



Marla Spivak

Figure 1.
Honey bee with red
coloured resin on her hind legs

HONEY BEE HEALTH

The Benefits of Propolis

Marla Spivak, PhD

(MacArthur Fellow and McKnight Distinguished Professor in Entomology
at the University of Minnesota, USA)

Most beekeepers I know dislike propolis with a passion. The presence of this sticky, resinous substance in bee hives makes opening and managing colonies very difficult.

Most of my clothes are permanently stained with propolis, usually on the backside from climbing into the bee truck and sitting down on a glob of it. I also was not so fond of propolis until we discovered that it has very amazing health benefits to bees. I hope by the end of the article, you become a propolis convert, too.

Propolis is the term beekeepers

use to refer to plant resins that bees collect and deposit in the nest cavity. Bees add varying amounts of wax to the resins but, to my knowledge, they do not modify the chemical nature of the resins.

Why?

There must be a reason bees go to the trouble of collecting plant resins. They are not easy to collect: bees have to scrape up the sticky resin with their mouthparts, pack it on their hind legs and, when back in the nest, other bees have to help pull it off their legs (Figure 1). There is no food reward in collecting propolis – they don't eat it, so why collect it?

The older bee books say that propolis is a barrier to seal cracks and provide mechanical support in the nest (reviewed in Simone-Finstrom and Spivak, 2010). But this answer is not entirely satisfactory.

Nest Lining

When bees nest inside hollow trees, they coat the inside of the cavity with propolis, sometimes several millimeters thick (Figure 2 (overleaf)).

Bees can deposit a very thick layer of propolis around the entrance to the tree cavity. They don't make this propolis envelope inside our man-made bee boxes, but they often reduce the size of the entrance

with propolis and stick propolis between boxes and where the frames touch the box.

Despite our intentional or inadvertent attempts to select against colonies that collect lots of propolis, the bees persist, so they must need it.

The most important clue about its benefit comes from this fact: we know that propolis has remarkable medicinal properties for humans. It is highly antimicrobial, meaning that it is antibacterial, antifungal and even antiviral. So does it have medicinal benefit to the bees?

Benefit to Bee Health?

One of my previous graduate students, Mike Simone-Finstrom, became interested in the potential benefits of propolis to bee health.

We constructed some small five-frame nucleus boxes and Mike painted the inside of some with a propolis extract (propolis dissolved in 70% ethanol at a known concentration). One set of boxes was painted with extract of propolis from Minnesota, another set with 'green' propolis from Brazil.



*Learn to love
propolis which
has health
benefits for our
honey bees*

A third set was painted with just ethanol as a control. He put small colonies of bees in each box, paint-marked a set of newly emerged bees, and introduced them into each colony. After seven days, he collected the painted bees and examined their immune systems by measuring gene transcripts for antimicrobial peptides (see box below).

He found that bees exposed to a propolis envelope for just seven days had lower bacterial loads in and on their bodies, and had 'quieter' immune systems compared with bees in a colony with no propolis envelope. In other words, the propolis in the colony was killing off microbes in the nest, so that the bees' immune systems did not have to gear up and make peptides and cellular responses that fight off infection.

In essence, the propolis envelope acts as an external antimicrobial layer that enshrouds the colony, benefiting bee immune defenses (Simone-Finstrom, et al, 2009). Yes, it seals cracks and probably provides structural support, but the main benefit is probably its antimicrobial value.

Comment

"Bees don't produce antibodies but their immune systems do produce a number of proteins, or antimicrobial peptides that can fight off infection. They also have cells that can phagocytize (eat up) or encapsulate microbes. We can measure the relative amount of gene transcripts of the peptides and cellular products using real-time quantitative PCR."

In Human Terms

Here is an analogy of the benefits of the propolis envelope in human terms.

Think of a house or office with mould in the walls. Some people's immune systems are chronically activated in mouldy environments, causing them to sneeze. If propolis was painted all over the walls of the house or office, it would probably kill the moulds, which in turn would reduce the person's immune response.

Mounting an immune response, especially a chronic one, is costly to an individual and eventually takes a toll on overall health.

Chalkbrood and Propolis

Mike Simone-Finstrom ran another clever experiment. He infected colonies with chalkbrood disease by grinding up chalkbrood mummies and homogenising them in pollen patties. He found that the number of resin foragers (per unit time) increased in colonies after infection with chalkbrood, but did not increase in uninfected colonies.

