Arachnologische Mitteilungen / Arachnology Letters 51: 57-63 Karlsruhe, April 2016

Impact of prescribed burning on a heathland inhabiting spider community

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doi: 10.5431/aramit5108

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

Zusammenfassung. Auswirkungen von kontrolliertem Brennen auf eine Heide bewohnende Spinnengesellschaft. Heidelandschaften können als Refugium für viele stenotope und gefährdete Arthropodenarten fungieren, wenn ein bestimmtes Heidemanagement angewandt wird. Eine Managementmaßnahme, die zwar heute selten praktiziert wird, obwohl sie sich positiv auf die Diversität von Arthropodengesellschaften auswirkt, ist kontrolliertes Brennen. In dieser Arbeit untersuchen wir die Auswirkungen von kontrolliertem Brennen auf eine Spinnenzönose einer mit *Calluna vulgaris* bestandenen Brandfläche im Naturschutzgebiet Lüneburger Heide in Nordwestdeutschland. Die Spinnen wurden in 39 Bodenfallen über einen Zeitraum von einem Jahr mit 17 Fallenleerungen auf der gebrannten und einer Kontrollfläche gefangen. Wir vergleichen die Artenvielfalt, die Individuenhäufigkeit und die Zusammensetzung der Spinnengemeinschaft der beiden Flächen miteinander. Wir fingen 5116 adulte Spinnenindividuen mit 99 Arten auf einer verhältnismäßig kleinen Probefläche. Diese Anzahl der Spinnenarten stellt fast ein Drittel des regionalen Artenpools der Heidespinnenarten dar. Wir fanden zwölf Arten ausschließlich auf der gebrannten und 28 ausschließlich auf der ungebrannten Fläche. Obwohl die durchschnittliche Artenzahl größer und die Gesamtzahl der Individuen fast doppelt so hoch auf der Kontrollfläche war, war dennoch die Artenvielfalt der gefährdeten Arten auf der gebrannten Fläche höher als auf der ungebrannten. Allein die Tatsache, dass wir insgesamt 24 gefährdete Arten auf der gebrannten Fläche und nur 20 gefährdete Arten auf der Kontrollfläche fanden, weist darauf hin, dass die angewandte Maßnahme des kontrollierten Brennens bestimmte Spinnenarten fördern und zur Erhaltung der Biodiversität der Heideökosysteme beitragen kann.

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. choppering, 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 (Gimingham 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 & Reading 2012) and prescribed burning is considered to be least harmful during winter when most of the reptiles are hidden in the ground where they are protected against the fire. For arthropods, however, benefits from prescribed burning have been demonstrated in several cases (e.g. some stenotopic ground beetles appear more abundantly about 2 or 3 years after prescribed burning; den Boer & van Dijk 1994). However, there are only a few studies on the effect of prescribed burning on the spider community of heathlands which are remarkably rich in species (Kaiser 2013). Moreover some endangered spider species are known to occur preferentially on burned sites (Schmidt & Melber 2004) and might even depend on this habitat management practice. Many spider species are known to react sensitively to habitat structures (Uetz 1990) which are also altered by prescribed burning. In contrast ground dwelling spider species are not very much affected by fire in general (prescribed and wild fire) as the temperatures at depths of 4 cm depth are not changed more than 2 °C and even at 1–2 cm depth do not exceed 40–50 °C for a very short timeframe depending on the season and the local soil conditions (Gerland 2004). In combination with other management practices, prescribed burning might thus create a heterogeneous complex of different habitats and habitat structures that could promote not only endangered species, but overall biodiversity as well.

