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The diversity of ground cover species in rocky, roadside and forest habitats in Trabzon (North-Eastern Turkey)

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The ground cover species assemblages in rocky, roadside and forest habitats in Trabzon (north-eastern Turkey), were studied to describe floristic structures and disclose diversity pattern. To provide a quantitatively based classification of these assemblages, both two-way indicator species analysis (TWINSPAN) and detrended correspondence analysis (DCA) were used. Nine groups for rocky habitats sampled from 100 sites, 10 groups for 100 roadside sites and four groups for 50 forest sites were classified. These groups primarily correspond to different effects of altitude, pH, sand, cover, skeleton and moisture content. Some alpha and beta diversity indices for each habitat and TWINSPAN groups at different altitudinal zones were assessed. Our results supported the hypothesis that altitudinal and other environmental properties have significant influences on species composition and diversity in three habitats, being similar to that on major vegetation composition.

Key words: floristic diversity, diversity indices, ground cover species, Trabzon, north-eastern Turkey.

Introduction

Most studies on ecological processes in any scale, have attempted to assess existing landscape areas by classifying some biotic and abiotic features, such as foremost vegetation structure and soil attributes (Gauch, 1982; ter Braak, 1987; van Tongeren, 1987). Despite major vegetation types and diversity investigated in Turkey, few empirical studies on the floristic diversity of azonal or extrazonal vegetation structure at a landscape level have been carried out (Kehl, 1998). Moreover, the components of species diversity have been recently integrated into site classification in describing and mapping landscape habitat types in forestry (Altun, 1997). Beside this study, the genetic diversity structures of most of the natural tree species have been conducted for *in situ* and *ex situ* nature conservation (Işik et al., 1995; Kaya & Raynal, 2001). However, plant diversity in habitats subjected to natural and anthropological effects such as rocks and roadsides was less documented (Acar & Var, 2000).

This paper attempts to contribute to the extension of the understanding of the relationship between species diversity and local ecosystems in biological-ecological application. The objective of this study was to describe the floristic structure and diversity of ground cover vegetation in the province of Trabzon, presenting general char-

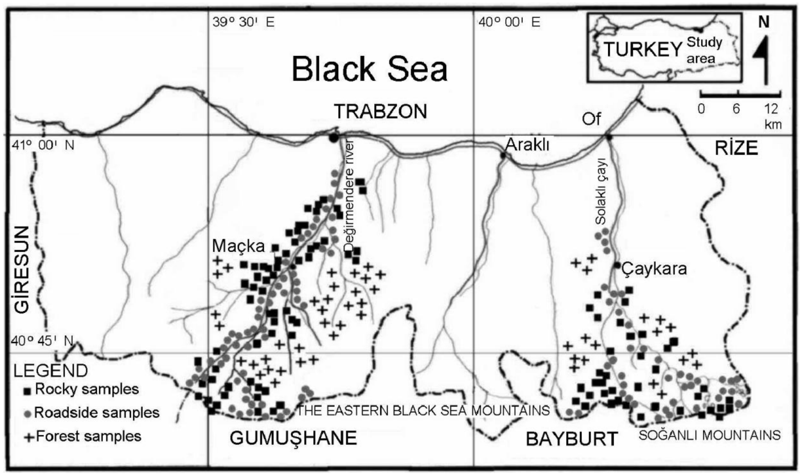

Fig. 1. Study area and the location of sample plots.

acteristics of vegetation pattern in north-eastern Turkey. In this context, we investigate following questions of basic diversity interest; 1) How do the floristic composition and diversity change along the rocky, roadside and forest habitats in relation to main vegetation?, and 2) Is the plant diversity in these habitats and their ecological groups affected by altitude, similarly to major vegetation types?

Material and methods

Study area

The study was carried out across two main river basins (Değirmendere and Solaklı in Trabzon province (40°33′–41°07′ N latitudes and 39°14′–39°45′ E longitudes), north-eastern Turkey (Fig. 1). The ecological characteristics of these river basins were described in detail by Acar & Var (2000). Briefly, the morphology is roughly mountainous, ranging from 0 to 3500 m in height. Volcanic and plutonic rocks dominate the geological structures of the region. A majority of the soils are podsolic with low values resulting from washing under high precipitation. The climate of the study area is similar to the Black Sea Climate Type of the region (Erinc, 1969); the winter is mild and rainy, the summer is moderately hot. The Değirmendere river basin has a short period of water deficit in summer season, but the deficit has not been observed in the Solaklı river basin. In the study area, the three major vegetation types dominate: pseudomaquis, forest, and alpine (Davis, 1965–1985; Anşin, 1980).

Sampling procedure

Floristic and environmental data were collected from June to September in 1997–2000. The habitats were sampled at three altitudinal zones (0–400 m, 400–1800 m and over 1800 m): 100 sample plots for rocky habitats, 100 plots for roadside habitats and 50 plots for forest habitats. The species occurrence and percent cover were recorded in mainly small quadrates (25 m^2). All species were identified in the Herbarium of Forestry Faculty, Karadeniz Technical University. Taxa names given in this study conform to those of Davis (1965–1985). In addition to floristic data, topographic (altitude, exposure, slope) features were recorded and soil samples were taken from 0–50 cm depth soil profiles for each plot. Soil samples were analyzed to describe some physical and chemical properties (soil texture, skeleton, organic matter, moisture content and pH) in the laboratory according to Gülçür (1974).

Data analysis

In order to analyse variation in the floristic composition and to obtain their environmental relations, two-way indicator species analysis (TWINSPAN) and detrended correspondence analysis (DCA) were used, classifying and ordinating the species/samples data matrix in three habitats (Hill, 1979a,b). TWINSPAN analysis is a polythetic and divisive classification technique and produces indicator species for each sample plot. Using DECORANA programme, DCA was performed to explore the relationship between the species composition of each habitat and the environmental variables (Hill, 1979b; Hill & Gauch, 1980). In this process, the cover data were transformed using five-point scale: 1 = 1–10%, 2 = 11–25%, 3 = 26–50%, 4 = 51–75%, 5 = 76–100%. Also, species cover data were ordinated with two axes and the data set of the environmental variables.

Some following alpha and beta indices were used to assess species diversity based on the floristic data for each habitat and the TWINSPAN groups. The species richness was regarded as the number of species encountered in each plot. The Shannon-Wiener index ($H' =$

$-\Sigma P_i \ln P_i$), where $P_i = n_i/N$ (ni is the number of individuals of the species i, and N is the total number of individuals), a measure to indicate the structural composition of the communities, and Pielou's evenness index ($J' = H'/\log S$), where S is the number of species) (MAGURRAN, 1988) were calculated. The dominance indices of Berger-Parker ($d = N_{\max}/N_T$) and Margalef ($D = (S-1)/\ln N$), ($N_{\max}$ is total dominant species in a habitat type and N_T is the proportion of the total species), were calculated to compare each habitat. The beta diversity indices were also obtained: Whittaker ($\beta_w = S/\alpha - 1$), Cody ($\beta_c = [g(H) + l(H)]/2$) and Wilson-Shmida ($\beta_T = [g(H) + l(H)]/2\alpha$), where α is the average species richness of the samples, g (H) is the number of species and l (H) the number lost moving along the samples (WILSON & SHMIDA, 1984).

To detect any significant differences in the species diversity among habitat types and the TWINSPAN groups, Kruskal-Wallis one-way analysis of variance (ANOVA) was performed using the package SPSS 7.5 for Windows.

Results

Distribution of the ground cover species

A total of 310 plant taxa belonging to 45 families and 146 genera were identified during this study. The best represented families were *Leguminosae* with 40, *Compositae* with 27 and *Labiatae* with 26 species.

