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Q1 Spiders are not less diverse in small and isolated grasslands, but less diverse in overgrazed grasslands: A field study (East Hungary, Nyírség)

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ABSTRACT

The effects of size, isolation and grazing intensity on spider assemblages were studied in the fragments of sandy grasslands (East Hungary, Nyírség). Spiders were sampled by sweep-netting at eight different-sized grassland fragments between 2001 and 2003 from April to October fortnightly. The following hypotheses were tested: (i) the rules of classical island biogeography are assessed for grassland fragments: the number of species increases with the size and decreases with the isolation of the fragment. (ii) Species richness of spiders decreases by the intensity of grazing. (iii) Grazing may have a negative influence on the large, web-builder spiders and on the diurnal hunters associated to the vegetation. During the 3-year study period, 3842 spider specimens belonging to 90 species were collected from the eight sandy grassland fragments. We found no significant relationship for the size and isolation of grassland fragments neither with the number of species nor the number of vegetation-dwelling species, species associated with sandy soils, and with the vegetation-dwelling species specific to sandy area. Our result suggests that even the small fragments had a relatively large species pool. There was a positive correlation of the average height of vegetation as a measure of grazing intensity with the total number of spider species, as well as with the number of vegetation-dwelling species, species associated with sandy soils, and also with the number of vegetation-dwelling species specific to sandy area. By indicator species analysis (IndVal) we found that the grazing had a negative influence on the large, web-builder spiders and also those diurnal hunters, which were associated to the vegetation.

1. Introduction

Recently, in many countries of the world, the development of agricultural and urban landscapes has been characterized by an increase in management intensity, and a consequent reduction and fragmentation of natural and semi-natural habitats. Agricultural intensification is currently considered as a major driver of worldwide biodiversity loss (Kleijn and Sutherland, 2003; Mattison and Norris, 2005; Tscharntke et al., 2005). Grasslands are especially threatened by the intensive agriculture. In Hungary, grasslands covered almost 33% of the land surface in the 19th century, while their recent area has dropped to 11% (Anon., 2003, 2005). At many localities, this decline created a network of isolated and fragmented grasslands. In Hungary mostly the sandy grasslands are affected. Such sandy grasslands, formerly used as pastures or meadows, have been ploughed and used as cropland, afforested with non-native trees (black locust (*Robinia pseudoacacia*), ennobled poplar species (*Populus* spp.), and pine species (*Pinus nigra*, and *Pinus sylvestris*)) or built over.

The classical theory of island biogeography relates species richness to island area and isolation (MacArthur and Wilson, 1967). These concepts are regarded both to true islands and to terrestrial habitat islands. Habitat islands are patches of favourable habitats surrounded by less hospitable habitats. The classical theory predicts that the number of species on islands (or habitat fragments) is a function of island size and distance to the mainland or continuous unfragmented habitats. Smaller, more isolated fragments retain fewer species than larger, less isolated ones. Recently, more papers refined the original hypothesis of the island biogeography theory emphasizing the effects of surrounding habitats (edges and matrix) on the species richness (Lövei et al., 2006; Raman, 2006; Devictor and Jiguet, 2007; Magura and Ködöböcz, 2007).

Fragmentation of the continuous grasslands has vital effect on the biodiversity of agricultural lands (Walker et al., 2004). It has two components. First, the total area of the habitat sustaining populations decreases. Secondly, these habitats tend to be more

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isolated (Saunders et al., 1991; Collinge, 1996). Spiders are also sensitive to the fragmentation (Miyashita et al., 1998; Marc et al., 1999). As arthropod predators they are important components of natural and agricultural ecosystems; they play vital role in structuring arthropod communities, and also in natural pest control (Sunderland and Samu, 2000; Marc et al., 1999). Usually they are the most diverse and abundant predatory animal group of grasslands. Besides fragmentation spider assemblages are influenced by many aspects of land use and management, like mowing regime (Pozzi et al., 1998; Cattin et al., 2003), burning (Haskins and Shaddy, 1986), and grazing intensity (Dennis et al., 2001; Warui et al., 2005). Biodiversity has an increasing value for the society, even in the agricultural policy (Duelli et al., 1999; Kleijn et al., 2006). Therefore, to study of spiders which are vital components of agricultural ecosystems is essential to understand the effect of land use processes.

