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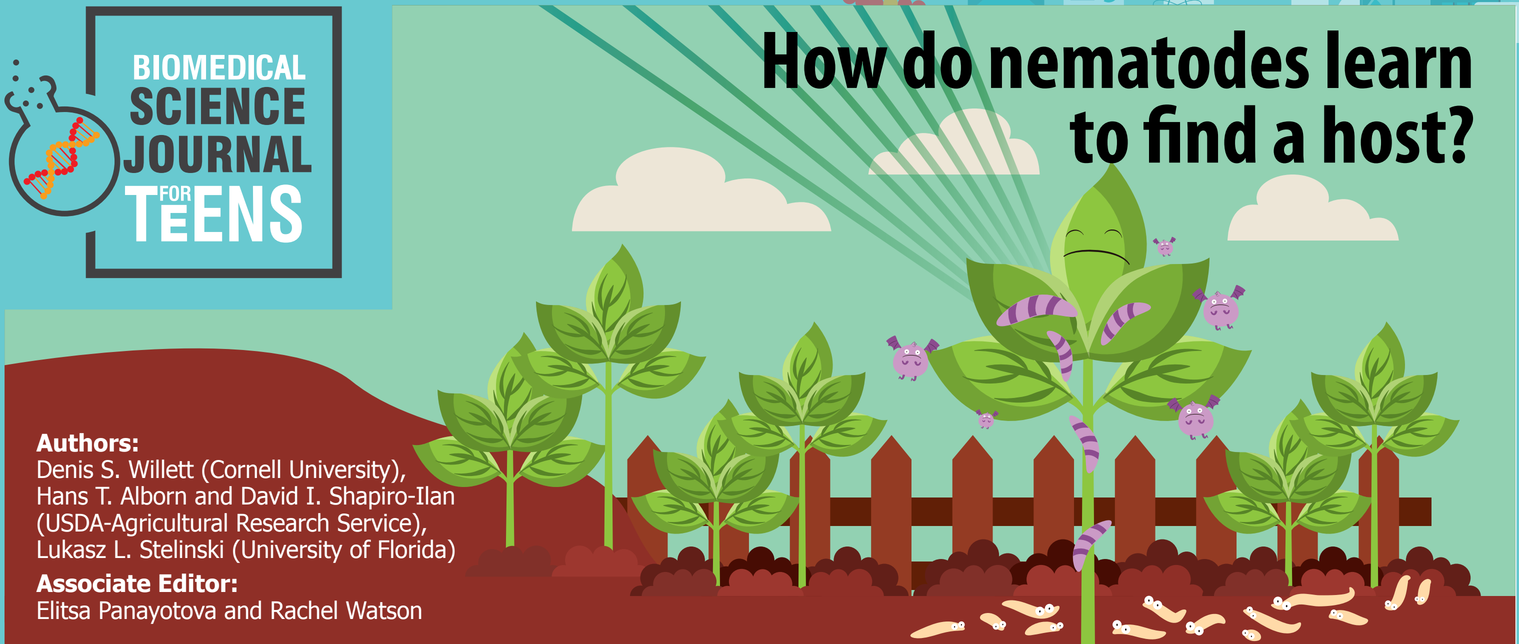
How do nematodes learn to find a host?



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Abstract

Parasites live in, or on, other organisms. All parasites want to find and successfully infect a host so that they can live and reproduce. It's hard and risky for an individual parasite to infect a host – a group attack is a safer option. Insect-infecting nematodes use this strategy by following environmental signals, such as plant *volatiles* (scents). We wanted to see if past experience with some volatiles changes the infection behavior of nematodes. We treated the host environment with different concentrations of two volatiles known to have an influence on nematodes and observed the infection success. Our experiments showed us that the nematodes' past experience alters their infection behavior.

Introduction

Imagine you are a parasite. You have to find a good home, a *host*, where you can settle down and reproduce. This sounds simple, but every host is trying to make it difficult for you. The hosts don't want to get infected, so their immune systems fight you off with everything they have. Now imagine a group of parasites attacking the host. It would be a lot harder for the immune system to fight against bigger numbers. Indeed, some parasites, like parasitic *nematodes* (Figure 1), have evolved this strategy for greater success in infecting their hosts. The nematodes move through soil together like a pack of wolves looking for their prey.