The increase in the number of resin foragers was subtle, as resin foragers are relatively rare in most colonies, especially compared with pollen and nectar foragers. But the result was remarkable (Simone-Finstrom and Spivak, 2012).

Do bee colonies self-medicate?

We are currently repeating this experiment with another bee disease, American foul brood, to see if the increase in resin foraging after infection is robust.

In another experiment, Mike S-F found that colonies with a propolis envelope had less chalkbrood infection compared

with colonies with no propolis envelope (Simone-Finstrom and Spivak, 2012). It is unclear how the propolis on the walls of the box helps fight off a brood infection. The mode of action of propolis is likely to come both from contact with it and from the rich smelling volatiles.

More research is needed in this area.

Where is it Collected?

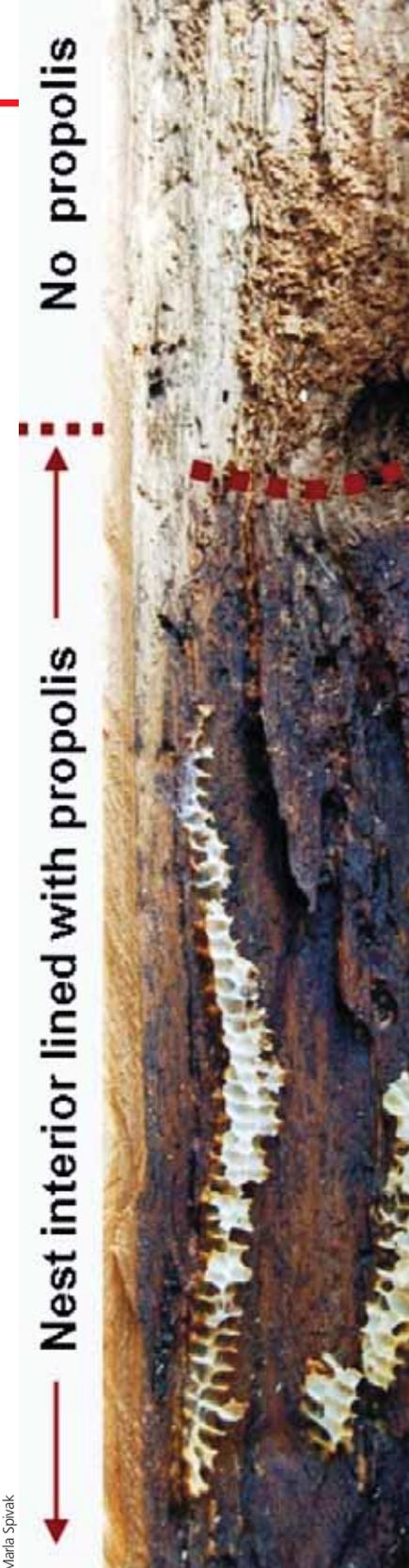
Two other graduate students are now pursuing other questions related to the health benefits of propolis to bees. One student, Mike Wilson (at one point I was advising three students named Mike – confusing!), is discovering from which plants bees collect resin.

This Mike climbs trees, and collects resin from leaf buds. Then he collects individual foragers returning to the hive with plant resin on their hind legs. He analyses the resin from the plant and the resin from the bee using RPHPLC time-of-flight mass spectrometry and gets a metabolic 'fingerprint' of all the compounds present in each sample. He can match the fingerprints statistically using principle components analysis (Wilson, et al, submitted for publication).

In our area, despite the presence of conifers, birch, alders and other trees, he found that bees collect resin mostly from cottonwood (*Populus deltoids*) and balsam poplar (*Populus balsamifera*). Cottonwood resin is yellow; balsam poplar resin is red. There are hybrid poplars in our area and when bees collect resin from them, this can be yellow, brown, orange or red.

Biological Activity

Mike Wilson is also testing the biological activity of the



Marla Spivak

Figure 2. A cross-section of a honey bee nest around the colony is coated in a layer of propolis the propolis envelope (Simone-Finstrom and Spivak, 2012).

individual resin loads against the bee pathogen, *Paenibacillus larvae*, the bacterium that causes American foul brood. Mike W runs these tests in the lab and has found out that balsam poplar is slightly better at inhibiting this bacterium than cottonwood resin. He has



nest within a tree cavity. The nest interior is covered with propolis. Fungal growth can be seen above and Spivak, 2010)

also determined that hybrid poplars are not nearly as good. This means that the resins have different 'strengths' and abilities to kill off bacteria and probably other microbes.