In the present study, we evaluated the spider assemblages of sandy grassland fragments in Eastern Hungary (Nyírség). Our hypotheses were as follows. (i) The rules of classical island biogeography were assessed for the size and isolation of grassland fragments. The number of species increases with the size and decreases with the isolation of the fragment. (ii) Species richness of spiders decreases with the intensity of grazing. (iii) Grazing may have a negative influence on the large, web-builder spiders and on the diurnal hunters associated to the vegetation.

2. Materials and methods

2.1. Study area and sampling

Spider assemblages of eight sandy grassland fragments located in the Nyírség region, part of the Great Hungarian Plain (Eastern Hungary) were studied (Table 1). In the 19th century, natural habitats (sandy grasslands, sandy oak woods, marshes, fen meadows, and mires) covered this region. With the intensification of landscape management during the 20th century these habitats were eliminated or became highly fragmented. Today, the fragmented sandy grasslands are surrounded by arable land and non-native tree plantations. In this area the typical grassland vegetation was *Potentillo arenariae - Festucetum pseudovinae* (Török et al., 2008). The patches were lightly and heavily grazed with cow and sheep (cattle density was 0.1–1 heads/ha). The distance between the investigated grassland patches was at least 2 km. Distance of the two furthest patches was 75 km. The Nyírség area, where the studied grasslands were located is the second largest plain area of Hungary of size 5100 km^2. All of the investigated grasslands were surrounded by non-native deciduous tree plantations (black locust, and ennobled poplar species), and croplands (maize (*Zea mais*) and corn (*Triticum aestivum*, *Secale cereale*, *Avena sativa*, *Hordeum vulgare*). Thus, the matrix habitats were similar for all the studied patches.

Table 1
Name and habitat characteristics of the studied sandy grassland fragments.

Site name	Area (ha)	Inverse isolation index (ha)[a]	Average height of vegetation (cm)
Bagamér	99.0	121.5	15
Bátorliget	249.7	122.1	15
Hajdúbagos	250.6	58.3	35
Martinka	353.5	137.6	9
Nyíregyháza	188.7	130.5	3
Nyírtura	29.1	1.6	25
Rohod	51.8	7.3	7
Újtanya	2.3	137.3	14

[a] Inverse isolation index was defined as the total grassland area within a radius of 1000 m around the studied grassland fragment.

In each grassland fragment samples were taken in a 200 m by 200 m sampling area by a sweep-net of 50 cm diameter from April to October every second week during a 3-year period (2001–2003). Each sample was based on 400 sweeps. Spiders were stored in 70% ethanol and identified to species level using standard keys (Heimer and Nentwig, 1991; Roberts, 1995). The nomenclature of Platnick (2008) was followed.

The intensity of grazing was characterized by the average vegetation height. In each grassland fragment within the 200 m by 200 m sampling area we randomly assigned a 50 m by 50 m plot and the height of the vegetation was measured in 10 randomly chosen locations in July. The average of these measures was used as the average height of the vegetation in the fragment. The vegetation height was inspected regularly during the field sampling (every second week) and it was stable. Grassland fragments were covered by the same kind of vegetation. Each grassland fragments were in the Nyírség area. Thus, soil type (FAO type: arenosols), nutrition, water table depth, moisture, amount of organic matter, and other herbivore activity was similar. Moreover, grazing is a traditional agricultural activity in this region and cattle stayed all summer long in the field. Therefore, the lower average height of the vegetation was resulted in by higher intensity of grazing. We found high correlation between the grazing intensity (density of grazing animals) and the vegetation height ($r = -0.8472$, $p < 0.0001$). Therefore, the lower average height of the vegetation was resulted in by higher intensity of grazing.

