

## LOW DENSITY CATTLE GRAZING ENHANCES ARTHROPOD DIVERSITY OF ABANDONED WETLAND

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**Abstract.** We studied the impact of low-density grazing on arthropod diversity in a small wetland (7 ha) in South Germany. The location was abandoned for 20 years, and was then grazed by Galloway for 4 to 5 years. The study site included the following habitat types: open land, a stand of alder (*Alnus glutinosa*), a stand of willows (*Salix spec*) and alder and a brookside. We counted higher species numbers on grazed than on neighbouring abandoned areas in ground beetles, rove beetles and spiders. Grazing explained a considerable amount of the variance of the species composition, and species typical for grazed plots could be identified. We found higher frequencies of insects during winter in *Cirsium* stems from grazed than from ungrazed areas. Grasshoppers and katydids (*Saltatoria*) of the grazed open land showed a general trend of increasing species number during the study period. Our findings show that low density grazing by cattle can favour habitat diversity even in small areas which enhances species numbers. However, special habitat types such as reed may need to be excluded from grazing in order to maintain the associated specific invertebrate community.

**Key words:** *Grazing, arthropods, insects, diversity, wetland*

### Introduction

In many wetlands species richness and diversity depend on traditional land use patterns such as mowing and grazing (35). In Central Europe changing land use and intensification of agriculture have dramatically reduced the area of traditionally used wetlands (25), consequently many wetland species are highly endangered nowadays. Since long, mowing was regarded the most suitable conservation tool to preserve open wetland habitats (5, 28). However, sporadically mowing nowadays fully depends on financial support, while extensive grazing can be partly included in agricultural production and may be a less expensive tool for nature conservation (41). Especially in restoration projects for abandoned wetlands, where the re-establishment of mowing is very expensive, grazing comes more and more into practice (3, 15, 19, 38). Many studies investigated the fauna of dry habitats demonstrating that extensive grazing can be an adequate management method (e.g. 2, 8, 12, 24). In contrast, literature on the influence of low density grazing on the fauna of wetlands is scarce, in spite of the fact that grazing was the traditional land use in many wetlands in the past (25, 29). The few studies conducted about the fauna of grazed wetlands in Central Europe focused on medium sized and large areas (>30ha). Regarding large areas, low density grazing is assumed to favour species diversity by the creation of diverse habitats (1, 11, 18, 27). However, approaches are needed in Central Europe for the management of small wetland areas (43).

In our study we present a restoration project where ongoing succession of a small abandoned wetland (6 ha) should be prevented by low density cattle grazing. The project was launched by the Bund Naturschutz in Bayern. The aim is to protect the biodiversity of open landscapes by extensive farming practices (41).

We studied the influence of cattle grazing on vegetation and on animal populations. Our earlier results showed that the low density cattle grazing favours plant diversity and creates small scale habitat heterogeneity (42), enhances species richness of dung beetles (39), and reproduction success of endangered amphibians (43). The objective of this study are (i) determining the influence of grazing on the relative abundance of epigeic spiders and carabid as well as staphylinid beetles (ii) investigating changes in the species community in relation to grazing, (iii) analysing the long term reaction of grasshopper species on grazing, and (iv) comparing the densities of stem-infesting insects in grazed and abandoned plots.

## Study area

The study area is located in South Germany (Oberbayern: 12°22'42" east, 48°10'05" north) and is about 7 ha in size. It includes a damp meadow and small woods (6 ha), which are grazed since 1996 except for a small area of the woodland which was not grazed before 1999. Additionally, an area of about 1 ha remained abandoned where natural succession could take place totally unaffected by grazing or other management activities. In the latter the samples for the ungrazed control were taken.

From April until November between six and nine Galloway cattle (one or two years old) roamed freely in the fenced area. Other management measures such as mowing in autumn were not applied.

## Methods

### *Community of spiders, ground beetles and rove beetles*

Spiders (Araneae), ground beetles (Carabidae) and rove beetles (Staphylinidae) were studied in grazed and adjacent abandoned (ungrazed) plots of the same habitat type. Pairs of sample plots (each 100m<sup>2</sup>) were situated in the following habitats:

1) Open wetland; in the abandoned plot (1a) *Urtica dioica*, *Phlaris arundinacea* and *Carex* spec. were the dominating plant species, in the grazed plot (1b) these vegetation had been largely replaced by grasses (*Poa* spec), *Mentha longifolia* and *Cirsium* spec. The vegetation at 1a was on average higher and much denser than at 1b, bare ground without vegetation existed only at 1b.

2) Stand of *Alnus glutinosa*. In the ungrazed area (2a) *Urtica dioica* was dominating. The ground at the grazed plot (2b) was sparsely covered with grasses (*Poa* spec), and about 50% of the ground was without vegetation cover.

3) Stand of *Salix caprea* and *Alnus glutinosa*. At the ungrazed plot (3a) as well as at the grazed plot (3b), *Urtica dioica*, *Galium aparine* and *Poa* spec. were dominant, but the vegetation was less dense at 3b because of trampling and grazing by Galloway cattle.

While at the grazed parts of the pairs 1 and 2 grazing started in 1996, plot 3 belonged to the woodland that was included in the grazed area (3b) in 1999.

As an additional sample plot (4) we included an ungrazed reed at the brookside composed of *Phragmites communis* and *Phalaris arundinacea* at the banks of a small stream.

