Vector behavior and plant defense influence vector-borne pathogen spread:

Assessing risks of enhanced spread of *Xylella fastidiosa* from grapevines with novel defensive traits

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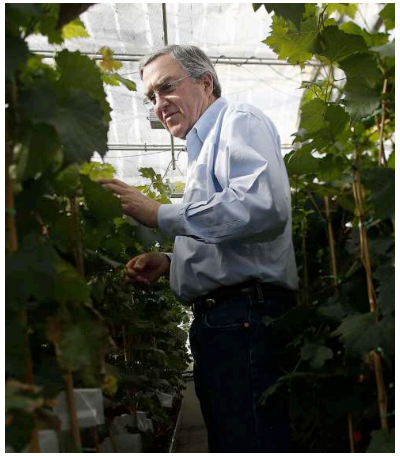
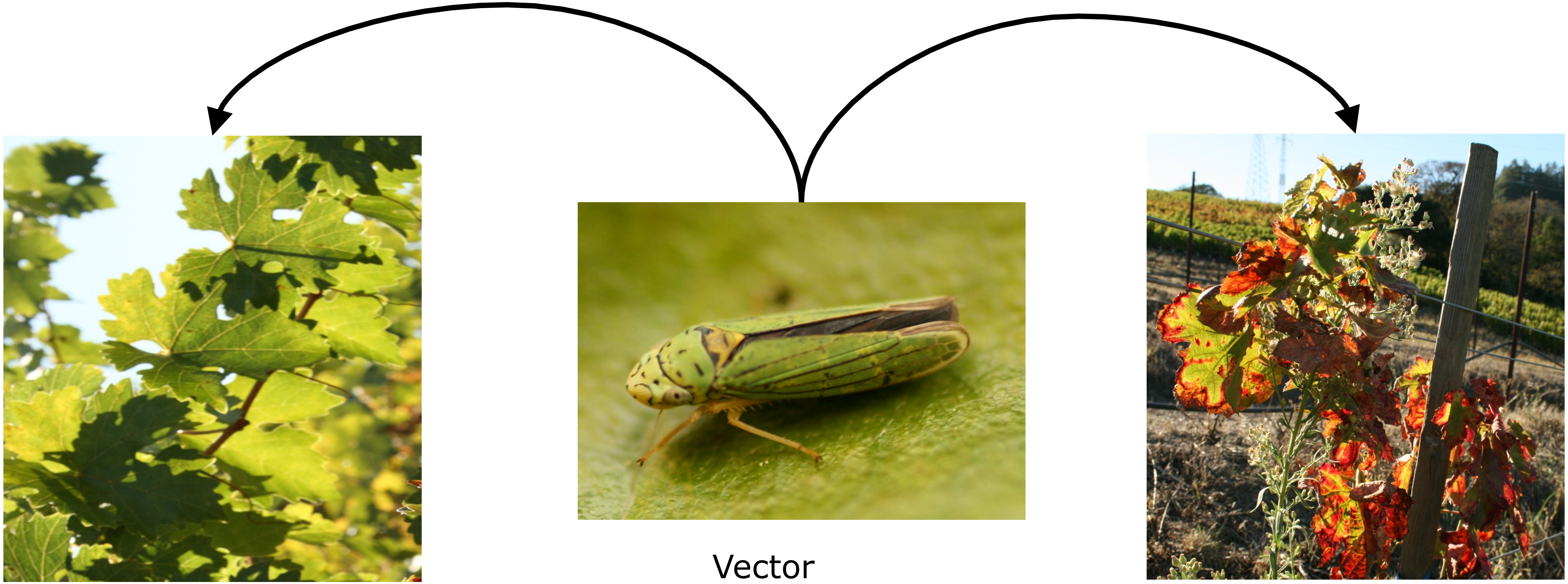


