A world without bees

Responsible for pollinating three-quarters of the world's leading food crops, honeybees are essential to modern agriculture. Yet with colonies collapsing across the globe bees are in crisis. ***Elliott Cannell****, Coordinator of PAN Europe, reviews* A World Without Bees *by journalist and beekeeper* ***Alison Benjamin*** *and co-author* ***Brian McCallum****.*

In April the pear orchards of southern Sichuan, China play host to one of the most bizarre events in the world agricultural calendar. Thousands of rural residents take to the trees clutching makeshift stepladders and feather dusters, to undertake the Olympic-sized challenge of brushing each pear blossom by hand. Despite appearances, Sichuan's labourers are not enacting an ancient Chinese fertility ritual or following the latest madcap orders of the Beijing politburo. They are conducting essential, perhaps pioneering work as human pollinators.

Welcome to a world without bees: a world in which most crops must be pollinated by hand. Chinese pear farmer Cao Xing Yuan, interviewed for US documentary *Silence of the Bees,* knows just how tough manual pollination is. Ever since bees in his region were wiped out by pesticides 20 years ago, he and his neighbours have had to scrub pollen from the pear trees, dry it by hand, and carefully dust it onto each pear blossom. It is a slow, laborious task – and much less efficient than honeybees, whose colonies visit up to three million blossoms per day.

Decline of the honeybee

While the Sichuan scenario remains almost unique, the spectre of chronic honeybee losses may yet haunt farmers globally. In recent years bees around the world have suffered on an unprecedented scale. Thousands of full-strength colonies have collapsed, often with adult bees leaving their hives never to return. US beekeepers lost 35% of their colonies last winter, and 30% the winter before. The worst affected report colony losses of 90% since the end of 2006. Mass bee deaths have also occurred in Canada, Brazil, India, and China, and Western Europe. In France mortality rates of up to 60% were reported, while the UK farming minister has warned that bee colonies could vanish in under a decade. The US National Research Council warns that bees could be extinct from North America by 2035.

A World Without Bees provides a timely, authoritative and intelligent overview of the role of bees in global agriculture and of the crisis they face. Part eulogy, part global wake-up call, the book is highly readable, and makes light work of hard evidence. Compiled by UK journalist and beekeeper Alison Benjamin and co-author Brian McCallum, this book ought to become recommended reading for farmers, regulators and campaigners worldwide. As its authors argue, the disappearance of bees may be a bigger problem than climate change.

No more bees, no more man

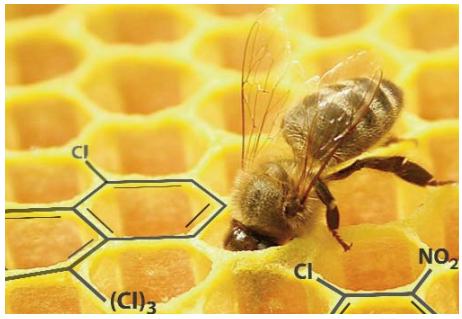
While environmentalists may find sacrilegious the proposal that honeybees are a bigger deal than our climate, they are responsible for the continued success of many leading commercial crops worldwide. Without bees these crops could go unpollinated. And as Albert Einstein observed: 'No more bees, no more pollination, no more plants, no more man.'

This apocalyptic scenario is supported by an international research team led by Alexandra-Maria Klein, agroecologist at the University of Göttingen, Germany. Klein found that three quarters of the world's 115 leading food crops require animal pollination. These crops account for US$1 trillion of the US$3 trillion in annual sales of agricultural produce worldwide, and provide 35% of the calories consumed by humans every year. Honeybees remain the most economically valuable pollinators of commercial crops worldwide. Yet despite their essential role, they face increasing threats.

Many of the negative factors affecting honeybees are born from the shift towards large-scale agriculture. When most farms were small family affairs, pollinators would come from nearby wildlands. But the spread of industrial farming, increased use of pesticides. Loss of habitat, led to declines in the role of wild insect populations such that they are now reported to account for just 15% of global crop pollination. In response, farmers started to hire in honeybees to pollinate their fields. Demand soon spawned an industry which today sees honeybees over-exploited, plagued by parasites, exposed to pesticides, and ill-adapted to their modern conditions.

On the road

In the winter of 1907, Utah farmer Nephi Ephraim Miller loaded beehives onto a railway wagon destined for the warmer climes of California. Miller is credited as being the first itinerant beekeeper in America. Today half of the 2.4 million honeybee colonies in the US travel to California each spring; some coming from as far away as Florida and Massachusetts. Mounted on the back of huge juggernauts, 500 hives at a time, these bees join others flown in from Australia, in spending 22 days pollinating the vast almond orchards in California's Central Valley. Fifty years ago this mass migration did not happen. But California's almond orchards now cover six times more land. Yields have risen substantially and the Central Valley now produces 80% of the world's almonds, earning California US$



1.9 billion in exports.

