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Collateral effects of beekeeping: Impacts on pollen-nectar resources and wild bee communities

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Abstract

Due to the contribution of honey bees (*Apis mellifera*) to wild flower and crop pollination, beekeeping has traditionally been considered a sustainable practice. However, high honey bee densities may have an impact on local pollen and nectar availability, which in turn may negatively affect other pollinators. This is exacerbated by the ability of honey bees to recruit foragers to highly rewarding flower patches. We measured floral resource consumption in rosemary (*Rosmarinus officinalis*) and thyme (*Thymus vulgaris*) in 21 plots located at different distances from apiaries in the scrubland of Garraf Natural Park (Barcelona), and related these measures to visitation rates of honey bees, bumblebees (*Bombus terrestris*) and other pollinators. In the same plots, we measured flower density, and used pan traps to characterize the wild bee community. Flower resource consumption was largely explained by honey bee visitation and marginally by bumblebee visitation. After accounting for flower density, plots close to apiaries had lower wild bee biomass. This was due to a lower abundance of large bee species, those more likely to be affected by honey bee competition. We conclude that honey bees are the main contributors to pollen/nectar consumption of the two main flowering plants in the scrubland, and that at the densities currently occurring in the park (3.5 hives/km^2) the wild bee community is being affected. Our study supports the hypothesis that high honey bee densities may have an impact on other pollinators via competition for flower resources.

Zusammenfassung

Wegen des Beitrages der Honigbiene (*Apis mellifera*) bei der Bestäubung von Wildblumen und Nutzpflanzen wurde die Bienenhaltung traditionell als eine nachhaltige Aktivität angesehen. Indessen können hohe Honigbienendichten Auswirkungen auf die lokale Verfügbarkeit von Nektar und Pollen haben, was wiederum andere Bestäuber negativ beeinflussen könnte. Dies wird verstärkt durch die Fähigkeit der Honigbiene, Sammlerinnen zu lohnenden Sammelstellen zu dirigieren. Im Buschland des Garraf-Naturparks bei Barcelona maßen wir den Verbrauch von Blütenressourcen an Rosmarin (*Rosmarinus officinalis*) und Thymian (*Thymus vulgaris*) an 21 Standorten, die unterschiedlich weit von Bienenständen entfernt lagen, und setzten diese Werte in Bezug zu den Besuchsraten von Honigbienen, Hummeln (*Bombus terrestris*) und sonstigen Bestäubern. An den gleichen Standorten bestimmten wir die Blütendichte und setzten Farbschalen ein, um die Wildbienengemeinschaft zu erfassen. Die Nutzung der Blüt enressou wurde weitgehend durch die Besuchsraten der Honigbiene erklärt und in geringfügigem Maße durch Hummelbesuch. Nach Berücksichtigung der Blütendichte wiesen Standorte in der Nähe von Bienenständen eine geringere Wildbienen-Biomasse auf. Dies war auf eine geringere Abundanz der großen Wildbienenarten zurückzuführen, also der Arten, die wahrscheinlich durch die Konkurrenz der Honigbiene beeinträchtigt werden. Wir schließen, dass Honigbienen

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den größten Beitrag zum Pollen- bzw. Nektarverbrauch bei den beiden wichtigsten Blütenpflanzen des Gebietes leisten und dass die Wildbienengemeinschaft bei den gegenwärtigen Honigbienendichten im Park (3.5 Völker/km^2) beeinflusst wird. Unsere Untersuchung unterstützt die Hypothese, dass hohe Honigbienendichten durch Konkurrenz um Blütenressourcen einen Einfluss auf andere Bestäuber haben könnten.

Keywords: Bee conservation; Exploitative competition; Honey bees; Pollinator community; Resource consumption

Introduction

The introduction of large populations of highly competitive species into a new area may affect resident populations, ultimately resulting in changes in the structure of native communities (Ehrenfeld, 2010; Levine et al., 2003). This may occur when exotic species, introduced either accidentally or intentionally, turn invasive and compete for limited resources with local species occupying a similar niche (Byers, 2000; Petren & Case, 1996). In addition to exotic species, domesticated species may also affect resident species. A clear example is the presence of cattle or sheep in natural or semi-natural areas, potentially competing with large herbivores for pasture (Young, Palmer, & Gadd, 2005; Stewart, Bowyer, Kie, Cimon, & Johnson, 2002). Domesticated animals benefit from human assistance, including protection against predators and veterinary care, and therefore may have a competitive advantage over wild species.

