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

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Varroa destructor

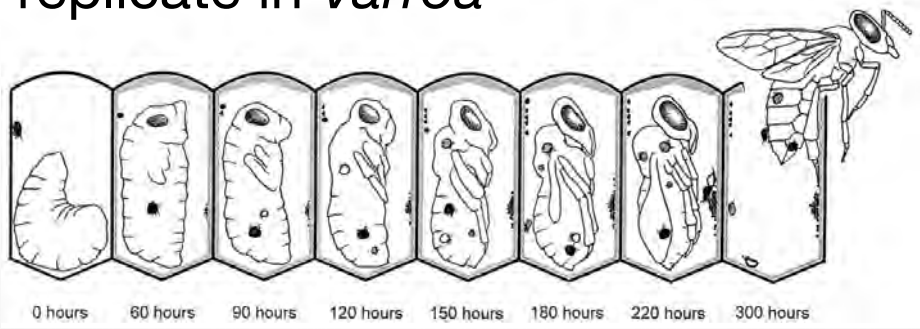
Without treatment, *Varroa* infestation typically kills colonies within 6-24 months

Wound honey bees

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

Vector viruses

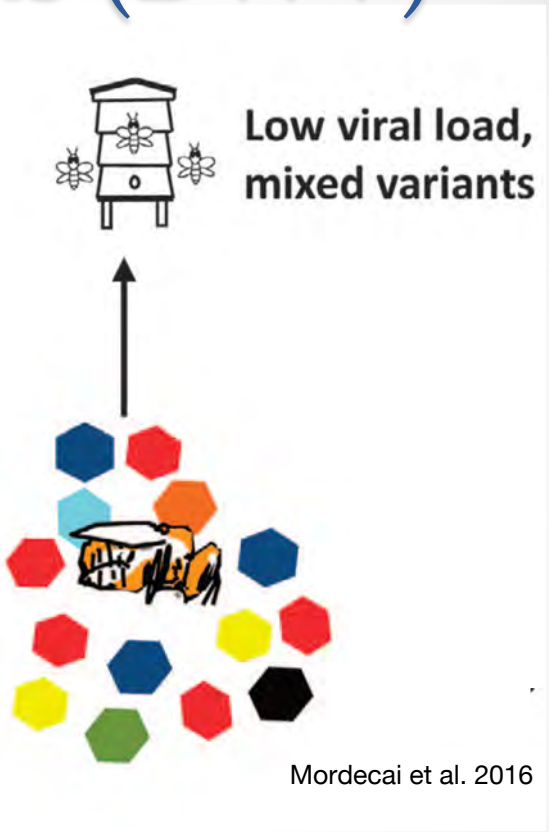
- Inject viruses into pupae during feeding
- DWV can replicate in *Varroa*



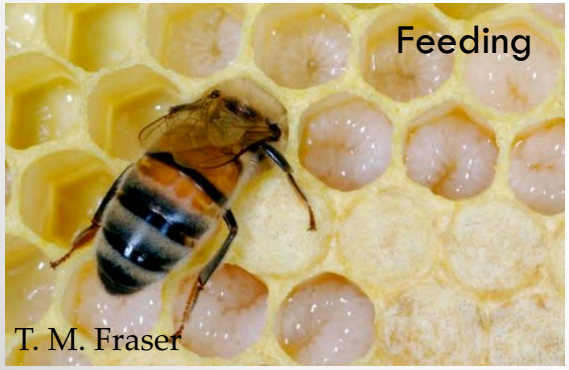
Deformed wing virus (DWV)

