Methods for creating bare ground on farmland in Hampshire, UK, and their effectiveness at recruiting ground-nesting solitary bees

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SUMMARY

Solitary bees have experienced a decline in both diversity and abundance over the past decade. Although their foraging requirements have been the subject of some recent studies, their nesting requirements have received little attention. Some species of ground-nesting solitary bees have shown an affinity for hard, bare ground as preferred locations for nests. Here we assessed two different methods for creating bare ground plots on farmland and observed the different rates at which these plots recruited ground-nesting bees. Three approximately 6 m^2 plots were created at each of 19 locations. One was scraped bare using machinery, a second was sprayed-off with herbicide, and the third was left undisturbed as a control plot. The results showed a significantly greater number of nests in the scraped plots compared to the sprayed or control plots, with the majority of these nests being created in April. This trial shows that an agri-environment scheme could be effective to support the creation of nesting areas for solitary bees on farmland.

BACKGROUND

Conservation efforts to halt the decline in pollinating insects have, more recently, turned to 'solitary' bees, sometimes described more accurately as the non-corbiculate wild bees. These efforts have focused primarily on identifying the floral communities required to support solitary bee diversity (Wood *et al*. 2017, Ouvrard *et al*. 2018, Warzecha *et al*. 2018, Nichols *et al*. 2019). Less effort has been made towards improving nesting resources for solitary bees, although man-made nesting structures for cavity nesting bees have been studied (MacIvor 2017, Gresty *et al*. 2018). In order to encompass greater solitary bee diversity, ground-nesting bees (which make up the majority of species) also need to be considered. Ground-nesting bees are important pollinators of a number of crop species including apples, pears and strawberries.

Previous studies have shown that ground-nesting solitary bees, such as furrow bee (Halictidae) and mining bee (*Andrena*) species, have an affinity for certain site characteristics. These include bare, firm, sometimes sloped ground, often of a certain soil vegetation composition and pH (Cane 1997, Potts & Willmer 1997, Wuellner 1999, Polidori *et al*. 2010, Carrié *et al*. 2018).

Conservation Evidence provides a summary of previous trials in which bare ground has been created and successfully recruited ground-nesting bees. These studies mostly describe making "scrapes" in the ground by removing vegetation (Wesserling & Tscharntke 1995, Gregory & Wright 2005), or creating areas of bare ground through raising soil within a designated plot (Wesserling & Tscharntke 1995, Fortel *et al*. 2016). However, only one study compared these scrapes against control plots (Wesserling & Tscharntke 1995), and none were conducted in agricultural settings.

Creating bare ground on farmland is not yet included in any agri-environment scheme (AES). In order to fully support ground-nesting solitary bees through AES, both their foraging resources and nesting sites need to be considered.

Our own surveys conducted on established nesting sites in 2018 (unpublished), combined with literature evidence of nesting sites, provided key aspects of 'preferred' site locations of a few ground-nesting bee species in the UK. The aim of this study was to determine whether these elements could be re-created as small plots on farmland, and whether they would be populated by ground-nesting bees. If successful, these plots could be introduced as an AES to provide more nesting locations for ground-nesting bees on farmland in the future, potentially increasing population sizes and reducing the risks of local extinctions or genetic bottle-necking.

ACTION

Treatments

The study was conducted on four farms across Hampshire in 2019 (grid references 51.27, -1.50; 51.26, -1.37; 51.04, -1.20; 51.15, -1.06). On each farm, 4-5 locations were identified for potential ground-nesting bee sites, giving a total of 19 locations. These locations were chosen by finding compacted ground (e.g. vehicle routes in field margins), preferably with a slope and on the south-side of any hedgerow / treeline. At each location, three approximately 6 m^2 plots were marked out. The first plot was scraped using a digger or similar farmyard machinery to create a bare area of ground (Figure 1). The second plot was sprayed with industry standard herbicide (glyphosate). The third plot was left as a control. All plots were made during March 2019 at a time convenient for the farmer and during appropriate weather to spray with herbicide. The plots were revisited in April to take exact measurements of the plot sizes, slope, and aspect.

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ISSN 1758-2067

Figure 1: Layout of treatments and control: scraped plot, herbicide sprayed plot, and control plot.

Surveys

All plots were surveyed once per month from April to July 2019. During each survey, photographs were taken of each plot, and distance to the nearest flowering crop (e.g. oilseed rape) was also measured. Percentage vegetation cover for each plot was recorded. Vegetation height was measured at three random points within each plot and the mean height recorded. Each plot was then watched for 5 minutes and activity by nesting bees was recorded. The plots were also inspected more closely, and the number of fresh / new nests counted (Figure 2). In cases of visibly active nests during the survey, returning bees were caught for identification. Differences in nest entrance-hole diameters were noted as these could potentially indicate presence of different species if activity was not observed.

