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ORIGINAL PAPER

Setting priorities and evaluation of habitats for the conservation of orthopterans: case study in the Aggtelek National Park (N Hungary)

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Abstract
The biodiversity conservation needs recent high-quality data and efficient methods for prioritizing species and sites for conservation. Here we prioritized Orthoptera habitats of the Aggtelek National Park, based on revised and actualized distribution data of 69 Orthoptera species living at 98 sites. The simple ranking and complementary areas methods were used with species richness (S), rarity weighted species richness (SR), and number of rare species (SQ). Additionally, the Grasshopper Conservation Indexes (GCI" and GCIn") combining European and local rarity and dispersal capacity of the species were also tested. Contrary to simple ranking the complementary areas method represented the whole fauna and significant part of the species-site data records. All the used indices performed similar except the standardized GCIn" which is highly affected by the differences in study intensity of sites. High-priority areas of the Aggtelek National Park were designated in the plateau above Jósvafő and Aggtelek villages and in the small, isolated hill near Jósvafő (Szőlő-hegy) covered with remained mosaic of former vineyards, orchards and hayfields. The combined use of the efficient indices provides additional ranking that allows the best selection of hotspots to support efficient use of limited resources in nature conservation.

Keywords Prioritization · Hotspot · Simple ranking · Complementary areas · Aggtelek Karst

Introduction

The loss of biodiversity is one of the major challenges of our civilization, and to stop or slow down it the effective use of limited resources is crucial. The conservation of the remaining natural and semi-natural sites needs prioritization and planning. Although insect orders are the most diverse terrestrial taxa, generally the vertebrates such as amphibians, birds and mammals are used in conservation prioritization (Ceballos and Ehrlich 2006). Databases including distribution data of different taxa can be successfully used for conservation prioritization through designation of biodiversity hotspots based on species richness, and number of rare and/or vulnerable species (Gaston and David 1994; Reid 1998; Sólymos and Fehér 2005; Sólymos et al. 2006). To regard the conservation value of species is more effective than prioritization based on the simple alpha diversity indices, which are usually affected by common or even invasive species (Matenaar et al. 2015).

In Central Europe secondary grasslands formed by long-term extensive use maintain especially high insect diversity endangered by habitat fragmentation and secondary succession caused by abandonment and intensification of land use (fertilization and intensive grazing or mowing) (Fischer and Stöcklin 1997; Bakker and Berendse 1999; Balmer and Erhardt 2000). In Hungary secondary grasslands of the Aggtelek Karst are among the most typical sites of these species-rich secondary grasslands. The invertebrate fauna considering molluscs (Deli 2002; Farkas 2008; Sólymos et al. 2009), isopods (Kontschán 2004; Vilisics et al. 2008), lepidopterans (Szabó et al. 2007; Végvári et al. 2015) and carabid beetles (Szél 1999; Magura and Lövei 2017) is well known, and in case of orthopterans this is the most studied region of Hungary (Rácz et al. 2003; Nagy and Rácz 2007a). Since 2005, when the last review of the Orthoptera fauna was made (Nagy and Rácz 2007b; Nagy 2008) intensive studies have been carried out in the National Biodiversity Monitoring Program (Kovács-Láng et al. 2000).

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Because of their large abundance, relatively high species richness, diverse life forms and their crucial role in the food chain orthopterans are one of the most important taxa of grasslands all over the World (Sinclair 1975; Gardiner et al. 2005). They are sensitive indicators of changes in vegetation structure and naturalness (Marshall 2010; Benton 2012; Cherrill 2015) and widely used in grassland ecology and conservation planning (Noss 1990; Spellerberg 1991; Pearson 1994; Báldi and Kisbenedek 1997; Batáry et al. 2007; Torma et al. 2014; Kenyeres et al. 2020).

Using the detailed and carefully revised distribution data of the Orthoptera fauna of the Aggtelek Karst region (North Hungary) priorities of conservation and further studies of the fauna were designated based on alpha diversity and distribution of rare and protected species. Additionally, a new approach of Grasshopper Conservation Index (GCI, Matenaar 2015; Szanyi et al. 2021; Arnóczkyné and Nagy 2022) calculating with local and regional frequencies and moving ability of species was also used to evaluate the natural value of different sampling sites.

Materials and methods

Source of distribution data

The database includes Orthoptera distribution data from the Aggtelek National Park (Fig. 1) was built with former published and newly collected partly unpublished data of several researchers. The studies have four periods (Table 1). From the first period unpublished data of Barnabás Nagy, István Rácz and Zoltán Varga are available, and papers of Rácz (1992), Rácz et al. (2003), Parragh (1983) and Garay (2002) contain reliable data. Between 1981 and 1993 (in the 2nd period) samplings become more intensive and Parragh (1983, 1987), Mező (1991, 1992) and Garay (1995) published their results, and some unpublished data of István Rácz and Zoltán Varga also could be found. The most intensive studies were carried out in the 3rd period. Kirill M. Orci made intensive samplings in the grassland patches

