A World Without Bees

Responsible for pollinating three quarters of the world's leading food crops, honeybees provide an essential service to modern agriculture. Yet with colonies collapsing in North America, Western Europe, Brazil, India and China, globally bees are in crisis. ***Elliott Cannell****, Coordinator of PAN Europe, reviews 'A World Without Bees' – a new book 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. Each spring thousands of rural residents are mobilised to take to the trees clutching makeshift stepladders and feather dusters. They then undertake the Olympic-sized challenge of brushing each of the pear blossoms 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 in fact conducting essential, perhaps pioneering work as human pollinators.

Welcome to a world without bees: in which most crops must be pollinated by hand. Chinese pear farmer Cao Xing Yuan, interviewed for the US documentary 'Silence of the Bees' knows just how tough manual pollination is.[1] 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 employing honeybees whose colonies visit up to 3 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 a scale never seen before. Thousands of full strength colonies have collapsed, often with adult bees leaving their hives never to return. US beekeepers lost 35% of their honeybee colonies last winter, after losing 30% the winter before. Those worst affected report colony losses of 90% since the end of 2006. Mass bee deaths have also occurred in Canada, Brazil, India, and China, as well as throughout Western Europe. In France recent media articles report mortality rates of up to 60%, 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' (Guardian Books, 2008) provides a timely, authoritative and intelligent overview of the role of bees in global agriculture and the colony collapses being witnessed worldwide. 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, 'A World Without Bees' should ought to become recommended reading for farmers, regulators and campaigners worldwide, not least because as its authors argue, the disappearance of bees represents a bigger problem than climate change.

No more bees, no more man

While environmentalists may find sacrilegious the proposal that pollinators are a bigger deal than our climate, honeybees *are* responsible for the continued success of many leading commercial crops worldwide – including apples, oranges, onions, carrots, broccoli, sunflowers, strawberries, melons, avocados, peaches, cotton, and cattle feeds such as soy and alfalfa. 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 recent findings by an international research team led by Alexandra-Maria Klein, agroecologist at the University of Göttingen, Germany. Klein's 2007 overview of global agriculture found that three quarters of the world's 115 leading food crop species require animal pollination.[2] Together 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, as well as most of the vitamins, minerals and antioxidants. Klein's team also reports that honeybees remain the most economically valuable pollinators of commercial crops worldwide. Yet despite their essential role in sustaining modern civilisation, the world's bees face increasing threats – not least from human activity.

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, and 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.[3] In response farmers started to hire in honeybees to pollinate their fields, thus creating a market for pollination. Demand soon spawned an industry which today sees honeybees over exploited, plagued by parasites, exposed to pesticides, and ill adapted to the conditions they work in.

On the Road

In the winter of 1907, Utah farmer Nephi Ephraim Miller loaded his beehives onto a railway wagon destined for the warmer climes of California. Miller is credited as being the first iterant beekeeper in America. Today half of the 2.4 million honeybee colonies in the US are transferred to California each spring; some travelling from as far 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 didn't happen. But since then California's almond orchards have expanded to cover six times more land. Yields have risen substantially and Central Valley now accounts for 80% of global almond production, earning California US$ 1.9 billion in exports – double the revenue from its Napa Valley wines.

With declining numbers of honeybee colonies, pollination has become big business – particularly in the US which has fewer wild pollinators than Europe.[4] Joe Traynor, a Californian 'pollination broker' interviewed by Benjamin and McCallum, has watched the cost of pollination soar in recent years. "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." Those runaway prices have made pollination expenses spiral to 20 percent of a California almond farmer's annual budget – more than fertilizer, water or even labour. Yet while the service they provide now attracts substantial economic returns, the industrialisation of pollination has brought negative consequences for the honeybee.

A Tour of Duty

Firstly the annual workload per colony been 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 over 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 months cycle. Such attenuation of 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 by no means 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 of local honeybee varieties. The honeybee, *Apis mellifera*, originated millions of years ago in Africa before spreading northwards to occupy most of Europe. Its vast territory once extended from the Cape of Good Hope to the Nile Delta, up through the Middle East and across Russia, Scandinavia and the Mediterranean. Environmental variation in the range of habitats and climates that *Apis mellifera* colonised, gave rise to 20 evolutionary sub-species; each better adapted to survival in a specific environment. Today studies confirm 36 physical differences including size, colour, and length of hair.

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. This explains why two European sub-species, *Apis mellifera ligustica*, from Italy, and *Apis mellifera carnica*, from the Balkans, now dominate beekeeping worldwide. A recent survey of colonies in south eastern USA for example found that 96% of bees belonged either to the Italian or Balkan variety.