2.2. Statistical analyses

The area of the sandy grassland fragments was measured using the ArcView GIS program package on a digitized 1:25,000 map. Isolation of a habitat island (grassland fragment) is most often measured as the distance to the nearest fragment. Isolation also depends on the area of the nearest fragment. A large grassland fragment is more likely to have greater number of species that can colonize the neighbouring fragments. Therefore, isolation of the grassland patches was measured by the inverse isolation measure. It was defined as the total sandy grassland area within a radius of 1000 m around the studied grassland fragment. This measure was used as an inverse of the isolation, because its value decreases as the isolation of the grassland fragment increases (Magura et al., 2001).

Various species have different lifestyle and habitat demands. They respond differently to the size of the habitat, isolation and structure of the vegetation. When studying predictions of island biogeography theory on habitat islands a distinction should be drawn between specialist species that perceive the habitat patches as islands and those species that occur in both the habitat patch and the matrix. Thus, depending on the ecological characteristics of the species we used the following categories during the statistical analyses: (i) all spider species, (ii) vegetation-dwelling species (web-builders and active hunters), (iii) species associated with sandy soils and (iv) vegetation-dwelling species associated with sandy soils (web-builders and active hunters). The categories are based on Buchar and Ruzicka (2002) and also on our field experience.

The relationships between the fragments' characteristics (size, isolation and grazing intensity) and the species richness of spider assemblages were examined by stepwise multiple linear regression analyses (Kutner et al., 1996). The distribution of data used in the multiple linear regression analyses was normal (tested by the Kolmogorov–Smirnov test, Sokal and Rohlf, 1995). The indicator value (IndVal) method was used to find the statistically significant characteristic species of the intensively and the moderately grazed grassland fragments (Dufrêne and Legendre, 1997). To the IndVal analysis grassland fragments were categorized according to grazing intensity: intensively grazed grasslands (vegetation shorter than 10 cm), and moderately grazed grasslands (vegetation higher than 10 cm). IndVal is using a Monte Carlo permutation test to assess statistical significance of the species indicator values.

3. Results

During the 3-year study period, 3842 spider specimens belonging to 90 species were collected from the studied sandy grassland fragments (Table 2). The *Chrysso nordica* species is the first identification of the species in Hungary. We have detected it four out of the eight studied sites (Bagamér, Kék Kálló Völgy; Bátorliget, Bátori-legelő; Hajdúbagos; Martinka).

The result of stepwise multiple linear regression analysis revealed that neither the area nor the isolation of the grassland fragments had an influence on the total number of species. We received the same result for the vegetation-dwelling species, species associated with sandy soils, and vegetation-dwelling species associated with sandy soils. Species richness has a positive correlation with grass height, but a negative correlation with grazing intensity. (Table 3, Fig. 1).

Table 2
Sampled species with specimens in the eight grassland fragments from 2001 to 2003.

