Diversity, distribution and abundance of honeybees (*Apis mellifera*) and wild bees (Apidae) on a willow short-rotation coppice

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Abstract: Diversität, Verteilung und Abundanz von Honigbienen (*Apis mellifera* Linnaeus 1758) und Wildbienen (Apidae) auf einer Weiden-Kurzumtriebsplantage

Angesichts der zunehmenden Verbreitung von Kurzumtriebsplantagen (KUP) wurden auf einer mit Weiden (*Salix spec.*) bestockten KUP bei Jamikow in der Uckermark die Honigbienen (*Apis mellifera*) und Wildbienen (Hymenoptera: Apidae) untersucht. Diese wurden von April bis Juni 2010 auf der KUP kartiert. Dazu wurden durch fünf unterschiedliche Bereiche der KUP (die Weidenreihen sowie die sie begleitenden Strukturen Ackerbrache, Binnensaum, Feldsaum und Feldweg) Transekte gelegt.
Insgesamt konnten auf der KUP 29 Bienenarten nachgewiesen werden, wovon drei Arten oligolektisch auf Weiden sind. Bei allen erfassten Wildbienen handelte es sich um nicht als gefährdet eingestufte Arten.
Das Auftreten der Bienen war sehr stark von dem jeweiligen Blühaspekt abhängig. Anfang April wurden sehr hohe Individuendichten der Bienen an den Weidenblüten (*Salix spec.*), insbesondere den männlichen, und nur sehr wenige auf den anderen Bereichen festgestellt. Ende April und im Mai kehrte sich dieses Verhältnis um. Die Artenzahlen deuten darauf hin, dass die Begleitstrukturen der KUP eine große Bedeutung für die Biodiversität von Wildbienen auf der KUP haben, die größte Artenvielfalt der Bienen konnte mit 15 Arten auf der Ackerbrache festgestellt werden.
Durch eine stichprobenhafte Strukturkartierung der Umgebung der KUP wurde festgestellt, dass diese einige für Bienen günstige Habitatstrukturen wie Blühstreifen, Hecken und Trockenrasenflächen aufweist. Eine Zuwanderung von diesen Flächen könnte die Biodiversität auf der KUP erhöht haben.
Die Ergebnisse deuten darauf hin, dass KUP sowohl Nist- als auch Nahrungshabitat für Wildbienen darstellen können und somit zur Biodiversität ausgeräumter Agrarlandschaften beitragen. Sie können jedoch auf keinen Fall naturschutzfachlich wertvolle Habitate wie Brachen und Trockenrasen ersetzen.

Keywords: Energiepflanzen, energy crop, Biodiversität, biodiversity, Kurzumtriebsplantage, short-rotation coppices, Bienen, bees, Apidae, Salix

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Introduction

The importance of short-rotation coppices (SRC) as a renewable energy resource is continuously increasing, but the impact of this on the biodiversity of animals has so far only been studied for some species groups. Particularly for invertebrates, there is a lack of data (Schulz & al. 2009). It is often claimed as an

advantage of short-rotation coppices in agro-ecosystems that willows provide forage for flower-visiting insects and, in particular, bees (Hymenoptera: Apidae) (NABU 2008). However, the only field study of bees on SRC conducted by Reddersen (2001) had to be stopped because bee densities were very low, not only on the SRC but also in the surrounding area.

Bees are key species due to their pollination ecosystem services, which is important for wild plants and agricultural crops (Byrne & Fitzpatrick 2009). In recent decades a decline in bee species has been observed worldwide (Allen-Wardell & al. 1998). So that conclusions can be drawn about how the expansion of short-rotation coppices could influence pollinators, and particularly bee populations in agricultural landscapes, the diversity, distribution and abundance of honey bees (*Apis mellifera*) and wild bees (Apidae) were studied on a willow short-rotation coppice.

