

# Deformed Wing Virus: how do vector transmitted viruses contribute to the death of honey bees?



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## *Varroa destructor*

Without treatment, *Varroa* infestation typically kills colonies within 6-24 months

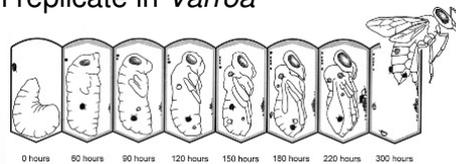
### Wound honey bees

- Pierce through honey bee integument
- Suck on haemolymph (bee blood)



### Vector viruses

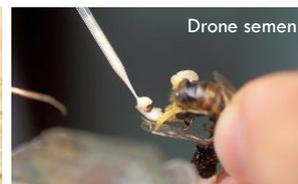
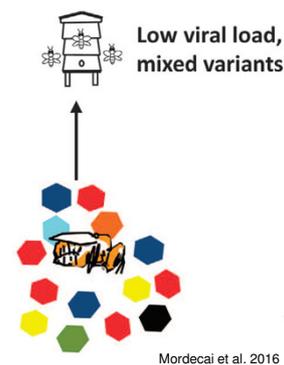
- Inject viruses into pupae during feeding
- DWV can replicate in *Varroa*



## Deformed wing virus (DWV)

### Before *Varroa*

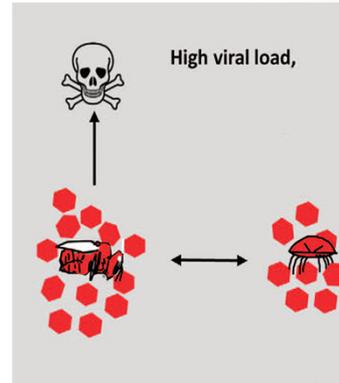
- Transmitted by feeding; contact; through eggs and sperm
- Low viral load
- Broad strain diversity



## Deformed wing virus (DWV)

### After *Varroa*

- Transmitted by mite feeding
- High viral load
- Decreased strain diversity
- Overt symptoms of disease
- Colony death



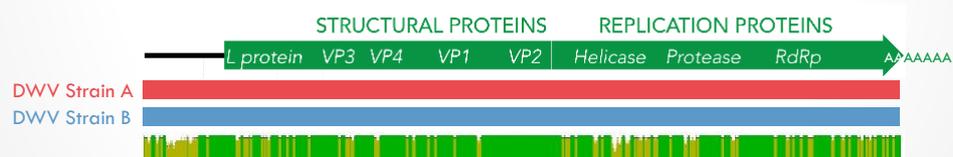
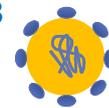
## DWV strains

- Multiple strains, 'master variants':

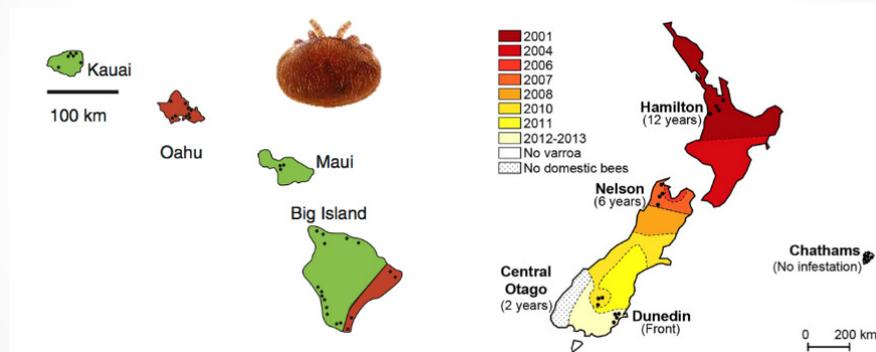


**DWV strain A** and **DWV strain B**

- Genome: 85% identical
- Protein: 95% identical



# Varroa increases DWV-A levels as it spreads



## Global Honey Bee Viral Landscape Altered by a Parasitic Mite

Stephen J. Martin,<sup>1\*</sup> Andrea C. Highfield,<sup>2</sup> Laura Brettell,<sup>1</sup> Ethel M. Villalobos,<sup>3</sup> Giles E. Budge,<sup>4</sup> Michelle Powell,<sup>4</sup> Scott Nikaido,<sup>3</sup> Declan C. Schroeder<sup>2\*</sup>

8 JUNE 2012 VOL 336 SCIENCE

## On the Front Line: Quantitative Virus Dynamics in Honeybee (*Apis mellifera* L.) Colonies along a New Expansion Front of the Parasite *Varroa destructor*

Fanny Mondet<sup>1,2,3\*</sup>, Joachim R. de Miranda<sup>4</sup>, Andre Kretzschmar<sup>4</sup>, Yves Le Conte<sup>4</sup>, Alison R. Mercer<sup>1</sup>

