PhD thesis

ORTHOPTERAN SPECIES AND ASSEMBLAGES OF THE BAKONY REGION

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DEBRECENI EGYETEM
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Debrecen, 2010

1. Introduction

Investigation of the orthopterans from community ecological, acoustic, autecological and conservation biological point of view has become one of the most popular topics of the biological researches by this time. Aims of the studies are mostly based on the economic and human significance of some species, but the interest of the nature preservation is also outstanding caused by the good indicative features of the species and assemblages and by the high number of the umbrella species. In the background of the great account of the Orthoptera taxon in the basic research is a fact that orthopterans are very useful for the testing of the general hypotheses of community ecology.

Zoogeographical and community ecological studies in the Bakony Region predicted several new results based on the size, the geo-morphological variety, climatic and biogeographical diversity and relative low frequency of the local researches. It was especially true of determination of the borders of the zoogeographical microregions and the background variables of these separations. From community ecological point of view the potential zoogeographical affects in local organization gives the basis of the new scientific results. Study of the annual dynamics of the assemblages was also reasoned – mainly in unstudied grasslands having marked annual microclimate change.

Results cover three main topics: (i) analyses of the local distribution patterns of the species; (ii) study of the orthopteran assemblages of the Bakony Region; (iii) study of the annual dynamics of the assemblages.

2. Aims

2.1. Aim of the analyses of the local distribution patterns of the species was to reveal the zoogeographical borders of the Bakony Region and the basic indicator variables (macroclimate, landscape structure) affecting the local zoogeographical features of the Orthoptera Fauna.

2.2. Aim of the study of the orthopteran assemblages was to reveal the local characteristics of the assemblages and to reveal the most important general elements of their organization.

2.3. Aim of the studies focused annual dynamics of the orthopteran assemblages occurring in grasslands with marked annual microclimate change was to reveal the relations between seasonality of the orthopteran assemblages and microclimate changing in habitats.

3. Study area

Study area was the Bakony Region according to the nomenclature of the traditional geography (without Pannonhalmi-dombság, ~3694 km^2). This territory is bordered by Lake Balaton and Mezőföld from south/south-east, by Hévízi-meridionális-valley and Kisalföld from west, by Pannonhalmi-dombság and Igmánd-Kisbéri-basin from north/north-east and by Móri-árok from east. Contingent of the potential Orthoptera-habitats (mainly natural grasslands, pastures, scrubs) from the total study area is ~17.5% (based on the map of CLC, sum of the area of the natural and semi-natural habitats is 60%).

4. Methods

4.1. *Analyses of the local distribution patterns of the species*

UTM-maps (2.5 × 2.5 km) of 84 species were used as distribution patterns of the species. Maps were drawn based on all data (presence-absence/quadrat) available in publications and collections. Based on the estimation of the database the extent of anomaly of research-intensity could not affect zoogeographical results. Over the presence-absence data of the species, relative frequency and overall cases of the different life-forms several abiotic background variables were also connected to each quadrat: height above sea level; geomorphological heterogeneity; annual mean temperature; annual waterfall; insolation in April; insolation in July. Data of the landscape and habitat-structure were determined based on Corine Land Cover and MÉTA (General National Habitat-classification System) database. Cover and relative frequency at landscape level of agrarian, scrubby, frondous forest, grassland, anthropogenic and wetland habitats; number of the habitat-patches and habitat-diversity of CLC were connected to UTM-quadrats. Further biotic variables: cover of

the relevant Á-NÉR categories and merged categories, diversity, overall cover and patch-numbers of the Á-NÉR categories.

Separation of the microregions was studied 61 merged samples of 673 UTM quadrats. Average area of the merged samples was 70.63 km^2. Cluster analysis, principal component analysis and correspondence analysis were used for the analyses of the merged samples. Diagnostic species were determined with Indval 2.0 programme.

Quantitative studies of the characteristic species-groups were carried out with box-plot analyses and the determination of relative frequency values of life-forms, thermic requirements, distribution types and fauna types.

Background variables of the distribution patterns of the species were studied with canonical correspondence analyses (background variables/species; background variables/life-forms and types of different thermic requirements). Ordination of the climatic data and data of the habitat structure was also carried out – both with the original (n=673) and merged (n=61) data bases.