In 1999 and 2000 a set of 5 pitfalls (diameter 7cm) was installed at each plot and activated to catch epigeic invertebrates for 14 days in May, July and September. Trapping fluid was 5% acetic acid and traps were covered with a non-transparent roof to avoid flooding by rain. Additionally, we used a sweeping net to collect spiders from the vegetation. Sampling was done at the end of each pitfall sampling periods and for each sample 100 net strikes were carried out. The arthropods were identified and differences in species number between grazed and ungrazed plots were tested with a t-test for paired samples, the tested combinations being the grazed-ungrazed pairs of each habitat type (1 – 3).

Additionally CANOCO 4.5 (30) was used, to analyse the epigeic arthropod communities among the plots and to separate the influence of grazing from those of habitat characteristics and yearly changing environmental factors. Rare species (represented by less than 20 individuals) that are captured only by chance, were excluded from these analysis. This resulted in 20, 14, and 12 ground beetle, rove beetle and spider species, respectively, which were included in the community analyses. To prevent taxa caught in high numbers from excessively influencing the ordinations, faunal counts were square-root transformed. Correspondence analysis (CA) was used to illustrate the major patterns in the community structure. Canonical correspondence analysis (CCA) and partial ordination was calculated to determine the influence of the grazing in relation to environmental conditions that differed among the habitats and the years by using categorical variables. We analysed Carabidae, Staphylinidae and Araneae separately and, additionally, all arthropod species together. Statistical significances were calculated by Monte Carlo permutation tests and taxa showing positive or negative correlation to grazing were identified by t-value biplots.

### ***The Grasshopper community***

Species numbers of grasshoppers were recorded visually on 8 grazed sample plots (each 100m<sup>2</sup>) from 1996-2004. They were all located in grazed open wetland (1b), except one plot in a stand of *Salix caprea*, (see Zahn et al. 2003, for an overview over the vegetation of these sites). Each plot was searched for grasshoppers for 15 minutes once a year in late August. We did not distinguish between *Chorthippus brunneus* and *Ch. biguttulus* and between *Tetrix undulata* and *T. subulata* because it was difficult to determine single individuals without catching or acoustic methods.

### ***Influence of grazing on insects infesting *Cirsium arvense****

To study the influence of Galloway grazing on insects infesting stems of plants, we sampled individuals of *Cirsium arvense* in the open wetland at 18 November 2002, in both the ungrazed (1a) and the grazed (1b) part. We distinguished between damaged and undamaged stems. Each sample consisted of 25 stems. As damaged we defined broken branches, open stems and partly browsed parts of the plant. The *Cirsium* - stems were spliced in the lab and searched for hibernating insects or signs of insect infestation (faeces, holes).

## Results

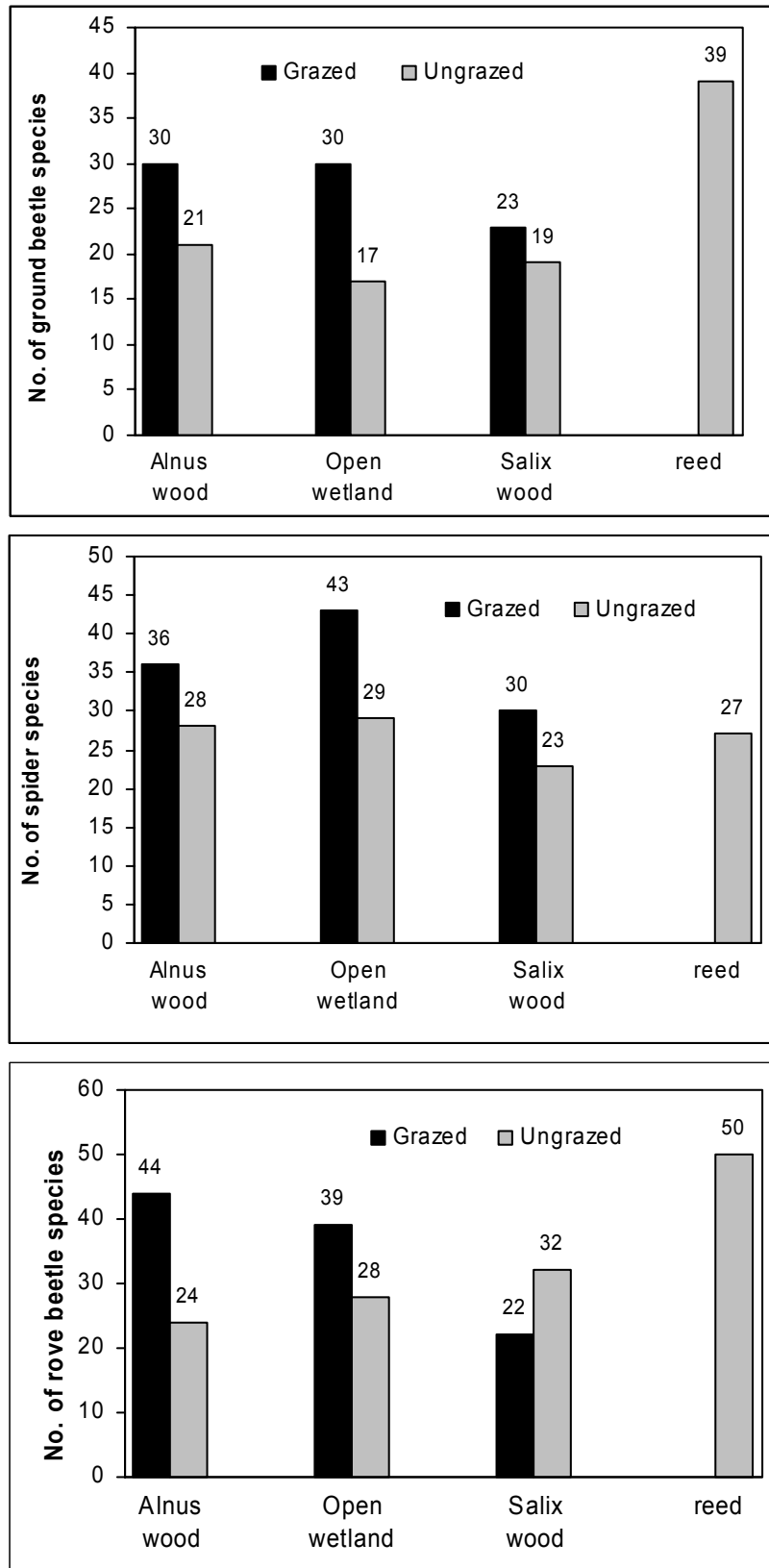
### *Spiders and beetles in grazed and ungrazed areas*

