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EDITED BY
Peter Kevan,
University of Guelph, Canada

REVIEWED BY
Freya Jackson,
Murdoch University, Australia
Erica Shelley,
Best for Bees, Canada

*CORRESPONDENCE
Melissa A. Y. Oddie
melissa.oddie@norbi.no

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One for all and all for one: a review on the commonality of risk to honeybees and wild pollinators and the benefits of beekeepers in conservation

Melissa A. Y. Oddie* and Bjørn Dahle

Norges Birøkterlag, Kløfta, Norway

Pollinator declines across the globe are centrally driven by a synergistic interaction between intensive land use, pesticides, and climate change. Competition between managed and wild pollinators has been a growing topic of research, however the ensuing social conflict builds antagonism between beekeepers and conservationists, two parties that have an interest in protecting natural diversity for pollinators. The threats perpetuating this potential for competition are as real for managed bees as wild species and uniting both groups, wherever possible, can create long lasting and meaningful change in current agricultural practices. This review examines the most recent literature on pollinator competition and the common threats that drive it. It also delves into the social elements of beekeeping and examines the potential for beekeepers to contribute to the protection of natural habitats. Beekeepers have a genuine interest to preserve natural space and with their charismatic species, dutiful observations, and innovative techniques, they can be valuable assets in filling knowledge gaps and generating public interest. Pollinator strategies in the future should include beekeepers as key stakeholders if their impacts are to be improved.

KEYWORDS

beekeepers, competition, conservation, honeybees, sustainability, wild pollinators

1 Introduction

Insect pollination is a vital service to both natural ecosystems and humans. At least 30% of the most nutritionally valuable crop yields produced for human consumption require insect pollinators (Klein et al., 2007; Eilers et al., 2011; Garibaldi et al., 2013; Rollin and Garibaldi, 2019). The dependence of human crops on pollination is increasing over time (Aizen et al., 2009) and plant-pollinator networks build a crucial base for the effectiveness of this ecosystem service (Kremen et al., 2004; Dainese et al., 2019). Managed pollinators, mostly managed honeybees (*Apis mellifera*), are tightly linked to this service in many human-mediated landscapes, now both in their native and non-native ranges (Rollin and Garibaldi, 2019). It has been well documented that pollinators are in global decline and in nearly all cases, the central driver is the intensification of land management (Kevan and Viana, 2003; Potts et al., 2010a; Burkle et al., 2013; Durant and Otto, 2019; Seibold et al., 2019; Dicks et al., 2021).

With increasingly limited natural resources, conflict between managed and wild pollinators becomes inevitable. Recently, there has been a research focus on identifying and assessing the potential for competition between wild pollinators managed bees (Mallinger et al., 2017; Wojcik et al., 2018). Likely this has come, at least partially, as a pushback against the misguided concept that honeybee conservation is a functional equivalent to species-level biodiversity conservation (Wilson et al., 2017; Geldmann and González-Varo, 2018). In their non-native ranges, managed species like honeybees kept at high densities, or large populations of escaped, feral bees can have severe impacts on local wildlife.

Though the risks of competition are evident, the social implications of this divisive stance splits two parties with a vested interest in protecting the same thing, namely, healthy environments for pollinators. The beekeeping industry has grown increasingly vulnerable in many areas due to its reliance on private and public land permissions. Shifting land use and conservation policy has created a more exclusionary environment which beekeepers must now navigate (Durant, 2019). As a result, many beekeepers have turned from small scale wild honey operations to large scale industrial honey or pollination services, that perpetuate unsustainable farming practices and make little room for wild space (Maderson, 2023b). Often, beekeeping cannot break away from agricultural landscapes, which are more exposed to threats that contribute to both pollinator decline and competition, making their presence and their plight more visible (Seibold et al., 2019).

This review explores the most current research on the underlying causes of competition and outlines the commonality between the threats that face both wild pollinators and kept honeybees in the Anthropocene. It also investigates the social elements that define the relationship between these threats and stakeholders and explores the role beekeepers have played as well as their future potential in insect conservation. The data presented here details the essential practicality of pooling the efforts of both beekeepers and conservation groups to improve conditions collectively for all pollinators in human-mediated landscapes.