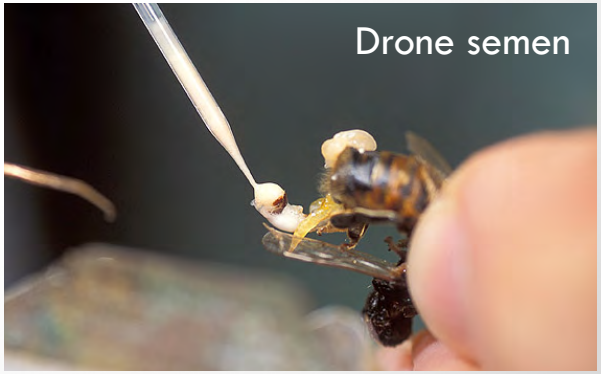
Before *Varroa*

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



Mordecai et al. 2016

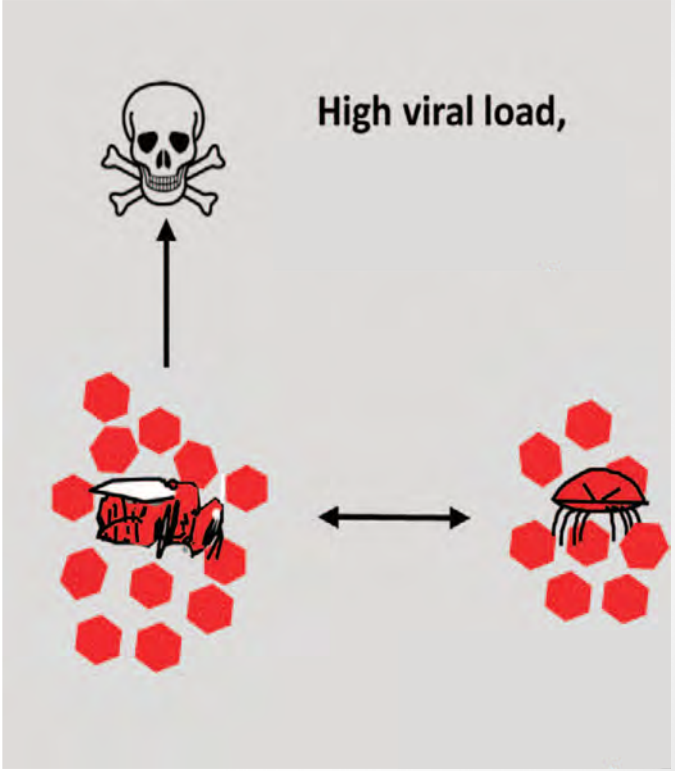




Deformed wing virus (DWV)

