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Impact of prescribed burning on a heathland inhabiting spider community

Rolf Harald Krause & Thorsten Assmann

Abstract. Heathlands can provide refuge for many stenotopic and endangered arthropods, if habitat management practices are applied. A management measure that is rarely being used today, but which has the potential to support diversity of arthropod communities, is prescribed burning. In this study we investigated the effects of prescribed burning on spider assemblages on a burned site with Calluna vulgaris in the nature reserve Lueneburg Heath, northwest Germany. We used pitfall trapping with a sampling design of 39 traps over a period of one year and 17 sampling intervals on a burned and a control site. We compared overall species richness, activity abundance patterns and community composition of the two sites, with a particular focus on stenotopic and endangered species. We collected 5116 adult spiders and 99 species altogether in a relatively small sampling area. This number of species represents nearly one third of the regional species pool of heathland spider species. Twelve species occurred exclusively on the burned site in contrast to 28 species exclusively found on the unburned site. Although we found more than twice as many spider individuals and higher mean species richness on the control site than on the burned site, the species richness of red-listed spiders was higher on the burned site. Especially the fact that we found 24 endangered species on the burned site and only 20 on the control site indicates that the applied measure of prescribed burning can foster certain endangered spider species and contribute to preserving the overall biodiversity of heathland ecosystems.

Keywords: endangered species, habitat management, Nature Reserve Lueneburg Heath (Lüneburger Heide), pitfall trapping, species richness

While the vascular plant community of heathlands seems to be rather poor in species numbers, the arthropod fauna of these habitats is rich in species, especially in stenotopic ones (e.g. Schikora & Fründ 1997, Finch 2013). The composition of the faunal communities and especially the occurrence of stenotopic species of heathlands seem to be strongly affected by the different habitat management practices that are applied (esp. chopping, sod-cutting, grazing, mowing, and burning) (see e.g. Gardner 1991). During historical times, north-west German heathlands were used by a diverse mixture of historical forms of land use. A consequence of these land use practices was that the development cycle of the dominant vascular plant species, the common heather (Calluna vulgaris) started consistently from seedlings or (re-)sproutings. The senescent stage with tall, strongly woody and sparsely foliated heather individuals was very rare during former centuries (Gimmingham 1972, Keienburg & Prüter 2004). In contrast, nowadays this stage is widely distributed in heathlands due to abandoned land use, and species that were formerly promoted by habitat conditions of early successional heather stages might be detrimentally affected by this development in heather management.

Prescribed burning, a historically frequently used habitat measure by shepherds is only rarely used nowadays to rejuvenate heather. The effects of this management practice on animals, especially on protected or heathland typical species, is controversially discussed. For reptiles, the benefits of prescribed burning are not well understood (Jofré & Rea-....
The advantages to apply different habitat management practices are also understood by political authorities and local conservation associations. Despite the high costs of some measures as e.g. choppering, some institutions are willing to manage heathlands also with prescribed burning (Lütkepohl 1993) provided that endangered animals of heathlands benefit from this specific heathland practice. Reliable data are scarce, however, and more research on the effects of prescribed burning on arthropods is needed.

Here, we studied the spider fauna of a heathland site one year after prescribed burning and compare spider richness, abundance and assemblage composition patterns to an unburned control site. The main questions of our study were: (1) To what extent does prescribed heathland burning affect the abundance and distribution of spider species, in particular of endangered species? (2) Is there any evidence that individual species benefit from prescribed burning, and is it possible to infer how such species reach the burned study site? (3) Can prescribed burning be considered an appropriate measure to foster endangered spider species and the biodiversity of the spider community in lowland heathlands?

Material and methods

Study area. The study site is situated in the nature reserve Lüneburger Heide (Lueneburg Heath) about 8 km east of Schneverdingen, Lower Saxony, Germany. The nature reserve includes the largest heathlands of north-west Germany, covering approximately 5000 ha, and is protected by the European Habitats and Species Directive as a Natura 2000 site. Its climate is humid, suboceanic with mean annual precipitation of 811 mm and a mean annual temperature of 8.4 °C (Niemeyer et al. 2007). Soils are predominantly nutrient-poor podzols with low pH values of 3.2 - 3.6.

