PLOS Science Wednesday: Hi Reddit, we're Niels and Nik, and we propose that cucumber mosaic virus repays its hosts luring pollinators to infected plants and increasing seed production and pollen export – Ask Us Anything!

PLOSScienceWednesday [1] and r/Science AMAs[1]

[1]Affiliation not available

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Abstract

Hi Reddit, My name is Simon "Niels" Groen and I am post-doctoral fellow at New York University. My research focuses on plant-microbe-insect interactions. I am joined by Nik Cunniffe, a University Lecturer in the Department of Plant Sciences at the University of Cambridge and co-author on the PLOS Pathogens article. Nik's research focuses on developing mathematical models of how plant diseases spread, evolve and can be controlled. We recently published a paper titled Virus Infection of Plants Alters Pollinator Preference: A Payback for Susceptible Hosts? in PLOS Pathogens. Cucumber mosaic virus, an important pathogen of tomato, causes plants to emit volatile chemicals that attract bumblebees - bumblebees are important tomato pollinators, but do not transmit this virus. We propose that under natural conditions, helping host reproduction by encouraging bee visitation might represent a 'payback' by the virus to susceptible hosts. We will be answering your questions at 1pm ET – Ask Us Anything! Don't forget to follow Niels and Nik on Twitter @simoncgroen and @nikcunniffe.

the WINNOWER

REDDIT

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PLOSSCIENCEWEDNESDAY R/SCIENCE

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So if I understand this right, bees are not viral vectors for CMV. Yet, when CMV infects tomato plants this causes the plant to produce chemicals which attract bees and promote pollination of the plant. On the face of it, this would seem like 'payback'.

Did you examine whether the same mechanism by which the virus causes the plant to attract bees also causes the plant to attract herbivorous insects? These would potentially be vectors for the virus, and if a viral infection also caused the plants to be more readily detected by these types of insects, this would seem much more 'selfish' of the virus.

SirT6

(Nik): A really insightful question. The phenomenon you mention - plant viruses promoting their transmission by attracting vectors (rather than pollinators) - has been actively studied by us and others for over a decade. John Carr (lead author on this study) led a previous study looking at this for CMV, which is in a PLoS journal, and so is freely available http://journals.plos.org/plosone/article?id=10.1371/journal.pone.0083066.

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SirT6

Niels here: as Nik pointed out, this is an active area of research. However, we have not examined viral effects on the attraction of the aphids that transmit CMV from plant to plant in tomato yet. Work done in the laboratory of John Carr and the laboratory of Consuelo de Moraes and Mark Mescher shows that CMV can have an attractive effect on aphids in a number of different plant species though.

So it does indeed seem like “pay-back”, yet, this outcome could either be the direct product of “selfish” virus and plant evolution and/or maybe a “by-product” of selection on a different process such as the attraction of aphids. John Carr’s laboratory is currently following up on studying this question.

Is the idea here that the virus is not being selfish? It seems to me that to do anything that results in I ncreasing the amount of viable plants to live in must be selfish to an extent?

eratosensei

Niels here: thank you, this is a very important question. I would like to stress that we are not implying that either the virus or the plants have been evolving with intent. The host plants would enhance their fitness by producing more offspring, whether infected or not. CMV would enhance its fitness if it can infect more host plants.

One way the virus might achieve this is by manipulating its host plants to become more attractive to aphids that transmit the virus to other plants. This process has been described by Kerry Mauck in 2010, when she worked at Penssylvania State University in the laboratory of Consuelo De Moraes and Mark Mescher.

Another way is by increasing the reproduction of susceptible hosts through the enhanced attraction of pollinators, which is what we described in our paper. In this case both CMV and the susceptible plants benefit: the virus because there will be more susceptible plants to infect and the susceptible plants because they produce more offspring. This positive effect of CMV on plant reproduction, whether the direct product of “selfish” virus and plant evolution and/or maybe a “by-product” of selection on a different process such as the attraction of aphids, can be visually described as a “pay-back” from the virus to its susceptible host plants because both benefit from this interaction. The word “pay-back” is only a visual description of the outcome of the plant-virus-bee interaction we see in our experiments. It does not refer to the evolutionary selection pressures that led to this outcome, which are of course free from intent.

How common is Cucumber mosaic virus?

chromesitar

(Nik): Well it's found all around the world, and - despite the name - can infect over 100 different species of plant, not just cucumbers, but also for example tomatoes (as in this study) and peppers. So pretty common.

How common is Cucumber mosaic virus?

chromesitar

Niels here: the American Phytopathological Society has published a very useful "pathogen profile" of CMV on the web:

http://www.apsnet.org/edcenter/intropp/lessons/viruses/Pages/Cucumbermosaic.aspx

CMV occurs worldwide and infects over 1200 plant species in more than 100 plant families. This probably makes it the virus with the widest known host range of any virus.