In this study, the distribution of species was determined as follows: 250 species in rocky, 175 species in roadside and 112 species in forest habitats (Tab. 1). According to altitudinal zones, sixty-three species at 0–400 m, 146 species at 400–1800 m and 133 species over 1800 m were recorded with a total of 100 sample plots taken from rocks, while in roadsides with 100 sample plots, these zones had 46, 101 and 96 species, respectively. The forest habitats were sampled both with 17 plots at 400–1000 m dominated by hardwood and softwood trees where 57 species were recorded, and 33 plots at 1000–1800 m dominated by conifer trees where 92 species were recognised.

Classification and ordination

TWINSPAN analysis revealed nine vegetation groups for rocks, ten vegetation groups for roadsides and four vegetation groups for forest sites, representing a specific species composition according to the most abundant species. In rocky habitats, TWINSPAN suggested two groups (H, I) at level 2 of the classification, three groups (A, B, G) at level 3 and four groups (C, D, E, F) at level 5. The first TWINSPAN dichotomy differentiated the 100 sample plots into two main groups in terms of organic matter and moisture content. The eigenvalues of the subdivisions down to the level 5 were between 0.489 and 0.417, including the first dichotomy value at 0.724. According to Fig. 2a, the most prominent species are consisting of *Fragaria vesca* in Group A, *Geranium purpureum* in Group B, *Ajuga orientalis* in Group C, *Hedera helix*, *Dianthus armeria* subps. *armeria, Sedum spurium* and *Galium palustre* in Group D, *Anagallis arvensis* in Group E, *Sempervivum minus* var. *minus* in Group F, *Anthemis tinctoria* var. *tinctoria* in Group G, *Campanula tridentata*, *Astragalus oreades*, *Sedum tenellum*, *Sedum pilosum* and *Draba polytricha* in Group H, and *Viola altaica* subsp. *oreades, Alchemilla caucasica* and *Sedum spurium* in Group I.

The roadside habitats were composed of one group (J) at level 2, four groups (I, H, G, A) at level 3, three groups (B, E, F) at level 4 and two groups (C, D) at the level 5. The first TWINSPAN dichotomy differentiated 100 sample plots into two main groups with regard to soil depth. The first dichotomy has the eigenvalue of 0.621, while the values of the subdivisions down to levels 4 and 5 ranged from 0.354 to 0.400. Fig. 2b indicates that the most abundant characteristic species are *Astragalus viridissimus* in Group A, *Veronica persica, Pethorhagia saxifraga, Lathyrus laxiflorus* subsp. *laxiflorus* and *Coronilla varia* subsp. *varia* in Group B, *Polygala pruinosa* and *Geranium robertianum* in Group C, *Anagallis arvensis* in Group D, *Stachys annua* subsp. *annua* in Group E, *Trifolium repens* var. *repens* in Group F, *Anthemis tinctoria* var. *pallida* in Group G, *Hypericum bithynicum* in Group H, *Gypsophila sileneoides* in Group I and *Sibbaldia parviflora* var. *parviflora* in Group J. These roadside species groups revealed some pioneer species in regard to components of natural communities, such as those of degraded conditions (Group B, D, F and I).

In the forest sites, four groups were obtained at the third division of the TWINSPAN classification, which consist of one group (D) at level 1, one group (A) at level 2 and two groups (B, C) at level 3. The eigenvalues of all dichotomies ranged from 0.347 to 0.491. As given in Fig. 2c, the species were included: *Campanula allariafolia* (Group A), *Ranunculus cappodocicus* (Group B), *Cardamine hirsuta, Potentilla elatior* and *Galium odoratum* (Group C) and, *Hedera colchica* (Group D). The first level in the TWINSPAN separated the samples according to sand percentages in the soil.

The diagrams produced by DCA are given in Figs 3a,c,e. In these figures, the vegetation groups based on species cover data in each habitat

Table 1. Ground cover species composition based on percent frequency of occurrence (%) in three habitats in Trabzon. Species occurring in more than 10% of the respective habitats are given.

	Rocky						**Roadside**						**Forest**			
Species	0–400		400–1800		1800 <		0–400		400–1800		1800 <		400–1000		1000–1800	
	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N
Woody species																
Cotoneaster nummularia	.	.	.	.	20	<10	.	.	.	.	.	.	.	.	.	.
Daphne glomerata	.	.	.	.	10	25	.	.	.	.	<10	<10	.	.	<10	<10
Genista tinctoria	23	14	22	15	.	.	.	.	<10	<10	.	.	.	.	.	.
Juniperus communis subsp. *alpina*	.	.	<10	<10	<10	25	.	.	.	.	<10	<10	.	.	<10	<10
Rhododendron caucasicum	.	.	.	.	<10	33	.	.	.	.	.	.	.	.	.	.
Vaccinium myrtillus	.	.	.	.	20	50	.	.	.	.	.	.	.	.	<10	13
V. uliginosum	.	.	.	.	<10	33	.	.	.	.	<10	<10	.	.	.	.
Herbaceous species																
Ajuga orientalis	.	.	.	.	40	33	.	.	.	.	14	<10	.	.	.	.
A. reptans	.	.	.	.	.	.	.	.	<10	<10	.	.	<10	30	.	.
Alchemilla barbatiflora	.	.	<10	10	.	.	.	.	.	.	.	.	.	.	33	21
A. caucasica	.	.	.	.	40	33	.	.	<10	17	36	22	.	.	.	.
A. erythropoda	.	.	<10	<10	30	<10	.	.	.	.	21	11	.	.	.	.
A. persica	.	.	17	<10	.	.	.	.	.	.	.	.	.	.	.	.
A. plicatissima	.	.	.	.	.	.	.	.	.	.	<10	22	.	.	.	.
A. retinervis	.	.	.	.	30	42	.	.	.	.	.	.	.	.	.	.
A.rizensis	.	.	.	.	20	<10	.	.	.	.	.	.	.	.	.	.
A. sintenisii	.	.	.	.	<10	<10	.	.	.	.	.	.	.	.	<10	13
Alyssoides utriculata	15	29	17	10	.	.	<10	25	<10	<10	.	.	.	.	.	.
Alyssum alyssoides	<10	<10	22	<10	.	.	.	.	.	.	.	.	.	.	.	.
Anagallis arvensis var. *arvensis*	.	.	<10	<10	.	.	14	25	<10	<10	.	.	.	.	.	.
Anemone blanda	.	.	<10	25	10	<10	.	.	.	.	14	<10	<10	<10	.	.
Antennaria dioica	.	.	.	.	20	33	.	.	.	.	<10	<10	.	.	.	.
Anthemis cretica subsp. *argaea*	.	.	.	.	20	<10	.	.	.	.	.	.	.	.	.	.
A. marschalliana var. *pectinata*	.	.	<10	<10	10	17	.	.	.	.	<10	11	.	.	.	.
A. tinctoria var. *pallida*	54	29	22	25	10	<10	29	50	22	<10	29	<10	.	.	.	.
A. tinctoria var. *tinctoria*	<10	<10	13	<10	10	<10	.	.	.	.	.	.	<10	10	.	<10
Anthyllis vulneraria subsp. *boissieri*	.	.	.	.	10	17	.	.	.	.	<10	11	.	.	.	.
Arenaria rotundifolia subsp. *rotundifolia*	.	.	.	.	<10	<10	.	.	.	.	14	11	.	.	.	.
Asperula pontica	.	.	.	.	<10	17	.	.	.	.	21	11	.	.	.	.
Asplenium trichomanes	<10	43	<10	10	<10	.	.	.	.	.	.	.	.	.	33	<10
Astragalus oreades	<10	14	.	.	50	<10	.	.	.	.	29	<10	.	.	.	.
A. viciifolius	<10	<10	22	15	.	.	.	.	<10	<10	.	.	.	.	.	.
A. viridissimus	<10	14	<10	15	<10	<10	.	<10	<10	<10	<10	<10	.	.	.	.
Bellis perennis	.	.	<10	<10	.	.	<10	<10	.	.	.	.	.	.	<10	13
Berteroa orbiculata	15	<10	<10	<10	.	.	.	.	.	.	<10	.	.	.	.	.
Bornmuellera cappadocica	.	.	.	.	10	<10	.	.	.	.	.	.	.	.	.	.
Calamintha grandiflora	.	.	<10	<10	.	.	.	.	<10	<10	.	.	<10	10	<10	17
Campanula alliariifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	<10	17
C. betulifolia	<10	14	17	<10	<10	17	.	.	.	.	.	.	.	.	.	.
C. patula	.	.	<10	.	<10	.	.	.	<10	<10	<10	22	.	.	.	.
C. rapunculoides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	33	<10
C. tridentata	.	.	<10	<10	40	50	.	.	.	.	<10	<10	.	.	.	.
Cardamine bulbifera	.	.	<10	20	.	.	.	.	.	.	.	.	.	.	33	<10
C. hirsuta	.	.	<10	10	.	.	.	.	.	.	.	.	.	.	<10	33

