgaris var. *vulgaris*	+1		+1				+1			+1						27	II
Euphrasia rostkoviana								1.1				+1		+1	+1	27	II
Digitalis ferruginea subsp. *ferruginea*			+1	+1			+1			+1						27	II
Dianthus carmelitarum									+1		+1	+1				20	II
Pimpinella saxifraga		1.1	1.1		1.2											20	II
Delphinium formosum							+1				+1	+1				20	II
Gnaphalium sylvaticum			+1											+1		20	II
Daphne mezereum					+1						+1		+1			20	II
Cirsium arvense subsp. *vestitum*			+1			1.1									+1	20	II
Anthyllis vulneraria subsp. *boissieri*								+1	+1		+1					20	II
Rhinanthus angustifolius subsp. *grandiflorus*							+1				+1					13	I
Trifolium rytidosemium									1.2				+1			13	I
Leontodon hispidus var. *hispidus*								1.2	1.1							13	I
Melampyrum arvense var. *arvense*								2.1								13	I
Rubus idaeus					+1		+1									13	I
Salix caprea						+1						+1				13	I
Salix cinerea								+1		+1						13	I
Alyssum murale subsp. *murale*								+1			+1					13	I
Vicia cracca subsp. *stenophylla*										1.2	+1					13	I
Tanacetum coccineum			+1													7	I
Vicia cracca subsp. *cracca*									+1							7	I
Prunella vulgaris	+1															7	I
Agrostis capillaris var. *capillaris*			+1													7	I
Rosa canina								+1								7	I
Polystichum lonchitis															+1	7	I
Lathyrus pratensis							+1									7	I
Juniperus sabina													+1			7	I
Viburnum lantana				+1												7	I
Berberis vulgaris																7	I
Silene multifida												+1				7	I
Senecio plathyphyllus var. *plathyphyllus*	+1															7	I
Pimpinella rhodantha									+1							7	I
Cynosurus cristatus									+1							7	I
Sedum album																7	I
Ranunculus brutius															+1	7	I
Cirsium pseudopersonata												+1				7	I
Cystopteris fragilis				+1												7	I
Phleum pretense	+1															7	I
Aster caucasicus					+1											7	I
Hieracium diaphanoidiceps					r											7	I
Hieracium umbellatum											+1					7	I
Anthriscus nemorosa														+1		7	I

The highest floristic affinity between the associations was due to the fact that such species as *Stachys macrantha, Polygonum bistorta* subsp. *carneum, Anemone narcissiflora* subsp. *narcissiflora, Astrantia maxima* subsp. *maxima, Cephalaria gigantea, Chaerophyllum aureum, Geranium psilostemon, Lilium carniolicum, Valeriana phu, Veratrum album, Thymus pseudopulegioides, Knautia involucrata,* and *Rhynchocorys stricta,* were the common taxa of this vegetation type in NE Anatolia in Turkey. Local vegetation classifications can be useful for some purposes, but regional classifications prevail, as they facilitate communication among the researchers from different areas (Kuželová & Chytrý 2004). There have been many studies on the flora and vegetation conducted both in Turkey (e.g. Karaer & al. 1997; Quezel & al. 1980; Düzenli 1988; Vural 1996; Terzioğlu 1998; Varol & Tatlı 2002; Varol & al. 2003; Parolly 2004; Terzioğlu 2005), and in Europe (e.g. Prieditis 1997; Doležal & Šrůtek 2002; Filipak & Kosiński 2002; Gallizia-Vuerich & al. 2002; Motta 2002; Blasi & al. 2003; Kuželová & Chytrý 2004; Poldini & al. 2004; Sebastiá & al. 2005; Stanisci & al. 2005; Willi & al. 2005; Banásová & al. 2006; Petrík & al. 2006). The results of such and other studies need to be communicated on regional and global scale for the purpose of determining biodiversity and for development of conservation strategies.

Diversity and spatial patterns of the associations

Table 3 represents the α diversity results for 13 associations described in the study area and based on the ANOVA test. All associations differed significantly ($p < 0{,}001$). According to the species richness, *Fago orientalis-Castaneetum sativae* had a greater number of species, while *Equiseto fluviatili–Lythretum salicariae* had few. *Oplismeno undulatifolii–Alnetum barbatae, Gentiano pyrenaicae–Nardetum strictae* and *Anemono narcissiflorae–Betuletum litwinowii* associations included 3.192, 3.176 and 3.104, respectively. Also, the species evenness value of *Vaccinio myrtilli–Rhododendretum caucasici* was higher than of the others. Given the calculation of β diversity values of all associations, *Agrostio lazicae–Sibbaldietum parviflorae* had higher values (Whittaker Bw: 4.676; Cody Bc: 116.5 and Wilson & Shmida Bt: 4,792),

Table 3. Alpha diversity variation for all associations in the study area based on ANOVA.