4.2. *Study of the orthopteran assemblages of the Bakony Region*

671 samples of 43 sampling sites were used for the analyses (study period: 2000–2009). Samplings sites represent all of the potential orthopteran habitats of the Bakony Region. Samplings taken with sweep-netting were repeated 3–4 cases per sampling site (June, July, August and September in the same year), thus the 182 merged samples covered all annual aspects of the sampled assemblages.

Habitats of the sampled Orthoptera assemblages belong to the following plant associations: *Junco obtusiflori-Schoenetum nigricantis*: 56; *Succiso-Molinietum*: 5; *Cirsio cani-Festucetum pratensis*: 3; *Anthyllido-Festucetum rubrae*: 9; *Pastinaco-Arrhenatheretum*: 9; *Salvio-Festucetum rupicolae*: 6; *Brachypodium pinnatum* grasslands: 11; *Sanguisorbo minoris-Brometum erecti*: 21; *Corynephoretum canescentis*: 5; *Koelerio-Corynephoretum*: 3; *Festucetum vaginatae*: 3; *Luzulo-Callunetum*: 10; *Chrysopogono-Caricetum humilis*: 38; *Seseli leucospermi-Festucetum pallentis*: 3.

The following background variables were recorded: (i) Plant coenological relevés. (ii) Data of the vertical habitat structure (height of the vegetation). (iii) Area of the sampled grassland. (iiii). Average distance of the sampling site from the min. 0.25 hectares sized forest-scrub patches. (iiiii) Data of the macroclimate: annual mean temperature; annual waterfall; insolation in April; insolation in July.

Cluster analysis and principal component analysis were used for the analyses of the merged samples. Diagnostic species of the classification's groups were determined with Indval 2.0 programme. The following parameters of the separated assemblages were given: relative frequency of the dominant species; Orthoptera species number; relative frequency of the arbusticol, geophil, graminicol, pratinicol, pseudopsammophil and silvicol species; relative frequency of the hygrophil, moderate-hygrophil, mesophil, moderate-thermophil and thermophil species; relative frequency of the Ensifera, Caelifera, Bradyporidae, Conocephalidae, Phaneropteridae, Tettigoniidae, Gryllidae, Tetrigidae, Acrididae taxa. Data lists of the sample-groups were compared with χ^2-test. Diversity ordering of the separated assemblages was also done. Relations among presence of different life-forms and thermic requirements, Ensifera/Caelifera ratio and percentage of the Orthoptera families and the potential background variables were studied with Spearman's rank correlation.

4.3. *Study of the annual dynamics of the assemblages*

342 samples of 55 sampling sites were used for the analyses (study period: 2000–2009). Microclimate of the studied grasslands [(1) Calcareous fens [*Junco obtusiflori-Schoenetum nigricantis; Caricetum davallianae*]; (2) Drying fens [*Succiso-Molinietum hungaricae; Agrostio-Deschampsietum caespitosae*]; (3) Hayfileds [*Pastinaco-Arrhenatheretum; Anthyllido-Festucetum rubrae; Cirsio cani-Festucetum pratensis*]; (4) Semi-dry grasslands [*Sanguisorbo minoris-Brometum erecti, Euphorbio-Brachypodietum, Brachypodium pinnatum* grasslands] show annual microclimate change (except *Bromus erectus* grasslands).

Recorded background variables were: plant coenological relevés, temperature (°C) and vapour content (%) in the grassland [256 cases, 4252 measurements (on the ground

surface, at heights of 10, 20, 30 cm in the grassland, and a control-measurement at 120 cm)].

Derived data of the orthopteran-assemblages: species number, density, relative frequency of the species (per samples), spectra of the thermic requirements.

Samples originate from different parts of the year were compared with multi-dimensional scaling per grassland-types. Relations among microclimate and structural features of the assemblages were studied with Pearson-correlation and Spearman's rank correlation (according to the results of the normality tests).

5. Results

5.1. Analyses of the local distribution patterns of the species

Examinations revealed 9 new species for the Bakony Region (*Isophya modestior, Poecilimon fussii, Polysarcus denticauda, Platycleis montana, Tettigonia caudata, Myrmecophilus acervorum, Pteronemobius heydenii, Chorthippus vagans, Euchorthippus pulvinatus*). Further, distribution of several species important in point of view of zoogeography and nature protection was mapped (*Barbitistes serricauda, Isophya costata, Isophya kraussii, Gampsocleis glabra, Saga pedo, Arcyptera microptera, Stenobothrus eurasius*). Before these studies local distribution of common species was also less known the precise zoogeographical estimation.

