Biologists discover that many nematode species make the same types of small-molecule pheromones

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Many different species of nematodes were found by the Sternberg lab to communicate using the same types of chemical cues. Credit: Caltech

(Phys.org) -- All animals seem to have ways of exchanging information—monkeys vocalize complex messages, ants create scent trails to food, and fireflies light up their bellies to attract mates. Yet, despite the fact that nematodes, or roundworms, are among the most abundant animals on the planet, little is known about the way they network. Now, research led by California Institute of Technology (Caltech) biologists has shown that a wide range of nematodes communicate using a recently discovered class of chemical cues.

A paper outlining their studies—which were a collaborative effort with the laboratory of Frank C. Schroeder, assistant scientist at the Boyce Thompson Institute for Plant Research (BTI) of Cornell University—was published online April 12 in the journal Current Biology.

Previous research by several members of this team had recently shown that a much-studied nematode, Caenorhabditis elegans, uses certain chemical signals to trade data. What was unknown was whether other worms of the same phylum "talk" to one another in similar ways.

But when the researchers looked at a variety of nematodes, they found the very same types of chemicals being combined and used for communication, says Paul Sternberg, the Thomas Hunt Morgan Professor of Biology at Caltech and senior author on the study. "It really does look like we've stumbled upon the letters or words of a universal nematode language, the syntax of which we don't yet fully understand," he says.

Nematodes are wide-ranging creatures; they have been found in hot springs, arctic ice, and deep-sea sediments. Many types of nematodes are harmless, or even beneficial, but others cause damage to plants and harm to humans and animals. Decoding the language of these worms could allow us to develop strategies to prevent the spread of unwanted nematode species, saving time and money for the agricultural and health-care industries.

"We can now say that many—maybe all—nematodes are communicating by secreting small molecules to build chemical structures called ascarosides," says Sternberg, whose past research in C. elegans found that those worms secrete ascarosides both as a sexual attractant and as a way to control the social behavior of aggregation. "It's really exciting and a big breakthrough that tells us what to look for and how we, too, might be able to communicate with this entire phylum of animals."

Building upon Sternberg's previous findings, he and Andrea Choe, then a graduate student and now a postdoctoral scholar in biology at Caltech, decided to look for evidence of ascarosides in other species of nematodes. These included some parasitic organisms as well as some benign roundworm samples.

"I turned a section of Paul's lab into a parasite zoo, and people were both intrigued by it and terrified to come back there," says Choe. "One day they would see me cutting carrots to culture plant parasites, and the next I would be infecting mosquitoes or harvesting hookworms from rat intestines. We really tried to get as many different samples as we could."

Once they had cultured a sufficient number of different nematode species, the creatures were bathed in a liquid solution dubbed "worm water." This worm water collected the chemicals given off by the nematodes. The worms were then filtered out and sent to Schroeder's lab at BTI to be analyzed using a mass spectrometer—a tool used to deduce the chemical structure of molecules.

"When the results came back from BTI, showing that the same ascarosides were present in all the worm-water samples, I thought that they had made a mistake," says Choe. "It was a very surprising finding."

Using technology developed by Dima Kogan, a former graduate student at Caltech and coauthor of the paper, the researchers were also able to test the responses of various worms to particular ascarosides. Worms were placed on an agar plate, along with an experimental cue—a blend of ascarosides. Any action that might occur on the plates was then recorded; Kogan's software analyzed those recordings frame by frame, counting the number of worms that were either attracted or repelled by the given chemicals.

When asked about the development of the software, Choe explains that it all began when Kogan noticed that the current method involved counting worms by eye. "He was stunned that we would spend our time doing this," says Choe, "and he came up with this software in less than a week. It removed user bias, sped up our research 10-fold, and allowed us to study more chemicals and more species."

Next, the researchers will work to learn more about how the worms actually sense the ascarosides.

"Now that we know these chemicals are broadly present in nematodes, we want to find the genes that are responsible for the ability to respond to these chemicals," says Sternberg, who is also an investigator with the Howard Hughes Medical Institute. "That knowledge could open up a whole other angle, not just for dealing with the chemicals, but for actually interfering with those communication systems a little downstream by hitting the receivers."

The team also plans to continue deconstructing the language they have found among nematodes. For example, Sternberg wonders, how many different combinations of chemicals mean "food," or "mate," or "attack"? If the scientists can crack the code in terms of what different blends mean to different species, they can begin to interfere with the actions of the nematodes that wreak havoc across the world—leading to better eradication of plant pests, as well as human and animal parasites.

"There is only one known worm pheromone used in agriculture," says Choe. "It is time for us change that. This research could be a very big breakthrough on that front."

More information: The *Current Biology* study, "Ascaroside Signaling is Widely Conserved Among Nematodes," was funded by a grant from the National Institutes of Health and was supported by the Howard Hughes Medical Institute. Additional authors on the study are Stephan H. von Reuss, from Schroeder's lab at BTI; Robin B. Gasser, from the University of Melbourne; and Edward G. Platzer, from UC Riverside.

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