2 Competition: when does it happen and why?

When species experience niche overlap, there is potential for competition. Exploitative competition decreases the fitness of at least one competitor group due to reduced access to a finite resource (Elton, 1946; Schoener, 1983; Abrams, 2022). The common belief is that a highly social, generalist pollinator like the honeybee, in high enough densities, can reduce the available nectar or pollen for wild pollinator species. This may often remove specialized resources for an already declining group of insects (Thomson, 2004; Cane and Tepedino, 2017; Wojcik et al., 2018; Rasmussen et al., 2021), or shift plant-pollinator interactions to affect the habitat as a whole (Valido et al., 2019). Honeybees also have the potential to spread pests and disease, and their large, tight-knit colony lifestyles creates opportunity for zoonotic shifts, which could lead to massive outbreaks in wild pollinator communities (Otterstatter and Thomson, 2008; Fürst et al., 2014; Goulson and Hughes, 2015; Mallinger et al., 2017). By human hands, honeybees have been moved to many places where they are not native. High domestic hive densities like those in the Americas (Geslin et al., 2017), as well as released, feral populations like those in Australasia (Prendergast, 2023; Pyke et al., 2023), have the potential to magnify the above-stated issues because of the sheer number of colonies present where they have never been before. Due to the increasing disappearance of key habitats, the ever-shifting use of harmful chemicals, climate change and invasive species, the effect of managed pollinators certainly has the potential to become damaging to local pollinator communities under the right circumstances (Brown and Paxton, 2009; Goulson et al., 2015; Brown et al., 2016; Baldock, 2020; Herrera, 2020; MacInnis et al., 2023).

Much of the current research on pollinator competition extrapolates potential risk from field observations but provides very little direct experimental evidence: The studies actively testing for impacts of honeybee-wild pollinator competition on fitness are surprisingly few, and relegated to handful of species, mostly bumblebees. Two recent reviews (Mallinger et al., 2017; Wojcik et al., 2018) investigated the number of papers on pollinator competition and pathogen spillover. In the field of competition, the first review examined 81 papers and found 19 that met their criteria for "direct impacts" on fitness, presenting experimental evidence and not only observational fluctuations in species abundance and richness based on proximity to honeybee hives or hive density. Of those 19, 10 found evidence of exploitative competition and 9 found no direct evidence. The second review found 38 out of 72 papers reporting negative effects of honeybees on wild pollinator foraging. Of the 27 papers investigating viral transmission, only 2 documented active transmission of viruses from honeybees to wild bees. An updated review (Iwasaki and Hogendoorn, 2022) found that the body of literature is increasing rapidly, growing by 47% since Mallinger et al. (2017), and the reporting of negative effects of competition has increased by about 13%, indicating a disproportionately slow growth of negative findings to the overall growth of the literature body. In short, there is little evidence that shows that the presence of honeybees has direct, negative impact on wild pollinator fitness, and likely, competition does not create easily measurable impacts in every instance of shared land.

Even with moderate rates of positive evidence, competition is inarguably a risk, and every case of honeybee presence must be considered as having the potential to impact wild pollinators negatively. There is much to be said for the precautionary principle in cases where honeybee competition with wild pollinators seems likely (Pyke, 1999). However, shifts in social perspective and the corresponding calls for policy change have been highly focused on mitigating the effects by restricting beekeeper access to often much-needed resources as a blanket strategy in all cases (Durant, 2019; Matsuzawa and Kohsaka, 2021). Efforts to mitigate the effects of competition may be more successful overall, if the focus was less on the damage from honeybees and more on the conditions under which that damage could occur. The largest underlying threats facing wild pollinators are very much the same threats facing honeybees. In this light, a growing body of research is being produced outlining the tight-knit similarities between the needs, problems, and solutions for all pollinators. Acknowledging beekeepers as fundamental stakeholders in the health of the natural environment plays well on two stages: scientifically beekeepers can offer much in their constant monitoring of a species that lives and thrives on natural biodiversity, and socially, beekeepers, their bees and their industry are charismatic bannermen for campaigns to involve the public in environmental challenges. If meaningful change is to occur for pollinators, all active players must be unified.

3 Common threats (and solutions)

3.1 Habitat loss

Habitat destruction is the most significant cause of biodiversity decline (Caro et al., 2022). Recent maps indicate an area of untouched "wild" land at just 25% across the globe (Allan et al., 2017). Additionally, species made vulnerable by the removal of needed habitat are much more susceptible to other threats like climate change and invasive species (Ganuza et al., 2022). Habitat loss is driven by the changing of land from a natural state to a state that provides food and other resources for human use (Tilman et al., 2017). Agricultural landscapes have historically been interlaced with natural and semi-natural habitats that were suitable for a large diversity of pollinators, but with the rapid increase in human population and general wealth, land is being handed to urbanization, farming practices are becoming more intense and this removes practical habitats that house many species (Shi et al., 2021). It is well-known that wild pollinators can only thrive if a suitable diversity of flowering plants is present in their environment. The issue lies in the area of land that is needed to maintain these natural landscapes. Stakeholders often see a loss of opportunity in natural landscapes, where they could instead be managed as more cropland (Kleijn et al., 2015; Montoya et al., 2020), and if pollinators are required, they can be purchased and fed with supplements (Noordyke and Ellis, 2021). The demand of pollination in today's landscapes in many areas however, is rising faster than the increase in honeybee colonies (Potts et al., 2010b). Wild pollinators can augment the performance of managed bees and sometimes surpass it (Garibaldi et al., 2013; Monasterolo et al., 2022), and there is now clear evidence that restoring natural diversity in intensely-managed landscapes may be required for honeybees as well. Natural and semi-natural habitats can improve nutritional intake and provide diverse resources during times of food scarcity in predominantly monofloral environments.