Associations	Sample	Shannon-Wiener	Simpson	Species richness	Evenness	Berger-Parker
1	16	3.049 ± 0.160 **cd**	37.736 ± 8.832 **c**	24.310 ± 3.720 **cd**	0.619 ± 0.032 **a**	0.125 ± 0.024 **a**
2	13	3.002 ± 0.134 **cd**	30.552 ± 6.872 **abc**	24.000 ± 3.190 **cd**	0.661 ± 0.030 **abc**	0.171 ± 0.032 **abc**
3	13	2.976 ± 0.135 **cd**	28.248 ± 5.068 **abc**	23.380 ± 2.790 **bcd**	0.616 ± 0.028 **a**	0.157 ± 0.029 **ab**
4	10	3.176 ± 0.182 **d**	52.403 ± 19.563 **d**	27.200 ± 4.390 **cd**	0.662 ± 0.038 **abc**	0.115 ± 0.023 **a**
5	11	2.708 ± 0.120 **abc**	19.946 ± 3.490 **ab**	18.180 ± 1.990 **ab**	0.646 ± 0.029 **abc**	0.203 ± 0.034 **bc**
6	13	2.687 ± 0.245 **abc**	20.480 ± 5.461 **ab**	18.080 ± 3.660 **ab**	0.606 ± 0.055 **a**	0.223 ± 0.046 **c**
7	9	2.505 ± 0.288 **ab**	19.169 ± 5.072 **ab**	14.890 ± 4.040 **a**	0.670 ± 0.077 **abcd**	0.197 ± 0.032 **bc**
8	11	2.851 ± 0.576 **bcd**	31.290 ± 12.686 **bc**	22.270 ± 6.900 **bc**	0.658 ± 0.133 **abc**	0.174 ± 0.097 **abc**
9	3	2.454 ± 0.170 **a**	17.404 ± 2.459 **a**	14.000 ± 2.650 **a**	0.753 ± 0.052 **d**	0.202 ± 0.038 **bc**
10	11	2.470 ± 0.131 **a**	20.536 ± 4.245 **ab**	13.640 ± 1.690 **a**	0.653 ± 0.035 **abc**	0.193 ± 0.028 **bc**
11	8	3.192 ± 0.109 **d**	37.355 ± 4.945 **c**	28.880 ± 2.850 **d**	0.728 ± 0.025 **cd**	0.127 ± 0.027 **a**
12	15	2.989 ± 0.107 **cd**	29.265 ± 4.803 **abc**	23.470 ± 2.360 **bcd**	0.640 ± 0.023 **ab**	0.141 ± 0.025 **ab**
13	5	3.104 ± 0.159 **d**	30.675 ± 7.061 **bc**	27.200 ± 4.440 **cd**	0.715 ± 0.037 **bcd**	0.159 ± 0.015 **ab**
Total	138	2.879 ± 0.318	29.448 ± 12.057	21.750 ± 5.670	0.651 ± 0.062	0.166 ± 0.051
F		*11.657*	*13.512*	*17.247*	*4.907*	*8.028*
Significance		*0.000*	*0.000*	*0.000*	*0.000*	*0.000*

Legend:

1, *Anemono narcissiflorae–Betuletum litwinowii***; 2,** *Sedo stoloniferi–Piceetum orientalis***; 3,** *Stachyo macranthae–Polygonetum carnie***; 4,** *Gentiano pyrenaicae–Nardetum strictae***; 5,** *Agrostio lazicae–Sibbaldietum parviflorae.* **6**. *Anthemido creticae–Centaureetum appendicigerae*; **7**, *Vaccinio myrtilli–Rhododendretum caucasici*; **8**, *Piceo orientalis–Fagetum orientalis*; **9**, *Equiseto fluviatili–Lythretum salicariae*; **10**, *Epimedio colchici–Pinetum sylvestris*; **11**, *Oplismeno undulatifolii–Alnetum barbatae*; **12**, *Otanthi maritimi–Euphorbietum paraliades*; **13**, *Fago orientalis–Castaneetum sativae.*

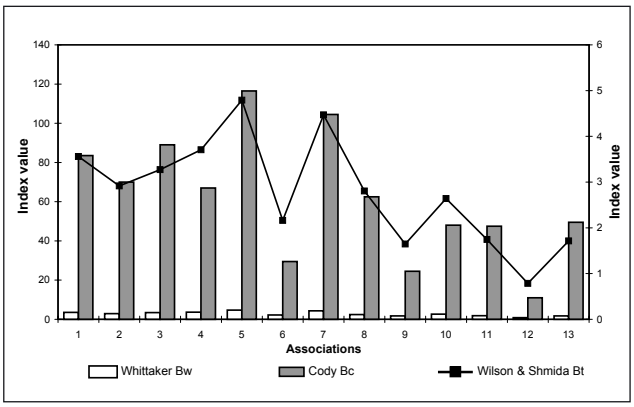

Fig. 2. Beta diversity variation for the associations.

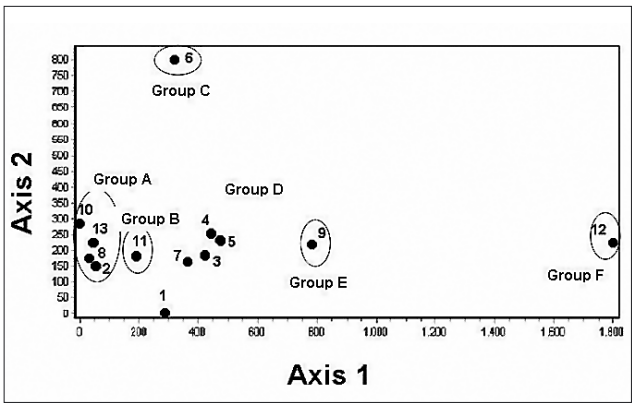

Fig. 3. PCA ordination of 13 associations by species coverage (associations' numbers correspond to those in Table 3).

while *Otanthi maritimi–Euphorbietum paraliadis* showed 0.857, 11.0 and 0.786, respectively (Fig. 2). Fig. 3 indicates the ordination of associations in terms of the species coverage in the relevés. All associations could be divided into six functional groups using the PCA analysis. This result corresponds to the field observations, surveys and species compositions findings. According to PCA, Group A had 13, 2, 8, and 10; Group B – 11; Group C – 6; Group D – 1, 3, 5, 4, and 7; Group E – 9, and Group F – 12. In terms of these findings, the association *Otanthi maritimi–Euphorbietum paraliadis* was related to axis 1 and *Stachyo macranthae–Polygonetum carnei* relatively correlated most with axis 2 (Fig. 3).

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