Figure 2: Fresh nests found in a single scrape in April 2019.

Data analysis

All data were handled and analysed in R (R Core Team 2018). Vegetation height was log-transformed to normalise the data and a linear mixed effects model was built to test the effect of treatment on vegetation height, with vegetation height as the dependent variable, treatment and month as explanatory variables plus their interaction, and site location as a random variable. A likelihood ratio test was then performed. The effect of treatment on proportion of vegetation cover and number of nests found was tested using a treatment and month interaction in a Scheirer-Ray-Hare test; and the effect of treatment and slope aspect on the number of nests found was tested using a treatment and slope aspect interaction in a Scheirer-Ray-Hare test. All are reported as χ^2 results.

CONSEQUENCES

Plot characteristics

Treatments resulted in different plot characteristics throughout the survey period. There was a significant difference in vegetation cover between treatments ($\chi^2 = 107.54$, d.f. = 1, $p < 0.001$), and vegetation cover and month ($\chi^2 = 20.41$, d.f. = 1, $p < 0.001$). Scraped plots had much lower vegetation coverage overall, which remained lower throughout the season, only reaching approximately 50% coverage by July, whereas the sprayed and control plots had on average between 69% and 97% coverage across all months (Figure 3). In some cases, coverage of the sprayed plots comprised dead vegetation that had not yet decomposed. There was also a significant difference in vegetation height between treatments across the months (*LMM*: $\chi^2 = 289.67$, d.f. = 11, $p < 0.001$). The vegetation heights of both the scraped and sprayed plots remained at similarly low levels, lower than that of the control plots, but gradually increasing over the summer.

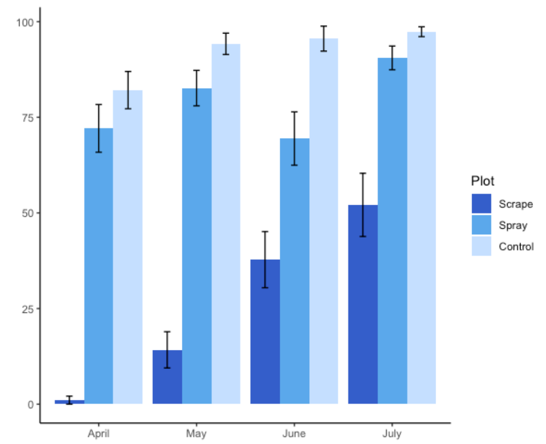

Figure 3: Mean percentage of vegetation cover for each treatment April – July 2019 (± SE).

Nests found

Across the 19 locations, 274 nests were counted between April and July 2019: 235 in scraped plots; 35 in sprayed plots; and four in control plots There was a significant difference in the number of nests

ISSN 1758-2067

found between treatments (χ^2 = 26.74, d.f. = 1, p < 0.001), and the number of nests found in each month (χ^2 = 27.52, d.f. = 1, p < 0.001). The greatest number of nests were found in the scraped plots, with the majority of nests found during the April survey (Figure 4).

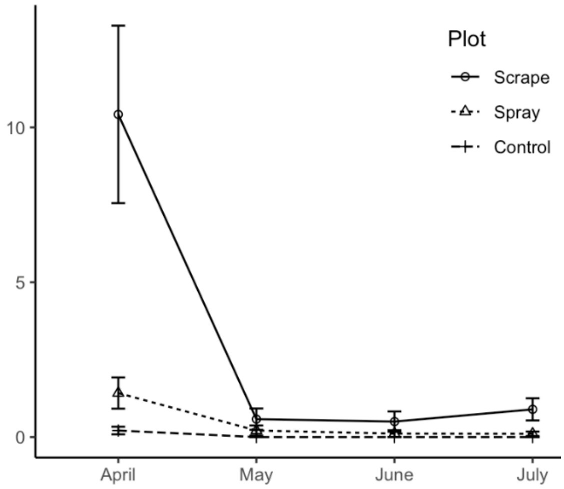

Figure 4. Mean number of nests found in different treatments across all locations for April – July 2019 (± SE).

After April, the number of new / fresh nests found in the scraped plots decreased to similar levels to those of the sprayed and control plots. Additionally, there was a significant relationship between number of nests found and the slope aspect (χ^2 = 11.42, d.f. = 1, p < 0.001), with more nests found in the south facing scrapes than slopes facing any other direction (Figure 5).