Altogether, 65 species of Carabidae were recorded. Of these 9 (14%) are considered as endangered species in the red data book of Bavaria and 6 (9%) in the red data book of Germany (Tab. 2, appendix). On average, numbers of carabid species were higher in plots grazed by Galloway cattle (44 species) compared to the ungrazed ones (38 species) ( $p = 0.01$ , habitats pooled,  $df = 2$ , t-test, Fig. 1). Grazed plots were characterized by the occurrence and/or high activity densities of species preferring moist and/or sunny environmental conditions such as *Elaphrus cupreus*, *Dyschirius globosus*, *Acupalpis flavicollis*, *Oodes helopioides* or *Poecilus* spp. (Tab 2, appendix.). The pitfall traps in the reed yielded the highest number of species recorded at one plot, i.e. 39 species (Fig. 1). *Agonum micans*, *A. thoreyi* and several species of the genus *Bembidion*, which are endangered and known for their special adaptations to survive in this type of habitat, were found exclusively at this site.

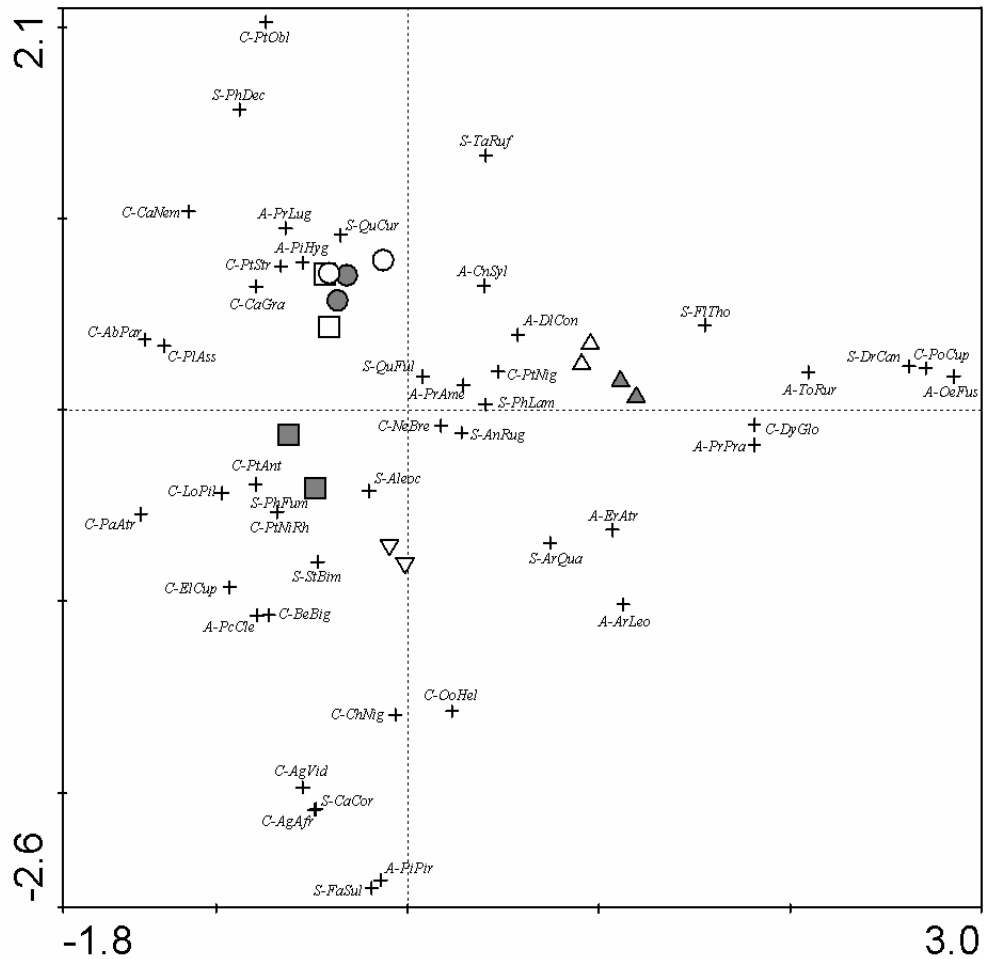
In total, 111 rove beetles species were recorded including four (4%) endangered species of the Bavarian red data book. Overall species numbers were again higher at the grazed samples plots than on ungrazed ones (73 and 47 species in grazed and ungrazed plots, respectively). However, in one of the three pairs of plots, the *Salix-Alnus* stand (3a/b), we found more species at the abandoned site -(Fig.1). At the brookside (reed) 51 species were captured. Of four red list species one was found in all habitats, one in the reed only, one at grazed plots only and at ungrazed plots only (Tab. 2, appendix).