A group attack more often results in an infection, but it doesn't mean that every single nematode will survive. They are all taking a risk: there is no group meeting, so none of them knows how many other parasites will attack the same host. So how do they decide what direction to go in to find a host together? Nematodes that infect insects look for various cues, such as chemical compounds called volatiles that are released from plants when they are under the insects' attack. These compounds basically tell the nematodes: "There is an available host here!" So do the parasites usually go for it when they sense these compounds? If they encountered that plant signal previously, do they learn from that experience and later look for the same compounds again? These are the questions we wanted to answer.

Figure 1:
Close-up look at the insect-infecting nematodes *Heterorhabditis indica*.
Credit: Juan Morales-Ramos, USDA

Methods

We tested the behavior of two species of nematodes: *Heterorhabditis indica* (Figure 1) and *Steinernema diaprepesi*, both of which infect insects – including pest insects. The host we used for these tests was the larvae of *Galleria mellonella* (Figure 2), an insect pest of honey bees.

First we compared the *infectivity* of the nematodes in the presence or absence of plant volatiles by creating small test arenas. In each one:

1) we treated 1 gram of sand with one of a few different concentrations of two well-known plant volatiles :

- Volatile 1 (pregeijerene) which attracts nematodes, or

- Volatile 2 (alpha-pinene) the first exposure to which is known to repel nematodes.

There were also test arenas with no plant volatiles that served as a *control group*. That told us how good the nematodes might be at infecting hosts when there are no plant volatiles at all present.

2) we placed one host larva inside.

3) we added 1000 nematodes.

We observed the *mortality* of the larvae and the number of nematodes inside them after 24 and after 48 hours.

To test how past experience could change the future infection behavior of nematodes, we conducted a slightly different experiment:

1) First, we placed groups of 1000 nematodes in vials containing water and different concentrations of the two plant volatiles. (Again, some had just water, to serve as a control group.)

2) After 48 hours we washed the nematodes and placed them in test arenas as before.

Figure 2:
Larvae of *Galleria mellonella*, the greater wax moth or honeycomb moth.
Credit: USDA-ARS

Results

When we compared the infectivity of nematodes in the presence or absence of plant volatiles, we made some interesting observations:

1) *H. indica* nematodes were twice as successful as *S. diaprepesi* in infecting the larvae.

2) Time was an important factor for infectivity: we found more than twice the number of nematodes inside the larvae after 48 hours as compared to 24 hours.

3) The presence of either of the two plant volatiles led to a significant increase in host infection.

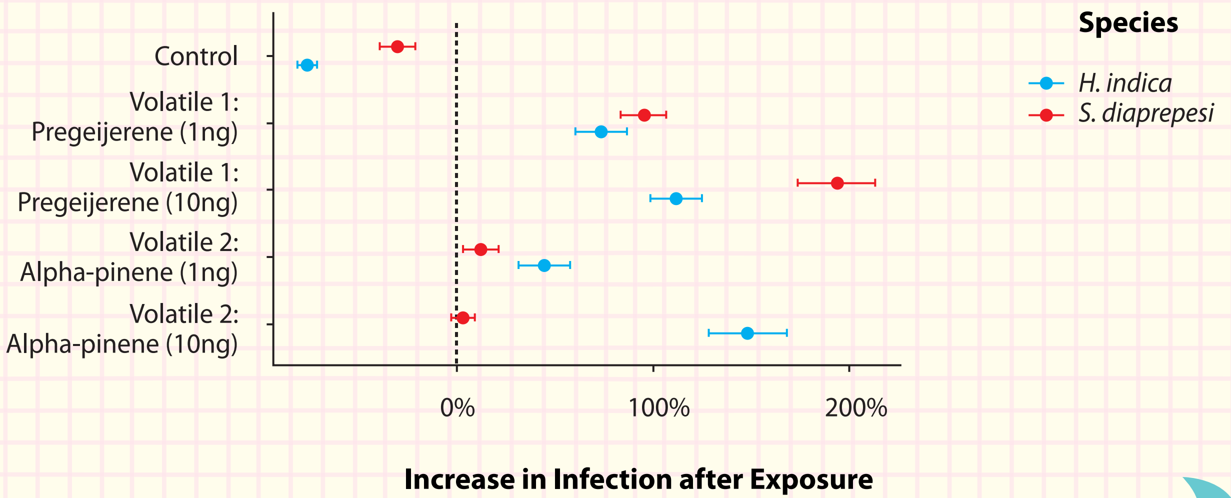
4) Higher doses of either volatile meant a higher number of nematodes inside the host.