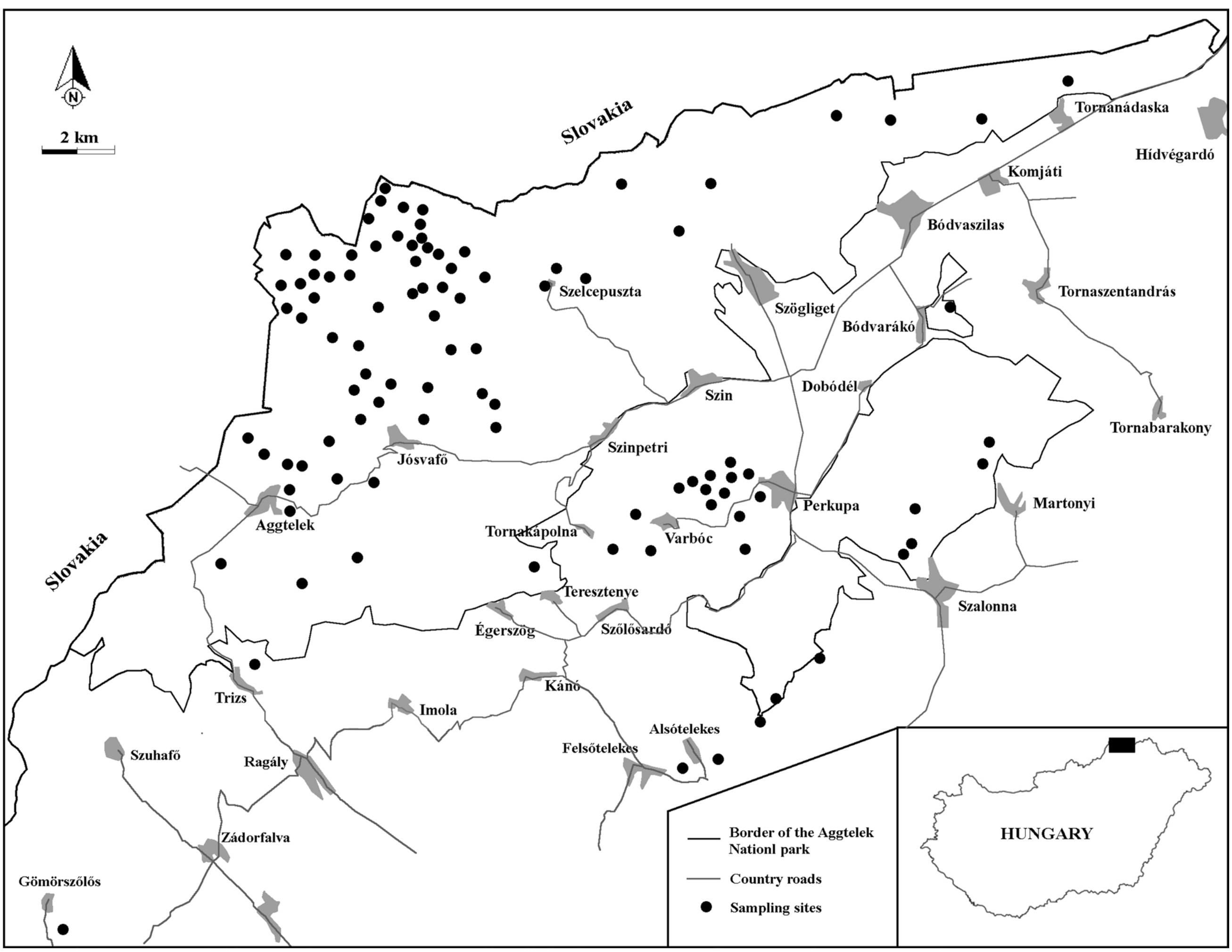

Fig. 1 Map of the Aggtelek National Park and its surroundings with Orthoptera sampling sites ($n=98$) have been studied since 1958

Table 1 Researchers of the Orthoptera fauna of the Aggtelek Karst and the periods of the studies: 1st period: 1958–1980., 2nd period: 1981–1993., 3rd period: 1994–2005, 4th period: 2006–2022

Researchers	Active Period	Periods of the studies 1	2	3	4
Zoltán Varga	1958–	+	+	+	+
Barnabás Nagy	1963–2005	+	+	+	
István Rácz	1975-	+	+	+	+
Dénes Parragh	1981–1985		+		
Hedvig Mező	1987–1993		+		
Adrienn Garay	1993–2005		+	+	
Kirill M. Orci	1994–1998			+	
Antal Nagy	1998-			+	+
Péter Sólymos	1998–2005			+	
Szabolcs Szanyi	2010-				+

of the plateau above Jósvafő and in the former vineyards and hayfields of the Szőlő-hegy near the village. Between 1998 and 2005 Antal Nagy continued these samplings and parallelly studied many other parts of the karst region. Most of the results were published in Orci (1997a, 1997b), Rácz et al. (2003, 2007), Nagy (2008), Nagy and Rácz (2007a), Nagy and Sólymos (2002), Nagy et al. (2003, 2005), Jordán (2003), Jordán et al. (2003) and Pecsenye et al. (2003a, 2003b). By 2005 Orthoptera assemblages of 67 locations had been studied and considering the estimated species richness the exploration of the fauna was 97.8% (Nagy 2008).

After 2005 most of the samplings were made by Antal Nagy in the National Biodiversity Monitoring Project and the results were recorded in scientific reports made for the Aggtelek National Park. In this latter period some studies designed on the basis of the priorities designated in the first review of the fauna (Nagy and Rácz 2007b; Nagy 2008) were also carried out (e.g. samplings of the Szalonna Karst and Rudabánya Hills and samplings for validation of doubtful data of *Isophya stysi* Cejchan). The result of reanalysis of *Pholidoptera transsylvanica* Fischer habitat network was published by Benedek et al. (2011), while studies on the wing polymorphism of the *Roeseliana roeselii* Hagenbach were published by Szanyi et al. (2014).

The critical review of the sampling sites and distribution data was made in 2007. After that only valid and complete data (with site name, coordinate, date, species name and collector name) were upload to the database.