Altogether, 90 species of spiders were recorded of which 72 and 57 species were found in grazed and ungrazed plots, respectively. Only 27 species were captured in the reed, i.e. the ungrazed reed contributed not as much to spider biodiversity as to beetle diversity (Tab. 2, appendix). Two species (2%) are listed in the red data books of Bavaria and Germany (Tab. 2. appendix); both occurred in ungrazed habitats only, *Donacochara speciosa* in the reed, and *Clubiona stagnatilis* in the reed as well as in the ungrazed open wetland. In all grazed plots the numbers of spider species tended to be higher compared to the abandoned references ( $p = 0.06$ , habitats pooled,  $df = 2$ , t-test, Fig. 1). Especially *Pirata*, *Pardosa* and *Oedothorax* species, which are known as hygrophilous and heliophilous showed higher activity densities in the grazed plots.

Twenty-five species of spiders, 10 species of ground beetles and 34 species of rove beetles occurred exclusively on grazed plots (Tab. 2., appendix). For ungrazed plots the respective numbers were 13, 7, and 10 for spiders, ground beetles, and rove beetles, respectively. The ungrazed reed was characterised by 5 species of spiders, 9 species of ground beetles and 28 species of rove beetles, which were found only in this habitat.



**Figure 1.** Impact of grazing on species numbers: Ground beetles, spiders and rove beetles on grazed and ungrazed habitats



**Figure 2.** Fig. 2: Impact of grazing on single species. Given is the ordination of species in relation to the sample plots. Rectangles, circles, upright triangles, and turned round triangles represent stands of *Alnus*, stands of *Salix* and *Alnus*, open wetland, and reed, respectively. Filled symbols indicate grazed plots, while open symbols indicate ungrazed plots. In each case both years are shown. Species names are replaced by abbreviations including C-, S-, or A- for Carabidae, Staphylinidae, or Araneae respectively followed by the first two letters of the genus and the first three letters of the species name. For the total name see Table 2 (Appendix).

An impact of grazing on the arthropod communities is also indicated by the ordination analyses. 6.3 % of the total variance in the species composition can be explained by grazing (Tab. 1, Fig 2). This effect was more obvious in the ground beetle community (7.6 %) than in spiders (4.0 %) or rove beetles (3.2 %). Not surprisingly, habitat characteristics have been found to be the main factor determining the composition of the soil surface active arthropod community. Differences among the years were marginal (thus are not presented separately). According to a t-values biplot (Fig. 2) several species were significantly influenced by grazing: the ground beetles *Nebria brevicollis*, *Poecilus cupreus*, *Patrobus atrorufus*, *Loricera pilicornis*, *Elaphrus cupreus*, *Pterostichus anthracinus*, and *Pterostichus nigrita/rhaeticus* as well as the spiders *Pardosa amentata*, *Erigone atra*, *Trochosa ruricola*, and *Pachygnatha clercki* (*A-PcCle*) reacted positively on grazing; The relative abundances of these 11 species

were higher on grazed plots than on ungrazed ones, irrespective of the influence of other environmental factors, habitat type and year. Negatively influenced by grazing were the rove beetles *Tachinus signatus*, *Aleocharinae spp.*, *Quedius fuliginosus*, *Quedius curtipennis*, *Philonthus decorus* and *Falagria thoracica*, the ground beetles *Carabus nemoralis*, and *Abax parallelepipedus*, as well as the spiders *Centromerus sylvaticus* and *Pardosa lugubris*.

**Table 1.** Tab 1: Variance decomposition of the effect of grazing and other environmental factors on the epigeic arthropod community. Besides the percentage of total variance that can be explained (“all variables”) or not explained (“unexplained”) by the studied variables, the uniquely explained percentage of total variance by habitat differences and yearly changing environmental conditions (“habitat&year”) and by grazing (“grazing”) is listed. “shared” gives the percentage of total variance that is explained by both (“habitat&year” and “grazing”)

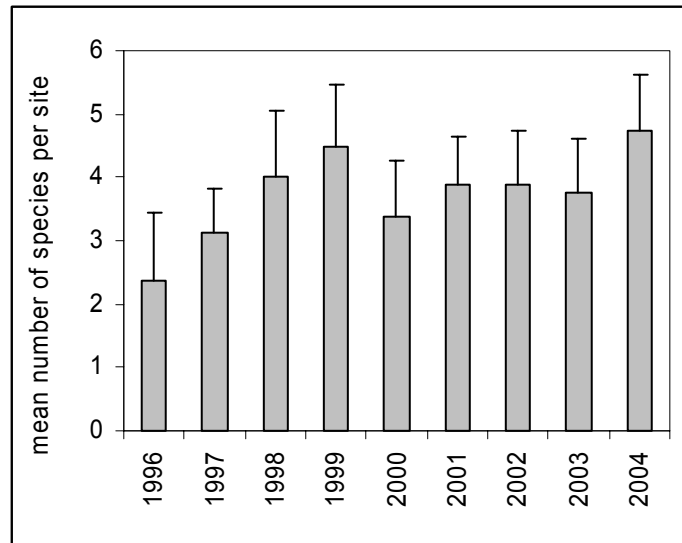
	all Arthropods	Ground beetles	Rove beetles	Spiders
<b>all variables</b>	<b>45.7</b>	<b>45.0</b>	<b>44.5</b>	<b>45.9</b>
<b>grazing</b>	<b>6.3</b>	<b>7.6</b>	<b>3.2</b>	<b>4.0</b>
<b>habitat&amp;year</b>	<b>39.1</b>	<b>37.9</b>	<b>40.8</b>	<b>40.8</b>
<b>shared</b>	<b>0.3</b>	<b>-0.6</b>	<b>0.5</b>	<b>1.2</b>
<b>unexplained</b>	<b>54.3</b>	<b>55.0</b>	<b>55.5</b>	<b>54.1</b>