M. Andy Walker

Host selection by vectors

Disease vectors may preferentially select symptomatic or asymptomatic hosts



Asymptomatic/ Healthy

Vector

Symptomatic/ Diseased

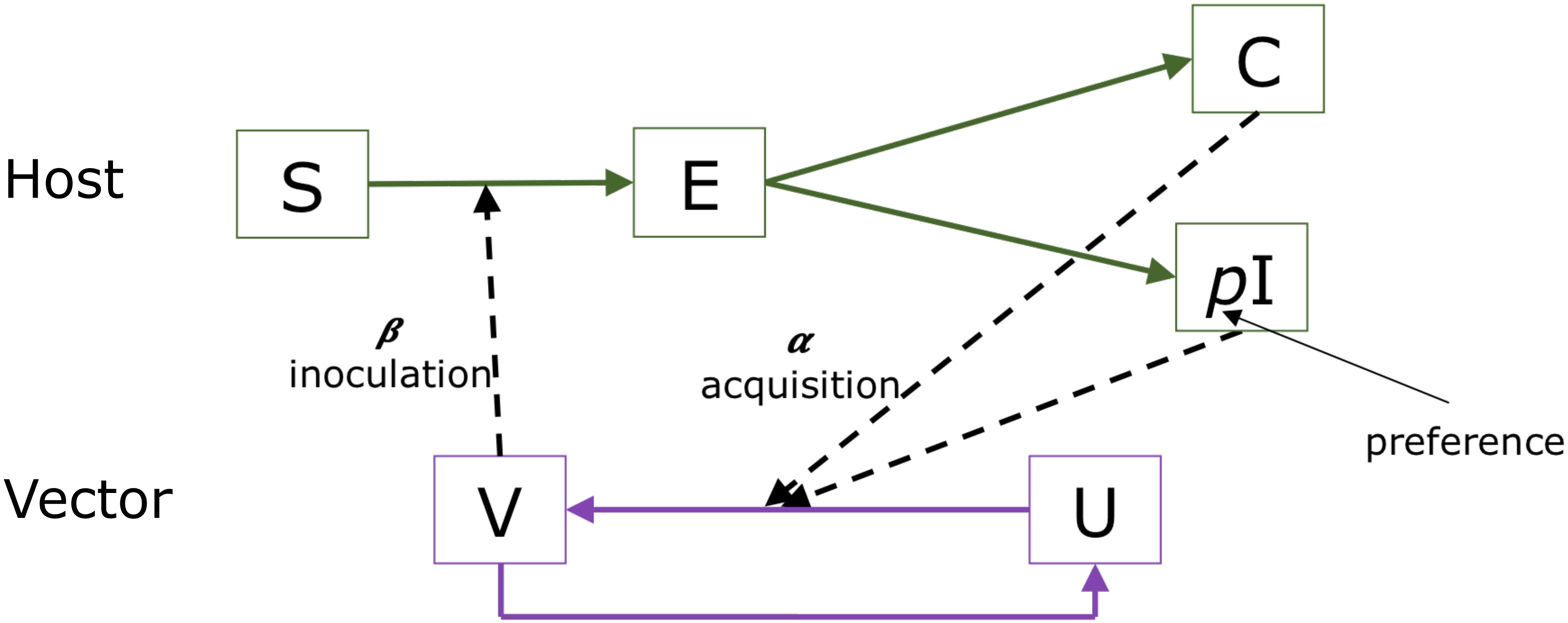
Host defense against pathogens

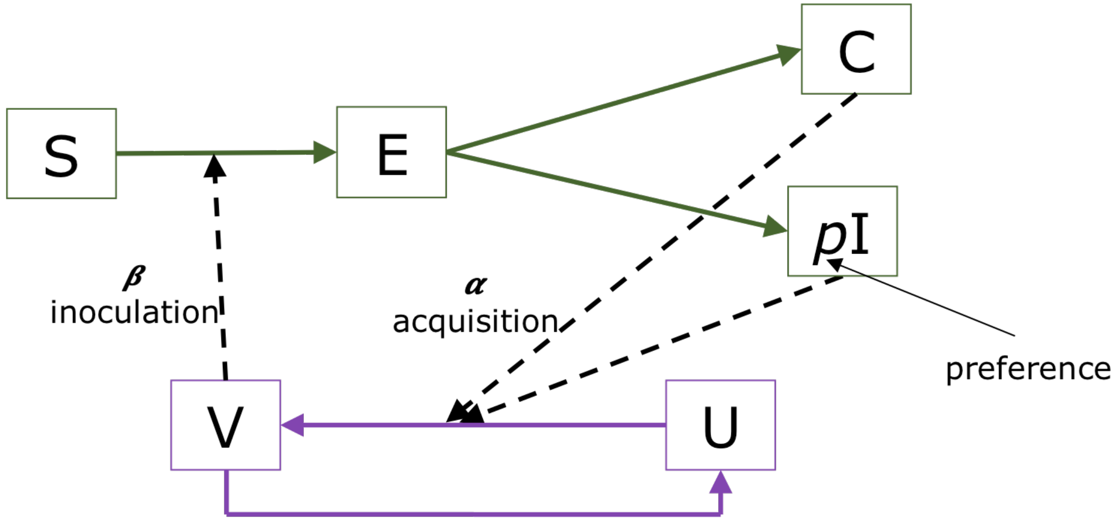
Defense: A trait that increases relative fitness of a host under pathogen exposure

Resistance: Low pathogen burden, no symptoms

Tolerance: High pathogen burden, no symptoms

How do vector preference and host defense interact to influence pathogen spread?


Host
S
E
C
pI
β
inoculation
α
acquisition
preference
Vector
V
U



Host equations

$$\frac{dS}{dt} = \eta(E + I + C) - \frac{\beta SV}{pI + S + E + C}$$

$$\frac{dE}{dt} = \frac{\beta SV}{pI + S + E + C} - (\delta + \eta)E$$

$$\frac{dC}{dt} = q\delta E - \eta C$$

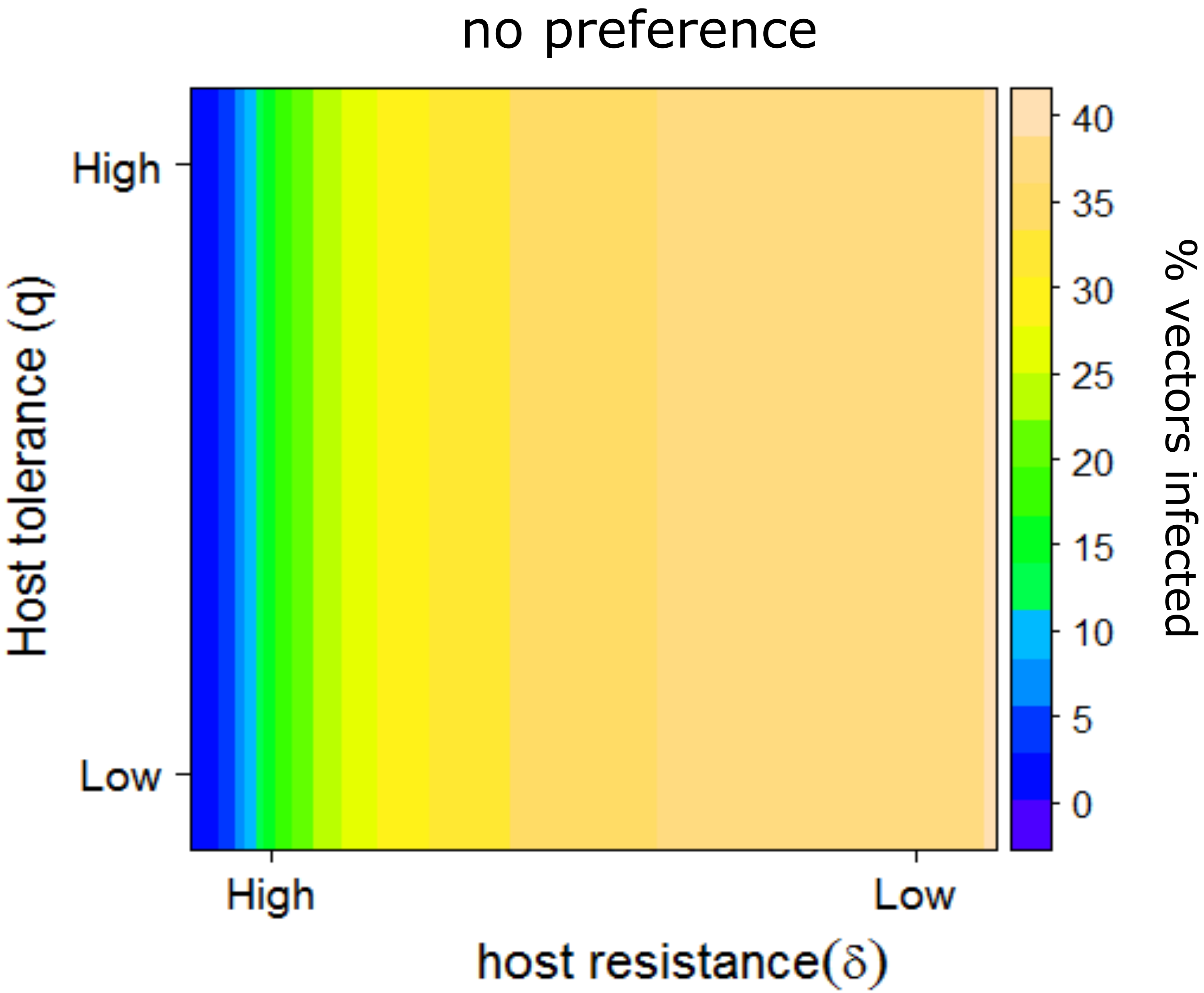
$$\frac{dI}{dt} = (1 - q)\delta E - \eta I$$

Vector equations

$$\frac{dU}{dt} = -\frac{\alpha pIU}{pI + S + E + C} - \frac{\alpha CU}{pI + S + E + C} + \lambda V$$