3.1.1 Nutrition and stressor resistance

A large body of literature illustrates the link between poor nutritional intake and honeybee susceptibility to other external stressors (Naug, 2009). Poor nutrition can lead to higher instances of disease (DeGrandi-Hoffman and Chen, 2015; Branchiccela et al., 2019; Dolezal et al., 2019) and a greater susceptibility to environmental toxins (Tosi et al., 2017). Numerous studies now link the loss of natural and semi-natural habitats to poor nutritional health in honeybees: A US study found a strong correlation between the decrease in rangeland (grazed natural grasslands) and honeybee colony losses. States with the highest areas of natural land cover had a higher honey production per hive. This tells us that lands with more diverse resources improved overall colony survival, likely by providing a higher diversity and volume of pollen and nectar (Naug, 2009). Similar patterns were found recently in Canada (Richardson et al., 2023), and more diverse pollen collection, a key for good nutrition, was also linked to natural landscapes in Great Britain (Woodcock et al., 2022), France (Odoux et al., 2012) and Papua New Guinea (Cannizzaro et al., 2022). A wide variety of pollen can even work synergistically to improve honeybee health (Donkersley et al., 2017). Looking at the impacts on individual bees, a higher natural diversity can reduce microbial imbalances (Gorrochategui-Ortega et al., 2022) and improve the production of vitellogenin (Alaux et al., 2017), a protein that has been linked to better toxin processing (Barascou et al., 2021) and is crucial for winter survival in temperate climates (Amdam et al., 2005).

Access to a variety of different pollens plays a large role in many aspects of honeybee health (Di Pasquale et al., 2016), and not all roles are entirely understood, therefore replicating the needed diversity artificially through food substitutes may not serve as a good long term strategy.

In addition to maintaining preexisting diversity, restoring natural diversity in agricultural landscapes can increase the volume of food available: An experiment performed by Zhang et al. (2023) examining prairie strips in an agricultural landscape found that honeybees collected 50% more pollen and colonies were 24% larger at the end of season monitoring. Many of the resources in the strips were left uncollected, meaning there was the potential capacity to provide food for other species. This study offers direct evidence that replacing some natural diversity in highly managed agricultural landscapes can work to reduce nutritional stress in honeybees and possibly reduce competition with wild pollinators.

3.1.2 Temporal availability

Floral diversity in natural habitats can increase the availability of resources like pollen and nectar on a temporal scale too (Mallinger et al., 2016). A study in Western France examining the composition of collected pollen over time revealed that honeybees collected up to 40% of their pollen from weed species growing between the desired crop flowerings (Requier et al., 2015). Honeybees do not often use a high level of diversity at any given point in a season, but the types of resources collected in diverse environments changes significantly over time (Jones et al., 2022). Temporal shifts in floral availability are just as present in tropical climates as temperate (Souza et al., 2018), so consideration of temporal diversity in landscape management planning is as important as area coverage. Limiting this availability exposes honeybee colonies to greater risk of malnutrition or starvation and could increase competition at key points in a season.

3.1.3 Strategies for maximizing floral diversity in agricultural landscapes

There are many strategies being implemented to improve conditions for pollinators, including diverse cropping (planting more than one crop in an area: Martínez-Núñez et al., 2022), flower strips (narrow lengths of planted flowers in or around cropland: Scheper et al., 2015) and lower crop seed densities (Sidemo-Holm et al., 2021). However, it is natural floral diversity that stands out as the most effective resource for wild pollinator and honeybee health:

Studies have shown that though flower strips and semi-natural habitats provide similar resources, the pollinator diversity supported by semi-natural habitats is often superior (Morandin et al., 2007; Hevia et al., 2021; Hadrava et al., 2022). This means that natural and semi-natural habitats provide better resources for rare species. Choosing seed mixtures can be a complex affair when considering the effects they must have, and often, natural mixtures provide the best nutrition for pollinating species (Haaland et al., 2011). A combination then, of natural, semi-natural and floral strip habitats might offer the best spread of strategies to accommodate a variety of landscape assemblages.

Though the benefit of natural diversity in farming landscapes is generally accepted, there is a large gap in knowledge from an economic and social perspective on the direct benefits of these strategies to the farmers who produce crops (Uyttenbroeck et al., 2016). It is not known if these strategies produce enough incentive alone to employ them in all cases, and in many cases, subsidies are required to encourage their use. The fastest solution may currently involve interested stakeholders like beekeepers and conservation groups working together to make natural diversity a requirement in landscape planning and not only an option, as it often is (Durant, 2019; Pe'er et al., 2022).