Zoogeographical microregions of the Bakony Region based on the local distribution patterns of orthopteran species are: (1) *Balaton Uplands,* which are characterized by *Stenobothrus nigromaculatus, Pterolepis germanica* and *Pezotettix giornae*. Typical occurrences of the above mentioned and further thermophytic species are caused by the high degree of insolation in April, and low degree of annual waterfall. (2) *Plate of the Tapolca- and Káli-Basin.* Indicator species of this microregion is *Isophya costata*. Separation of the microregion is also confirmed by the more typical occurrences of mesophytic and hygrophytic species than in others. (3) *Eastern-Bakony*. Absolute character species of the microregion is *Arcyptera microptera*, further character species: *Stenobothrus eurasius*, *Oedaleus decorus*, *Platycleis affinis*, *Platycleis montana* and *Gampsocleis glabra*. Markant presence of

pseudopsammophytic species is caused by high degree of insolation in April, but rendzina soil mixed with sand covering large areas in this region is also adequate for the colonization of these species. (4) *Central-Bakony and the Kab Hill.* Character species of the microregion are *Pholidoptera aptera* and *Tettigonia cantans*, and – common with the Southern-Bakony – *Leptophyes boscii*. Occurrences of these species are depended by high annual waterfall and the cover of the frondous forests (CLC). (5) *Sandy areas near Fenyőfő*. Xerophytic sandy elements of the Orthoptera Fauna of the Bakony Region occur mainly in this region. (6) *Southern-Bakony*. This microregion is characterized by many occurrences of *Isophya kraussii*, and high frequency of silvicol, rarity of thermophytic species. (7*) Western-Bakonyalja.* Species of the middle-mountainous and collin areas have a few occurrences in this microregion. (8) *Keszthely Mountains* is characterized by high relative frequency of arboricol and arbusticol species.

Results show positive correlation between presence of *Tettigonia cantans, Leptophyes boscii, Pholidoptera aptera, Ph. fallax, Ph. griseoaptera, Gomphocerippus rufus, Chorthippus dorsatus* and *Omocestus rufipes* and the value of annual waterfall, height above sea level and percental cover of frondous forests. Contemporaneously presence of *Celes variabilis, Platycleis montana* and *Arcyptera microptera* is related to high degree of insolation in April and high relative frequency (at landscape level) of natural and semi-natural grasslands.

High annual mean temperature and habitat-diversity affect positively the frequency of *Isophya costata, Ruspolia nitidula* and *Isophya modestior*. High degree of insolation in July is preferential for *Pezotettix giornae* and *Pterolepis germanica*.

Results connected to distribution of life-forms and types of thermic requirements show that (a1) silvicol species are in close relation with the cover of the frondous forests (CLC); (a2) silvicol species are related to low annual mean temperature, to rich annual waterfall and to moderately homogeneous landscape structure; (a3) occurrences of graminicol and pseudopsammophil species are more affected by the degree of insolation in April than in July; (a4) significant positive correlations were found between the presence of graminicol species and the cover of the natural grasslands and

not-frondous forests (CLC) and closed, dry and semi-dry grasslands (Á-NÉR), further presences of graminicol species are related to poor annual waterfall and high degree of insolation in April; (b1) occurrences of mesophil, moderate-hygrophil and hygrophil species are strongly affected by the annual waterfall; (b2) occurrences of thermophytic species are affected positively by the poor annual waterfall and by the high degree of insolation in April; (b3) mesophytic species are mainly related to xerotherm frondous forests (CLC) and closed, dry and semi-dry grasslands (Á-NÉR) (occurrences of the latest species show positive correlation with the annual waterfall); (b4) presence data of moderate-hygrophytic and hygrophytic species show positive correlation just with the surface cover of the frondous forests.