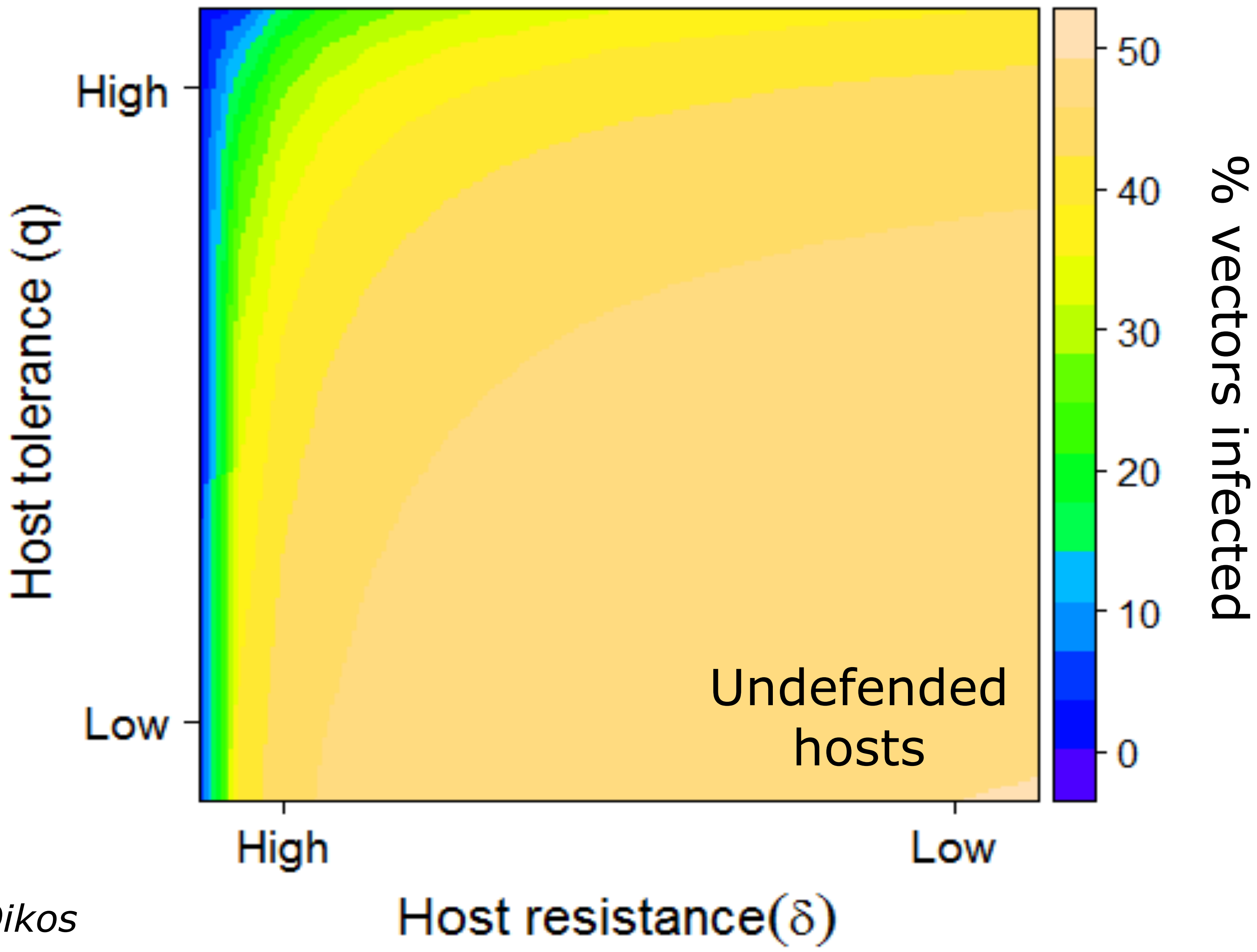
$$\frac{dV}{dt} = \frac{\alpha pIU}{pI + S + E + C} + \frac{\alpha CU}{pI + S + E + C} - \lambda V$$