Among domesticated animals, the European honey bee (*Apis mellifera*) is undoubtedly one of the globally most spread. Native to Eurasia and Africa, honey bees are now kept in all continents except Antarctica, initially for honey production (Crane, 1990), but mostly for crop pollination (Free, 1993), being, by far, the main managed pollinator worldwide (Garibaldi et al., 2013; Breeze et al., 2014; Aizen & Harder, 2009). Consequently, beekeeping has traditionally been considered a beneficial practice, and its sustainability has been taken for granted. This is reflected in the current lack of specific legislation in most countries worldwide, whereby beekeeping is considered to be beneficial and is usually allowed in nature reserves and other types of protected areas, including some National Parks. In many cases, beekeeping in these areas is not only allowed but even promoted as a traditional, sustainable activity (information obtained from natural park and wildlife managers from 8 European countries, see acknowledgements). It is therefore not surprising that *A. mellifera* is routinely reported as a dominant species in plant-pollinator networks worldwide, even in studies conducted in natural habitats (Valido, Rodriguez-Rodriguez, & Jordano 2014; Bosch, Martín González, Rodrigo, & Navarro 2009; Kaiser-Bunbury, Memmott, & Müller 2009; Forup, Henson, Craze, & Memmott 2008; see Davila & Wardle 2008 for a rare exception). However, as in other kinds of animal husbandry, large apiaries resulting in high densities of foragers may have an impact on local food resources (pollen and nectar in this case), which ultimtely may negatively affect other flower-visiting insects. Because they live in large colonies comprising tens of thousands of individuals and because they maintain elevated hive temperatures even during the winter (Seeley, 1985), honey bees have high energetic requirements, and their foraging ranges span several kilometres (Visscher & Seeley, 1982). In addition, honey bees have the ability (unique to them and some stingless bees) to communicate the location of flower resources to nest mates, thus concentrating large numbers of foragers in highly rewarding patches (Von Frisch, 1967). Thus, honey bees are highly efficient pollen-nectar foragers and, when present in large densities, may potentially create a competition scenario with other pollinators.

Competition may take place through interference or through resource exploitation (Tilman, 1982). Interference competition occurs directly between individuals through aggressive encounters (e.g., honey bees chasing other pollinators out of a flower or flower patch). Such aggressive interactions have sometimes been observed (e.g. Pinkus-Rendon, Parra-Tabla, & Meléndez-Ramírez 2005), but the fact that most studies do not report aggressive encounters indicates that they are not common (e.g. Hudewenz & Klein 2013; Roubik 1978). After several years of field work, we can assert that such interactions are very rare in our study area. Exploitative competition occurs indirectly between individuals through a limiting resource, such as food or nesting sites. Competition for nesting resources can be ruled out in this case because wild bees in temperate zones do not nest in the kind of large cavities used by honey bees, and because feral colonies are very rare in our study area, as in most of Europe (Jaffé et al., 2009). Competition for flower resources is much more likely to occur because honey bees are highly generalistic in pollen and nectar use, and their diet widely overlaps with that of other flower-visiting species.

Various studies have explored potential adverse effects of honey bees on local pollinator communities. However, demonstrating a competition scenario is extremely difficult owing to the large foraging ranges of honey bees (several km) (Goulson, 2003; Seeley, 1985), combined with their ability to communicate the location of rich flower patches, thus allowing colonies to adjust their foraging areas and flower choices as pollen-nectar standing crops vary through time and space (Visscher & Seeley, 1982). For this reason, most studies have so far focused on indirect evidences of competition between honey bees and wild bees, such as resource overlap (Steffan-Dewenter & Tscharntke, 2000), changes