

Evidence for multi-host manipulation by vector-borne plant viruses

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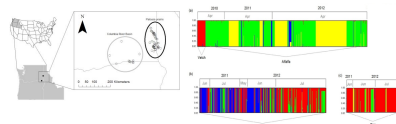
Introduction

- Vector-borne plant viruses can promote their spread by manipulating their vectors via infection-induced changes their plant hosts.
- Although hundreds of studies have detected such effects for plant viruses [1,2], none has considered the implications for virus transmission among different host plant species, despite the fact that most plant viruses have multiple hosts.
- In the Pacific Northwest (PNW) *Pea enation mosaic virus* (PEMV) and *Bean leaf roll virus* (BLRV) (both within Luteoviridae) infect multiple cultivated and feral leguminous host species. Each is transmitted almost exclusively by pea aphid, *Acyrtosiphon pisum* [3].

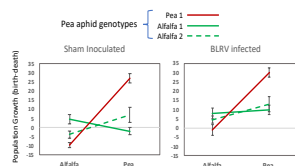


Pea plants infected by PEMV (left) and BLRV (center); the vector, pea aphid (right)

- PNW pea aphids form genetically distinct host races that are prevalent on one of these hosts, and exhibit differential performance among these hosts [4].



Locations of pea aphid samples (left) and analysis in Structure based on 11 microsatellite markers (K = 4 groups) showing alignment with host plants from which they were collected, vs. greater diversity for flying aphids caught in yellow pan traps [3].



Performance of three pea aphid genotypes on 'healthy' alfalfa and pea (sham inoculated using noninfectious aphids) and on plants infected with BLRV [4].

- With this model system we tested the hypothesis that plant viruses manipulate multiple hosts to facilitate interspecific virus transmission.
- Under this hypothesis, we expected that differential performance and preference would be muted or eliminated by virus infection, thereby facilitating interspecific virus transmission.

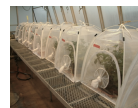
Research Objectives

- Compare the performance of five pea aphid genotypes on six host plant species, with or without PEMV or BLRV infection
- Compare the preference of two pea aphid genotypes among these five host plant species, with or without PEMV or BLRV infection

Materials and Methods

Aphids, plants and viruses

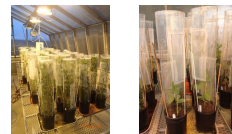
- Clonal colonies of pea aphids were established from foundresses collected from different host plants in the PNW and maintained in the greenhouse on faba bean (*Vicia faba*).
- Viruses are PNW isolates of PEMV and BLRV collected near Moscow, ID and maintained in infected pea aphid colonies.
- Plants (pea, alfalfa, vetch, faba bean, lentil) were propagated from commercially available seed.



Pea aphid colonies

Performance bioassay

- Plant species were sown at different times to standardize plant size at time of testing and grown in the greenhouse (16:8, L:D; 25°C:18°C)
- Virus inoculation or sham inoculation was performed approximately two weeks prior to testing.
- Individually-caged plants of each species (n = 6) were infested with 10 pea aphid foundresses from one of the pea aphid genotypes. The numbers of aphids per plant were counted after 10 days.



Preference bioassay

- In the greenhouse, plants were positioned around the perimeter of a circular arena surrounded by a Fluon™ coated barrier to prevent aphids escape.
- 50 apterous pea aphids were released into the center of the arena.
- After 24 hours, aphids were counted on all plants.



Results

Performance bioassay

Overall, virus infection generally improved performance of pea aphid on the host plants tested (Table 1). Performance was also affected by plant species and the interaction between virus and plant species and aphid biotype x plant species.

Table 1. Analysis of Deviance Table, Type II tests

| Effect | χ^2 | p |
|---------------------|----------|---------------|
| Aphid Genotype | 0.533 | 0.465493 |
| Plant Species | 33.301 | 3.279e-06 *** |
| Virus infection | 9.308 | 0.009523 ** |
| Genotype:Plant | 44.727 | 1.649e-08 *** |
| Genotype:Virus | 4.983 | 0.027776 . |
| Plant:Virus | 39.445 | 9.573e-06 *** |
| Biotype:Plant:Virus | 9.336 | 0.406835 |

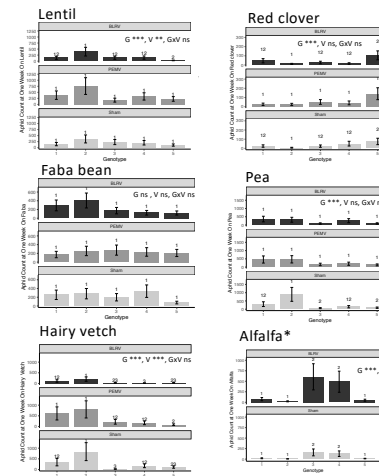
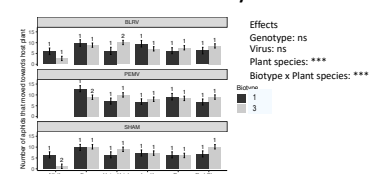


Fig. 1. Effects of virus and aphid genotype on performance within each plant species. G = Aphid genotype, V = virus, G x V = interact.

The performance profiles of aphid genotypes differed from one another except the common host, faba bean; the effect of virus was significant on three of the six hosts, but the aphid genotype x virus was not significant.

* Alfalfa is a nonhost for PEMV

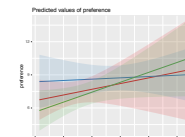
Preference bioassay



* Alfalfa is a nonhost for PEMV

Results, cont.

Preference x performance



Among genotypes on different hosts, preference and performance tended to a positive correlation.

This relationship appears to be weakened by virus infection, especially by BLRV

Discussion and Conclusion

- Effects of host plant differed among aphid genotypes consistent with the existence of pea aphid host races.
- Overall, infection by both viruses generally improved performance of pea aphid on the host plants tested, except for BLRV infecting hairy vetch.
- Virus infection did reduce differences in performance among host plants, an expectation if viruses manipulate hosts to promote interspecific spread.
- Preference for settling on different hosts differed among host plants and an interaction between aphid genotype and plant species is consistent with pea aphid host races.
- Virus infection did not affect settling preference or interact with among host settling preference, an expectation of multi-host manipulation by PEMV and BLRV.
- Although effects of PEMV and BLRV infection on aphids differed among hosts, between one another, and among some pea aphid biotypes, the patterns are not consistent with expected decrease in specificity of pea aphid genotypes.
- Whether such effects would influence or promote interspecific transmission of either virus by the pea aphid genotypes tested is doubtful under simple assumptions of uniform presence of hosts, viruses, and genotypes within the landscape.
- Epidemiological models parameterized using these results might reveal effects of interspecific transmission and overall spread.
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Acknowledgements

References

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