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submitted 23.6.2015, accepted 1.2.2016, online 4.3.2016

Fig. 1: The study area showing the unburned (left) and the burned site (right) one and a half years after burning during the sampling period (March 2008)

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 =1 0) 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

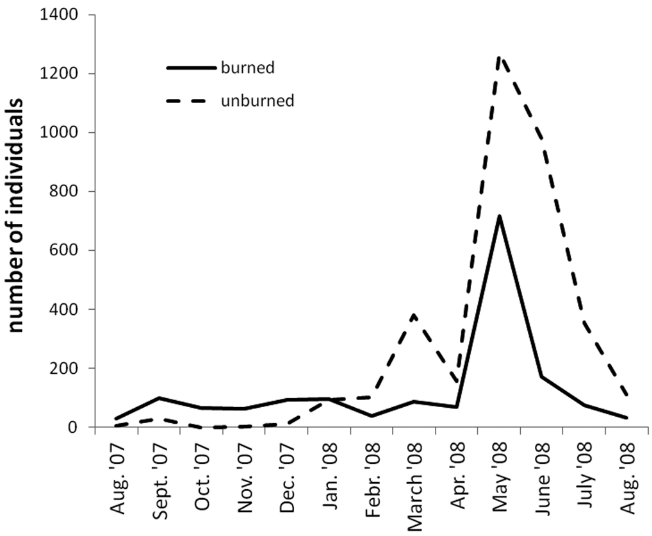

Fig. 2: Seasonal dynamics of spider activity abundance in the burned and unburned sites

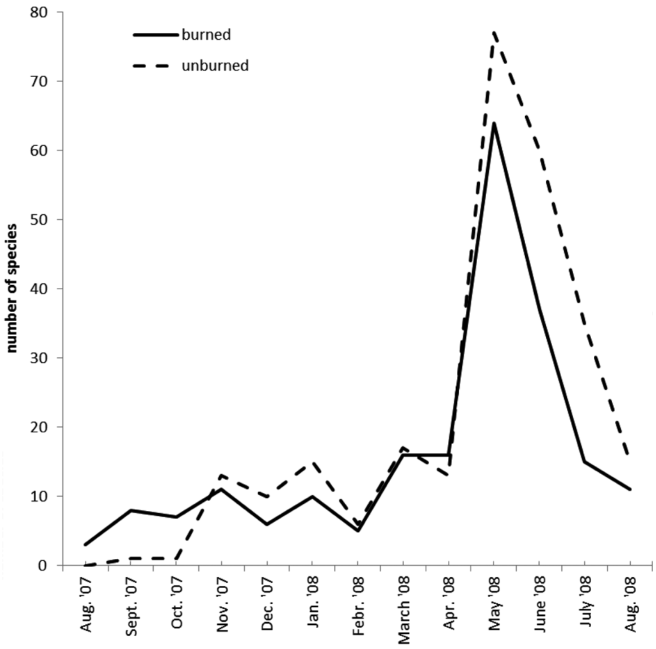

Fig. 3: Seasonal dynamics of spider species richness in the burned and unburned sites

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).

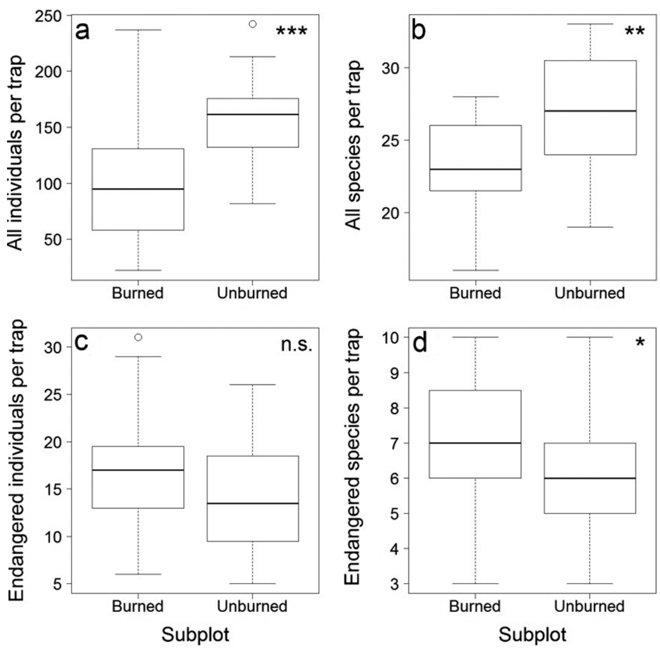

Fig. 4: Mean species activity abundance and richness for the burned (left) and unburned site (right). **a.** = all individuals, **b.** species per trap over the whole period; **c.** and **d.** show the results for endangered spiders. * = p < 0,05; ** = p < 0,01; *** = p < 0,001

