Honey bees and beekeeping on protected areas

Under certain conditions, honey bees may transmit parasites and diseases to wild bees and compete for floral resources, thus posing a threat to other pollinators. Because of these risks, we need to consider a precautionary approach towards new beekeeping operations on National Nature Reserves or other protected areas with biological interests.

Background

The Western or European honey bee (*Apis mellifera*) is the most economically important managed pollinator in the world (Vanengelsdorp & Meixner, 2010: Kennedy *et al*., 2013; Kleijn *et al*., 2015; Potts *et al*., 2016), particularly for mass-flowering crops (Rader *et al*., 2009) and in countries subject to intensive agricultural practices, such as the UK. In Scotland, around 30 commercial bee farmers and 2,400 hobbyists keep honey bees, collectively employing local people, generating several million pounds in honey bee products each year and providing pollination services. Beekeeping plays an indispensable role in the survival of the European honey bee because there are few remaining colonies in the wild.

Honey bees have uncommon degrees of sociality and colony longevity when compared to most bee species (Michener, 2000; O'Toole & Raw, 2004). They are very effective in harvesting pollen and nectar, and are known to forage 5 km or more from their nests. An average honey bee colony (approximately 50,000 bees) collects up to 120 kg nectar and 55 kg pollen, although these figures depend greatly on location, time of year, floral abundance and climatic conditions (O'Neal & Waller, 1984; Seeley, 1995; Winston, 1987; Rortais *et al*., 2005 and references therein). Heinrich (1979) estimated that a large apiary collects the equivalent amount of nectar and pollen to support 102 bumble bee colonies, and Cane & Tepedino (2017) calculated that a 40-hive apiary collects the pollen equivalent of four million wild bees at high season (June–August); according to these figures, one hive gathers pollen sufficient to produce 100,000 progeny of an average solitary bee species.

Honey bees can be effective generalist pollinators in the natural environment (Aslan *et al.,* 2016 and references therein), increasing fruit production and seed set of many native plants (Cayuela *et al*., 2011). However, because they are so efficient at what they do, concerns have been raised about possible competition for nectar and pollen with other pollinators, particularly wild bees (bumble bees and solitary bees).

Risks of competition

No experiment has clearly demonstrated that honey bees have caused long-term reductions in populations of other pollinators because rigorous manipulative experiments of competition are difficult to design, particularly for highly mobile organisms such as bees (Butz-Huryn, 1997; Steffan-Dewenter & Tscharntke, 2000; Steffan-Dewenter & Kuhn, 2003; Forup & Memmott, 2005). Nonetheless, a number of studies have shown adverse impacts of honey bees on wild bees (Goulson, 2003; Mallinger *et al*., 2017, Wojcik *et al.,* 2018). In several cases where honey bee hives have been removed, wild bee abundances have increased, suggesting there has been competition (Pyke & Balzer, 1985; Thorp *et al*., 1994).

In some situations, wild bees switch to less abundant and less rewarding plant species when honey bees are present (Anderson & Anderson, 1989; Buchmann *et al*., 1996; Walther-Hellwig *et al*., 2006; Shavit *et al*., 2009; Hudewenz & Klein, 2013). Other studies have demonstrated that some wild bees were more scarce, foraged on different flower species, gained less weight, and produced fewer and smaller offspring when in the proximity of honey bees (Schaffer *et al*., 1983; Sugden & Pyke, 1991; Evertz, 1993; Thomson, 2004, 2006, 2016; Paini & Roberts, 2005; Goulson & Sparrow, 2009; Elbgami *et al*., 2014; Hudewenz & Klein, 2015; Torné-Noguera *et al*., 2016).

Managed honey bees may drift from mass-flowering crops such as oil-seed rape into semi-natural and natural habitats, increasing the interactions with the local fauna (González-Varo & Vilà, 2017, Magrach *et al*., 2017), and lowering the densities of wild bumble bees, solitary bees, hoverflies and other flies (Lindström *et al*., 2016). Reduction in the occurrence of local wild bees, and nectar and pollen harvesting may reach distances of 600–1.100 m around apiaries (Henry & Rodet, 2018). Because of their large numbers, honey bees have the potential to alter their environment (Geslin *et al*., 2017).