The samplings were made mainly with sweep-netting and transect count, additionally between 1994 and 1999 dish traps were also used. *P. transsylvanica* included in habitat directive Annex II and N2000 was sampled also with the acoustic detection method during the mapping of its distribution and estimation of population size.

In 2022 the actualized and revised database contained data of 98 sites (Fig. 1) and 77 species (Appendix Tables 4 and 5). Considering *Acheta domestica*, *Conocephalus dorsalis*, *Leptophyes punctatissima*, *Stethophyma grossum*, *Myrmeleotettix maculatus*, *Platycleis affinis*, *Polysarcus denticauda* and *Poecilimon intermedius* only data collected in the first and second periods (> 30 year) of the studies were available. Additionally, *A. domestica* and *P. denticauda* data are localized only with village names. These species were excluded from the further analysis, and thus, it was performed with 69 species and 98 sites. Considering nomenclature and taxonomy the Fauna Europaea online database was followed (fauna-eu.org; Heller and Willemse 2023).

Identifying diversity hotspots

The sites were prioritized based on both simple ranking and complementarity using the actualized distribution data of local Orthoptera fauna (Williams et al. 1996; Reid 1998; Margules and Pressey 2000). During the ranking of sites species richness (S), rarity weighted species richness (SR) and number of rare species (SQ) were used as scoring indices. Species richness of the areas and the sampling intensity showed significant correlation (Pearson $r = 0.736$, $p < 0.001$). Methods for estimation of species richness (Soberón and Llorente 1993; Colwell and Coddington 1994) can be limitedly used in area prioritization since they can correct only the species richness, but do not regard the qualitative composition of the fauna. During the analysis the equal sampling intensity was assumed, and species richness (S) were determined as the number of species of orthopterans recorded in each site. The rarity weighted species richness (SR) is a sum of rarity scores (R_c) calculated from country wide relative frequency (spatial constancy) (x_{ic}) of the species using $R_c = 1 - x_{ic}$ equation. The x_{ic} values were provided by Nagy and Rácz (2007a) based on the ratio of UTM cells occupied by a given species to all Hungarian 10 × 10 km UTM cells with Orthoptera data. R_c is maximal if a given species occupies only one UTM cell and 0 if a given species appears in all occupied cells. The number of rare species (SQ) were established based on the quartile definition of rarity (Gaston 1994) using country wide relative frequencies of the species (x_{ic}) provided by Nagy and Rácz (2007a).

During simple ranking areas was arranged by the single indices listed above. After that 5% and 10% of sites with the highest values (5 and 10 sites) were chosen. In the case of the complementarity algorithm sites minimally necessary for cover the whole fauna were selected. This algorithm tries to cover the highest species richness with selection of the lowest number of sites (Church et al. 1996; Justus and Sarkar 2002). During the analysis first the site with highest score were selected and all species represented there were removed from the data set. Then the selection criteria scores were recalculated, and this process was repeated until all the species were

Table 2 Result of the area selection of simple ranking and complementary areas methods using different indices in the Aggtelek National Park

	Sites selected ($n=98$)	Number of redundant sites	Species represented ($n=69$)	Rare species represented ($n=10$)	Protected species represented ($n=10$)	Data records represented ($n=1914$)
Simple ranking						
S	5 (5.1)	–	61 (88.4)	9 (90.0)	9 (90.0)	238 (12,4)
	10 (10.2)	–	65 (94.2)	9 (90.0)	10 (100.0)	446 (23.3)
SR	5 (5.1)	–	61 (88.4)	9 (90.0)	9 (90.0)	238 (12.4)
	10 (10.2)	–	65 (94.2)	9 (90.0)	10 (100.0)	445 (23.2)
SQ	5 (5.1)	–	55 (79.7)	9 (90.0)	9 (90.0)	207 (10.8)
	10 (10.2)	–	65 (94.2)	9 (90.0)	10 (100.0)	416 (21.7)
GCI”	5 (5.1)	–	59 (85.5)	8 (80.0)	9 (90.0)	237 (12.4)
	10 (10.2)	–	65 (94.2)	9 (90.0)	10 (100.0)	446 (23.3)
GCIn”	5 (5.1)	–	25 (36.2)	5 (50.0)	4 (40.0)	28 (1.5)
	10 (10.2)	–	66 (95.7)	9 (90.0)	9 (90.0)	179 (9.4)
Complementary areas, with redundancy check						
S	5 (5.1)	16	69 (100.0)	10 (100.0)	10 (100.0)	188 (9.8)
SR	5 (5.1)	4	69 (100.0)	10 (100.0)	10 (100.0)	174 (9.1)
SQ	5 (5.1)	5	69 (100.0)	10 (100.0)	10 (100.0)	167 (8.7)
GCI”	5 (5.1)	16	69 (100.0)	10 (100.0)	10 (100.0)	188 (9.8)
GCIn”	12 (12.2)	22	69 (100.0)	10 (100.0)	10 (100.0)	393 (20.53)

Values show the number and ratio (% in parenthesis) of sites selected, species, protected- and rare species, and data records represented on the sites selected

accounted for. The analysis was carried out manually with MS Excel environment. During the ranking, if two or more areas have equal values their selection lead to the same result. To improve the performance of the algorithms redundancy check was carried out (Csuti et al. 1997). The ties between complementary sites were broken with species richness (S) as secondary and rarity weighted species richness (SR) as tertiary variable, and we chose the highest-ranking sites.