3.2 Agrochemicals

Agrochemicals are essentially all chemicals used in agriculture, from fertilizers to pesticides that target a number of taxa and can have severe detrimental effects. Most current agrochemical application practices for the globalized agricultural sector are unsustainable (Weltin et al., 2018). Often these chemicals affect species and areas outside the intended and cause toxin buildup in the environment. This endangers organisms on all trophic levels and can eventually damage ecosystem services, food production and subsequently human health (Singh et al., 2018). The effects of many agrochemicals on pollinators are no different. Depending on the method and timing of application, these chemicals have the capacity to cause mass deaths and serious sublethal conditions for honeybees and wild pollinators alike (Woodcock et al., 2017; Holder et al., 2018; Fikadu, 2020).

Honeybees are often chosen as a model organism for assessing the toxicity levels of pesticides, however honeybees, due to their eusocial, large colony-nesting strategies are often more resistant to the effects, and not the best proxies for assessing the threats to wild pollinators (Franklin and Raine, 2019). Even other eusocial bees, like neotropical stingless bees, can suffer stronger effects than those measured in managed honeybees. Two studies found a much more profound effect of a combination of pesticides and fungicides on one species of stingless bee (*Partamona helleri*) than the tested *A. mellifera* (Tomé et al., 2017; Almeida et al., 2021). So, if a chemical is found to affect honeybees in a serous way, it may well affect many wild pollinator species more profoundly.

Methods of assessing the toxicity of agrochemicals often fall very short of the entire system of effect they can have on species in the field. Until recently, focus for assessment had generally been on the LD50: the concentration of the chemical that caused a 50% mortality rate in tested subjects (Trevan and Dale, 1927). This would be realistic if there were no other stressors posing challenges to pollinator health, but pesticides can affect learning and memory in foraging (Henry et al., 2012), reduce reproductive success (Sandrock et al., 2014; Woodcock et al., 2017), alter parasite loads (Evans et al., 2018; Schwartz et al., 2021), lower immunity (Pettis et al., 2013; Sánchez-Bayo et al., 2016), and cause changes to food webs and species assemblages in the ecosystems that pollinators require to sustain themselves (Tooker and Pearsons, 2021). In short, with all other challenges, both natural and man-made, pesticide effects can become synergistic with other threats to make "sublethal" effects very lethal indeed (Goulson et al., 2015; Siviter et al., 2021a).

3.2.1 Lack of knowledge in policymaking

Methods for successfully predicting pesticide exposure and the (not so) sub-lethal effects are still under development (Barmaz et al., 2010; Siviter et al., 2021b). Currently, many regulatory bodies are relying on the published results of independent studies and the hope that large-scale decision-makers will take the data into account when reworking policies. As of yet, there have been very few steps taken to include any species other than honeybees in most assessments (Siviter et al., 2021b).

Current EFSA guidelines for the risk assessment of plant protection products (PPPs) only have clear sublethal effect thresholds for honeybees, thresholds for wild pollinators remain 'undefined', due to insufficient data (Authority (EFSA) et al., 2023). Today, studies on the agrochemical effects on honeybees still dominate the literature at about 80% (Vanbergen, 2021; Dirilgen et al., 2023), and the majority of studies on other insects are focused on bumblebees, mason bees and leaf-cutter bees (Dirilgen et al., 2023). There are large gaps in the knowledge on the synergistic effects of pesticides and by this, policy makers may excuse non-committal opinions in favor of continued, intense agricultural production.

3.2.2 Strategies for minimizing the effects of agrochemicals on non-target systems

The growing global human population is increasing the demand on our agricultural systems (Noel et al., 2016), and land users often see the call for a reduction of agrochemicals as a threat to their productivity (Young et al., 2022; Argüelles and March, 2023). However, food production cannot persist outside the framework of stable ecosystems (Dudley and Alexander, 2017; Kopittke et al., 2019), and some reduction in the intensity of management to make way for that healthy framework may be necessary for the production to continue indefinitely.

Interestingly, pollinators themselves, both domestic and wild may provide an incentive to reduce the use of chemical pest control. One study found that by reducing pesticide use in oilseed rape fields, the subsequent increase in pollinator abundance raised crop yield to the point where it negated the cost of product loss from pest species, and cut production costs by reducing the volume of the purchased pest control chemicals (Catarino et al., 2019). Similar evidence was found when measuring wild pollinator abundance in watermelon fields in relation to a reduction in pesticide applications (Pecenka et al., 2021), increasing yield via improved pollination services beyond the crop loss from pests.

Knowing the unsustainability of current agrochemical applications in most countries and given the evidence that providing for pollinators can nullify the crop loss from pest species, governments must put a high value on farmers, crops and pollinators (both domestic and wild) and work to consider strategies beneficial to all groups.

