1. Introduction

Spiders are among the most abundant polyphagous predators occurring in all terrestrial ecosystems. The high number of species and abundance make their assemblages suitable for ecological studies. Majority of the spider species has well defined habitat requirements, therefore, the species composition of the assemblages is a sensitive indicator of changes in habitat quality.

According to my hypothesis, based on the result of the previous arachnological studies, the structural and abiotic properties of the habitat (e.g. vegetation architecture, water content of the soil, shading etc.) type, defined on the basis of the vegetation, have major effect on the species composition and the structure of the spider assemblages.

The assembly rules brought about by the biotic interactions (e.g. competition) have presumably minor effects in shaping the spider assemblages.

Out of the landscape-scale variables, the patch size and the heterogeneity of the surrounding habitat patches has been proved to influence the diversity and the species richness of the spider assemblages. Although numerous authors have demonstrated the significance of the spatial structure of the landscape on spider and other invertebrate assemblages, it is difficult to generalize the effect of the landscape heterogeneity and the configuration of the patches, as various taxa react differently to the habitat and landscape features, since species ecology and dispersal abilities are different for every organism.

The restrictions of possible generalization make reasonable the case studies on spider assemblages both on local (i. e. habitat) and on landscape scale.

2. Aims

The aim of this dissertation is to contribute the knowledge of spider assemblages and their regulator conditions of some characteristic habitats of the Hungarian Great Plain. The following questions are addressed in the dissertation:

(1) Are the pitfall traps applicable for faunistical surveys, estimation of species richness and comparing assemblages of spiders?
(2) Has the heteromorphy of the sandy grasslands an effect on the spider assemblages? How the micro-relief influences the spider assemblages at the sand dunes of Kiskunság Region?
(3) How the spatial changes in habitat structure alter the species composition of spider assemblages at the edges of different habitats or habitat patches (forest edges and the edges of grassland patches)?
(4) How the habitat size influences the spider assemblages? What size is the smallest habitat which support own spider assemblages?
(5) How do habitat quality and landscape parameters affect assemblages? Which parameters have significant effect on the species richness and composition of spider assemblages at the lower reach landscapes of the River Tisza?

3. Methods

The estimation of species richness, the effect of habitat heterogeneity, habitat edges and habitat size were studied in the Kiskunság region at the natural forest-steppe zone. The effect of habitat and landscape parameters was studied at the reach of the River Tisza.

The spider assemblages were sampled using plastic cups as pitfall traps. We used ethylene-glycol and water solution as preservative.

The following variables were considered as external conditions potentially affect the composition and diversity patterns spider assemblages: the cover of mosses, lichens and herbaceous vegetation at the ground level, at 10 and 40 cm above the ground and the water content of the soil were measured near the traps. To assess the features of the landscape, the proportion of land-use types was measured in a radius of 250 m around each site, based on aerial photographs (i.e. grasslands, forests and arable fields).

Non-parametric estimators were used to estimate the species richness and assess the efficiency of pitfall traps in sampling the spider fauna.

The effects of the habitat properties and landscape parameters on the species richness and rarefaction diversity were tested with linear models.

To compare the diversity of different assemblages I used the Rényi's diversity ordering.

To identify the width and the position of the transition zone between the assemblages, I calculated the Wilson-Schmida β diversity measure and the Chao modified Jaccard similarity index.

To gain insight to the existence of distinct assemblages we applied non-metric multidimensional scaling (NMDS).

The canonical correspondence analysis (CCA) was used to reveal the correlations between the habitat characteristics, landscape parameters and the structure of the spider assemblages.

4. Results and Discussion

4.1 Pitfall traps in faunistical surveys at dry grasslands

As the majority of the present research was done in sandy habitat complexes, I tested the applicability of pitfall trap sampling method in a sandy grassland.

The spider fauna was sampled using 110 pitfall traps in a grassland near Bugacpusztaháza village. The traps were arranged in 22 sampling plots and were open from March to December 2007. A total of 8486 individuals belonging to 92 species were collected. According to the non-parametric estimators, 82-93% of the total species pool was collected. Between 2002 and 2006, 7810 individuals were collected using pitfall traps at the same grassland, representing 70 species, 19 of which were not collected in 2007. The majority of the species with low abundance were vegetation dwelling or web building spiders. I estimated the minimum sampling effort to detect all the species of the estimated asymptotic species richness. On the basis of Chao 1 and Chao 2 estimators, further 41088 collected individuals or 599 pitfall traps are needed in order to gain a complete faunistical inventory.

