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Epigeobiont Animal Assemblages from two Landscapes of the Bulgarian Black Sea Coast: Relationship to Habitat Type, Assemblage Structure and Biodiversity
II. Spiders (Araneae)

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Abstract: The spatial pattern, species composition and structure of spider assemblages from two areas along the Black Sea coastal strip were analyzed. The main gradients affecting the spatial pattern of spider assemblages were the moisture, light conditions and structure of vegetation. The geographical gradient was of a secondary importance. The most diversified assemblages occur in open and disturbed sites. However, they were composed by a large number of widely distributed species. The most specific, from zoogeographic point of view, spider assemblages were associated with various natural or semi-natural habitats little influenced by man. The potential limitation of the use of spider pitfall data in applied studies was analyzed.

Key words: gradients, ordination, environmental variables, taxon-guild and zoogeographic spectra, diversity.

Introduction

On the basis of the remarkable diversity of habitats, plant and animal communities, the Black Sea coastal strip has been considered as an area of significant biological diversity (Deltshev et al., 1998) and identified as a region of priority under the National Biological Diversity Conservation Strategy. Our main interests were to document the biological richness of some animal groups in two areas within the coastal strip in order to assess their value as wildlife refuges and to define, on variable scales, the possibilities and constraints of pitfall data for spiders for site assessment and biomonitoring.

Spiders, being „megadiverse“ and ubiquitous group of substantial ecological importance (Coddington et al., 1996), have a potential to reveal early and subtle changes in environmental variables (Turnbull, 1973, Uetz, 1976, 1979), associated with stress and disturbance, which characterize the main value of an indicator group (New, 1995, Churchill, 1997). Although many researches point out that the diversity and abundance of spider taxa exhibit clear shifts across environmental and successional gradients, our detailed and regionally oriented knowledge on the structure and pattern of spider assemblages as well as on ecology of individual species is still poor. The regional differences in the species reaction to the environmental gradients, caused by climatic

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variations across Europe, mean that one can not rely on data collected in other regions. So, in order to refine our knowledge on the responses of spider associations and individual species to various agents of ecological change, special investigations based on ordination analyses were undertaken. The aim was to evaluate their indicator potential with respect to specific disturbance, or natural environmental variables. Relationships between the observed pattern and other structural components of the spider assemblages, such as diversity, functional and zoogeographic composition, can offer a further understanding of the key processes behind the ecological change.

Studied Areas and Sites

Two areas are studied. The northern area (Fig. 1, NA) is situated between the village of Kranevo and the city of Balchik. The southern area (Fig. 1, SA) lies between the river of Ropotamo to the south, and the resort „Kavatsite“ to the north. The sampling sites (Fig. 1, A - Q) were related to the major habitats, considered here as segments of a landscape with relatively homogeneous physiognomy and structure, characterized by a particular set of environmental factors (topography, soil, humidity, and vegetational type). In each area the alphabetical order of the sampling sites (NA: A - J; SA: K - Q) corresponds to the combined gradient of vegetation and humidity - from open and dry sites to moist and wooded ones.

Northern area, sampling sites (Fig. 1, NA: A - J): A (traps A_1, A_2): field margin cropland; B (traps B_1 - B_{12}): short-grass dry steppe on poor soils on the limestone margin of the Dobrudzha's plateau (traps B_1- B_4, B_7- B_{12}), high-grass dry meadow (B_6), occasional bushes and solitary trees (B_5); Ba (traps Ba_1 - Ba_5, preliminary sampling for a short period of one year): short-grass dry steppe on poor soils on the limestone margin of the Dobrudzha's plateau in the nature reserve „Kaliakra“ only one-year sampling (not shown on Fig. 1); C (traps C_1 - C_{13}): shrubs (*Paliureta spina-christi, Amigdaleta nanae*), combined with xerothermal grass communities on well drained marl substrate with poor soils, large exposures of bare ground; Ca (traps Ca_1 - Ca_5, preliminary sampling for a short period of one year): shrubs (*Paliureta spina-christi, Carpineta orientalis*), combined with grass communities on limestone substrate with poor soils, nature reserve Jilata; only one-year sampling (not shown on Fig. 1); D (traps D_1- D_{10}): hedgerows (shrubs of *Prunus spinosa, Rosa* sp. etc. and occasional trees, (*Juglans regia, Prunus divaricata, Acer tataricum*) between cultivated (wheat, maize) fields on clayey soils, on the place of the primary wet forests reduced by drainage and agriculture; E (traps E_1 - E_5): dry mixed oak (*Quercus pubescens* Willd.) and oriental hornbeam (*Carpinus orientalis* Mill.) forest with Mediterranean elements, traps E_1- E_3 were at forest edge and small dry meadows, traps E_4- E_5 - inside of the forest (scarce understory and thick layer of litter); H (traps H_1 - H_4): willow grove and temporal marsh in site with high water table; F (traps F_1 - F_4): rich hygrophilous and mesophilous vegetation, consisting of *Phragmites australis* (Cav.) Trin. ex Stend., *Equisetum* sp. and similar plants, on the banks of small permanent stream, wet and soft soil; G (traps G_1 - G_5): two year-old clearing at the fringe of the wet forest („Baltata“), overgrown with mesic dense shrubs, tall grasses, and new growth of elm and ash-tree; I (traps I_1 - I_{10}) and J (traps J_1 - J_{13}): swamp (longos) forest of field elm (*Ulmeta minoris*) and field ash-tree (*Fraxineta oxycarpae*) of downstream flood plain the river of Batova (nature reserve „Baltata“), wet clayey (J, part of I) or sandy (part of I) soils, covered with a more or

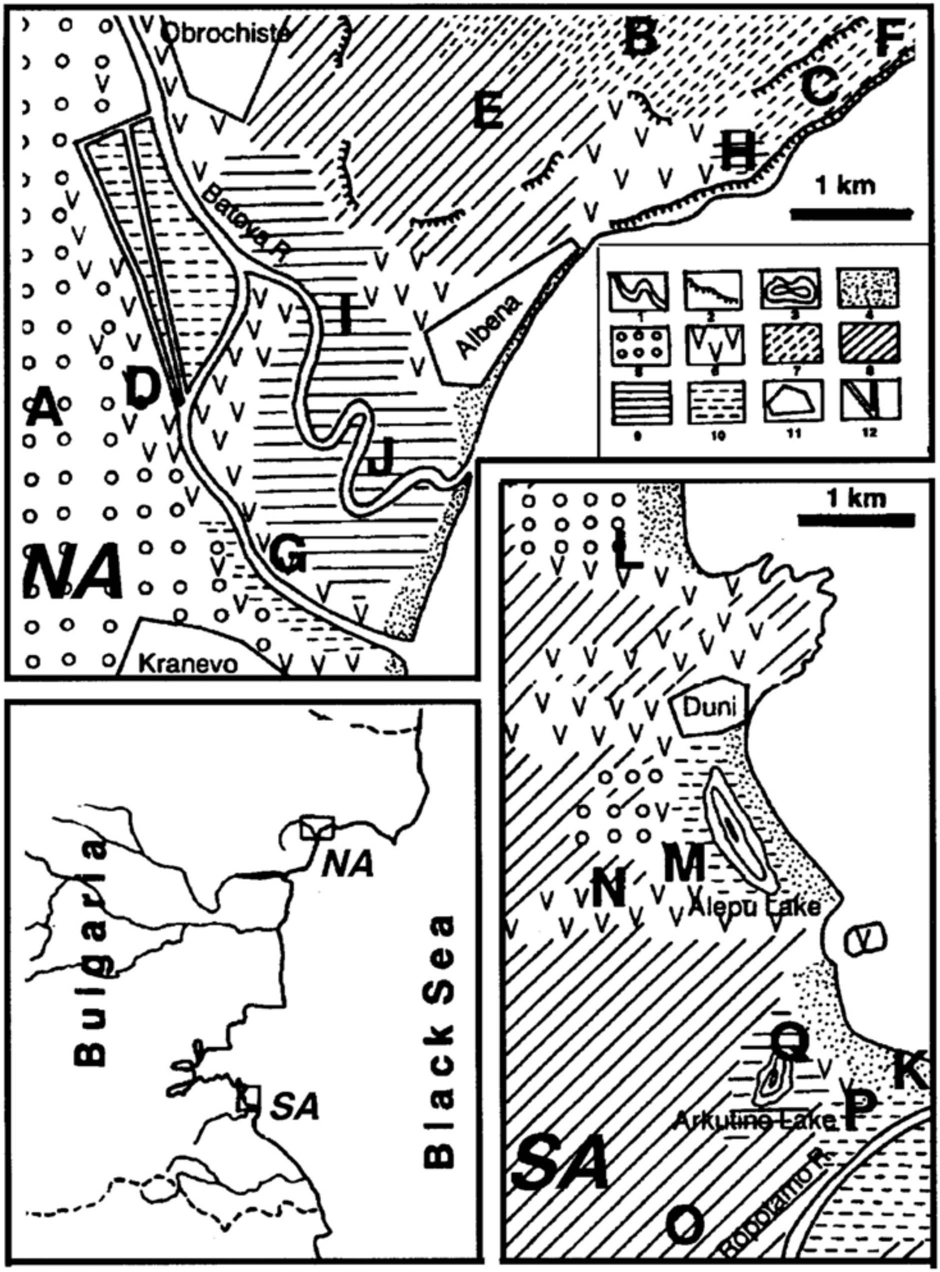

Fig. 1. Location of the studied areas (*NA* - northern area, *SA* - southern area) and sampling sites (A - Q, for details - see text)). Landscape elements: 1. rivers, 2. limestone and marl cliffs, 3. lakes, 4. coastal sand dunes and sand beaches, 5. crops, 6. fallow land, waste places, hedges, rural mosaic, 7. steppes and dry calcareous grassland, 8. dry deciduous forests, 9. swamp forests, 10. water fringe vegetation and mesophilous bushes; 11. villages and resorts, 12. drainage channels.

less thick layer of leaf litter and numerous thrunks in every stage of decomposition, covered with moss; considerable shade; parts of these sites were inundated seasonally (spring, autumn, winter).

Southern area, sampling sites(Fig. 1, SA: K - Q): K (traps K_1- K_2): Sand dune with sparse vegetation - xerophilous grasses and shrubs (*Paliurus spina-cristi*) and high percentage cover of lichens; L (traps L_1 - L_7): a fine grained mosaic of arable fields (L_7), hedgerows (L_5, L_6) and dry meadows on sandy or heavy clayey soils (L_3, L_4); vegetated dune near small steam (L_1, L_2) - particularly dry sandy facies with sparse xerophilous grasses and shrubs (*Prunus spinosa, Rubus* sp.) is combined with hygrophilous vegetation *(Phragmites australis)* (L8); M (traps M_1- M_6): the bank of Alepu lake covered with marshy hydrophilous vegetation, sparse willow and poplar groves with lower level of *Rubus* sp.;N (traps N_1- N_5): oak forest with young coniferous stand near its edge; O (O_1- O_{11}): more or less light deciduous forests (*Fraxinus ornus* with dense low evergreen shrub layer of *Ruscus aculeatus*) on rocks, alluvial or sandy soils and sand dune above a marsh near the river of Ropotamo; P (traps P_1- P_4): light dry forest (*Fraxinus ornus*) near the river; Q (traps Q_1 - Q_3): swamp forest (*Ulmeta minoris, Fraxineta oxycarpae*) inundated seasonally (nature reserve "Arkutino").

Material and Methods

1. Sampling

At each site irregular transects of permanent pitfall traps were established. The intertrap distances were 50 - 200 m so as to represent independent samples of respective microhabitats. The traps were cylinders (8 cm in diameter at the opening and 25 cm in depth), made from transparent plastic 1.5 litter bottles by cutting out their upper parts which were dug at ground level, and filled with water solution of formalin (2 - 10 %) to a depth of approximately 10 cm. Each pitfall was supplied with a drainage hole, situated 15 cm from the bottom. The traps were run continuously during the snow-free periods of each year and were emptied at intervals of about 1 month. Monthly catches were pooled to obtain totals for each trap for the entire five-year period of study (1.04. 1993 - 15. 10. 1997).

2. Material

This study is based on 7012 specimens, belonging to 206 species. These figures per area are as follows: northern area - 164 species, 5250 specimens; southern area - 123 species, 1762 specimens. The whole material is deposited in the collections of the Institute of Zoology, Sofia.

3. Data Analysis

We used pooled data from each trap in the further analyses. In this way we characterized the spider assemblages in individual microsites, having the possibility to control quantitatively the effect of microhabitat environmental variables. We standardized species catches to percentage of the sample total, so that the analyses showed up changes in the assemblage structure, rather than in the the actual numbers caught.

The following three multivariate approaches were applied to summarize the above pitfall data and to reveal the main spatial patterns: 1. indirect gradient analysis based on principal component analysis (PCA) and (detrended) correspondence analysis [(D)CA)]; 2. direct gradient analysis, based on redundancy analysis (RDA), and canonical correspondence analysis (CCA); and 3. two-way indicator species analysis (TWINSPAN) (see van Tongeren, 1987, and ter Braak, 1987, for description of the techniques). As a result homogene spatial assemblages were deifined. At the subsequent phases of the study these spider assemblages were analyzed in a greater detail in terms of diversity, taxonomic and zoogeographic structure.

The diversity was considered as composed by the following elements - point diversity (diversity at microhabitat level, represented by individual pitfall samples), alpha-diversity (diversity of spider spatial assemblages which were associated with small areas of homogeneous habitat type), beta-diversity (rate of change of species composition across habitats) and gamma-diversity (changes along the geographic gradient, i. e. differences between areas). The effect of various habitat parameters (see bellow), (ML, MSM, SDGS, SDSS, DS, AREA) on the diversity measurements was tested. The assemblages Ba and Ca, based on a short sampling period, were not included in these analyses.

We used rarefaction for independent examination of the species richness (ES), (Heck et al., 1975). In addition twenty one-parameter diversity indices, available in the BIODIV software package (Baev, Penev, 1995), have been used in order to describe the diversity of assemblages.

In order to reveal the regularities determining the functional composition of spatial spider assemblages, they were separated into functional units, composed of species with similar ecological strategy. This approach has been advocated to increase the understanding of the processes maintaining the biodiversity (Walker, 1992). The following groups were considered in this respect: ground hunters (GH), ground web-builders (GW), aerial web-builders (AW) and aerial hunters (AH), (Coddington et al., 1996). Additionally, in each assemblage the species were grouped according to family. In this way an attempt to obtain ecologically homogene groups was made. It is known that most spider families differ in their primary foraging mode (Canard, 1990). More over, the most important taxonomic characters at family level, such as size and arrangement of eyes, legs and silk producing organs, are directly related to the perception and use of important environmental components, including prey (Churchill, 1997). Combining the above functional groups and families, 16 final groups were obtained. These groups can be regarded as taxon-guilds - groups of closely related (confamilial) species that exploit the same class of environmental resources in a similar way (Schoener, 1986, Simberloff, Dayan, 1991). Root (1967) considered guild associates to be moulded by adaptation to the same class of resources, but also by competition among themselves. Thus, by analyzing the guild structure the role of the competition in the structuring of the entire community can be inferred. The usefulness of the taxon-guilds relates to the possibility to overcome the problem of the paucity of detailed information on the biology and ecology of many species.