Table 1. (continued)

	Rocky						Roadside						Forest			
Species	0–400		400–1800		1800 <		0–400		400–1800		1800 <		400–1000		1000–1800	
	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N
Cardamine impatiens var. *impatiens*	.	.	.	<10	.	.	.	.	.	.	.	.	<10	10	67	<10
Centaurea cheiranthifolia	<10	<10	22	15	.	.	14	<10	11	33	.	.	.	.	.	.
C. nigrifimbria	.	.	.	.	.	.	.	.	.	.	<10	22	.	.	.	.
Cephalanthera longifolia	.	.	<10	<10	.	.	.	.	.	.	.	.	<10	30	<10	21
Chaerophyllum temulum	.	.	.	.	.	.	.	.	22	33	.	.	.	.	.	.
Chamaesciadium acaule	.	.	.	.	20	17	.	.	.	.	.	.	.	.	.	.
Clinopodium vulgare	<10	14	<10	<10	.	.	.	.	<10	<10	.	.	<10	20	<10	25
Clypeola jonthlaspi	.	.	.	.	.	<10	<10	25	<10	<10	14	<10	.	.	.	.
Convolvulus cantabrica	.	.	<10	<10	.	.	43	50	<10	<10	.	.	<10	30	.	.
Coronilla orientalis var. *balansae*	.	.	.	.	20	17	.	.	.	.	.	.	.	.	.	.
C. orientalis var. *orientalis*	<10	<10	<10	<10	.	.	43	75	22	<10	.	.	.	.	.	.
C. varia subsp. *varia*	.	.	.	.	.	.	29	50	14	<10	.	.	.	.	.	.
Cruciata laevipes	.	.	.	.	40	<10	.	.	<10	<10	<10	<10	.	.	.	.
C. taurica	46	14	30	15	.	.	<10	50	16	<10	.	.	.	.	.	.
Cyclamen coum var.*coum*	15	29	<10	45	.	.	.	.	.	.	.	.	<10	40	67	25
Dianthus armeria subsp. *armeria*	<10	14	17	15	.	.	.	.	<10	<10	.	.	.	.	.	.
Doronicum orientale	.	.	<10	20	.	.	.	.	.	.	.	.	<10	<10	.	.
Dorycnium pentaphyllum	.	.	.	<10	.	.	29	25	<10	<10	.	.	<10	10	<10	<10
Draba bruniifolia subsp. *bruniifolia*	.	.	<10	10	20	33	.	.	.	.	<10	33	.	.	.	.
D. polytricha	.	.	.	.	40	50	.	.	.	.	.	.	.	.	.	.
Echium vulgare	.	.	.	<10	.	.	<10	25	.	.	.	.	.	.	.	.
Epimedium pubigerum	.	.	.	.	.	.	.	.	.	.	.	.	<10	80	<10	<10
Erodium moschatum	.	.	<10	.	.	.	<10	25	.	.	.	.	.	.	.	.
Fragaria vesca	.	.	<10	20	.	.	.	.	<10	<10	.	.	<10	20	67	54
Galium odoratum	15	<10	13	<10	.	.	.	.	.	.	.	.	<10	50	67	38
G. palustre	.	.	26	25	.	.	.	.	<10	<10	.	.	.	.	.	.
G. rotundifolium	.	.	<10	10	.	.	.	.	.	.	.	.	<10	50	67	79
G. sylvaticum	46	71	35	10	<10	25	86	50	54	42	.	.	.	.	.	.
G. verum subsp. *verum*	.	.	.	.	.	.	.	.	<10	<10	<10	22	.	.	.	.
Gentiana pyrenaica	.	.	.	.	<10	<10	.	.	.	.	.	.	.	.	.	.
G. verna subsp.*pontica*	.	.	.	.	<10	33	.	.	.	.	.	.	.	.	.	.
Geranium asphaloides	.	.	<10	.	.	.	.	.	<10	25	.	.	.	.	.	.
G. cineraria	.	.	.	.	<10	25	.	.	.	.	.	.	.	.	.	.
G. cinerum var. *subcaulescens*	.	.	.	.	.	<10	.	.	.	.	<10	22	.	.	.	.
G. columbinum	<10	14	.	.	.	.	.	.	.	.	.	.	.	.	.	.
G. gracile	.	.	.	.	.	.	.	.	.	.	.	.	.	.	<10	25
G. purpureum	.	.	<10	<10	.	.	.	.	<10	17	.	.	<10	10	<10	25
G. pyrenaicum	.	.	<10	.	.	.	.	.	35	33	.	.	.	.	.	.
G. robertianum	<10	29	<10	10	.	.	14	50	<10	<10	.	.	<10	60	33	<10
G. sanguineum	.	.	.	.	<10	17	.	.	<10	<10	<10	44	.	.	.	.
Gypsophila silenoides	.	.	22	<10	<10	17	.	.	<10	<10	21	33	.	.	<10	<10
Hedera colchica	.	.	<10	<10	.	.	.	.	<10	<10	.	.	<10	60	33	13
H. helix	15	43	13	10	.	.	.	.	<10	10	.	.	<10	60	<10	<10
Helianthemum nummularium	<10	<10	<10	<10	20	<10	29	<10	16	33	29	11	.	.	.	.
Helichrysum graveolens	.	.	.	.	20	<10	.	.	.	.	29	<10	.	.	.	.
Helloborus orientalis	<10	29	<10	30	.	.	.	.	<10	25	.	.	<10	60	<10	<10

Table 1. (continued)