Competition between honey bees and other pollinators depend on whether resources are limiting, which would imply the habitat is close to its carrying capacity. If not, resources are simply shared with no disadvantage to the species involved. Therefore, competition is more likely to occur on small areas, homogeneous landscapes, on semi-natural habitats with scarce flower resources (Beard, 2015; Herbertsson *et al*., 2016), at the beginning or at the end of bees' foraging period, and during unusually cold or dry years. Availability of flowering plants and densities of *A. mellifera* hives are the main factors determining the intensity of competition (Aslan *et al.,* 2016). Considering that wild bees are capable of collecting up to 97–99% of all pollen available in a foraging area (Schlindwein *et al.,* 2005; Larsson & Franzen, 2007), competition for a limiting resource is a likely outcome of interactions with honey bees (Cane & Tepedino, 2017).

The competitive potential of honey bees is greatest where they are not native and have been introduced, leading to calls for legislation to ban or control beekeeping in national parks and other sensitive areas in Australia, Israel, New Zealand and the USA (Pyke, 1999; Shavit *et al*., 2009; Beard, 2015; Kleijn *et al.,* 2018). Islands are particularly vulnerable; native bees have become endangered in New Caledonia, New Zealand, Japan and Tasmania after honey bees were introduced (Kato & Kawakita, 2004 and references therein).

The impact of honey bees is not always negative, and in some environments these generalist pollinators may protect wildflower communities from the decline in wild pollinators (MacIvor *et al.*, 2017; Hung *et al.,* 2018). However, honey bees can only pollinate about 50% of flowering plants, so there is still a need to encourage recovery of wild pollinators and ensure that sufficient resources are available for both wild and managed pollinators (Hung *et al.,* 2018).

Risks of diseases

Pathogens have emerged as a significant threat to beekeeping in recent years; more than 18 viruses have been identified from honey bee eggs, larvae, pupae, adult workers, drones and queens. However, the main culprit in pathogen-related colony losses is the mite *Varroa destructor,* which does not affect non-*Apis* species. This parasite facilitates the spread of viral diseases and intensifies their virulence, causing dramatic declines in honey bee populations (Vanengelsdorp & Meixner, 2010; Manley *et al*., 2015).

Recent research has demonstrated that some honey bee diseases such as Deformed Wing Virus (DWV) and multiple RNA viruses can be found on bumble bees and other species of native bees, and likely transmitted by flower-sharing (Durrer & Schmid-Hempe, 1994; Genersch *et al*., 2006; Singh *et al*., 2010; Fürst *et al*., 2014; Li *et al*., 2014). The pathogenicity of most of these RNA viruses to bumble bees has not yet been evaluated, but bumble bees infected with DWV can develop malformed wings (Genersh *et al*., 2006) and have higher mortality (Fürst *et al*., 2014). In addition, bumble bees have recently been seen to harbour *Nosema ceranae*, an emergent and particularly virulent disease of honey bees (Paxton, 2010; Graystock *et al*., 2013; Fürst *et al*., 2014). Managed honey bees and bumble bees are likely to be linked to the dispersal of many diseases observed in wild bees, therefore it is reasonable to assume that the proximity of managed bees of any species may be detrimental to vulnerable or declining native bees (Fürst *et al*., 2014; Manley *et al*., 2015; McMahon *et al*., 2015; Graystock *et al*., 2016; Mallinger *et al*., 2017).

The purpose of the Scottish Honey Bee Health Strategy (2010) is to improve the health and sustainability of Scottish honey bee populations, hence reducing the need for importation of large numbers of honey bees and reducing the potential of disease transmission from infested honey bees to native pollinator populations. Whilst the risk of honey bee diseases to wild pollinator communities have yet to be fully established, encouraging and educating sustainable beekeeping in Scotland with good disease control may reduce the potential risk of pathogen spillover.

Conservation objectives

Addressing these threats are embedded in the Pollinator Strategy for Scotland, namely *identifying actions required to minimise the risk of managed bees to native pollinator species, and increasing awareness within key sectors and amongst the public of opportunities to help pollinators and their habitat*. The Scottish Biodiversity Strategy also includes measures to safeguard our wild pollinators: *reduce adverse pressures on ecosystems, habitats and species*, and *develop a wildlife management framework to address the key priorities for sustainable species management, conservation and conflict issues, including reintroductions and invasive non-native species*. Honey bees may be necessary for crop pollination, but beekeeping is an agricultural activity that may add pressure on wild bee species, and should not be considered wildlife conservation (Geldmann & González-Varo, 2018).

