WHAT'S BEST FOR BEES

Pollinating insects are in crisis. Understanding bees' relationships with introduced species could help.

BY SHARON LEVY

Bees thrum among bright red blossoms on a spring day on Mount Diablo, near San Francisco Bay. Alexandra Harmon-Threatt, a young ecologist just finishing her doctorate at the University of California, Berkeley, lovingly identifies an array of native pollinators. She points out three species of bumblebee, each with a unique pattern of black and yellow stripes. There are bee-flies, members of the fly family covered in soft brown fur, which look and act like bees. Among the native insects are plenty of honeybees (*Apis mellifera*), the species raised by beekeepers worldwide and introduced to the Americas by English settlers in the seventeenth century. All these insects are drawn to a clump of red vetch (*Vicia villosa*), an invasive weed. Just down the road is a patch of native lupins, laden with purple blossoms. But the lupins bloom in silence: no bees attend them.

For the past three years, Harmon-Threatt has been studying the ways in which the native yellow-faced bumblebee (*Bombus vosnesenskii*) uses the plants growing in the area. By capturing bees as they visit plants and then sampling the pollen they carry, she has confirmed in unpublished work that they get much of their food from introduced plants. And by analysing the amino-acid content of pollen, Harmon-Threatt has shown that bee foraging behaviour can be driven by a craving for nutrients rather than an evolved attachment to a specific plant. Although many conservationists assume that introduced plants are always destructive, her work shows that it's not necessarily so from a bee's point of view. What matters to most bee species is the abundance and quality of pollen — and if an introduced plant, such as the red vetch, offers more protein-rich food than the natives around it, the bees will collect its pollen.

Harmon-Threatt is one of a growing group of scientists studying the evolving relationships between native bees and introduced plants. Their work is critical in a world where human actions have dramatically shifted the distributions of plants and are forcing a pollinator crisis. Most flowering plants need animal pollinators in order to reproduce, and bees serve that role for many important crops — including fruits, pulses, some vegetables and alfalfa — many of which were themselves introduced to the United States. Yet stocks of the domesticated honeybee have been declining in the United States and Europe: the number of managed hives in the United States, for example, has dropped from nearly 6 million in the 1940s to 2.3 million in 2008 (see 'Sting in the tale'). Habitat loss, pesticide poisoning, viruses and parasitic mites, any or all of which may be behind the mysterious syndrome called colony collapse disorder, have taken their toll on the domesticated bees, leaving farmers increasingly dependent on native bees. But they, too, are suffering from the effects of pesticides, disease and changes in land use.

What bees need most, the new pollination studies have shown, is a diverse community of flowering plants that bloom throughout the spring and summer. Abundance and diversity

An American bumblebee collects pollen from the non-native dandelion. E. RESCHKE/GETTY

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matter more than whether species are native or exotic. These findings could inform conservation strategies used by farmers and other land managers. Park managers tend to target invasive weeds such as red vetch with herbicides because they can outcompete native plants. But for bees, "just taking all the vetch out might not be the best idea", says Harmon-Threatt. "It might take ten to fifteen different species of native plants to support this array of pollinators."

Stories of exquisitely specialized pollination systems — such as those of yuccas, which are pollinated only by coevolved moth species — can give the impression that pollination is an exclusive, highly choreographed dance. "Until the past five or ten years, people thought that exclusive pollination relationships were more common," says Rachael Winfree, a pollination biologist at Rutgers University in New Brunswick, New Jersey.

By studying entire networks of pollinators and plants, however, biologists have learned that most native bees are far less picky than was imagined. Winfree and her colleagues have investigated the ways in which bees use flowers growing in agricultural, urban and natural areas — ranging from woodland to farm fields and suburban gardens — in central California and southern New Jersey. The study, led by Neal Williams at the University of California, Davis, and published earlier this year[1], found that bees collect pollen from both alien and native plants in proportion to a plant's abundance in the landscape. In highly disturbed habitats, bees make greater use of alien plants — not because the bees prefer them, but simply because introduced plants are more common where people have transformed the landscape. That makes sense to Winfree. "I don't see why bees would know or care whether a plant was native or exotic," she says.

But not all altered landscapes are equal for bees: modern agriculture has taken a severe toll on wild bee numbers. Vast monocultures — such as the almond orchards of central California and the soybean fields of Argentina — bloom for only three or four weeks each season, offering no food for bees the rest of the time. "The expansion of these crops destroys habitat for bees," says Marcelo Aizen, a pollination biologist at the National University of Comahue in San Carlos de Bariloche, Argentina.

