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Eur. J. Entomol. 107: 129–132, 2010
http://www.eje.cz/scripts/viewabstract.php?abstract=1518
ISSN 1210-5759 (print), 1802-8829 (online)

The importance of habitat mosaics for Orthoptera (Caelifera and Ensifera) in dry heathlands

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Key words. Orthoptera, Caelifera, Ensifera, *Calluna* heath, coastal heath, grey dune, heathland

Abstract. In summer 2008, the Orthopteran species *Chorthippus biguttulus*, *Myrmeleotettix maculatus* (Caelifera), *Decticus verrucivorus* and *Platycleis albopunctata* (Ensifera) were sampled in coastal heathland on the German Baltic Sea island of Hiddensee. The aim of this study was to assess differences in abundance of Orthoptera in three different habitats and determine the importance of habitat mosaics. Distribution patterns varied among species and total abundance of Orthoptera differed significantly among the three habitats. Due to species-specific habitat preferences the Caelifera were most abundant in grey dunes and the Ensifera in dwarf-shrub heath adjoining grey dunes. In conclusion, grey dunes are a suitable habitat for the Caelifera studied, while the Ensifera require a heathland mosaic consisting of both grey dunes and dwarf shrub vegetation.

INTRODUCTION

Heath ecosystems are protected under the EU Habitats Directive (Ssymank et al., 1998). Like many other dry, nutrient-poor open habitats (e.g. calcareous and sandy dry grassland, inland and coastal dunes) they harbour a high biodiversity, especially of insects (Webb, 1998; van Swaay, 2002; Riksen et al., 2006). Typical heath ecosystems are characterized by a mosaic of dwarf-shrub vegetation, grass-dominated heath, bare ground and isolated shrubs or trees. According to the habitat heterogeneity hypothesis (Tscharntke et al., 2002; Tews et al., 2004) there should be a greater diversity of insects in complex than simple habitats, as the number of niches increases with increase in habitat complexity (Dupont & Overgaard Nielsen, 2006).

The dune heath on the Baltic Sea island of Hiddensee is dominated by *Calluna vulgaris* heath, except on the grey dunes, which are dominated by *Corynephorus canescens*. Typical Orthoptera present in the Hiddensee dune heath are the Caelifera *Chorthippus biguttulus* (Linnaeus, 1758) and *Myrmeleotettix maculatus* (Thunberg, 1815) (Köhler & Reinhardt, 2002) and Ensifera *Decticus verrucivorus* (Linnaeus, 1758) (Köhler & Reinhardt, 2002) and *Platycleis albopunctata* (Goeze, 1778) (Schirmel et al., 2010).

The aim of this study was to answer the following questions: (i) How do the abundances of the different species of Orthoptera differ among the three habitats a) grey dune, b) adjoining heath and c) heath located at least 20 m away from the grey dunes? (ii) How can the abundance patterns of the species be explained? (iii) What can be concluded from this study about the conservation of heathland Orthoptera?

MATERIAL AND METHODS

The study area was the dune heath on the Baltic Sea island of Hiddensee, Germany (54°32´N, 13°5´E; Fig. 1a). It is a distinctive feature of the landscape and covers an area of about 200 ha. The average annual precipitation is 547 mm and average annual temperature 7.5°C (Reinhard, 1962). After cultivation of the land was abandoned about 100 years ago, the landscape was kept open by clearing shrubs, sod cutting, mowing and, since 2004, sheep grazing. Plant cover consists mainly of *Calluna vulgaris* and small-scale occurrence of grey dune vegetation (*Corynephorus canescens*, *Carex arenaria* and *Cladonia* spp.).

Three habitats were sampled a) grey dunes (GD), b) dwarf-shrub heath adjoining grey dunes (HN) and c) dwarf-shrub heath at least 20 m away from grey dunes (HF). Five 500 m^2 sites at which the vegetation was homogeneous were established in each habitat. The sites in the GD were at least 5 m from dwarf-shrub heath. At least one side of the rectangular HN sites was situated at a maximum of 5 m from grey dunes and the HF sites were at least 20 m from grey dunes (Fig. 1b).