### **Grasshoppers in grazed open wetland**

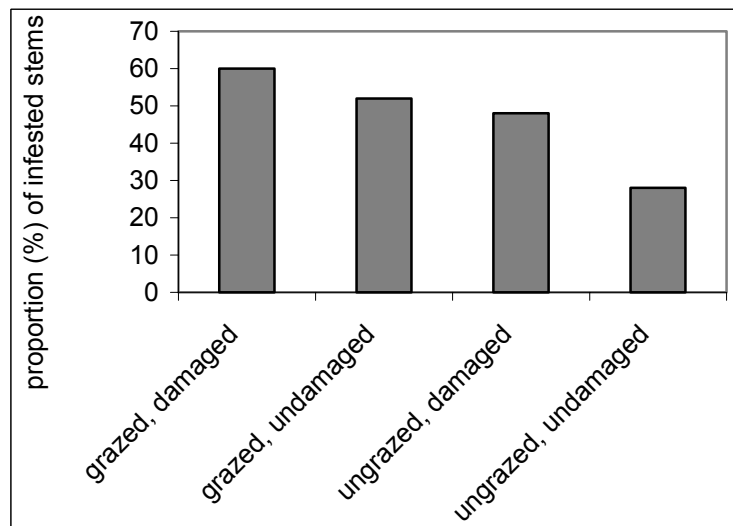
Grazing favoured the distribution of grasshopper species. The numbers of species on the sample plots increased during the first years and stayed on a higher level during the last years. (Fig 3). Since the beginning of the study in 1996, new species (*Chorthippus parallelus* and *Chrysochraon dispar*) were found in the area in 2004 only. *Chorthippus albomarginatus* was found sporadically outside the plots in 1996 but continuously on 2 plots during the last years of the study. *Chorthippus brunneus/biguttulus* and *Gomphoceris rufus* were found in increasing numbers until 1998, but slightly decreased again in the subsequent years. No tendency was obvious in *Chorthippus dorsatus*, *Conocephalus discolor*, *Metrioptera roeseli*, *Pholidoptera griseoaptera*, *Tetrix undulata/subulata* and *Tettigonia cantans*. In general, the mean number of single grasshopper species per site increased only in the beginning of the study. However, most species occupied more patches at the end of study indicating that the overall area of suitable habitats had increased.

### **Stem-infesting insects**

We found the highest percentage of infested *Cirsium* plants in damaged stems from the grazed area and the lowest percentage in undamaged ones from the ungrazed plot (Fig. 4). However, the percentage of infested stems was also high in undamaged plants from the grazed area and only slightly lower in damaged plants from the ungrazed plot. The frequencies of infestation differed significantly (Chi-square =11.8,  $p < 0.01$ ,  $df = 3$ ).



**Figure 3.** Number of *Saltatoria* species per sample plot (1996 – 2004), mean and standard error.



**Figure 4.** Percentage of stems infested by insects on neighbouring grazed and ungrazed plots. Each sample consisted of 25 stems. Damaged: Stem or twigs of a stem broken or bitten off.

## Discussion

In general, higher species numbers of arthropods were found on grazed plots. Most likely the habitat mosaic created by the cattle was causing this result (11, 12, 23, 27). While some parts of the area are grazed intensively, other parts are hardly affected through grazing pressure. Some habitat types such as lawn-like, grass-dominated vegetation and bare ground exist only due to the presence of cattle, and are not present in the adjacent abandoned areas. High and low vegetation, bare ground and thick layers of organic material exist in the grazed areas in a low scale mosaic that remains quite stable over years (42). These predictable structural conditions favour species that depend on several habitat types, e.g. during different stages of their life cycle (26).



However, biodiversity increased by grazing must not necessarily result in higher numbers of endangered species. Considering the “red book species” on the paired plots (grazed – abandoned), we found 9 species of spiders, rove and ground beetles on abandoned and 6 on grazed sites. Perhaps, immigration of endangered species into newly created habitats (the grazed area was abandoned before) is less likely than immigration of common species: many rare species depend on rare habitats (33), and therefore populations from which immigrants can come are scarce, too. Especially highly endangered wetland species can have very special habitat requirements (31), which may not be fulfilled in early restoration projects. And some species may not tolerate grazing at all (14).

