

## Occurrence of Caelifera larvae depending on zoogenic disturbances

### Vorkommen von Larven der Kurzfühlerschrecken (Caelifera) in Abhängigkeit von zoogenen Störstellen

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#### Schlüsselwörter:

Kurzfühlerschrecken, Caelifera, Larven, zoogene Störstellen, wildlebende Huftiere

#### Zusammenfassung

Mit Hilfe von Transekterfassungen wurde die Zahl an Caelifera-Larven auf 12 Probeflächen im Kreis Segeberg, Schleswig-Holstein ermittelt. Bei den Flächen handelte es sich um 7 junge, eingezäunte Aufforstungen, eine gleichaltrige, ungezäunte Aufforstung sowie 4 von wildlebenden Huftieren (insbes. Damhirsch) beäzte Sukzessionsflächen. Während die den Huftieren zugänglichen Flächen regelmäßig Störstellen (Offenboden) durch Wühlen oder Vertritt aufwiesen, fehlten diese in den gezäunten Flächen fast vollständig. Störstellen gingen hier auf den Einsatz von Maschinen oder das Wirken von Kleinsäugern oder Ameisen zurück. Die vorliegenden Ergebnisse zeigen, dass auf den gezäunten Flächen deutlich weniger Larven gefunden werden konnten. Eine mögliche Erklärung hierfür ist der Mangel an Störstellen wodurch zum einen Reproduktionsstätten, zum anderen mikroklimatische Gunsträume für Caelifera-Larven fehlten.

#### Keywords:

short-horned grasshopper, Caelifera, larvae, zoogenic disturbances, ungulates living in the wild

#### Abstract

The amount of Caelifera-larvae was recorded by linear transect walks at 12 study sites in the district of Segeberg, Schleswig-Holstein. Of the 12 study sites, seven were young, fenced reforestations, one unfenced reforestation of similar age and four strongly browsed (fallow deer) succession sites. While on sites accessible to ungulates disturbances (open soil) due to burrowing or trampling occurred regularly, disturbances on fenced sites lacking almost completely. Here, disturbed areas could instead be traced back to the use of machines or to activities of small animals like rodents or ants. Results show that on fenced sites the amount of caught Caelifera larvae per transect was much lower than on browsed succession sites. A possible explanation could be the lack of areas with open soil on fenced sites, and therefore a lack of reproduction sites and preferred sites for larvae of Caeliferalarvae due to microclimatic conditions.



**Figs. 1 & 2:** Transect examples, from left to right: fenced forestation near Trappenkamp (FFT), fenced forestation near Negernbötel (FFN).

## 1. Introduction

Commonly, the word ‘disturbance’ has a negative meaning. From the ecological point of view, however, the term is neutral and describes processes as components of the steady state of an ecosystem. Apart from profound alterations of a system caused by fire, storms or insect calamities, smaller disturbances occurring regularly which are variable in time and space play an important role in for the preservation of local species diversity. According to the Intermediate Disturbance Hypothesis (IDH) (Connell 1978) local diversity of species is highest at intermediate levels of disturbance, while local diversity is lower in undisturbed sites as well as at higher levels of disturbance. Species like ants, rodents as well as large herbivores (Thompson Hobbs 2006) can change their environments and create new structures such as spots of open soil, which might offer important functions for other organisms like grasshoppers as well (Reck 1993, Schulz 2003). Species which affect their environments permanently are considered ecosystem engineers (Jones 1994), while their effect on an ecosystem is termed a key-factor (Steward

2001). Goal of the project ‘Game and Biodiversity’ is to identify the effect of free ranging ungulates in ecosystems and to understand their importance for the habitat studying short-horned grasshoppers (Caelifera) (Reck et al. 2009). Investigations not only considered imagines (Krütgen 2012a), but also included studies of clutches or larvae. Here, however, we present results on the influence of zoogenic disturbance of sites (by free ranging ungulates) for the occurrence of Caelifera larvae in a cultural landscape.

## 2. Methods

### Research area

The research area is located at the eastern border of the natural geographic region “Holsteinische Vorgeest”. It is characterized by an open landscape with less than 20 % of woodland and without high amounts of arable fields (> 50 %) or grassland (> 25 %) (BfN 2007). The moraine landscape originating from the Saalian glaciation was covered by glaciofluvial sand and gravel transported by the melting glaciers of the Weichselian





**Figs. 3 & 4:** Transect examples, from left to right: unfenced forestation (UF), heavily browsed succession site (BSS4).

glaciation. Later mires, fens and inland dunes developed, of which nowadays only relics remain. Historically frequent dwarf shrub heathlands were either afforested with coniferous trees (e.g. Segeberger Forest) or used as arable fields after deep ploughing.