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 furtiva* (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. *Theridion uhligi* Martin, 1974 was recorded for the first time in Lower Saxony and occurred only on the burned site with six specimens. 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

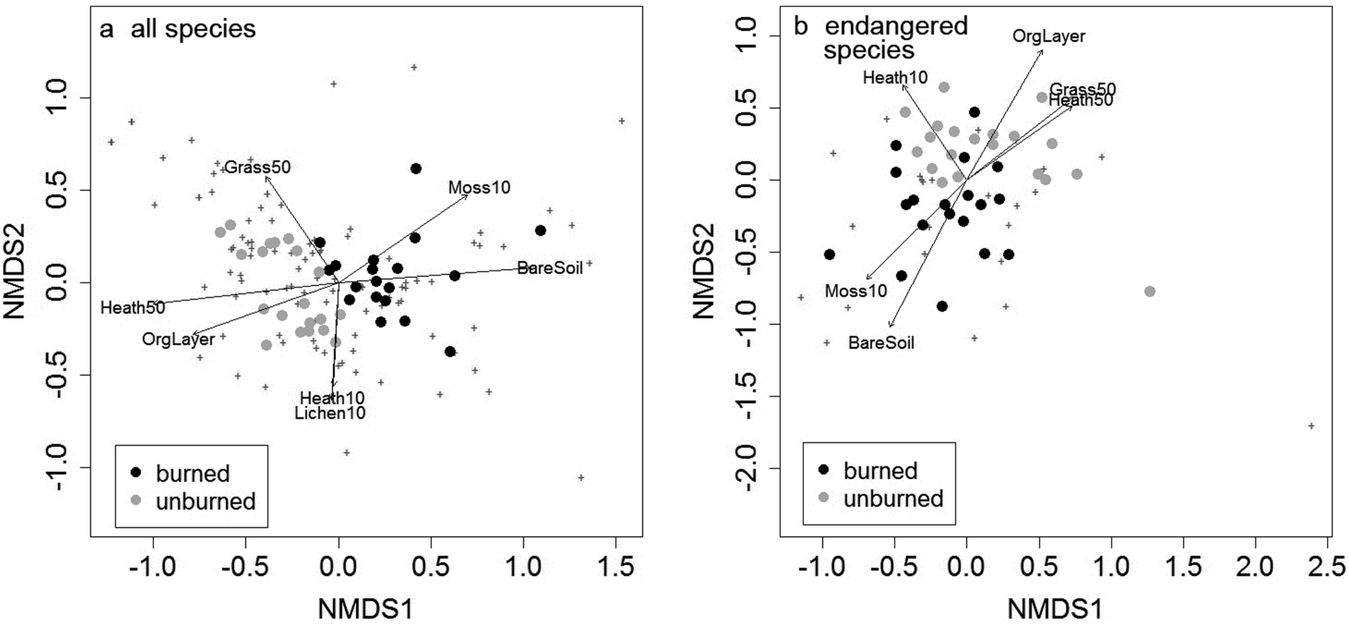

Fig. 5: Relationship between spider species and habitat components **a.** all species, **b.** red list species. Light spots = pitfall catches on unburned area; dark spots = pitfall catches on burned area. Crosses = species. Heath 10 = heather <10 cm; Heath50 = heather 10–50 cm; Moss10 = mosslayer < 10 cm; Grass50 = Grasses 10–50 cm

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 occuring exclusively on the burned site (nl = not listed)

