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Optimizing arthropod predator conservation in permanent grasslands by considering diversity components beyond species richness

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ABSTRACT

Grasslands host large parts of Europe's agricultural arthropod diversity. Considering the adverse effects of ongoing land use changes on many grassland taxa, there is an urgent need to establish measures that allow for optimizing the conservation of permanent grassland habitats and their climatic, environmental and ecological benefits. Here, data from 42 permanent grasslands were used to quantify the effect of individual management practices on different diversity components in spider and ground beetle communities. Intensive fertilization and frequent cutting reduced the species richness of spiders and the number of threatened spider species, but increased the average taxonomic distinctness of communities. Moreover, high grazing intensity reduced the average body size of individuals in local spider communities. Frequent cutting led to a higher abundance of predaceous and omnivorous ground beetles but a lower abundance of herbivorous species. These opposing responses of both different biodiversity components and different taxa to individual grassland management practices confirm that no single management practice maximizes the biodiversity of arthropod predators in permanent grasslands at the local scale. Rather, our study suggests that arthropod predator diversity can only be conserved by promoting a landscape-scale combination of different management practices and intensities in permanent grasslands. When considering conservation measures, conservation goals should not only be formulated in terms of local species richness, but also need to address other components of diversity such as taxonomic or functional diversity.

1. Introduction

Grasslands host large parts of Europe's agricultural arthropod diversity (Söderstrom et al., 2001; Jeangros and Thomet, 2004; Dahms et al., 2010). Accounting for this fact, the European Commission (EC) recently implemented so called 'greening' measures into the funding scheme of the Common Agricultural Policy, which inter alia explicitly aim at maintaining species-rich permanent grassland habitats for providing climatic, environmental and ecological benefits. However, the EC very loosely defined permanent grasslands as all "grasslands that have not been part of a crop rotation for the last five years" (Regulation No. 1307/2013 Article 4), without taking different management practices into account. Sites covered by this regulation thus range from semi-natural grasslands to intensively grazed pastures or even fertilized hay meadows. This is surprising, as it is well established that management intensification is a major threat to grassland biodiversity (e.g., Grandchamp et al., 2005; Dauber et al., 2005; Joern and Laws, 2013).

Here, we used data from 42 permanent grasslands to quantify the impact of management on spider and ground beetle communities. These two taxa were chosen because generalist arthropod predators play an important role in grassland functioning as natural enemies of pests (Symondson et al., 2002) or as food for insectivorous vertebrates (Vickery et al., 2001; Mooney et al., 2010). From a conservational perspective, generalist predators have been proven to be informative indicators of both local habitat conditions (Marc et al., 1999; Rainio and Niemelä, 2003) and the species richness in other taxa (Wolters et al., 2006; Beck et al., 2013). Numerous studies have shown that the species richness or the number of threatened species of spiders and ground beetles in grasslands decrease with the intensity (e.g., grazing) and the type (e.g., organic versus conventional farming) of management as well as with landscape homogenization (e.g., proportion of annually

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tilled arable land) in the surrounding area (Morris, 2000; Dennis et al., 2004; Dauber et al., 2005; Birkhofer et al., 2008a; Humbert et al., 2009; Albrecht et al., 2010; Klaus et al., 2013).

Neither species richness nor the presence of threatened species, is however, necessarily linked to the contribution of arthropod predators to ecosystem functioning (Gerisch et al., 2012; Gagic et al., 2015). It is, for example, a matter of considerable debate whether species richness of predators per se relates to biological control of pests (Bruno and Cardinale, 2008; Letourneau et al., 2009; Tscharntke et al., 2007; Cardinale et al., 2012). In fact, predation on pests by arthropod predators may also be affected by body size distribution (Rusch et al., 2015), feeding preferences (Jonason et al., 2013) or hunting modes (Birkhofer et al., 2008a). The body size distribution and composition of trophic groups in arthropod communities can be negatively affected by land-use intensification (e.g., Birkhofer et al., 2008a; Postma-Blaauw et al., 2010), but may also show no response to more intense management (Birkhofer et al., 2014a).

Focusing on local species numbers as the only diversity measure also bears the serious risk of overlooking critical changes in species richness at the regional scale. For example, closely related species tend to respond similarly to environmental change (Diaz et al., 2013), since the share of evolutionarily conserved traits that determine this response increases with decreasing phylogenetic distance (Webb et al., 2002). Thus, certain management practices may simultaneously eliminate whole subsets of closely related species (e.g., Andersson et al., 2013). Prioritizing management practices without considering such effects in an attempt to conserve high levels of local species richness, however, may lead to a homogenization of grassland types and a subsequent decline in regional species richness, due to the loss of more distantly related species with a different response to anthropogenic disturbance.