	Rocky						Roadside						Forest			
Species	0–400		400–1800		1800 <		0–400		400–1800		1800 <		400–1000		1000–1800	
	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N
Hieracium gentile	.	.	.	.	<10	<10	.	.	.	.	.	.	<10	10	<10	<10
Hypericum androsaemum	.	.	.	.	<10	<10	.	.	.	.	.	.	<10	<10	33	13
H. bitynicum	.	.	.	.	<10	.	.	.	<10	17	<10	33	.	.	<10	<10
H. pruinatum	.	.	.	.	20	<10	.	.	<10	<10	43	22	.	.	.	.
H. orientale	.	.	26	10	.	.	.	.	<10	<10	<10	11	.	.	.	.
Lamium maculatum	15	29	<10	<10	.	.	<10	<10	.	.	.	.	.	.	.	.
L. ponticum	15	29	9	10	.	.	.	.	<10	<10	.	.	.	.	.	.
Lathyrus aphaca var. *biflorus*	.	.	.	.	.	.	14	<10	.	.	.	.	.	.	.	.
L. laxiflorus subsp.*laxiflorus*	<10	<10	<10	10	.	.	.	.	<10	<10	.	.	<10	50	<10	<10
L. pratensis	.	.	.	.	.	.	.	.	<10	17	.	.	.	.	.	.
L. roseus	.	.	.	<10	.	.	.	.	<10	<10	.	.	.	.	<10	13
Lathyrus vernus	.	.	.	.	.	.	<10	.	.	.	.	.	<10	70	.	.
Lotus corniculatus var.*alpinus*	.	.	.	.	30	25	.	.	.	.	43	44	.	.	.	.
L. corniculatus var. *corniculatus*	31	<10	26	<10	<10	17	29	25	27	50	<10	33	.	.	<10	<10
L. corniculatus var. *tenuifolius*	.	.	.	.	.	.	14	50	<10	<10	.	.	.	.	.	.
Malcolmia africana	<10	29	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Melilotus papillosa	.	.	.	.	10	<10	.	.	.	.	<10	11	.	.	.	.
M. falcata	<10	.	.	.	.	.	14	<10	.	.	.	.	.	.	.	.
M. officinalis	.	.	.	.	.	.	29	50	14	<10	.	.	.	.	.	.
M. circassica	.	.	.	.	40	58	.	.	.	.	21	44	.	.	.	.
Minuartia imbricata	.	.	.	.	40	<10	.	.	.	.	10	<10	.	.	.	.
M. recurva subsp. *oreina*	.	.	.	.	40	25	.	.	<10	<10	21	<10	.	.	.	.
Muscari armeniacum	15	43	17	35	40	<10	.	.	<10	25	.	.	.	.	.	.
Myosotis alpestris subsp.*alpestris*	23	<10	<10	20	70	33	.	.	.	.	29	22	.	.	.	.
M. sylvatica	.	.	22	35	.	.	.	.	46	17	.	.	.	.	.	.
Onobrychis armena	.	.	.	.	10	17	.	.	.	.	.	.	.	.	.	.
Onosma tauricum var. *tauricum*	23	14	13	10	.	.	29	<10	<10	<10	.	.	.	.	.	.
Origanum vulgare	.	.	<10	10	.	.	14	<10	<10	<10	.	.	<10	10	<10	<10
Oxalis acetosella	.	.	<10	<10	.	.	.	.	.	.	<10	11	<10	10	67	83
O. corniculata	15	<10	.	.	.	.	.	.	<10	<10	.	.	.	.	.	.
Oxyria digyna	.	.	.	.	10	<10	.	.	.	.	.	.	.	.	.	.
Pachyphragma macrophyllum	.	.	17	15	.	.	.	.	.	.	.	.	.	.	33	<10
Pethorhagia saxifraga	.	.	13	<10	.	.	14	<10	<10	<10	.	.	.	.	.	.
Pilosella hoppeana	.	.	<10	15	10	25	.	.	<10	<10	21	22	.	.	<10	<10
Polygala alpestris	.	.	<10	<10	<10	25	.	.	<10	<10	14	22	.	.	.	.
P. major	.	.	<10	<10	.	.	29	<10	14	25	<10	11	.	.	.	.
P. pruinosa subsp. *pruinosa*	15	71	<10	30	.	.	29	75	46	17	.	.	<10	20	<10	<10
P. vulgaris	23	<10	.	.	.	.	.	.	.	.	.	.	<10	20	<10	<10
Polygonum bistorta subsp. *carneum*	.	.	.	.	<10	25	.	.	.	.	<10	33	.	.	.	.
Potentilla crantzii var. *crantzii*	.	.	.	.	10	17	.	.	.	.	.	.	.	.	.	.
P. elatior	.	.	<10	10	.	.	.	.	.	.	.	.	.	.	33	17
P. erecta	.	.	.	.	.	.	.	.	.	.	.	.	.	<10	13	

Table 1. (continued)

	Rocky						Roadside						Forest			
Species	0–400		400–1800		1800 <		0–400		400–1800		1800 <		400–1000		1000–1800	
	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N
P. ruprechtii	.	.	.	.	10	17	.	.	.	.	14	<10	.	.	<10	<10
Primula elatior	.	.	<10	15	10	<10	.	.	.	.	<10	<10	<10	<10	.	.
P. elatior subsp. *meyeri*	.	.	.	.	10	17	.	.	.	.	.	.	.	.	.	.
P. elatior subsp. *pseudoelatior*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	33	29
P. vulgaris subsp. *vulgaris*	<10	<10	22	45	<10	17	.	.	11	33	14	11	<10	60	33	42
Prunella vulgaris	.	.	13	<10	.	.	<10	25	14	17	29	44	.	.	<10	54
Psoralea bituminosa	.	<10	.	.	.	.	14	<10	<10	<10	<10	11	.	.	.	.
Pyrola rotundifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	<10	17
Ranunculus cappadocicus	.	.	<10	10	.	.	.	.	<10	<10	.	.	<10	30	33	33
R. caucasicus	.	.	.	.	<10	<10	.	.	.	.	.	.	<10	10	<10	<10
Rumex acetosella	.	.	.	.	10	<10	.	.	.	.	14	11	.	.	.	.
Sagina saginoides	.	.	.	.	10	33	.	.	.	.	.	.	.	.	.	.
Salvia forskahlei	.	.	<10	.	.	.	.	.	<10	.	.	.	.	.	<10	21
S. verticillata	<10	<10	<10	<10	.	.	.	.	14	33	.	.	.	.	.	.
Sanguisorba minor	<10	29	<10	20	.	.	57	50	24	33	.	.	.	.	.	.
Sanicula europaea	.	.	.	.	.	.	.	.	.	.	.	.	<10	20	33	21
Satureja sipicigera	<10	14	<10	<10	.	.	.	.	<10	<10	.	.	.	.	.	.
Saxifraga cymbalaria var. *huetiana*	<10	29	13	30	<10	<10	.	.	.	.	<10	11	<10	10	<10	29
S. paniculata subsp. *cartilaginea*	.	.	<10	10	<10	25	.	.	.	.	<10	11	.	.	.	.
S. rotundifolia	.	.	<10	<10	<10	<10	.	.	.	.	.	.	.	.	33	<10
Scilla bifolia	.	.	<10	10	.	.	.	.	.	.	.	.	<10	<10	.	.
Scleranthus annuus subsp. *annuus*	.	.	.	.	10	<10	.	.	.	.	29	11	.	.	.	.
Scutellaria pontica	.	.	.	.	.	.	.	.	.	.	<10	11	.	.	.	.
Sedum acre	.	.	13	<10	10	<10	.	.	.	.	.	.	.	.	.	.
S. gracile	.	.	13	<10	10	25	.	.	.	.	29	11	.	.	.	.
S. hispanicum var. *hispanicum*	<10	14	<10	10	10	17	.	.	<10	<10	29	<10	.	.	<10	13
Sedum pallidum var. *bithynicum*	69	71	35	40	<10	<10	43	25	24	<10	21	11	.	.	.	.
S. pilosum	.	.	<10	<10	10	17	.	.	.	.	.	.	.	.	.	.
S. spurium	23	43	35	45	50	33	.	.	30	<10	36	56	.	.	33	<10
S. stoloniferum	.	.	26	10	.	.	.	.	.	.	.	.	<10	40	33	63
S. telephium subsp. *maximum*	<10	29	<10	<10	.	.	.	.	.	.	.	.	.	.	<10	.
S. tenellum	.	.	<10	<10	30	42	.	.	.	.	.	.	.	.	.	.
Sempervivum armenum var. *armenum*	.	.	<10	<10	20	<10	.	.	.	.	.	.	.	.	.	.
S. minus var. *minus*	.	.	13	<10	10	<10	.	.	.	.	.	.	.	.	.	.
Senecio vernalis	.	.	.	.	10	<10	.	.	.	.	.	.	.	.	.	.
Sibbaldia parviflora var. *parviflora*	.	.	.	.	50	25	.	.	.	.	<10	67	.	.	<10	<10
Silene saxatilis	.	.	22	<10	<10	17	.	.	.	.	<10	<10	.	.	.	.
S. vulgaris var. *vulgaris*	.	.	<10	<10	.	.	.	.	.	.	<10	22	.	.	.	.
Sobolewskia clavata	.	.	.	.	.	.	.	.	16	<10	.	.	.	.	.	.
Stachys annua subsp. *annua*	23	29	13	15	.	.	29	25	46	17	<10	11	.	.	.	.
S. macrantha	.	.	<10	<10	20	<10	.	.	.	.	<10	11	.	.	.	.
S. iberica subsp. *iberica*	.	.	13	<10	.	.	14	<10	11	<10	.	.	.	.	.	.
Stellaria holostea	.	.	<10	<10	<10	33	.	.	<10	<10	.	.	.	.	.	.