Species	1	2	3	4	5	6	7	8
Uloboridae								
Uloborus walckenaerius Latreille, 1806	2	0	1	0	0	3	0	0
Theridiidae								
Chrysso nordica (Chamberlin and Ivie, 1947)	3	0	0	0	2	12	1	0
Enoplognatha sp.	2	0	0	1	0	1	0	0
Euryopis saukea Levi, 1951	2	0	1	0	1	3	0	0
Neottiura suaveolens (Simon, 1879)	0	0	0	1	0	0	0	0
Steatoda phalerata (Panzer, 1801)	2	0	0	0	0	0	0	0
Theridion impressum L. Koch, 1881	14	7	41	49	16	20	20	4
Linyphiidae								
Araeoncus crassipes (Westring, 1861)	0	0	0	0	0	0	1	0
Araeoncus humilis (Blackwall, 1841)	5	0	1	1	1	3	0	1
Bathyphantes gracilis (Blackwall, 1841)	0	1	0	0	0	0	0	0
Donacochara speciosa (Thorell, 1875)	1	0	0	1	0	0	0	0
Erigone dentipalpis (Wider, 1834)	0	1	0	0	0	0	0	0
Gnathonarium dentatum (Wider, 1834)	1	0	0	0	0	2	0	0
Hypomma fulvum (Bösenberg, 1902)	1	0	0	0	0	0	1	0
Linyphia triangularis (Clerck, 1757)	0	0	1	0	0	0	0	0
Meioneta rurestris (C. L. Koch, 1836)	0	1	2	5	2	1	1	0
Microlinyphia pusilla (Sundevall, 1830)	1	4	4	3	0	2	0	0
Neriene radiata (Walckenaer, 1842)	0	11	6	1	0	0	0	0
Oedothorax apicatus (Blackwall, 1850)	0	0	0	0	0	0	1	0
Trichopterna cito (O. P.-Cambridge, 1872)	0	0	18	0	0	0	0	0
Tetragnathidae								
Pachygnatha listeri Sundevall, 1830	0	0	0	2	0	0	0	0
Tetragnatha sp.	0	0	2	5	3	1	1	2
Araneidae								
Aculepeira sp.	0	0	1	0	0	0	0	0
Agalenatea redii (Scopoli, 1763)	69	15	17	29	103	9	0	0
Araneus angulatus Clerck, 1757	1	0	0	2	0	0	0	0
Araneus diadematus Clerck, 1757	1	0	0	1	3	0	0	0
Araneus quadratus Clerck, 1757	2	2	1	0	1	0	0	0
Araniella opisthographa (Kulczynski, 1905)	0	1	0	0	0	0	0	0
Argiope bruennichi (Scopoli, 1772)	52	151	25	9	167	67	0	3
Gibbaranea sp.	1	0	0	0	0	0	0	0
Hypsosinga albovittata (Westring, 1851)	3	0	0	0	0	3	2	0
Hypsosinga pygmaea (Sundevall, 1831)	2	6	7	1	8	2	1	1
Hypsosinga sanguinea (C. L. Koch, 1844)	0	1	8	5	0	0	0	0
Larinioides suspicax (O. P.-Cambridge, 1876)	0	1	0	0	0	0	0	0
Mangora acalypha (Walckenaer, 1802)	83	26	19	62	31	13	8	1
Neoscona adianta (Walckenaer, 1802)	122	2	71	89	539	58	1	0
Singa hamata (Clerck, 1757)	9	0	0	5	6	0	0	0
Singa lucina (Audouin, 1826)	0	0	0	0	1	0	0	0
Lycosidae								
Pardosa agrestis (Westring, 1861)	0	0	0	0	0	1	0	0
Pardosa palustris (Linnaeus, 1758)	0	0	0	1	0	0	0	0
Pisauridae								
Pisaura mirabilis (Clerck, 1757)	4	1	7	6	3	1	0	0
Oxyopidae								
Oxyopes heterophthalmus (Latreille, 1804)	57	0	0	0	18	31	0	0
Oxyopes ramosus (Martini & Goeze, 1778)	0	0	0	0	0	2	0	0
Dictynidae								
Archaeodictyna consecuta (O. P.-Cambridge, 1872)	1	0	0	0	0	1	0	1
Dictyna arundinacea (Linnaeus, 1758)	10	47	7	215	7	5	22	0
Dictyna uncinata Thorell, 1856	0	0	0	0	0	0	1	0
Nigma sp.	1	0	0	0	0	0	0	0

Table 2 (*Continued*)