Species	Family	unburned	burned	red list	woodland	open landsc.	heath	ballooning	thermo-phil
Aelurillus v-insignitus	Salticidae	0	2	3	0	1	0	0	1
Araneus quadratus	Araneidae	0	3	-	0	1	0	0	0
Arctosa perita	Lycosidae	0	2	3	0	1	1	1	1
Centromerus arcanus	Linyphiidae	0	4	3	0	1	0	0	0
Clubiona corticalis	Clubionidae	0	1	-	1	0	0	0	0
Dicymbium tibiale	Linyphiidae	0	1	-	1	1	0	0	0
Drassyllus praeficus	Gnaphosidae	0	1	3	0	1	0	1	1
Hypsosinga albovittata	Araneidae	0	1	3	0	1	0	1	1
Neoscona adianta	Araneidae	0	1	-	0	1	1	0	1
Palliduphantes pallidus	Linyphiidae	0	2	-	1	1	0	0	0
Theridion uhligi	Theridiidae	0	6	nl	0	1	0	1	1
Trichopterna cito	Linyphiidae	0	3	3	0	1	0	1	1

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

Species	Family	n = unburned	n = burned	red list	wood-land	open landsc.	heath	ballooning	thermo-phil
Alopecosa 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	1	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	0	1

Tab. 3: List of spider species captured on the unburned and on the burned site

Species	Family	un-burned	burned
Aelurillus v-insignitus	Salticidae		2
Agelena labyrinthica	Agelenidae	4	2
Agroeca lusatica	Liocranidae	5	3
Agroeca proxima	Lycosidae	17	11
Alopecosa barbipes	Lycosidae	10	37
Alopecosa cuneata	Lycosidae	201	79
Alopecosa fabrilis	Lycosidae	5	8
Alopecosa pulverulenta	Lycosidae	12	2
Araneus quadratus	Araneidae		3
Arctosa perita	Lycosidae		2
Asagena phalerata	Theridiidae	55	97
Centromerita bicolor	Linyphiidae	11	7
Centromerita concinna	Linyphiidae	703	218
Centromerus arcanus	Linyphiidae		4
Centromerus incilium	Linyphiidae	27	6
Centromerus prudens	Linyphiidae	5	1
Centromerus sylvaticus	Linyphiidae	88	31
Cercidia prominens	Araneidae	1	
Cheiracanthium erraticum	Eutichuridae	1	2
Cheiracanthium virescens	Eutichuridae	2	4
Clubiona corticalis	Clubionidae		1
Clubiona diversa	Clubionidae	2	
Clubiona subsultans	Clubionidae	1	
Cnephalocotes obscurus	Linyphiidae	1	1
Coriarachne depressa	Thomisidae	1	1
Dicymbium tibiale	Linyphiidae		1
Dismodicus elevatus	Linyphiidae	1	
Drassodes cupreus	Gnaphosidae	9	1
Drassodes pubescens	Gnaphosidae	14	9
Drassyllus praeficus	Gnaphosidae		1
Drassyllus pusillus	Gnaphosidae	4	1
Enopognatha thoracica	Theridiidae	2	1
Erigone atra	Linyphiidae	8	22
Erigone dentipalpis	Linyphiidae	9	23
Ero furcata	Mimetidae	2	
Euophrys frontalis	Salticidae	3	