<sup>1</sup>Department of Zoology, University of Otago, Dunedin, New Zealand, 2100A, US 400 Alaska St. Environnement, Angers, France, 3 AgriParTech, Paris, France, <sup>4</sup>Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden, 8100A, 101 86 Statistiska och Processus Sociales, Angers, France

# DWV in *Varroa*-resistant bees

- **Swindon, UK:** Breeding program selecting for *Varroa*-resistance



**DWV Strain A**  
= Collapsing colonies



**DWV Strain B**  
= Surviving colonies

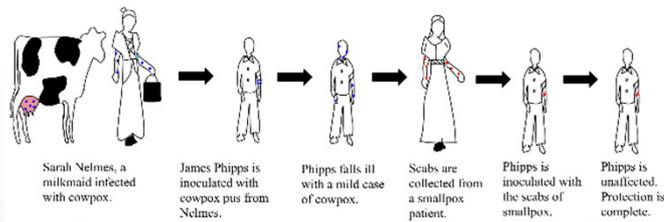
**Superfection Exclusion?**

<http://www.swindonhoneybeeconservation.org.uk/research/>

Mordecai, C, et al., (2015) Superinfection exclusion and the long-term survival of honey bees in *Varroa*-infested colonies. *ISMEJ* 10.1038/ismej.2015.186: 1-10.

## Superinfection exclusion

- Mild virus protects against a similar, more virulent (deadly) virus



By Sdcyr16 - CC BY-SA 4.0, <https://commons.wikimedia.org/w/index.php?curid=40659361>

## DWV Superinfection exclusion?

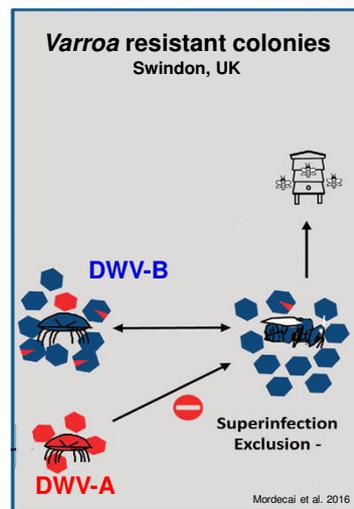
- Could exposure to **DWV-B** inhibit secondary **DWV-A** infection?

The ISME Journal (2016) 10, 1182–1191  
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[www.nature.com/ismej](http://www.nature.com/ismej)

OPEN

### ORIGINAL ARTICLE Superinfection exclusion and the long-term survival of honey bees in Varroa-infested colonies

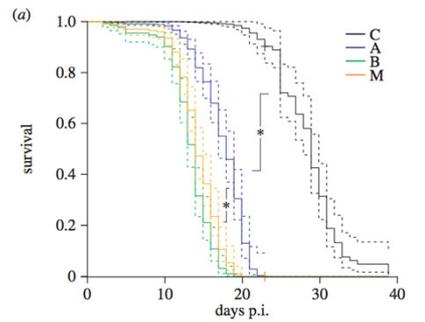
Gideon J Mordecai<sup>1,2</sup>, Laura E Brettell<sup>3</sup>, Stephen J Martin<sup>4</sup>, David Dixon<sup>1</sup>, Ian M Jones<sup>2</sup> and Declan C Schroeder<sup>5</sup>  
<sup>1</sup>Viral Ecology, Marine Biological Association, Plymouth, UK; <sup>2</sup>School of Biological Sciences, University of Reading, Reading, UK and <sup>3</sup>School of Environment and Life Sciences, The University of Salford, Manchester, UK



Mordecai et al. 2016

## BUT: Is DWV-B more virulent?

Lab experiment: adult workers injected with DWV-B had in higher mortality vs. DWV-A



## Do DWV strains differ in virulence?



DWV-A

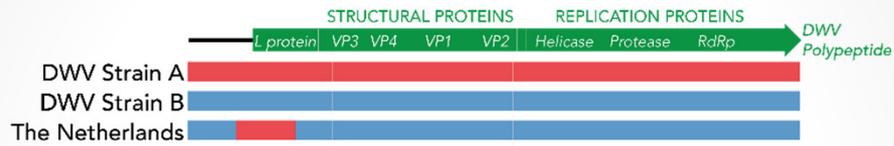
- associated with Varroa and colony loss



DWV-B

- associated with Varroa resistant bees  
- increased adult mortality in the lab

## DWV-recombinant, Netherlands



- Netherlands colonies have not been chemically treated for *Varroa* since 2008
- Colonies have developed “*Varroa* tolerance” and keep mite numbers low

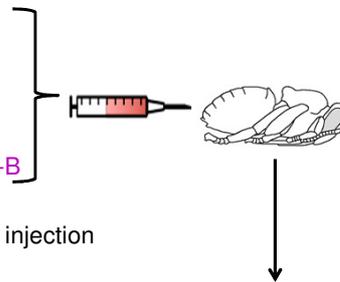


## Investigating DWV strain replication and competition in *Varroa*-naïve pupae

Extracted ~ 1700 white-eyed pupae from 3 colonies

Injected with:

- Buffer (virus –ve control)
  - DWV-A
  - DWV-B
  - DWV-recombinant
  - 50:50 Mixture DWV-A + DWV-B
- Un-manipulated controls = no injection



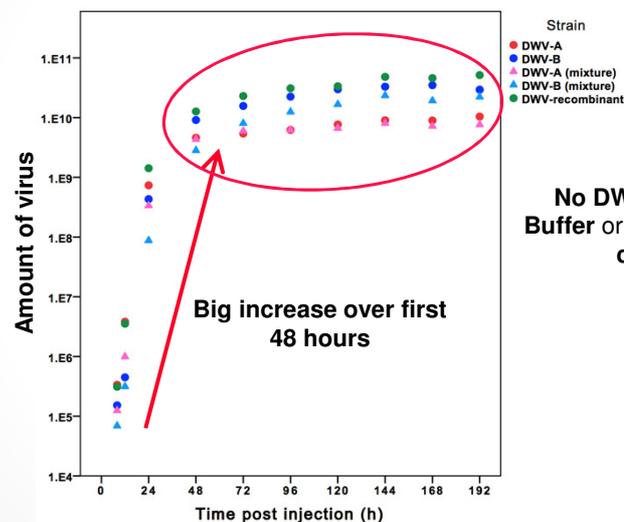
1. Collected pupae at multiple **time points**
2. Recorded **daily survival**
3. Measured **viral concentration** daily

## Quarantine approved facility

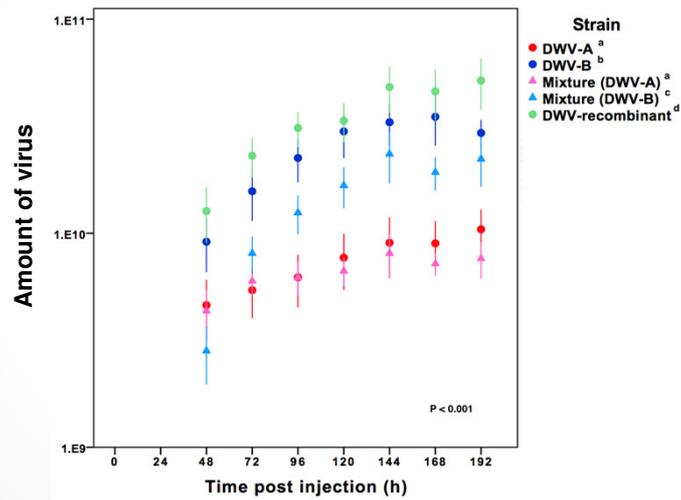
- Permit to import and administer DWV to local honey bee pupae (0000917783), within our quarantine approved laboratory (N2083)
- All methods strictly adhere to quarantine protocol
- Pupae frozen @  $-80^{\circ}\text{C}$  prior to eclosion



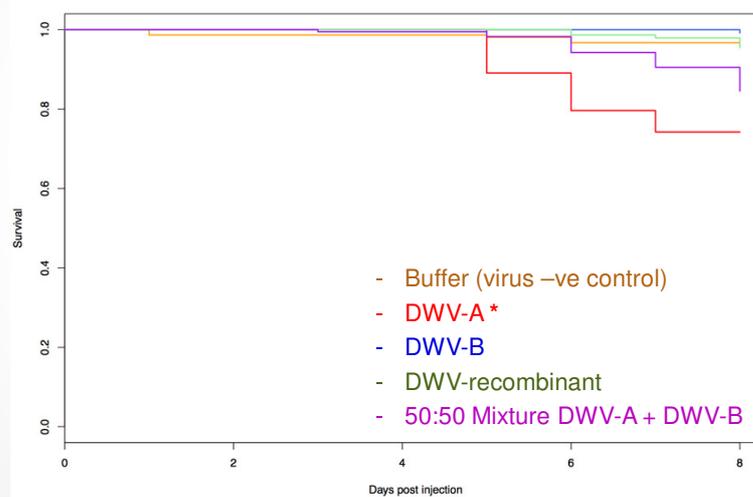
## DWV replication



## DWV-recombinant and Strain B levels are higher than Strain A



## BUT: Strain A injected pupae have reduced survival



## Take home messages

- **DWV-A** significantly reduced survival compared to **DWV-B** and **DWV-recombinant**
- **DWV-recombinant** and **DWV-B** replicate to higher concentrations than **DWV-A**
- Virus levels do not equal virulence in pupae



## Take home messages

- No evidence that **DWV-B** inhibits **DWV-A** in pupae
- No evidence of competition between **DWV-A** and **DWV-B**
- Our results do not support superinfection exclusion theory



# Amanda would like to acknowledge

*Behaviour and Genetics of Social Insects Laboratory*

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