Grasshopper Conservation Index

Orthopterans are sensitive indicators of changes in vegetation structure and naturalness of open habitats. Their species richness, qualitative composition, dominance rank structure and life form spectra of assemblages are all may be useful variables. As a novel approach, Matenaar et al. (2015) suggested the Grasshopper Conservation Index (GCI) based upon the endemism, dispersal capacity and rarity as a tool for conservation prioritization and made a case study in the extraordinary species rich diversity hotspot of Cape Floral Region in South Africa. In the original GCI each of the three parameters regarded were grouped into three classes and were summed for each species and divided by nine (the maximum value) to obtain a value between zero and one.

Since in the temperate zone and especially in Central Europe the endemism is a less important factor the index should be modified as Szanyi et al. (2021) and Arnóczkyné and Nagy (2022) did in the case of orthopterans of two regions in the Carpathian Lowland.

Our modified Grasshopper Conservation Index (GCI”) uses variables grouped into four classes. Instead of endemism we used European distribution of species based on Heller et al. (1998): distributed in all 12 European regions (=1), distributed in 9–11 regions (=2), distributed in 6–8 regions (=3), distributed in 1–5 regions (=4). In the case of dispersal capacity and rarity, the original method was followed but parameters were grouped into four categories as in case of European distribution. Considering dispersal capacity, the groups of well flying (=1), poorly flying (=2), wing-dimorphic (=3) (also contains mesopterous mainly flightless species) and flightless (=4) (wingless, macropterous and mesopterous flightless species) species were used. In the case of rarity, the categorization of Rácz (1998) and Nagy and Rácz (2007a) was followed. The local rarity was measured using spatial constancy (SC) of the species calculated based on revised Orthoptera data of 98 sites. Using the quartile definition of rarity (Gaston 1994) species was considered as common (=1; $SC \geq 0.4$), frequent (=2; $0.4 > SC \geq 0.19$), low frequent (=3; $0.19 > SC \geq 0.06$) and rare (=4; $SC < 0.06$). The three parameters were summed and divided by 12 (the maximum value) to obtain a GCI” value between zero and one. The GCI” values of the sites were calculated as the sum of the GCI” scores of the species recorded on the given site.

The standardized grasshopper conservation index (GCIn”) was also calculated for each area as dividing GCI” by the number of species (S) living in the given site. While the GCI value is affected by both to species richness and conservation value of the species, the GCIn'' is independent from the species richness (Matenaar et al. 2015).

Between the used indices there were significant correlations (Pearson $r = 0.2942–0.998$, $p < 0.003$) that was higher among S, SR, SQ and GCI", while in the case of GCIn" it was less characteristic. The S-SR and SR-GCI" showed the highest correlations. The GCI" and GCIn" values were also used as ranking variables of area selection both in simple ranking and complementary area methods.

Results

The use of different indices led to different results with both selection methods. The simple ranking with 5% and 10% limits resulted in site combinations that did not represent all the local Orthoptera fauna, independently the index used (Tables 2 and 3). Simple ranking based on species richness and rarity weighted species richness showed nearly the same result considering both representation of species and set of the selected sites. The set of the sites selected differed only in the case of the 10th site and the most widespread species were represented multiple times at them (Table 3). The sites selected based on the number of rare species (SQ) differed and the representation of the species was lower selecting 5% of sites. In this case four new sites were selected, but species-rich ones were absent among them. The sites selected using modified Grasshopper Conservation Index (GCI") were the same as that were selected based on species richness and rarity weighted species richness only their order differed. The sites selected with the above mentioned highly correlated indices except one all located in the plateau north to Aggtelek and Jósvafő villages. These are isolated remains of former hayfields maintained by nature conservation. Additionally, grasslands of the Szőlő-hegy of Jósvafő also were selected. This small hill is isolated from the plateau and it is covered with remains of a mosaic of formerly extensively used vineyards, hayfields, orchards and forests. The use of the standardized formula of the index (GCIn") resulted in a quite different composition of sites selected. Using 5% limit five new sites, while in case of 10% limit seven new sites were selected. The representation of the local Orthoptera fauna was also especially lower than in other cases (Tables 2 and 3).

In contrast, the complementary area method covered the total local fauna selecting 5.1–12.2% of the sites depending on

Table 3 Sampling sites chosen with different selection methods and different indices

Simple ranking					
	S	SR	SQ	GCI''	GCIn"
5%	Szőlő-hegy (Jósvafő)	Szőlő-hegy (Jósvafő)	Luzsok	Szőlő-hegy (Jósvafő)	Lopó-galya
	Dénes doline	Dénes doline	Szilicei-kaszáló	Stipás	Galya-tető
	Stipás	Stipás	Százholdas	Dénes doline	Karst Res. St
	Lófej-völgy	Lófej-völgy	Nagy Nyilas	Szilicei-kaszáló	Telekes-völgy
	Luzsok	Luzsok	Ló-kosár	Luzsok	Szád-vár
10%	Szilicei-kaszáló	Szilicei-kaszáló	Lófej-völgy	Lófej-völgy	Hollófészek-völgy
	Húszaskői-töbör	Százholdas	Húszaskői-töbör	Százholdas	Ducsmány
	Nagyoldal	Húszaskői-töbör	Szelcepuszta	Nagyoldal	Százholdas
	Százholdas	Nagyoldal	Haragistya	Húszaskői-töbör	Stipás
	Erdészti-kaszáló	Nagy Nyilas	Szőlő-hegy (Jósvafő)	Erdészti-kaszáló	Szőlő-hegy (Jósvafő)
Complementary areas with redundancy check					
	Szőlő-hegy (Jósvafő)	Szőlő-hegy (Jósvafő)	Luzsok	Szőlő-hegy (Jósvafő)	Lopó-galya
	Százholdas	Nagy Nyilas	Szelce-völgy	Százholdas	Karst Res. St
	Karst Res. St	Karst Res. St	Karst Res. St	Karst Res. St	Stipás
	Szelcepuszta	Ménes-völgy (Szögliget)	Szőlő-hegy (Jósvafő)	Szelcepuszta	Nagyoldal
	Erdészeti-kaszáló	Nagyoldal	Kalaczkó-tető	Erdészeti-kaszáló	Alsó-hegy (Komjáti)
					Kopasz-tető
					North of Nagyoldal
					Patkós-völgy
					Vecsem-bükk
					Százholdas
					Szőlő-hegy (Jósvafő)
					Lófej-völgy