The relatively large number of species identified throughout the study provides possibilities to analyze in detail the zoogeographic composition of the assemblages. The aim is twofold: 1) to reveal the role of the environmental gradients in forming the recent fauna and 2) to identify habitats supporting species with restricted ranges and assemblages composed by regionally specific species. The occurrence of endemic species in a particular assemblage is often considered as an important criterium in evaluating the conservation value of the respective sites and habitats. A species is endemic, if restricted to a particular area for historical, ecological or physiological reasons (Major, 1988). On the other hand, there are no criteria where the boundary should be placed, separating the whole range of area sizes, on endemic and non-endemic. In order to avoid the subjectivity in this respect, we typify the distributional ranges of the observed species and arrange them from wide (Cosmopolites, Holaractic, Palaearctic, West-Palaearctic) to the most restricted ones - Bulgarian endemics. In the analyses special attention is paid to species with ranges characteristic for this part of Europe and to species with more restricted ranges, characteristic for the particular areas under study.

As a rule, having in mind that the functional (taxon-guilds) or zoogeographical groups combine species with different requirements to the immediate environmental factors, the obtained patterns could not correspond to the regularities revealed by the analyses at species level. In order to expose the new general patterns, the variability of the obtained structures (percentage data, based on number of species or number of specimens) of spider assemblages, based on these functional or zoogeographical groups, were analyzed by means of PCA and RDA. The subsequent step of study was directed towards a more detailed analysis of the effect of the main environmental factors, such as light, moisture, structure of grass and shrub stratums, anthropogene impact and area on the obtained spectra. In this way it may be possible to reveal parameters suitable for indication in applied ecological studies. A multiple regression analysis (qualitative variables) and Kruskal-Wallis one-way ANOVA tests were performed to examine for significant differences in composition and diversity between assemblages.

The statistical programs used in the analyses were CANOCO (ter Braak, 1987), TWINSPAN (Hill, 1979), BIODIV (Baev, Penev, 1994), STATISTICA for WINDOWS.

4. Habitat Variables

Initially, 40 variables were recorded around each trap. By eliminating the redundant ones, in preliminary analyses, a subset of 20 measures was used in subsequent canonical analyses. Ten variables were based on the cover of some structural components: v1. leaf litter; v2. dry twigs; v3. standing dead wood; v4. stumps; v5. moss layer; v6. grass up to 10 cm. v7. the same, up to 50 cm; v8. herbaceous layer up to 10 cm, v9. the same up to 50 cm, v10. low shrubs up to 50 cm. They were evaluated within 1 x 1 m square centered on each trap, using subjective scores: 1 = low < 10%; 2 = moderate 10 - 50 %; 3 = high >50 %. Six variables represented the grass, herb and foliage density at different height above ground : v11. grasses at 1m; v12. the same at 2 m; v13. herbs at 1 m; the same at 2 m; v14. shrubs at 1 m; v15. the same at 2 m; v16. the same at 3 m. The scores were based on the number of contacts of stems and branches at respective height along two perpendicular 5-m-transects, centered on trap: 1. low density (1 - 10 contacts/m), 2. moderate (11 - 30 contacts/m.), 3. high (more than 31 contacts/m). Variables representing the physical conditions were: v17. reflected light - average of six measures of reflection of ground surface, made at 360° around each trap, at cloudless sky, during July, between 10 a. m. - 2 p. m., with a photographic lux meter (scale 0-12), v18. variability of light - the standard deviation of the above average. v19. soil moisture expressed in a three-class scale: 1. dry during the main part of the growing season; 2. changeable moisture conditions (from dry to wet), depending of the season, and 3. wet during the main part of the growing season; v20. substrate type: 1. clayey, poorly drained; 2. sand or marl, well drained.

The variables (except soil moisture) were measured or recorded once (1996) in July, when the vegetation reached maximum growth for the season, and the spiders were in the greatest activity and abundance. Although the variables changed throughout the season, they were thought to vary in a congruent way at the different sampling points. In few cases, when some of the parameters around a particular trap were changed, they were remeasured. In the final analyses the median of these measures, as well as the mean forthe year estimates of the soil moisture, was used.

The structural diversity of sampling sites was described by the following complex variables: Mean Light (ML) - mean of the light estimates (reflection of the soil surface) measured around each trap (see above). Mean Soil Moisture (MSM) - mean of the respective scores at each trap; Structural Diversity of ground stratum, including low-growing vegetation (up to 50 cm) - leaf litter, twigs, mosses, grass and herbs (SDGS) - mean of the sums of the scores of respective variables measured around each trap. Structural Diversity of low canopy (shrub layer) (SDSS) - the same for respective variables, describing this layer.

Additionaly, each site was scored in respect to its disturbance status (DS): 1. low disturbance - there are not considerable changes of the vegetation in the area surrounding the site; 2. moderate disturbance - the site is little disturbed, but it is situated near disturbed areas - fields, gardens, roads, buildings, etc. 3. disturbed - the samling site represents highly modified habitat - cultivated fields, ruderal vegetation near field margins, artificial stands, clearings, etc. In some analyses the area (AREA) was used as a categorial variable.

Results

1. Spatial Pattern of Species Distribution within Areas

We examined the spatial changes in the structure of the spider samples from individual traps using indirect (correspondence analysis - CA, for the northern area and detrended correspondence analysis - DCA, for the southern area) and direct (canonical correspondence analysis - CCA) ordination analyses. They were based on log-transformed percentage data and downweighting of rare species. Samples with less than 30 specimens were made passive.

1.1. Northern Area

Indirect analysis (Figs. 2a, b). The initial analysis revealed the following lengths of the gradients of the first four axes (in SD-units): 4.66, 3.69, 2.54, 2.19. These data show that CA is a more appropriate model for analysis of this data set (ter Braak, 1987). The first axis (eigenvalue 0.69) separates the trap samples in two groups (Fig. 2a). Those located in dry, open, short-grass sites have positive scores on this axis. The remaining samples from shrubby and/or forested habitats form the second group with negative scores on this axis. The species clearly associated with the positive half of the first axis are: *Xysticus caperatus, Lepthyphantes tenius, Lycosa radiata, Alopecosa*

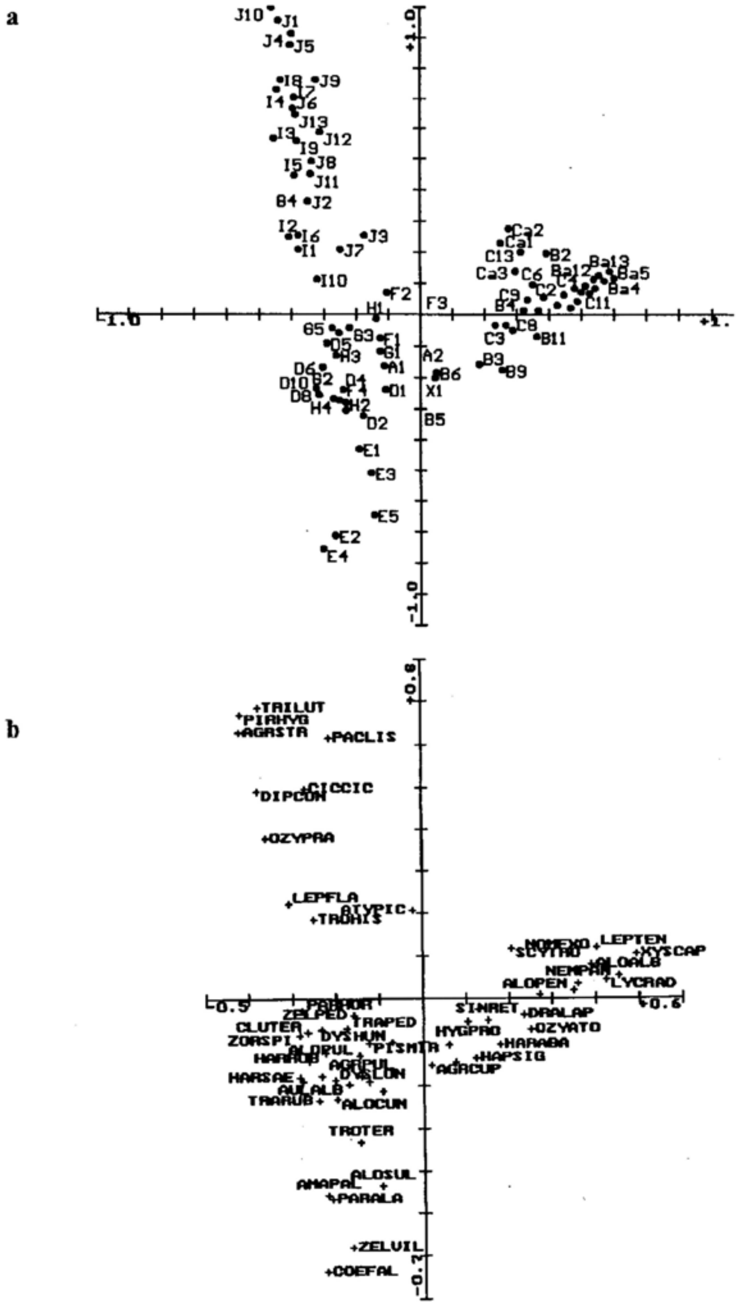

Fig. 2. Ordination diagrams based on the first two axes of indirect ordination analysis (correspondence analysis) of the individual pitfall samples from traps in the northern area.

a. samples, symbols of samples as in Fig. 1; **b.** species, the species abbreviations consist of the first three letters of their generic and specific names, see also Table 2.

albofasciata, Nemesia pannonica, etc. (Fig. 2b). Evidently, the first axis of the ordination identifies a gradient from open, dry, steppe-like habitats to more or less closed habitats.

The second axis (eigenvalue 0.45) is determined by the variation among traps located in the more or less forested habitats (Fig. 2a). The trap samples from the wet (longos) forest Baltata form a loosely spaced group along the positive half of this axis. In contrast, the samples from the dry forest on the Dobrudzha plateau occupy the lowest part of the diagram. The first group of samples is characterized by mesophilous and hygrophilous species such as *Tricca lutetiana, Pirata hygrophilus, Agraecina striata, Ozyptila praticola, Trohosa hyspanica*, etc. The species showing high negative scores on the second axis are: *Coelotes falciger, Zelotes villicus, Pardosa alacris, Amaurobius pallidus*, etc. (Fig. 2b). These data indicate that the second axis reflects a clear gradient of humidity within the more closed habitats.

The ecotone samples from the shrubby habitats occupy a central position near to the origin of the diagram (Fig. 2a), showing little specificity in species composition. The third and fourth axes (eigenvalues 0.30 and 0.22, respectively) have not a clear biological interpretation and thus are not considered in further analyses. The first two axes explain 23.2% of the variance of species data. This low explanatory power most probably is related to the circumstance that the data set is quite "noisy" as a result of the large number of rare species. On the other hand the eigenvalues of the first two axes, being greater or near to 0.5, indicate a good separation of species optima along the hypothetical gradients, identified above.

Direct gradient analysis (Figs. 3a, b). The spider data were related to the variation in environment using CCA. The results give quantitative argumentation of the regularities obtained above. The first axis (eigenvalue 0.552) represents the differences between the open sites, on one hand, and more or less closed sites, on the other (Fig. 3a). The environmental variables, having a significant effect on the spider species composition in open sites, are the intensity of the reflected light (v17), and the well developed herbaceous and grass cover (Fig. 3a: v6, v7, v8, v11). The soil moisture and leaf litter are the most important variables for the forested sites (Fig. 3a: v1, v19, Table 1). The second axis is less correlated with environmental variables. It represents the effect of humidity and herbaceous vegetation, well pronounced in the moist forest, on one hand, and shrub cover, associated with forest edges and ecotone habitats, on the other (Fig. 3a: v15, Table 1). The third and fourth axes, having low eigenvalues (0.218 and 0.179), are of minor biological importance. They represent some details of the effect of some of the above variables. The Monte Carlo permutation test shows that the obtained model is statistically significant (99 random permutations, P=0.01). Nevertheless, the effect of environmental variables explains the relatively low proportion of the variance. The first two axes account for 19 % of the variance of species data.

1.2. Southern Area

Indirect analysis (Figs. 4a, b). The lengths (in SD-units) of gradients are as follows: 4.46, 1.97, 2.14, 189. These data show that since the first gradient is very important, it can be expected that the spatial species variation of spider assemblages is explained perfectly by the first axis. This circumstance leads to a well pronounced arch effect in CA. The preliminary analyses have showed that in this case the best results appear when using DCA, based on detrending by second order polynomials. This kind of analysis is

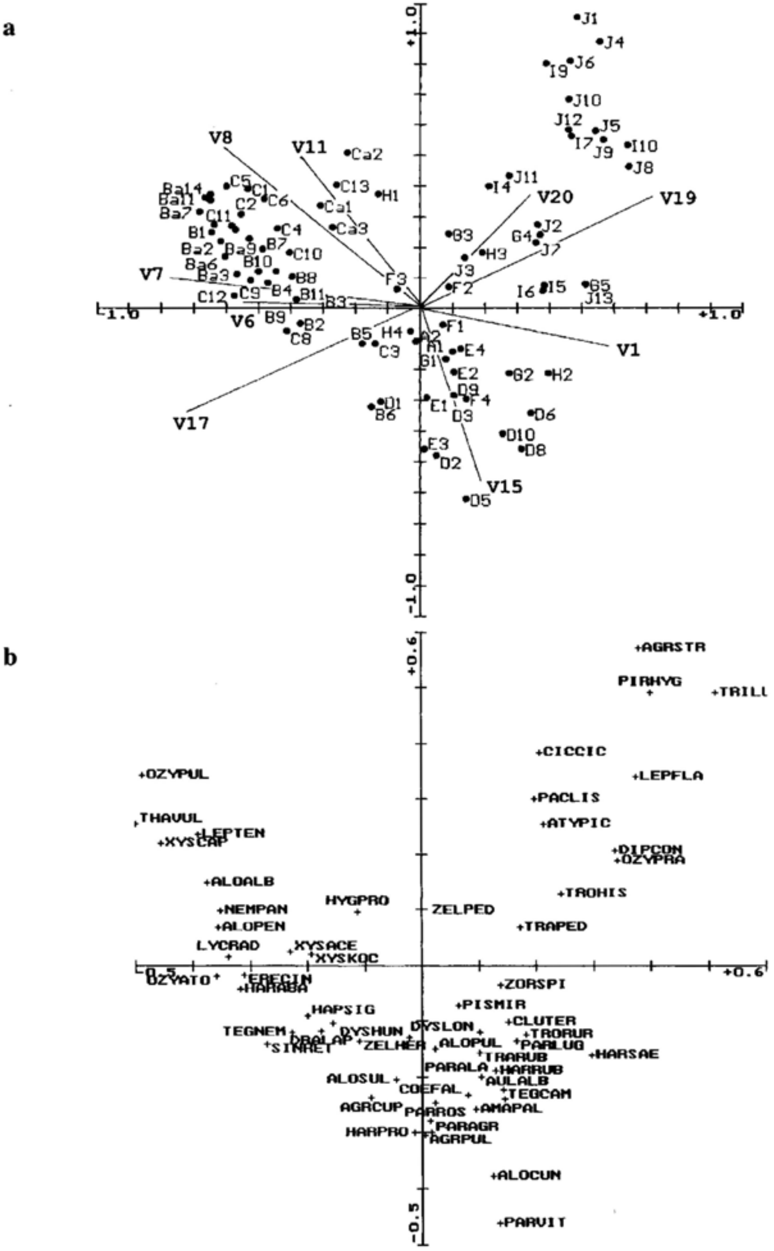

Fig. 3. Ordination diagrams based on the first two axes of direct ordination analysis (canonical correspondence analysis) of the individual pitfall samples from traps in the northern area.

a. samples, the arrows represent the environmental variables: v17-reflected light, v8 - cover of herbaceous layer up to 10 cm; v19 - soil moisture; v15 - foliage density of shrubs up to 2 m; v1 - cover by leaf litter; v20 - substrate type; v11 - cover of herbaceous layer up to 50 cm; v6 - cover by grass up to 10 cm; v7 - the same up to 50 cm; **b.** species

Table 1. Results of CCA analysis of trap samples from the northern area: importance (variance explained) and interset correlations of selected (forward selection) environmental variables with ordination axes. For identification of variables see the text and Fig. 3a.