The study area itself (53°15’N; 09°58’E; 105 m a.s.l., Niemeyer et al 2006) (Fig. 1) is slightly sloping to the south and consisted of two parts: 1. The unburned site with approximately ten year old heather of about 50 cm height; 2. the burned site covering an oblong of 220 x 200 m surrounded by the unburned area. Prescribed burning took place in autumn 2006, one year before we started to carry out our study.

Sampling design. We installed a total of 39 pitfall traps, filled with a mixture of 50 % ethanol, 20 % glycerol and 30 % water (Renner 1982), along a transect with 20 pitfalls across the burned site and 19 pitfalls along the edges in the unburned heather, 10 m apart from the burned site. Pitfall trapping represents the most efficient method for capturing ground-dwelling spiders, especially for locomotory active spider species (Curtis 1980, Southwood & Henderson 2000).

The pitfall traps were set up on 14th August and the catching period was extended over the length of twelve months beginning on 28th August 2007 and ending on 14th August 2008. The capturing periods in August 2007 and August 2008 each lasted only half a month. The traps were emptied once per month during the winter and fortnightly during the summer, resulting in a total of 17 sampling intervals.

Only adult spiders were identified using the online spider guide of Nentwig et al. (2014). Taxonomy follows the World Spider Catalog (2015).

Habitat characteristics. Vegetation data was gathered within a circle of 100 cm diameter around each trap. We visually estimated the percentage cover of Calluna vulgaris, grasses, lichens, mosses, trees, and bare soil in three layers: a) 0–5 cm, b) 5–50 cm, c) over 50 cm. Additionally for measuring the pH-value we took 20 samples of approximately 0.5 L with a spade every three months from randomly chosen plots in the burned (n = 10) and unburned site (n = 10).

Statistical analysis. Differences between the burned and unburned site were analysed with t-tests. Homogeneity of variances was checked prior to the analyses. Differences in the composition of the spider assemblages of the burned and unburned plots were analyzed using non-metric multidimensional scaling (NMDS; vegan package in R; Oksanen et al. 2013). The NMDS was based on abundance-weighted dissimilarities in spider assemblages among the 39 pitfall traps, using the Morisita-Horn index on square-root transformed abundance data. A stable solution with k = 2 dimensions was computed from multiple random starting configurations. Results were centred and principal components rotation was used to obtain maximum variance of points on the first dimension. The relationship with environmental factors was assessed by fitting habitat parameters (after standardization) to the ordination plot on the basis of a regression analysis with the NMDS axes scores. Significance of the correlations.
Spider community and prescribed burning

was assessed with permutation tests (N = 1000). All analyses were conducted with R 3.0.2 (http://www.R-project.org/package=vegan).

Results

We found 3175 spider individuals on the unburned and 1941 on the burned site. Consequently, we captured 5116 adult spiders in total (Fig. 2), of which 3621 were males and 1495 were females, belonging to 99 spider species. Twenty-eight of them are red-listed species of Lower Saxony (Finch 2004), of which seven are classified as 'highly endangered', 19 as 'endangered' and one as 'increasingly endangered', and one is not listed yet in the list of Finch (2013) but regarded 'endangered' in the list of Platen & Broen (2005) (Tab. 3). On the unburned plot, we found 28 species active only in this plot with only 3 species on the Red List of Lower Saxony. 20 species were active in at least double numbers on this site in comparison with the burned plot. In contrast, 12 species occurred exclusively in the burned plot of which six species are listed in the Red List (Tab. 1), and 10 species were twice as active on the burned site than on the unburned site (Tab. 2). It should be noted, however, that most of the exclusive species were recorded in low abundances (e.g., five out of the 12 exclusive species in the burned plot were singletons).

Altogether we found 20 endangered species in the unburned and 24 endangered species in the burned plot with overlapping patterns of 16 species. Three further endangered species are heather specialists according to Roberts (1995): Neriene furita (O. Pickard-Cambridge, 1871) (Linyphiidae), Ozyptila scabricula (Westring, 1851) (Thomisidae) and Steatoda albomaculata (De Geer, 1778) (Theridiidae).