Infected vectors at equilibrium



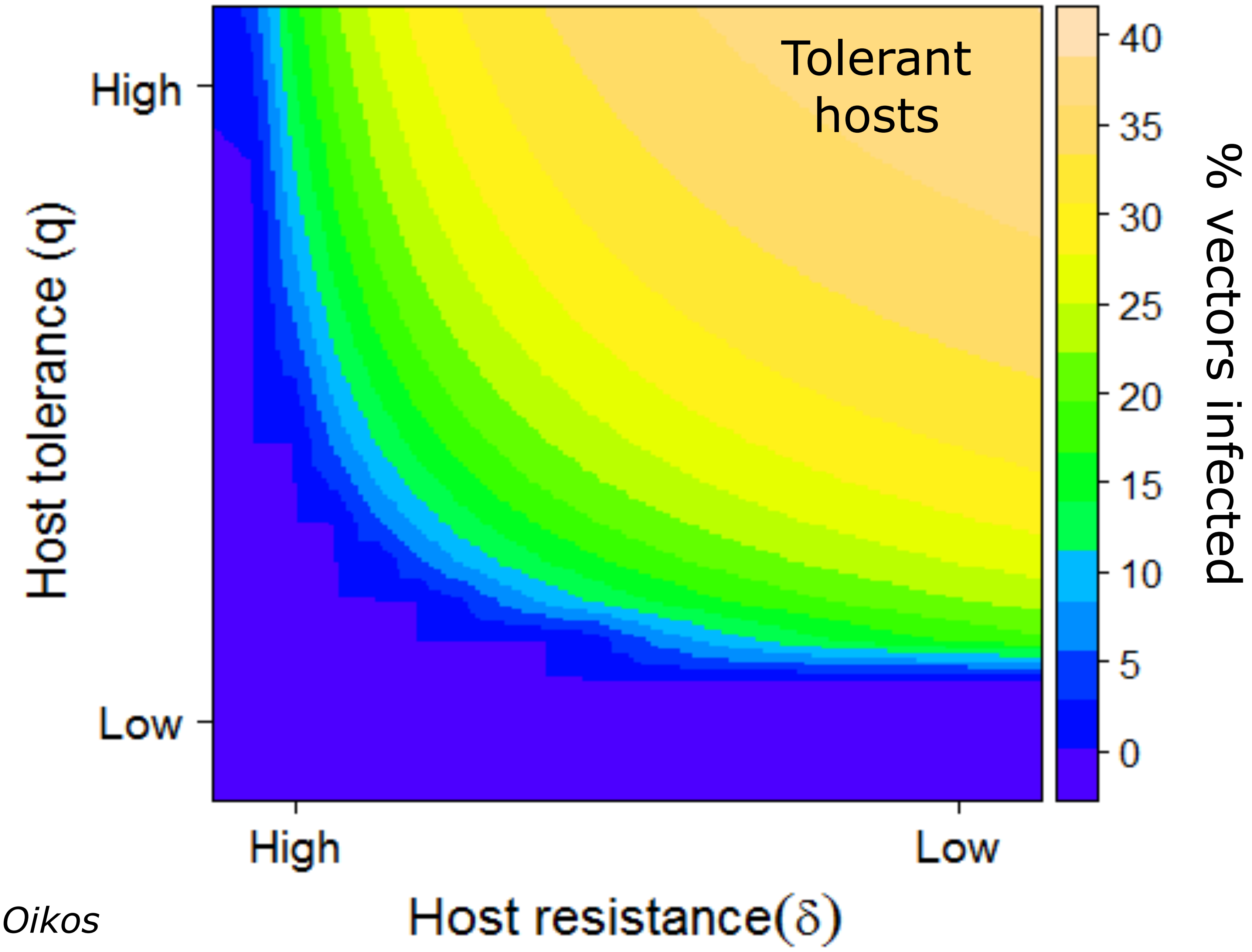
Zeilinger and Daugherty 2014 *Oikos*

Vectors prefer symptoms



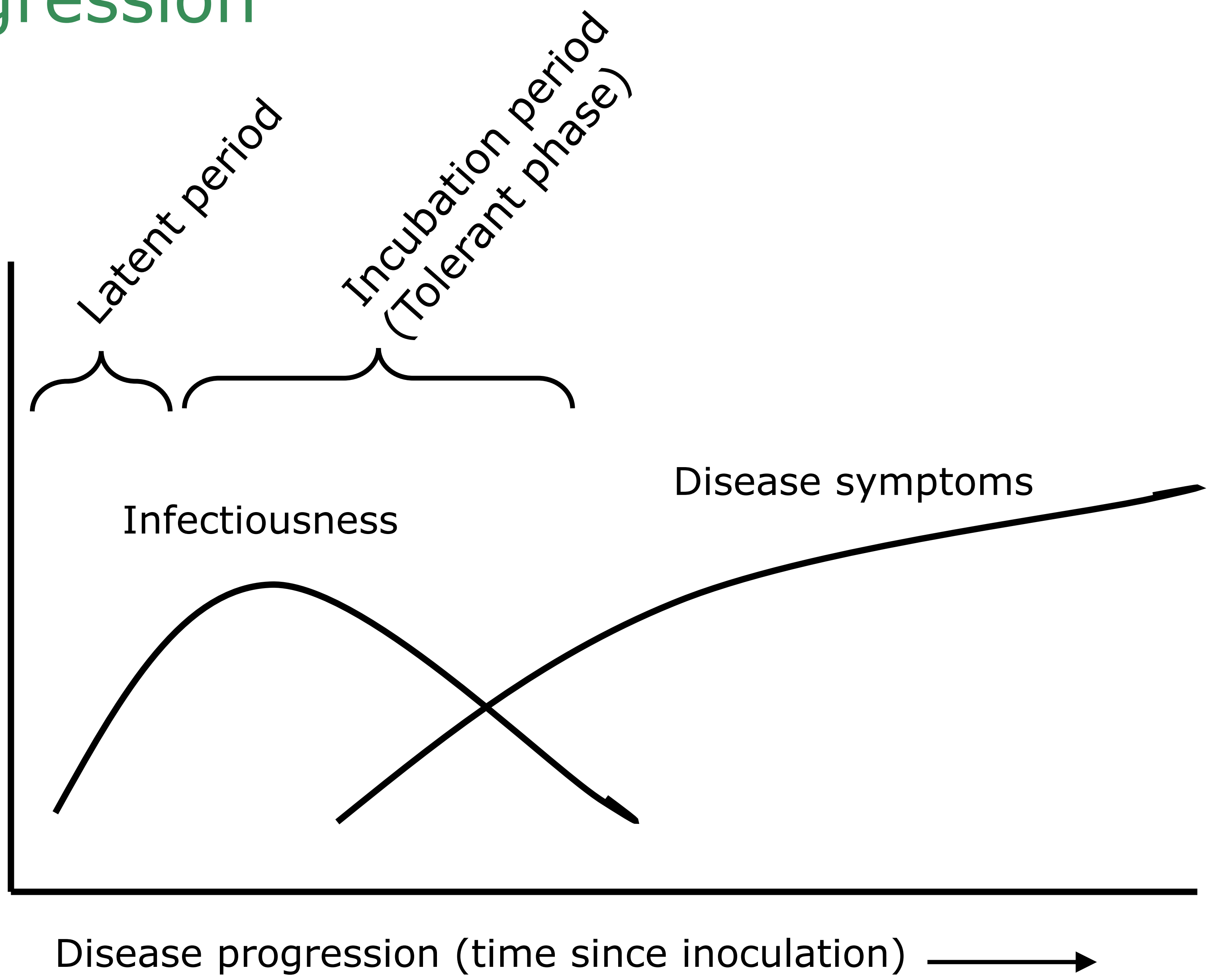
Zeilinger and Daugherty 2014 *Oikos*

Vectors avoid symptoms



Zeilinger and Daugherty 2014 *Oikos*

Disease progression



Pierce's Disease of grapevines

Caused by *Xylella fastidiosa*

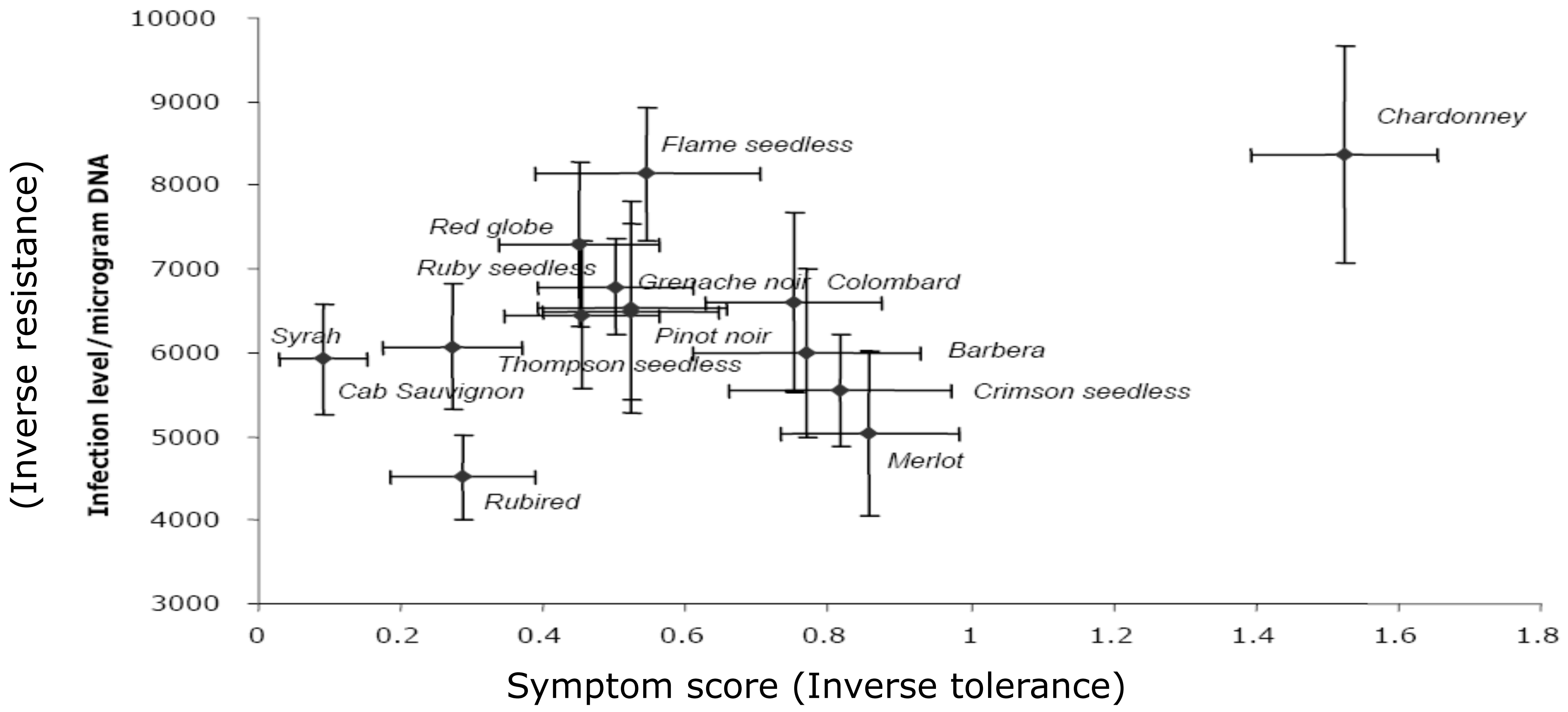
Sharpshooter vectors prefer healthy grapevines