Variable	Variance explained	Axis 1	Axis 2	Axis 3	Axis 4
v17	0.44	-0.779	-0.261	-0.313	0.001
v8	0.24	-0.590	0.437	0.127	-0.093
v19	0.20	0.721	0.296	-0.232	-0.206
v15	0.17	0.137	-0.398	0.239	-0.376
v1	0.14	0.603	-0.137	0.567	0.271
v20	0.12	0.254	0.281	0.120	0.148
v11	0.12	-0.389	0.387	0.000	-0.544
v6	0.11	-0.410	0.09	-0.184	-0.382
v7	0.10	-0.571	0.033	-0.302	0.038

considered more appropriate than the other methods of detrending, since it removes only the specific defects of CA (ter Braak, 1987).

The first axis (eigenvalue 0.487) represents the differences between more or less open or shrubby sites (positive scores) from those from more or less forested habitats (Fig. 4a). The characteristic species for the forested sites are: *Steatoda albomaculata, Liocranum rupicola, Microneta viaria, Ozyptila praticola*, etc. The species closely associated with the more open sites are: *Phlegra fasciata, Thanatus meronensis, Alopecosa sulzeri*, etc. (Fig. 4b). The second axis (eigenvalue 0.306) reflects the effect of humidity. The samples from the swamped forest have highly positive scores on this axis, while the samples from the sand dune have negative ones (Fig. 4a). The species closely associated with the "humid" end of the second axis are: *Pirata latitans, P. hygrophilus, P. pirata, Pardosa prativaga*. The characteristic inhabitants of open and dry sites are: *Xysticus kochi, Pholcus opilionoides, Thanatus vulgaris,* etc. (Fig. 4b). The majority of samples are situated in the central part, near to the origin of the ordination diagram (Fig. 4a). This result indicates that the effect of the above gradients is less pronounced in comparison with the situation in the northern area. Most probably this circumstance is related to the fine grained habitat mosaic in the southern area. More over, the clayey and poorly drained soils, prevailing in the southern area, in combination with the relatively great precipitation (see Popov, Krusteva, 1999) level off the differences in humidity. The last two axes do not contribute to the understanding of the spatial pattern of spider assemblages in the southern area.

Direct gradient analysis (Figs. 5a, b). The CCA ordination gives a very similar picture to that obtained by DCA. The first axis (eigenvalue 0.408) is highly correlated with the light conditions (v17), (R=0.848) and grass cover (v7),(R=0.605). Evidently, it describes the effect of the most characteristic factors and structural components of the open sites, from one hand, and these of more or less forested sites, from the other (Fig. 5a). The second axis is positively related to the soil moisture (v19), (R=0.647) and negatively to the lower shrub layer (presence of *Ruscus* spp., v10), (R= -0.555), characteristic for the relatively dry and light forests (Fig. 5a). The most important variables, are the intensity of the reflected light (v17) and the soil moisture (v19), explaining 0. 36 and 0. 21 of the total variance (3. 77). The variance explained by each of the structural components, included in the model (grass and shrub cover, v7, v10), varies between 0. 16 and 0.13. Regardless of

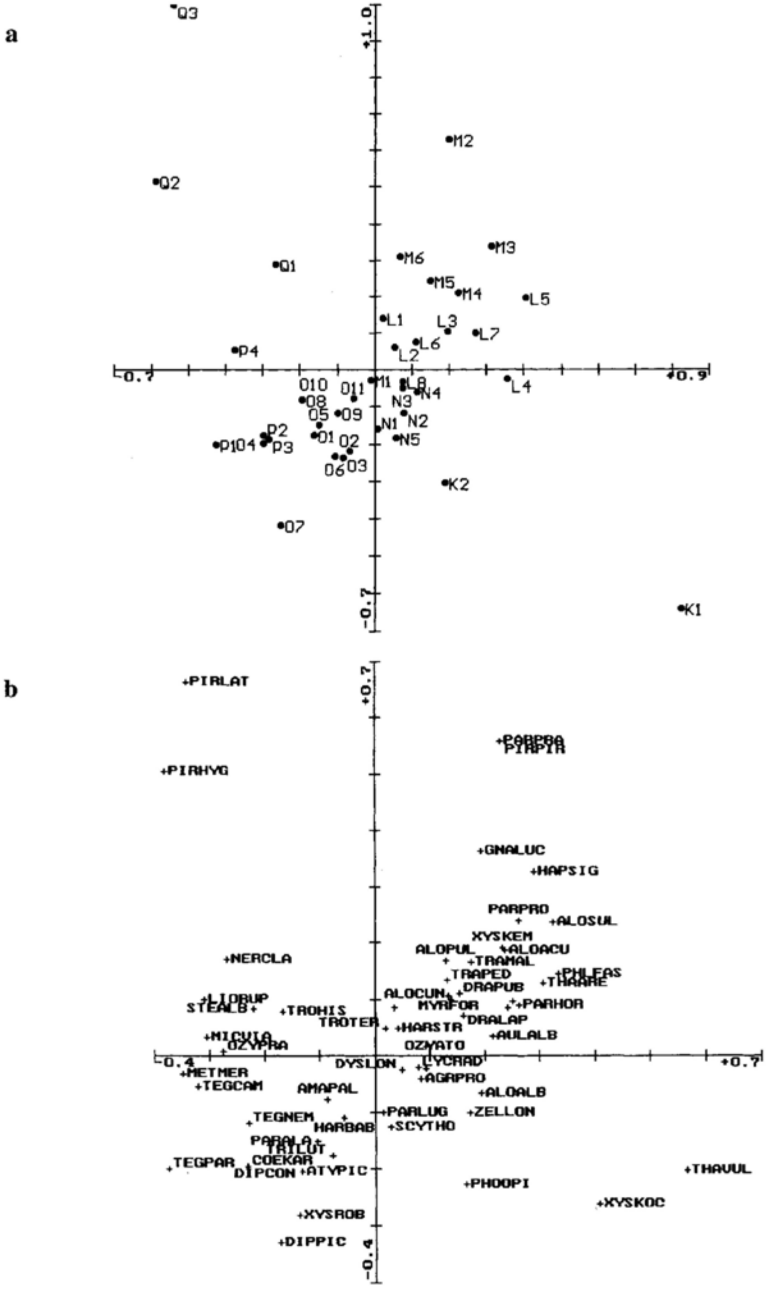

Fig. 4. Ordination diagrams based on the first two axes of indirect ordination analysis (detrended correspondence analysis) of the individual pitfall samples from traps in the southern area.

a. samples; **b.** species the species; the abbreviations consist of the first three letters of their generic and specific names, see also Table 2..

these low values, the overall Monte Carlo permutation test shows that the model is highly significant (trace = 1.80, F-ratio = 1.74, P = 0.01). Although at a lower level, the effect of the first axis is also statistically significant (P = 0.03).

2. General Spatial Pattern

The above ordination analyses show that in general the obtained clusters of trap samples correspond to the habitat type. In order to preserve the small scale spatial homogeneity within these typological categories, these initial samples were pooled according to their spatial proximity (sampling site). As a result 20 (Fig. 1: A - Q) ecologically and spatially defined spider assemblages were obtained.

2.1. Ordination Analysis

In order to evaluate the relative influence of gradients of various scales (local - acting within areas and regional - between areas), all spider assemblages, identified above (A-Q), were subjected to indirect ordination analysis. The length of gradients were 3.39; 2.00; 1.96 and 1.69 SD-units. These data prove the application of DCA (Figs. 6a, b). The best results were obtained by detrending by third order polynomials.

The first axis (eigenvalue 0. 434) contrasts the spider assemblages from the dry and open sites (positive scores) from the assemblages associated with the forested and more or less humid habitats (negative scores). Many assemblages, mainly those from the ecotone, shrubby or anthropogene influenced sites, fall in the central part of this axis. These rough groups consist of assemblages from both areas (Fig. 6a). The characteristic species for the open sites, represented predominantly in the northern area, are: *Xystus caperatus, Dysdera taurica, Callilepis concolor, Nomisia exornata, Nemesia pannonica*, etc. The species closely associated with the forested and/or mesophilous habitats (negative scores on the first axis) are: *Neriene clathrata, Diplocephalus picinus, Metellina merianae, Pirata hygrophilus, Liocranum rupicola, Microneta viaria,* etc. (Fig. 6b).

The second axis (eigenvalue 0.291) separates the spider assemblages according to their geographic location. The assemblages from the southern area have positive scores on this axis and *vise versa* (Fig. 6a). Evidently, this axis represents the effect of geographic (latitudinal) gradient. Here again the spider associations from the ecotone and/or disturbed habitats occupy an intermediate position. Characteristic species for the forests of the southern area (high positive scores on the second axis and negative ones on the first axis) are: *Coelotes karlinskii, Harpactea babori, H. strandjica Microneta viaria*, etc. The northern forested habitats are characterized by the occurrence or predominance of such species as *Agraecina striata, Diplostila concolor, Pirata hydrophilus, Tricca lutetiana*, etc. The species associated mainly with the southern open habitats are: *Araneus angulatus, Pholcus opilionoides, Alopecosa taeniopus*, etc. Some of the species, characteristic for the northern open habitats are mentioned above. (Fig. 6b).

These results show that the composition of spider assemblages within the landscapes along the Black Sea coast are influenced mainly by the structure of vegetation and soil moisture. The latitudinal geographic gradient is of secondary importance. These gradients reflect primarily the differences between spider assemblages from the less disturbed sites: steppe-like habitats in the northern area, dune habitats in the southern area, forests of both areas. In contrast, the assemblages from the ecotone and human influenced sites show little particularity.

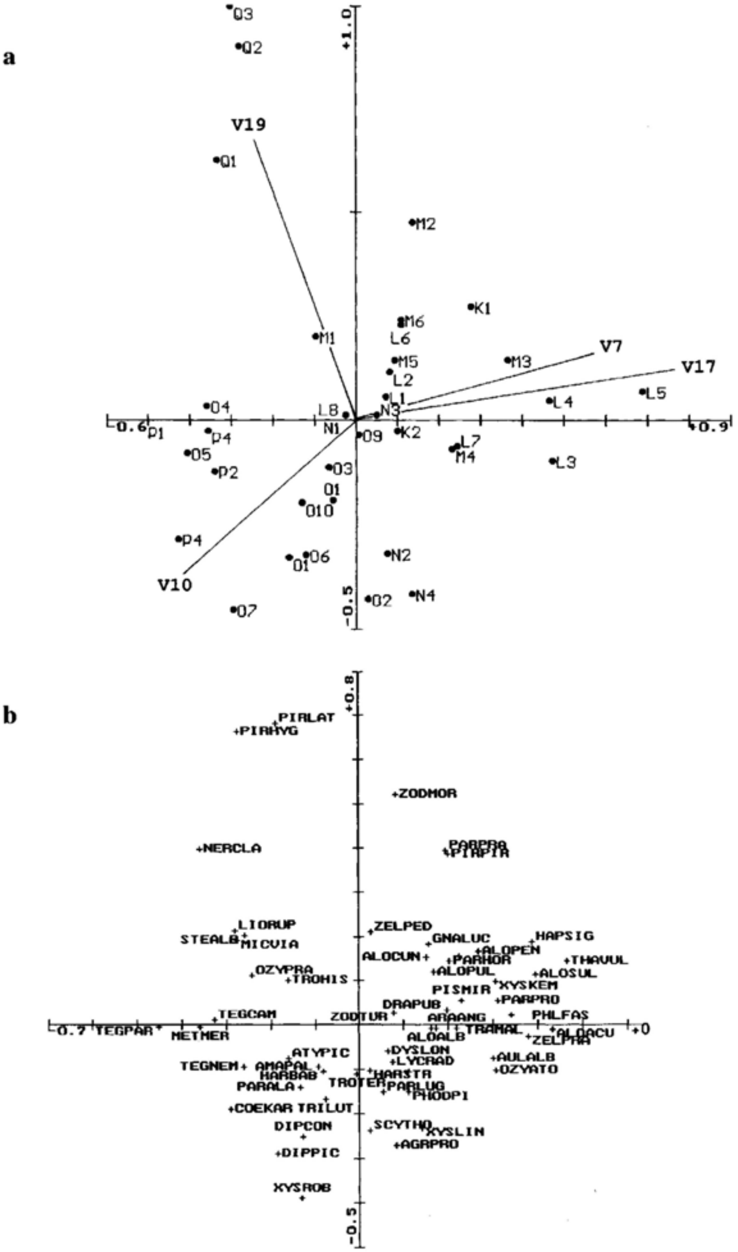

Fig. 5. Ordination diagrams based on the first two axes of direct ordination analysis (canonical correspondence analysis) of the individual pitfall samples from traps in the southern area.

a. samples, the arrows represent the environmental variables: v17 - intensity of reflected light, v7 - cover of grass stratum (up to 50 cm), v10 - cover of low shrubs (up to 50 cm), v19 - soil moisture; **b.** species, the abbreviations consist of the first three letters of their generic and specific names, see also Table 2.

