ECOLOGY

Conserving honey bees does not help wildlife

High densities of managed honey bees can harm populations of wild pollinators

By **Jonas Geldmann** *and* **Juan P. González-Varo**

There is widespread concern about the global decline in pollinators and the associated loss of pollination services. This concern is understandable given the importance of pollinators for global food security; ~75% of all globally important crops depend to some degree on pollination, and the additional yield due to pollination adds ~9% to the global crop production (*1*). These services are delivered by a plethora of species, including more than 20,000 species of bees as well as butterflies, flies, and many species of vertebrates (*1*). Yet, concern has focused on one species above all: the western honey bee (*Apis mellifera*). This is unfortunate because research shows that managed honey bees can harm wild pollinator species, providing an urgent incentive to change honey bee management practices.

The western honey bee is the most important single species for crop pollination, with a rapid global growth in managed colony numbers over the past decades, particularly in much of its introduced range. Honey production can also be an important source of income, particularly in many rural communities. Lack of pollination of commercial crops associated with the current honey bee die-off in some countries—most notably, the United States—is, however, an issue of agricultural rather than environmental importance.

Despite this, news stories often view honey bee losses through the lens of environmental concern (*2*). This has led to initiatives, masked as conservation, that promote honey bees in cities and even in protected areas far from agriculture (see the photo) (*3*). Nongovernmental organizations have even responded to the pollinator crisis with a call to action that includes suggestions to buy local honey and support honey bee conservation (*4*, *5*).

Across organizations and strategies, there is a recognition that there are pollinators other than the western honey bees. Nevertheless, the general belief that addressing the decline in managed honey bees would be an environmental feat persists in the media (*2*) and among the public (*6*). This lack of distinction between the declines of wild pollinators and the plight of a heavily managed, agricultural species may even reduce efforts to conserve wild pollinator species, many of which are nationally or even globally threatened (*1*).

Furthermore, there is increasing evidence that unnaturally high densities of honey bees, associated with beekeeping, can exacerbate declines in wild pollinators (*7*). This problem is particularly evident in areas where western honey bees have been introduced (*7*); but even in their native range in Europe, managed honey bees have been shown to depress the densities of wild pollinators around apiaries both in natural habitats (*8*) and in crop fields (*9*). Furthermore, they move toward surrounding natural habitats in unnaturally high densities after the blooming period of mass-flowering crops (*10*), potentially outcompeting wild pollinators (*11*).

Besides competing with wild species for resources (*12*), honey bees are linked to the spread of diseases to wild pollinators via shared flowers, an effect that is likely amplified by trade with and movement of honey bees (*13*). Honey bees can also have a negative impact on the reproductive success of wild plants (*11*) and even depress nonpollinator species—for example, the threatened Lear's Macaw in Brazil, which competes with honey bees for nest sites in rock cavities. The western honey bee thus unequivocally fits Geslin and colleagues' concept of a "massively introduced managed species," which, regardless of whether they are native or not, can negatively affect their environment through sheer numbers (*14*).

We do not dispute that managed honey bees are a useful, even a necessary agricultural tool for improving the yield of many mass-flowering crops. Additionally, many factors that negatively affect managed honey bees (such as neonicotinoids, parasites, and diseases) are also harming native pollinators. Thus, honey bees can serve as a "canary in a coalmine"; the declines observed in managed colonies across Europe and the United States are likely mirrored by many wild pollinator species. In fact, strategies developed to reduce managed honey bee losses, such as banning neonicotinoids, will also benefit many wild pollinators desperately in need of conservation attention.

But managed honey bees are a means, not an end, and strategies to ensure sufficient crop pollination need to take account of potential competition with native wild pollinators. This necessitates a better assessment of when, where, and in what densities honey bees are required to ensure effective pollination of mass-flowering crops without harming wild native pollinators or plants. Such assessments must

In the Teide National Park, Spain, up to 2700 honey bee hives are introduced each spring for honey production.