Species	1	2	3	4	5	6	7	8
Miturgidae								
Cheiracanthium pennyi O. P.-Cambridge, 1873	2	2	0	0	0	0	0	0
Clubionidae								
Clubiona pseudoneglecta Wunderlich, 1944	0	1	0	0	0	0	0	0
Gnaphosidae								
Micaria pulicaria (Sundevall, 1831)	0	0	0	0	0	1	0	0
Philodromidae								
Philodromus aureolus (Clerck, 1757)	0	0	0	1	0	0	0	0
Philodromus cespitum (Walckenaer, 1802)	0	0	0	1	0	0	0	0
Philodromus collinus C. L. Koch, 1835	0	0	0	0	0	1	0	0
Philodromus histrio (Latreille, 1819)	1	0	0	0	0	0	0	0
Philodromus praedatus O. P.-Cambridge, 1871	0	0	1	0	0	0	0	0
Thanatus arenarius L. Koch, 1872	0	1	0	3	0	0	0	0
Thanatus formicinus (Clerck, 1757)	1	0	0	0	0	0	0	0
Tibellus maritimus (Menge, 1875)	3	1	0	1	1	2	0	0
Tibellus oblongus (Walckenaer, 1802)	6	17	0	0	5	21	0	0
Thomisidae								
Coriarachne depressa (C. L. Koch, 1837)	1	0	0	0	0	1	0	0
Cozyptila blackwalli (Simon, 1875)	0	0	0	0	0	1	0	0
Diaea dorsata (Fabricius, 1777)	0	0	0	0	0	1	0	0
Diaea livens Simon, 1876	0	0	0	2	5	0	2	0
Heriaeus sp.	0	0	0	1	0	0	0	0
Misumena vatia (Clerck, 1757)	7	4	4	8	30	7	1	0
Ozyptila atomaria (Panzer, 1801)	0	1	0	0	0	0	0	0
Ozyptila scabricula (Westring, 1851)	0	1	0	0	0	0	0	0
Runcinia grammica (C. L. Koch, 1837)	0	0	0	0	0	1	0	0
Thomisus onustus Walckenaer, 1805	52	0	6	8	127	225	17	0
Tmarus piger (Walckenaer, 1802)	0	0	0	2	0	0	0	0
Xysticus acerbus Thorell, 1872	1	5	4	1	17	0	0	0
Xysticus audax (Schrank, 1803)	0	0	1	0	2	0	0	0
Xysticus cristatus (Clerck, 1757)	7	2	0	5	7	7	0	0
Xysticus kempeleni Thorell, 1872	1	0	0	0	0	0	0	0
Xysticus kochi Thorell, 1872	10	0	0	0	7	6	0	1
Xysticus lanio C. L. Koch, 1835	0	0	1	1	1	0	0	0
Xysticus luctuosus (Blackwall, 1836)	4	1	0	0	0	1	0	0
Xysticus ninnii Thorell, 1872	3	0	0	4	5	7	0	0
Xysticus sabulosus (Hahn, 1832)	15	0	1	4	27	12	0	0
Xysticus striatipes L. Koch, 1870	3	33	22	12	14	3	1	7
Xysticus ulmi (Hahn, 1831)	0	0	0	1	2	0	0	0
Salticidae								
Aelurillus v-insignitus (Clerck, 1757)	1	0	0	0	3	3	0	1
Ballus sp.	0	0	0	0	0	1	0	0
Evarcha arcuata (Clerck, 1757)	4	12	0	7	8	2	0	0
Heliophanus flavipes (Hahn, 1832)	35	8	10	10	15	18	1	0
Marpissa sp.	0	0	0	2	1	0	0	0
Philaeus chrysops (Poda, 1761)	77	2	0	1	5	56	1	0
Phlegra fasciata (Hahn, 1826)	0	0	0	0	1	0	0	0
Sitticus dzieduszyckii (L. Koch, 1870)	0	1	0	0	0	0	0	0
Yllenus vittatus Thorell, 1875	2	0	0	0	3	1	2	0
Total	688	370	290	569	1198	619	86	22

Notations: 1: Bagamér; 2: Nyírtura; 3: Rohod; 4: Újtanya; 5: Bátorliget, Bátori-legelő; 6: Hajdúbagos; 7: Martinka; and 8: Nyíregyháza.