Table 1. (continued)

	Rocky						Roadside						Forest			
Species	0–400		400–1800		1800 <		0–400		400–1800		1800 <		400–1000		1000–1800	
	S	N	S	N	S	N	S	N	S	N	S	N	S	N	S	N
Symphytum asperum	.	.	.	.	.	.	.	.	16	25	.	.	.	.	.	.
S. longipetiolatum	<10	14	.	.	.	.	.	.	.	.	.	.	.	.	<10	<10
Tamus communis	.	.	.	.	.	.	.	.	.	.	.	.	<10	40	.	.
Tanacetum armenum	.	.	.	.	20	<10	.	.	.	.	.	.	.	.	.	.
Taraxacum officinale	.	.	.	.	.	.	.	.	.	.	.	.	.	.	33	<10
Teucrium chamaedrys subsp. *chamaedrys*	23	14	<10	15	.	.	29	25	19	25	.	.	.	.	.	.
T. chamaedrys subsp.*trapezunticum*	.	.	.	.	.	.	.	.	.	.	.	.	<10	20	.	.
T. polium	54	14	17	10	.	.	43	25	<10	<10	.	.	.	.	.	.
Thlapsi arvense	<10	<10	.	.	.	.	.	.	<10	<10	.	.	.	.	.	.
Thymus praecox subsp.*caucasicus* var. *caucasicus*	.	.	17	<10	10	33	.	.	<10	17	21	56	.	.	.	.
T. praecox. subsp. *caucasicus* var.*grossheimii*	.	.	.	.	<10	25	.	.	.	.	57	56	.	.	<10	<10
T. praecox subsp. *jankae* var.*jankae*	.	.	.	.	40	<10	.	.	.	.	14	<10	.	.	.	.
T. pseudopulegioides	.	.	<10	<10	<10	<10	.	.	.	.	14	11	.	.	<10	<10
Trifolium repens var. *repens*	.	.	<10	<10	.	.	29	<10	<10	<10	.	.	.	.	.	.
T. aureum	.	.	.	.	.	.	14	25	14	17	<10	<10	.	.	<10	<10
T. campestre	15	<10	<10	<10	.	.	71	50	38	25	.	.	<10	30	<10	<10
T. canascens	.	.	.	.	.	.	.	.	19	<10	<10	11	.	.	<10	21
T. ochroleucum	.	.	17	<10	10	<10	.	.	<10	25	50	33	.	.	.	.
T. pratense var.*pratense*	<10	14	13	<10	<10	17	43	50	51	67	36	33	<10	20	<10	17
T. repens var. *repens*	.	.	<10	<10	10	33	14	50	14	25	21	22	<10	10	<10	<10
T. rytidosemium var.*rytidosemium*	.	.	.	.	<10	17	.	.	.	.	<10	<10	.	.	.	.
Tripleurospermum oreades var. *oreades*	.	.	17	20	40	33	.	.	11	<10	36	56	.	.	.	.
Tussilago farfara	.	.	17	20	.	.	.	.	.	.	.	.	.	.	.	.
Valeriana alliariifolia	.	.	.	.	.	.	.	.	.	.	<10	11	<10	40	<10	29
Veronica baranetzkii	.	.	.	.	20	<10	.	.	.	.	21	<10	.	.	.	.
V. gentianoides	.	.	.	.	40	33	.	.	.	.	.	.	.	.	.	.
V. officinalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	33	63
V. persica	62	71	43	40	.	.	<10	25	24	<10	.	.	<10	40	<10	13
V. filiformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	<10	21
V. verna	.	.	.	.	<10	17	.	.	.	.	21	<10	.	.	.	.
Vicia cracca subsp. *cracca*	.	.	.	.	.	.	.	.	24	25	<10	11	.	.	.	.
V. sepium	.	.	.	.	.	.	.	.	.	.	.	.	<10	10	<10	<10
Viola altaica subsp. *oreades*	.	.	.	.	10	25	.	.	.	.	.	.	.	.	.	.
V. odorata	15	43	13	25	.	.	.	.	<10	17	.	.	<10	40	33	17
V. reichenbachiana	.	.	<10	<10	.	.	.	.	.	.	.	.	<10	10	<10	13
V. sieheana	.	.	<10	10	10	<10	.	.	.	.	<10	11	<10	10	67	46

were compatible with TWINSPAN results. Ordination of 100 rocky sample plots with TWINSPAN groups superimposed (eigenvalues: axis 1 = 0.775; axis 2 = 0.576; axis 3 = 0.471 and axis 4 = 0.382) revealing that there exists a considerable variability among sample plots. The group I had relatively

