

Can Plant Viruses Manipulate the Host Range of Their Vectors?

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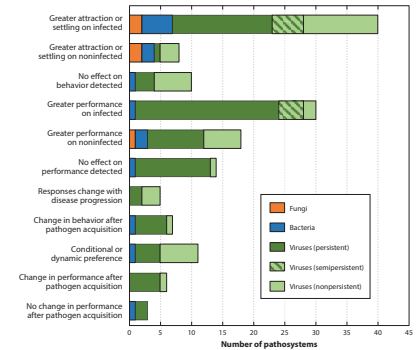
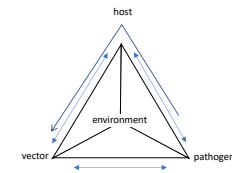
⁴Entomology, Washington State University



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Annual Review of Entomology Insect-Borne Plant Pathogens and Their Vectors: Ecology, Evolution, and Complex Interactions

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Eigenbrode, et al. 2018 Ann. Rev. Entomol.

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Host and Vector Manipulation by Plant Pathogens

Behavior	Performance	Label	Transmission
Greater orientation to and settling on infected vs. noninfected plants	Often greater on infected plants	"Honest"	Persistent
Greater orientation to infected but reduced or unaffected settling on infected plants	Often reduced on infected plants	"Deceptive"	Nonpersistent
Non-infective vectors attracted to infected plants; infective vectors mixed	Variable	"Conditional"	Persistent
Attract vector at certain stages of disease progression	Variable	"Dynamic"	Persistent
Induce changes in feeding on infected plants	Variable	"Consumption related"	Persistent

Mauck and Chesnais 2020; Eigenbrode et al. 2018; Davis et al. 2017

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Gaps in study of vector manipulation by plant viruses

- Most studies (109/119 cited in Eigenbrode et al. 2018) use a single genotype of a single host plant species (almost always a crop).
- Most use a single vector species and a single genotype of that vector.
- All concern intra-specific transmission.

But...

- Most plant viruses have many host species.
- Interspecific transmission will contribute to pathogen fitness
- Interspecific transmission potentially affects disease management.
 - Multiple crop hosts in production landscapes
 - Weedy hosts as reservoirs

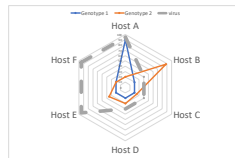
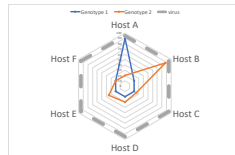
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Hypothetical Framework

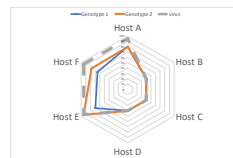
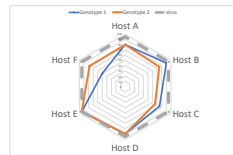
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Host range
broadening

2
Host range
modifying

Non-infected hosts

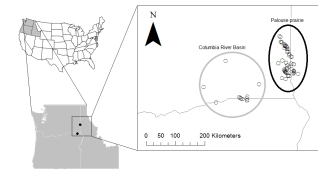


Virus-infected hosts



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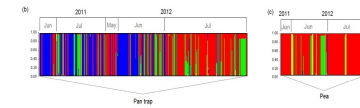
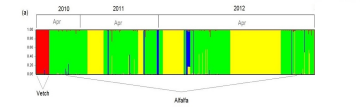
A Study System



Acyrthosiphon pisum

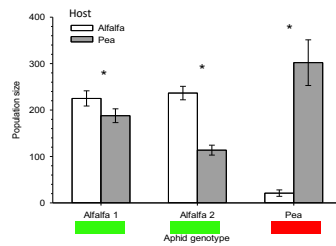


Eigenbrode et al. 2016. Journal of Applied Ecology 53:1382-1390.

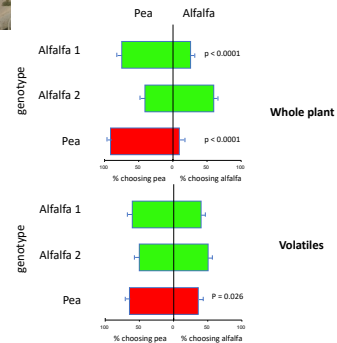


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Performance



Settling Preference



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Hosts: cultivated legumes present in the Pacific Northwest



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Pea enation mosaic virus



Bean leaf roll virus

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PEMV

- Persistently transmitted by pea aphid
- Infected pea plants preferred for settling by pea aphid
- Not phloem limited, so
- Shorter acquisition and transmission
- Infected pea plants not superior hosts for pea aphid
- Host range > 12 plant species including 5 of the six previously listed, excluding alfalfa.