Although a great sampling effort is needed to collect all the spider species of the habitat using exclusively pitfall traps, this method offers the opportunity to compare the assemblages of different habitats, as it collects the dominant ground dwelling species of the spider assemblages.

4.2 The effect of habitat heteromorphy in the sandy grasslands on the spider assemblages

The data from the studies described in the section 4.1, provide an opportunity to investigate the role of the measured habitat variables and habitat patchiness in the structuring of spider assemblages. The species richness of spiders was influenced by the soil moisture and vegetation height. CCA revealed the significant effect of

the soil moisture and coverage of the vegetation also on the composition of spider assemblages. The coverage of the mosses and lichens and elevation did not influence the spider assemblages. However spiders were influenced by vegetation emerged according to the 1.5-2 meters difference of elevation and soil moisture of the sandy grassland. Structurally complex habitats may provide more potential shelter and sites for web building, thus influences the composition of spider assemblages.

The results of previous studies shown that the structural heterogeneity of the habitat presumably influences the density of the prey populations and therefore it has also an indirect effect on the spider assemblages.

4.3 Spider assemblages at forest edges and at the edges of grassland patches

The spider assemblages of two forest edges were studied in the Kiskunság region (dense juniper shrub – open grassland and poplar and juniper forest – open grassland). Considerable differences were observed between the spider assemblages of the grasslands and that of the forest. Both the observed species richness and the species diversity by Rényi's diversity ordering were higher for the grasslands than for the forests. At the poplar and juniper forest edge, a higher number of forest specialist species penetrated into the grassland. Presumably this was due to the shading effect of the nearby poplar trees. CCA revealed a strong influence of the cover of the mosses, lichens and herbaceous vegetation structure on the spider assemblages.

Two adjacent sand dunes and the dune valley between them were sampled with pitfall traps along a transect. The NMDS revealed different spider assemblages on the two slopes, possibly due to the more dense and diverse vegetation on the north facing slope, which is presumably brought about by the different insolation and moisture conditions of the slopes. The results of the canonical correspondence analysis emphasized the importance of the total coverage

of vegetation, the elevation and the soil moisture on the distribution of spider species.

4.4. The effect of habitat size on spiders

As a part of the Kiskunság forest-steppe region is a network of poplar forest fragments surrounded by open grasslands, it offers an opportunity to study the ecological effects of natural fragmentation on invertebrates. The spider assemblages of 15 forest patches and the grassland matrix between them were sampled using pitfall traps. The NMDS and the Rényi's diversity ordering revealed three distinct groups of forest assemblages: (1) small patches (88-166m^2) with high species diversity, similar to the surrounding grassland, (2) medium sized patches (265-725m^2) and (3) large forests (1025-5000m^2) with the lowest diversity. The only significant relationship was observed between the frequency of forest specialist species and the fragment size.

4.5 The effect of the habitat quality and landscape parameters on the spiders

Two habitat complexes of the lower Tisza-valley were selected for sampling spider assemblages. The southern habitat complex is situated near Szeged, where the landscape mainly consists of arable fields with small patches of grasslands, forest plantations. The Dóc habitat complex lies 40 km north of Szeged in a structurally more complex landscape. 10 grasslands and 10 forests were sampled in the two habitat complexes, respectively. At each site three lines of traps were placed, each line consisted of five traps. According to the linear models, the NMDS and CCA ordinations the soil moisture, vegetation cover, regular flooding events and the relative area of neighboring forests played major roles in shaping of the species richness and composition of grassland spiders assemblages. A negative correlation was found between the number of grassland specialist species and the proportion of

the forests, and the number of forest species increased significantly with the neighboring forest area.

In case of the studied forests the soil moisture and the coverage of the leaf litter were the influential parameters at the habitat scale. At the landscape scale the area of neighboring forests and grasslands were the influential parameters. The results of the present study emphasize the importance of the effect of both habitat and landscape properties on spider assemblages.