used indices. With redundancy check all algorithms showed similar result except the use of standardized Grasshopper Conservation Index (Table 2). This algorithm showed the worst result with the higher number of both selected and redundant sites. Considering the other indices both species richness and Grasshopper Conservation Index produced higher number of redundant sites than the rarity weighted species richness and the number of rare species (Table 2). Two of the sites (Szőlő-hegy of Jósvafő and Karst research station) were selected with each index. Three other sites (Százholdas, Szelcepuszta and Erdészeti-kaszáló) were selected using three different indices, while other six sites were selected using only one algorithm. In the case of standardized Grasshopper Conservation Index (GCIn") 12 sites had to be selected to represent all the local fauna. Although eight of them were not selected with other indices, one was also selected with four, another one with two, while the others with one other indices (Table 3).

Discussion

The Orthoptera fauna of Hungary is relatively well studied compared to other insect taxa, and the Aggtelek National Park including the Aggtelek and Szalonna Karst and the Rudabánya Hills is one of the most intensively studied part of the country (Nagy and Rácz 2007a). Although relatively poor data may be effective in the representation of the species (Gaston and Rodrigues 2003); however, even the quality of our actual and relatively accurate data might have influenced the efficiency of the area selection. Eight species were excluded from the analysis because they have only dubious more than 30-year-old data. Because of natural (e.g. climate change, secondary succession, etc.) and anthropogenic (e.g. changes of land use, abandonment, etc.) processes, and data collected during revision of dubious data and samplings based on gap analysis, the known distribution of the species are continuously changing, thus the results of area selection need reconsideration for time to time.

The scoring indices we used were correlated with one another. The species richness (S) and the rarity weighted species richness (SR) were essentially similar regarding both the correlation between them and the results of the area selection. The Grasshopper Conservation Index (GCI") and the SR showed similar performance using both simple ranking and complementarity methods; however, the number of the redundant sites was higher using GCI" values. Although the use of indices considering the conservation value of species is generally more effective than prioritization simply with species richness (Matenaar et al. 2015), in our study the combined indices did not perform significantly better than the simple alpha diversity, which performed well in both simple ranking and complementarity analyses.

High correlation between species richness and number of rare and protected species indicated that the protected species and species rare at country-level inhabit mainly the most species-rich sites of the Aggtelek National Park. Nevertheless, the number of rare or protected species is not certainly a good predictor of species richness as it could be seen, e.g. in case of the Hungarian land snail fauna (Sólymos and Fehér 2005).

The similarities were the lowest in case of the standardized Grasshopper Conservation Index (GCIn") which provided the worst performance considering the representation of the total fauna, rare and protected species and even the representation of species-site records. The differences between the site sets provided by simple ranking and complementarity analysis refers to the opposing integration and segregation model of nature conservation, respectively (Mader 1991). Sites on the Szőlő-hegy (Jósvafő) and the plateau above Jósvafő and Aggtelek villages selected with simple ranking showed multiple representations of both rare and common species. In case of the complementary areas this kind of multiple representation of species did not decrease the efficiency of the area selection and both the simple and combined indices could provide a good performance except the standardized GCIn". In many cases researchers focus to the protected and rare species disregarding the less interesting ones leading to the overestimation of their number and ratio, which highly affect the value of GCIn", and makes it less effective in area selection.

Despite the correlation between the simple and the combined indices considering variables of conservation value, they provide slightly different combination of hotspots. Since these scoring indices showed similar efficiency, they could not be ranked but sites selected based on two or more of them at the same time can be highly prioritized. In this way the combined use of efficient indices provides an additional ranking of sites that may help the area prioritization and efficient use of limited resources of nature conservation.

Conclusion for future biology

Our study provided data on the efficiency of formerly used and newly developed scoring indices of area prioritization. To develop the methodology of the combined use of alpha diversity and indices regarding conservation value of species (rarity weighted species richness, number of rare species and Grasshopper Conservation Index (GCI)) and to integrate these data into the conservation practices further studies should be carried out at wider range of geographical regions.

Appendix

See Tables 4, 5.

Table 4 Actualized check list of Orthoptera fauna of the Aggtelek National Park with actual status, European distribution (ER: number of occupied European regions based on work of Heller et al. 1998), dispersal capacity categories (DC: 1 = well flying, 2 = poorly flying, 3 = wing-dimorphic and mesopterous mainly flightless species, 4 = flightless), local spatial constancy (SC_l = occupied sites/all sites with actual Orthoptera data), conservation status (in a superscripts after the scientific names; Cons.: p: protected, P: highly protected, II and IV listed in the Annex II of Habitat Directive of European Union) and modified Grasshopper Conservation Index (GCI”) of the species