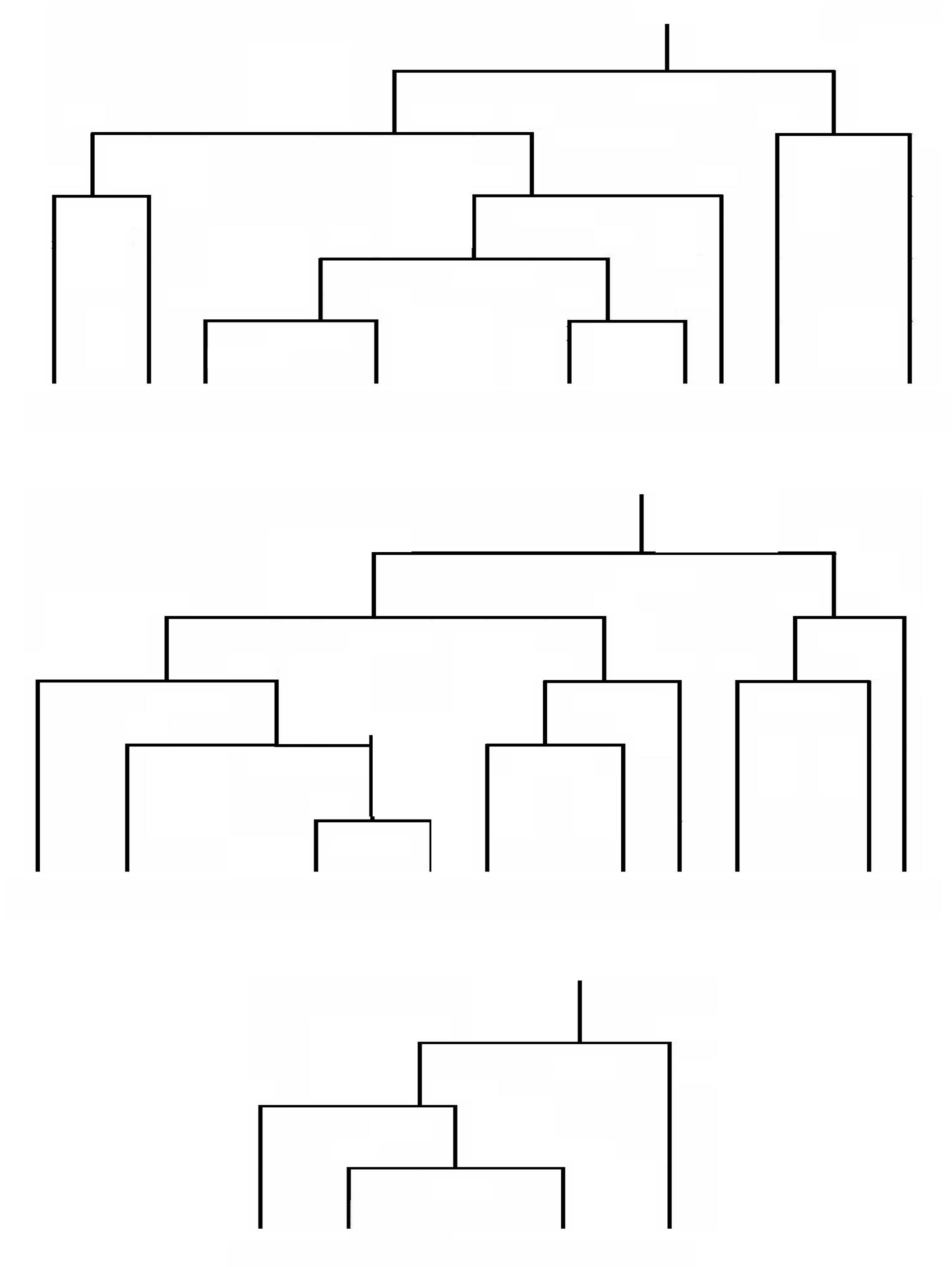

Fig. 2. TWINSPAN classification of groundcover species groups in rocky (2a), roadside (2b), and forest habitats (2c). (Bold letters indicate different groups. The numbers of sample plots are given in parentheses. Species names shown in dichotomies were abbreviated to the first three letters of the genus and the first three of the species, see text and Tab. 1)

Table 2. Mean values (± S.E.M) of the diversity indices for three habitat types.

HABITAT	Species Richness	Shannon-Wiener (H')	Evenness (J)	Berger-Parker Index (d)	Margalef (D)	Whittaker's β_w	Cody's β_c	Wilson-Shmida's β_T
Rocky								
0–400 m	9.25 ± 2.75	2.18 ± 0.31	0.53 ± 0.08	0.12 ± 0.04	3.68 ± 0.74	5.38	48.5	5.24
400–1800 m	12.09 ± 3.65	2.45 ± 0.32	0.50 ± 0.06	0.09 ± 0.04	4.42 ± 0.93	10.08	121	10.01
Over 1800 m	16.77 ± 4.14	2.79 ± 0.26	0.59 ± 0.05	0.06 ± 0.03	5.57 ± 0.98	5.92	99	5.90
Significance	**	**	**	**	**	**	**	**
Roadside								
0–400 m	9.91 ± 2.43	2.27 ± 0.23	0.62 ± 0.06	0.11 ± 0.03	3.87 ± 0.63	2.94	28.5	2.88
400–1800 m	9.84 ± 3.7	2.22 ± 0.38	0.49 ± 0.08	0.12 ± 0.05	3.82 ± 0.98	8.66	85.5	8.69
Over 1800 m	12.30 ± 4.08	2.46 ± 0.34	0.55 ± 0.08	0.09 ± 0.03	4.47 ± 1.03	6.07	78	6.34
Significance	*	*	**	*	*	**	**	**
Forest								
400–1200 m	14.00 ± 2.40	2.63 ± 0.18	0.68 ± 0.05	0.07 ± 0.01	4.92 ± 0.59	2.36	36.00	2.57
1200–1800 m	13.59 ± 3.39	2.57 ± 0.28	0.57 ± 0.06	0.08 ± 0.03	4.80 ± 0.85	5.47	78.50	5.78
Significance	n.s	n.s	**	*	n.s	**	**	**

*: $0.01 < p < 0.05$; **: $p < 0.01$; n.s.: not significant

high scores on the axis 1, while the groups D, E and F had generally lower scores on the axis 2. Plots with low values for the axis 1 are dominated by alpine ground cover species from the right side to the left on this axis, whereas the species in lower altitude could be formed from bottom to top on the axis 2. As it is shown in Fig. 3b, the correlation analysis enabled to identify environmental variables that contribute to variability along DCA ordination axes. Four of the twelve measured factors were significant at $p < 0.001$ (axis 1 = 87%; axis 2 = 4%; axis 1 and 2 = 92% of the variation). Of these factors, skeleton and covering were positively related with the axis 1, while pH was a more negative factor associated with this axis than the others.

The DCA ordination of roadsides (eigenvalues: axis 1 = 0.679; axis 2 = 0.503; axis 3 = 0.435 and axis 4 = 0.415) showed a considerable variability (Fig. 3c). The group I had higher scores on the axis 1, while the groups F, G and H had lower scores on axis 2. Plots with high values for the axis 1 are dominated by the alpine zone species, whilst the species in lower altitude are arranged along the axis 2. As given in Fig. 3d, the correlation analysis showed that seven of the twelve measured factors were significant at $p < 0.001$ (axis 1 = 87%; axis 2 = 5%; axis 1 and 2 = 92% of the variation). Of these factors, cover, sand and skeleton were strongly related to the axis 1, whereas altitude and pH were negatively associated.

As for the forest habitats, the scatter diagram to demonstrate the distribution of the samples along the first and second ordination axes (eigenvalues: axis 1 = 0.504; axis 2 = 0.401; axis 3 = 0.316 and axis 4 = 0.267) suggested distinct covering differences in separating of the groups (Fig. 3e). Group D had relatively high scores on axis 1, while Groups B and C had generally lower scores on axis 2. According to the correlation analysis, plot scores on the first axis of the DCA ordination are correlated with three factors (sand, altitude and pH) being significant at $p < 0.001$ (axis 1 = 88%; axis 2 = 7%; axis 1 and 2 = 95% of the variation) (Fig. 3f).

Diversity of habitat types and ground cover species assemblages

The habitat types denote the differences based on species richness and diversity along altitudinal zones as given in Table 2. Assessing alpha diversity measures, the species diversity differed significantly among rocky habitats, while there was no significant difference in species richness among the roadside and forest sites. There was a strong influence by the high diversity at rocky sites over 1800 m, which had a significantly greater number of species (16.77 ± 4.14) than any other habitats ($p < 0.05$). Compared to indices of each habitat type, the species diversity for rocky habitats showed an increasing trend of variation and ANOVA found significant differences among these habitats ($p < 0.05$). The same trend was not observed in Berger-Parker and evenness indices. However, the forest sites had a reverse trend in diversity, but not index of Berger-Parker, and