Publications related to the topic of the dissertation

Gallé, R., Torma, A., Körmöczi, L. 2007: Epigeic invertebrate assemblages (Araneae, Heteroptera) of natural forest edges. *Proceedings of the 8th Central European Workshop on Soil Zoology*, Ceske Budejovice.47-53

Gallé, R. 2008: The effect of a naturally fragmented landscape on the spider assemblages. *North-Western Journal of Zoology*. 4: 61-71.

Gallé, R., Torma, A. 2009: Epigeic spider (Araneae) assemblages of natural forest edges in the Kiskunság (Hungary). *Community Ecology*, 10: 146-151

Torma, A., Bozsó, M., **Gallé, R.** 2009: Határok és átmenetek hatása az ízeltlábú együttesek mintázatára a Kiskunság természetközeli élőhelyein. In Gallé, L. (szerk): *Entomológia: kutatás, szemléletformálás, ismeretterjesztés.* SZTE, Szeged, 136-155.

Gallé, R., Torma, A., Körmöczi, L. 2010: Small scale effect of habitat heterogeneity on invertebrate assemblages in Hungarian sandy grasslands *Polish Journal of Ecology*, 58: 333-346.

Gallé, R., Vesztergom, N., Somogyi, T. 2011: Environmental conditions affecting spiders at the lower reach of the River Tisza in Hungary. *Entomologica Fennica*. accepted manuscript

Publications not directly related to the topic

Gallé, L., **Gallé, R.**, Markó, B., Mikó, I. & Sárkány-Kiss E. 2000: Habitat correlates of ground invertebrate assemblages in a flood plain landscape complex. *Tiscia monograph series*, 31-36.

Gallé, R., Urak, I. 2001:Contribution to the spiders (Arachnida: Araneae) of upper Mures river valley with some new data for the Romanian fauna. *Entomologica romanica*, 6: 141-144.

Gallé, R., Urák, I. 2002: Faunistical data on the spiders (Arachnida: Araneae) of Nemeria Mountain's bog complex with two species new for the Romanian fauna. *Entomologica romanica,* 7: 85-88.

Gallé, R. 2002: Assemblage structure of wolf spiders in south Hungarian grasslands. In: *European Arachnology 2002* (F. Samu & Cs. Szinetár eds.), Plant Protection Institute & Berzsenyi College, Budapest, 151-156.

Urak, I., **Gallé, R.** 2005: Some new records and rare species for the Romanian spider fauna. *Entomologica Romanica,* 10: 33-37.

Gallé, R., Fehér, B. 2006: Edge effect on spider assemblages *Tiscia*, 35:37-40.

Gallé, R., Urák, I. 2006: Faunistical data on spiders (Arachnida: Araneae) of the Lacul Dracului bog complex with new data for the Romanian fauna. *Scientific Annals of the Danube Delta Institute.* 2006, 29-32.

Árendás, O., Bozsó, M., **Gallé R.**, Torma, A., Körmöczi, L. 2007: Composition of assemblages of ants (Hymenoptera: Formicidae) and associated arthropods (Heteroptera, Orthoptera, Araneae) at natural forest edges. *Myrmecological News,* 10: 100.

Urák, I,, **Gallé, R.** 2008: Further Data on the Arachnofauna (Arachnida:Araneae) of Dobrogea / Újabb adatok Dobrudzsa pókfaunájáról (Arachnida: Araneae). *Acta Scientiarum Transylvanica – Biologia,* 16: 79-87.

Dudás, Gy., **Gallé, R.,** Papp, V.G., Varga, J. 2008: A Bodrogköz pókfaunája. In Tuba, Z. (szerk): *Bodrogköz.* (A magyarországi Bodrogköz tájmonográfiája). Lórántffy Zsuzsa Alapítvány, Gödöllő-Sárospatak. 779-789.

Presentations with published abstracts

Gallé R. 2001: Dél-alföldi gyepek farkaspók közösségeinek összehasonlító vizsgálata. *3. Magyar Pókász Találkozó* Budapest, május 2-4.

Gallé, R. 2002: Assemblage structure of wolf spiders in south Hungarian grasslands. *20 th.European Colloquium of Arachnology*, Szomathely, július 22-26.

Margóczi, K., Körmöczi L., Bozsó M., **Gallé, R.**, Sághy, M., Torma, A. 2002: Faji szintű védelmet megalapozó vizsgálatok a Dél-Kiskunságban. *I. Magyar Természetvédelmi Biológiai Konferencia,* Sopron, november 14-17.

