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Assessing the value of Rural Stewardship schemes for providing foraging resources and nesting habitat for bumblebee queens (Hymenoptera: Apidae)

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ABSTRACT

Bumblebees (*Bombus* spp.) play a key role within agricultural systems as pollinators of crops and wild flowers. However, this taxon has suffered severe declines as a result of agricultural intensification. Conservation efforts largely focus on providing forage resources for bumblebees through the summer, but providing suitable habitat during the period of nest foundation in early spring could be a more effective method of boosting local bumblebee populations. This study assesses the attractiveness of three different farmland habitat types (hedgerow, field margin and grassland), and the relative merits of respective land management prescriptions under the Scottish Rural Stewardship scheme to nest site searching and foraging bumblebee queens during the period of queen emergence and colony foundation. Hedgerows were the least attractive habitat type to spring queens. Rural Stewardship species-rich grassland comprised a complex vegetation structure attracting nest site searching queens, whilst grassland that had been abandoned allowing natural regeneration contained more flowers, attracting foraging queens. Field margin habitats were the most attractive habitat type, and Rural Stewardship field margins attracted both nest site searching and foraging queens at relatively high densities. This management option consisted of a sown grass mix, giving rise to the complex vegetation structure preferred by nest site searching queens, but regular disturbance allowed invasion by early flowering bumblebee forage plants. These findings suggest that it should be possible to develop simple combined management strategies to provide both suitable nesting sites and spring forage resources on farmland, promoting bumblebee colony foundation and therefore abundance in the agricultural environment.

1. Introduction

Agricultural intensification has caused the decline of many native plant and animal species in the UK and western Europe (Donald et al., 2001; Wilson et al., 1999). The drive towards self-sufficiency that followed the World Wars led to the destruction of vast areas of natural and semi-natural habitat to be replaced by large-scale and more intensively managed farmland. Such changes in countryside management have led to the loss of farmland biodiversity havens such as hedgerows and hay meadows, giving rise instead to a uniform rural landscape of large monocultures divided by simpler field boundary features (Stoate et al., 2001). In the UK, bumblebees (*Bombus* spp.) have suffered severe declines as a result of this agricultural intensification and it is widely accepted that these are directly related to declines in the wild flowers upon which they rely. It has been shown that many of the forage plants that bumblebees prefer have declined disproportionately (Carvell et al., 2006a), and that those species of bumblebee that have suffered the most severe declines tend to be those that display least plasticity in forage plant preferences (Goulson and Darvill, 2004; Goulson et al., 2005).

Bumblebees play a key role within agricultural systems, providing a pollination service that can increase yields of many flowering crops (Corbet et al., 1991). Many of the wildflower species associated with the rural environment also rely on bumblebee populations for survival (reviewed in Osborne and Williams, 1996). The provision of sufficient resources to support large, diverse bumblebee populations is therefore likely to provide both economic advantages and broader conservation benefits.

In recent years, an increasing awareness of the negative effects of intensive farming on native biodiversity has led to the implementation of a number of government-funded agri-environment schemes across Europe (Kleijn and Sutherland, 2003). One principle aim of these schemes is to restore and create areas of semi-natural habitat on farmland and thereby increase landscape heterogeneity. The management options presented in these

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schemes are often designed with target species in mind, and these commonly include game animals, beneficial invertebrates and rare arable plants. However, it is assumed that the improvement of farmland for these species will also provide benefits for a wider range of non-target flora and fauna. The value of these schemes across different taxa is widely debated, but many studies do indicate that certain schemes are of conservation value. For example, benefits of agri-environment prescriptions have been shown for many insects, birds, small mammals and wildflowers (e.g. Marshall et al., 2006; MacDonald et al., 2007). One of the most popular forms of conservation management has been arable field margin management, and suitably managed field margins are recognized as havens for biodiversity (Marshall and Moonen, 2002).

The effects of field margin management options on bumblebee communities have been the focus of many studies in recent years, particularly in England, and it has been found that those options involving the sowing of annual or perennial wildflowers or agricultural cultivars of legume species can have positive effects on the abundance and diversity of foraging bumblebees (Carreck and Williams, 2002; Meek et al., 2002; Carvell et al., 2004, 2006b, 2007; Pywell et al., 2005, 2006). It has also been suggested that it may be possible to develop a management strategy that will combine high quality forage with nest site provision for bumblebees (Carvell et al., 2004). However, the suitability of these schemes for providing nesting habitat has not been evaluated, and almost all studies of agri-environment schemes and bumblebees to date have focussed on populations of worker bees in the summer. Paradoxically, it is arguable that habitat quality in early spring may be the most important factor determining bumblebee abundance, for at this time of year queens first emerge after diapause and must find a suitable nest site and single-handedly rear the first cohort of workers (Goulson, 2003).