Beekeepers have a stake in making the landscape more hospitable for pollinators, and beyond the use of their bees, their power of advocacy can be a formidable tool. As an example of policy change regarding agrochemicals in Europe, the three neonicotinoids Clothianidin, Thiamethoxam and Imidacloprid, which were where three of the most widely used pesticides at the time, were banned for outdoor use (EC, 2013), partly as a result of lobbying by beekeepers (Demortain, 2021). Beekeepers have a very keen awareness of how their bees fair in the environments they navigate, and honeybee potential as an ecological monitor, through the attentive beekeepers, may be a strong resource to provide some missing data for policymakers (Cunningham et al., 2022), keeping in mind the effects of these chemicals are likely more severe for any pollinator that is not a honeybee (Thompson and Pamminger, 2019).

Honeybees are often used as indicator species to measure the effects of agrochemicals like pesticides, however they are often not good representatives for the other insect species present in the systems. The increasing pressure on food production systems is pressing for a higher-level of chemical inputs, but this in turn, decreases the stability of the land processes required to grow food successfully. Now we are discovering that there may be alternatives to more intensive land management and using natural solutions, like reducing pesticides to encourage pollinators may prove just as profitable. Accounting for a trade-off between crop productivity and ecological sustainability, involving indirect stakeholders like beekeepers, and pushing for more research to close knowledge gaps should bring us closer to building an agricultural system that can coexist with natural diversity and continue safely into the future.

3.3 Climate change

Climate change is likely one of the most daunting yet seemingly vague threats facing the world. It is difficult to attribute real time events to a force that cannot be seen or measured except over long periods of time, however recent data have now illuminated the effects quite clearly.

Climate change is impacting global temperatures (Hansen et al., 2006; Seneviratne et al., 2006; Sun et al., 2014) and this is causing more frequent and more violent extreme weather events like droughts, floods, wildfires and storms (National Academies of Sciences, Engineering, and Medicine, 2016; Stott, 2016). The effects of these events and increasing temperatures pose problems for most life on earth, and makes current human problems, like taxing an already stressed food production system, harder (Brás et al., 2021).

3.3.1 The varying effects of climate change on pollinators

The effects of climate change on honeybees (both managed and feral) and on other wild and native bees will likely be similar. Extreme weather, for example, can limit forage, and in areas where habitat quality is already reduced (intensely managed landscapes) this could have serious impacts for food collection and nesting habitat (Goulson et al., 2015). Changing weather and temperature patterns can alter local assemblages and shift home ranges, hinder flowering phenology, and make way for invasive species (Parmesan, 2007; Schweiger et al., 2010; Duchenne et al., 2020). Wildlife, and to an extent honeybees, recover from extreme events by being recolonized from surrounding populations that were not affected (Macarthur and Wilson, 1967; Venturini et al., 2017), but reducing habitat patch size and increasing distance between those patches affects recolonization potential (Parmesan et al., 2000). This means there must be suitable habitat within reachable distance with which to support populations that will recolonize after a drastic disturbance (Vasiliev and Greenwood, 2021) created by climate change. Recolonization might be less problematic for domestic pollinators, that can be repopulated by human means, but decreasing the amount of suitable environment makes even honeybees weaker and more susceptible to other threats (Naug, 2009; Potts et al., 2010b). Data on the direct impacts of climate change on pollinators are scant (Decourtye et al., 2019). Many papers detailing potential effects rely on laboratory studies or theoretical modelling which, though insightful, is not a substitute for tangible evidence (Forrest, 2017; Giannini et al., 2017; Hannah et al., 2017).

Despite this lack of concrete knowledge, there are strategies providing necessary data. The effects of climate change, though difficult to predict, are very measurable in their impacts.

3.3.2 Strategies for mitigating the effects of climate change for pollinators

Because it is so hard to measure, and studies that capture discernible effects must be long term and include many samples, there simply is not a large amount of conclusive field data detailing climate change effects on pollinators. The problem then, is one of time and work force. Beekeepers often make excellent watch dogs for the effects of extreme weather. For example, professional beekeepers in Italy retained good records and offered insight into the changes of nectar amount and type in tandem with the weather from year to year (Vercelli et al., 2021). These data might be useful as a proxy for floral abundances of significant resources for pollinators in the environment and could be valuable data to inform policy makers on climate change mitigation strategies. The fact is, much of a beekeeper's data is empirical, they are highly motivated, and with a small amount of training, many can provide high quality data for long term monitoring projects (Maderson and Wynne-Jones, 2016; Gratzer and Brodschneider, 2021).

To directly mitigate the impacts of climate change, restoring natural habitat can be a viable option. A recent global study concluded that insect biodiversity benefitted directly from more natural habitat in the area, reducing the synergistic impact of climate change and landscape degradation, though the amount of natural habitat needed was great (Outhwaite et al., 2022). A less intense strategy for agriculture could permit a large amount of natural diversity to persist interlaced with needed cropland, and indeed, multiple studies have found that smaller, more diverse crop spaces increase biodiversity and landscape connectivity with minimal losses to productivity by area (Dudley and Alexander, 2017; Tscharntke et al., 2021).