The structure of the vegetation in each of the three habitats was characterized at the beginning of August by recording the following parameters: total vegetation cover, grass cover (including sedges), cryptogam cover (all estimated in %) and vegetation height (cm). At each site, the vegetation was sampled in three 2 × 2 m (GD) or two 5 × 5 m (HN, HF) randomly located squares, respectively.

The Orthoptera were recorded by slowly walking along transects three times between the end of July and end of August 2008. At each site transects consisted of loops of a total length of 70 m. All visually and acoustically detected individuals at a distance of up to 0.5 m on both sides of transects (total area sampled per site = 70 m^2) were counted. Scientific nomenclature followed Coray & Lehmann (1998).

One-way ANOVA followed by Fisher's LSD post-hoc tests were used for the results that met ANOVA assumptions. If necessary, a log (x + 1) transformation was used, and for results that still deviated from normality, the Kruskal-Wallis test followed by multiple U-test comparisons (Bonferroni-corrected to a significance level of $\alpha \leq 0.017$) were performed. For all tests, the SPSS 11.5 statistics package was used.

RESULTS

Except for the cover of cryptogams (GD: 61.0 ± 3.0; HN: 66.2 ± 1.6; HF: 66.4 ± 2.1), all the other vegetation parameters recorded for the grey dunes differed highly significantly from

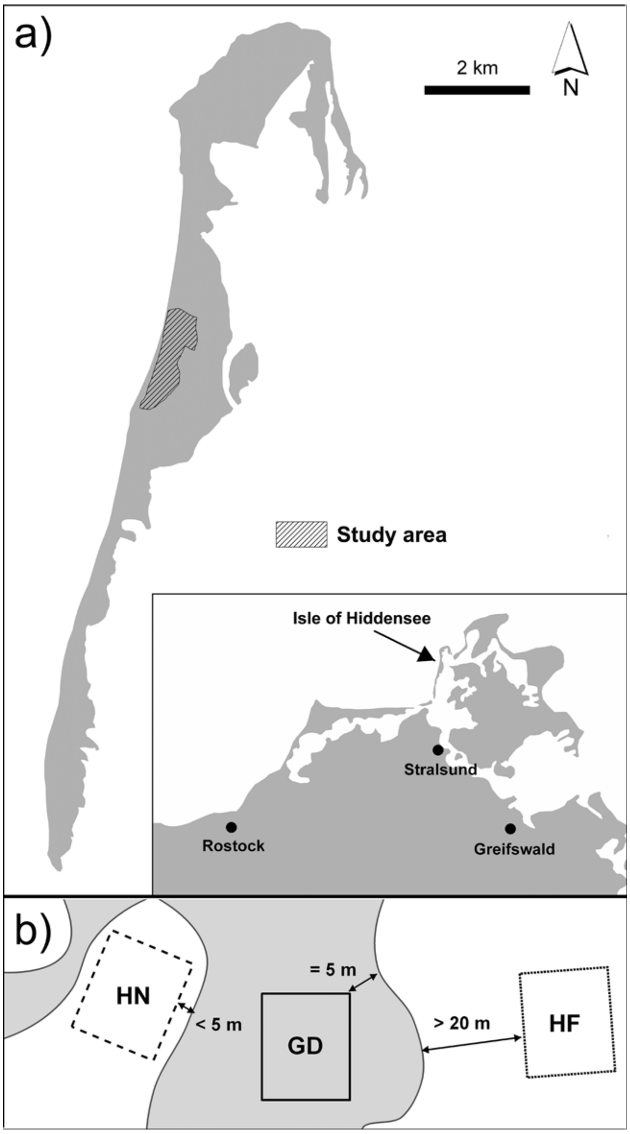

Fig. 1. The a) position of the isle of Hiddensee at the Baltic Sea (small map) and of the study area (hatched) and the b) placement of the sampling sites in the study area. GD = grey dunes, distance of at least 5 m from the dwarf-shrub stands (n = 5), HN = dwarf-shrub heath adjoining to grey dunes (n = 5), HF = dwarf-shrub heath > 20 m away from grey dunes (n = 5); white = homogeneous dwarf-shrub stands (*Calluna vulgaris*), grey = grey dunes (*Corynephorus canescens*).

