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The effect of field size on the number of bumble bees

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Abstract. Bumble bees are important pollinators in agricultural and natural ecosystems. In recent decades their numbers have been declining due to the intensification of agriculture and establishment of large homogenous fields. Our goal was to study the effect of the field size on the abundance of bumble bees in Estonia. The data was collected from 66 farms located in different regions of the country. Bumble bees were counted along the field transect of each farm. The relationship between field size and number of bumble bees present was calculated. We found a negative correlation between the field size and the abundance of bumble bees: as the field area increased the number of bees decreased.

Key words: bumble bees, abundance, field size, landscape homogeneity, conservation

INTRODUCTION

Bumble bees are valuable pollinators both in agricultural and natural ecosystems (Corbet et al., 1991; Goulson, 2003). The reduction of pollination would not only decrease the quantity and quality of agricultural crops but also influence the survival of native plant species (Williams, 1996).

In the last decades there have been serious declines in the number of bumble bees in Europe and North America (Goulson et al., 2008; Grixti et al., 2009). Several possible factors have been suggested as contributors, however the main factor is most likely the intensification of agriculture and changes in land-use (Corbet et al., 1991; Goulson et al., 2005). In many European countries the number of small, traditional farms has been decreasing, being replaced by larger and more specialized farms (EUROSTAT, http://www.europa.eu/). This has led to a more homogeneous landscape, characterized by large cereal fields and few non-cultivated habitats, such as ditches and hedgerows. Habitat degradations have been linked to the declines in many species in agricultural landscapes (Berg, 2002). The loss of different food resources and nesting habitats are also the main limiting factors in the diversity and colony numbers of bumble bees (Fussell & Corbet, 1991).

In contrast with the study areas in Central and Western Europe, the agricultural landscape in Estonia is very heterogeneous with rather small fields surrounded by semi-natural habitats (Mänd et al., 2002). This kind of landscape may not have a significant impact on the abundance of bees in terms of the field size. Therefore our goal was to study the effect of field size on the number of bumble bees in the context of the Estonian agricultural landscape.

MATERIALS AND METHODS

The monitoring of bumble bees was carried out from June to August 2007. The data was collected from 66 farms located in three areas (22 farms in each): Southern-Estonia (Võru County), Western-Estonia (Saare County) and Mid-Estonia (Tartu and Jõgeva County).

Bumble bees were counted along a 400 m transect, providing for 2 m coverage, one transect per farm. Transects were located at the edges of different sized cereal fields.

The time of the transect walk, air temperature, cloudiness and wind speed was recorded. The monitoring was carried out only in dry weather when the ambient temperature was above 16 ºC and wind speed did not exceed 6 ms^{-1}, which are the most favourable conditions for bumble bee activity.

Monitoring was carried out once a month, three times per transect in total. The counting of bumble bees took place from 10:00 to 17:00, with the intervals between counts on one transect at least 15–20 days, timing the monitoring of the fields in one region as synchronously as possible.

The data was analyzed using regression analysis (STATISTICA 8, StatSoft Inc. USA). The number of bumble bees was calculated as the sum of the three observations per 100 m of transect. Since the number of individual bees was not normally distributed, the data was log-transformed. The abundance of bumble bees was determined in relation to the average surface area of the crop field.

RESULTS AND DISCUSSION

The results of our study showed that the average surface area of the field is negatively correlated with the abundance of bumble bees: as the size of the field increases, the number of bumble bees decreases ($b = -0.49$, $R^2 = 0.23$, $df = 1.64$, $F = 19.9$, $P < 0.01$) (Fig. 1).

These results are similar to those of Belfrage and co-workers (2005), who found that smaller fields and higher crop diversity increased the number of bumble bees on the field. Also Schmitzberger et al. (2005) and Marini et al. (2009) have found a negative correlation between farm size and plant and insect diversity in agricultural landscapes.

The size of the field has an important role influencing the number of bumble bees present in the field, since many bumble bees have a limited foraging range, for some species only 450 m (Knight et al., 2005). This might partially explain why many bumble bee species with shorter flight distances have disappeared from intensively farmed open areas.

The abundance of bumble bees in agricultural landscape is largely dependent on the availability of food resources. It is important to grow different plant species (crops and wild flowers) so the bees will have food throughout the whole foraging season.

Bumblebees forage for the colony as well as for themselves, but only store a few days' worth of reserves, requiring therefore a continuous supply of food (nectar and pollen) throughout the whole period of colony activity (Prys-Jones & Corbet, 1991). Reduction of nectar and pollen availability within the foraging range of the nest is an important limiting factor of colony growth (Pelletier & McNeil, 2003). Therefore it is crucial to provide bumble bees with a sufficient number of food plants in the agricultural landscape.

Another possible reason for the lower bumble bee population in the larger fields is that large homogeneous fields offer very few nesting places. It has been found that diverse and heterogeneous landscapes provide bumble bees with better hibernating, nesting and foraging opportunities than intensively managed homogenous fields (Rundlöf et al., 2008).

Management practices to enhance bumble bee populations on the crop fields should involve maintaining undisturbed perennial vegetation along field boundaries (Fussell & Corbet, 1992). One possibility for achieving that is to create flower-rich field margins of different native wild flowering plants, which will not only guarantee a continuous food resource but also provide nesting, mating and hibernating places for bumble bees and other beneficial insects (Banaszak, 1992; Pywell et al., 2005).

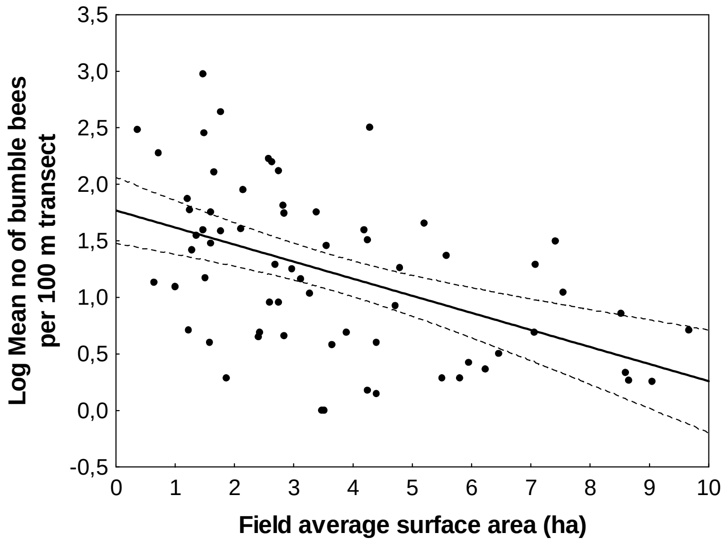

Figure 1. The number of bumble bees per 100 m transect depending on the field size monitored in Estonia in 2007.

CONCLUSIONS

Bumble bees constitute an important pollinator group whose numbers have been declining partly due to intensification of agriculture and the establishment of large homogenous fields. We found that the number of bumble bees decreased as the size of the field increased, suggesting that large homogenous fields deprive bees from food sources and nesting sites that are crucial for their existence. To avoid the further decline of bees in large fields, perennial flower-rich field margins should be established, to provide bumblebees with continuous food and sufficient nesting and hibernation sites.

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