2.2. Classification Analysis

Based on TWINSPAN, the 20 sites were classified according to their spider assemblages into seven end groups (Table 2). The classification of sites according to TWINSPAN corresponds to site groupings of forests (more or less mesophilous), hedges between cultivated fields through shrubs, dry meadows, and finally steppes of the northern area.

The first TWINSPAN division separates the well drained open sites of both areas (indicator species *Alopecosa albofasciata*) from the rest. Evidently the first level of division corresponds to the gradient of humidity and the general structure of vegetation.

The second level of division within the "dry" cluster partitions the northern steppe-like habitats (B, Ba, C, Ca) from the southern bare or shrubby sites (K, L), characterized by *Harpactea babori* . Within the "wet and more forested" cluster, this level of division separates the mesophilous forests (I, J, N, O, P, Q) from both areas from the shrubby sites, ecotones, hedgerows, etc. (A, D, E, F, G, H, M). The first group of sites is characterized by *Neriene clathrata*, while *Hygrocrates lycaoniae, Pardoza lugubris, Haplodrassus signifer* are indicators for the second groups.

The third-level division separates the southern, more or less dry forests (N, O, P), with indicator species *Harpactea strandjica*, from the swamped forests of both areas (I, J, Q). This level of division separates the dry oak forest from the northern area (E), with indicator species *Berlandia cinerea*, from the remaining sites from the "shrubby" cluster. At the forth level of division the last cluster is separated into two. The first group consists of the mesophilous shrubby sites (F, H), characterized by *Atypus piceus*. The second group comprises mainly human disturbed sites of both areas - cultivated fields, hedgerows, forest clearing, etc. (A, D, G, M).

At the fourth level of division the TWINSPAN classification produces 36 distributional groups of species (Table 2).

3. Assemblage Structure and Composition

3.1.Diversity

Point diversity. The differences in point diversity, evaluated by reciprocal of Simpson's index (N2), between assemblage types in each area were at the boundary of the statistical significance (Kruskal-Wallis ANOVA, northern area: $H = 17.93$, $p=0.036$; southern area $H = 12.93$, $P= 0.043$). Consequently, neither the above habitat parameters, nor the habitat (assemblage) type showed any correlation with the overall variability of this parameter, regardless of area (multiple regression analysis).

Alpha-diversity. There is a rich literature concerning the usefulness of various diversity indices, designed to describe the distribution of individuals between species in an assemblage (for review see Pesenko, 1982). Here we followed an empirical rather than purely statistical approach to make decision which index to use in the more detailed analyses of spider assemblages. This analysis based on a simultaneous use of twenty diversity indices, available in the BIODIV software package (Baev, Penev, 1995). They, together with two parameters - sample size (N) and trap number (TRP), reflecting the sampling effort, were processed by PCA, in order to find groups of indices, representing different aspects of the diversity data (Figs. 7a, b).

Axis 1 of the ordination seems to represent the diversity itself. The majority of indices form a coherent cluster on the positive end of this axis, while the Simpson's

Table 2. TWINSPAN classification of spider assemblages from two areas of the Bulgarian Black Sea Coast according to their quantitative species composition. For location of assemblages see Fig. 1.The relative abundance of the species per assemblage is presented using the following scale: 1 = 0-0.9%; 2= 1.0-3.9%; 3= 4.0-9.9%; 4= 10.0-19.9%; 5= 20.0-100.0%.

Species aranged in distributional groups (1-36)		**Abbreviations**			**Assemblages**																			**To-tals**
		Species	**Fam.**	**Area**	**N**	**O**	**P**	**Q**	**I**	**J**	**F**	**H**	**A**	**D**	**G**	**M**	**E**	**K**	**L**	**B**	**Ba**	**C**	**Ca**	
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
1.	*Centromerus valkanovi* Deltshev, 1983	CEN VAL	LIN	BG	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	Coelotes karlinskii (Kulczynski, 1906)	COE KAR	AMA	BK	-	4	4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	119
	**Dysdera richteri* Charitonov, 1956	DYS RIC	DYS	NEM	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	3
	Echemus angustifrons (Westring, 1861)	ECH ANG	GNA	E	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Evarcha arcuata (Clerck, 1757)	EVA ARC	SAL	WD	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Lepthyphantes collinus (L. Koch, 1872)	LEP COL	LIN	MSEE	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Lepthyphantes floriana Van Helsdingen, 1977	LEP FLO	LIN	BK	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Micrommata ligurina (C.L. Koch, 1845)	MIC LIG	HET	MED	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Micrommata virescens (Clerck, 1757)	MIC VIR	HET	WD	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Scotophaeus blackwalli (Thorell, 1871)	SCO BLA	GNA	WD	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	Scotophaeus scutulatus (L. Koch, 1866)	SCO SCU	GNA	E	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Steatoda meridionalis (Kulczynski, 1894)	STE MER	THE	EE	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	**Tegenaria boitanii* Brignoli, 1978	TEG BOI	AGE	BKMA	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	Tegenaria ferruginea (Panzer, 1804)	TEG FER	AGE	E	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Tegenaria parietina (Fourcroy, 1785)	TEG PAR	AGE	WD	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	Xysticus lanio C.L. Koch, 1835	XYS LAN	THO	WD	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Xysticus robustus (Hahn, 1832)	XYS ROB	THO	E	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5
	Zelotes clivicola (L. Koch, 1870)	ZEL CLI	GNA	WD	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Zodarion turcicum Wunderlich, 1980	ZOD TUR	ZOD	BKMA	2	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	8
2.	*Agraecina striata* (Kulczynski, 1882)	AGR STR	CLU	E	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	17
	Anyphaena accentuata (Walckenaer, 1802)	ANY ACC	ANY	E	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Bathyphantes gracilis (Blackwall, 1841)	BAT GRA	LIN	WD	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Bathyphantes nigrinus (Westring, 1851)	BAT NIG	LIN	E	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Dictyna uncinata Thorell, 1856	DIC UNC	DIC	WD	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Diplocephalus picinus (Blackwall, 1841)	DIP PIC	LIN	E	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	7
	Diplostyla concolor (Wider, 1834)	DIP CON	LIN	WD	-	1	-	-	1	1	-	1	-	-	-	-	-	-	-	-	-	-	-	17
	Gongylidiellum murcidum Simon, 1884	GON MUR	LIN	E	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2

Table 2 - continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Gongylidium rufipes (Linnaeus, 1758)	GON RUF	LIN	WD	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
	Liocranum rupicola (Walckenaer, 1830)	LIO RUP	LIO	E	1	1	1	2	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	19
	Metellina merianae (Scopoli, 1763)	MET MER	TET	E	-	1	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	5
	Neriene clathrata (Sundevall, 1830)	NER CLA	LIN	WD	-	1	1	1	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	6
	Pardosa luctinosa Simon, 1876	PAR LUC	LYC	WD	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	Pirata hygrophilus Thorell, 1872	PIR HYG	LYC	E	-	-	1	5	3	2	-	-	-	1	-	1	-	-	-	-	-	-	-	101
	Steatoda albomaculata (De Geer, 1778)	STE ALB	THE	WD	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2
	Tegenaria campestris C.L. Koch, 1834	TEG CAM	AGE	E	-	2	3	1	1	1	-	1	-	1	-	-	1	-	-	-	-	-	-	50
	Arctosa lutetiana (Simon, 1876)	TRI LUT	LYC	MSE	1	1	-	-	-	4	-	-	-	-	-	-	-	-	-	-	-	-	-	132
	Walckenaeria antica (Wider, 1834)	WAL ANT	LIN	WD	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1
3.	*Centromerus sylvaticus* (Blackwall, 1841)	CEN SYL	LIN	WD	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	3
	Lepthyphantes flavipes (Blackwall, 1854)	LEP FLA	LIN	WD	-	1	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	-	-	5
	Ozyptila praticola (C.L. Koch, 1837)	OZY PRA	THO	WD	-	1	1	2	2	2	1	1	1	1	-	-	-	-	-	-	-	-	-	84
	Pirata latitans (Blackwall, 1841)	PIR LAT	LYC	E	1	-	-	2	1	-	2	-	-	-	-	-	-	-	-	-	-	-	-	14
	Walckenaeria alticeps (Denis, 1952)	WAL ALT	LIN	E	-	1	-	-	-	1	-	-	-	-	1	-	-	-	-	-	-	-	-	5
4.	*Drassodes cupreus* (Blackwall, 1834)	DRA CUP	GNA	E	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	-	-	-	2
	Ozyptila blackwalli Simon, 1875	OZY BLA	THO	WD	-	-	-	-	-	1	-	-	-	1	-	-	-	-	-	-	-	-	-	3
	Xysticus lineatus (Westring, 1851)	XYS LIN	THO	E	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	2
	Zora spinimana (Sundevall, 1833)	ZORSPI	ZOR	WD	-	1	-	-	-	1	-	1	-	1	-	-	-	-	-	-	-	-	-	9
5.	*Amaurobius pallidus* L. Koch, 1868	AMA PAL	AMA	MEE	5	4	3	2	-	-	1	1	-	1	-	2	2	-	2	1	-	-	-	214
	Harpactea babori (Nosek, 1905)	HAR BAB	DYS	BKMA	4	4	4	1	-	-	-	-	1	-	1	2	-	2	1	-	-	-	-	162
	Harpactea strandjica Dimitrov, 1996	HAR STR	DYS	BG	2	1	1	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	22
	Microneta viaria (Blackwall, 1841)	MIC VIA	LIN	WD	-	1	1	2	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	11
	Tegenaria nemorosa Simon, 1916	TEG NEM	AGE	SE	1	1	2	-	-	1	-	1	-	1	-	1	-	-	-	-	-	1	-	25
6.	*Pachygnatha listeri* Sundevall, 1830	PAC LIS	TET	WD	-	1	-	-	1	1	-	-	-	-	1	-	-	-	-	1	-	-	-	28
	Trochosa hispanica Simon, 1870	TRO HIS	LYC	MSE	2	5	5	5	5	5	5	5	4	4	5	5	1	-	3	2	-	1	2	1548
7.	*Clubiona terrestris* Westring, 1851	CLU TER	CLU	E	-	1	-	-	-	1	2	1	-	1	-	-	1	-	-	-	-	-	-	10
	Harpactea saeva Herman, 1879	HAR SAE	DYS	EE	-	-	-	-	1	1	1	-	2	1	-	-	1	-	-	-	-	-	-	19
	Pardosa alacris (C.L. Koch, 1833)	PAR ALA	LYC	E	2	1	1	-	-	-	3	2	-	-	-	1	4	-	-	1	-	-	-	107
	Trochosa ruricola (De Geer, 1778)	TRO RUR	LYC	WD	-	1	-	-	-	1	2	-	2	1	1	-	-	-	-	-	-	-	-	22
8.	*Coelotes falciger* Kulczynski, 1897	COE FAL	AMA	SEE	-	-	-	-	-	-	-	-	-	-	-	1	5	-	-	-	-	-	-	141
	**Harpactea doblikae* (Thorell, 1875)	HAR DOB	DYS	SEE	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	2
	Lepthyphantes crucifer (Menge, 1866)	LEP CRU	LIN	E	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
	Micaria fulgens (Walckenaer, 1802)	MIC FUL	GNA	WD	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1

Table 2 - continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Pardosa amentata (Clerck, 1757)	PAR AME	LYC	WD	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
	**Tapinocyba mitis* (O.P.-Cambridge, 1882)	TAP MIT	LIN	E	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
	Zora nemoralis (Blackwall, 1861)	ZOR NEM	ZOR	WD	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	3
	Zora silvestris Kulczynski, 1897	ZOR SIL	ZOR	E	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1
9.	*Gnaphosa modestior* Kulczynski, 1897	GNA MOD	GNA	EE	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	-	4
10.	*Agelena gracilens* C.L. Koch, 1841	AGE GRA	AGE	MSE	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	-	-	3
	Alopecosa pinetorum (Thorell, 1856)	ALO PIN	LYC	WD	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	4
	Araneus diadematus Clerck, 1757	ARA DIA	ARA	WD	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	2
	Neriene furtiva (O.P.-Cambridge, 1870)	NER FUR	LIN	WD	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1
	Scotina celans (Blackwall, 1841)	SCO CEL	LIO	E	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
	Tmarus piger (Walckenaer, 1802)	TMA PIG	THO	WD	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1
11.	*Aelurillus v*-insignitus (Clerck, 1757)	AEL V-I	SAL	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
	Assianelus festivus (C.L. Koch, 1834)	PHL FES	SAL	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
	Ballus chalybeius (Walckenaer, 1802)	BAL CHA	SAL	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
	Clubiona pallidula (Clerck, 1757)	CLU PAL	CLU	WD	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
	Clubiona similis L. Koch, 1867	CLU SIM	CLU	WD	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	2
	Drassyllus lutetianus (L. Koch, 1866)	ZEL LUT	GH	E	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
	Ero furcata (Villers, 1789)	ERO FUR	MIM	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
	Haplodrassus dalmatensis (L. Koch, 1866)	HAP DAL	GNA	E	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
	Lepthyphantes zimmermanni Bertkau, 1890	LEP ZIM	LIN	E	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
	Marpissa muscosa (Clerck, 1757)	MAR MUS	SAL	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
	Maso sundevalli (Westring, 1851)	MAS SUN	LIN	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
	Mecopisthes peusi Wunderlich, 1872	MEC PEU	LIN	E	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
	Ozyptila scabricula (Westring, 1851)	OZY SCA	THO	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
	Pachygnatha degeeri Sundevall, 1830	PAC DEG	TET	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	8
	Pardosa paludicola (Clerck, 1757)	PAR PAL	LYC	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	3
	Pardosa prativaga (L. Koch, 1870)	PAR PRA	LYC	ES	-	-	-	-	-	-	-	-	1	1	-	1	-	-	-	-	-	-	-	23
	Pardosa roscai (Roewer, 1951)	PAR ROS	LYC	SEE	-	-	-	-	-	-	-	-	2	1	-	-	-	-	-	-	-	-	-	8
	Pelecopsis parallela (Wider, 1834)	PEL PAR	LIN	E	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	1
	Pirata piraticus (Clerck, 1757)	PIR PIR	LYC	WD	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	5
	Steatoda paykulliana (Walckenaer, 1806)	STE PAY	THE	WD	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1
	Tallusia experta (O.P.-Cambridge, 1871)	TAL EXP	LIN	E	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
	Theonina kratochvili Miller & Weiss, 1979	THE KRA	LIN	SEE	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1
	Titanoeca schineri L. Koch, 1872	TIT SCH	TIT	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	4
	Xerolycosa miniata (C.L. Koch, 1834)	XER MIN	LYC	WD	-	-	-	-	-	-	-	-	2	-	-	-	-	-	-	-	-	-	-	3
	Zora armillata Simon, 1878	ZOR ARM	ZOR	E	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1