5.2. *Study of the orthopteran assemblages of the Bakony Region*

Orthopteran assemblages of the Bakony Region characterized by individual structure are:

(1) *Calcareous fens, drying fens and marshy meadows* – Indicator- and at once dominant species of the assemblage are hygrophytic and mesophytic species (*Conocephalus discolor*, *Chrysochraon dispar, Euthystira brachyptera*). Further, this assemblage is characterized by the absence of the eurytopic species of the dry grasslands (*Chorthippus brunneus, Chorthippus biguttulus, Stenobothrus lineatus, Euchorthippus declivus*), the absolute dominance of pratinicol species, rarirty of the moderate-thermophytic and thermophytic species, and frequent presence of Conocephalidae species.

(2) *Hayfields* – Indicator- and dominant species of the assemblage are *Chorthippus parallelus* and *Metrioptera roeselii*. Spectrum of the thermic requirement is off-centred to thermophytic species, further feature of the assemblage is the rarity of Conocephalidae species.

(3) *Semi-dry grasslands* – Indicator species of the assemblage are *Metrioptera bicolor, Leptophyes albovittata* and *Gomphocerippus rufus*. Assemblage is dominated by mesophytic species. Arbusticol and silvicol species are also dominant caused by the characteristics of the habitat (clearing origin, occurrences in openings, ecotons etc.).

(4) *Calciphobe open sandy grasslands* – Indicator- and dominant species of the assemblage are *Dociostaurus brevicollis* and *Myrmeleotettix maculatus*. Assemblage is characterized by absolute dominance of pseudopsammophil, thermophytic and Acrididae species.

(5) *Scrubby semi-dry grasslands* – Indicator species of the assemblage are *Pterolepis germanica*, *Ephippiger ephippiger* and *Pholidoptera griseoaptera*. Assemblage is dominated by the thermophytic, Ensifera and Tettigoniidae species.

(6) *Closed dry grasslands* – Indicator- and at once dominant species of the assemblage are *Stenobothrus nigromaculatus* and *Oedipoda caerulescens*. Assemblage is dominated by pratinicol species.

(7) *Open dry grasslands, rocky grasslands* – Indicator species of the assemblage contain both species of short-grasslands (*Calliptamus italicus, Stenobothrus crassipes*) and species of tall-grasslands (*Platycleis albopunctata, Omocestus haemorrhoidalis*). Assemblage is dominated by graminicol species.

Main relations among the structural parameters of the assemblages and the potential background variables are: (1) vertically well-structured vegetation (tall-grass) and the closing of the grassland correlate negatively with the orthopteran species-groups related to open ground surfaces, short-grasslands, and with density of moderate-thermophytic, thermophytic, graminicol and pseudopsammophil species; contemporaneously the above mentioned factors correlate positively with occurrences of hygrophytic, moderate-hygrophytic, mesophytic, graminicol, pratinicol and arboricol species; (2) presence of arboricol and silvicol species is typical on small grassland patches; (3) occurrences of geophitic, pratinicol, moderate-hygrophytic, mesophytic species-groups correlate negatively with the cover of the dicotyledonous plant species; density of monocotyledonous plant species characterized by mesophitic contexture correlate positively with the occurrences of geophitic, pratinicol, moderate-hygrophytic and mesophytic species-groups, and correlate negatively with the occurrences of thermophytic species; (4) occurrences of mesophytic species correlate positively with the annual waterfall; (5) total cover of dicotyledonous plant species correlate negatively with density of hygrophytic and moderate-hygrophytic species,

and correlate positively with density of thermophytic and moderate-thermophytic species; (6) high degree of insolation in April affects negatively the occurrences of mesophytic species and positively the occurrences of moderate-thermophytic species; (7) hygrophytic, moderate-hygrophytic and mesophytic species are related mainly to vertically well-structured grasslands (tall, multi-levelled), whereas thermophytic and moderate-thermophytic species are related to short, one-levelled grasslands.

