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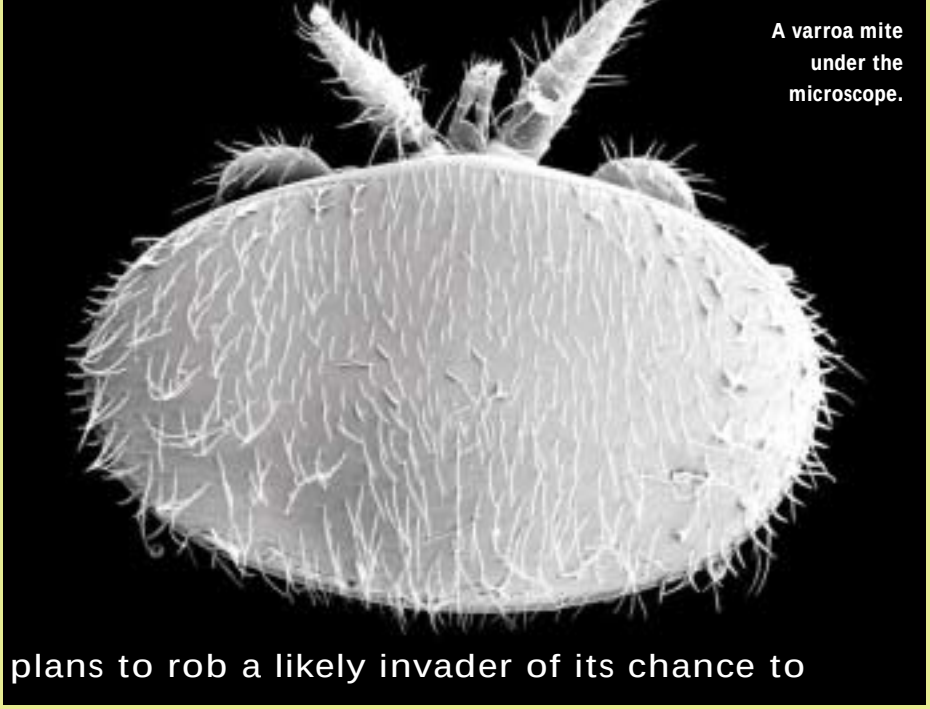
The sting



A varroa mite under the microscope.

Entomologists have canny plans to rob a likely invader of its chance to ravage our major pollinator, the European honeybee. Wendy Pyper reports.

AUSTRALIA is the final frontier for a tiny mite that parasitises honeybees and threatens our $1.2 billion pollination industry. The mite is poised to enter the country after incursions in New Zealand and Indonesia. Scientists warn it's just a question of when.

Dr Denis Anderson from CSIRO Entomology in Canberra has been studying the varroa mite since 1989, to better understand its biology and behaviour, and identify effective control strategies. His research has taken him on a rollercoaster ride across 32 countries, culminating in a recent discovery that could end the mite's reign of destruction.

The varroa mite was first described on its native host, the Asian hive bee (*Apis cerana*), in Java in 1904. The mite, formally named *Varroa jacobsoni*, begins its parasitic relationship with the Asian bee when the female mite lays up to six eggs in a drone brood cell.

When the young mites hatch, they feed on the developing drone, weakening it and reducing its adult life span. During adulthood, the unfortunate drone acts as a living food source for the mites, which slip under its intersegmental membranes, where they can avoid detection and feed on the bee's soft tissue.

While the mites also feed on female worker bees, they cannot reproduce inside worker bee brood cells. According to Anderson, this is because they do not receive a recognisable chemical signal from the developing worker bee to stimulate egg laying. Developing drones, however, do release a signal the mites recognise. This means that although some drones die prematurely, enough survive to mate with new queens, and the driving force of the colony – the worker bees – remains strong.

DNA analysis by Anderson has shown that *V. jacobsoni* and the Asian hive bee have co-evolved for thousands of years. During this time the bees have developed a range of behavioural traits that reduce the harmful effects of the mite. Some of these traits, such as a tendency to swarm and a willingness to abandon their hives, may have effectively countered the mite, but they have produced a bee that is not the most reliable or productive honey gatherer or pollinator.

A sweeter host

To overcome these problems, a second, more reliable and productive bee was introduced into Asia about 30 years ago. The European honeybee, *Apis mellifera*, is the 'bees knees' in terms of honey production and pollination. Not long after the bee's introduction however, the varroa mite jumped hosts. Mite-infested *A. mellifera* were subsequently transported around the world via quarantine incursions and the normal practice of shipping live bees between countries.

Unfortunately for the European honeybee and its keepers, the varroa mite proved to be more virulent on its new host. In mainland Asia, America and Europe, European honeybee colonies were dying, as the mite was capable of reproducing on both drones and workers.