Table 2 - continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
12.	*Harpactea rubicunda* (C.L. Koch, 1838)	HAR RUB	DYS	E	1	-	-	-	2	1	3	2	2	3	1	-	2	-	-	1	-	1	-	148
	Pardosa lugubris (Walckenaer, 1802)	PAR LUG	LYC	WD	2	1	-	-	2	1	-	3	3	5	5	-	4	-	1	1	-	-	-	375
	Trachyzelotes pedestris (C.L. Koch, 1837)	TRA PED	GNA	E	1	1	-	1	2	1	1	2	1	1	2	3	1	-	3	2	-	-	-	60
13.	*Drassodes pubescens* (Thorell, 1856)	DRA PUB	GNA	WD	-	1	-	-	-	-	-	-	-	1	1	1	-	-	1	-	-	-	-	8
	Pardosa proxima (C.L. Koch, 1847)	PAR PRO	LYC	E	1	-	-	-	-	-	-	-	-	1	-	2	-	-	1	-	-	-	-	15
	Pardosa vittata (Keyserling, 1863)	PAR VIT	LYC	MSE	-	-	-	-	-	-	-	-	1	2	-	1	-	-	1	-	-	-	-	21
	Pisaura mirabilis (Clerck, 1757)	PIS MIR	PIS	WD	1	1	1	-	1	1	1	1	2	3	4	2	1	1	1	1	1	1	1	113
	Xysticus kempeleni Thorell, 1872	XYS KEM	THO	E	1	-	-	-	-	1	1	1	2	2	2	2	-	-	2	-	1	-	-	69
14.	*Agroeca cuprea* Menge, 1873	AGR PUL	LIO	E	-	-	-	-	-	1	2	-	-	2	1	-	-	-	-	1	-	2	-	20
	Alopecosa pulverulenta (Clerck, 1757)	ALO PUL	LYC	WD	1	-	-	-	-	1	-	4	2	2	-	1	-	-	1	-	-	1	1	93
	Gnaphosa lucifuga (Walckenaer, 1802)	GNA LUC	GNA	WD	-	-	-	-	-	-	-	-	2	-	-	1	-	-	-	-	-	1	-	7
	Pardosa agrestis (Westring, 1861)	PAR AGS	LYC	WD	-	-	-	1	-	-	-	-	2	1	-	-	-	-	-	1	-	-	-	15
	Pardosa agricola (Thorell, 1856)	PAR AGI	LYC	E	-	-	-	1	-	-	-	-	2	1	-	-	-	-	-	1	-	-	-	13
	Trochosa robusta (Simon, 1876)	TRO ROB	LYC	WD	-	-	-	-	-	-	-	1	-	1	-	-	1	-	-	1	-	-	-	10
	Zelotes hermani (Chyzer, 1897)	ZEL HER	GNA	EE	-	-	-	-	-	-	-	-	1	1	-	1	-	-	-	1	-	-	-	5
15.	*Alopecosa aculeata* (Clerck, 1757)	ALO ACU	LYC	WD	-	-	-	-	-	-	-	-	-	1	-	1	-	-	1	-	-	-	-	12
	**Harpactea abantia* (Simon, 1884)	HAR ABA	DYS	BK	-	-	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	1	-	15
	Zelotes latreillei (Simon, 1878)	ZEL LAT	GNA	E	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	1	-	-	-	11
16.	*Alopecosa cuneata* (Clerck, 1757)	ALO CUN	LYC	WD	-	-	-	-	-	-	-	-	1	1	-	1	-	-	1	1	-	-	-	12
	Haplodrassus signifer (C.L. Koch, 1839)	HAP SIG	GNA	WD	-	-	-	-	-	-	-	-	2	1	-	1	1	-	1	-	1	1	-	31
17.	*Alopecosa sulzeri* (Pavesi, 1873)	ALO SUL	LYC	MSEE	-	-	-	-	1	-	-	-	-	-	-	3	4	-	1	2	-	-	-	110
	Drassodes lapidosus (Walckenaer, 1802)	DRA LAP	GNA	WD	2	1	-	-	-	-	-	-	2	2	2	1	-	-	1	2	1	-	1	88
	Drassyllus praeficus (L. Koch, 1866)	ZEL PRA	GNA	E	1	1	-	-	-	-	-	1	3	1	-	1	-	-	2	1	-	1	-	33
	Dysdera hungarica Kulczynski, 1897	DYS HUN	DYS	SEE	-	-	-	-	1	-	1	-	-	1	1	1	-	-	-	1	-	1	-	14
18.	*Myrmarachne formicaria* (De Geer, 1778)	MYR FOR	SAL	WD	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	3
	Pardosa hortensis (Thorell, 1872)	PAR HOR	LYC	WD	1	1	-	-	1	-	-	-	1	1	1	1	-	1	1	-	-	-	-	20
19.	*Drassyllus villicus* (Thorell, 1875)	ZEL VIL	GNA	MSEE	-	1	-	-	-	-	-	-	-	-	-	-	2	-	-	1	-	-	-	30
	Dysdera longirostris Doblika, 1853	DYS LON	DYS	EE	3	4	2	2	1	1	4	4	2	2	-	4	2	3	4	1	-	1	-	329
	Trochosa terricola Thorell, 1856	TRO TER	LYC	WD	1	1	1	-	-	-	1	1	2	2	-	1	2	-	1	3	-	-	-	110
	Zelotes subterraneus (C.L. Koch, 1833)	ZEL SUB	GNA	WD	-	1	-	-	-	1	1	-	-	1	-	-	-	-	-	1	-	-	-	5
20.	*Agroeca proxima* (O.P.-Cambridge, 1871)	AGR PRO	LIO	E	2	1	-	-	-	-	-	-	-	1	-	-	-	-	1	1	-	-	-	9
	Cheiracanthium elegans Thorell, 1875	CHE ELE	CLU	E	-	-	-	-	-	1	-	1	-	-	-	-	-	-	-	1	-	-	-	3
	Tegenaria domestica (Clerck, 1757)	TEG DOM	AGE	WD	-	1	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	3

Table 2 - continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
21.	*Aulonia albimana* (Walckenaer, 1805)	AUL ALB	LYC	WD	1	-	-	-	-	-	-	1	2	1	-	1	-	1	2	1	-	-	-	31
22.	*Atypus piceus* (Sulzer, 1776)	ATY PIC	ATY	E	1	2	2	-	1	1	1	2	-	-	-	-	1	3	-	1	-	1	3	75
	Scytodes thoracica (Latreille, 1802)	SCY THO	SCY	WD	2	1	1	-	-	-	-	-	-	1	-	-	-	-	1	-	-	1	1	15
23.	*Alopecosa taeniopus* (Kulczynski, 1895)	ALO TNI	LYC	PM	1	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2
	Araeoncus anguineus (L. Koch, 1869)	ARA ANG	LIN	E	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	3
	Lepthyphantes istrianus Kulczynski, 1914	LEP IST	LIN	EE	-	-	-	-	-	1	-	-	-	1	-	-	-	1	-	1	-	-	-	4
	Pholcus opilionoides (Schrank, 1781)	PHO OPI	PHO	WD	1	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	3
24.	*Cicurina cicur* (Fabricius, 1793)	CIC CIC	AGE	E	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	1	-	7
	Nurscia albosignata Simon, 1874	NUR ALB	TIT	NEM	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	1	-	2
25.	*Alopecosa cursor* (Hahn, 1831)	ALO CUR	LYC	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	-	-	-	-	4
	Alopecosa taeniata (C.L. Koch, 1835)	ALO TAE	LYC	WD	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	-	-	3
	Phlegra fasciata (Hahn, 1826)	PHL FAS	SAL	WD	-	-	-	-	-	-	-	-	1	1	-	-	-	-	1	1	-	-	-	6
	Xysticus kochi Thorell, 1872	XYS KOC	THO	WD	-	-	-	-	1	-	-	-	3	1	1	1	1	4	1	3	-	1	-	72
26.	*Euophrys frontalis* (Walckenaer, 1802)	EUO FRO	SAL	WD	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	2
	Euophrys herbigrada (Simon, 1871)	EUO HER	SAL	E	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	2
	**Ozyptila confluens* (C.L. Koch, 1845)	OZY CON	THO	NEM	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	2
	Phrurolithus festivus (C.L. Koch, 1835)	PHR FES	LIO	WD	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	-	-	-	2
27.	*Berlandina cinerea* (Menge, 1872)	BER CIN	GNA	E	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	2
	Eresus cinnaberinus (Olivier, 1789)	ERE CIN	ERE	WD	-	-	-	-	-	-	1	-	-	1	-	-	1	-	1	1	1	1	1	15
	Zelotes erebeus (Thorell, 1870)	ZEL ERE	GNA	MSEE	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	-	-	2
28.	*Alopecosa albofasciata* (Brulle, 1832)	ALO ALB	LYC	WD	3	2	1	1	-	1	1	-	1	-	-	2	1	5	4	4	5	5	4	533
	Hogna radiata (Latreille, 1817)	LYC RAD	LYC	WD	3	2	-	-	-	1	-	-	2	1	-	2	1	2	3	3	5	2	2	252
	Thanatus meronensis Levy, 1977	THA MER	PHI	EMED	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	-	-	-	7
	Xysticus acerbus Thorell, 1872	XYS ACE	THO	WD	-	-	-	-	-	-	1	-	-	1	-	-	-	-	1	2	-	1	-	26
	Zelotes longipes (L. Koch, 1866)	ZEL LON	GNA	ES	-	1	-	-	-	-	1	-	-	-	-	-	-	1	1	1	-	1	-	6
29.	*Ozyptila atomaria* (Panzer, 1801)	OZY ATO	THO	WD	-	1	-	-	-	-	-	-	-	1	-	-	-	-	1	1	-	-	-	7
30.	*Araneus angulatus* Clerck, 1757	ARA ANU	ARA	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1
	Dysdera crocota C.L. Koch, 1838	DYS CRO	DYS	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3
	Gibbaranea bituberculata (Walckenaer, 1802)	GIB BIT	ARA	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
	Linyphia triangularis (Clerck, 1757)	LIN TRI	LIN	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
	Pardosa monticola (Clerck, 1757)	PAR MON	LYC	WD	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1	-	-	-	-	4
	Trabea paradoxa Simon, 1876	TRAPAR	LYC	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
	Xysticus erraticus (Blackwall, 1834)	XYS ERR	THO	E	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1

Table 2 - continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Zelotes atrocaeruleus (Simon, 1878)	ZEL ATR	GNA	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	1
	Zodarion morosum Denis, 1935	ZOD MOR	ZOD	NEM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	2
31.	*Sintula retroversus* (O.P.-Cambridge, 1875)	SIN RET	LIN	E	-	-	-	-	-	-	-	-	-	1	-	-	-	2	-	1	-	-	-	10
32.	*Callilepis concolor* Simon, 1914	CAL CON	GNA	SE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	-	4
	Episinus truncatus Latreille, 1809	EPI TRU	THE	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	3
	Micaria albimana O.P.-Cambridge, 1972	MIC ALB	GNA	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	2
33.	*Alopecosa pentheri* (Nosek, 1905)	ALO PEN	LYC	BKMA	-	-	-	-	-	-	-	-	1	1	-	-	1	3	1	2	1	1	-	40
	Thanatus vulgaris Simon, 1870	THA VUL	PHI	SE	-	-	-	-	-	-	-	-	1	-	-	-	-	1	1	-	1	2	-	23
	**Trachyzelotes malkini* Platn. & Murphy, 1984	TRA MAL	GNA	BKMA	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1	1	1	-	-	4
34.	*Dysdera taurica* Charitonov, 1956	DYS TAU	DYS	SEE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	1	4
35.	*Agelena orientalis* C.L. Koch, 1841	AGE ORI	AGE	SE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
	**Alopecosa schmidti* (Hahn, 1835)	ALO SCH	LYC	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2
	Argiope bruennichi (Scopoli, 1772)	AGR BRU	ARA	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
	Callilepis schuszteri (Herman, 1879)	CAL SCH	GNA	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	2
	Cheiracanthium pelasgicum (C.L. K., 1737)	CHI PEL	CLU	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
	Cheiracanthium punctorium (Villers, 1789)	CHE PUN	CLU	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
	Coelotes longispinus Kulczynski, 1897	COE LON	AMA	SEE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
	Heliophanus kochii Simon, 1868	HEL KOC	SAL	WD	-	-	-	-	-	-	-	-	–	-	-	-	1	-	-	-	1			2
	Heriaeus simoni Kulczynski, 1903	HER SIM	THO	NEM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	2
	Lepthyphantes tenuis (Blackwall, 1852)	LEP TEN	LIN	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	6
	Maimuna vestita (C.L. Koch, 1841)	MAI VES	AGE	EMED	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
	Mangora acalypha (Walckenaer, 1802)	MAN ACA	ARA	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2
	Meioneta rurestris (C.L. Koch, 1836)	MEI RUR	LIN	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	2
	Neoscona adianta (Walckenaer, 1802)	NEO ADI	ARA	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
	Neottiura suaveolens (Simon, 1879)	THE SUA	THE	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
	Nomisia aussereri (L. Koch, 1872)	NOM AUS	GNA	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
	Nomisia exornata (C.L. Koch, 1839)	NOM EXO	GNA	E	-	-	-	-	-	-	1	-	-	-	-	-	-	-	1	1	1	1	1	9
	Ozyptila claveata (Walckenaer, 1837)	OZY CLA	THO	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
	**Ozyptila conostyla* Hippa, Kop. & Oks., 1986	OZY CNO	THO	BKMA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	4
	Ozyptila pullata (Thorell, 1875)	OZY PUL	THO	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	3
	Ozyptila rauda Simon, 1875	OZY RAU	THO	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	-	2
	Pardosa riparia (C.L. Koch, 1833)	PAR RIP	LYC	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1
	Pardosa tatarica (Thorell, 1875)	PAR STR	LYC	SE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	4
	Pelecopsis elongata (Wider, 1834)	PEL ELO	LIN	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1
	Pellenes nigrociliatus (Simon, 1875)	PEL NIG	SAL	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1

Table 2 - continued

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
	Philaeus chrysops (Poda, 1761)	PHI CHR	SAL	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	1	2
	Phrurolithus szilyi Herman, 1879	PHR SZI	LIO	E	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	1
	Prinerigone vagans (Audouin, 1826)	PRI VAG	LIN	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2
	Stemonyphantes lineatus (Linnaeus, 1758)	STE LIN	LIN	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	4
	Talavera aequipes (O.P.-Cambridge, 1871)	TAL AEQ	SAL	WD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	2
	**Xysticus caperatus* Simon, 1875	XYS CAP	THO	MED	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	2	1	2	25
	Zelotes aurantiacus Miller, 1967	ZEL AUR	GNA	EE	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1
36.	*Nemesia pannonica coheni* Fuhn & Pol., 1967	NEM PAN	NEM	BK	-	-	-	-	-	1	3	3	-	-	-	1	2	-	-	5	5	5	5	867
Number of specimens:					**120**	**590**	**272**	**126**	**477**	**807**	**167**	**176**	**143**	**868**	**149**	**272**	**578**	**72**	**266**	**521**	**577**	**665**	**166**	**7012**
Number of species:					**38**	**49**	**26**	**17**	**25**	**42**	**30**	**32**	**39**	**69**	**18**	**50**	**36**	**19**	**53**	**63**	**20**	**41**	**18**	**206**

Notes: Vertical lines separate TWINSPAN assemblage groups; double lines represent first level of division, thick lines-second level, thin lines-third level, broken lines - forth level.