Today, agriculturally used area dominates the landscape with a recent shift to arable land. Woodlands are used for forestry (BfN 2012).

#### Study sites

In total, 12 sites were investigated. Of these, four were young fenced forestations, one an unfenced forestation of similar age and four heavily browsed succession sites in the vicinity of Negernbötel, district Segeberg. Additionally, three fenced forestations near Trappenkamp, district Segeberg, were studied (fig. 1-4).

The four fenced forestations near Negernbötel as well as the unfenced forestation and succession site 4 were located adjacent to each other. The other succession sites were located in a distance between 500 to 1500 m. The three fenced forestations near Trappenkamp were about 4 km north of the study sites at Negernbötel.

All study sites were characterized by sandy, nutrient poor and non-cohesive soils.

### 3. Grasshopper fauna

In the course of various monitoring or research programs, the grasshopper fauna in the vicinity of Negernbötel was investigated intensively since 2005 (Krütgen 2012b, Reck et al. 2009, Schulz et al. 2013, Winkler 2012, 2016). On the study sites and in their surroundings the short horned grasshopper species *Chorthippus albomarginatus*, *Chorthippus apricarius*, *Chorthippus biguttulus*, *Chorthippus brunneus* and *Omocestus viridulus* were found relatively frequent. Furthermore, *Pseudochortippus parallelus*, *Myrmeleotettix maculatus* as well as *Tetrix undulata* and *Tetrix subulata* were observed regularly, while *Chorthippus mollis*, *Omocestus haemorrhoidalis* and *Stetophyma grossum* occurred more rarely and *Chorthippus montanus* and *Stenobothrus lineatus* were found only once.

### 4. Data collection and analysis

On three successive days (June 4th – 6th 2010) with comparable weather conditions (base temperature 20°C, cloud cover < 10 %, no precipitation, max. weak

**Tab. 1:** Amount of larvae per transect and study site, mean, standard deviation and median; transects: BSS heavily browsed succession site, UF: unfenced forestation, FF: fenced forestation, N: Negernbötel, T: Trappenkamp.

Study site	Accessed by ungulates	transect			total	mean	Standard deviation	median
		1	2	3				
BSS1	+	58	64	34	156	52	15,87	58
BSS2	+	15	14	30	59	19,67	8,96	15
BSS3	+	21	16	108	145	48,33	51,73	21
BSS4	+	6	32	16	54	18	13,11	16
<b>total BSS</b>	<b>+</b>	<b>101</b>	<b>128</b>	<b>191</b>	<b>414</b>	<b>34,5</b>	<b>29,13</b>	<b>25,5</b>
UF	+	13	26	39	78	26	13	26
FFN1	-	7	10	15	32	10,67	4,04	10
FFN2	-	25	12	23	60	20	7	23
FFN3	-	16	6	9	31	10,33	5,13	9
FFN4	-	9	0	5	14	4,67	4,51	5
<b>total FFN</b>	<b>-</b>	<b>57</b>	<b>28</b>	<b>52</b>	<b>137</b>	<b>11,42</b>	<b>7,3</b>	<b>9,5</b>
FFT1	-	3	7	13	23	7,67	5,03	7
FFT2	-	3	10	16	29	9,67	6,51	10
FFT3	-	20	22	28	70	23,33	4,16	22
<b>total FFT</b>	<b>-</b>	<b>26</b>	<b>39</b>	<b>57</b>	<b>122</b>	<b>13,56</b>	<b>8,71</b>	<b>13</b>

**Tab. 2:** Mann-Whitney pairwise comparisons: above: uncorrected p-values, underneath: Bonferroni corrected p-values.

	BSS	FFN	FFT
Heavily browsed succession site (BSS)		0,006022	0,03574
Fenced forestation Negernbötel (FFN)	0,01807		0,6183
Fenced forestation Trappenkamp (FFT)	0,1072	1	

wind) the number of Caelifera larvae was recorded in 36 transects. Data was sampled in three days at approximately the same daytime (forenoon till afternoon) to ensure comparability of results. Each transect was recorded for ten minutes. Transects were sampled in a width of 50 cm each. To avoid a negative influence due to shadowing by young trees, transects in the forestations were only chosen in open and sunny sections.