Do you think it's possible that something like this could happen in humans?

Example.

goatcoat

Niels here: this is a thought-provoking question! I am not aware of any human infections that make infected people produce more children. However, there seems to be some evidence that certain sexually transmitted disease-causing microbes enhance their spread by changing human reproductive behavior. Examples would be Toxoplasma, Candida and human papilloma virus. However, more research is needed to establish these links with more certainty.

Are there other viruses that do something similar to CMV in other plants?

Xyzbaconxyz

Niels here: This is not known at the moment, but we would like to know that too. John Carr's laboratory at the University of Cambridge is currently trying to find answers to this.

Does this virus pose any threat to humans consuming the plants? Also, how easy (or difficult) is it to detect the presence of this virus in nature?

Dragongeek

(Nik): No, no threat to humans: as far as I know it is accepted that plant viruses cannot infected animals and vice versa. I didn't actually do any of the experiments, but I think in this study Niels had much more to worry about from bee stings than getting infected with CMV! The level of symptoms expressed in infected plants depends on the species of host plant (CMV can infected many types of host), how old it is, and how long since it has been infected. Often the symptoms can be very visible. Some nice pictures in Figs 3-5 of here http://www.apsnet.org/edcenter/intropp/lessons/viruses/Pages/Cucumbermosaic.aspx

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Dragongeek

Niels here: following on from Nik's answer. CMV does not pose any known threat to humans consuming the plants indeed. Aside from looking at symptoms, the presence of the virus in plants can

also be detected using molecular biological techniques. With these techniques you can look for CMV in aphids that transmit the virus from plant to plant too.

If you only want to look for CMV and not other viruses, you can try to detect the viral coat protein (the building block of virus particles) with commercially available kits that use antibodies. You can also try to amplify viral RNA with RT-PCR using specifically designed primers and sequence the resulting product.

If you want to cast a wide net to see if CMV occurs together with other viruses you can do "deep-sequencing" using next-generation sequencing.

Does the virus transmit via infected pollen? I'm asking as a gardener who routinely loses cukes to viruses & pests.

harkdark

(Nik): I am sorry to hear about your cucumbers! This virus is not transmitted by pollen, but there are a small number of viruses that can be pollen-transmitted. For most plant viruses, though, the main transmission pathway is via herbivorous vectors (often insects) which transmits the virus by feeding on plants. Same idea as mosquitoes and malaria.

Why is the virus personified with intent when a virus that happens to increase the survivability simply takes part in a niche?

codabat

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What is the next step? Will you look at the feasibility of using this at an industrial level to improve production? Or perhaps you will try to genetically modify the virus to release more volatile chemicals to enhance the payback?

SaliVader

Niels here: in terms of finding a practical use for our findings, the next step would be to identify the plant genes that are involved in producing a mixture of volatile chemicals that is attractive to pollinators. Once we find out which genes are involved and how these genes are regulated we can use this knowledge in plant breeding to get crops that are more attractive to pollinators and produce higher yields.

Is the idea here that the virus transmit via infected pollen?

Orcey26

Niels here: CMV is mainly transmitted via aphids. When CMV causes susceptible plants to become more attractive to pollinators this enhances the reproduction of these plants. We propose that this is beneficial for the virus because there will be more susceptible plants for the virus to infect.

Are there examples of other "benevolent" types of viruses which actually give a net benefit to the host? Why haven't more viruses selected for this strategy?

Xeltar

Niels here: At the moment it is not known if other viruses have a similarly beneficial effect on plant reproduction, but we would like to find out too. There might be many more or only very few viruses with such beneficial effects, but this simply has not been studied before. John Carr's laboratory at the University of Cambridge is currently trying to find answers to this.

Why is the virus causes the plant to attract herbivorous insects?

ryginu

(Nik): One explanation of why viruses might attract herbivorous insects to the plant they are in is since these insects can spread the virus.

How do these volatiles compare to others that are emitted during various stressors such as other diseases, drought stress, etc? Can the bees differentiate volatiles in a field setting where there are many plant compounds being emitted?

dontmakemepoop

Niels here: currently not much is known about how bumblebees respond to tomato plants that are experiencing other stresses.

In a series of studies Andre Kessler at Cornell University found that leaf damage by chewing herbivores had a negative effect on pollinator attraction in a wild relative of tomato. The damaged plants emitted higher amounts of certain terpenoids. We would also like to know how pollinators would respond to the volatiles of virus-infected plants in a field setting and are currently thinking about ways to conduct field experiments.

Nelis! Gefeliciteerd met je verjaardag namens de boys van HBR. En natuurlijk ook gefeliciteerd met je fantastische artikel!

Lykal

Niels here: Dank je! De boys van HBR zijn bij dezen ook vereeuwigd in het archief van deze sessie :)