Consequently, the impact of management practices (e.g., fertilization intensity, cutting frequency and grazing intensity in permanent grasslands under the CAP) on grassland biodiversity at large spatial scales may only be fully evaluated when – in addition to species richness – other components of biodiversity are taken into account (cf. Purvis and Hector, 2000; Swenson, 2011; Diaz et al., 2013). Against this background, we analysed whether permanent grasslands can be managed in such a way as to simultaneously benefit species richness, the presence of red-listed species and components of diversity that either include information about morphometric or ecological traits (body size and feeding ecology) or about the taxonomic relatedness between species. We hypothesized that agricultural management affects components of diversity within taxa differently, as for example species richness may be reduced under higher land-use intensity, but without taxonomic distinctness showing the same negative relationship for all taxa (Birkhofer et al., 2015). If this hypothesis is confirmed, it logically follows that recommendations prioritizing just one management practice for permanent grasslands bear the risk of benefiting only a single component of arthropod predator diversity.

2. Material and methods

2.1. Site selection and sampling

The grassland sites investigated were located in three different regions of Germany that span a latitudinal gradient of more than

Table 1
Regional means ± standard deviation and ranges for (a) individual management practices (all site-specific means for the period 2006–2008), the area of annually tilled arable land in a 250 m radius around each site and a compound land-use index (Blüthgen et al., 2010) and (b) all univariate diversity components calculated for spiders and ground beetles and abundance of potential *Collembola* prey and vegetation coverage.

	Schwäbische Alb	Hainich-Dün	Schorfheide-Chorin
(a) Management practices			
Fertilization intensity (kg N ha^{-1})	39.4 ± 52.0	36.0 ± 39.2	19.0 ± 38.0
Range	0–196.9	0–100.0	0–97.3
Cutting frequency (# of cuts)	1.2 ± 1.0	1.2 ± 1.1	1.1 ± 0.7
Range	0–3	0–3	0–2
Grazing intensity (LSU 100 ha^{-1})	123.8 ± 171.2	157.0 ± 188.1	64.9 ± 77.5
Range	0–596.3	0–592.1	0–243.1
Area arable land (250 m radius, ha)	20091 ± 22406	26002 ± 37617	20503 ± 34624
Range	0–61184	0–115946	0–97696
Land-use index (LUI, Blüthgen et al. 2012)[a]	1.7 ± 0.2	1.7 ± 0.2	1.6 ± 0.2
Range	0.5–3.0	1.1–2.8	0.9–2.8
(b) Plants and animals			
Spiders, species richness	16.4 ± 3.4	17.1 ± 3.1	19.5 ± 2.7
Range	12–26	12–23	16–26
Spiders, taxonomic distinctness (Δ*)	63.4 ± 6.4	63.4 ± 5.5	60.5 ± 7.3
Range	43.9–69.5	54.3–73.7	41.0–73.6
Spiders, CWM body size (mm)	7.2 ± 0.8	5.4 ± 1.3	5.9 ± 0.6
Range	5.6–8.4	3.6–7.3	4.7–7.0
Ground beetles, species richness	9.8 ± 2.8	14.8 ± 3.6	15.9 ± 3.6
Range	5–14	9–21	9–22
Ground beetles, taxonomic distinctness (Δ*)	73.9 ± 7.1	85.2 ± 7.7	92.6 ± 3.4
Range	61.9–87.3	68.2–97.8	86.9–97.7
Ground beetles, CWM body size (mm)	12.1 ± 1.1	9.1 ± 2.4	11.5 ± 3.9
Range	10.4–14.8	6.7–16.4	4.8–18.0
Collembola, abundance spring (ind m^{-2})	20954 ± 16214	7957 ± 6747	19153 ± 17359
Range	6366–70921	891–22919	1655–57552
Collembola, abundance autumn (ind m^{-2})	30868 ± 34659	8622 ± 6044	16955 ± 15968
Range	5093–139424	3820–26229	637–60947
Vegetation, ground cover spring (%)	89.9 ± 6.2	80.1 ± 14.8	89.6 ± 4.4
Range	76.7–100	46.7–93.3	78.3–96.7
Vegetation, ground cover autumn (%)	92.5 ± 5.7	85.7 ± 7.7	94.4 ± 5.2
Range	81.7–100	65.0–93.3	81.7–100

[a] The LUI is a management intensity index that has been developed for grassland sites in the biodiversity exploratory regions and incorporates information on grazing intensity, cutting frequency and fertilization intensity.