Generally grazing favours xerothermophilous species which do not find suitable conditions in dense abandoned stands (34). However, trampling compressed the soil, especially at the woodland sample plots, which reduced drainage loss, thus favouring wet spots, which was reflected by the occurrence of hygrophilous carabids and spiders (*sensu* 20, 21). Wetland species, including some rare and endangered ones, were also typical for the sample plot in the reed, a habitat which could exist only because it was fenced and grazing pressure was excluded. This example demonstrates that low-density grazing does not enhance species richness in every case. Habitats, dominated by plant species such as reed that are preferably eaten by cattle, may even be destroyed, causing the loss of specific plant communities and the associated fauna (42).

In the case of the stem-infesting insects, damaged *Cirsium* individuals probably favour infestation by insects, and therefore the highest infestation rates are found on the grazed areas where plants are more often damaged. Additionally, the extent of damage of most *Cirsium*-plants is higher where the cattle moves. This may explain the difference in the infestation rate of damaged *Cirsium* on grazed and abandoned plots. However, even the undamaged stems are more frequently infested at the grazed plots. An explanation could be that these stems are not partly covered by the surrounding vegetation due to grazing which makes them more obvious as compared to ungrazed plots. In addition, the more open vegetation structure at grazed plots may offer a microclimate favouring insects.

The example of stem infesting insects illustrates, that grazing acts as a permanent disturbance in the studied ecosystem. Beneath the creation of new habitat types (e.g. bare ground, lawn, broken stems), disturbance generally decreases interspecific competition and may prevent the extinction of inferior competitors (24) which also favours species richness (7).

However, previous studies demonstrated that the intensity of disturbance is a key factor: Very intensively grazed areas show low biodiversity (4, 10, 13, 16, 22). Van Wingerden et al. (36, 37) proposed a model in which moderate grazing intensity favours habitat diversity and species richness. If the grazing pressure is too high, the habitat diversity decreases again which reduces also the species numbers.

This indicates that management methods that reduce habitat diversity in extensively used grazing areas such as sporadic mowing (which is often practiced by farmers to reduce weeds) or short term high grazing pressure (which exists if the cattle is fenced for short periods on small areas e.g. to avoid selective grazing in endangered plant communities (28) have a negative influence on arthropod diversity.

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**Appendix: Tab. 2. Araneae, Carabidae and Staphylinidae recorded on grazed, ungrazed plots and in the reed along the brook. Species listed in the Red Data book of Bavaria and/or Germany are underlined (Lorenz 2003; Trautner et al. 1998; Bussler & Hofmann 2003; Blick & Muster 2003).**

Spiders	ungrazed			reed	Ground beetles	ungrazed			reed	Rove beetles	ungrazed			reed
	ungrazed	grazed	reed			ungrazed	grazed	reed			ungrazed	grazed	reed	
<i>Achaearanea simulans</i>	x				<i>Abax parallelepipedus</i>	x	x	x		<i>Aleochara brevipennis</i>		x	x	
<i>Aculepeira ceropegia</i>		x			<i>Acupalpus flavicollis</i>		x	x		<i>Aleocharinae sp.</i>	x	x	x	
<i>Antistea elegans</i>			x		<i>Agonum afrum</i>		x	x		<i>Aloconota insecta</i>		x		
<i>Araeoncus humilis</i>	x	x			<i>Agonum fuliginosum</i>	x	x	x		<i>Anotylus mutator Lohse</i>	x			
<i>Araneus diadematus</i>	x	x			<u><i>Agonum micans</i></u>			x		<i>Anotylus rugosus</i>	x	x	x	
<i>Araneus marmoreus</i>		x			<i>Agonum muelleri</i>		x	x		<i>Anotylus sculpturatus</i>	x	x		
<i>Araneus quadratus</i>	x				<i>Agonum sexpunctatum</i>	x	x	x		<i>Anotylus tetracarinated</i>	x			
<i>Araniella cucurbitina</i>	x				<u><i>Agonum thoreyi</i></u>			x		<i>Arpedium quadrum</i>	x	x	x	
<i>Araniella sp.</i>		x	x		<i>Agonum viduum</i>		x	x		<i>Atheta ravilla cf.</i>		x		
<i>Arctosa leopardus</i>	x	x	x		<i>Amara aulica</i>	x	x			<i>Bledius erraticus</i>	x			
<i>Argiope bruennichi</i>		x			<i>Amara communis</i>	x				<i>Bledius opacus</i>		x		
<i>Bathyphantes approximatus</i>		x			<i>Amara plebeja</i>			x		<i>Carpelimus arcuatus</i>			x	
<i>Bathyphantes gracilis</i>		x	x		<i>Anisodactylus binotatus</i>	x	x			<i>Carpelimus corticinus</i>		x	x	
<i>Batyphantes nigrinus</i>		x			<i>Asaphidion cf. austriacum</i>			x		<i>Carpelimus rivularis</i>			x	
<i>Centromerita bicolor</i>		x			<i>Badister lacertosus</i>	x	x			<i>Chilopora longitarsis</i>		x		
<i>Centromerus sylvaticus</i>	x	x	x		<i>Badister sodalis</i>	x	x	x		<i>Chilopora rubicunda</i>			x	
<i>Cercidia prominens</i>		x			<i>Bembidion articulatum</i>	x	x	x		<i>Deubelia picina</i>			x	
<i>Clubiona lutescens</i>	x	x			<i>Bembidion biguttatum</i>			x		<i>Dexiogyga corticina</i>	x			
<i>Clubiona phragmitis</i>			x		<i>Bembidion lampros</i>			x		<i>Drusilla canaliculata</i>	x	x	x	
<u><i>Clubiona stagnatilis</i></u>	x		x		<i>Bembidion properans</i>		x			<i>Falagria sulcatula</i>			x	
<i>Coelotes terrestris</i>	x	x			<i>Bembidion tetracolum</i>		x	x		<i>Falagria thoracica</i>	x	x	x	
<i>Diaea dorsata</i>		x			<i>Blemus discus</i>			x		<i>Falagris sulcatula</i>		x		
<i>Dicymbium cf. brevisetosum</i>		x			<u><i>Carabus cancellatus</i></u>	x	x			<i>Gabrieus pennatus</i>		x	x	
<i>Dicymbium tibiale</i>	x	x			<i>Carabus coriaceus</i>	x		x		<i>Gabrieus subnigritulus</i>		x		
<i>Diplocephalus cristatus</i>	x	x			<i>Carabus granulatus</i>	x	x	x		<i>Gabrieus trossulus</i>	x	x	x	
<i>Diplocephalus latifrons</i>	x	x			<i>Carabus hortensis</i>	x	x			<i>Geostiba circellaris</i>		x		
<i>Diplostyla concolor</i>	x	x	x		<u><i>Carabus irregularis</i></u>	x				<i>Gyrophypnus scoticus</i>	x	x		
<i>Dismodicus bifrons</i>		x	x		<i>Carabus nemoralis</i>	x				<i>Hygropora cunctans cf.</i>	x		x	
<u><i>Donacochara speciosa</i></u>			x		<u><i>Chlaenius nigricornis</i></u>	x	x	x		<i>Hypostenus cicindeloides</i>		x		
<i>Drapetisca socialis</i>		x			<i>Chlaenius vestitus</i>			x		<i>Ilyobates propinquus</i>	x	x		