Asymptomatic/ Healthy

Vector

Symptomatic/ Diseased

Grape vine defense against Pierce's Disease

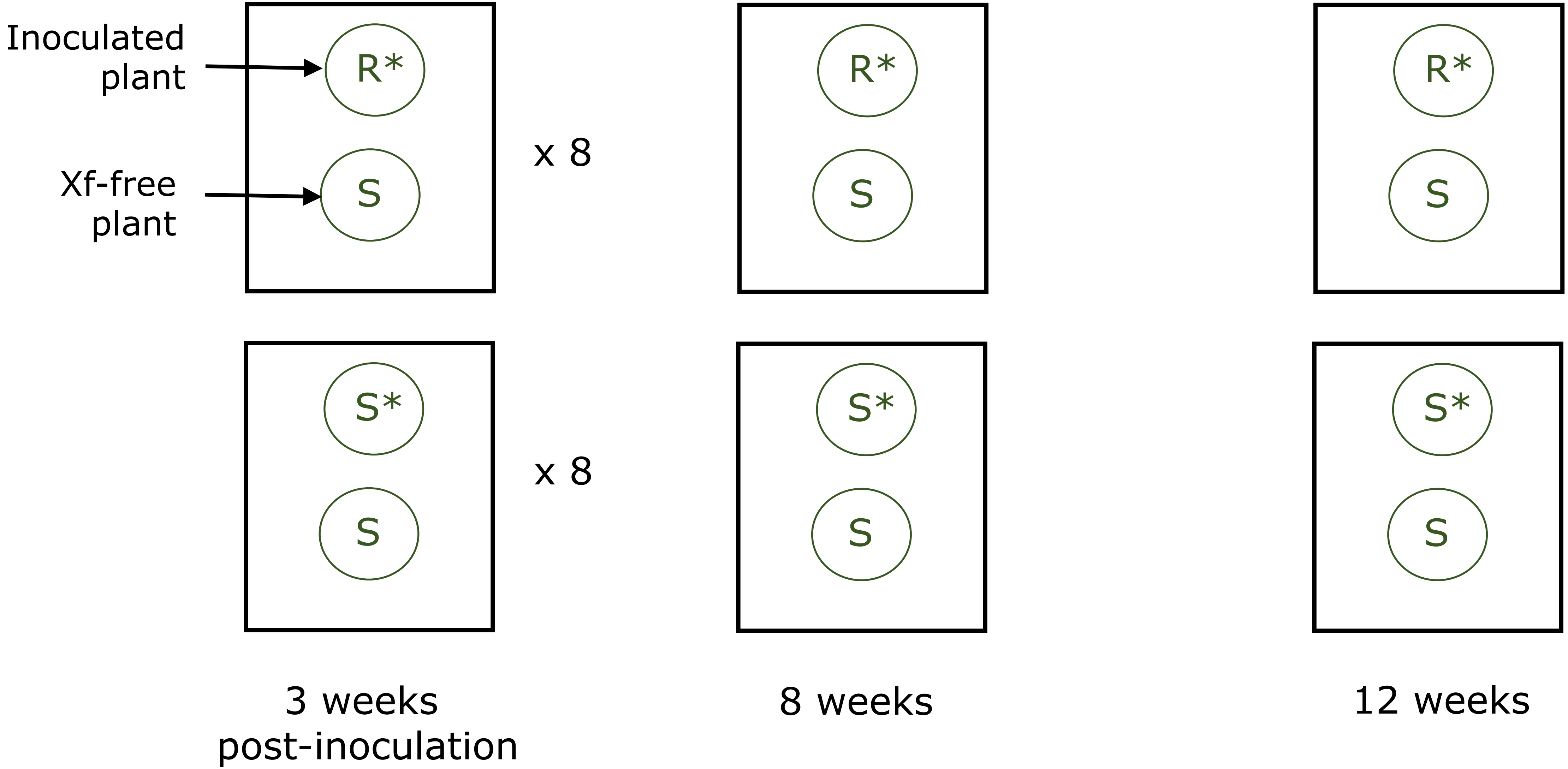


Almeida et al. *Proceedings PD Research Symposium*

Transmission and vector preference experiment – PdR1 hybrid plants

(Vitis rupestris x *V. arizonica)* x *V. vinifera* cv. Airen

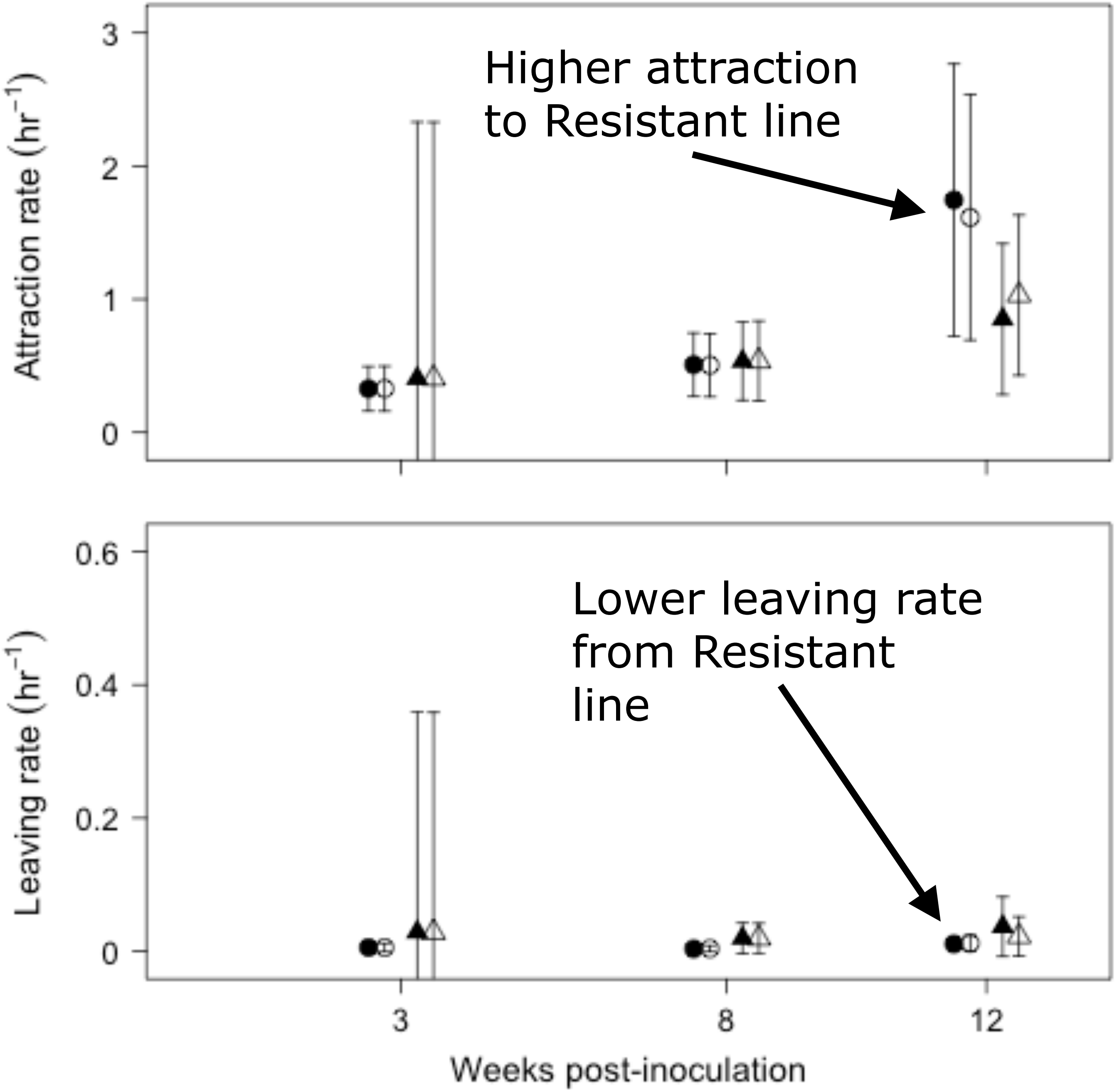
Experimental design



8 non-infectious BGSS per cage