	Status	ER	DC	SC_l	GCI”
Ordo: Ensifera					
Superfamilia: Tettigonioidea					
Ephippiger ephippiger (Fiebig, 1784)	Actual	6	4	0.276	0.75
Conocephalus fuscus (Fabricius, 1793)	Actual	9	2	0.133	0.58
Conocephalus dorsalis (Latreille, 1804)	Dubious	12	4	0.010	0.75
Ruspolia nitidula (Scopoli, 1786)	Actual	8	1	0.163	0.58
Meconema thalassinum (De Geer, 1773)	Actual	10	1	0.173	0.50
Barbitistes constrictus Brunner von Wattenwyl, 1878	Actual	5	4	0.153	0.92
Isophya kraussii Brunner von Wattenwyl, 1878	Actual	2	4	0.520	0.75
Isophya stysi Cejchan, 1957 [P/II/IV, 1]	Actual	2	4	0.092	0.92
Leptophyes albovittata (Kollar, 1833)	Actual	8	4	0.765	0.67
Leptophyes discoidalis (Frivaldszky, 1867) [p]	Actual	3	2	0.112	0.92
Leptophyes punctatissima (Bosc, 1792)	Dubious	7	4	0.020	0.92
Phaneroptera falcata (Poda, 1761)	Actual	9	1	0.684	0.33
Phaneroptera nana Fieber, 1853	Actual	7	1	0.041	0.67
Poecilimon fussii Brunner von Wattenwyl, 1878 [p]	Actual	3	4	0.082	0.92
Poecilimon intermedius (Fieber, 1853) [p]	Dubious	5	4	0.020	1.00
Polysarcus denticauda (Charpentier, 1825) [p]	Dubious	5	4	-	-
Saga pedo (Pallas, 1771) [p/IV]	Actual	9	4	0.133	0.75
Decticus verrucivorus (Linnaeus, 1785)	Actual	12	2	0.633	0.33
Gampsocleis glabra (Herbst, 1786) [p]	Actual	8	2	0.051	0.75
Bicoloriana bicolor (Philippi, 1830)	Actual	10	3	0.714	0.50
Metrioptera brachyptera (Linnaeus, 1761)	Actual	10	3	0.327	0.58
Roeseliana roeselii (Hagenbach, 1822)	Actual	12	3	0.459	0.42
Pachystachys gracilis (Brunner von Wattenwyl, 1861)	Actual	3	4	0.184	0.92
Pholidoptera aptera (Fabricius, 1793)	Actual	5	4	0.092	0.92
Pholidoptera fallax (Fischer, 1853)	Actual	4	4	0.622	0.75
Pholidoptera griseoaptera (De Geer, 1773)	Actual	11	4	0.531	0.58
Pholidoptera transsylvanica (Fischer, 1853) [p/II/IV]	Actual	2	4	0.347	0.83
Platycleis affinis Fieber, 1853	Dubious	8	2	0.010	0.75
Platycleis albopunctata (Goeze, 1778)	Actual	3	2	0.367	0.67
Pterolepis germanica (Herrich-Schäffer, 1840)	Actual	5	4	0.082	0.92
Tettigonia cantans (Füssli, 1775)	actual	9	2	0.367	0.50
Tettigonia caudata (Charpentier, 1842) [p, 1]	Actual	7	1	0.051	0.67
Tettigonia viridissima (Linnaeus, 1758)	Actual	12	1	0.224	0.33
Superfamilia: Grylloidea					
Acheta domesticus (Linnaeus, 1758)	Dubious	12	4	-	-
Eumodicogryllus bordigalensis (Latreille, 1804)	Actual	8	4	0.010	0.92
Gryllus campestris Linnaeus, 1758	Actual	11	4	0.337	0.67
Melanogryllus desertus (Pallas, 1771)	Actual	9	4	0.020	0.83
Modicogryllus frontalis (Fieber, 1844)	Actual	7	4	0.020	0.92
Oecanthus pellucens (Scopoli, 1763)	Actual	8	4	0.214	0.75
Gryllotalpa gryllotalpa (Linnaeus, 1758)	Actual	9	4	0.010	0.83
Ordo: Caelifera					
Superfamilia: Tetrigoidea					
Tetrix bipunctata (Linnaeus, 1758)	Actual	10	4	0.439	0.58
Tetrix subulata (Linnaeus, 1758)	Actual	12	4	0.082	0.67
Tetrix tenuicornis Sahlberg, 1893	Actual	10	4	0.071	0.75
Superfamilia: Acridoidea					
Calliptamus italicus (Linnaeus, 1758)	Actual	9	1	0.551	0.33
Paracaloptenus caloptenoides (Br. von Wattenwyl, 1861) [p/II/IV]	Actual	3	4	0.265	0.83

Table 4 (continued)

