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Invited review

Do managed bees drive parasite spread and emergence in wild bees?

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ABSTRACT

Bees have been managed and utilised for honey production for centuries and, more recently, pollination services. Since the mid 20th Century, the use and production of managed bees has intensified with hundreds of thousands of hives being moved across countries and around the globe on an annual basis. However, the introduction of unnaturally high densities of bees to areas could have adverse effects. Importation and deployment of managed honey bee and bumblebees may be responsible for parasite introductions or a change in the dynamics of native parasites that ultimately increases disease prevalence in wild bees. Here we review the domestication and deployment of managed bees and explain the evidence for the role of managed bees in causing adverse effects on the health of wild bees. Correlations with the use of managed bees and decreases in wild bee health from territories across the globe are discussed along with suggestions to mitigate further health reductions in wild bees.

Contents

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1. Introduction

Growing demand for food and agricultural intensification is resulting in a growing demand for pollination services and, ironically, growing pressures on wild bees. Currently both managed and wild pollinators are suffering alarming declines in many parts of the world (Potts et al., 2010). In the last century, many wild bee populations have become reduced and fragmented, and with reduced genetic diversity are now facing increased vulnerability to infectious diseases and other stressors such as pesticides and reduced resources (McCallum and Dobson, 2002; Tarpy, 2003; Whitehorn et al., 2011). Over 25% of wild bees in Belgium and 47% of native bumblebee species in Hungary have exhibited recent declines (Sárospataki et al., 2005). Similar declines in wild pollinators are found in Britain, Ireland, Spain, France, Morocco, Corsica, Tibet, Brazil and Madagascar (Fitzpatrick et al., 2007; Kosior et al., 2007; Martins and Melo, 2010; Rasmont et al., 2005; Williams, 1982; Xie et al., 2008). In the North American mid-west, half of the native bumblebee species have declined during the mid-twentieth century (Grixti et al., 2009), while bumblebees have also declined in diversity, evenness and abundance in eastern North America between 1971 and 2006 (Colla and Packer, 2008). Today 11% of all bumblebee species worldwide are listed as threatened in the IUCN Red list (Williams and Osborne, 2009).

Emergent infectious diseases (EIDs) are ranked as one of the top five causes of species extinction worldwide (Daszak et al., 2000). They are defined broadly as diseases that have recently increased in either incidence, demographic or host range, or that have recently evolved or been discovered (Daszak et al., 2001, 2000; Lederberg et al., 1992; Morse, 1993). Many instances of EIDs in wild animals are the result of interactions with domesticated/managed species (Fig. 1). One of the main conservation concerns regarding the use, and particularly the importation, of managed bees, is that of exotic parasite (or parasite strain) introduction and subsequent spillover to wild populations (Blitzer et al., 2012; Goulson et al., 2008). By allowing managed and/or imported bees to mix with wild pollinators, there is the potential for disease emergence via direct transmission and facilitated by changes in host susceptibility.

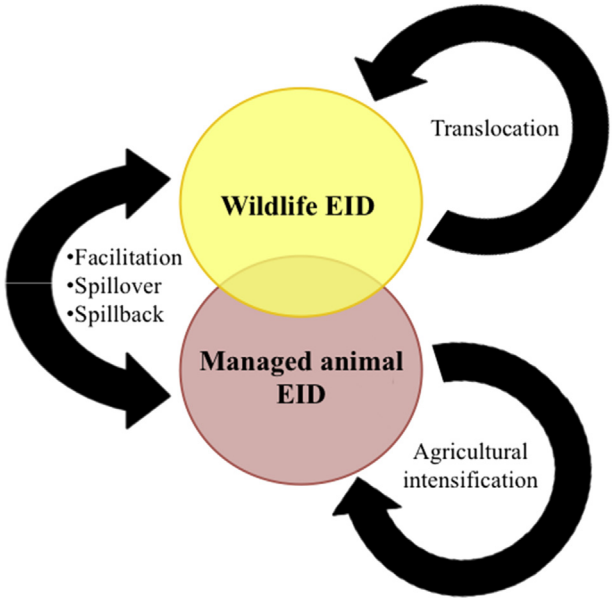

Fig. 1. The key factors that may drive disease emergence within and between populations of managed and wild bees. Adapted from Daszak et al. (2000).

2. Parasite facilitation

As with other animals, bee susceptibility and subsequent pathology is often increased when individuals are stressed (Freestone et al., 2008; Jokela et al., 2005; MacKinnon, 1998; Møller et al., 1998). Dense populations of managed bees can cause stress to wild populations and have been linked to developmental retardation in wild bees (Elbgami et al., 2014; Goulson and Sparrow, 2008; Thomson, 2004). It's also likely that, as in other organisms, such competitive and nutritional stresses can influence their susceptibility to infection (Brown et al., 2003; Graystock et al., 2014; Hedtke et al., 2011; MacKinnon, 1998). This stress would therefore facilitate an increase in prevalence or intensity of natural parasite infections in wild bees, independent of any transmission between the two groups of bees.

3. Parasite spillover

Parasite spillover occurs when the reservoir population (usually managed stock) transmit disease to the sink (in this case, wild) population (Daszak et al., 2000; Fig. 2). Emergence of the parasite in wild populations may be self-supporting or may require continued mixing with the source/reservoir population. When intra-specific and/or inter-specific transmission rates are low, infection of susceptible individuals may occur in many instances without the parasite establishing in the wild population (Hatcher and Dunn, 2011). Closely related, sympatric hosts have a greater potential to transmit pathogens between them, though the virulence of the parasite may differ (Graystock et al., 2013a; Perlman and Jaenike, 2003; Schmid-Hempel, 2011).

4. Parasite spillback

In parasite spillback, a natural parasite infection in the wild host population transmits to the managed host population, increases in prevalence within it, and then spills back into the wild population, resulting in an increase in prevalence in wild populations (Hatcher and Dunn, 2011; Kelly et al., 2009; Fig. 2). Here, the newly infected animals may achieve unnaturally high parasite prevalence due to their high density (for example, honey bee colonies in apiaries are much denser than in wild honey bee populations). This unnaturally high parasite prevalence then spills back, driving parasite levels in the wild population higher than would naturally occur (Hatcher and Dunn, 2011; Kelly et al., 2009). Another factor in spillback from managed populations is that well managed, healthy animals may be able to tolerate pathogenic effects better than wild hosts. Such tolerance may result in a population of asymptomatic, yet infectious, managed bees.

5. Is spillover/spillback between wild and managed bees common?

Over the past century there have been huge advancements in agricultural intensification, combined with a rapid global demand for food (Aizen and Harder, 2009; Aizen et al., 2009; Gallai et al., 2009; Velthuis, 2002). One of the advances farmers increasingly utilise is the purchase of pollination services via managed honey bees or managed bumblebee colonies (VanEngelsdorp and Meixner, 2010; Velthuis and Van Doorn, 2006). The practices and regulations in place for managed bee use are not uniform across the globe and there is growing concern that managed bees may pose a disease risk to other pollinators (Goulson and Hughes, 2015; Graystock et al., 2014; Meeus et al., 2011). Here we review the domestication of bumblebees and honey bees before looking at specific examples from across the world where parasite