Vector preference over time

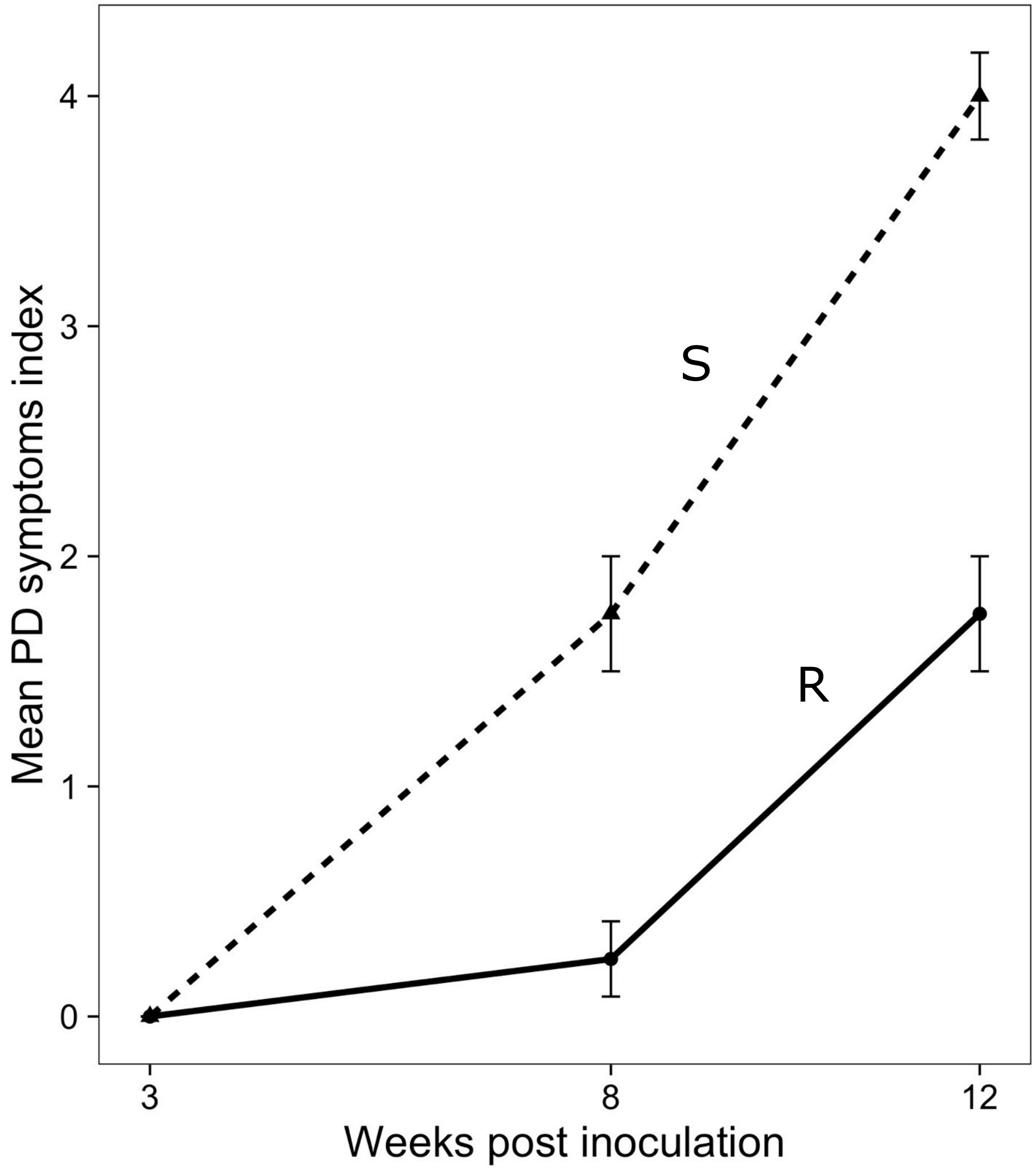
Greater attraction rate and lower leaving rate for Resistant over Susceptible plants



Pierce's Disease symptoms

Significant increase over time
(*P* = 0.044)

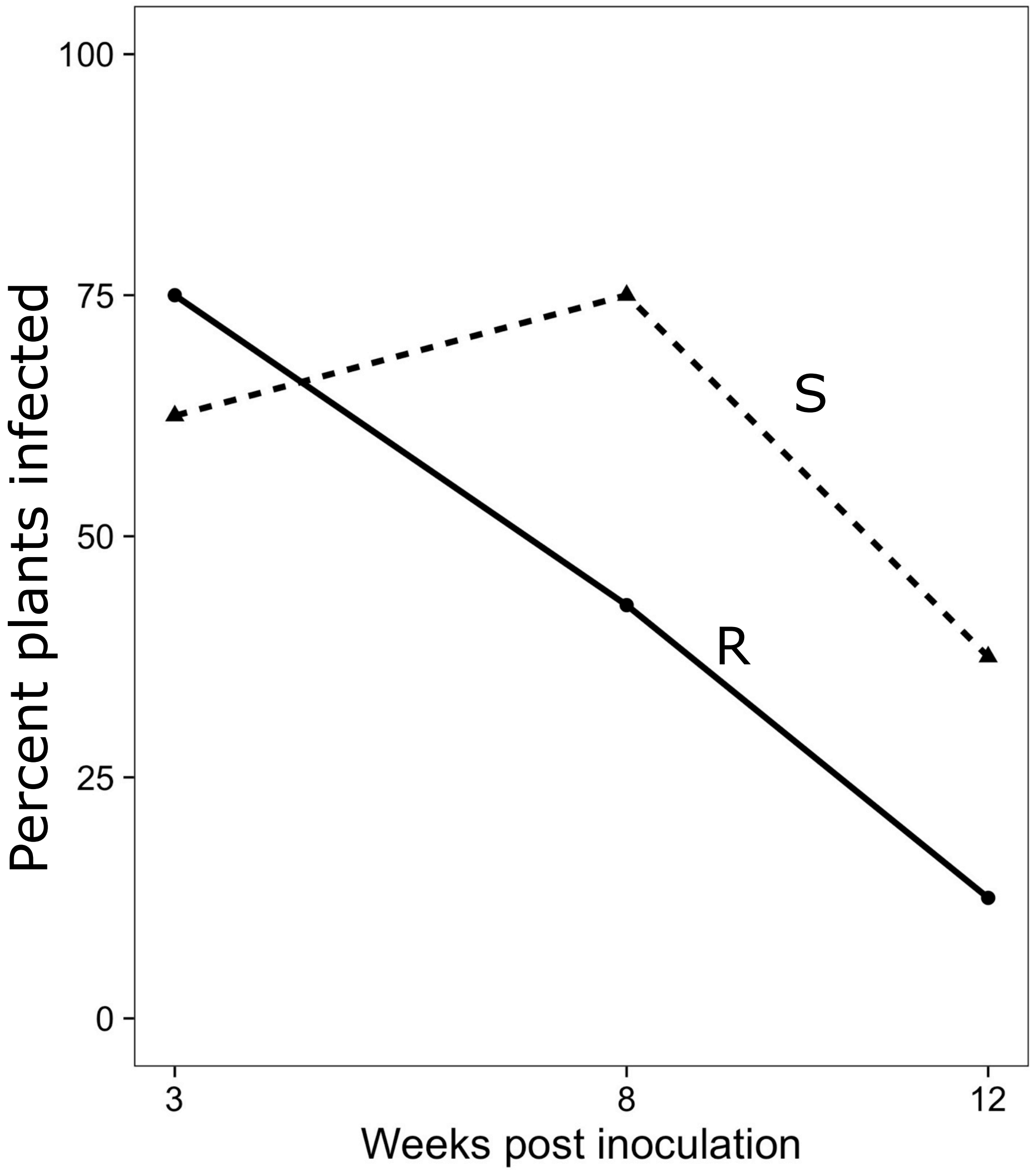
Marginal difference between genotypes
(P = 0.056)



Transmission results

Significant decline in transmission over time (P = 0.021)