Pardosa monticola (Clerck, 1757) (Lycosidae) was the most abundant species with a total number of 1007 individuals, whereas 24 species occurred as only one individual. The same applies to other species. The highest peak of activity was in May with 2498 specimens and the lowest in October with only 12 individuals (Fig. 2). Nearly throughout the whole period we found more individuals in the unburned than in the burned site. Only from September till December was this proportion inverted with extremely low total numbers. We found similar effects regarding the distribution of species with the highest peak in May and the lowest in September and October (Fig. 3).

The mean number of individuals per trap (t = 3.67, DF = 32.992 P < 0.001) and the mean number of species per trap (t = 3.13, DF = 36.812, P = 0.003) was higher on the unburned site (cf. Fig. 4a, 4b). In contrast, red-listed species were more species-rich on the burned site (t = 2.27, DF = 36.572, P = 0.029), whereas the mean number of individuals per trap of the endangered species did not significantly differ between the burned and unburned area (t = 1.52 DF = 35.275, P = 0.136) (Fig. 4c, 4d). In total we found 24 red-listed species on the burned site and 20 endangered species on the unburned one, while there is an overlap of 16 species between the two sites.

The mean value of body size was determined for all species using figures given in the literature (Hänggi et al. 1995, Roberts 1995) (t = -1.4741, df = 34.442, p-value = 0.1495). We found that the results did not differ significantly between the burned and the unburned site.

NMDS-analysis showed a clear separation in overall spider species composition between the burned and unburned area. This separation was correlated with the strong differences in the cover of heath and bare soil (Fig. 5a). Red List species showed a similar separation between the two sites (Fig. 5b).

Discussion

Finch (2004) listed 675 species altogether for Lower Saxony and Bremen (Germany) of which 86 are classified as highly endangered and 100 as endangered. The list of spider species for north German heathlands by Finch (2013) contains 360 species. We found 99 species on our study site, with seven
species highly endangered and 19 species endangered. This total number of recorded species – nearly one third of all known species in the Lüneburg Heath – appears as high species richness against the background of the relatively small size of the investigated site. Among the three species which are classified as heather specialists *Ozyptila scabricula* (Thomisidae) and *Steatoda albomaculata* (Theridiidae) are known to appear especially in burned areas (Roberts 1995), and our results confirm that these species may especially profit from the measure of prescribed burning.

The fact that we found more than a doubled activity density on the unburned site than on the burned site was to be

### Tab. 1: Species and individuals occurring exclusively on the burned site (nl = not listed)

<table>
<thead>
<tr>
<th>Species</th>
<th>Family</th>
<th>unburned</th>
<th>burned</th>
<th>red list</th>
<th>woodland</th>
<th>open landsc.</th>
<th>heath</th>
<th>ballooning</th>
<th>thermo-phil</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Aelurillus v.-insignitus</em></td>
<td>Salticidae</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><em>Araneus quadratus</em></td>
<td>Araneidae</td>
<td>0</td>
<td>3</td>
<td>-</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Arctosa peria</em></td>
<td>Lycosidae</td>
<td>0</td>
<td>2</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>Cenromerus arcanus</em></td>
<td>Linyphiidae</td>
<td>0</td>
<td>4</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Clubiona corticis</em></td>
<td>Clubionidae</td>
<td>0</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Dictynium tibiale</em></td>
<td>Linyphiidae</td>
<td>0</td>
<td>1</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Drassyllus praeficus</em></td>
<td>Gnaphosidae</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>Hyposigla albovittata</em></td>
<td>Araneidae</td>
<td>0</td>
<td>1</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>Nescona adiatica</em></td>
<td>Araneidae</td>
<td>0</td>
<td>1</td>
<td>-</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td><em>Palliduphantes pallidus</em></td>
<td>Linyphiidae</td>
<td>0</td>
<td>2</td>
<td>-</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Theridion umbigii</em></td>
<td>Theridiidae</td>
<td>0</td>
<td>6</td>
<td>nl</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>Trichopterna cito</em></td>
<td>Linyphiidae</td>
<td>0</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