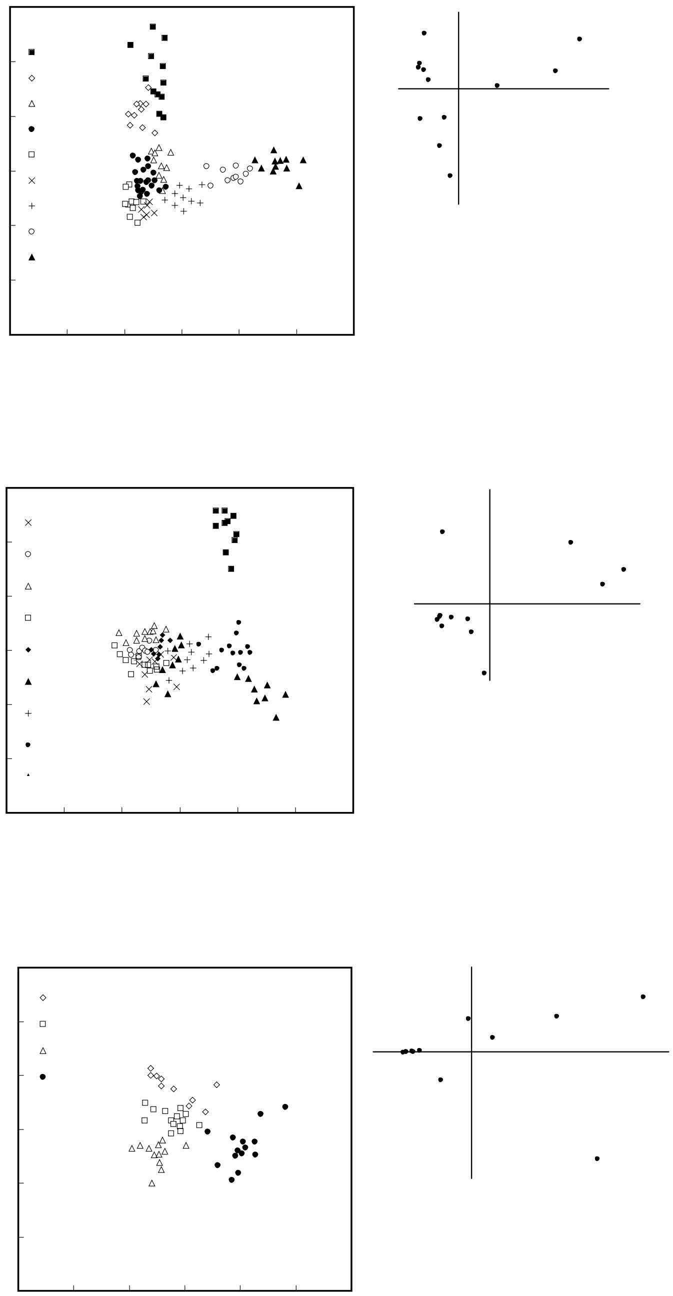

Fig. 3. Two-dimensional ordinations of the sample plots in three habitat types (Fig. 3a,b: rocky, Fig. 3c,d: roadsides, Fig. 3e,f: forest) based on detrended correspondence analysis (DCA) of the cover values. Symbols indicate the TWINSPAN groups for the 100 rocky sample plots (A-I), 100 roadside sample plots (A-J) and 50 forest sample plots (A-D). The scatter plots results of the correlation analyses for the 12 environmental factors measured are represented next to DCA ordinations. Significance levels are given as * ($0.01 < p < 0.05$), ** ($p < 0.001$) and n.s. (not significant).

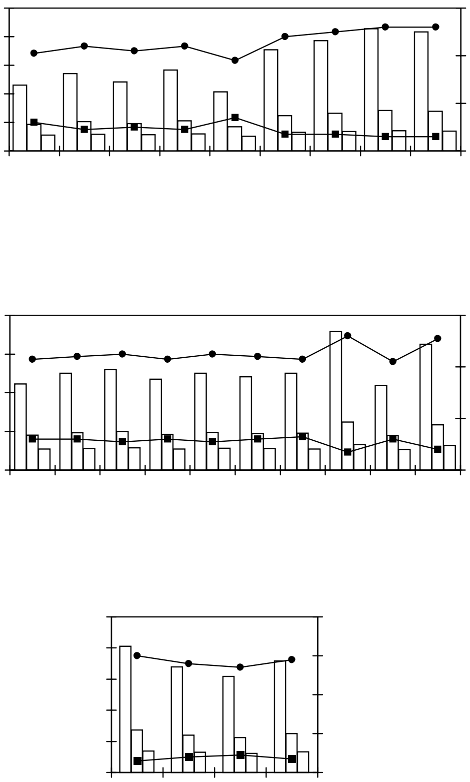

Fig. 4. Variation in richness and diversity of ground cover species assemblages. (Fig. 4a: rocky habitats, Fig. 4b: roadsides, Fig. 4c: forest sites). Significance levels for each group are given as * ($0.01 < p < 0.05$), ** ($p < 0.001$) and n.s. (not significant).
(▭ Species richness (SR), ▧ Margalef (M), ▩ Shannon-Wiener (SW), • Evenness (E), ■ Berger-Parker dominance (BP))

species diversity in the roadsides showed regular trend. Likewise, beta diversity, as measured by Whittaker, Cody and Wilson-Shmida indices in this study, indicated that turnover in composition was not constant along the habitat types. According to Tab. 2, Whittaker index values ranged from 2.36 to 10.08, while Cody and Wilson-Shmida values were found to be between 28.5–121, and 2.57–10.1, respectively. Among habitat types, beta diversity values showed a statistically significant difference at $p < 0.05$ according to ANOVA.

Figs 4a–c represent the variation of TWINSPAN groups for each habitat type in terms of alpha and beta diversity indices. ANOVA test suggested that the species diversity indicates considerable variability among each group in rocky and roadside habitats at $p < 0.01$ and $0.01 < p < 0.05$. However, there is insignificant variability among different species groups in forest sites.

Discussion

For the first time, the ground cover vegetation and diversity was studied in north-eastern Turkey. This study deals with determining ground cover species, and investigating the floristic composition of species in the natural flora of Trabzon province. For this purpose, a total of 250 relevés were sampled in rocky, roadside and forest habitats. The number of the species recorded in three habitats was 310, and this constituted nearly 13.47% of the total species numbers in north-eastern Turkey.

The forest species results were compatible with earlier studies although the results of rocky and roadside habitats could not be discussed because of the lack of studies relating to species distribution patterns in these habitats. In a study conducted by Anşin (1979), who investigated a part of Degirmendere river basin (Meryemana), it was in the pure Oriental spruce stands that *Oxalis acetosella, Galium odoratum, Cardamine impatiens, Cyclamen coum, Fragaria vesca, Veronica officinalis, Geranium gracile* etc. had rich floristic compositions. Similarly, Küçük (1998) defined *Picea orientalis* and *Pinus sylvestris-Vaccinium myritillus* associations on a part of the north-eastern Black Sea Region, Kurtun-Orumcek forests, and described the distinctive species of the association such as *Veronica officinalis, Oxalis acetosella* and *Cyclamen coum.* Quezél et al. (1980) and Akman (1995) also stated some plant associations belonging to vegetation types of the region and some distinctive and similar species in the TWINSPAN groups were determined in our study. They included, for instance, *Pinus sylvestris-Epimedium pinnatum* subsp. *colchicum, Picea orientalis-Sedum stoloniferum* in forest vegetation; *Sibbaldia parviflora-Agrostis lazica, Centaurea appendicigera-Senecio taraxifolia* and *Rhododendron caucasicum-Vaccinium myritillus* in alpine vegetation.