Policy and practice advice for SNH

Given these potential risks, SNH should take a precautionary approach and consider new requests for apiary sites on National Nature Reserves or other protected areas comprising biological interests by assessing possible consequences. Risks to be taken into consideration include:

- Nature of the environment (e.g., degree of isolation, extent and composition of floral components).
- History of beekeeping in the area (removing stock may be detrimental in areas of extended beekeeping activity).
- Presence of native plants requiring pollination.
- Status of wild pollinators: presence of vulnerable species or declining wild pollinator populations.
- Beekeeper details: number of colonies, heritage of the bees (Scottish/recently imported), health records (*Varroa* control, frame replacement).

It is further advised that any SNH officers consulted about beekeeping on protected areas should discuss such plans with the Policy & Advice Officer (terrestrial invertebrates) and the Biodiversity and Geodiversity Activity team.

References

Anderson, G.J. & M.K. Anderson. 1989. Assaying pollinator visitation to *Solanum* flowers. *Solanaceae newsletter* 3, 71.

Aslan, C.E. *et al*. 2016. The role of honey bees as pollinators in natural areas. *Natural Areas Journal* 36, 478-488.

Beard, C. 2015. Honeybees (*Apis mellifera*) on public conservation lands: a risk analysis. *New Zealand Department of Conservation, Hamilton, New Zealand.*

Buchmann, S.L. 1996. Competition between honey bees and native bees in the Sonoran Desert and global bee conservation issues. In: *The Conservation of Bees*, A. Matheson, S.L. Buchmann, C. O'Toole, P. Westrich & I.H. Williams (eds.), Academic Press, London.

Butz-Huryn, V.M. 1997. Ecological impacts of introduced honey bees. *Quarterly Review of Biology* 72, 275–297.

Cane, J.H. & V.J. Tepedino. 2017. Gauging the effect of honey bee pollen collection on native bee communities. *Conservation Letters* 10, 205–210.

Cayuela, L. *et al*. 2011. Honeybees increase fruit set in native plant species important for wildlife conservation. *Environmental Management* 48, 910–919.

Durrer, S. & P. Schmid-Hempe. 1994. Shared use of flowers leads to horizontal pathogen transmission. *Proceedings of the Royal Society of London B* 258, 299–302.

Elbgami, T. *et al*. 2014. The effect of proximity to a honeybee apiary on bumblebee colony fitness, development, and performance. *Apidologie* 45, 504-513.

Evertz, S. 1993. Untersuchungen zur interspez chen Konkurrenz zwischen Honigbienin (*Apis mellifera* L.) and solitaren Wildbienen (Hymenoptera, Apoidea). Ph.D. Dissertation, Rheinisch Westfalische Technische Hochschule Aachen, Germany.

Forup, M.L. & J. Memmott. 2005. The relationship between the abundances of bumblebees and honeybees in a native habitat. *Ecological Entomology* 30, 47–57.

Fürst, M.A. *et al*. Disease associations between honeybees and bumblebees as a threat to wild pollinators. *Nature* 506, 364-366.

Geldmann, J. & J.P. González-Varo. 2018. Conserving honey bees does not help wildlife. *Science* 2018, 359-392.

Genersch, E. *et al*. Detection of deformed wing virus, a honey bee viral pathogen, in bumble bees (*Bombus terrestris* and *Bombus pascuorum*) with wing deformities. *Journal of Invertebrate Pathology* 91, 61–63.

Geslin, B. *et al*. 2017. Massively introduced managed species and their consequences for plant–pollinator interactions. *Advances in Ecological Research* 57, 147-199.

González-Varo, J.P. & M. Vilà. 2017, Spillover of managed honeybees from mass-flowering crops into natural habitats. *Biological Conservation* 212, 376–382.

Goulson, D. 2003. Effects of introduced bees on native ecosystems. *Annual Review of Ecology, Evolution & Systematics* 34, 1-26.

Goulson, D. & K.R. Sparrow. 2009. Evidence for competition between honeybees and bumblebees: effects on bumblebee worker size. *Journal of Insect Conservation* 13, 177-181.

Graystock, P. *et al*. 2013. Emerging dangers: deadly effects of an emergent parasite in a new pollinator host. *Journal of Invertebrate Pathology* 114, 114–119.