PHOTO: ALFREDO VALIDO

Conservation Science Group, Department of Zoology, University of Cambridge, Cambridge CB2 3EJ, UK. Email: jg794@cam.ac.uk; jpg62@cam.ac.uk

explicitly account for the contributions of native wild pollinators, which may be responsible for as much as 50% of the needed pollination services (*15*). Within their native range, some amount of pollination by western honey bees is natural, although the historic density of wild colonies is largely unknown. Safe densities of managed honey bees will vary from natural and protected habitats, where wild native pollinators are most abundant and beekeeping is mainly done for honey production, to agricultural and managed landscapes, which are less important for the conservation of the most threatened pollinator species.

Management practices must also address the periods when no or insufficient mass-flowering crops are in bloom because managed honey bees are likely to compete most intensively with wild native pollinators during these times. In the United States, honey bee hives are moved around to track the bloom of various crops, from California almond groves in early spring to Washington apples in the late summer. Similar approaches might be needed across Europe and other places to match pollinator supply to pollination demand but must address the risk of spreading diseases. Policies to limit the number of honey bees in specific periods might also be needed, such as early honey removal and keeping the individual hives smaller. If implemented wisely, such strategies will come with no extra cost to farmers but may increase the price of honey.

Fulfilling the need for sufficient and effective pollination of the world's crops without jeopardizing biodiversity will also require an ambitious research agenda. The past decade has seen an explosion in research tackling the decline in managed honey bees, specifically focused on the potential loss of pollination services. This research has been heavily supported by the private sector and governments, particularly in Europe and the United States, which have invested millions to reverse the loss of managed honey bees. Comparatively little research has been undertaken to understand wild native pollinator declines, including the potential negative role of managed honey bees. The European project STEP (Status and Trends in European Pollinators; www.step-project.net), which aimed to document the nature and extent of pollinator declines and brought together 21 universities and institutions from 16 countries, exemplifies the type of research initiative needed to elucidate the drivers of pollinator declines.

Concern about honey bees has been an engine for shining light on the decline of pollinators and has likely been important in raising awareness of pollinator declines at large (*4*, *5*). Thus, a more nuanced understanding of the role of domesticated honey bees must not be misconstrued as a general lack of importance of conservation attention on wild native pollinators. Half of all European bees are threatened with extinction (*1*), and the conservation of wild native pollinators is among the most important conservation challenges in many parts of the world. We therefore see a need for a conservation strategy that explicitly focuses on the main drivers of the current declines in wild native pollinators, not on agricultural yield.

As a first step, crop pollination by managed honey bees should not be considered an ecosystem service because those pollination services are delivered by an agricultural animal and not by the local ecosystems. Further, managed honey bee hives should not be placed in protected areas, where they are likely to do the biggest damage to wild pollinators. In other areas of conservation importance, beekeeping may require impact assessments that consider potential spillover after the bloom of adjacent mass flowering crops. Honey bees may be necessary for crop pollination, but beekeeping is an agrarian activity that should not be confused with wildlife conservation. ■

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QUANTUM INFORMATION

Toward a silicon-based quantum computer

A controlled NOT gate for two quantum bits is demonstrated with a strained-silicon device

By **Lars R. Schreiber** *and* **Hendrik Bluhm**

Quantum computing could enable exponential speedups for certain classes of problems by exploiting superposition and entanglement in the manipulation of quantum bits (qubits). The leading quantum systems that can be used include trapped ions, superconducting qubits, and spins in semiconductors. The latter are considered particularly promising for scaling to very large numbers of qubits. On page 439 of this issue, Zajac *et al.* (*1*) demonstrate a quantum operation involving two qubits in silicon (Si), which is a major step for the field of semiconductor qubits. Together with easier-to-achieve manipulation of single qubits, these operations represent the basic steps of any quantum algorithm.

"...creating systems that cannot be simulated with today's supercomputers will take about 50 qubits."

The coupling between the two qubits is achieved through the so-called exchange interaction, which results from coupling of the two electrons through a tunnel barrier. This barrier can be controlled by changing the voltage on the central gate. The authors further use microwave excitation to implement the desired operation. In an external magnetic field, spins that are not aligned with the field precess around it like an

Jülich Aachen Research Alliance (JARA), Institute for Quantum Information, RWTH Aachen and Forschungszentrum Jülich, Germany. Email: lars.schreiber@physik.rwth-aachen.de