Gnaphosa leporina	Gnaphosidae	7	1
Gonatium rubens	Linyphiidae	1	
Hahnia helveola	Hahniidae	2	4
Haplodrassus signifer	Gnaphosidae	121	65
Heliophanus flavipes	Salticidae	1	
Hygrolycosa rubrofasciata	Lycosidae	1	
Hypsosinga albovittata	Araneidae		1
Macrargus rufus	Linyphiidae	1	
Micaria silesiaca	Gnaphosidae	4	23
Micrargus herbigradus	Linyphiidae	1	
Neoscona adianta	Araneidae		1
Neriene furtiva	Linyphiidae	1	
Oedothorax apicatus	Linyphiidae	1	
Ozyptila atomaria	Thomisidae	10	12
Ozyptila scabricula	Thomisidae	3	1
Pachygnatha degeeri	Tetragnathidae	2	1
Palliduphantes pallidus	Linyphiidae		2
Pardosa amentata	Lycosidae	1	1
Pardosa lugubris	Lycosidae	1	
Pardosa monticola	Lycosidae	336	671
Pardosa nigriceps	Lycosidae	127	22
Pardosa palustris	Lycosidae	147	111
Pardosa pullata	Lycosidae	339	36
Pellenes tripunctatus	Salticidae	18	28
Philodromus aureolus	Philodromidae	4	
Philodromus collinus	Philodromidae	2	
Phlegra fasciata	Salticidae	1	1
Phrurolithus festivus	Phrurolithidae	3	2
Pisaura mirabilis	Pisauridae	97	6
Pocadicnemis juncea	Linyphiidae	1	
Robertus lividus	Theridiidae	4	4
Scotina palliardii	Liocranidae	5	2
Steatoda albomaculata	Theridiidae	1	18
Stemonyphantes lineatus	Linyphiidae	14	13
Talavera aequipes	Salticidae	2	5
Talavera petrensis	Salticidae	2	
Tenuiphantes tenuis	Linyphiidae	1	
Theridion uhligi	Theridiidae		6
Theridion varians	Theridiidae	2	
Tibellus oblongus	Philodromidae	5	2
Tiso vagans	Linyphiidae	3	
Trichopterna cito	Linyphiidae		3
Trochosa ruricola	Lycosidae	1	
Trochosa terricola	Lycosidae	399	130
Walchenaeria cucullata	Linyphiidae	1	
Walckenaeria acuminata	Linyphiidae	12	
Walckenaeria atrotibialis	Linyphiidae	1	
Walckenaeria capito	Linyphiidae	1	
Walckenaeria dysderoides	Linyphiidae	3	6
Walckenaeria furcillata	Linyphiidae	7	4
Walckenaeria monoceros	Linyphiidae	31	7
Xerolycosa nemoralis	Lycosidae	4	5
Xysticus audax	Thomisidae	1	
Xysticus bifasciatus	Thomisidae	18	17
Xysticus cristatus	Thomisidae	29	23
Xysticus erraticus	Thomisidae	23	13
Xysticus kochi	Thomisidae	11	18
Zelotes electus	Gnaphosidae	1	4
Zelotes latreillei	Gnaphosidae	24	3
Zelotes longipes	Gnaphosidae	24	38
Zelotes petrensis	Gnaphosidae	99	50
Zelotes subterraneus	Gnaphosidae	2	
Zora spinimana	Miturgidae	7	
Total: 99 species		**3175**	**1941**
Total number of specimen			**5116**