After *Varroa*

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

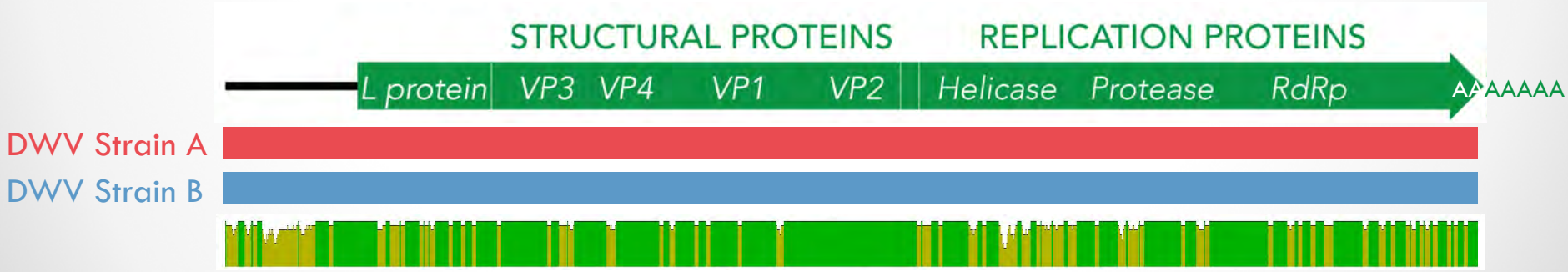


DWV strains

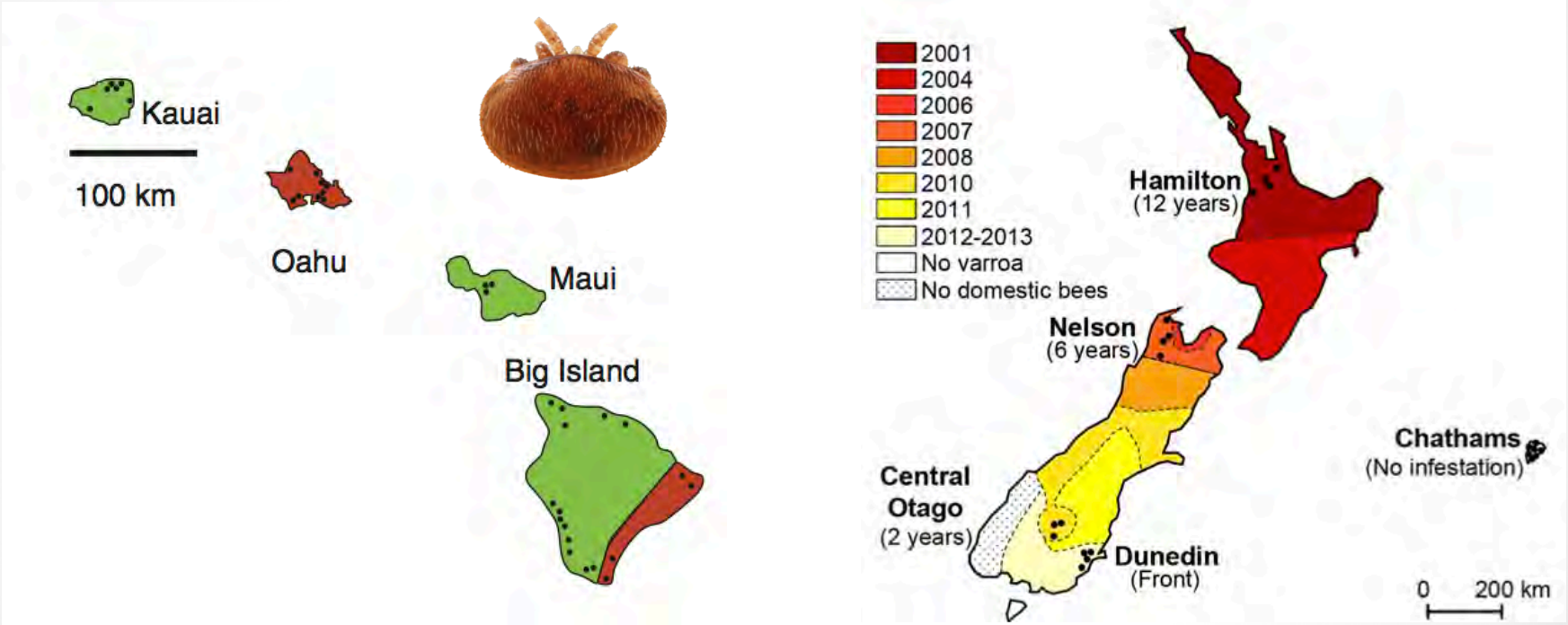
- Multiple strains, ‘master variants’:

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,[1*] Andrea C. Highfield,[2] Laura Brettell,[1] Ethel M. Villalobos,[3] Giles E. Budge,[4] Michelle Powell,[4] Scott Nikaido,[3] Declan C. Schroeder[2*]

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[1,2,3*], Joachim R. de Miranda[4], Andre Kretzschmar[5], Yves Le Conte[2], Alison R. Mercer[1]

1 Department of Zoology, University of Otago, Dunedin, New Zealand, 2 INRA, UR 406 Abeilles et Environnement, Avignon, France, 3 AgroParisTech, Paris, France, 4 Department of Ecology, Swedish University of Agricultural Sciences, Uppsala, Sweden, 5 INRA, UR 546 Biostatistique et Processus Spatiaux, Avignon, France

DWV in *Varroa*-resistant bees

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

DWV Strain A
= Collapsing colonies

DWV Strain B
= Surviving colonies

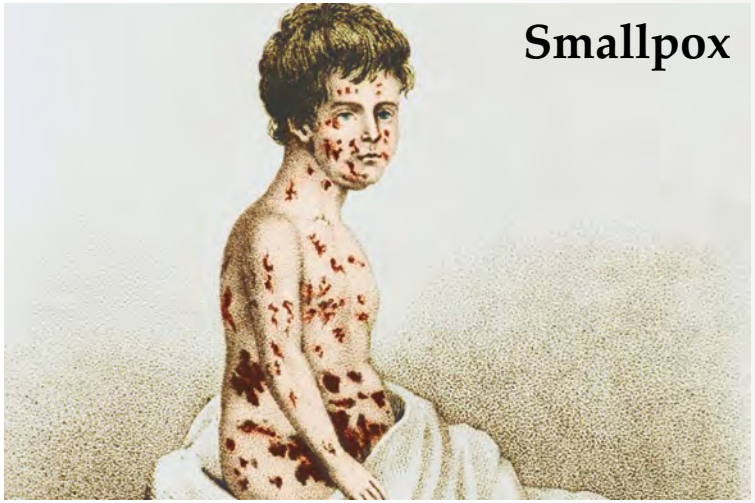
Superfection Exclusion?