* New species for the Bulgarian fauna.

Abbreviations

Species: the species abbreviations, used on ordination diagrams, consist of the first three letters of their generic and specific names.

Family: ATY – Atypidae, NEM – Nemesiidae, SCY – Scytodidae, PHO – Pholcidae, DYS – Dysderidae, MIM – Mimetidae, ERE – Eresidae, THE – Theridiidae, LIN – Linyphiidae, TET – Tetragnathidae, ARA – Araneidae, LYC – Lycosidae, PIS – Pisauridae, AGE – Agelenidae, DIC – Dictynidae, AMA – Amaurobiidae, TIT – Titanoecidae, ANY – Anyphaelinae, LIO – Liocranidae, CLU – Clubionidae, ZOD – Zodariidae, GNA – Gnaphosidae, ZOR – Zoridae, HET – Heteropodidae, PHI – Philodromidae, THO – Thomisidae, SAL – Salticidae.

Areal: BG – Bulgarian, BK – Balkan, BKMA – Balkan-Asiaminorian, PM – Ponto-Mediterranean, MED – Mediterranean, EMED – East-Mediterranean, NEM – North-East-Mediterranean, MSEE – Middle-Southeast-European, SEE – Southeast-European, MEE – Middle-East-European, SE – South-European, EE – East-European, MSE – Middle-South-European, E – European, ES – Eurosiberian, WD – Widely distributed.

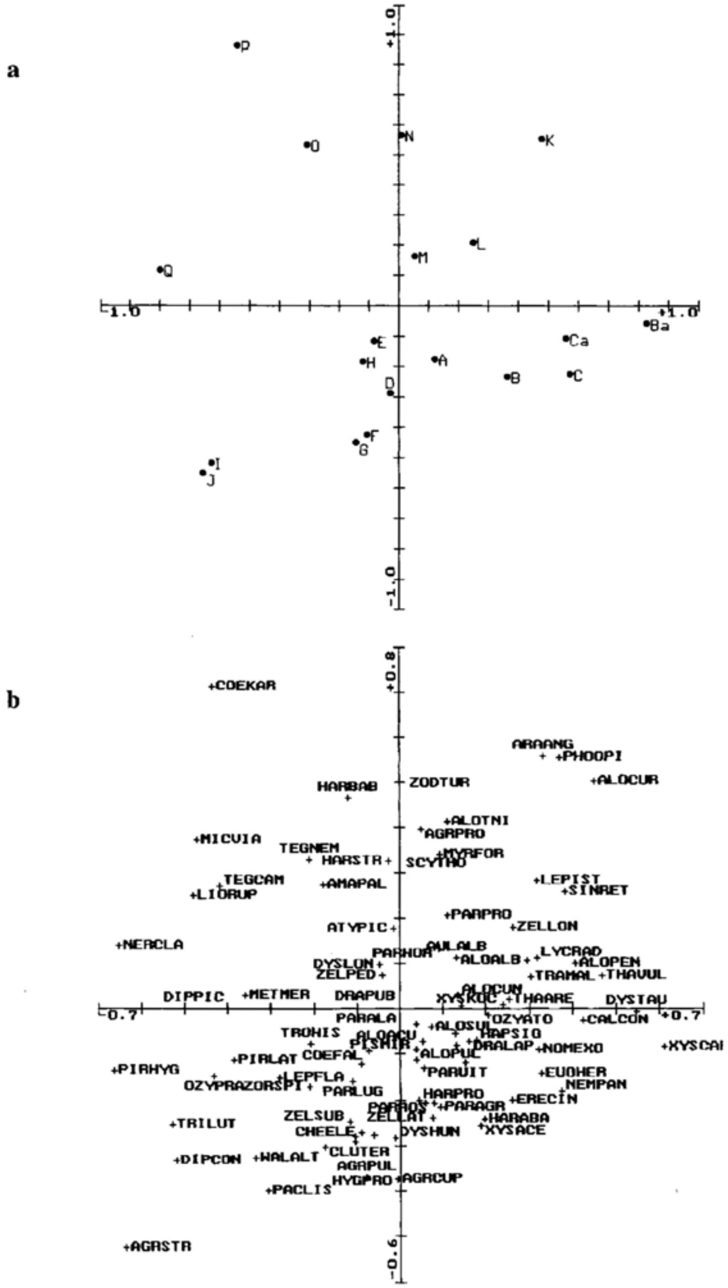

Fig. 6. Ordination diagrams based on the first two axes of indirect ordination analysis (detrended correspondence analysis) of the spider assemblages from both areas.

a. assemblages; the designation corresponds to the sampling sites, presented on Fig. 1; **b.** species; the species abbreviations consist of the first three letters of their generic and specific names, see also Table 2.

"concentration of dominance" index (C) and Berger-Parker's dominance index (d) are negatively correlated with this axis (Fig. 7a). The second axis reflects the negative association between the sample characteristics (N, TRP) and the McIntosh's diversity index (U), on one hand and some eveness measures (Hill's index, E1, Alatalo index, F, Molinari's index, G), on the other. As it may be expected, the variance (VH) and correction for the sample size (DH) of the Shannon's index are also negatively related to the two sample characteristics. Four indices - HBE, E, PIE and D, occupied an intermediate position between the first and second axes (Fig. 7a). The second axis may be interpreted as "eveness".

The highest diversity was estimated for three assemblages from each area - A, B and D, for the northern area, and L, M and N, for the southern one (Fig. 7b). Three of these assemblages were from anthropogene disturbed sites - cultivated fields and hedgerows (A, D, L) or ecotone shrubby sites (M); one assemblage represented a short-grass steppe-like habitat on a well drained substrate (B). Low diversity and great dominance were obtained mainly for the assemblages from some forested sites - I, J, G, Q, P, O. According to the examined data, the assemblages, based on low number of traps and collected specimens, tended to show greater eveness - K, G, Q, A. In contrast the assemblages, based on a great number of traps and larger number of collected specimens - J and C, show the lowest eveness. Most probably the notable spider abundance in these habitats is the main cause for this result. Some assemblages from the ecotone habitats (small mesophilous forest patches - H, F) and dry oak forest - E, O occupy an intermediate position in the gradient of species richness presented by the first axis of PCA (Fig. 7b).

Evidently the indices associated with the second axis are not suitable for further analyses since they are biased by sampling effort. In the first group of indices (not related to the sampling effort) the expected number of species (ES_100) occupies a central position, indicating that these measures are strongly affected by species richness. So, among this group of indices, the expected number of species (ES_100), based on rarefaction, was chosen for further analyses.

The multiple regression analysis provided more information on the causes for the variability of species richness, estimated as ES_100. The only statistically significant correlation was obtained with the light conditions (partial correlation = 0.54, P= 0.05; multiple correlation = 0.77, R - square = 0.83, F=8.19, P=0.002), confirming that in general the open sites were more diversified than the forested ones.

The shape of complete rarefaction curves (Fig. 8a, b) indicates that the numbers of collected specimens for all assemblages are insufficient to represent the "real" number of species in the spider assemblages.

The comparisons between areas show that the diversity in both areas is nearly equal (Fig. 8c): the species richness, standardized to 1000 specimens (ES_1000), for the southern area is 98 +/- 16, while for the northern area it is 92 +/- 23. Although the southern area tends to show greater richness the difference is not statistically significant. Similar results are shown by the reciprocal of Simpson's index, having the values of 12. 6 and 10. 3, respectively.

3.2. Functional Composition of Spatial Spider Assemblages

The taxon-guild spectra of spider assemblages arranged according to the composite gradient revealed throughout TWINSPAN are shown on Fig. 9. Nearly all assemblages

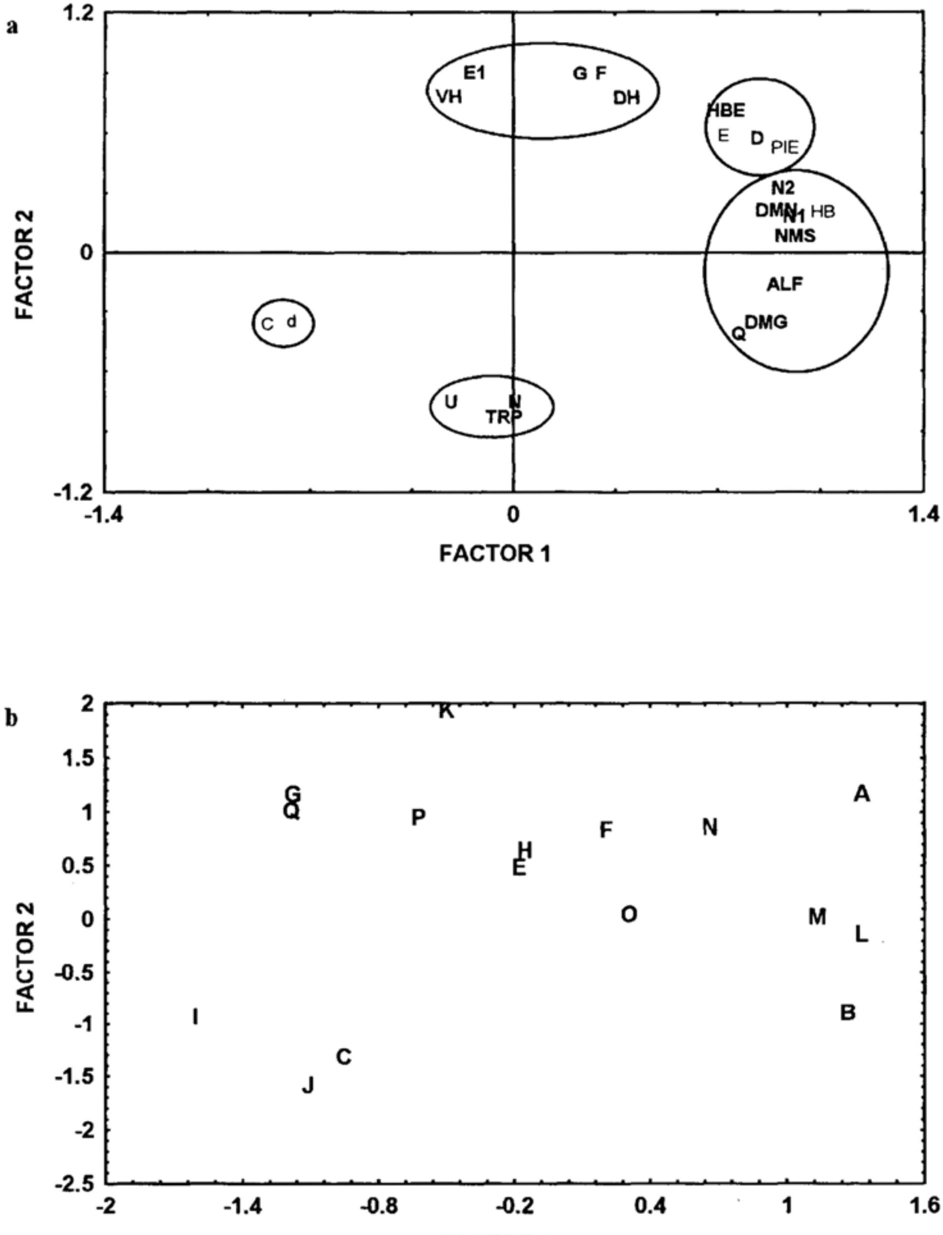

Fig. 7. Ordination diagrams based on the first two axes of the principal component analysis of diversity indices of spider assemblages.

a. diversity indices; for abbreviations see text; b. assemblages.

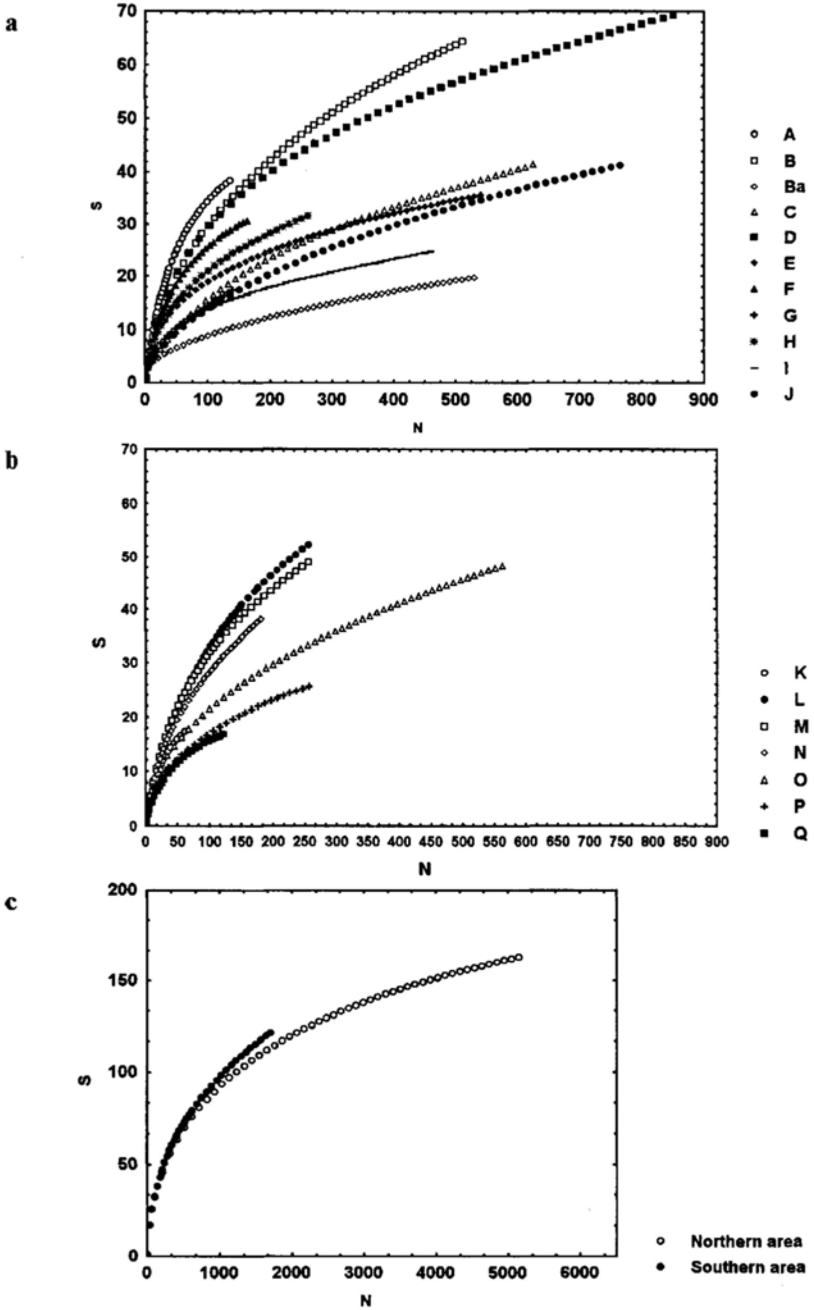

Fig. 8. Rarefaction curves for spider assemblages.

a. assemblages from the northern area (A - J); **b.** assemblages from the southern area (K - Q); **c.** rarefaction curves for the pooled data of each area. S - cumulative number of species; N - number of collected specimens.