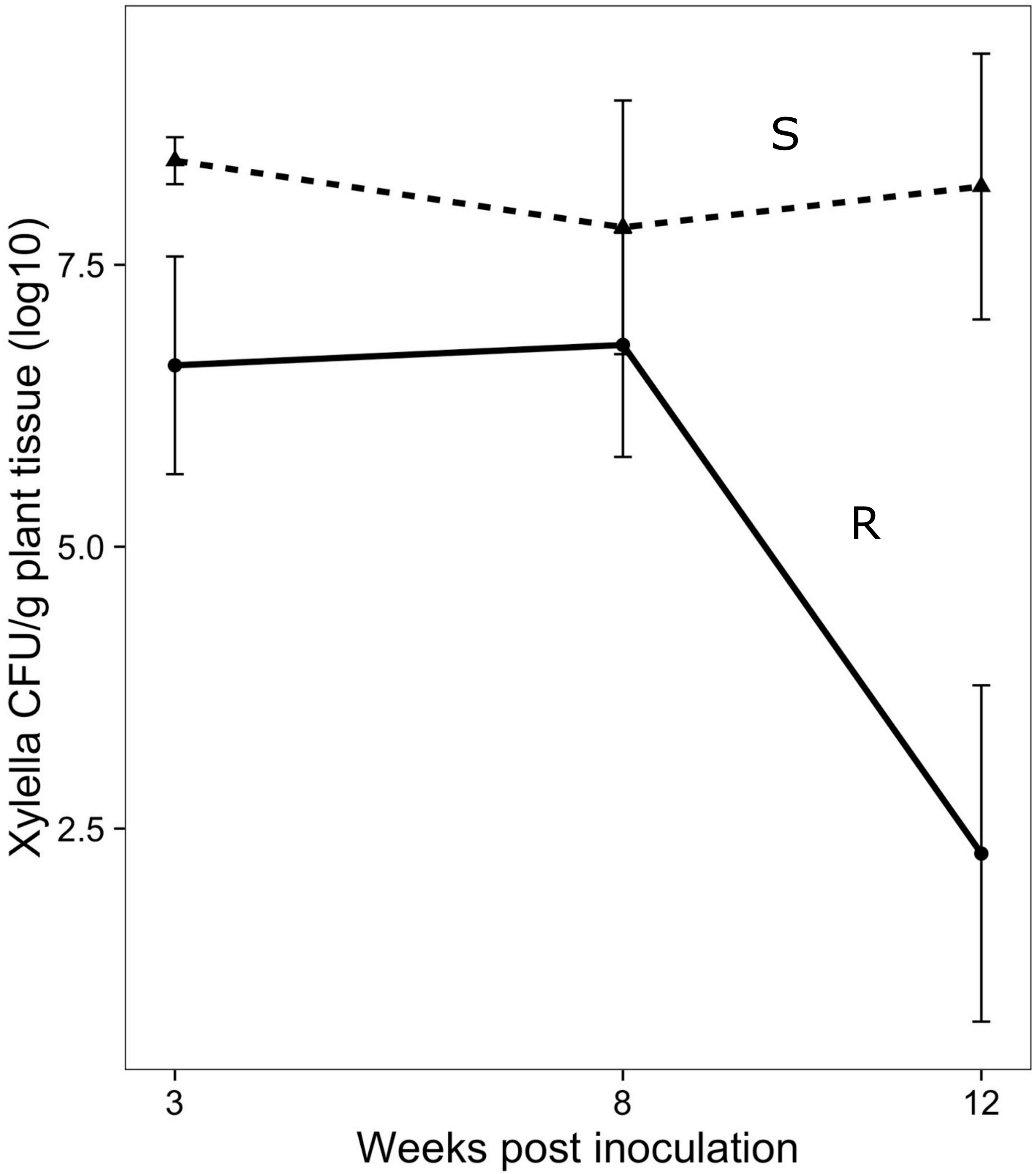
No difference between genotypes



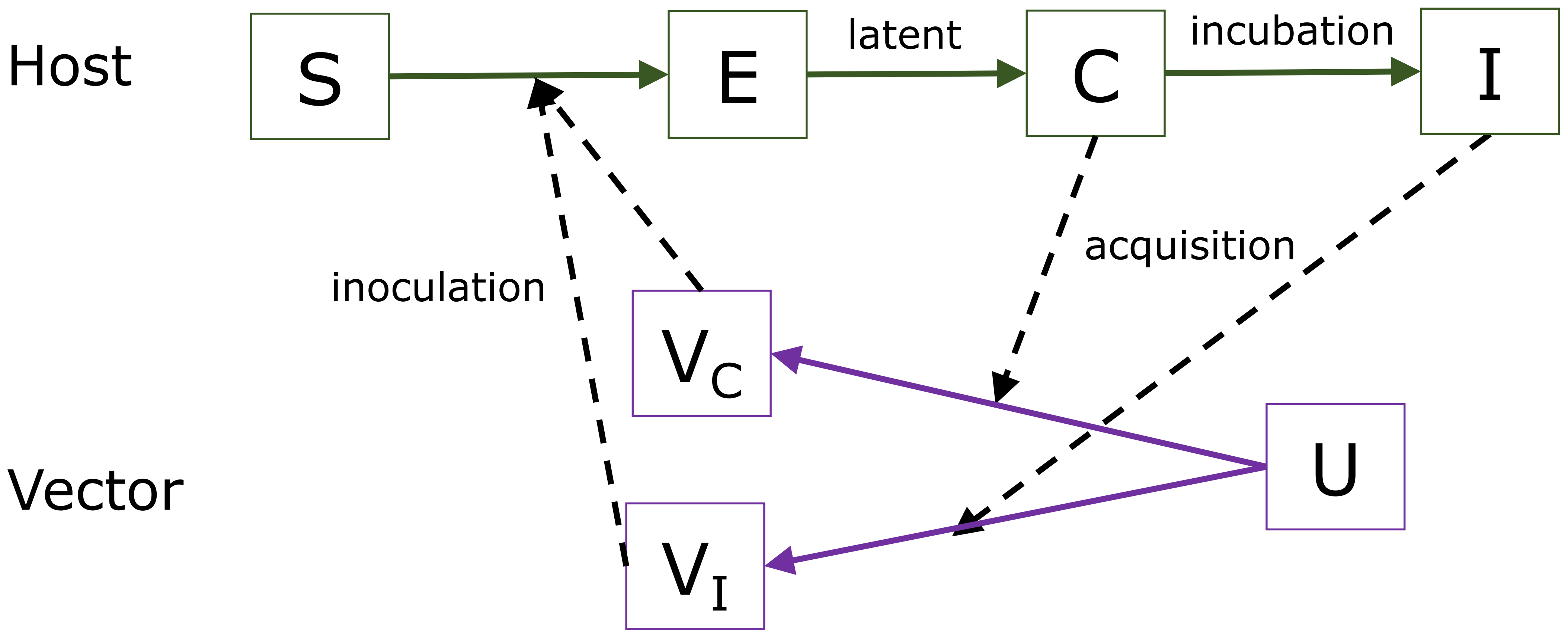
Xylella populations

Significant decline over time

Marginally significant interaction

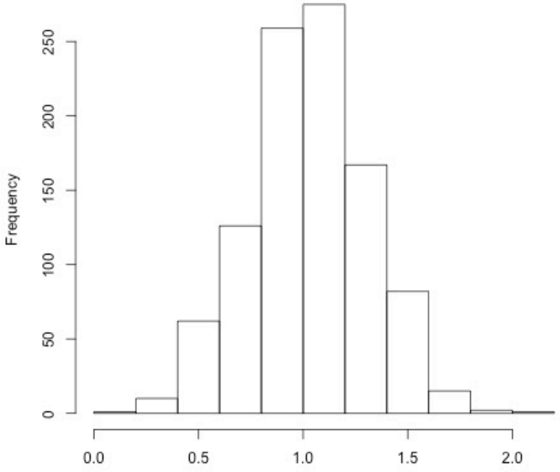


Modeling experimental results

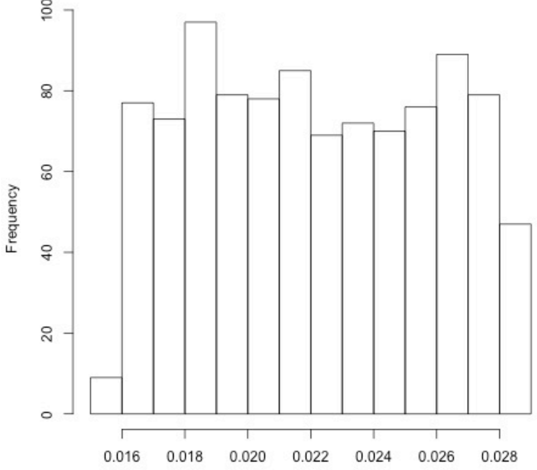


Propagating uncertainty with Monte Carlo

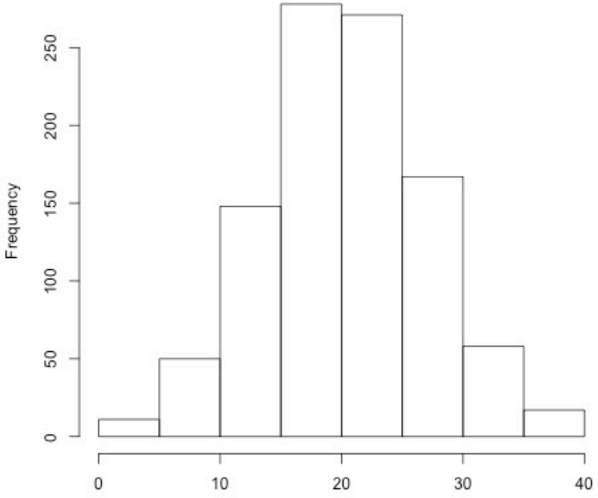