The species diversity for three habitats showed significant differences among habitat types in altitudinal zones (Tab. 2). So, the richness of ground cover species recorded in rocky habitats ranged from 9.25 to 16.77, while the range for roadside and forest sites were 9.84 to 12.30

and 13.59 to 14.00, respectively. Regarding species richness and diversity pattern along altitudinal gradients, several researches have suggested some hypotheses based on climatic severity, relationship between photosynthesis and daytime temperature, disturbance and productivity (RAHBEK, 1995 & 1997; SANDERS, 2002). The results of this study support the hypothesis that altitudinal and other environmental properties would have significant influences on species diversity in forest habitats, being similar to studies on major vegetation composition in rocks and roadsides. The results reported for the forest habitats in this study correspond to Rapoport's rule which refers to a monotonic decrease in species richness with increasing altitude (STEVENS, 1992; COLWELL & HURTT, 1994). But, the species distribution and diversity in rocky and roadside habitats probably suffers from little or no effect of disturbance, and show thereby increasing species diversity at higher altitudes.

As compared with the studies regarding diversity of forest composition or riparian vegetation, the species habitat types and indicator environmental factors characterised by these habitats led to a certain effect (PABST & SPIES, 1998). It can be concluded that altitude in any vegetation structure plays a role on this point; high altitudes cause the decreas of plant species diversity due to extreme environmental or climate factors (AIBA & KITAYAMA, 1999). The species distribution of floristic composition in each habitat type proved that the relations of altitude, species richness and diversity reflected these effects. As compared with the forest compositions, the characteristic species in forest sites in this study correspond with the findings conducted by ANŞIN (1979 and 1980). Furthermore, the forest species assemblages had more species than those of the other two habitats. The reason can be explained in considering that these habitats are more homogenous than the other habitats. Also, considering the total species composition of each habitat group described in this study, the simple relationship between diversity indices values of TWINSPAN groups is evident, indicating that this relationship between each habitat type generally is different.

The species-environment relations in this study were assessed with multivariate analysis techniques suggested by most researches (HILL & GAUCH, 1980; ULLMAN et al., 1995; CILLIERS & BREDENKAMP, 2000). Consequently, a total of 23 functional groups, identified by TWINSPAN and DCA, occur in differing sets of habitat conditions. Considering the defined groups, the species distribution and diversity associated with abundance and covering values in each habitat is clearly different from each other. Among the species groups, the groups from A to G in rocky sites, B to F in roadsides and the group D in forest sites were generally observed in low altitudes, yet other groups in each habitat appeared above 1800 m. The findings obtained from these groups indicated that some groups including species such as *Sedum stoloniferum, Sibbaldia parviflora* var. *parviflora* and *Galium odoratum*, are taxonomically differential species for the given habitats in comparison with the other studies (AKMAN, 1995; KÜÇÜK, 1998; TERZIOĞLU, 1998). PITKÄNEN (1998) discussed some stand variables and diversity indices in the distribution of ground cover vegetation recorded in managed boreal forest of Finland. Along environmental gradients and diversity indices represented by the first and second scores in an ordination of the floristic data, the most significant ones were species richness and evenness, site fertility, stand age, topography and soil type. In the research area, some environmental factors such as altitude, pH, and moisture content in soils influenced the floristic compositions that can occur at different habitats (Fig. 3). The way in which ground cover species in rocks respond to environmental gradients is different from the way in which roadside and forest plants respond to these gradients. Broad trends in the plant species associations were related to what was perceived as an altitudinal gradient across the studied area (Tab. 1). These results can be explained by the hypothesis that available energy limits species richness (NEAVE & NORTON, 1998).

In landscape management, the knowledge on alpha, beta and gamma diversity of habitats is crucial in concern (NOSS, 1983; GRUMBINE, 1994). Therefore, this study has important implications for the ecology of the natural landscape areas. Consequently, future studies should be proposed to examine the management procedures of distinctive habitats or their species groups as given in this study, with respect to priority in conservation, rolling in planning actively and ecologically rehabilitated.

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Sparganium angustifolium (Sparganiaceae) – a new locality in the Carpathians

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Sparganium angustifolium (= *S. affine* Schnizl.) is a circumpolar taxon. Its distribution centre in Europe is in the Scandinavian Peninsula and in the northern part of the European continent. The species reaches its southern limits in the Pyrenees Peninsula, in Alps, and in the east – up to Macedonia. Its patchy occurrence was recorded in the Bohemian Forest (the Czech Republic), in the West Carpathians and in the Balkan Peninsula (Meusel, Jäger & Weinert, 1965; Müller-Doblies & Müler-Doblies, 1980).

In the Carpathian Range, *S. angustifolium* was recorded in four localities of the Tatra Mts in the West Carpathians – two in Slovakia and two in Poland.

In Slovakia, the species was discovered by Kotula (1890) in two glacial lakes: the 2nd and the 3rd Roháčske pleso in the Západné Tatry Mts. The details on the taxon occurrence in the mentioned localities were given by Dostál (1929). The lakes, which are close to each other (with some dozen meters in between them), are situated in the altitude 1650 and 1653 m a.s.l. The lower one, the 2nd Roháčske pleso, has an area of 0.21 ha with max. depth of 1.2 m. *S. angustifolium* stand covers over two thirds of the lake's bottom with approximately 90% cover. In the upper, the 3rd Roháčske pleso, with the area of 0.61 ha and maximum depth 3.7 m, the two large stands of *S. angustifolium* were found. The stand nearby the northern lakeshore was larger, occupying up to 140 m^2 (20 × 6–7 m), though the plant cover was lower there (only about 40%). Outside the continuous stand, the plants were occurring in smaller fragmented colonies. In the second stand of the size 10 m^2 (2.5 m × 4 m), which was close to the southern shore, the cover of *S. angustifolium* exceeded 90%.

In Poland, *S. angustifolium* was found in two neighbouring glacial lakes: Nižny and Vyšny Toporowy staw. These lakes are situated in the altitude 1105 and 1130 m a.s.l., respectively. The lower one, Nižny Toporowy staw, has an area of 0.62 ha and max. depth of 5.9 m. Vyšny Toporowy staw occupies 0.03 ha having the max. depth of 1.1 m. In Nižny Toporowy staw, the species was discovered in 1951, however, only sterile specimens were found (Radwanska-Paryska, 1981). Unfortunately, since 1976 the species has not been confirmed any more in this locality, and it is considered to be extinct (Piękś-Mirkowa, in verb.). In Vyšny Toporowy Lake, growing sterile plants of *S. angustifolium* were found in the area of about 20 m^2 (Piękoś-Mirkowa, 1982). In 2001 and 2002 no specimen was found in this site. It will be seen in the future, whether this phenomenon was caused by natural fluctuation or was due to the species extinction in this locality (PĘKOŚ-MIRKOWA, in verb.).

In August 2003, we have discovered a new locality of the species *S. angustifolium*. The locality is situated in the NW part of glacial lake Nižné Žabie pleso in the Žabia Bielovodská dolina Valley in the Vysoké Tatry Mts in Slovakia, at the altitude of 1674 m a.s.l. The stand covers the area up to 50 m^2 being separated by boulders from the rest of the lake. The granite boulders on the lake bottom are covered with thick layer (more than half a meter) of fine black sediment. Apart from the main colony, there are three other small colonies of *S. angustifolium* of about 1 m^2 in size.

Slovakia, the West Carpathians, the Vysoké Tatry Mts, glacial lake Nižné Žabie Bielovodské pleso (49°12′03″; 20°06′37″), depth 0.4–0.6 m, sample area 16 m^2, 1674 m a.s.l., pH 5.52, conductivity 20.6 μS/cm.E_1: 95%, E_0: 0%, August 14, 2003, (sampled by Dítě, Pukajová), E_1: *Sparganium angustifolium* 5.

Note: Except the conventional habitat variables, pH and conductivity were measured directly in the groundwater using CyperScan PC 300 device. The conductivity values related to the temperature 20 °C, subtracting the hydrogen ions conductivity (SJÖRS, 1950). pH values were re-calculated according to DU RIETZ (sec. SJÖRS, 1950).

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