	Status	ER	DC	SC_1	GCI"
Pseudopodisma nagyi Galvagni et Fontana, 1996 [2]	Actual	1	4	0.245	0.83
Arcyptera fusca (Pallas, 1773) [p]	Actual	7	4	0.194	0.75
Chorthippus apricarius (Linnaeus, 1758)	Actual	11	2	0.357	0.50
Chorthippus biguttulus (Linnaeus, 1758)	Actual	11	2	0.510	0.42
Chorthippus brunneus (Thunberg, 1815)	Actual	11	2	0.551	0.42
Chorthippus dorsatus (Zetterstedt, 1821)	Actual	10	2	0.643	0.42
Chorthippus mollis (Charpentier, 1825)	Actual	10	2	0.245	0.50
Chorthippus oschei Helversen, 1986 [3]	Actual	1	2	0.204	0.67
Pseudochorthippus montanus (Charpentier, 1825)	Actual	8	2	0.173	0.67
Pseudochorthippus paralellus (Zetterstedt, 1821)	Actual	12	3	0.633	0.42
Euchorthippus declivus (Brisout de Barneville, 1849)	Actual	6	4	0.051	0.92
Euchorthippus pulvinatus (Fischer de Waldheim, 1846)	Actual	8	4	0.102	0.83
Chrysochraon dispar (Germar, 1834)	Actual	11	3	0.408	0.50
Euthystira brachyptera (Ocskay, 1826)	Actual	10	3	0.867	0.50
Gomphocerippus rufus (Linnaeus, 1758)	Actual	11	2	0.367	0.50
Myrmeleotettix maculatus (Thunberg, 1815)	Dubious	12	2	0.010	0.58
Omocestus haemorrhoidalis (Charpentier, 1825)	Actual	11	2	0.245	0.50
Omocestus petraeus (Brisout de Barneville, 1856)	Actual	8	2	0.051	0.75
Omocestus rufipes (Zetterstedt, 1821)	Actual	12	2	0.480	0.33
Omocestus viridulus (Linnaeus, 1758)	Actual	12	2	0.112	0.50
Stauroderus scalaris (Fischer de Waldheim, 1846)	Actual	9	2	0.214	0.50
Stenobothrus crassipes (Charpentier, 1825)	Actual	2	4	0.663	0.75
Stenobothrus eurasius Zubowskii, 1898 [p/II/IV]	Actual	6	2	0.153	0.67
Stenobothrus lineatus (Panzer, 1796)	Actual	11	2	0.755	0.42
Stenobothrus nigromaculatus (Herrich-Schäffer, 1840)	Actual	9	2	0.235	0.50
Stenobothrus stigmaticus (Rambur, 1838)	Actual	8	2	0.082	0.67
Aiolopus thalassinus (Fabricius, 1781)	Actual	9	1	0.031	0.58
Mecostethus parapleurus (Hagenbach, 1822)	Actual	8	1	0.041	0.67
Oedaleus decorus (Germar, 1826)	Actual	9	1	0.031	0.58
Oedipoda caerulescens (Linnaeus, 1758)	Actual	11	1	0.184	0.50
Psophus stridulus (Linnaeus, 1758)	Actual	11	3	0.306	0.58
Stethophyma grossum (Linnaeus, 1758)	Dubious	12	1	0.010	0.50

[1]Its occurrence is dubious despite their data from the third part of the studies

[2]Was recorded as *Pseudopodisma fieberi* and was revised based on Galvani and Fontana (1996)

[3]Was recorded as *Chorthippus albomarginatus* and was revised based on Orci (2002)

Table 5 Sampling sites with recent Orthoptera distribution data in the Aggtelek National Park with their species richness (S), rarity weighted species richness (SR), number of rare species (SQ), and cumulative modified (GCI") and standardized modified Grasshopper Conservation Index (GCIn")

	Township	Site	S	SR	SQ	GCI"	GCIn"
1	Aggtelek	Baradla-tető	23	16.69	0	12.17	0.53
2	Aggtelek	Baradla-völgy	13	8.51	0	6.33	0.49
3	Aggtelek	South-West of Dobos	12	9.57	1	6.83	0.57
4	Aggtelek	Galya-tető	2	1.72	0	1.33	0.67
5	Aggtelek	Haragistya	32	25.64	6	18.58	0.58
6	Aggtelek	Hollófészek-völgy	6	5.12	0	3.83	0.64
7	Aggtelek	Húszaskő doline	41	33.05	6	24.25	0.59
8	Aggtelek	Huszonegyeskő doline	17	13.90	2	9.50	0.56
9	Aggtelek	Huszonkettes doline	17	13.66	2	9.25	0.54
10	Aggtelek	Iván-hegy	21	17.15	3	11.75	0.56
11	Aggtelek	Juh-lápa	24	18.85	3	13.33	0.56
12	Aggtelek	Káposztás-bérc	14	11.02	1	7.75	0.55
13	Aggtelek	Kardos-völgy	32	24.45	1	16.92	0.53
14	Aggtelek	Kék-kő-völgy	28	22.00	4	16.25	0.58
15	Aggtelek	Közép-hegy	5	3.73	0	2.67	0.53
16	Aggtelek	Ló-kosár	37	29.96	7	21.67	0.59
17	Aggtelek	Luzsok	45	36.41	7	27.42	0.61
18	Aggtelek	Luzsok road	14	11.46	2	8.25	0.59
19	Aggtelek	Magas-hegy	13	9.46	0	7.17	0.55
20	Aggtelek	Ménes-völgy	25	19.55	2	13.50	0.54
21	Aggtelek	Mész-völgy	2	1.38	0	1.00	0.50
22	Aggtelek	North of Mihály-láza	18	14.62	2	10.42	0.58
23	Aggtelek	South of Mihály-láza	38	30.01	4	22.08	0.58
24	Aggtelek	Mogyorós-bérc doline	28	21.51	3	15.08	0.54
25	Aggtelek	Mogyorós-forrás	14	11.08	1	7.83	0.56
26	Aggtelek	Mogyorós-kúti-rétek	20	15.55	2	10.17	0.51
27	Aggtelek	Nagy-Nyilas	39	31.75	7	23.25	0.60
28	Aggtelek	Nagy-völgy	4	2.69	0	1.67	0.42
29	Aggtelek	Ocsisnya-tető doline	35	27.59	3	19.67	0.56
30	Aggtelek	North of Ocsisnya-tető	15	12.09	2	8.58	0.57
31	Aggtelek	Ördögszántás	17	13.19	0	9.83	0.58
32	Aggtelek	Pásztor-völgy	31	23.89	3	17.58	0.57
33	Aggtelek	Százholdas	41	33.60	7	25.75	0.63
34	Aggtelek	South of Százholdas	17	13.48	2	9.50	0.56
35	Aggtelek	North of Százholdas	27	21.63	4	15.50	0.57
36	Aggtelek	Szilicei-kaszáló	45	36.40	7	27.50	0.61
37	Aggtelek	Vörös-tó	4	2.83	0	2.08	0.52
38	Aggtelek	Zombor	6	4.38	0	3.33	0.56
39	Alsótelekes	Mosó-tető	13	9.04	0	6.75	0.52
40	Bódvarákó	Esztramos	22	16.17	1	12.25	0.56
41	Bódvaszilas	Szabó-pallag	12	8.11	0	5.67	0.47
42	Bódvaszilas	Vecsem-bük	30	22.66	0	17.50	0.58
43	Felsőtelekes	Tempomka	14	9.98	1	7.00	0.50
44	Gömörszőlős	Zánkó-hegy	26	19.71	0	14.83	0.57
45	Jósvafő	Császár-tisztás	12	9.24	0	6.50	0.54
46	Jósvafő	Dénes doline	48	38.17	5	28.58	0.60
47	Jósvafő	Ducsmány	5	3.73	0	3.17	0.63
48	Jósvafő	Erdészeti-kaszáló (Szőlő-hegy)	40	31.08	2	23.75	0.59
49	Jósvafő	Fertős-tető	30	24.11	3	17.92	0.60
50	Jósvafő	Gerge-bérc	12	9.62	0	7.00	0.58
51	Jósvafő	Hegy-tető	9	6.73	0	4.67	0.52