The research focused on young states of Caelifera larvae, because especially these should benefit from dry and warm microclimatic conditions (Ingrisch & Köhler 1998, Wunsch et al. 2010).

For statistical analysis data was grouped into two categories. On the one hand the browsed succession sites accessed by wild living ungulates (+) and on the other hand the fenced forestations without access



to wild living ungulates (-). In the latter case, samples were further grouped according to study sites near Negernbötel (FFN) and those near Trappenkamp (FFT). The unfenced forestation was not taken into consideration because it is a mixture of both classifications and there is insufficient data for an own class. Its interpretation is purely descriptive.

Groups of sites (BSS, FFN & FFT) were compared by the number of Caelifera larvae per transect.

Since numerical data are typically not normally distributed, a Kruskal-Wallis-median-test was used (Wheater et al. 2011).

In addition, a Mann-Whitney-median-test was used for single pair comparisons of fenced versus unfenced sites.

The analyses were done using the statistic program PAST (Hammer 2012).

## 5. Results

Highest mean number of larvae per transect were found on browsed succession sites (Tab.1), with three times as many larvae found on browsed succession sites than on fenced forestation sites. The total amount of larvae at the unfenced forestation was also above all fenced sites. The standard deviation was higher at the browsed succession sites. The lowest standard deviation was recorded at fenced forestations.

Table 1 shows the amount of Caelifera larvae per transect and study site. In addition the arithmetic mean, standard deviation and median of the study sites are given. The three groups of studied sites differed significantly in the mean number of larvae found per transect (Kruskall-Wallis-median-test:  $H: 8,769$   $H_c: 8,793$ ,  $p(\text{same}): 0,01247$ ). The number of larvae found at fenced forestation sites at Negernbötel (FFN) differed significantly from the number found at heavily browsed succession sites (BSS) ( $\text{padj.} < 0,02$ ). No significant differences were found between the number of larvae found at FFN and FFT ( $\text{padj.} = 1$ ) or BSS and FFT ( $\text{padj.} = 0,1072$ ).

On heavily browsed succession sites significantly more Caelifera larvae per transect were found than on fenced forestation sites (Mann-Whitney U: 48;  $p(\text{same}): 0,003681$ ).

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**Figs. 5-7:** Spot of open soil due to trampling, oviposition of *Pseudochorthippus parallelus parallelus*, Caelifera larvae on a zoogenic disturbed site.

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## 6. Discussion

Differences in the number of Caelifera larvae found on study sites can be explained by differences in the amount of areas with open soil (Schulz 2003). Wunsch et al. (2010) found young larvae of *Myrmeleotettix maculatus* especially in warm microhabitats with reduced vegetation cover. Warm surroundings are considered to benefit the development of larvae (Ingrisch & Köhler 1998, Willott & Hassal 1998). Oschmann (1973) and Cherill & Brown (1992) suggest that the occurrence of young larvae can indicate the location of oviposition sites.

It can be assumed that beneficial effects of a warm microclimate are especially important for various short-horned grasshopper occurring in poor and dry habitats. Areas of open soil are considered important reproduction sites for most of the species occurring on the study sites. 70 % of all species, recorded in the study area, use soil for oviposition (Ingrisch & Köhler 1998). Therefore, if patches of open soil, where young larvae were found, existed already in the year prior to the study, these were most likely used for oviposition and larvae hatched here. On fenced forestation sites, disturbances only occurred due to anthropogenic use of machines and were commonly older and heavily overgrown. Patches of open soil caused by zoogenic disturbance were common only in the browsed succession sites, without a regular distribution pattern. The irregular distribution of patches of bare soil explains the partially high standard deviation on these study sites. The number of larvae found per transect therefore highly depends on the proportion of open soil. On fenced forestation sites, where fewer disturbances were recorded, fewer larvae were found (except for FFN2 and FFT3), but the distribution of larvae along the transects was more regular, resulting in a lower standard deviation. An explanation for this could be the more regular distribution of disturbed patches due to anthropogenic influences (machines) and the general lack of suitable reproduction sites.

Schulz (2003) suggests that in areas with dense vegetation cover the oviposition sites are rare and clutches arise cumulatively.

The results show that the exclusion of free ranging ungulates may lead to a loss of suitable habitats for Caelifera. The suitability depends on the lack of favorable microhabitats for larvae as well as suitable reproduction sites. The amount of larvae on the unfenced forestation shows that this happens before the pioneer forests generally lose their habitat suitability due to shadowing.

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