Acquisition



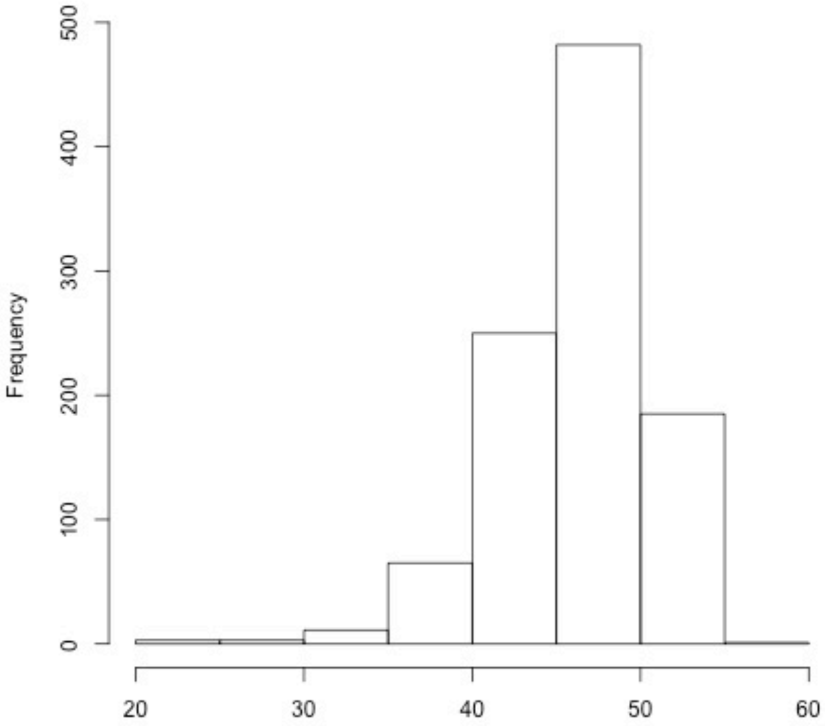
Incubation



Attraction rate

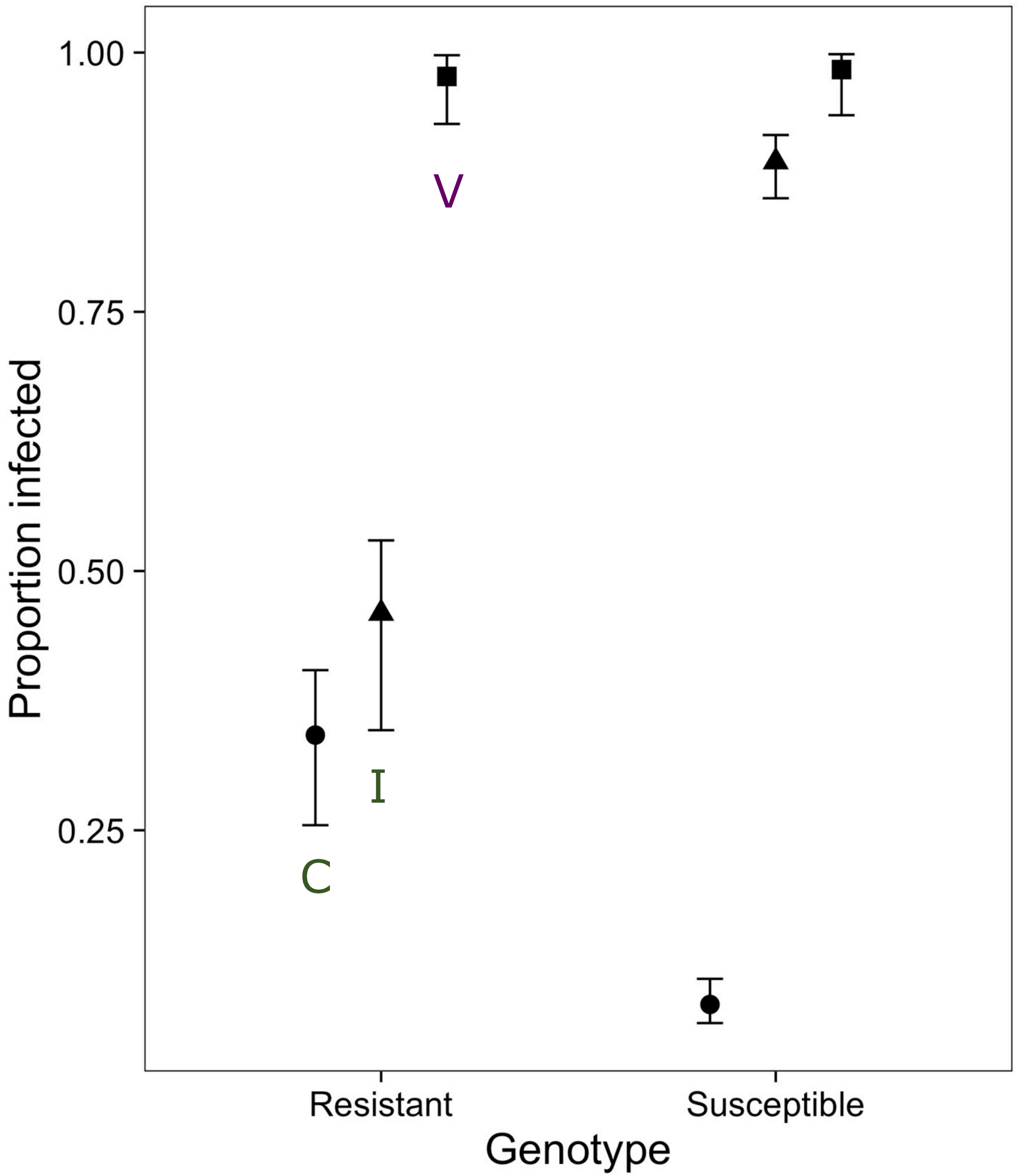


Diseased host density



5000 simulations

Proportion of hosts and vectors infected at equilibrium



Future work

Additional experiments into mechanisms of resistance in PdR1 plants

Tests of transgenic PD-resistant plants

Validation with field data and statistical epidemic models