Gallé R. 2004: Pókközösségek foltdinamizmusa. *5. Magyar Pókász Találkozó* Uzonkafürdő, szeptember 10-12.

Gallé, R., Fehér B. 2004: Pókközösségek vizsgálata nyárerdő szegélyen. *2. Szünzoológiai szimpózium,* Budapest, március 8-9.

Gallé R. 2005: Természetes erdőszegélyek pókközösségei. *6. Magyar Pókász találkozó* Mórahalom, szeptember 15-18.

Gallé, R., Torma, A. 2005: Soil fauna (Araneae, Heteroptera) of natural forest edges. 8th Central European Workshop on Soil Zoology, Ceske Budejovice, április 20-22

Gallé R., Torma A., Körmöczi L. 2006: Ízeltlábú közösségek változása természetközeli szegélyeken. 7. *Magyar Ökológus Kongresszus*. Budapest, szeptember 4-6.

Makra, O., Gallé, L., Fülöp, D., **Gallé, R.**, Bozsó, M., Kőváry, K., Rostási, Á. 2006: Egy Tisza-menti táj mintázata különböző közösségek leképezésében. *7. Magyar Ökológus Kongresszus*. 2006 Budapest, szeptember 4-6.

Torma, A., **Gallé, R.**, Körmöczi, L. 2007: Ízeltlábú közösségek vizsgálata kiskunsági mozaikos élőhelyen. *III. Kárpátmedencei Környezettudományi Konferencia*, Kolozsvár, 2007 március 29-31.

Gallé R., Torma A., Bozsó M., Körmöczi L. 2007 Izeltlábú együttesek homoki élőhelyeken. *8. Biológus Napok*, Kolozsvár, április 20-21.

Gallé, R. 2007 Erdőfoltok méretének hatása a pókegyüttesek szerveződésére. *3. Szünzoológiai Szimpózium,* Budapest, március 5-6.

Gallé, R., Torma, A., Bozsó, M., Körmöczi, L. 2007 Invertebrate assemblages of the mosaic habitats in the Kiskunság Region (Hungary). *9 th Central European Workshop on Soil Zoology,* Ceske Budejovice, április 17-20.

Gallé, R. 2009: Dél-Tisza menti pókegyüttesek szerkezete. *8. Magyar Ökológus Kongresszus*. augusztus 26-28.

Gallé R., Strifler G., Vesztergom N. 2009: Dél-Tisza menti pókegyüttesek szerkezete. *10. Magyar Pókász Találkozó* Oroszlány-Gánt október 9-11
Varga Cs., Bozsó M., **Gallé R.**, Torma A., Varga M.: Ízeltlábú közösségek szerkezete dél-alföldi gyepeken. *8. Magyar Ökológus Kongresszus*. Szeged, 2009 augusztus 26-28.

Fischer, C., Schlinkert, H., Ludwig, M., Holzschuh, A. **Gallé, R**. Tscharntke, T., Batáry, P. 2010: The impact of hedgerow-forest connectivity on carabid beetle and spider communities in agricultural landscapes. IXth European Congress of Entomology 2010 augusztus 22-27.

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I hereby confirm that the manuscript 'Environmental conditions affecting spiders in grasslands at the lower reach of the River Tisza in Hungary', authors Róbert Gallé, Norbert Vesztergom & Tamás Somogyi, has been accepted for publication in Entomologica Fennica.

Kai Ruohomäki

Társszerző nyilatkozat

Alulírott tanúsítom, hogy **Gallé Róbert**, mint társszerző, meghatározó mértékben járult hozzá az alábbi tudományos munkák elkészítéséhez:

Torma, A., Bozsó, M., **Gallé, R.** 2009: Határok és átmenetek hatása az ízeltlábú együttesek mintázatára a Kiskunság természetközeli élőhelyein. In Gallé, L. (szerk): Entomológia: kutatás, szemléletformálás, ismeretterjesztés. Szeged. 136-155

Az alábbiakban egyetértek azzal, hogy Gallé Róbert a publikációban szereplő arachnológiai adatokat felhasználja a PhD fokozat eléréséhez szükséges dolgozat elkészítéséhez. Alulírott nem szándékszik adatokat hasonló fokozat eléréséhez felhasználni.

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