Graystock, P. *et al*. 2014. The relationship between managed bees and the prevalence of parasites in bumblebees. PeerJ 2:e522; DOI 10.7717/peerj.522.

Graystock, P. *et al*. 2016. Do managed bees drive parasite spread and emergence in wild bees? *International Journal for Parasitology: Parasites and Wildlife* 5, 64-75.

Heinrich, B. 1979. *Bumblebee Economics*. Harvard University Press, Cambridge, USA.

Henry, M., & G. Rodet. 2018. Controlling the impact of the managed honeybee on wild bees in protected areas. Scientific Reports 8, 9308. https://doi.org/10.1038/s41598-018-27591-y.

Herbertsson, L. *et al.* 2016. Competition between managed honeybees and wild bumblebees depends on landscape context. *Basic & Applied Ecology* 17, 609–616.

Hudewenz, A. & A.-M. Klein. 2013. Competition between honey bees and wild bees and the role of nesting resources in a nature reserve. *Journal of Insect Conservation* 17, 1275–1283.

Hudewenz, A. & A.-M. Klein. 2015. Red mason bees cannot compete with honey bees for floral resources in a cage experiment. *Ecology & Evolution* 16, 5049-5056.

Hung, K.-L. *et al*. 2018. The worldwide importance of honey bees as pollinators in natural habitats. *Proceedings of the Royal Society B: Biological Sciences.* 285. 20172140. 10.1098/rspb.2017.2140.

Kato, M. & A. Kawakita. 2004. Plant-pollinator interactions in New Caledonia influenced by introduced honeybees. *American Journal of Botany* 91, 1814–1827.

Kennedy, C.M. *et al*. 2013. A global quantitative synthesis of local and landscape effects on wild bee pollinators in agroecosystems. *Ecology Letters* 16, 584–599.

Kleijn, D. *et al*. 2015. Delivery of crop pollination services is an insufficient argument for wild pollinator conservation. *Nature Communications* 6:7414: 10.1038/ncomms8414.

Kleijn, D. *et al.* 2018. Bee conservation: inclusive solutions. *Science* 360, 389-390.

Larsson, M. & M. Franzen. 2007. Critical resource levels of pollen for the declining bee *Andrena hattorfiana* (Hymenoptera, Andrenidae). *Biological Conservation* 134, 405-414.

Li, J.L. *et al*. 2014. Systemic spread and propagation of a plant-pathogenic virus in European honeybees, *Apis mellifera*. mBio 5(1):e00898-13. doi:10.1128/mBio.00898-13.

Lindström, S.A.M. *et al.* 2016. Experimental evidence that honeybees depress wild insect densities in a flowering crop. *Proceedings of the Royal Society of London B* 283 (1843) 20161641.

Magrach A. *et al.* 2017. Honeybee spillover reshuffles pollinator diets and affects plant reproductive success. *Nature, Ecology & Evolution* 1, 1299–1307.

Mallinger, R.E. *et al.* 2017. Do managed bees have negative effects on wild bees?: A systematic review of the literature. PLoS ONE 12(12): e0189268.

Manley, R. *et al.* 2015. Emerging viral disease risk to pollinating insects: ecological, evolutionary and anthropogenic factors. *Journal of Applied Ecology* 52, 331–34.

MacIvor, J.S. *et al*. 2017. Honey bees are the dominant diurnal pollinator of native milkweed in a large urban park. *Ecology and Evolution* 7, 8456-8462.

McMahon, D.P. *et al*. 2015. A sting in the spit: widespread cross-infection of multiple RNA viruses across wild and managed bees. *Journal of Animal Ecology* 84, 615–624.

Michener, C.D. 2000. *The Bees of the World*. The John Hopkins University Press, Baltimore, USA.

O'Neal, R.J. & G.W. Waller. 1984. On the pollen harvest by the honey bee (*Apis mellifera* L.) near Tucson, Arizona (1976-1981). *Desert Plants* 6, 81-109.

O'Toole, C. & A. Raw. 2004. *Bees of the World*. Facts on File, Inc., London.

Paini, D. & J. Roberts. 2005. Commercial honey bees (*Apis mellifera*) reduce the fecundity of an Australian native bee (*Hylaeus alcyoneus*). *Biological Conservation* 123, 103–112.