With declining numbers of honeybees, pollination has become big business – particularly in the US, which has fewer wild pollinators than Europe. Joe Traynor, a Californian 'pollination broker', has watched the cost of pollination soar. 'When I started in 1960, the price for honeybee rentals was $3 per hive. In 2004 it was $60 per hive. This year it was $160 to $180 per hive.' Pollination expenses now account for 20% of a California almond farmer's annual budget – more than fertilizer, water or even labour. Yet while the service they provide now brings substantial economic returns, the industrialisation of pollination has brought negative consequences for the honeybee.

A tour of duty

Firstly, the annual workload per colony has greatly increased. Commercial hives in the US typically do a five month tour of duty, of which California is just the beginning. Having worked the Central Valley almond blossoms, bees are bussed up to the apple orchards in Washington State, before heading to the north east for cranberries and pumpkins. From here they may go to Maine to pollinate blueberries, before spending the summer in the prairies of South Dakota collecting nectar for honey. Beekeepers in Australia work their hives just as hard. In some states the climate allows for beekeeping all year round and hives are moved as many as six times in a 12 month cycle.

Maintaining the honeybees' workload demands artificial interventions. US beekeepers use a suite of protein and energy supplements to coax their bees into action immediately after winter. Other hives are treated with synthetic pheromones which stimulate increased foraging activity.

Commercial beekeepers argue that modern working conditions are not responsible for collapses in the honeybee population. Bret Adee of Adee Honey Farms told Benjamin and McCallum, 'We've been trucking bees for 50 years, and in that time conditions have improved for the bees: the roads are smoother, the trucks are better, it takes less time to move them about, and we pay a premium for special [bee friendly] haulage companies.' But Adee's views are not universal. Joe Traynor the Californian pollination broker says: 'We're interfering with their natural cycle … As a result they're suffering burnout.' Many others in the industry agree.

Loss of local varieties

A second negative consequence of the industrialisation of pollination has been the decline in local honeybee varieties. The honeybee, *Apis mellifera*, originated millions of years ago in Africa before spreading northwards to occupy most of Europe. Environmental variation in the range of habitats and climates that *Apis mellifera* colonised gave rise to 20 evolutionary subspecies; each better adapted to survival in a specific environment.

But while natural selection favours diversity, beekeepers worldwide prefer much the same kind of bee – gentle, industrious and good at living in man-made hives. Two European sub-species, *Apis mellifera ligustica*, from Italy, and *Apis mellifera carnica*, from the Balkans, now dominate beekeeping worldwide.

But Professor Robin Moritz, who led a European Union funded research network on the biodiversity of honeybees in Europe, warns that we have made bees much more susceptible than species adapted for local conditions. The resultant decrease in genetic diversity reduces the honeybee's potential to evolve in response to environmental change.

The varroa mite

The construction of the trans-Siberian railway, finished in 1916 under Tsar Nicolas II, opened new horizons in the transport of goods between Asia and Europe. For bees the railway also marked a new dawn. Russian beekeepers could now transport their western honeybees to countries where *Apis cerana*, the Asiatic honeybee lived. The move opened a Pandora's Box, sparking one of the most devastating developments in the 5,000 year history of beekeeping.

The Asiatic honeybee has for centuries played host to the varroa mite; a blood-sucking parasite closely related to the tick. The varroa mite lives in symbiosis with its host which has in turn evolved ways of controlling it such that it rarely causes harm. Western honeybees have no such defences. When infested bees were exported back to Russia the varroa mite soon spread. By 1953 the first case of varroa was reported inside the Soviet Union. By the 1960s the mite had spread to Hong Kong, Philippines, China, India and Japan. A decade later it invaded Eastern Europe and South America: all the time hitching a lift on the back of hapless bees as they were moved around the world by man. Today Australia is the only continent free of varroa.

Colonies were decimated and the parasite became the most deadly honeybee pest ever seen. Its arrival in the US sent shock waves through the beekeeping community and was documented by Malcolm Stanford, an entomologist at the University of Florida: 'The introduction of the Asiatic bee mite is a nightmare come true for the North American beekeeping industry ... many persons are in a state of shock. There is near unanimous support that it is potentially the most serious pest ever to threaten US beekeeping.'

A viral vector

Initially scientists assumed that the mite's parasitic feeding habits were killing the bees. But the losses incurred were not always proportional to the number of mites infesting a colony. This anomaly was resolved by Brenda Ball, a British virologist, who showed that the varroa was not the primary cause of death. Instead it acted as a vector.

Bees, like humans, carry a cocktail of latent viruses which occasionally activate. Varroa mites were devastating bee colonies by spreading active viruses, much as HIV is spread by sharing dirty needles. Up to 14 potentially lethal honeybee viruses have now been identified globally.

Yet while the varroa, and the viruses it spreads, are doubtless responsible for bee deaths worldwide, it is unlikely that the mite is to blame for the recent spate of colony failures. As US investigations reveal, a significant proportion of dead colonies contain no varroa. This discovery has led some epidemiologists to suggest that lethal viruses might be transmitted directly from bee to bee. Others point to evidence that pollen on flowers can become contaminated with viruses, potentially infecting each bee that visits. However, a worldwide honeybee survey of 2005 found that nearly all bee colonies, including healthy ones, are infected with potentially deadly viruses. Other evidence also suggests that colony failure does not follow the profile of a viral infection.