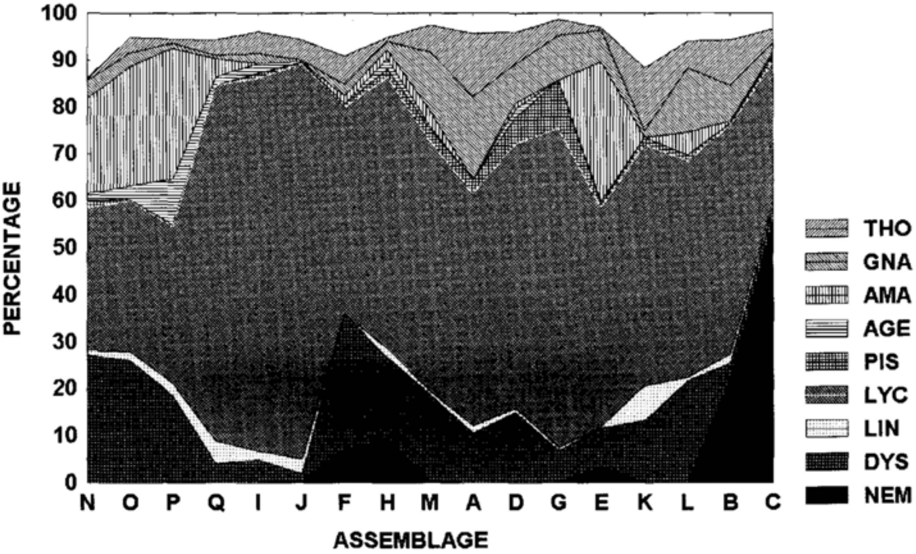

Fig. 9. Taxon-guild spectra of spider assemblages (percentages, based on specimen numbers in each family). The assemblages are arranged according to the overall environmental gradient as revealed by TWINSPAN analysis. THO- Thomisidae, GNA- Gnaphosidae, AMA- Amaurobiidae, AGE- Agelenidae, PIS- Pisauridae, LYC- Lycosidae, LIN- Linyphiidae, DYS- Dysderidae, NEM- Nemesiidae.

are dominated by the ground hunters of family Lycosidae. The exceptions concern two groups of assemblages. The first group comprises the assemblages from the light, more or less dry forests of both areas (E, N, O, P) which show a relatively great share of the ground web-builders from the family Amaurobiidae and the ground hunters of Dysderidae. The second group of outliers comprises the assemblages from the steppe-like habitats of the northern area (B, Ba, C, Ca), strongly dominated by *Nemesia pannonica* - a ground hunter from the family Nemesiidae. These pecularities were examined in greater details by ordination and multiple regression analyses.

The indirect analysis (principal component analysis - PCA) reveals a clear pattern in the quantitative guild structure of spider assmblages. The ordination biplot (Fig. 10) indicates that the first axis represents the gradient from humid (positive half of the axis) to more or less arid (negative half) sites, while the second one - the gradient of structure of vegetation and light conditions of relatively well drained sites - the assemblages from open sites scored on the positive half of the second axis, while those from forested sites, especially those from southern area - on the negative half. The following guilds appear to be closely related to particular habitat types: LYC_GH and THO_GH are positively associated with moisture, NEM_GH is especially characteristic for the open steppe-like sites of the northern area, while AMA_GW, DYS_GH and AGE_AW are associated with the light and dry forests in the southern area. The interset correlations of the environmental variables with axes, obtained through RDA, confirm these general relationships:

		Axis 1	Axis 2
ML	Mean light	–0.30	–0.50
MSM	Mean soil moisture	0.75	0.01
SDGS	Structural diversity of ground stratum	–0.15	–0.15
SDSS	Structural diversity of shrub stratum	–0.21	–0.56

For further examination of the effect of some of the important factors, identifeid above, on particular guilds, a more detailed pairwise comparisons were undertaken. These analyses revealed significant difference among groups of sites representing various disturbance regimes in the combined percentage of individuals belonging to GNA_GH (Kruskal - Wallis one-way ANOVA, H=8.58, df=2, P=0.0137). The multiple regression analysis shows that the share of LYC_GH is positively affected by the moisture (partial correlation 0.68, P=0.01; multiple R = 0.83, R- square = 0.68, F=3.59, P=0.04).

3.3. Zoogeographic Composition of Spider Assemblages

The zoogeographic spectra based on presence/absence data show a great homogeneity (Fig. 11). All assemblages are composed mainly by widely distributed species and European elements. The share of the first category is especially large (about 50%) in

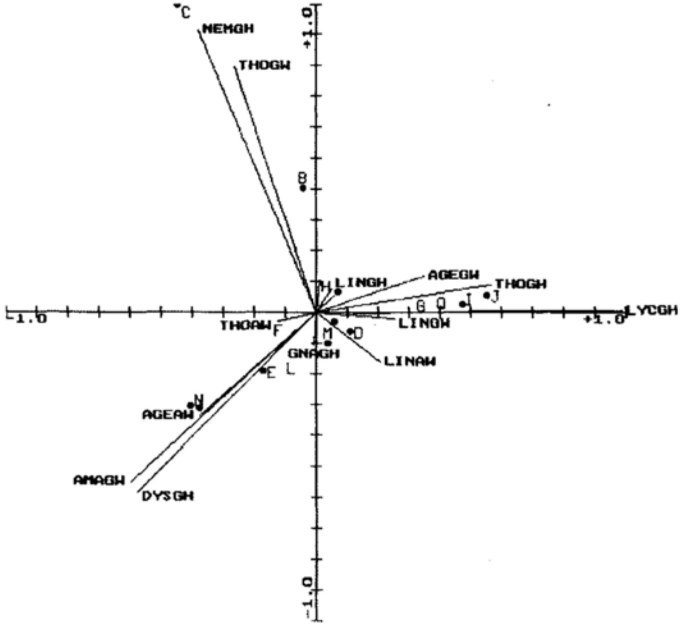

Fig 10. Ordination biplot diagram based on the first two axes of the principal component analysis of taxon-guild spectra of spider assemblages. The taxon-guilds (arrows) are designated by the first three letters represent families, see Fig. 9, the second two letters represent the hunting strategy: GH ground hunters, GW - ground web-builders, AW - aerial web-builders and AH - aerial hunters; for abbreviations of assemblages (points) see text and Fig. 1.

the spider assemblages from the cultivated fields and neighbouring hedgerows and shrubs (assemblages A, D, L) and some forested sites (assemblages O and J). The second category is well represented in the more humid and forested part of the composed gradient (assemblages I, J, P, Q). The other zoogeographic categories comprise low number of species. Their share does not change considerably along the overall gradient (Fig. 11).

In order to obtain a better insight of the qualitative zoogeographic composition of spider assemblages, these data were analyzed by multiple regression analysis and Kruskal-Wallis ANOVA. It was found that the share of European species in the spider assemblages is negatively affected by the light conditions (partial correlation = —0.66, P=0.017; multiple correlation = 0.84, R- square = 0.71, F=4.13, P=0.02), indicating that most probably this zoogeographical group is composed mainly of forest dwellers. It must be emphasized that the percentage of middle-east european species, a group represented by a realtively low number of species, is negatively associated with disturbance regime of sites (Kruskal-Wallis one-way ANOVA, H = 0.8, P=0.014).

The obtained uniform zoogeographic composition of assemblages shows that it reflects mainly the general geographic position of the areas under consideration. In contrast, the quantitative representation of these zoogeographic categories, expressed by percentages, based on the number of individuals, shows much more diversified picture (Fig. 12). The widely distributed species are especially numerous on the right part of the composite gradient. They are associated mainly with the human influenced and open sites. These species are not abundant in forested habitats, represented mainly on the left part of the composite gradient (Fig. 12). Some other zoogeographic elements show more restricted distribution along the composite gradient - they are well presented only

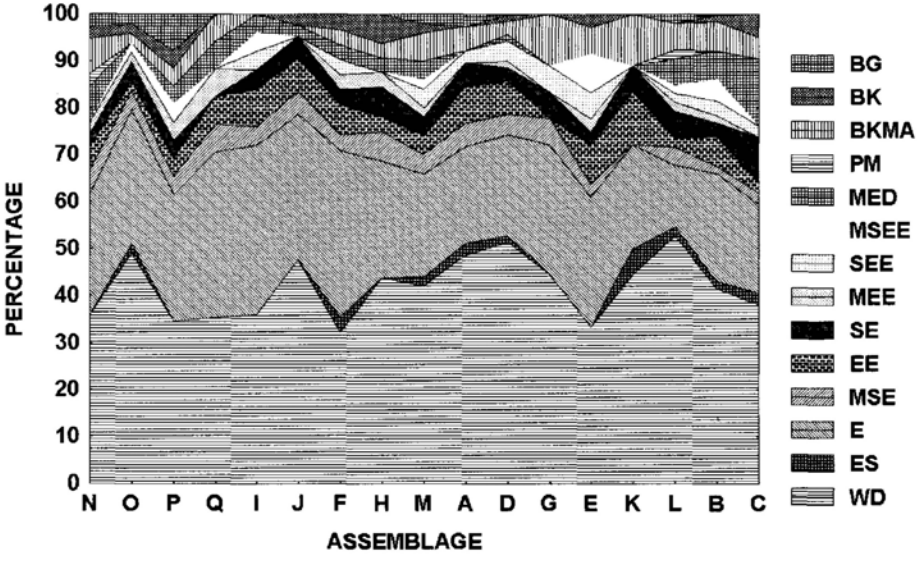

Fig. 11. Qualitative zoogeographical spectra of spider assemblages (percentages based on presence/absence data). The assemblage arrangement follows the TWINSPAN overall gradient. For abbreviations see Table 2.

in particular groups of assemblages (Fig. 12). The group of East-European species comprises seven species. They are especially numerous in the more or less mesophilous, forested or shrubby habitats (O, F, H). The group of the Middle-East -European species is especially abundant in the dry forests and their surroundings (N, O) in the southern area. The South-East-European group is well represented in the dry forest in the northern area (E).

Special attention deserve the zoogeographic elements, representing species with more or less restricted ranges, characteristic for the studied areas. The group of Balkano-Asiaminorian elements shows greatest relative frequency in the ecotones and light forests in the southern area (Fig. 12). The Balkan elements are well presented in some sites from both areas. The Bulgarian endemics occur in some sites (Fig. 12), but in relatively low quantity.

In order to summarize the observed regularities of the quantitative zoogeographic composition of spider assemblages, the above discussed data were subjected to redundancy analysis - RDA (Fig. 13). The first principal component contrasts the spider assemblages from the forested, more or less humid sites (positive scores) and these from dry and open (negative scores), (Fig. 13). The first group of assemblages is characterized by the quantitative prevalence of zoogeographic elements with Middle-South-European and European distribution. The widely distributed and South-European species are associated with the second group of assemblages (Fig. 13). The second principal component separates the spider assemblages from open and disturbed habitats, mainly from the northern area (negative scores), from the more or less dry and forested habitats, especially these from the southern area (Fig. 13). The first group of assemblages is characterized by the great share of widely distributed species, while the second one - by

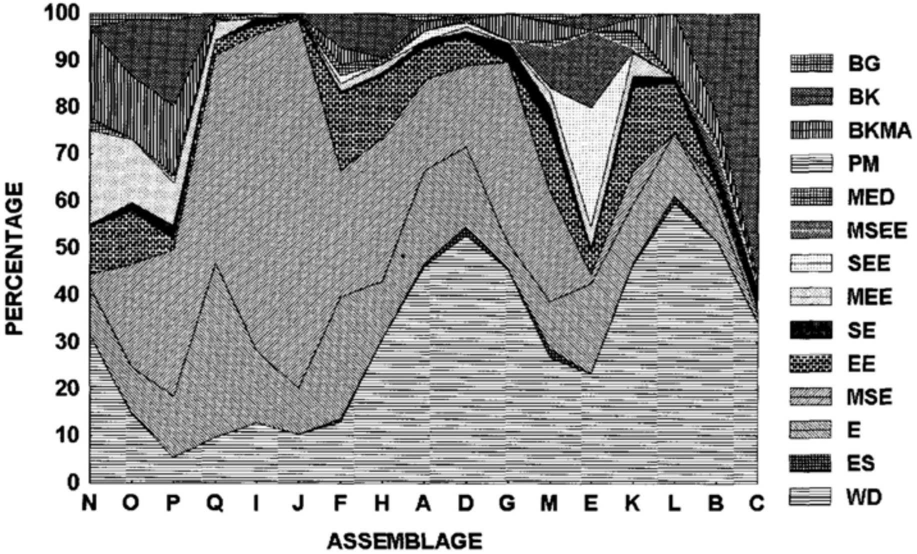

Fig. 12. Quantitative zoogeographical spectra (percentages based on specimen numbers) of spider assemblages, arranged according to their TWINSPAN order. For abbreviations see Table 2.

Balkano-Asiaminorian, Bulgarian and Middle-East-European elements (Fig. 13). The interset correlations of the environmental variables with axes, obtained throughout RDA, confirm these general relationships:

		Axis 1	Axis 2
ML -	Mean light	–0.65	–0.48
MSM -	Mean soil moisture	0.65	–0.32
SDGS -	Structural diversity of ground stratum	–0.23	0.53

The first axis and the whole model are statistically significant (Monte Carlo permutation test, P= 0.01).