Table 5 (continued)

	Township	Site	S	SR	SQ	GCI"	GCIn"
52	Jósvafő	Hosszú-völgy	12	9.69	0	7.00	0.58
53	Jósvafő	Karst Research Station	17	14.32	3	11.33	0.67
54	Jósvafő	Kató-lápa	30	24.35	4	17.08	0.57
55	Jósvafő	Kecső-patak-völgye	5	3.91	0	2.92	0.58
56	Jósvafő	Kopasz-tető	39	30.59	4	23.08	0.59
57	Jósvafő	Lófej-völgy	46	36.56	6	27.17	0.59
58	Jósvafő	Lopó-galya	1	0.99	1	0.83	0.83
59	Jósvafő	Nagyoldal	41	33.04	3	24.33	0.59
60	Jósvafő	North of Nagyoldal	33	26.76	4	20.17	0.61
61	Jósvafő	Szelce-völgy	33	25.74	4	19.42	0.59
62	Jósvafő	Szőlő-hegy	52	41.58	5	32.00	0.62
63	Jósvafő	Stipás	47	37.88	5	29.42	0.63
64	Jósvafő	Tohonya-bérc	26	18.62	0	13.50	0.52
65	Jósvafő	Tohonya-völgy	3	2.32	0	1.50	0.50
66	Komjáti	Alsó-hegy	26	19.26	0	15.08	0.58
67	Martonyi	Szőlő-hegy	13	8.80	0	6.42	0.49
68	Martonyi	Veres-hegy	14	10.04	0	6.83	0.49
69	Perkupa	Almafa-tető	13	9.12	0	6.58	0.51
70	Perkupa	Bakó-fej	6	4.35	0	3.50	0.58
71	Perkupa	Bankás	11	7.97	0	5.25	0.48
72	Perkupa	Bérc-dűlő	13	9.43	0	7.08	0.54
73	Perkupa	Érje-tető	14	10.15	0	7.58	0.54
74	Perkupa	Hajagos	8	5.56	0	4.42	0.55
75	Perkupa	Mester-hegy	8	5.67	0	4.08	0.51
76	Perkupa	Nádas	16	11.87	1	9.33	0.58
77	Perkupa	Őr-hegy	10	7.20	0	4.75	0.48
78	Perkupa	Piszkor	8	5.73	0	4.08	0.51
79	Perkupa	Somos-tető	10	7.27	0	5.08	0.51
80	Perkupa	Telekes-völgy	1	0.76	0	0.67	0.67
81	Szalonna	Duna-tető	11	7.55	0	5.83	0.53
82	Szalonna	Kalaczkó-tető	20	14.53	0	10.67	0.53
83	Szalonna	Malom-oldal	10	7.11	0	4.75	0.48
84	Szelcepuszta	Bérc-tető	9	6.22	0	4.92	0.55
85	Szendrő	Kis-korlát-tető	4	3.01	0	1.75	0.44
86	Szendrő	Korlát-hegy	11	7.97	0	5.92	0.54
87	Szendrő	Tót-hegy	10	7.90	1	5.83	0.58
88	Szin	Patkós-völgy	20	14.98	2	11.00	0.55
89	Szin	Szelcepuszta	38	30.73	6	22.92	0.60
90	Szögliget	Kecskés	18	13.15	1	9.75	0.54
91	Szögliget	Ménes-völgy	25	19.61	3	13.58	0.54
92	Szögliget	Szád-vár	7	5.62	1	4.50	0.64
93	Szőlősardó	Zabanyik-hegy	14	10.46	0	7.75	0.55
94	Teresztenye	Teresztenyei-fennsík	24	18.00	0	13.08	0.55
95	Tornanádaska	Alsó-hegy	20	14.98	0	11.75	0.59
96	Trizs	Akasztó-bérc	12	8.58	0	5.42	0.45
97	Varbóc	Bokány-tető	3	2.25	0	1.25	0.42
98	Varbóc	Borház-tető	7	5.06	0	3.75	0.54

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