those for the dwarf-shrub heath. The grey dunes had lower cover of total vegetation (59.0 ± 1.3), higher cover of grasses (39.4 ± 2.2) and a shorter turf (25.8 ± 1.0), compared to HN (88.4 ± 2.3; 3.4 ± 1.3; 54.0 ± 2.5) and HF (89.4 ± 2.0; 4.0 ± 1.2; 60.6 ± 1.2), respectively. The only vegetation parameter that differed significantly between the two types of heath was the height of the vegetation, which was slightly higher on the HF (60.6 ± 1.2) than HN (54.0 ± 2.5).

All four species of Orthoptera were recorded in the GD and HN (Table 1). In HF only *C. biguttulus*, *M. maculatus*, and *D. verrucivorus* were observed. Total numbers of individuals recorded decreased from GD (537 individuals) to HN (208 individuals) to HF (94 individuals). Mean abundances per 10 m^2 of the four species decreased from GD > HN > HF and differed significantly among habitat types. *C. biguttulus* abundances decreased significantly from GD > HN > HF. Abundance of *M. maculatus* also decreased from GD > HN > HF. However, the abundances in the two dwarf-shrub heaths did not differ significantly. *D. verrucivorus* was most abundant in HN and differed significantly from that in GD but not HF. *P. albopunctata* was absent in HF and did not differ in abundance in GD and HN (Table 1).

DISCUSSION

As the Orthoptera differ in their life-history traits (Ingrisch & Köhler, 1998; Braschler et al., 2009) it was expected that they would differ in their distribution among the habitats studied. The Caelifera *C. biguttulus* and *M. maculatus* were most abundant in grey dunes. Both species are heat-loving and require open and warm oviposition sites (Detzel, 1998) and *M. maculatus,* especially, prefers habitats with little vegetation (Detzel, 1998; Willot & Hassall, 1998). Both species were also recorded in dwarf-shrub heath (HN, HF), but only in small numbers. *M. maculatus* requires very little space and can survive in extremely small microhabitats (Detzel, 1998), which might account for its presence in heath vegetation. Moreover, *M. maculatus* is only partly graminivorous (Zehm, 1997) and therefore capable of finding sufficient food (such as mosses) in the nearly grass-free dwarf-shrub heath. This might be why its abundance in HN and HF did not differ significantly. In contrast, the spatial proximity to grey dunes positively influenced the abundance of *C. biguttulus* in dwarf-shrub heath (more abundant in HN than HF). This could be due to the high proportion of grasses, the preferred food of this orthopteran, in grey dunes.

As in most large-sized grassland Ensifera (Gottschalk, 1997; Schuhmacher & Fartmann, 2003; Braschler et al., 2009) the occurrence of the Ensifera *D. verrucivorus* and *P. albopunctata* strongly depends on the existence of habitat mosaics, as in the different stages of their life cycle they require different environmental conditions. Like the two Caelifera species, *D. verrucivorus* and *P. albopunctata* need bare ground for oviposition (Ingrisch & Boekholt, 1983; Gottschalk, 1997) and their heat-loving nymphs (Ingrisch, 1978) depend on sparsely vegetated microhabitats (Schuhmacher & Fartmann 2003). On the other hand, the adults of the two Ensifera species are bigger (18–44 mm; Detzel, 1998) than the Caelifera (11–23 mm; Detzel, 1998) and therefore require taller (dwarf-shrub) vegetation for shelter and song posts (Schuhmacher & Fartmann, 2003; Braschler et al., 2009). These requirements account for the high abundance of *D. verrucivorus* and *P. albopunctata* in heath adjoining grey dunes. The high abundance of *P. albopunctata* in GD may also be due to its higher heat requirement and the presence there of grasses, as it prefers to feed on grass seeds (Gottschalk, 1997).