Pea enation mosaic virus

BLRV

- Persistently transmitted by pea aphid
- Infected pea plants preferred for settling by pea aphid
- Phloem limited
- Longer acquisition and transmission
- Infected pea plants superior hosts for pea aphid
- Host range > 25 plant species within Leguminosae, including all 6 previously listed.

Bean leaf roll virus

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Experiments

- Five clonal colonies of pea aphids from PNW
 - Two in pea host race cluster and three in alfalfa host race cluster
- Maintained on common host, *Vicia faba*
- Single PNW isolates of BLRV and PEMV
- Six plant species, stagger-sown to standardize plant size
- Virus inoculation two weeks prior to testing vs. controls "Sham"-inoculated
- Assessed performance (colony growth: 10 days after infestation w/ 10 aphids); $n = 5/\text{genotype} \times \text{plant species} \times \text{virus}$
- Assessed preference in a six-choice arena, groups of 50 aphids, 24 h; $n = 5/\text{genotype} \times \text{virus}$,



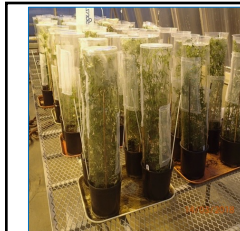
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Performance Bioassay

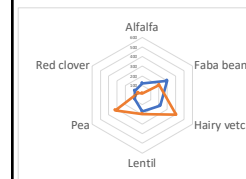
Analysis of deviance table, Type II tests, aphid reproduction

Effect	χ^2	P
Aphid Host Race	0.53	0.465
Plant Species	33.30	<0.001
Virus Infection	9.31	<0.010
Aphid Host Race x Plant Sp.	44.72	<0.001
Aphid Host Race x Virus	4.98	0.082
Plant Species x Virus	39.44	<0.001
Host Race x Plant Sp. x Virus	9.33	0.410

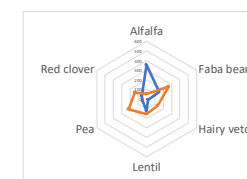
Pea host race genotypes — (orange line)
 Alfalfa host race genotypes — (blue line)