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.

Acknowledgements
We are grateful to Dirk Merkens of the Verein Naturschutzpark e.V. for his support with his expert knowledge in the field, and the Alfred Toepfer Academy (NNA) for permission to collect the samples in the nature reserve.

References

Bell JR, Bohan DA,Shaw EM & Weyman GS 2005 Ballooning dispersal using silk: world fauna, phylognies, genetics and models. – Bulletin of Entomological Research 95: 69-114 – doi 10.1079/BER2004350
Boer P den & Dijk TS van 1994 Carabid beetles in a changing environment. – Wageningen Agricultural University Papers 94-6: 1-30
British Arachnological Society 2015 Spider and harvestman recording scheme website. – Internet: http://srs.britishspiders.org.uk/portal.php/p/Welcome (13.07.2015)
Curtis D 1980 Pitfalls in spider community studies. – Journal of Arachnology 8: 271-280
Finch O-D 2004 Rote Liste der in Niedersachsen und Bremen gefährdeten Webspinnen (Araneae). – Informationsdienst Naturschutz Niedersachsen 24(5 Suppl.): 1-20
Finch O-D 2013 Webspinnen. In: Kaiser T (Hrsg.) Das Naturschutzgebiet Lüneburger Heide – Natur und Kulturerbe von europäischem Rang. Teil 1. – VNP-Schriften 4: 306-338
Gardner SM 1991 Ground beetle (Coleoptera: Carabidae) communities on upland heath and their association with heathland flora. – Journal of Biogeography 18: 281-289 – doi 10.2307/2845398
Gimingham CH 1972 Ecology of heathlands. Chapman & Hall, London, UK. 266 pp.
Hänggi A, Stöckli E & Nentwig W 1995 Lebensräume mitteleuropäischer Spinnen. Charakterisierung der Lebensräume der häufigsten Spinnenarten Mitteleuropas und der mit diesen vergesellschafteten Arten. – Miscellanea Faunistica Helvetiae 4: 1-459
Jofré GM & Reading CJ 2012 An assessment of the impact of controlled burning on reptile populations. – ARC Research Report 12/02: 1-30 – Internet: http://nora.nerc.ac.uk/20507/1/N020507CR.pdf
Kaiser T (Hrsg.) 2013 Das Naturschutzgebiet Lüneburger Heide – Natur- und Kulturerbe von europäischem Rang. Teil 1. VNP-Schriften 4: 1-414.
Keienburg T & Prüter J 2004 Conservation and management of Central European lowland heathlands. Case study: Lüneburger Heide nature reserve, north-west Germany. – Mitteilungen aus der NNA 15, Sonderheft 1: 1-64
Koponen S 2005 Early succession of a boreal spider community after forest fire. – Journal of Arachnology 33: 230-235 – doi 10.1636/CT04-112.1
Lütkepohl M 1993 Schutz und Erhaltung der Heide. Leitbilder und Methoden der Heidepflege im Wandel des 20. Jahrhunderts am Beispiel des Naturschutzgebietes Lüneburger Heide. – NNA-Berichte 6(3): 10-19
Nentwig W, Blick T, Gloor D, Hänggi A & Kropf C 2014 araneae – Spiders of Europe, version 7.2014. – Internet: http://www.araneae.unibe.ch/ (15.07.2014)
Niemeyer MT, Niemeyer S, Fottner W, Hardtle W & Mohamed A 2007 Impact of sod-cutting and choppering on nutrient budgets of dry heathlands – Biological Conservation 134: 344-353 – doi 10.1016/j.biocon.2006.07.013
Oksanen J, Blanchet FG, Kindt R, Legendre P, Minchin PR, O'Hara RB, Simpson GL, Solymos P, Stevens MHH & Wagner H 2013 vegan: community ecology package. R package version 2.0-10. – Internet: http://cran.r-project.org/package=vegan (13.07.2015)

Platen R & Broen B von 2005 Gesamtartenliste und Rote Liste der Webspinnen und Weberknechte (Arachnida: Araneae, Opiliones) des Landes Berlin. In: Rote Listen der gefährdeten Pflanzen und Tiere von Berlin. pp. 1-84 – Internet: http://www.stadtentwicklung.berlin.de/natur_gruen/naturschutz/downloads/artenschutz/rotelisten/28_spinnen_print.pdf (13.07.2015)

Renner B 1982 Coleopterenfänge am Sandstrand der Ostseeküste, ein Beitrag zum Problem der Lockwirkung von Konservierungsmitteln. – Faunistisch-ökologische Mitteilungen 5:137-146

Roberts MJ 1995 Spiders of Britain and northern Europe. Collins, London. 383 pp.

Schmidt T & Melber A 2004 Einfluss des Heidemanagements auf die Wirbellosenfauna in Sand- und Moorheiden Nordwestdeutschlands. – NNA-Berichte 17: 145-164

Schikora HB & Fründ HC 1997 Spinnen. In: Cordes H, Kaiser T, Lancken H von den, Lütkepol M & Prüter J (Hrsg.) Naturschutzgebiet Lüneburger Heide: Geschichte – Ökologie – Naturschutz. Hauschild, Bremen. pp. 297-306

Southwood TRE & Henderson PA 2000 Ecological methods. Blackwell Science, Oxford. 575 pp.

Uetz GW 1990 Habitat structure and spider foraging. In: Bell SS, McCoy ED & Mushinsky HR (eds) Habitat structure. The physical arrangement of objects in space. Chapman & Hall, London. pp. 325-348

World Spider Catalog 2015 World Spider Catalog. Version 16. Natural History Museum Bern. – Internet: http://wsc.nmbe.ch (16.04.2015)