The availability of sufficient nest sites is vital, yet this requirement is often overlooked. Little is known about bumblebee nest site preferences as nests are inconspicuous although broad species-specific differences are understood. For example in the UK, species such as *Bombus terrestris* and *Bombus lucorum* tend to nest under the ground whilst species such as *Bombus pascuorum* prefer to nest on the ground surface. In both cases there appears to be a strong tendency towards the use of abandoned nests of other small animal species such as small mammals or birds (Rasmont et al., 2008). Nest-searching bumblebees have been found to be associated with linear features such as hedgerows and woodland edges, and also with tall, tussocky grassland (Fussell and Corbet, 1992; Kells and Goulson, 2003). However, these habitat types have declined as a result of agricultural intensification and it is possible that this has resulted in increased competition for nesting sites. It is notable that the bumblebee species that have shown the greatest declines in the UK tend to be those that emerge from hibernation later in the year and their declines may be at least partially accounted for by an increase in competition for nesting sites, with surface nesters such as *Bombus muscorum* competing with the earlier emerging *B. pascuorum* and subterranean nesters such as the late emerging *Bombus soroeensis* competing with earlier emerging *B. terrestris* and *B. lucorum*. Indeed, a recent study in the USA has shown that bumblebee abundance in urban parks is limited by nest site availability (McFrederick and LeBuhn, 2006).

The availability of forage in close proximity to the nest must also be crucial in spring. The bumblebee queen must incubate the brood clump, so it seems unlikely that queens are able to embark on lengthy foraging trips (Cresswell et al., 2000). A recent study in the UK has shown that bumblebee nests appear to be more common in gardens than they are in the countryside (Osborne et al., 2008) and this may reflect a paucity of suitable nesting habitat and/or a shortage of early forage to support nests in the rural environment. Encouraging bumblebees to nest on farmland by offering suitable nesting habitat in combination with plentiful spring forage may help to ensure efficient pollination of crops as well as many wildflowers associated with the farmland environment.

Although most studies of agri-environment scheme suitability for bumblebees have focussed on field margin management, other management options are also likely to influence bumblebee populations. For example, the sowing of tussocky grass strips adjacent to, or bisecting crop fields, restoration or creation of hedgerows and wooded areas and restoration or creation of species-rich grasslands are all likely to promote the sorts of vegetation structure generally associated with nesting bumblebees. However, to date there have been few attempts to quantify the value of these schemes for bumblebees.

We use a paired-farm comparison to quantify the relative value of three management options offered as part of the Scottish Rural Stewardship scheme 2004 for nest site searching and foraging spring bumblebee queens (similar or identical schemes are available in England and Wales). The aim of the study is to assess the potential of these schemes to promote nest foundation and thereby enhance bumblebee abundance in the agricultural environment.

2. Methods

2.1. Study sites

Ten predominantly arable low lying (0–200 m altitude) farms in East and Central Scotland were chosen for inclusion in this study. Five of these were participants of the Scottish Rural Stewardship scheme (referred to hereafter as RSS) and as such, had signed up to a management plan beginning in 2004. The management plan for each farm consisted of at least one each of the following management prescriptions (adapted from Anon 2006).

2.1.1. Management of grass margin or beetle bank in arable fields

This prescription involves sowing or maintaining a crop-adjacent strip of land between 1.5 and 6 m wide with a suitable mix of grass species, and is specifically targeted at fields containing an arable crop. The application of fertilisers is forbidden and grazing is not allowed until the crop has been harvested.

The aim of this prescription is to provide a refuge for beneficial insects as well as cover for birds. However, the prescription results in the establishment of large areas of tussocky, undisturbed grassland which may also be of benefit to nesting bumblebees.

2.1.2. Management or creation and management of species-rich grassland

The former stipulates restrictions on the mowing or grazing of existing areas of unimproved grassland between the months of March and August. The latter involves the removal of existing vegetation cover of an area followed by priming of the land (e.g. by reducing soil fertility and/or removing weed species) and the establishment of a new sward using a low productivity grass and herb mix.

The aim of these prescriptions is to promote the growth and spread of flowering plants and other grassland species. One of the goals was that these should be of conservation value to pollinator species including butterflies and bumblebees, providing a source of wildflowers on which they can feed. The tussocky structure of this grassland may also provide nesting sites for surface-nesting bumblebees as well as attracting small mammals which in turn may provide nest sites for subterranean-nesting species.

2.1.3. Management of hedgerows

This prescription involves managing hedgerows by filling in gaps and limiting cutting to once every 3 years at most and only