Study Area

The SRC under investigation is situated in Brandenburg in North Eastern Germany, approximately 20 km north of Angermünde in the Uckermark region. The total area of the SRC is 8 ha, but the bees were only studied in the south-western part and on suitable habitat structures of the surrounding area. The study area was divided into five different plots: the young stocks of willow hybrids (*Salix spec.*) which are planted in 37 rows and four accompanying areas: an agricultural fallow, a field boundary, a boundary between the willows, and a path.

Methods

The field study was conducted from 1 April to 24 June 2010. Transects were established on the plots of the study area and the bees were recorded along these on nine days during the study period in sunny and windstill conditions. The place of first sighting was recorded on a map for each individual bee at the transect line, as well as the species and the activity wherever possible, e.g. foraging on a flower or flying. During the willows' flowering time, transects were used between all of the 37 rows, so that differences could be recorded between the cultivars and genders of the willows. When the willows had flowered, only three transects were maintained in the willow plot. The flowering plant species were also recorded, so that interactions between flowers and foragers could be recorded.

Additionally, the surrounding area was investigated for suitable habitat structures. Aerial images were initially used to get an overview, and interesting sites were then investigated on foot within a radius of 2 – 3 km of the SRC.

Results

Overall, 29 bee species were found on the SRC (Tab. 1), including the honey bee (*Apis mellifera*). Most species were recorded on the agricultural fallow (15). If all of the willow transects are considered together they have the second highest species richness with 13 species. If the transects are considered separately, they have a much lower species richness (4, 5 and 6) than all the other transects.

Three of the species (*Andrena clarkella, Andrena vaga* and *Colletes cunicularius*) were oligolectic and specialised on willows (*Salix spec.*). Eight of the bee species were cuckoo bees, which are breeding parasites of other bee species. For each parasite the host bee species named by Westrich (1989) was also found.

None of the species was categorised as "endangered" in either the Red List of Germany (Westrich & al. 2008) or the Red List of Brandenburg (Dathe & Saure 2000), and most of the species were very common. The flowers most frequented by bees during the study were willows (*Salix spec.*) in April and dandelions (*Taraxacum officinale*) in May. There was a strong correlation between the flowering time of those two species and the bee density on the SRC. The highest number of individuals – 39 foraging bees and 53 bees in total, including flying bees – was recorded on 9 April, during the flowering time of *Salix spec.*, on Willow Transect 3 (males). No foraging bee was recorded in the accompanying structures on this day. Male willows were much more frequently visited by bees than female willows.

At the end of April the bee density declined on the willows that had already flowered, and then peaked again in mid-May, when 30 foraging bee individuals were recorded on the agricultural fallow, coinciding with the flowering time of *Taraxacum officinale*. No foraging bees were recorded on the willow transects on this day.

Other flowering plant species in the accompanying structures on which foraging bees could be observed included *Lamium purpureum* and *Arabidopsis thaliana* in April, *Sisymbrium altissimum* in May, and *Cynoglossum officinale, Rosa spec., Hypochaeris radica* and *Sisymbrium altissimum* in June.
The investigation of the surrounding area showed that the area is mainly characterised by intensive agricultural land use, but some habitats such as field boundaries rich in flowering plants and unimproved grassland were discovered as well.

Tab. 1: Bee species on the SRC, **Key**:
Red List Categories: * – Least Concern, NT – Near Threatened, V – Vulnerable, EN – Endangered, CE – Critically Endangered, E – Extinct, DD – Data Deficient
Abundancy Categories according to Red List Germany: vc – very common, c – common, mc – moderately common, r – rare , vr – very rare