<i>Drassyllus pusillus</i>	x	x		<i>Clivina collaris</i>	x		x	<i>Ilyobates subopacus</i>			x	
<i>Enoplognatha ovata</i>	x	x		<i>Clivina fossor</i>	x	x	x	<i>Lathrimaem atrocephalum</i>	x		x	
<i>Erigone atra</i>		x	x	<i>Cychnus caraboides</i>			x	<i>Lathrobium castaneipenne</i>	x	x	x	
<i>Erigone dentipalpis</i>	x	x		<i>Dromius quadrimaculatus</i>	x			<i>Lathrobium dilutum</i>				x
<i>Evarcha arcuata</i>		x		<i>Dyschirius globosus</i>	x	x	x	<i>Lathrobium fovulum</i>	x			x
<i>Evarcha sp.</i>	x	x		<i>Elaphrus cupreus</i>	x	x	x	<i>Lathrobium impressum</i>	x			
<i>Gnathonarium dentatum</i>			x	<i>Epaphius secalis</i>	x		x	<i>Lathrobium laevipenne</i>				x
<i>Helophora insignis</i>	x			<i>Leistus ferrugineus</i>			x	<i>Lathrobium pallidum</i>				x
<i>Larinioides sp.</i>	x	x	x	<i>Loricera pilicornis</i>	x	x	x	<i>Lathrobium terminatum</i>				x
<i>Lepthyphantes cristatus</i>	x	x		<i>Nebria brevicollis</i>	x	x	x	<i>Lathrobium volgense</i>	x		x	
<i>Lepthyphantes pallidus</i>	x	x		<i>Notiophilus palustris</i>	x	x	x	<i>Lesteva longelytrata</i>				x
<i>Lepthyphantes tenuis</i>	x			<i>Oodes helopiodes</i>	x	x	x	<i>Lesteva punctata</i>				x
<i>Leptorhoptrum robustum</i>		x		<i>Paranchus albipes</i>			x	<i>Liogluta microptera</i>	x	x	x	
<i>Leptyphantes sp.</i>	x	x		<i>Patrobus atrorufus</i>			x	<i>Liogluta pagana</i>	x		x	
<i>Linyphia hortensis</i>	x	x		<i>Platynus assimilis</i>	x	x	x	<i>Neobisnius procerulus</i>				x
<i>Linyphia triangularis</i>	x	x		<i>Platynus dorsalis</i>			x	<i>Neobisnius villosulus</i>				x
<i>Mangora acalypha</i>	x	x		<i>Poecilus cupreus</i>			x	<i>Nestus boops</i>				x
<i>Metellina cf. merianae</i>	x			<i>Poecilus versicolor</i>			x	<i>Nestus canaliculatus</i>				x
<i>Metellina menzei</i>	x	x		<i>Pterostichus anthracinus</i>	x	x	x	<i>Nestus humilis</i>				x
<i>Metellina segmentata</i>	x	x	x	<i>Pterostichus melanarius</i>	x	x		<i>Ocypus fuscatus</i>				x
<i>Micrargus herbigradus</i>	x			<i>Pterostichus minor</i>			x	<i>Ocypus melanarius</i>	x		x	
<i>Misumenops tricuspidatus</i>	x	x		<i>Pterostichus niger</i>	x	x	x	<i>Olophrum fuscum</i>				x
<i>Neriere clathrata</i>	x	x		<i>Pterostichus nigrita</i>			x	<i>Omalius rivulare</i>				x
<i>Neriere montana</i>	x			<i>Pterostichus nigrita/rhaeticus</i>	x		x	<i>Omalius rugatum</i>	x			
<i>Neriere peltata</i>	x			<i>Pterostichus oblongopunctatus</i>	x	x		<i>Ontholestes haroldi</i>				x
<i>Oedothorax agrestis</i>		x		<i>Pterostichus rhaeticus</i>			x	<i>Othius myrmecophilus</i>				x
<i>Oedothorax fuscus</i>	x	x	x	<i>Pterostichus strenuus</i>	x	x	x	<i>Othius punctulatus</i>				x
<i>Ozyptila praticola</i>		x		<i>Pterostichus vernalis</i>			x	<i>Oxytela lividipennis</i>	x		x	
<i>Ozyptila trux</i>	x			<i>Stomis pumicatus</i>	x			<i>Oxytelops tetracarinaris</i>				x
<i>Pachygnatha clercki</i>	x	x	x	<i>Synuchus nivalis</i>	x			<i>Paederus schönherri</i>	x			
<i>Pachygnatha listeri</i>	x	x		<i>Trechus cf. secalis</i>	x	x		<i>Philonthus addendus</i>	x			
<i>Paidiscura pallens</i>	x			<i>Trechus obtusus</i>	x	x	x	<i>Philonthus atratus</i>				x
<i>Pardosa amentata</i>	x	x	x	<i>Trechus pilisensis</i>	x			<i>Philonthus carbonarius</i>				x
<i>Pardosa lugubris</i>	x	x	x	<i>Trechus quadristriatus</i>			x	<i>Philonthus cognatus</i>				x
<i>Pardosa palustris</i>		x						<i>Philonthus debilis</i>				x
<i>Pardosa prativaga</i>	x	x	x					<i>Philonthus decorus</i>	x	x	x	
<i>Pardosa pullata</i>	x	x						<i>Philonthus fimetarius.</i>	x			
<i>Pardosa riparia</i>		x						<i>Philonthus fumarius)</i>	x	x	x	
<i>Pelecopsis parallela</i>		x						<i>Philonthus laminatus</i>	x	x	x	
<i>Philodromus sp.</i>	x							<i>Philonthus mannerheimi</i>	x	x		
<i>Pirata hygrophilus</i>	x	x	x					<i>Philonthus rubripennis</i>				x
<i>Pirata latitans</i>		x	x					<i>Philonthus splendens</i>				x
<i>Pirata piraticus</i>		x	x					<i>Philonthus tenuicornis</i>	x		x	
<i>Pisaura mirabilis</i>	x	x						<i>Pseudocypus fuscatus</i>				x
<i>Porrhomma convexum</i>		x						<i>Quedius curtipennis</i>	x	x	x	
<i>Robertus lividus</i>	x	x						<i>Quedius fuliginosus</i>	x	x	x	
<i>Robertus neglectus</i>		x						<i>Quedius maurorufus</i>				x
<i>Singa hamata</i>		x	x					<i>Quedius molochinus</i>				x
<i>Tetragnatha extensa</i>	x	x	x					<i>Raphirus maurorufus</i>	x			x
<i>Tetragnatha montana</i>	x	x						<i>Rugilus erichsoni</i>				x
<i>Tetragnatha pinicola</i>	x	x						<i>Rugilus rufipes</i>	x		x	
<i>Theridion impressum</i>								<i>Scopaeus laevigatus</i>				x
<i>Theridion varians</i>	x							<i>Sepedophilus marshami</i>	x			
<i>Trematocephalus cristatus</i>		x						<i>Staphylinus erythropterus</i>				x
<i>Trochosa ruricola</i>	x	x	x					<i>Stenus biguttatus</i>				x