On a local scale, native plants can be more drought resistant than monoculture crops, and a high enough diversity makes sure there are more floral resources that can tolerate varying conditions. Honeybees in Iowa, when given access to natural resources during times of drought switched from their main source of pollen at the time (clover, *Trifolium* spp), which was much less abundant, to a small variety of natural prairie species and the amount of pollen collected was statistically comparable to other years (Zhang et al., 2022), effectively mitigating a climate-induced forage dearth.

To bring it together: Direct measures to mitigate the effects of climate change, apart from reducing greenhouse gases, lie most prominently in doing what we can to restore natural habitat and reduce the intensity of management in affected landscapes, while also protecting the natural diversity that remains. More data on the effects of climate change would help drive decisions, and beekeepers might offer the efficient and long-term information collection that could help obtain it. Beekeepers have a keen understanding of the importance of natural diversity, and they can provide a force for conservation that is both insightful and passionate. Ultimately, beekeepers have much to offer in the battle for biodiversity.

4 Beekeepers in conservation

Beekeepers have a vested interest in protecting resources for their bees, and this ultimately includes resources for wild pollinators as well. There has recently been significant dialogue on whether or not honeybees fall under the category of "pollinators that need conserving" (Geldmann and González-Varo, 2018; Kleijn et al., 2018; Saunders et al., 2018; Alaux et al., 2019). Arguably, they are managed in most cases, their survival is aided, their numbers bolstered beyond natural limits, or, they are non-native to where they occur. In addition, many projects promoting beekeeping have been pedaled as efforts to increase biodiversity, but this claim is false (Colla and MacIvor, 2017). Outside of wild honeybee colonies in their natural ranges, the conservation of honeybees does very little to aid other species directly.

In terms of practical solutions for habitat loss, the discourse on whether honeybees should be the targets of conservation is irrelevant. Resources required by honeybees and wild pollinators overlap enough that the commonality can be exploited, as ultimately it is not the species that should be the focus in many cases, but the habitats they need to live.

Negatively targeting beekeepers in the effort to preserve wild pollinators alienates an industry that has the most to gain by aligning with them. The repercussions of being restricted from forage for the sake of conservation may be effective in some cases, and short term, but the longstanding, widespread consequences might be that beekeepers seek a sustainable profit in other areas, like industrial scale commercial pollination, and end up supporting a practice even more hostile to the preservation of natural space (Maderson, 2023b). The effects of competition, even those highlighted in the vying for policy attention, can be effectively mitigated in many cases if efforts are combined by these two passionate sides to preserve natural ecosystems in our changing landscapes. Resources must be considered common between both parties and equally protected by both. Wild pollinator conservation groups and the beekeeping industry have unique resources to lend to this cause, and they complement each other in ways that could be synergistic in solving the common problems outlined at length in previous sections.

4.1 Lessons from developing countries: value creation for intact natural habitat

Compared to the West, the story of pollinator conservation in Africa and Southeast Asia includes beekeeping, it being adopted to generate a sustainable income for those who would otherwise depend on trades that are damaging to natural landscapes (Kassa Degu and Regasa Megerssa, 2020; Harianja et al., 2023). Many countries like Ethiopia, Kenya, Tanzania Uganda, India, Indonesia, and Nepal have created conservation programs that center around managing honey-producing bees. The strategy is to generate value in intact natural landscapes and restore disturbed habitats by promoting an industry that can harvest resources with minimal impact on ecosystem function (Wagner et al., 2019; Bareke et al., 2022). As a result, the people who practice beekeeping have gained economic benefits (Kadigi et al., 2021) and are more aware of factors affecting the health of their forests and surrounding land. Some projects have found that beekeepers are active drivers in restoring and protecting local diversity (Sialuk, 2014). Though restricted resources and difficulties in developing appropriate training programs hinder success, observers are optimistic about the potential of this strategy to eventually safeguard natural space (Wagner et al., 2019; Ghode, 2022).

The circumstances surrounding rural communities in developing countries obviously differ from many issues present in places like Europe and North America, however working to create economic value in intact natural landscapes offers an additional level of protection and a new cohort of people ready to defend them. Beekeeping raises conservation awareness wherever it has been measured, and beekeepers have a lot to give in the push for better pollinator conservation (Maderson and Wynne-Jones, 2016).