These data are in agreement with the above assumption that the qualitative zoogeographic composition of spider assemblages is affected primarily by the structure of the vegetation, resulting from the disturbance pattern and moisture conditions, on one hand,

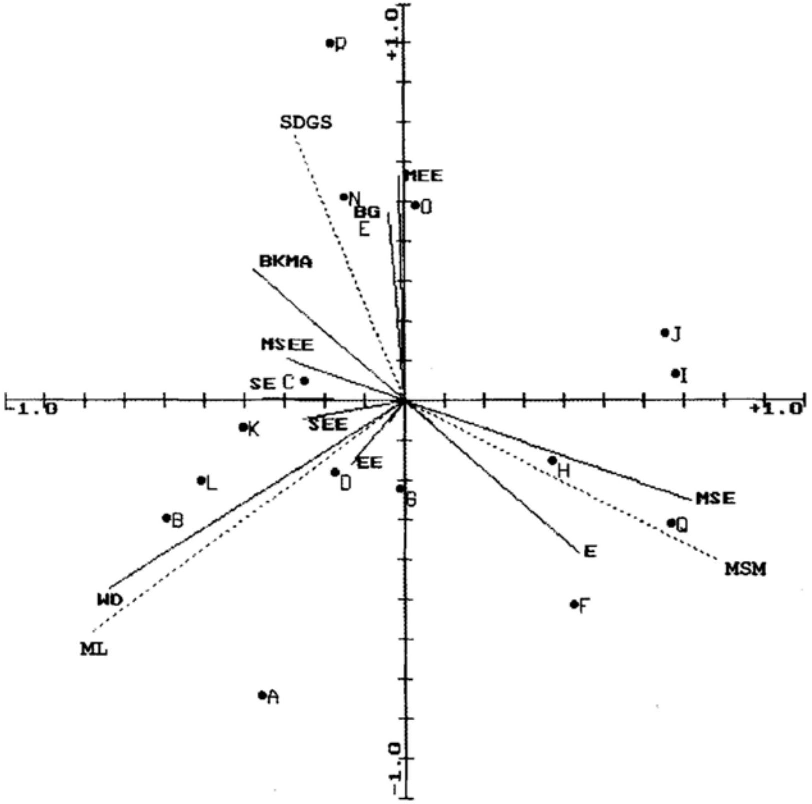

Fig. 13. Ordination triplot diagram based on the first two axes of the redundancy analysis of quantitative zoogeographical spectra (arrows) of spider assemblages (points); for abbreviations see Table 2 and Fig. 1. Broken lines represent the effect of the folowing composite environmental variables: ML - mean light, MSM - mean soil moisture, SDGS - structural diversity of ground stratum, for details see the text.

and by the latitudinal gradient, associated probably with the temperatures and the prevailing habitat types in each area, on the other. This effect is especially well pronounced in the zoogeographic categories combining a great number of abundant species. This analysis, in comparison with the qualitative one, appears to be more useful in this spatial scale since it provides more detailed information for factors affecting the zoogeographic composition of particular assemblages. The main cause is that the quantitative zoogeographical structure is affected by the ecological preference of some abundant species. It can be supposed that the general distribution of these species is governed by their adaptations to a particular combination of environmental factors. This kind of analysis may be considered as a promising approach in analyzing regionally restricted data.

The multiple regression analysis and Kruskall-Wallis rank tests reveal some interesting pairwise relationships. The quantitative representation of the widely distributed species in spider assemblages is closely and positively associated with the light conditions (partial correlation = 0.67, P= 0.01; multiple correlation = 0.77, R - square = 0.83, F=8.19, P= 0.002) - they are especially abundant in open habitats. The pairwise regression analysis of this relationship shows that three out of four assemblages from the disturbed sites have greater share of widely distributed species, than it may be expected on the basis of light conditions alone - their points are above the regression line. It can be supposed that the disturbance regime is also a factor affecting positively the share of these species. The nonparametric Kruskal-Wallis ANOVA confirms this - the share of the widely distributed species is significantly greater in spider assemblages from disturbed sites (H=6.22, P=0.04). As it may be expected, the share of Middle-South European species, dominated by *Trochosa hispanica*, is strongly positively influenced by moisture conditions (partial correlation = 0.69, P= 0.01; multiple correlation = 0.91, R - square = 0.84, F = 8.55, P=0.002).

The zoogeographic diversity (reciprocal of Simpson's indice), calculated on the basis of quantitative data, shows greatest values for the southern assemblages, representing the light forests and their surroundings, ecotones and shrubs. The lowest measurements were associated mainly with the wet forests of both areas.

Discussion

1. Ecology of Species and the Indicator Potential

In the above gradient analyses the main factors, affecting the spatial pattern of spider assemblages, were identified on the basis of the environmental variables and general characteristics of the sampling sites. However, as it is often by necessity in applied ecology, we have to reflect and monitor the environmental conditions on the basis of species composition itself. In these cases the term "indicator taxa" is often employed (Greenslade, Greenslade, 1984, New, 1995). For this purpose the knowledge of the ecological requirements of species is of particular importance. However, for many species detailed data on their habitat requirements and main environmental determinants are still scarce. Moreover, it may be expected the occurrence of some differences between the realized niche in each particular combination of biotic and abiotic factors and the potential or fundamental niche. The extent to which the realized and fundamental niches differ depend of the concrete situations. In general these differences may prevent the ecological interpretation.

Some comparisons with data from other parts of Europe may help to clarify the extend of validity of these general considerations. The available data for habitat preference of spiders in Central Europe (Hanggi et al., 1995) allow to compare the ecological preferences of some species, identified on the basis of the above ordination analyses and summarized in Fig. 6b and Table 2.

The species associated with the wooded part of the gradient (axis 1 in Fig. 6b) were: *Microneta viaria*, *Liocranum rupicola, Wackenaerial alticeps, Pachygnatha listeri*. The first two species, characteristic for the southern area, were associated with more or less light forests and their edges. Very often these habitats, although relatively dry, were situated near bodies of stagnant water. The last two species were characteristic for mesic forests in the northern area. The data from Central Europe show similar habitat relations of these species. In Central Europe *Microneta viaria* and *Liocranum rupicola* occur mainly in dry and fresh deciduous forests, xerothermic wood steppes, ruderal areas, etc. *Pachygnatha listeri* is associated with moist meadows, ferns, fresh deciduous forests and coniferous forests. *Wackenaerial alticeps* occurs mainly along forest edges, field shrubs and fresh deciduous forests.

Pardosa alacris and *Alopecosa sulzeri* were characteristic species for the relatively dry deciduous forest and its surroundings in the northern area. They show similar preferences in Central Europe: xerothermic wood steppes, fallow meadows, ruderal areas.

Species scored on the central part of the first ordination axis, such as *Scytodes thoracica, Pardosa proxima, P. agrestis, Aulonia albimana, Dysdera longirostris, Alopecosa cuneata, Trohosa hispanica,* may be characterized as species with relatively wide habitat preferences. The data from Central Europe agree with these observations. The majority of these species show rather wide habitat preference. In particular, *Scytodes thoracica* is characteristic for fallow and moist meadows; *P. hortensis* shows preference to ruderal areas, forest edges, heaths, vineyards, etc.; *Alopecosa cuneata* occurs mainly in fresh meadows, oligotrophic grasslands, forest edges, urban zones; *Dysdera longirostris* is frequent in dry and semi-dry grassland, xerothermic wood-steppes, forest edges, etc; *Trohosa hispanica* occurs mainly in fresh fallow meadows, oligotrophic grassland, dry deciduous and mixed forests, etc.

The open habitats in the studied areas were characterized by such species as *Lycosa radiata, Eresus cinnnaberinus, Stemonyphantes lineatus, Xysticus acerbus*. In Central Europe these species show similar preferences: perennial rye-grass, pastures, oligotrophic grassland, heaths, etc.

The comparisons presented above show that certain generalized patterns of species distribution along the local and regional gradients exist, which are suggested and often predictable on the basis of the known pattern of habitat preference from other areas. It can be concluded that the data set (gradient ranges) reveals well the ecological tolerances of species. Thus, it may be expected that the ecological grouping of the species, obtained in the course of the study, may serve as a basis for a rough characteristic of the habitat preference of spider species under analysis.

The obtained results show that the spiders have potential as indicators for ecological change since they display a sensivity to changes in habitat structure and/or associated microclimatic parameters which can be altered by many aspects of human activity. The above data are in agreement with the results known from other parts of Europe (Turnbull, 1973, Haskins, Shaddy, 1986, Wise, 1993).

The above gradient analyses show that the spatial pattern of spiders was influenced by two key-factors - the amount of sun radiation and humidity. These observation correspond well with the data available in literature (Tretzel, 1952). In this study, as usually in other investigations, this statement is based on the habitat preference, not on laboratory experiments. So, it is difficult to decide whether these factors affect the spider distribution directly, or through the temperature, vegetation structure, soil type, and other secondary factors. Nevertheless, the present study provides data, concerning this aspect of autecology of large number of species, especially those presented by large number of specimens. Among others, these data offer a possibility to identify stenoecious species. The presence of such species in particular habitats, sites or areas is often considered as an important criterium for their conservation importance. The available data permit to characterize the following species as stenotopic: *Coelotes karlinski* (O, P), *Zodarion turcicum* (N), *Pirata hygrophilus* (Q, I, J), *Tricca lutetiana* (J), *Xysticus caperatus* (B, Ba, C, Ca), *Nemesia pannonica* (B, Ba, C, Ca).

Recently the investigations of spider assemblages at a family level are considered as relevant to the current concerns for rationalizing the coast and benefits of the monitoring surveys (Yen, 1993). Our data show that the analyses at this level are less sensitive in respect to the identification of the environmental gradients, affecting the spider assemblages. The main cause for this effect is the loss of important biological, ecological and biogeographic information, associated with species level. Evidently, the phylogenetic groups are not directly related to the environmental factors, at least to these represented within the scale of this study. The members of a particular taxon-guild, composed by confamilial species, although having similar hunting strategies, may be adapted to different environmental conditions. It may be expected that the application of analyses at family level may be more useful in identifying some general environmental patterns at broader spatial scale, when they may help to avoid the information noise, caused by local variability at species level (Yen, 1995). Nevertheless, the positive reaction of GNA_GH on the disturbance regime derives special attention and more detailed further study.

2. Diversity

The diversity is often considered as a valuable criterium for identifying the conservation value of particular assemblages and respective habitats. However, the usefulness of various measures of diversity is controversial. On one hand, the measurement of diversity meets with some difficulties. The above analyses showed that before its application in indications some methodological considerations should be made. Our analyses pointed out that the eveness measures were highly dependent on the sampling effort. Most probably the main cause for this result is the circumstance that the data set contains very large number of rare species. This correspond to the opinion of some students (Pielow, 1969, Peet, 1974) that the use of eveness measures is correct only when the whole number of species in the assemblage is known (Baev and Penev, 1995). Having in mind the great number of singletons and the respective shape of the rarefaction curves, it is evident that the increasing of the number of collected specimens will lead to additional captures of rare species and consequently to the dependence of these measures on the sampling effort.

On the other hand, it is not clear which parameters of diversity must be analyzed (Cousins, 1991). As shown above, the diversity analyzed on species level is not necessarily related to the conservation value. The present data show that the diversity is positively correlated with open sites and the presence of a wide number of widely distributed species. Most probably the diversity measures depend mainly from the structural complexity of lower vegetational layer which offered a great variety of microclimates, larger variety of resources and wider range of shelters from predators and unfavourable environmental changes. These conditions provide many possibilities for niche segregation and permit a great number of potentially competitors to coexist. However, there was no direct correlation with the structural characteristic of this layer. Edge effects were also probably significant in determining the recorded diversity of hedgerows. This is attributed to wanderers from adjacent biotopes that are nearer to the traps than they are in larger shrubby or forested sites. The diversity measured on functional level (taxon-guilds) provides more differentiated picture. The assemblages from the southern area, associated with the light forests were most diversified.

3. Environmental Gradients and Composition of the Fauna. Conservation Implications

The obtained results indicate that there is a clear pattern of habitat association and zoogeographic structure of spider assemblages. Species with wide ranges were especially numerous in open sites - the correlation of their relative frequency, based on the number of specimens, with the intensity of reflected light is rather high. More over, they are also associated with disturbed sites. Thus, this group of species can be used for indication of disturbance, taking into account, of course, the other pecularties of sites (structure of vegetation, light conditions). In contrast, the species with European type of distribution (E, MSE, SEE), forming the geographically characteristic component of the fauna and being also especially numerous, were associated mainly with the mesophilous and/or forested habitats. Species with restricted ranges (BG, BK, BKMA, PM), constituting the regionally specific part of spider fauna, were better represented in the southern area. In general, it can be stated that the species, characteristic for this part of the country (E, MSE, EE) or those of particular biogeographic interest (BG, BKMA, BK) are associated with relatively undisturbed or slightly disturbed natural vegetation (i. e. forests, forest edges, steppe-like grasslands, etc.). Therefore any disturbance of natural habitats will have a disproportionately greater negative impact on regionally specific portions of the local spider fauna than on the widespread component. As shown above, the disturbed habitats support particularly diversified assemblages, but it is clear that they are of lower conservation value.

The above analyses show that the evaluation of spider associations from the point of view of conservation indication must be based on a complex of criteria. The most suitable seems to be the presence of species of restricted ranges or characteristic for the geographic area under investigation, the presence of stenotopic species, the great functional (measured at the level of taxon-guilds) and zoogeographic diversity.

4. Potential Limitation of the Study

As shown by the analyses of the functional composition of spider assemblages, they were dominated by ground hunters from the family Lycosidae. This circumstance is most probably related to the sampling method. It is widely known that the ground hunters are readily captured by pitfall traps (Canard, 1982, Merrett and Snazell, 1983). Thus, the observed regularities, relate mainly to this part of the spider fauna. Evidently, the other functional component are underestimated by pitfall trapping. It must be emphasized that is, the great number of rare species, represented by one or two specimens, was not restricted to a particular guild. A large number of such species occurs also in the guild of ground hunters, which in general may be considered readily sampled by this method. It could be assumed that the large number of rare species in the spider data most probably reflects real peculiarities of their biology - the occurrence of large number of more or less sedentary or solitary species within this guild. Regardless of causes, this structure of the samples poses some limitations when using the spider assemblages in applied ecology. In the most cases analyzed here, even the largest samples, collected for relatively long periods, do not reveal the whole species array, occurring in a particular homogene habitat - all rarefaction curves do not reach asymptote. Consequently, similar analyses should be based on samples obtained by a large number of traps, acting more than one growing season. When analyzing such data one must rely mainly on the most numerous and/or regularly captured species. The conclusions based on the species absences or on the occurrence of rare species may be quite doubtful. In particular, the analysis of presence/absence data, as shown in this study, is not useful at these spatial scales, because the presence and absence at individual sites depends on sample size.

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