### Tab. 2: Species and individuals occurring at least twice as much on the burned site than on the unburned site

| Species                        | Family    | n = | | n = | | red list | wood-land | open | heath | ballooning | thermo-phil |
|--------------------------------|-----------|-----| | | | | | | | | | | |
| *Alopexxa barbipes*             | Lycosidae | 10  | | 37  | | 3      | | 0   | | 1     | | 0   | | 1     | | 1    |
| *Cheiracanthium erraticum*      | Eutichuridae| 1  | | 2   | | -      | | 0   | | 1     | | 0   | | 0     | | 1    |
| *Cheiracanthium virescens*      | Eutichuridae| 2  | | 4   | | -      | | 0   | | 1     | | 0   | | 0     | | 1    |
| *Erigone atra*                  | Linyphiidae| 8  | | 22  | | -      | | 0   | | 1     | | 0   | | 0     | | 1    |
| *Erigone dentipalpis*           | Linyphiidae| 9  | | 23  | | -      | | 0   | | 1     | | 1   | | 1     | | 1    |
| *Micaria silesiaca*             | Gnaphosidae| 4  | | 23  | | 2      | | 0   | | 1     | | 1   | | 1     | | 1    |
| *Pardosa monticola*             | Lycosidae | 336 | | 671 | | -      | | 0   | | 1     | | 0   | | 1     | | 0    |
| *Steatoda albomaculata*         | Theridiidae| 1  | | 18  | | 3      | | 0   | | 1     | | 1   | | 0     | | 1    |
| *Talavera aequipes*             | Salticidae| 2  | | 5   | | 3      | | 1   | | 0     | | 0   | | 0     | | 1    |
| *Walckenaeria dysderoides*      | Linyphiidae| 3  | | 6   | | -      | | 1   | | 1     | | 1   | | 1     | | 0    |
Species | Family | unb. | burned
--- | --- | --- | ---
Aelurillus v-insignitus | Salticidae | 2 | 2
Agelena labyrinthica | Agelenidae | 4 | 2
Agroeca lucaticia | Liocranidae | 5 | 3
Agroeca proxima | Lycosidae | 17 | 11
Alopecosa barbipes | Lycosidae | 10 | 37
Alopecosa cuneata | Lycosidae | 201 | 79
Alopecosa fabrilis | Lycosidae | 5 | 8
Alopecosa pulex/ulenta | Lycosidae | 12 | 2
Araneus quadratus | Araneidae | 3 | 3
Arctosa perita | Lycosidae | 2 | 2
Austena phalerata | Theridiidae | 55 | 97
Centromerita bicolor | Linyphiidae | 11 | 7
Centromerita concinna | Linyphiidae | 703 | 218
Ceridiana prominens | Araneidae | 1 | 1
Cletucanthium erraticum | Eutichuridae | 127 | 22
Cletucanthium virescens | Eutichuridae | 2 | 4
Clubiona corticalis | Clubionidae | 2 | 1
Clubiona diversa | Clubionidae | 2 | 1
Clubiona subulata | Clubionidae | 1 | 1
Ctenopsites obscurus | Linyphiidae | 1 | 1
Coriaceae depressa | Thomisidae | 1 | 1
Dicyoninum hyle | Linyphiidae | 1 | 1
Dismodicus electo | Linyphiidae | 1 | 1
Dressodes capreus | Gnaphosidae | 9 | 1
Dressodes pubescens | Gnaphosidae | 14 | 9
Dressylla praecox | Gnaphosidae | 1 | 1
Dressylla pusilla | Gnaphosidae | 4 | 1
Erycogonotha thoracica | Theridiidae | 1 | 1
Erigone atra | Linyphiidae | 8 | 22
Erigone dentipalpis | Gnaphosidae | 9 | 23
Erro furcata | Mitididae | 2 | 2
Europhora frontalis | Salticidae | 3 | 3
Gnaphosa leporina | Gnaphosidae | 7 | 1
Gnathostoma rubens | Linyphiidae | 1 | 1
Habnia helveola | Hahniidae | 2 | 4
Haplochrysalis signifer | Gnaphosidae | 121 | 65
Heliophosius flavipes | Salticidae | 1 | 1
Hygrocybea rubrofasciata | Lycosidae | 1 | 1
Hypoctopsia albovittata | Araneidae | 1 | 1
Macrargus rufus | Linyphiidae | 1 | 1
Mecia silexina | Gnaphosidae | 4 | 23
Mecia verigigradus | Linyphiidae | 1 | 1
Neoscona adianta | Araneidae | 1 | 1
Neronea furcata | Linyphiidae | 1 | 1
Oedocorax apicatus | Linyphiidae | 1 | 1
Ozytis atraria | Thomisidae | 10 | 12
Ozytis austrorina | Thomisidae | 3 | 1
Pachygnatha degerei | Tetragenathidae | 2 | 1
Pallidippus pallidus | Linyphiidae | 1 | 2
Pardosa amputata | Lycosidae | 1 | 1
Pardosa lugubris | Lycosidae | 1 | 1
Pardosa monticola | Lycosidae | 336 | 671