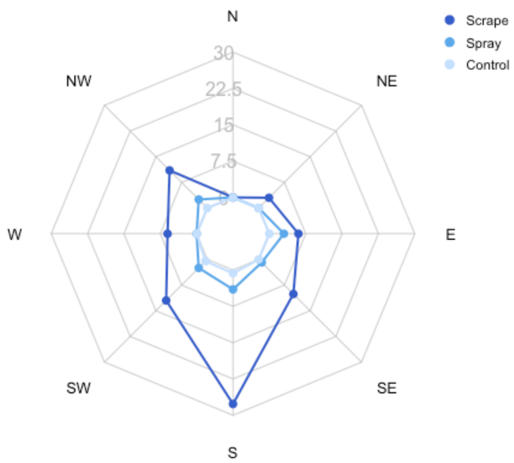

Figure 5: The average number of nests found on each aspect for each treatment, pooled across all 19 locations and each month. The greatest number of nests (n = 3) were found in the scrapes on a south facing aspect (X^2 = 11.42, d.f. = 1, p < 0.001). In total, the scrapes contained 83 nests, giving an average of 27.67 nests.

Where possible, individuals using nests were caught and identified (Table 1). Four species of solitary bee (three *Lasioglossum* and one *Andrena)* and one species of solitary wasp (a *Philanthus* sp.) were identified. There were a number of nests found that had no emerging / returning bees recorded during the 5-minute observations, but that were presumed to be a different species to those already seen due to nest size differences. These are listed as "Unknown". Cleptoparasitic bees, nomad *Nomada* spp. and blood bees *Sphecodes* spp. were also seen at seven out of the 19 nesting site locations throughout the summer. They were observed to hover over the areas of bare ground, and *Sphecodes* bees in particular were sometimes observed inspecting potential nest site entrances.

Table 1. Ground-nesting species found creating nests in plots, and their corresponding flight seasons in brackets.

Month	Treatment	Species
April	Scrape	*Andrena dorsata* (Mar-May & Jul-Sept)
		Lasioglossum malachurum (Mar-Oct)
	Spray	*Andrena dorsata* (Mar-May & Jul-Sept)
		L. malachurum (Mar-Oct)
		Unknown
	Control	*L. malachurum* (Mar-Oct).
May	Scrape	*L. leucopus* (May-Oct)
		Unknown
	Spray	Unknown
	Control	None
June	Scrape	*L. malachurum* (Mar-Oct)
		Unknown
	Spray	Unknown
	Control	None
July	Scrape	*L. fulvicorne* (Mar-Oct)
		Philanthus Triangulum (Jul-Sept)
		Unknown
	Spray	*L. fulvicorne* (Mar-Oct)
		Unknown
	Control	None

DISCUSSION

Our study indicates that constructing scraped plots was the most successful strategy for recruiting ground-nesting bees and wasps compared to the herbicide or control plots. We therefore recommend that scrapes are created using a digger or similar farmyard machinery in field margins or other compacted ground on a south-facing aspect to provide potential breeding areas for ground-nesting bees and wasps.

The scrapes were not difficult or time-consuming for farmers to create, did not take up a lot of space on the farm margins, and were situated in uncropped areas. This makes the addition of scrapes on farmland as an AES a highly viable option to increase potential ground-nesting site locations for

ISSN 1758-2067

solitary bees and wasps. With simple guidelines for optimum scrape locations, this AES could be integrated into any country's current scheme with ease.

The production of scrapes appeared to reduce the proportion of vegetation cover the most and for the longest compared to the sprayed and control plots. We suggest this had the greatest impact on recruitment, as although vegetation height was reduced in scrapes and sprays, the number of nests in scrapes was significantly greater than in the sprayed or control plots. Nest numbers began to decrease after April, which could be due to a number of unknown factors. However, we suggest it could be caused by the increased proportion of vegetation cover, or that many ground-nesting bees having earlier flight seasons. For example, *Andrena dorsata* was discovered in the plots during the spring flight season, but not during the late summer flight season, potentially indicating that the scrapes were no longer as attractive once vegetation returned. Further research is needed to determine whether fresh scrapes are more attractive, if revegetation deters nesting, or if differences in nesting phenology are responsible for the lower rates of colonisation later in the summer.

Ground nesting bees and wasps require both suitable nest sites and suitable food within reasonably close proximity. It is unknown whether their populations are generally limited by nest site availability or by other factors such as food availability. Much previous research has focussed on providing additional floral resources. Here we have shown that a simple and cheap intervention can boost nest site availability for some species and may be worth considering for inclusion in agri-environment schemes.

ACKNOWLEDGEMENTS

We would like to thank the four farmers/land managers for allowing us to choose nesting site locations on their farms, and for taking the time to create them with their own machinery and equipment. R.N.N was funded by a NERC CASE studentship (NE/P009972/1) with additional support from The Game and Wildlife Conservation Trust.

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ISSN 1758-2067