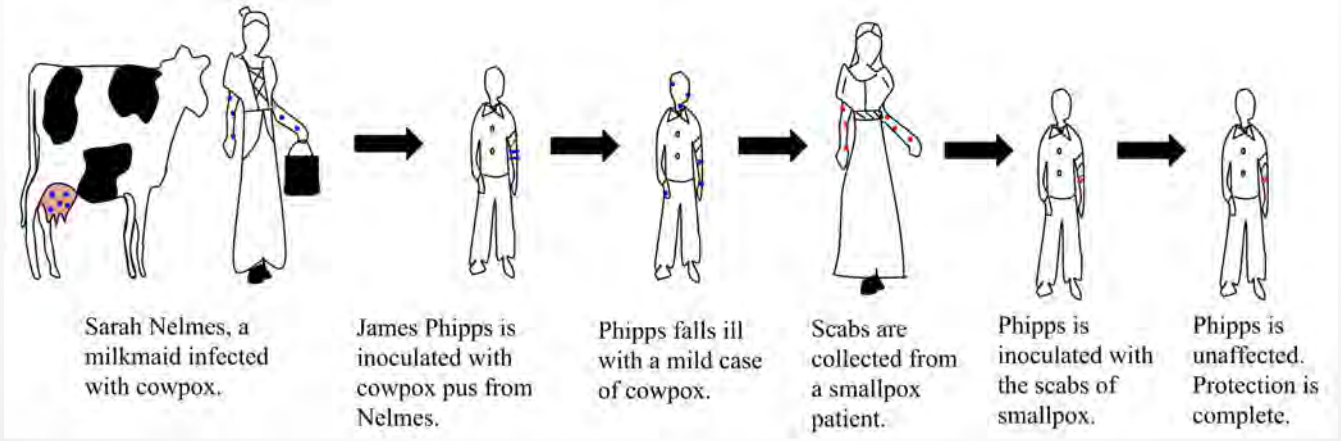
http://www.swindonhoneybeeconservation.org.uk/research/

Mordecai, G, *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





DWV Superinfection exclusion?