Species	**Red List Germany** (Westrich & al. 2008)		**Red List Brandenburg** (Dathe & Saure 2000)	**Oligolectic** (Westrich 1989)
	Category	**Abundancy**		
Andrena cineraria	*	c	*	-
Andrena clarkella	*	mc	*	Salix
Andrena flavipes	*	c	*	-
Andrena fulva	*	c	*	-
Andrena gravida	*	vc	*	-
Andrena haemorrhoa	*	vc	*	-
Andrena minutula	*	vc	*	-
Andrena nigroaenea	*	mc	*	-
Andrena nitida	*	vc	*	-
Andrena vaga	*	mc	*	Salix
Andrena varians	*	mc	DD	-
Anthophora plumipes	*	vc	*	-
Apis mellifera	*	vc	*	-
Bombus lapidarius	*	vc	*	-
Bombus pascuorum	*	vc	*	-
Bombus rupestris	*	c	*	-
Bombus sylvarum	NT	mc	*	-
Bombus terrestris	*	vc	*	-
Bombus vestalis	*	mc	*	-
Colletes cunnicularius	*	mc	*	Salix
Lasioglossum calceatum	*	vc	*	-
Lasioglossum spec.				-
Lasioglossum xanthopus	*	c	NT	-
Nomada bifida	*	c	*	-
Nomada fucata	*	c	*	-
Nomada goodeniana	*	vc	*	-
Nomada lathburiana	*	c	*	-
Sphecodes albilabris	*	mc	*	-
Sphecodes monilicornis	*	vc	*	-

Discussion

Regarding the question of the impact of SRC on bees, the results suggest that SRC can provide nesting and foraging habitats for some common wild and domestic bees. Particularly bees appearing early in the year, such as bumble bees and oligolectic species specialised on *Salix* benefit from the willows. It was proven by Westphal & al. (2003) that mass flowering crops such as oilseed rape (*Brassica napus*) can have a significant influence on bumble bee densities by providing highly rewarding forage resources. It can be assumed that willow short-rotation coppices have a similar effect. But Westphal & al. (2003) also highlight the problem that forage is provided only for a short period of time. This is why most species depend on the accompanying structures, where the highest species richness was discovered. It must be considered that the study took place between the start of the growing season and the end of June, and species appearing in late summer or autumn were not considered. It is assumed that these would increase the deviation between the species richness of willows and accompanying structures. The importance of these structures is confirmed by the fact that most of the cuckoo bee species (6, n=8) were discovered there, indicating that they are the nesting habitats.

It is interesting to compare the results with another study of bees conducted by Saure & Berger (2006) in the same area. They discovered 161 wild bee species in the Uckermark region. Compared with the highest number of species of a diversely structured fallow, where 109 bee species were discovered on one 3 ha plot, the number of wild bee species on the SRC (28) seems low, but the agricultural fields in this study had only 0-4 species.

This shows that SRC can add to the biodiversity of bees in agricultural landscapes, but cannot replace semi-natural habitats. The landscape context is also important, as shown in the study conducted by Reddersen (2001), in which virtually no bees were found on the SRC, because of low densities in the landscape in general. The high bee diversity in the Uckermark region (Saure & Berger 2006) and the field boundaries rich in flowering plants, small fallows within the fields and a nature reserve with unimproved grassland may have added to the biodiversity of bees on the SRC, because these provide nesting sites and forage throughout the vegetation period. Nevertheless, a high proportion of agricultural fields in the surrounding area can also lead to higher bumble-bee densities on forage patches due to the lack of other habitats (Heard & al., 2007).

Recommendations

Some recommendations for planting SRC to improve habitat conditions for flower-visiting insects can be made based on the results. Schulz & al. (2009) have already made many recommendations for SRC with regard to other animal groups. The importance of the accompanying structures and the recommendation that semi-natural habitats should not be replaced by SRC also apply to bees.

Further recommendations for bees are, firstly, that willows should be favoured over poplars (*Populus spec.*). As poplars are pollinated by wind they are much less important for bees than willows. Furthermore, male willows should be favoured over females as the transect with male willows had a much higher abundance of bees than those with females. The pollen is the main resource for the larvae and therefore the male willows are more important for bees.

A variety of cultivars could also promote bee species, because their time of anthesis varies slightly. Forage will be provided for a longer period if there are different cultivars on one site.

Acknowledgements

We would like to thank Prof. Dr. H.H. Dathe (Senckenberg Deutsches Entomologisches Institut) for his kind help with identifying the bee species and for providing explanations and making useful comments.

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