By the IndVal method we found the following significant characteristic species of the intensively and moderately grazed grassland fragments (vegetation height was higher than 10 cm; Table 4). The species which are insensitive to the grazing intensity, and were abundant in each grassland fragments were as follows: *Theridion impressum* L. Koch, 1881; *Mangora acalypha* (Walckenaer, 1802); *Xysticus striatipes* L. Koch, 1870. Species characteristic to the moderately grazed grassland fragments with vegetation higher than

Table 3
Relationship between the spider species and the studied habitat characteristics, determined by forward stepwise multiple linear regression.

	All spider species[a]	Vegetation-dwelling species[b]	Species associated with sandy soils[c]	Vegetation-dwelling species associated with sandy soils[d]
Size of the grassland patch	Not entered	Not entered	Not entered	Not entered
Inverse isolation index	Not entered	Not entered	ns	Not entered
Grazing intensity measured by average height of vegetation	+*	+*	+*	+*

[a] $F(1,6) = 10.51$, $p = 0.018$, $r = 0.798$.
[b] $F(1,6) = 10.86$, $p = 0.016$, $r = 0.803$.
[c] $F(2,5) = 5.10$, $p = 0.062$, $r = 0.819$.
[d] $F(1,6) = 8.51$, $p = 0.027$, $R = 0.766$.
[*] Significant positive relationships are indicated: $p < 0.05$.

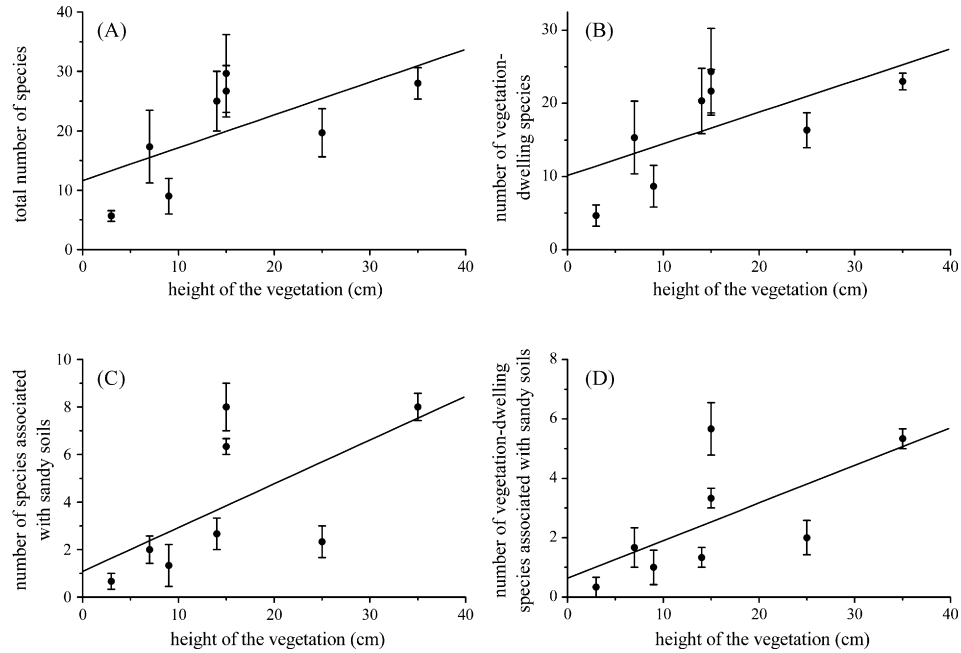

Fig. 1. Relationship between the grazing intensity measured by the average height of the vegetation and the total number of spider species (A) and the number of vegetation-dwelling species (B) and the number of species associated with sandy soils (C) and the number of vegetation-dwelling species associated with sandy soils (D) collected. Every regression are significant ($p < 0.05$). Lower vegetation height indicates higher intensity of grazing. Vertical bars denotes the mean ± S.E. of the number of species.