<i>Trochosa spinipalpis</i>			x				<i>Stenus bimaculatus</i>	x	x	x
<i>Trochosa terricola</i>	x	x					<i>Stenus boops Ljungh</i>		x	x
<i>Walckenaeria acuminata</i>		x					<i>Stenus canaliculatus</i>		x	x
<i>Xerolycosa miniata</i>		x					<i>Stenus circularis</i>		x	
<i>Xysticus bifasciatus</i>							<i>Stenus humilis</i>	x	x	x
<i>Xysticus cf. cristatus</i>	x	x					<i>Stenus juno</i>		x	
<i>Xysticus kochi</i>		x					<i>Stenus providus</i>		x	
<i>Xysticus sp.</i>	x	x	x				<i>Styloxis rugosus</i>	x	x	x
<i>Xysticus ulmi</i>	x	x					<i>Tachinus corticinus</i>	x	x	
<i>Zelotes latreillei</i>		x					<i>Tachinus laticollis</i>	x	x	
<i>Zora spinimana</i>		x					<i>Tachinus signatus</i>	x	x	x
							<i>Tachyporus abdominalis</i>			x
							<i>Tachyporus chrysomelinus</i>	x	x	
							<i>Tachyporus formosus</i>	x	x	
							<i>Tachyporus nitidulus</i>		x	
							<i>Tachyporus obtusus</i>		x	
							<i>Tachyusa constricta</i>			x
							<i>Tetartopeus fennicum</i>			x
							<i>Tetartopeus terminatum</i>			x
							<i>Trogopogon rivularis</i>			x
							<i>Trogophloeus arcuatus</i>			x
							<i>Trogophloeus corticinus</i>			x
							<i>Trogophloeus dilatatus</i>			x
							<i>Trogophloeus rivularis</i>		x	
							<i>Xantholinus laevigatus</i>	x	x	
							<i>Xantholinus longiventris</i>	x	x	