Paxton, R. J. 2010. Does infection by *Nosema ceranae* cause "Colony Collapse Disorder" in honey bees (*Apis mellifera*)? Journal of Apicultural Research 49: 80–84.

Potts, S.G. *et al.* 2016. Summary for policymakers of the assessment report of the intergovernmental science-policy platform on biodiversity and ecosystem services on pollinators, pollination and food production. *Secretariat of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*, Bonn, Germany.

Pyke, G.H. 1999. The introduced honeybee *Apis mellifera* and the precautionary principle: reducing the conflict. *Australian Zoologist* 31, 181–186.

Pyke, G.H. & L. Balzer. 1985. *The Effects of the Introduced Honeybee (Apis mellifera) on Australian Native Bees: A Report Prepared for NSW National Parks & Wildlife Service*. National Parks and Wildlife Service, Sydney.

Rader, R. *et al.* 2009. Alternative pollinator taxa are equally efficient but not as effective as the honeybee in a mass flowering crop. *Journal of Applied Ecology* 46, 1080–1087.

Rortais, A. *et al*. 2005. Modes of honeybees exposure to systemic insecticides: estimated amounts of contaminated pollen and nectar consumed by different categories of bees. *Apidologie* 36, 71-83.

Schaffer, W.M. *et al.* 1983. Competition for nectar between introduced honey bees and native North American bees and ants. *Ecology* 64, 564–577.

Schlindwein, C. *et al.* 2005. Pollination of *Campanula rapunculus* L. (Campanulaceae): how much pollen flows into pollination and into reproduction of oligolectic pollinators? *Plant Systematics & Evolution* 250, 147-156.

Seeley, T.D. 1995. *The wisdom of the hive: the social physiology of honey bee colonies*. Harvard University Press.

Shavit, O. *et al.* 2009. Competition between honeybees (*Apis mellifera*) and native solitary bees in the Mediterranean region of Israel—Implications for conservation. *Israel Journal* *of Plant Sciences* 57, 171–183.

Singh, R. *et al.* 2010. RNA viruses in hymenopteran pollinators: evidence of inter-taxa virus transmission via pollen and potential impact on non-*Apis* hymenopteran species. Public Library of Science ONE 5 DOI:10.1371/journal.pone.0014357.

Steffan-Dewenter, I. & A. Kuhn. 2003. Honeybee foraging in differentially structured landscapes. *Proceedings of the Royal Society of London B* 270, 569–575.

Steffan-Dewenter, I. & T. Tscharntke. 2000. Resource overlap and possible competition between honey bees and wild bees in central Europe. *Oecologia* 122, 288-296.

Sugden, E.A. & G.H. Pyke. 1991. Effects of honey bees on colonies of *Exoneura asimillima*, an Australian native bee. *Australian Journal of Ecology* 16, 171–181.

Thomson, D. 2004. Competitive interactions between the invasive European honeybee and native bumble bees. *Ecology* 85,: 458–470.

Thomson, D.M. 2006. Detecting the effects of introduced species: a case study of competition between *Apis* and *Bombus*. *Oikos* 114, 407-418.

Thomson, D.M. 2016. Local bumble bee decline linked to recovery of honey bees, drought effects on floral resources. *Ecology Letters* 19, 1247–1255.

Thorp, R. *et al.* 1994. Flowers visited by honey bees and native bees on Santa Cruz Island. *The Fourth California Islands Symposium: Update on the Status of Resources*, 351–365.

Torné-Noguera, A. *et al*. 2016. Collateral effects of beekeeping: impacts on pollen-nectar resources and wild bee communities. *Basic & Applied Ecology* 17, 199–209.

Vanengelsdorp, D. & M.D. Meixner. 2010. A historical review of managed honey bee populations in Europe and the United States and the factors that may affect them. *Journal of Invertebrate Pathology* 103, S80 –S95.

Walther-Hellwig, K*. et al*. 2006. Increased density of honeybee colonies affects foraging bumblebees. *Apidologie* 37, 517–532.

Winston, M.L. 1987. *The biology of the honey bee*. Harvard Univ. Press, Cambridge, USA.

Wojcik, V.A. *et al.* 2018. Floral resource competition between honey bees and wild bees: is there clear evidence and can we guide management and conservation? Environmental Entomology (in press).

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