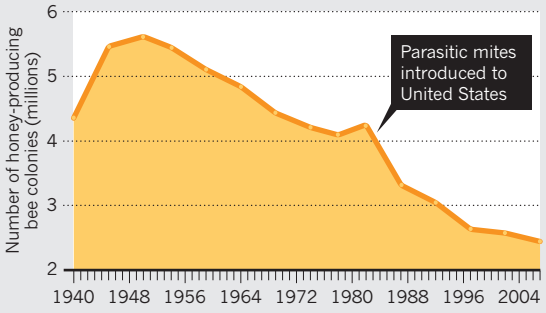
Claire Kremen, a conservation biologist at the University of California, Berkeley (and Harmon-Threatt's mentor), has shown that the diversity of pollinators drops with increasing distance from wild habitat, as does the number of visits by wild bees to flowering crops[2,3]. This cuts crop yields. A study by Aizen and his colleagues, published in April this year, documented a drop in the yield per acre of pollinator-dependent crops since 1961, even as total global production has increased[4]. Falling yields have prompted farmers to put more land under cultivation, further eroding bee habitat. Modern agriculture seems locked in a vicious circle of pollinator destruction.

Yet Kremen and her colleagues showed in 2004 that crop pollination by native bees increases dramatically when natural habitat exists within 1–2.5 kilometres of farm fields[3]. Farms where just 30% of the surrounding landscape is covered in wild vegetation are completely pollinated by native bees, and flourish without help from domesticated honeybees.

As most crops in California's Central Valley are far from patches of wild habitat, Kremen and Williams have been experimenting by growing hedgerows of diverse flowering plants in orchards and fields. They now have a list of native California plants, such as redbud (*Cercis occidentalis*) and wild asters, which can be combined to create ideal hedgerows, providing pollen-rich blooms from early spring to late autumn. The results are not yet published, but Kremen says it is already clear that the hedges boost the diversity of native bees, and they are being adopted by farmers. The burning question now, says Kremen, is "how much hedgerows can contribute to long-term population persistence of individual bee species".

STING IN THE TALE

Honeybees — highly valuable pollinators — are in decline in the United States because of habitat loss, pesticide poisoning, viruses and parasitic mites.



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WEEDS WILL DO

Winfree finds that bees don't even need pristine hedges — weeds will do. She studies bee communities in parts of New Jersey and Pennsylvania where native bees pollinate about 90% of the crops. In one study, she and her team watched 6,187 bee visits to watermelon and tomato crops on 23 farms[5]. Both computer modelling and observation suggest that these crops are fully pollinated by wild bees. That's possible, Winfree explains, because the wet climate encourages the growth of weedy plants that spring up at the field edges, and bees use these scraps of habitat to nest and forage. There's another crucial difference from California: in Winfree's study area most farmers plant a variety of crops rather than monocultures.

In a study of New Jersey pine–oak forest[6], Winfree was surprised to find that bee populations are more abundant and diverse near sites of human disturbance — where backyard gardens or farm fields add to the range of blossoms available. But the picture is likely to vary from one area to the next. In a recent review of the literature, Winfree and her colleagues concluded that land-use changes such as urbanization and deforestation can affect native pollinators differently, depending on whether they increase or reduce the numbers and diversity of flowering plants[7].

There's yet another complication: although some exotic plants can feed native pollinators, such plants can also fuel the growth of alien bee populations. Aizen and his colleagues have analysed webs of plants and pollinators in the southern Andes and on islands in the North Atlantic and the Indian Ocean[8]. They found that, in some cases, exotic plants and pollinators team up to dominate resources, to the detriment of native bees and native plants. "You cannot generalize and say it is good or bad to have alien plants," says Aizen. Problems arise when the alien plants become so widespread in an ecosystem that they lower the diversity of species. "It takes a diverse assemblage of plants to support a diverse assemblage of bees. That is the lesson," he says.

There are still many lessons to learn. Winfree notes the relatively primitive state of pollination ecology: most research on bee diversity has simply counted the number of species, without tracking their fates over time. Her current work examines which bee species are most vulnerable to human disturbance, and explores in more detail whether both rare native bees and efficient pollination services can be restored by increasing the diversity of flowering plants.

Still, a new awareness of the vital role of native bees is spreading. Bruce Rominger, who farms onions in Yolo County, California, has interlaced his crops with hedgerows of native plants, including buckwheat and willow. Now, strolling through his fields on a spring day, he recognizes a variety of insects visiting the blossoms — from plump bumblebees to slender, iridescent solitary bees. Hedgerows are becoming common among Yolo County farms. "The more native pollinators we have," says Rominger, "the better off we'll be." ■

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