5) The mortality of the host depended on the number of nematodes inside and the amount of time after the infection.

When testing how past experience changes the future infection behavior of the nematodes, we saw that prior exposure to the volatiles significantly increased infection (Figure 3). Furthermore, once exposed to a volatile, the nematodes seem to lose interest in seeking a host if that volatile was absent.

Please see Figure 3 on Page 3

Figure 3:
Influence of previous exposure to volatiles on nematode infection.



What do higher concentrations of the volatiles lead to? Is there a difference between the two species of nematodes' rates of infection?

Discussion

Both the past experience of the nematodes and the environment of the hosts really influence the infection behavior of these parasites. There is safety in numbers, so every individual nematode wants to infect a host where it expects to find others attempting the same. Nematodes naturally try to stay in groups. The parasites follow the signal of the plant volatiles, expecting that others will do so as well. This greatly reduces the risk of an unsuccessful infection, which is the parasites' primary goal after all!

Moreover, nematodes prefer to follow signals with which they have a previous experience. And they are less likely to infect a host if a known volatile is not present. This means that the presence of such compounds can serve as an indicator for the probability of infection. Farmers might be able to use this knowledge for better *biological control* of insect pests.

Conclusion

Biological control can be a good alternative to the most common way of controlling pests in agriculture now: chemical pesticides. Using the natural enemies of pest insects (in our case, insect-parasitic nematodes) is a lot more environmentally friendly. By using plant volatiles to help insect parasitic nematodes find a host, we might be able to better control the insect pests eating your lawn or your food. You can even try infecting insect pests yourself: you can buy "beneficial" nematodes in hardware stores or online and do your own parasitic experiment.

Glossary of Key Terms

Biological control – the control of a pest by the introduction of a natural enemy – predator, parasite.

Control group – one of the tested groups in a scientific experiment, which is NOT exposed to any experimental treatment but is tested under the same conditions as all other groups. This helps the scientists confirm that the experimental treatment actually makes a difference. Here, the control group wasn't exposed to either plant volatile.

Host – in biology or medicine, this means an organism harboring a parasite (or a beneficial partner).

Infectivity – the ability of a pathogen (virus, bacterium, parasite) to successfully establish an infection.

Mortality – the number of deaths due to the parasite infection.

Nematodes – roundworms, many of them are parasites but not all. The parasitic nematodes have complicated life cycles that include several stages of development.

Parasite – an organism (i.e. flatworms, round worms and many others) that lives inside or attached to another organism, called the host.

Volatile – chemical which easily evaporates at room temperature.

Check your understanding

1. Why is an individual parasitic nematode less likely to infect a host successfully (as compared to a larger group of nematodes)?
2. How do insect-infecting nematodes sense the presence of an available host?
3. According to our data, do higher concentrations of volatiles attract more nematodes or less?
4. What happens when nematodes have past experience with a volatile?
5. Why is biological control a good alternative to pesticides?

REFERENCES

Denis S. Willett, Hans T. Alborn, Lukasz L. Stelinski, David I. Shapiro-Ilan. *Risk taking of educated nematodes*. 2018 PLOS ONE 13(10): e0205804.
https://doi.org/10.1371/journal.pone.0205804

David I. Shapiro-Ilan, Edwin E. Lewis, and Paul Schliekelman 2014. *Aggregative group behavior in insect parasitic nematode dispersal*. International Journal of Parasitology 44: 49-54.
http://dx.doi.org/10.1016/j.ijpara.2013.10.002

Cornell University College of Agricultural and Life Sciences: Nematodes.
https://biocontrol.entomology.cornell.edu/pathogens/nematodes.php

Good Housekeeping: What are nematodes?
https://www.goodhousekeeping.com/home/gardening/a20705657/nematodes/