Pesticides: toxic by design

Dave Hackenberg, a commercial beekeeper from Pennsylvania, lost nearly 75% of his 3,200 honeybee colonies. Before renting out his hives, Hackenberg now asks farmers whether they use a variety of insecticides called neonicotinoids. 'I'm quizzing every farmer around, he says. If you're going to use that stuff, then you're going to have to go to somebody else.'

Pesticides have become a leading culprit in the quest to understand mass bee deaths and have most likely been killing bees since they were first sprayed onto crops decades ago. But it was not until the development of a new family of insecticides – the neonicotinoids – that links between pesticides and bee colony failure became a global issue.

As the sunflowers opened in July 1994, France's honeybee population suddenly crashed. Beekeepers described whole colonies 'melting away'. Bees that did not vanish behaved strangely or seemed paralysed. Four times more bees than normal died that winter. French beekeepers soon spotted that 1994 was the first year imidacloprid was used as a seed dressing on sunflowers in the parts of France where mass bee mortality occurred. A neonicotinoid, imidacloprid is the world's best selling pesticide with global sales of US$ 860 million. The insecticide is a powerful neurotoxin described by US Environmental Protection Agency as 'highly toxic' to honeybees.

Banned in France and Germany

Following extensive scientific research, and the death of one third of French honeybees, politicians in Paris suspended the use of imidacloprid as a seed dressing on sunflowers. Follow-up studies by the French government found imidacloprid impairs the honeybee's neural capacity, even at very low doses. These findings were later backed by Italian research showing that imidacloprid exposure makes it harder for bees to find their way back to their hives – which could explain the sudden disappearance of healthy colonies.

Subsequent investigations have since led France to slap further curbs on imidacloprid as well as fipronil, while Germany recently suspended seed treatments containing three neonicotinoids: imidacloprid, thiamethoxam, and clothianidin, as well as methiocarb. In 2006, European beekeepers demanded an EU-wide ban on imidacloprid, fipronil, thiamethoxam, and clothianidin, while a year later the European Parliament supported the withdrawal of all pesticides toxic to bees – though this proposal has yet to make it into law. In the US, scientists, beekeepers and NGOs have voiced similar concerns.

Yet while mounting evidence now links exposure to neonicotinoids with the disappearance of bee colonies, researchers doubt these chemicals are the sole cause of colony failures. Firstly, honeybee colonies were collapsing long before neonicotinoids were used to treat crops. In addition, many colony failures have occurred in large-scale farming areas where neonicotinoids had not been used. To complicate things further, many non-neonicotinoid pesticides are now identified as being toxic to bees. A study by the UK government identified 40 pesticides in this category, including 37 not from the neonicotinoid family, while estimates from the pesticides industry suggest between 15% and 20% of 210 pesticide substances used in the European Union are toxic to bees (HQ>50%).

What's to blame?

While a diversity of factors threatens the honeybee's wellbeing, the scientific community has yet to agree a single coherent theory for colony collapses. Having analysed the major culprits, and some of the minor ones, Benjamin and McCallum conclude with perhaps the only consensus statement currently available: that no single factor is entirely to blame. As many top researchers are now saying the bee crisis is likely due to multiple factors acting in combination or apart.

Without doubt these factors include pesticides. Not only are many pesticides toxic to bees, but pesticides are ubiquitous contaminants of the honeybee's world. A US survey just published identified 70 pesticides or breakdown products in pollen and bees: all bees tested showed at least one pesticide, and pollen averaged six pesticides with as many as 31 in a single sample. As Bernard Vaissière, of France's national agricultural research institute says of neonicotinoids: 'It is difficult to imagine that these insecticides

had no impact. They were in the pollen and the nectar.'

The road ahead

Policy makers must chart the path ahead. Several factors affecting the honeybee are beyond political control. The varroa genie is well out of the bottle: so too are the viruses it carries. There is little any jurisdiction could do to curb their impact.

The trend towards large-scale agriculture also offers no quick fix. Only in the long term might global farming methods shift such that bees are no longer trucked around, or coaxed with artificial supplements. A switch to other sub-species better suited is unlikely as most honeybee varieties are maladapted to commercial conditions.

Changing the mix of pesticides applied to pollinated crops arguably represents the best strategy option in the policymaker's tool kit. Wherever possible, replacing pesticides toxic to bees with safer chemical or non-chemical alternatives would undoubtedly serve a fillip to honeybee colonies at a time of global crisis. While we have yet to see whether this option can make it past industry lobbyists, one thing seems certain: if honeybees do take their last dance sometime soon, probably so shall we.

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For ongoing news updates on the global bee crisis, visit Alison Benjamin's website at: www.aworldwithoutbees.com

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