Presence of Propolis

This leads to the research by

the third student, Renata Borba. Renata is testing whether bees need a full propolis envelope within the nest to help their immune system, or if just the presence of a propolis trap on top of the frames is sufficient. She also repeating the self-medication experiment I referred to above, by infecting colonies with American foul brood (by spraying spore solution on the combs).

In addition to counting returning resin foragers before and after infection, she will collect the resin loads and, using Mike Wilson's metabolomic fingerprinting techniques, determine if the bees switch resin species after infection. Do bees select resins of greater 'strength' after infection?

The jury is still out – Renata will be repeating her experiments over at least two summers to obtain a large enough data set to analyse because resin foragers are relatively rare.

There are many questions still unanswered and others we need to resolve further. But I do have two take home-messages for beekeepers:

Messages for Beekeepers

It would be good to allow colonies to make a propolis envelope inside beekeeping equipment as it would benefit the bees' immune systems. You can help them do this in two simple ways:

- cut and staple commercial propolis traps in the inside of each brood box
- construct bee boxes that have unfinished lumber on the inside and the rough surface will stimulate bees to line the inside of the box with propolis.

I don't recommend you make your own propolis extract to

paint inside the boxes because it requires harvesting propolis and then dissolving it in 70% ethanol. It is easier to let the bees collect the propolis and deposit it directly where it is needed.

I do not advocate feeding propolis to bees. Bees do not eat propolis. Even though it is a natural plant product, it is a powerful antibiotic. One summer, we tried feeding propolis dissolved in sugar syrup to bees and it did not cure American foul brood within the colonies.

I would not feed it to my bees.

Beekeeping Lore

Lastly, I bring up a challenge to beekeeping lore.

It has not been tested if bees incorporate propolis into brood cells. There seems to be a beekeeping legend that brood combs turn dark because bees deposit propolis in them. I do not think this is the case. In a tree cavity, bees DO put propolis on the cells that touch the tree wall (Figure 3). On rare occasions, I have seen some new comb look as though the rim has a very narrow band of resin around it. But I do not know how common this is, or if bees add more resin into the cell.

To test this, the wax comb would need to be dissolved, filtered and the residue tested for the presence of plant resins. We have tried to dissolve brood combs in ethanol and end up with a sludge that looks like

'slum gum' (the mess left after you have melted the wax out of old brood comb). It probably contains remnants of the silk cocoons, bee faeces and wax.

But does it contain propolis? I think not. But I'm very open to solid evidence to the contrary. □

References

- 1 Simone M, Evans J, Spivak M. 2009. Resin collection and social immunity. *Evolution*, **63**, 3016–3022.
- 2 Simone-Finstrom M, Gardner J, Spivak M. 2010. Tactile learning in resin foraging honeybees. *Behavioural Ecology & Sociobiology*, **64**, 1609–1617.
- 3 Simone-Finstrom M, Spivak M. 2010. Propolis and bee health: the natural history and significance of resin use by honey bees. Special Issue on Bee Health: *Apidologie*, **41**, 295–311.
- 4 Simone-Finstrom, MD, Spivak M. 2012. Increased resin collection after parasite challenge: a case of self-medication in honey bees? *PLoSOne* 7(3), e34601. doi:10.1371/journal.pone.0034601

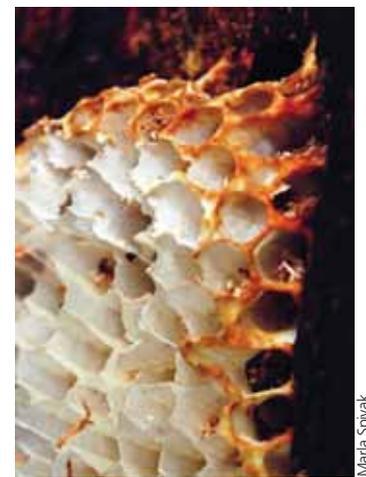


Figure 3. New combs from a colony nesting in a tree cavity. The bees have put propolis around the rims of cells that are in contact with the tree wall. It is not clear if bees add propolis to cells within the brood nest



Marla Spivak is a MacArthur Fellow and McKnight Distinguished Professor in Entomology at the University of Minnesota. She has bred a line of honey bees, the Minnesota Hygienic line, available commercially in the US, to defend themselves against diseases and parasitic mites. Current studies include the benefits of propolis to honey bees and the effects of agricultural landscapes and pesticides on honey bee and native bee health.