

ANALYSIS OF FITNESS TRADE-OFFS LIMITING HOST RANGE EXPANSION IN PEPPER-INFECTING TOBAMOVIRUSES

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I. INTRODUCTION:

The adaptation of a virus to a new host may result in a host-switch or in host range expansion. Host range expansions provide a virus with more opportunities for transmission and survival, but may be limited by **across-host fitness trade-offs**. A major cause of across-host trade-offs in viruses is **antagonistic pleiotropy** which means that the effects of mutations will be beneficial in one host and detrimental in another. Here, we analyze if adaptation to new hosts involves fitness trade-offs using two systems. First, adaptation of tobacco mild green mosaic virus (TMGMV) to two different host species. Second, adaptation of pepper mild mottle virus (PMMoV) to pepper genotypes resulting in **resistance-breaking (RB)**. Under the **gene-for-gene (GFG)** model of host-pathogen interactions, resistance breaking should be associated

with fitness costs in non-resistant hosts. RB-associated costs have been reported for tobamovirus pathotypes that overcome *L*- gene resistance in pepper according to a GFG interaction (Fraile et al. 2014).

HOST	GENOTYPE	Virus Pathotype				
		P ₀	P ₁	P ₁₂	P ₁₂₃	P ₁₂₃₄
<i>C. annuum</i>	L ⁺ L ⁺	+	+	+	+	+
<i>C. annuum</i>	L ¹ L ¹	-	+	+	+	+
<i>C. frutescens</i>	L ² L ²	-	-	+	+	+
<i>C. chinense</i>	L ³ L ³	-	-	-	+	+
<i>C. chacoense</i>	L ⁴ L ⁴	-	-	-	-	+

II. ADAPTATION TO DIFFERENT HOST SPECIES – TMGMV

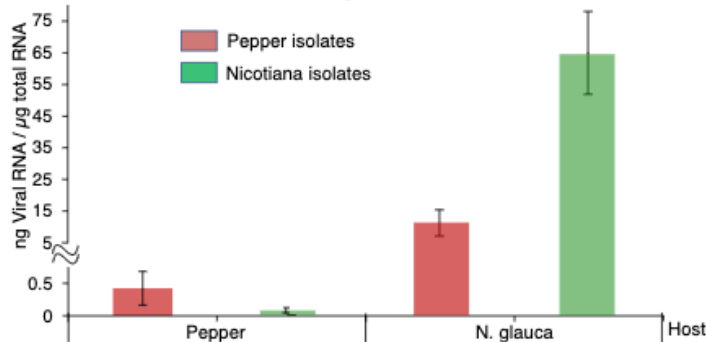


Fig. 1 – TMGMV infects in nature *Nicotiana glauca* Grah. and pepper (*Capsicum annuum* L.) plants. The comparison of sympatric isolates from these two hosts showed that *N. glauca* is a better host for all isolates, but **TMGMV isolates performed better in their original host.**

III. ADAPTATION TO RESISTANT HOST GENOTYPES – PMMoV

The overcoming of *L* gene resistance in pepper plants by PMMoV is due to mutations in the coat protein. To analyze if RB has fitness penalties, and their cause, we introduced all reported mutations resulting in RB of L³ and L⁴ alleles, into two infectious cDNA clones of isolates overcoming L² allele (Pathotype P_{1,2}).

Virus Genotypes	Pathotype	Overcomes allele
TS	P _{1,2}	L ¹ L ²
TS-(M138N)	P _{1,2,3}	L ¹ L ² L ³
TS-(T43K+D50G)	P _{1,2,3}	L ¹ L ² L ³
TS-(L13F+G66V)	P _{1,2,3}	L ¹ L ² L ³
MG	P _{1,2}	L ¹ L ²
MG-(M138N)	P _{1,2,3}	L ¹ L ² L ³
MG-(A87G)	P _{1,2,3,4}	L ¹ L ² L ³ L ⁴

IV. QUANTIFICATION OF FITNESS AND VIRULENCE OF DIFFERENT GENOTYPES OF PMMoV IN PEPPER PLANTS HARBOURING DIFFERENT ALLELES OF RESISTANCE

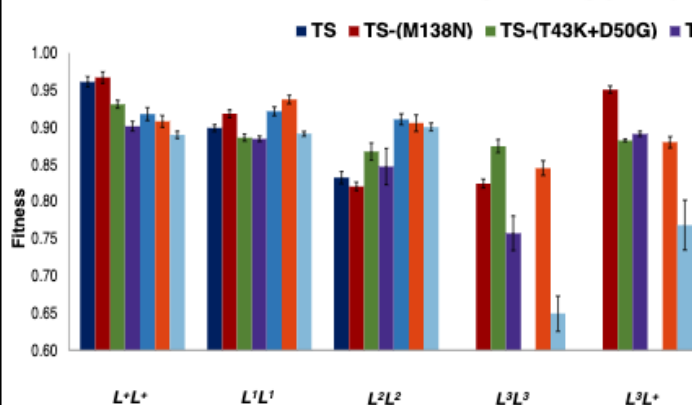


Fig. 2 – The fitness of different virus genotypes depended on the viral genotype per environment (host) interaction. **RB mutations have positive or negative pleiotropic effects on fitness according to the host environment.**

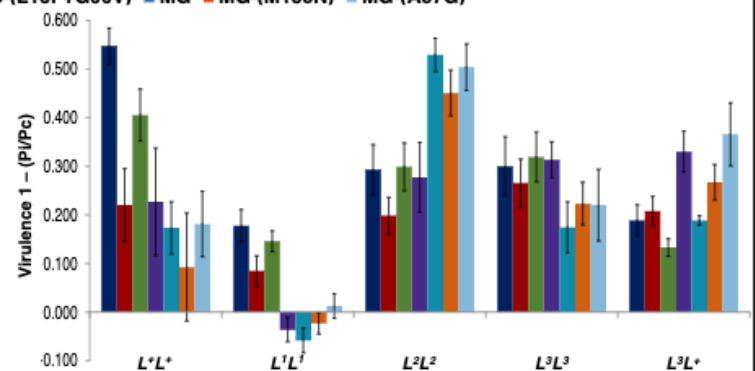


Fig. 3 – RB mutations also had pleiotropic effects on virulence, estimated as the effect of infection on host biomass (P). **Virulence was again dependent on viral genotype per environment (host) genotype interaction, but it did not correlate with virus fitness.**

V. CONCLUSIONS

- Across host fitness trade-offs in TMGMV adaptation to two different host species will result in host switches rather than host range expansion.
- Adaptation of PMMoV to overcome resistance in pepper plants is due to coat protein mutations with pleiotropic effects on virus fitness and virulence.
- Pleiotropic effects of RB mutations depend on the host environment, being either negative or positive.
- The complex viral genotype per host environment interactions will make predictions on virus adaptation and RB difficult.

References :

- Fraile A, et al.(2014). Host resistance selects for traits unrelated to resistance-breaking that affect fitness in a plant virus. *Mol Biol Evol.* 31(4): 928– 939
- Fraile A, et al.(2011). Rapid genetic diversification and high fitness penalties associated with pathogenicity evolution in a plant virus. *Mol Biol Evol.* 28:1425–1437