4.2 Beekeeper drive and public motivation

Applying a monetary value to natural diversity is a solid conservation strategy, but beekeepers' understanding of its real value goes beyond money. A study done in Massachusetts found that beekeepers are more aware of conservation issues than the general public, and more willing to engage actively in pollinator conservation beyond their own bees (DiDonato and Gareau, 2022). Another study found that some beekeepers can be more willing to work for and pay for the conservation of wild pollinators (Penn et al., 2019). These findings are understandable when considering the day-to-day of a beekeeper and their livestock. Beekeepers, especially commercial beekeepers, live the threats to biodiversity every day, because they are often the same threats that affect their own livelihoods. This would not apply to all beekeepers, however, the awareness and incentives are present enough as to consider the beekeeping community as a valuable resource in the endeavor of preserving natural landscapes.

One of the most common reasons given by people starting a hobby beekeeping business is to aid in conserving natural diversity (Duarte Alonso et al., 2021). Beekeeping is used to raise environmental awareness, promote local identity (regional honey) and reignite an interest in traditional and low-impact farming practices (Kohsaka et al., 2017; Cho and Lee, 2018). Though there are apparent misunderstandings of the real impact of honeybees on natural diversity, the willingness to be part of the solution is irrefutably present (Lorenz and Stark, 2015; Duarte Alonso et al., 2021). So, hobby beekeepers want to help, and potentially focusing on environmental education for this particular group of stakeholders may be an easy method to engage them in impactful solutions.

Another possible way beekeepers might influence changes in agricultural strategies is by indirect contact, engaging with crop-based farmers that rely on pollination services for productivity. Studies investigating farmer perception on pollinator declines and supporting management strategies found that knowledge of the threats and the willingness to enact change was related to on-farm experiences and age (Bloom et al., 2021) rather than their use of managed pollinators, and was also linked to their level of knowledge on the subject (Osterman et al., 2021). Still, no studies were found on the perception of crop farmers on the topic of pollinator conservation and their level of engagement with beekeepers, so the possibility exists that beekeepers may well be able to interact as intermediaries between farmers and wild pollinator conservation strategies, providing education to crop farmers by simple interaction.

Ultimately, be it commercial beekeeper, hobby beekeeper or non-beekeeper, there is a great deal of human love for the honeybee both in and outside of beekeeping circles; they have been consistent and valuable partners for millennia (Prendergast et al., 2021). We have many reasons to look on honeybees favorably. They are pollinating allies that make us food, provide sweet treats, and draw us in with their complex social behavior that is easily related to our own societies: Honeybees work together, they care for their young and they dance.

When looking at media representation, honeybees receive much more attention than wild pollinators (Smith and Saunders, 2016; van Vierssen Trip et al., 2020). This has been seen by conservationists as part of the problem as honeybees are the least threatened pollinator globally (Iwasaki and Hogendoorn, 2021), but it can also be seen as part of the solution.

A flagship species is defined as a charismatic species that draws the attention and sympathy of the public to raise awareness and action for a specific cause (Jepson and Barua, 2015). In many countries it is part of our cultural upbringing to be aware of honeybees and what they do. The awareness of the plight of the pollinators is growing around the world (Hall and Martins, 2020), and within that, our practical and emotional connections to the honeybee creates a drive that galvanizes many people to take action (Schönfelder and Bogner, 2017). A fantastic example of this was presented during the debate which ended in a Europe-wide ban of the three damaging neonicotinoid pesticides. The public cry "Save the bees" is still well-known to this day (Demortain, 2021). There is a pitfall to be avoided here however, and strategies must be careful to use honeybees to draw attention but build the focus of conservation around needed habitats and not the honeybees themselves (Basset and Lamarre, 2019). If properly harnessed with structured outreach and education (elements that honeybees already contribute to), our collective love for honeybees could be one of the central public drivers to sway policy in favor of more sustainable practices and protect natural habitats for all pollinators.

4.3 For science: practical contributions of beekeepers and their bees

Both beekeepers and their bees have a large potential to contribute practically to conservation projects. Honeybees may not be the most sensitive bioindicators, nesting in large numbers and using a suite of effective eusocial behaviors to reduce stressors at the individual level (Franklin and Raine, 2019), however they are abundant, easily managed, respond predictably to their environment, their data can be standardized across large areas, and they come with their own passionate people who are already collecting their data (Quigley et al., 2019; Cunningham et al., 2022). Honeybees will not be able to provide all data needed for informed decision-making on pollinator conservation, but in situations where large amounts of similar data are needed on a multi-regional scale, they may be one of the best options for scientists to use.

This is an example of how beekeepers can contribute to scientific knowledge. Scientific knowledge is one of the most reliable types of knowledge, using strict, repeatable methods and numerical quantification to form conclusions. However, it is expensive, time-consuming, and very limited due to restricted funding. If practical solutions are to be found for issues like the growing decline of insect pollinators, other types of knowledge must be included and taken seriously, knowledges like the practical and experiential knowledges of people who keep bees for a living. Oftentimes issue is taken with incorporating the knowledge of laymen because it is not considered as well-collected or based in concrete scientific understanding and therefore, is not as valuable (Maderson, 2023b, 2023a). However traditional and lay knowledges have the benefit of direct, long term experience with the systems under study, a different lens that can add much-needed insight to solving on-the-ground problems (Maderson and Wynne-Jones, 2016).