“Commercial selection is directly opposite to what natural selection would achieve”, says Professor Robin Moritz, who led a European Union funded research network on the biodiversity of honeybees in Europe. By breeding a gentle, efficient honey maker, he warns, we have made bees much more susceptible than species adapted for local conditions. Worst still for evolutionists, the resultant decrease in genetic diversity hampers the honeybee’s potential to evolve in response to changes in climate, or the arrival of novel parasitic species.

The Varroa Mite

The construction of the trans-Siberian railway, finished in 1916 under Tsar Nicolas II, delivered exciting new horizons in the transport of goods between Asia and Europe. Cheap Siberian grain could be imported to central Russia, while large areas of the East were opened to settlement and industrialization. For the world of 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. While the two species could happily co-exist, 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 lives in symbiosis with its long-term host and in turn the Asiatic honeybee has evolved ways of controlling the varroa such that it rarely causes harm. Western honeybees have no such defences. And 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. In the 1960s the mite 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.

The spread of varroa has killed billions of honeybees worldwide. Colonies were decimated and the parasite became the most deadly honeybee pest ever seen. Its arrival in US sent shock waves through the beekeeping community and was documented in a note 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, Even as I write this, 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 this didn’t explain why the losses incurred were not always proportional to the number of mites infesting a colony.[5] This anomaly was later resolved by Brenda Ball, a British virologist, who showed that the varroa was not in fact the primary cause of death in bees. Instead varroa 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 – as is certainly the case in varroa-free Australia where bee viruses are common. Others point to evidence that pollen on flowers can become contaminated with viruses, potentially infecting each bee that visits. Yet this theory is itself undermined by a worldwide honeybee survey of 2005 which found nearly all bee colonies are infected with potentially deadly viruses. Other evidence suggests the phenomenon of colony failure does not follow the profile of an infectious disease.[6]

Pesticides: Toxic by Design

Having lost nearly 75% of his 3,200 honeybee colonies, Dave Hackenberg, a commercial beekeeper from Pennsylvania, doesn't take any chances. Before renting out his hives, Hackenberg now asks farmers whether they use a variety of insecticides called neonicotinoids.[7] "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 better understand mass bee deaths and have most likely been killing bees since they were first sprayed onto crops decades ago. Indeed, Rachel Carson described how as long as a century ago beekeeping was almost wiped out in southern US after arsenic was applied to the cotton fields. But it wasn't until the development of a new family of insecticides – the neonicotinoids – that the links between pesticides and bee colony failure really 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 didn't vanish behaved strangely or seemed paralysed. That winter four times more bees died than normal. 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.[8] The insecticide is a powerful neurotoxin described by US Environmental Protection Agency as 'highly toxic' to honeybees – meaning it can kill on contact, as well as in residues.

Banned in France, Germany

Following extensive scientific research, and the death of one third of French honeybees, politicians in Paris decided to act, suspending 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. While the findings set industry officials doing a waggle dance of their own, they were later backed up by Italian research showing that imidacloprid exposure makes it harder for bees to find their way back to their hives – which would help 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.[9] 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 all voiced concerns on pesticides and bees, including the Sierra Club which recently demanded the withdrawal of neonicotinoids – including imidacloprid, thiamethoxam, and clothianidin.[10]

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 worldwide. Firstly honeybee colonies were collapsing long before neonicotinoids were used to treat crops. In addition many colony failures have been confirmed 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 pesticide substances in this category, including 37 not from the neonicotinoid family,[11] 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%).[12]

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 explaining how bees are being killed. Having analysed the major culprits, as well as 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 global 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 published in August 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.[13] As Bernard Vaissière, a researcher at 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

While scientists are free to focus on academia, policy makers must chart the path ahead. From this perspective it is significant that several factors affecting the honeybee are beyond political control. Whatever the importance of parasites, for example, the varroa genie is well out of the bottle: so too are the viruses it carries. Regardless of future scientific theories on the role these factors might play, 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 won't be trucked from field to field or coaxed with artificial supplements. A switch to other sub-species better suited to local climates is also unlikely as most honeybee varieties are mal-adapted 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.

END NOTES

Alison Benjamin and Brian McCallum, A World Without Bees, Guardian Books, London, 1 July 2008, 298 pp, ISBN 978-0-85265-092-9, £9.99

A second book on bees is expected on 16 September 2008: Rowan Jacobsen, Fruitless fall: The Collapse of the Honeybee and the Coming Agricultural Crisis', Bloomsbury Press, London, 288 pp, ISBN – 978-1596916395

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

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