Table 4
Two-way indicator table showing the species indicator power of the habitat clustering hierarchy for the species that were represented by more than 15 individuals.[a]

Species	IndVal	Vegetation shorter than 10 cm	Vegetation higher than 10 cm
All sites			
Theridion impressum	91.67 ns	65/8	106/14
Xysticus striatipes	79.17 ns	30/6	65/13
Mangora acalypha	66.67 ns	28/5	215/11
Moderately grazed sites (vegetation higher than 10 cm)			
Argiope bruennichi	90.53*	28/5	446/15
Neoscona adianta	81.29*	72/4	810/14
Evarcha arcuata	80.00*	0/0	33/12
Tibellus oblongus	80.00*	0/0	49/12
Dictyna arundinacea	79.76*	29/4	284/14
Misumena vatia	75.44*	5/3	56/13
Thomisus onustus	73.19*	23/5	412/12
Philaeus chrysops	72.48*	1/1	141/11
Heliophanus flavipes	71.44*	11/2	86/13
Xysticus sabulosus	71.28*	1/1	58/11
Oxyopes heterophthalmus	60.00*	0/0	106/9
Xysticus cristatus	60.00*	0/0	28/9
Agalenatea redii	59.21*	17/1	225/10
Xysticus ninnii	53.33*	0/0	19/8

ns: not significant.
[a] In the row for each species, the first number indicates the number of specimens present and the second number corresponds to the number of samples where the species is present, in this sample group. The IndVal column indicates the species indicator value for the corresponding clustering level, which is the maximum indicator value observed in all the clustering hierarchy.
* $p < 0.05$.

10 cm were as follows: e.g. *Agalenatea redii* (Scopoli, 1763); *Argiope bruennichi* (Scopoli, 1772); *Neoscona adianta* (Walckenaer, 1802); *Dictyna arundinacea* (Linnaeus, 1758); *Thomisus onustus* (Walckenaer, 1805). There were no characteristic species of the overgrazed grassland fragments (vegetation height was below 10 cm).

4. Discussion

4.1. Effects of habitat size and isolation

In a number of studies, a significant positive relationship was proved between the species richness of habitat fragments and their size (Abensperg-Traun et al., 1996; Collinge, 1998; Miyashita et al., 1998). Other investigations contrary to the classical theory of island biogeography reported that there was a significant negative correlation between the total number of species and area or isolation of habitat islands (Hopkins and Webb, 1984; Webb and Hopkins, 1984; Balkenhol et al., 1991; Usher et al., 1993). Other studies found that the number of species was unrelated to both the habitat size and isolation (Balkenhol et al., 1991; Pajunen et al., 1995; Steffan-Dewenter and Tscharntke, 2000; Magura et al., 2001; Bonte et al., 2002; Gibb and Hochuli, 2002; Pearce et al., 2005; Kapoor, 2008). We also found no significant relationship between the number of species and the area or the isolation of the grassland fragments. The lack of area–species relationship is that even in a small patch of grassland (2.3 ha) majority of the characteristic species of the grasslands were present. The insignificant influence of isolation on species richness is explained by the fact that all captured spider species can survive in the sandy grasslands and also in the surrounding habitats (arable lands, plantations). Moreover, spiders are able to disperse long distances by wind; thus, isolation is not a significant factor controlling the spider richness of the grassland fragments.