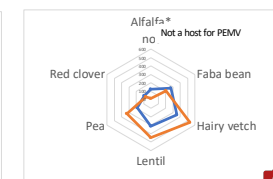
Sham



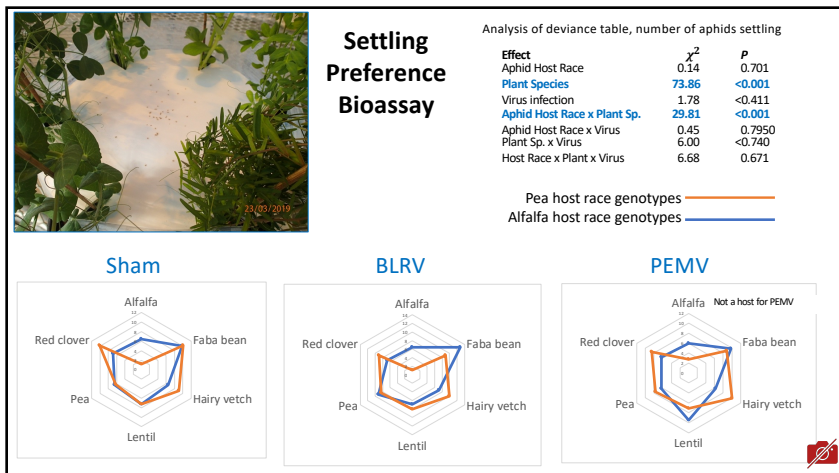
BLRV



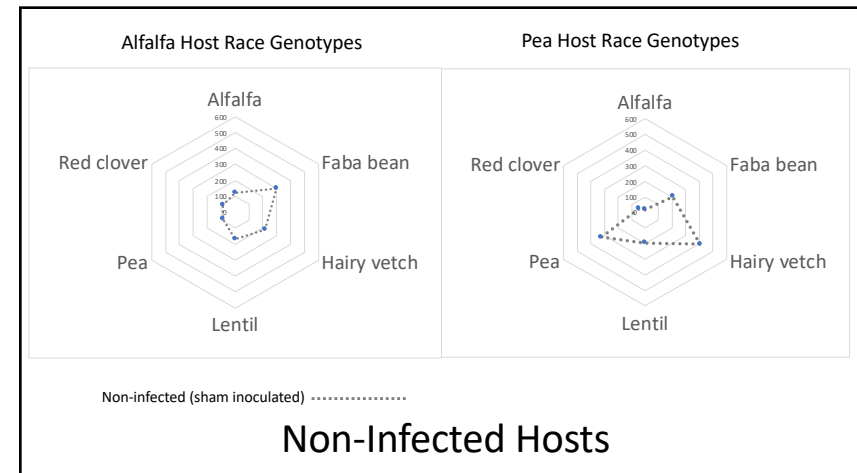
PEMV



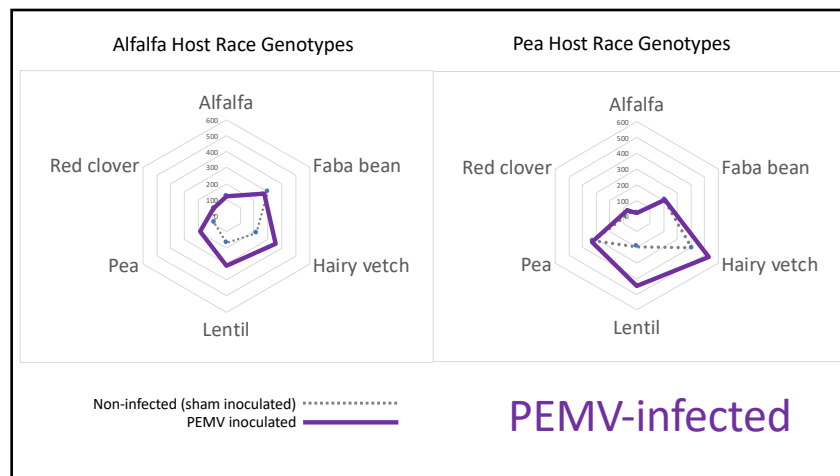
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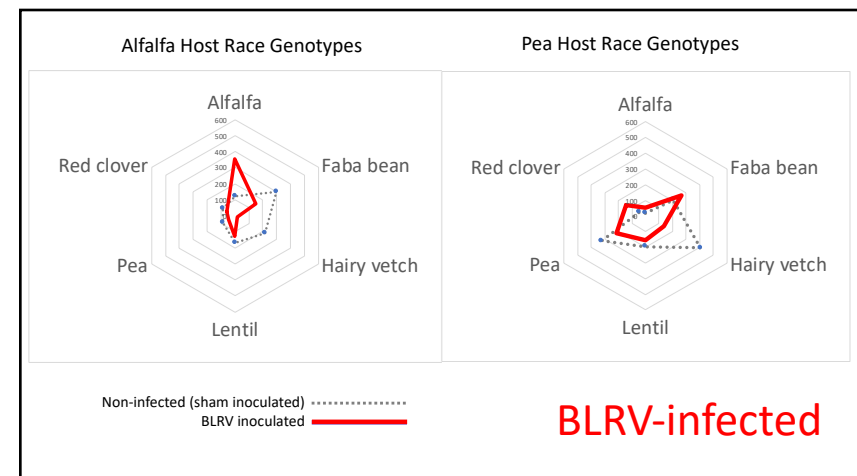
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Summary

- Pea aphid host races occur in the PNW where they infest multiple leguminous hosts.
- The aphids are vectors of legume viruses PEMV and BLRV
- Inoculation of six hosts with these viruses altered host range profiles of pea aphid host races based on altered *performance* (virus x host species interaction) but not relative *preference*.
- Provides some support for vector host range manipulation
 - 'PEMV' effect – Hypothesis 1 - broaden host range
 - 'BLRV' effect – Hypothesis 2 - constrain host range
 - Differences between PEMV and BLRV may stem from their relative host ranges (PEMV's smaller) or their different requirements for transmission
- A pilot study

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Host Breadth Manipulation by Plant Viruses?

- Perhaps - additional study seems merited
- Next
 - Scaling up to the multi-host landscape, explore with modeling
 - Effects on spread and persistence;
 - Incorporating host plant abundance, distribution and phenology
 - Assess importance of manipulating all or some hosts
 - Elucidating and comparing molecular mechanisms
 - Alates, greater replication
- Evidence for its evolution as a strategy?
- Implications for virus management

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- UI's Center for Health in the Human Ecosystem

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Center for Health
in the Human
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<http://www.uidaho.edu/cals/chhe/>

Biology of Vector-borne Diseases 6-day course
June 20-25, 2021

<https://www.uidaho.edu/vector-borne-diseases>



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