Anderson began investigating the mite following its introduction into New Guinea on imported Asian bees. Initial observations indicated that only the European honeybees in New Guinea and Java appeared able to resist the parasite. A closer look showed the mites to be incapable of reproducing on these bees, something never observed elsewhere.

Anderson hypothesised three likely causes for this discrepancy: the European bees in New Guinea and Java were resistant to the mite, environmental factors impaired the mite's ability to reproduce, or the mites were genetically different from those affecting European bees in other parts of the world. To test these possibilities, he raised 40 genetically identical European queen bees and shipped half to Germany and half to New Guinea.

'We found the offspring of the bees were susceptible to the mite in Germany, while those in New Guinea were not affected,' Anderson says. 'So we realised it was not resistance by the bees, but something to do with the environment or the mite.'

At the time, Anderson and his colleagues were using only physical characteristics to identify the mites, all of which looked the same, although some were larger than others. Then in 1993, European honeybees in Java started dying as the mites

Top: The Canadian leafcutter bee is an effective pollinator of Australian crops. Three hundred thousand leafcutter bees were released in Australia last year.
Above: Asian hive bee pupa and a varroa mite (magnification, 2:1). The varroa mite begins its parasitic relationship with the Asian bee when the female mite lays up to six eggs in a drone brood cell.

suddenly started reproducing. Anderson began to suspect that there were actually two different mites involved.

'We decided to develop genetic markers for the mites that couldn't reproduce on the European honeybee. Then when we compared the markers with those from mites that could reproduce, we found the two were distinct,' Anderson says.

Multiple mites

Anderson concluded that European honeybees infested with a larger, virulent mite had been recently introduced into Java, accidentally or through standard importation practices.

The discovery sparked the collection of mites infesting populations of the natural host – Asian hive bees – from Japan, Korea, Nepal, Vietnam, China, Thailand, India, Sri-Lanka, the Philippines and the Malaysian and Indonesian archipelagos. Genetic analysis revealed a 'species complex' consisting of five species and about 13 strains within these species.

Anderson identified the original species, *V. jacobsoni*, on bees from the Malaysian and Indonesian archipelagos. Three species, yet to be named, were identified on bees from different islands in the Philippines. And a fifth species, which Anderson named *V. destructor*, was identified on bees from mainland Asia.

'We found six strains of *V. destructor* on Asian hive bees from mainland Asia,' Anderson says. 'The adult females of *V. destructor* are significantly larger and less spherical in shape than females of *V. jacobsoni* and they are also reproductively isolated from the other species.'

Anderson's next step was to collect mites from European honeybees in 32 countries. Of the whole complex of mites identified on the Asian hive bees, however, only two mites, both strains of *V. destructor*, were identified on the European bees.

'We found the Korean strain of *V. destructor* on the European bees in every country,' Anderson says. 'We also found a Japan / Thailand strain of *V. destructor* on bees from Brazil.'

While the second observation seemed incongruous, a search through the literature showed that European bees had been introduced into Brazil from Japan in 1971. These discoveries raised even more questions. In particular, why, out of a complex of 18 different mites, had only two jumped host?

Further research showed that only the Korean and Japan / Thailand strains of *V. destructor* could reproduce on the European honeybee. Anderson says this is because only these two strains of *V. destructor* can recognise a chemical signal they need to reproduce on the European honeybee.

'We know the signal is produced in a 72-hour period, just before the brood cells of the honeybee larvae are sealed and the larvae begin to pupate,' Anderson says. 'The signal tells the mite when to start laying eggs. We suspect the signal is a hormone released by the bee brood and that its concentration is critical for mite reproduction.'

Anderson and his colleagues are trying to isolate the hormone. When they find it, they will be able to breed or produce European bees that release chemical signals the two mites cannot recognise.

'After we've found the signal, we'll look for European bees that have a signal profile the mites don't recognise,' he says. 'We could then artificially inseminate queens reared from one resistant colony with semen from drones from another resistant colony, or artificially inseminate susceptible queens to produce lines of totally resistant honeybees,' Anderson says.

If the mite arrives in Australia before this research is complete, Anderson says it will decimate our major pollinator. But he and his colleagues are working on a second strategy to counteract such an incursion: the introduction of alternative pollinators such as the Canadian leafcutter bee. This solitary bee is an efficient pollinator of lucerne and other crops. Three hundred thousand leafcutter bees were released in New South Wales and Canberra last year, and 300 000 offspring are expected this year.

'We're well on the way to establishing a new industry,' Anderson says.

While the leafcutter bee will be a valuable addition to our insect pollinators, Anderson believes the varroa mite research should enable the European honeybee to continue its important work.

'We think we're on the path of overcoming the varroa problem world-wide,' he says.

More about varroa mite

Anderson DL and Trueman JWH (2000) *Varroa jacobsoni* (Acari: Varroidae) is more than one species. *Experimental and Applied Acarology*, 24:165–189.