A hard truth is that scientists often do not obtain sufficient funding to complete the tasks that would supply all the information needed for solid policymaking. Citizen science is defined as a collection of volunteers that participate in data collection for scientific studies (Cohn, 2008). It requires an interest in the subject and a consistent time commitment from the participants. Today we have an extensive list of tools to train and employ large numbers of dedicated volunteers in science monitoring projects. The fact that almost everyone on the planet now carries a smartphone, effectively a small computer, has made the idea of citizen science all the more practical. Combine these tools with the expertise, passion, and keen observational skills of a beekeeper, and you are likely to get data that rival the fastidious detail found in the scientific community.

Several studies have now been published using the data collected by beekeepers on their honeybees: some to assess pollen availability and the use of forage plants by honeybees over the active season (Brodschneider et al., 2019), others to examine the field levels of pesticides (Woodcock et al., 2022) or heavy metals (Shaw et al., 2023). These studies identified seasonal declines in pollen diversity, successfully linked foliar insecticides to an increase in disease, and monitored levels of several heavy metals present in an environment.

In addition to participating in data collection, beekeepers have been shown to contribute to the design of novel data collection tools. They optimized methods to align with their capabilities, identified pitfalls and streamlined the collection plans when set to the task of improving technologies (Phillips et al., 2013). Beekeepers are natural innovators and are often willing to lend their expertise to improving projects when invited.

Citizen science offers an address to the problem of resources for scientific studies, and involving beekeepers in science is, in itself, a form of outreach and education. One of the central issues around pollinator declines is a lack of understanding of the core elements of the issue, both by the public and some beekeepers. Involving these key stakeholders in scientific solutions and data collection can provide the education missing in many of the stakeholder groups that have been historically excluded from direct scientific findings (Vohland et al., 2021).

In the end too, creating strategies around people is usually the most long-lasting form of conservation, as it creates value for the communities using these systems, includes them as stakeholders in solutions and ensures that effects can be intergenerational, building local culture around sustainable principles and allowing an internalization of core practices.

5 Conclusion

In the end, honeybees do not contribute directly to improving the environment for wild pollinators, and in some cases, can be detrimental, but this does not mean that beekeepers are, by default, antagonists to conservation. Managed honeybees, like wild pollinators, stand to lose a considerable amount of stability with the reduction of natural and semi-natural habitats, and without sufficient natural diversity in the landscape, competition between the two species groups is inevitable. Competition dynamics have the potential to cause both great harm to natural systems and threaten to restrict the land beekeepers depend on for their livelihoods. The effects of land use intensification can combine with other threats like climate change and competition to exacerbate conditions and magnify problems, and it is only in the direct mitigation of these larger threats that broadscale solutions can be found. The literature body is growing however, knowledge is still lacking in key areas and this allows policymakers to sidestep meaningful action.

Beekeepers have a good deal to offer in needed data collection and the development of strategies to mitigate habitat loss. For example, they are the bannermen that generate public interest for pollinators, and the honeybees they keep are charismatic flagships. Beekeepers are present on the ground for many direct changes and can offer pinpointed local information as well as largescale, long-term data that can aid in policymaking. With precise education, training and guidance, beekeepers can harness their interest and passion and the weight of their industry to afford better protections for natural lands and push for more sustainable agriculture.

It would be a powerful combination to arm beekeepers with the factual knowledge of conservation and channel their endeavors into a collective effort to protect all pollinators. The beekeeping industry is one that closely aligns with the goals of sustainable agriculture due to their livestock's dependency on natural diversity for good health. Honeybees and beekeepers, in the context of human-mediated landscapes could be said to have a symbiotic relationship with wild pollinator groups in the context of their mutual need for wild space and the drive of the domestic bee industry to create a sustainable future for itself. A collaborative, unified effort between beekeepers and wild pollinator advocates will provide a louder voice when pushing for policy improvements regarding the preservation of natural habitats. Both groups standing together may serve as a needed example on how our agricultural systems in their entirety could benefit from taking the needs of the natural environment into account.

There must be a push to understand the underlying causes of competition, and education for both beekeepers and other farmers will be needed to deepen knowledge and understanding of the issues surrounding it. Like the Three Musketeers, beekeepers and wild pollinator conservationists must rally together and unite their efforts. Involving beekeepers in decision-making, acknowledging them as key stakeholders and keepers of valuable knowledge, and promoting their potential to be part of the solution is the only way to create long-lasting and self-perpetuating change directly in the environments that must be conserved, both for wild pollinators and for our bees.

Author contributions

MO: Conceptualization, Data curation, Funding acquisition, Project administration, Resources, Validation, Visualization, Writing – original draft, Writing – review & editing. BD: Writing – review & editing.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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