Our results indicate that extensive, homogeneous and undisturbed stands of dwarf-shrub heath are not optimum habitats for many Orthoptera (Clausnitzer, 1994; Stuke, 1995). Only *M. maculatus* and *D. verrucivorus* tend to occur regularly in large numbers in such habitats. In contrast, grey dunes or disturbed areas are very suitable habitats for the Caelifera studied and in combination with neighbouring heath are also suitable for some Ensifera (Schuhmacher & Fartmann, 2003). Therefore, the conservation of species- and individual-rich heathland Orthopteran communities depends on the creation of heterogeneous heathland with open dunes and disturbed patches next to *Calluna* stands.

The Orthopteran fauna of homogeneous *Calluna* heaths can be considerably influenced by the nature of the adjacent habitats, as shown for grey dunes in this study. To avoid edge effects, the minimum distance of a plot from adjacent habitats should be at least 20 m, when recording the indigenous Orthop-

TABLE 1. The abundance of Orthoptera (mean number of individuals per 10 m^2 ± SE) in grey dunes (GD, n = 5), dwarf-shrub heath adjoining grey dunes (HN, n = 5) and dwarf-shrub heath at least 20 m away from grey dunes (HF, n = 5), and the results of one-way ANOVA's or Kruskal-Wallis tests. Different letters indicate significant differences between abundances (Fisher's LSD-Test at $P \leq 0.05$; Kruskal-Wallis test: Bonferroni-corrected U-Test at $P \leq 0.017$).

	GD	HN	HF	Statistics
All species	5.11 ± 0.45^{a}	1.98 ± 0.23^{b}	0.90 ± 0.23^{c}	F = 45.288, d.f. = 2, $P \leq 0.001$ GD-HN: $P < 0.001$ GD-HF: $P < 0.001$ HN-HF: $P = 0.037$
Chorthippus biguttulus	1.27 ± 0.14^{a}	0.45 ± 0.12^{b}	0.07 ± 0.02^{c}	$\chi^2 = 12.750$, d.f. = 2, $P \leq 0.01$ GD-HN: $P \leq 0.01$ GD-HF: $P \leq 0.01$ HN-HF: $P \leq 0.01$
Myrmeleotettix maculatus	3.68 ± 0.49^{a}	1.18 ± 0.15^{b}	0.71 ± 0.25^{b}	F = 23.606, d.f. = 2, $P \leq 0.001$ GD-HN: $P \leq 0.001$ GD-HF: $P \leq 0.001$ HN-HF: $P = 0.335$
Decticus verrucivorus	0.04 ± 0.02^{ac}	0.21 ± 0.05^{bc}	0.11 ± 0.04^{c}	F = 4.413, d.f. = 2, $P \leq 0.05$ GD-HN: $P \leq 0.05$ GD-HF: $P = 0.227$ HN-HF: $P = 0.117$
Platycleis albopunctata	0.14 ± 0.03^{a}	0.14 ± 0.04^{a}	0^{b}	F = 7.422, d.f. = 2, $P \leq 0.01$ GD-HN: $P = 0.908$ GD-HF: $P \leq 0.01$ HN-HF: $P \leq 0.01$

teran fauna of *Calluna* heath (e.g. as part of the Habitats Directive monitoring program).

ACKNOWLEDGEMENTS. For comments on earlier versions of the manuscript we wish to thank M. Konvička, S. Buchholz and an anonymous referee. For support during the field work we thank J. Lendzion. The study was carried out as part of the project "Biodiversity, Ecology and Management of Coastal Habitats of the Baltic Sea" and financially supported by the Bauer-Hollmann Foundation.

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Received October 9, 2009; revised and accepted November 25, 2009