PEST AND DISEASE CONTROL

Genetic tools for managing *Varroa* in honey bees?

Phil Lester, Ocean Mercier, Symon Palmer and Peter Dearden

Professor Phil Lester and colleagues discuss the potential for 'gene silencing', a new and highly targeted approach to varroa management.

Varroa mite on bee larva.

Varroa travelling on a bee.

The most devastating pest of honey bees here in New Zealand and around the globe is the parasitic mite *Varroa destructor*. The global consensus is that "no other pathogen or parasite has a comparable impact on honey bees", as it "is the greatest threat to honey bee health" (Traynor et al., 2020).

Varroa consume the fat bodies of the bees and spread viruses, including the deformed wing virus (DWV). These viruses appear to be becoming more virulent. The *Varroa* problem is becoming worse (Traynor et al., 2020).

Commercial beekeepers are spending tens of thousands, or more, each year on *Varroa* control. Typically, much of that is spent on chemical pesticides. *Varroa* mites, like many pests in agriculture, unfortunately appear to be developing resistance to these pesticides around the globe and perhaps even in New Zealand. We need new management tools. These tools need to be effective, safe, and societally acceptable. We've been investigating one new and highly targeted approach called gene silencing.

Gene silencing works with small, simple sugar molecules called ribonucleic acids (RNA). These little molecules are tiny, but also highly specific and can be targeted to specific genes. Their specificity is typically amazing, working on only a single gene pathway and a single species. Within your cells these simple sugars are recognised as a 'stop' signal for gene expression. It is now possible for companies to make double-stranded RNA (dsRNA) specifically designed to stop the expression of genes essential to the metabolism or reproduction of pests.

In 2012, a group of researchers in Israel published work using synthetic double-stranded RNA (dsRNA) to control *Varroa* mites (Garbian et al., 2012). They fed bees these simple sugars, which were then passed onto the brood or absorbed through the gut and into the bee, and then into the *Varroa* mite when the mite fed. The RNA stopped the expression of vital genes in the mites. Mites were killed while the bees were unaffected. One company in the USA has now developed this approach to the point of testing it on many thousands of hives (Masucci, 2020).

In 2020, a group in Texas took this gene silencing approach one step further. They genetically modified a species of bacteria that lives inside the bee gut. The bacteria themselves produced the dsRNA, which targeted the *Varroa* and the deformed wing virus. Bees survived viral challenges and *Varroa* mites were killed (Leonard, 2020).

These technologies offer new approaches to *Varroa* management. The approach with adding dsRNA is perhaps the simplest option and easiest to develop for New Zealand, as it does not involve genetic modification (no DNA is altered in the mite or each bee). But even with this approach, a huge amount of scientific work is required and many questions to be answered with this technology. Are we absolutely sure that only *Varroa* mites would be affected? Would gene silencing be effective in New Zealand *Varroa* and bee populations?

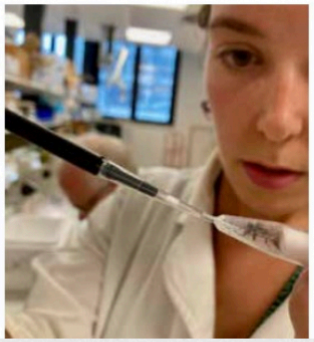
An important issue is also to account for societal perspectives and acceptance of these novel pest control methods. Perspectives clearly differ within society on these technologies. Our work with Māori communities, for example, shows

the full spectrum of views (Palmer & Mercier, 2020). A clear outcome from our discussions with Māori business owners and groups was that 'doing nothing' is not an acceptable option. Pest control technologies are needed and broad-spectrum pesticides are not preferred.

One group we talked with advocated for natural processes and dismissed any genetic modification, saying, "Nothing where there's DNA splicing. Nothing where there's gene characteristics changing. Nothing that inserts or modifies a queen or anything like that". Technologies involving the delivery of synthesised dsRNA might be more acceptable for these groups. Other Māori in our study noted that "...we're dealing with an issue that essentially post-dates many of the essential elements of the kaupapa we work with ... some of the pests are things that our old people wouldn't have necessarily had the tools to deal with. They wouldn't have necessarily had the issues to deal with anyway. The pests weren't there. We can't see any conflict with the adoption of new approaches to control".

Considerable scientific work and public consultation need to be achieved before genetic tools could be adopted for pest management. The Royal Society Te Apārangi has begun a public consultation process, but much more needs to be done. We also need to consider if legislative change and updates are needed for the 23-year-old Hazardous Substances and New Organisms (HSNO) Act (1998). Technology and pests we need to manage have both changed substantially over the last two decades, including with the introduction of *Varroa*.

Bees under investigation. Photos: Phil Lester.



REFERENCES

Garbian, Y., Maori, E., Kalev, H., Shafir, S. & Sela, I. (2012). Bidirectional transfer of RNAi between honey bee and *Varroa destructor: Varroa* gene silencing reduces *Varroa* population. *PLoS Pathogens, 8*, e1003035.

Leonard, S. P., et al. (2020). Engineered symbionts activate honey bee immunity and limit pathogens. *Science, 367*(2477), 573–576.

Masucci, J. D. (2020, May). Developing double-stranded RNA as a new *Varroa* control product. *American Bee Journal, 160*, 1–6.

Palmer, S., & Mercier, O. R. (2020). Biotechnologies in pest wasp control: taking the sting out of pest management for Māori businesses? *New Genetics and Society*, 1–23.

Traynor, K. S., et al. (2020). *Varroa destructor*: a complex parasite, crippling honey bees worldwide. *Trends in Parasitology, 36*, 592–606.