Expected and has also been found in similar studies that analyzed the impact of prescribed burning on spiders in other habitats (e.g. Gerland 2004, Koponen 2005). However, such studies in part also reported that the species richness of spiders was actually higher on the burned sites (Koponen 2005). Despite the fact that 28 species were captured exclusively on the unburned site (emphasizing the value for biodiversity conservation also of unburned heathland) only three of them were endangered, whereas out of the twelve species recorded exclusively on the burned plot, six were red-list species. While the comparison with the results of our study is limited by the
fact that Koponen (2005) studied the effect of burning on spiders in forests, our findings indicate that prescribed burning in heathland systems might show dynamics that differ from those of other systems and might require separate analysis.

There are several possibilities for how these 12 species occurring invariably on the burned site might have colonized this plot. The next burned area to our study site is approximately 100 m apart from our burned plot. It was burned only two years earlier. It is less likely that these spiders crossed the matrix of older heather lying in between these sites on the ground, as they could not be proved on the adjoining unburned site. Another way of reaching the study site may be ballooning. Koponen (2005) assumed that a certain amount of species reached the burned site in his study by ballooning. Among the species being predominant on the burned site in our study, we found altogether 10 species that are known to use ballooning (Bell et al. 2005). Thus we can assume that mobile taxa such as spiders, similar to many insects with the ability to fly, can recolonize suitable heathland habitats created by specific management practices such as prescribed burning (or stochastic events such as wild fires, which infrequently occur also in the studied heathlands and which might contribute to explain why species adapted to burned sites are able to persist in the absence of prescribed burning) via dispersal over longer distances. They might thus benefit from these management practices even when only applied locally and in smaller patches within a mosaic of differently managed heathland habitats. We note that many of the species recorded exclusively on only one of the two plots were recorded in low abundances. The limitations regarding replication of burned and unburned plots due to lack of further suitable study plots thus make it difficult to verify whether all of these species were established but rare on the plots, or whether some species were accidentally recorded vagrants (the latter of which is likely at least for the three web-building Araneidae on the burned plot).

Nevertheless, the results indicate that burned areas may provide a refuge for certain endangered species, considering that several other endangered species that were altogether more abundant and classified as heathland specialists were recorded in much higher abundance on the burned than the unburned plot. Schmidt & Melber (2004) investigated the impact of winter burning in heathlands on spider assemblages and found that thermophilic species showed a positive effect on this kind of burning. In our study, several of the spider species being found preferentially on the burned site also tended to be thermophilic (Roberts 1995, Nentwig et al. 2014, British Arachnological Society 2015). It is notable that many endangered species seemed to be fostered by burning. This management practice probably creates specific habitat conditions that are less readily available in the surrounding heather and that meet the requirements of several of these species. Prescribed burning on a smaller scale achieves a high heterogeneity of vegetation structure, which is known to promote high species diversity of arthropods and may thus create suitable habitats for species that would not be present in a more uniform landscape. In this sense prescribed burning, in combination with other management practices, can be regarded as an appropriate measure for species specialized on plots like our study site to maintain a part of the spider fauna of the Atlantic lowland heathlands. Presumably other thermophilic arthropod species can benefit from this heathland measure as well. While our study design limits our ability for generalizations beyond our study system, the results nevertheless show the need for, and hopefully stimulate, more intensive research of landscape management practices in heathland ecosystems to develop efficient ways for promoting and conserving heathland biodiversity.

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