4.2. Effects of grazing

We found a significant positive relationship between the species richness of spiders and grazing intensity measured by vegetation height. Our result supports the hypothesis that the grazing influences significantly the species richness. Moderate grazing intensity results in higher vegetation, which is usually vertically more structured and it increases the spider richness. Dennis et al. (2001) and Harris et al. (2003) also pointed out that rich vertical structure and the height of vegetation facilitate the spider richness. Intense grazing decreases the spider diversity, and it increases the abundance of disturbance-tolerant species (Gibson et al., 1992a; Bell et al., 2001). De Keer et al. (1989), Maelfait and De Keer (1990) and Gibson et al. (1992a) demonstrated that heavily grazed pastures were dominated by Linyphiidae species, characteristic of disturbed land. A controlled management based on moderate grazing may result in a more species-rich spider assemblage, because it increases the habitat diversity. The increased habitat diversity increases the number of spider species (Pozzi et al., 1998). In the case of grazed grasslands the number of spider species increases by the height of the herbaceous vegetation, because they are sensitive to the vegetation structure (Gibson et al., 1992a,b). The hunting spiders and the web-builders are the most sensitive to the complexity of the habitats. Higher prey density, more shelter, decreasing intra-guild predation and the alternative food sources may be mentioned as the main reasons of this sensitivity (Langellotto and Denno, 2004). Delchev and Kajak (1974) found that intensive grazing completely destroyed the spider assemblage of the former vegetation. Thomas and Jepson (1997) established that the heavy grazing caused virtual extinction of spider species. Gibson et al. (1992a) pointed out that mainly large web-builders are sensitive to grazing. Warui et al. (2005) found that the grazing by domestic herbivores significantly reduced the diversity of spiders; surprisingly wild herbivores (mega- and meso-herbivores) did not have a significant influence on the diversity of the spider fauna. Bonte et al. (2000) demonstrated that the spider's diversity was highest in the border zone between the cattle-grazed and non-cattle-grazed sites.

By the IndVal method we found only three characteristic species which were insensitive to the change of the intensity of grazing. Two of them (*T. impressum, M. acalypha*) were a small sized web-builder spider, which were able to use their web even in a short grass vegetation. Therefore, these two species were not limited by the grazing intensity. The third species (*X. striatipes*) hunted on the lower part of the plants. Thus, it was also insensitive to the intensive grazing. However, large majority of the spiders were able to survive only in the moderately grazed grassland fragments, where the vegetation was higher than 10 cm. The several web-builders using large orb web (*A. redii, A. bruennichi, N. adianta*), and the other spider species using large-sized space web for hunting (*D. arundinacea*). These species were not able to survive in the intensively grazed grasslands with low vegetation height, because the size of their web would be larger than the vegetation height. Large majority of the diurnal hunters [e.g. *Oxyopes heterophthalmus* (Latreille, 1804), *Philaeus chrysops* (Poda, 1761)] were hunting on the upper parts of the plant or on the flowers of the plants. These parts of the plants were eliminated by grazing; therefore, the species were suppressed to the lower parts of the plants where they could not exist.

4.3. Implications for conservation and management

Grassland conservation is one of the top priorities in the European Community. These grasslands are also characteristic elements of the landscape in the Nyírség area. Therefore, their management and conservation have high priority both on the national and international level. Spiders, as secondary consumers have vital role in supporting the diversity and functioning of these kinds of grassland ecosystems. We would like to stress that even a small, isolated grassland fragment can support a species rich spider association. These small fragments are not entirely isolated, because spiders are especially successful in dispersal. The spiders of the fragments may create a metapopulation supporting the species richness of the whole Nyírség area. Therefore, it is vital to maintain and protect even the small grassland fragments. Our results also suggest that the richness of spider assemblage was significantly controlled by the vegetation height. Overgrazed, short grasslands were characterized by low number of spider species. Thus, only a moderate level of grazing is proposed to maintain a high alpha diversity in the fragments.

We found that the rules of classical biogeography failed for the spiders of grassland fragments. Neither the size nor the isolation was important in supporting diversity of spiders. Our result suggests that metapopulation dynamics may be the key factor supporting spiders' biodiversity. Large majority of the spiders were able to survive in the moderately grazed grassland fragments, but not in the overgrazed ones. Grazing had a negative influence on the large, web-builder spiders and also on the diurnal hunters.

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