5.3. *Study of the annual dynamics of the assemblages*

In the Bakony Region seasonal structural changes of orthopteran assemblages occurring in calcareous fens, drying fens and *Brachypodium pinnatum* grasslands show differences at aspect-changing scale. This phenomenon is caused by the seasonal changes of the vapour content of these grasslands. Aspect-changing was not explored in *Bromus erectus* grasslands characterized by stable annual microclimatic circumstances. In some grassland-types the separed early-summer and late-summer/autumn aspects show further differences. In *Brachypodium pinnatum* semi-dry grasslands two types of early-summer aspect can be described (*Euthystira brachyptera*-type and *Chorthippus parallelus–Metrioptera bicolor*-type), contemporaneously autumn aspect with characteristic structure is not seen in this grassland-type. In calcareous fens two autumn aspect-types are present. In stands with good water supply hygrophytic species are dominant, density of xerophytic species are restricted. In stands with bad water supply thermophytic and xerophytic species are dominant in the autumn aspect. In drying fens can also be seen early summer and late summer aspects of orthopteran assemblage. It manifests in the annual changes of relative frquency of dominant and subdominant species. Early summer aspect characterized by high overall-density are dominated by hygrophytic and mesophytic species. Late summer/autumn aspect is characterized by low overall-density of hygrophytic species.

6. Summary of new scientific results and conclusions

6.1. *Analyses of the local distribution patterns of the species*

(i) Quantitative zoogeographical analyses of the ortopterans are very usable for the determination of zoogeographical borders at microregional scale.

(ii) Zoogeographical differences of microregions in the Orthoptera Fauna are not manifested in the distribution of species groups of different faunal-types, but in the distribution of species groups of different eco-types.

(iii) Description of those elements of macroclimate and landscape features which determinate regional distribution patterns of the orthopteran species-groups (common life-form, thermal- and humidity requirements) and species is possible.

6.2. *Study of the orthopteran assemblages of the Bakony Region*

(i) It is confirmed that orthopteran assemblages characterized by individual features are not related to plant associations but to higher vegetation units having similar structural characteristics.

(ii) Most of the revealed orthopteran assemblages of the Bakony Region can fit into the published Hungarian types.

(iii) Orthopteran assemblages of the Bakony Region depend on water-gradients, but globally general mechanisms of the community organization of the taxon also play important role. Revealed main influential factors in the Bakony Region are: horizontal and vertical structure of the vegetation, annual waterfall, degree of insolation in April.

6.3. *Study of the annual dynamics of the assemblages*

(i) The microclimate of grasslands is not only a spatial but also a temporal factor (within a year) in organization of the orthopteran assemblages.

(ii) Orthopteran assemblages of grasslands characterized by markant annual microclimate-changing over the variation caused by phaenology show markant seasonal structural changes at aspect-changing scale.

(iii) Annual dynamics of the orthopteran assemblages is affected by the microclimate, phaenology of the species, characteristics of the adjoining habitats and human effects.

7. Publications related to the Thesis

Articles in refereed journals

Kenyeres, Z., Bauer, N. & Rácz, I. (2002): *Saga pedo* Pallas dans le bassin Carpates, synthès et nouvelles données (Orthoptera, Tettigoniidae). – *Bulletin de la Société entomologique de France* **107**(2): 149–156.

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Kenyeres, Z. & Bauer, N. (2001): Javaslat az egyenesszárnyú együttesek (Orthoptera) természetességének megállapítására. – *Természetvédelmi Közlemények* **9**: 219–228. [Suggestion for the determination of naturalness of Orthoptera communities.]

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Kenyeres, Z., Bauer, N. & Nagy, B. (2004): Az Orthoptera-együttesek és a habitatok változásai a Tihanyi-félszigeten 1947. és 2001. évi felvételek alapján. – *Állattani Közlemények* **89**(1): 37–53. [Differences in the Orthoptera assemblages in the Tihany Peninsula (W Hungary) based on samplings of 1947 and 2001.]

Bauer, N. & Kenyeres, Z. (2005): Adatok néhány, a Dunántúli-középhegységben jellemző gyeptársulás állományklímájához. – 2. Kvantitatív Ökológiai Szimpózium (KÖSZi), Veszprém, 2005. április 18. Kivonatkötet: 8. [Data to the microclimate of some grassland associations typical in the Transdanubian Mountains.]

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Kenyeres, Z. (2006): Egy rovarcsoport útja a szervezett irtástól a Vörös Könyvig. – *Természetvédelmi Közlemények* **12**: 105–121. [The road of an insect group from organised disinsecting to the Red Data Book.]

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Kenyeres, Z. & Bauer, N. (2009): Daily activity of *Poecilimon intermedius* (Fieber, 1853) in a typical steppe habitat of the species (Central-Europe, Hungary). – 10th International Congress of Orthopterology, Antalya, Turkey, 21–25 June 2009, Metaleptea, Special Conference Issue:106.