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

The ISME Journal (2016) 10, 1182–1191

www.nature.com/ismej

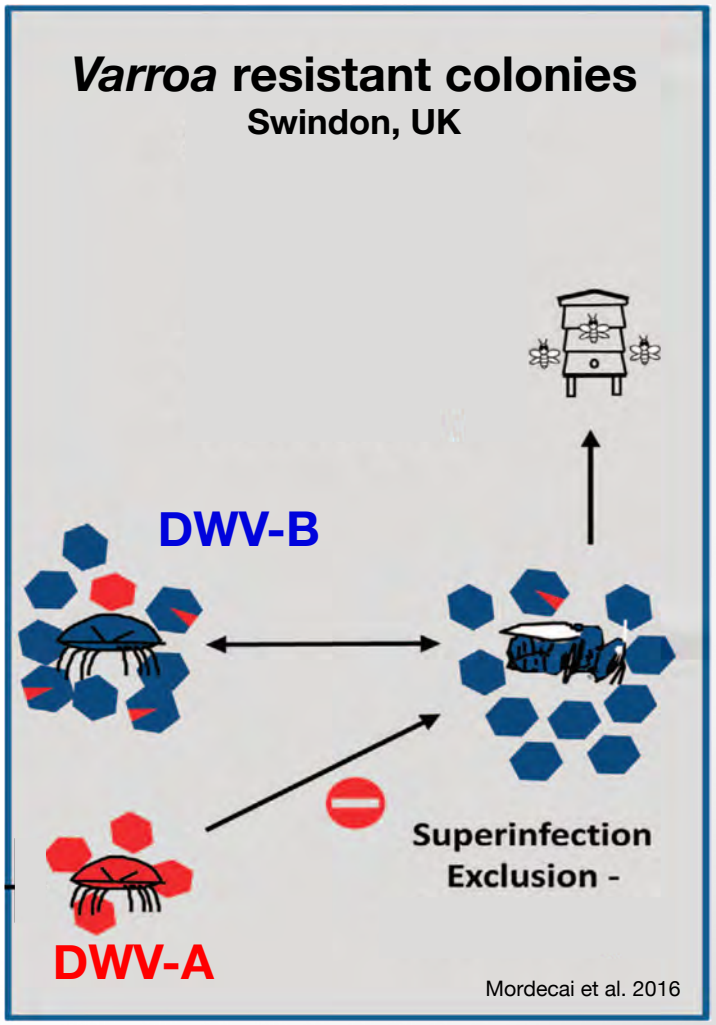
OPEN

ORIGINAL ARTICLE

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

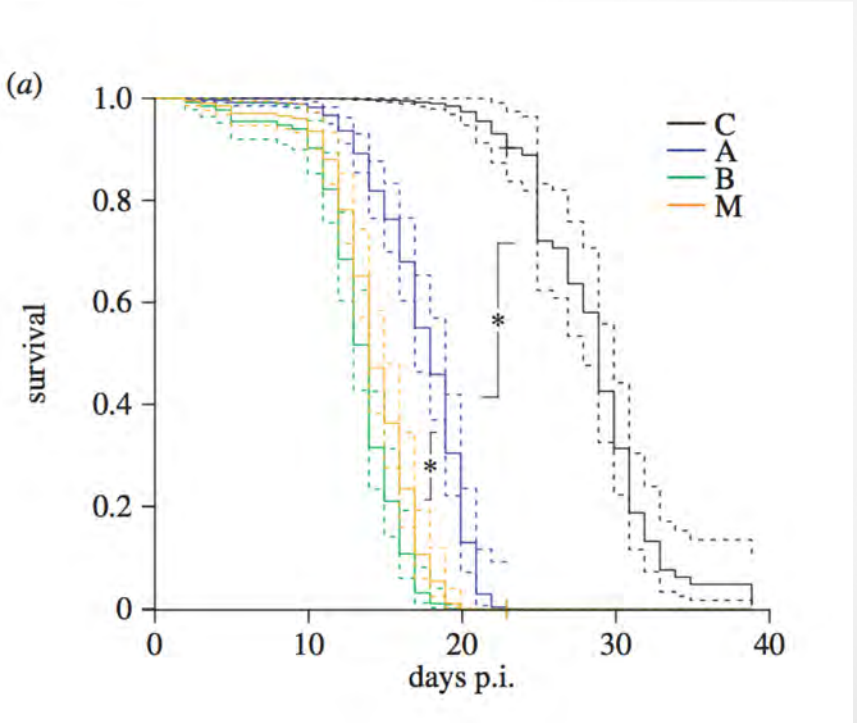
Gideon J Mordecai[1,2], Laura E Brettell[3], Stephen J Martin[3], David Dixon[1], Ian M Jones[2] and Declan C Schroeder[1]

[1]*Viral Ecology, Marine Biological Association, Plymouth, UK;* [2]*School of Biological Sciences, University of Reading, Reading, UK and* [3]*School of Environment and Life Sciences, The University of Salford, Manchester, UK*



BUT: Is DWV-B more virulent?

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

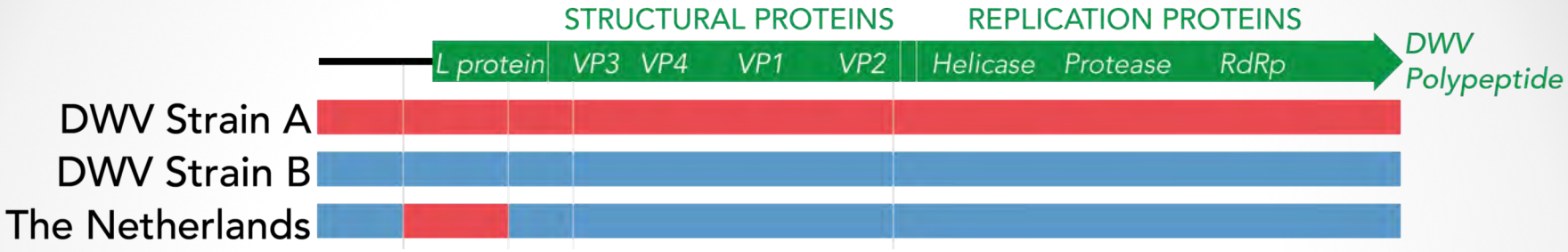


Do DWV strains differ in virulence?

DWV-A
- associated with Varroa and colony loss

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

DWV-recombinant, Netherlands



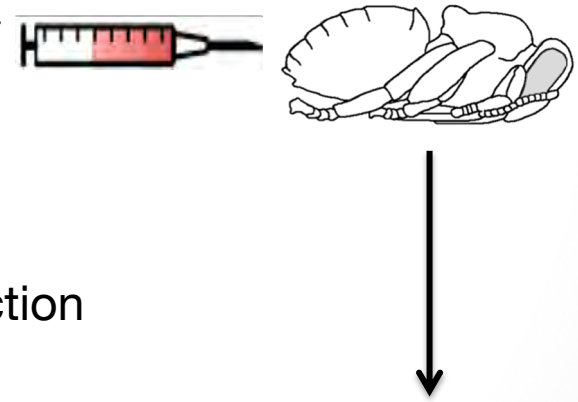
- Netherlands colonies have not been chemically treated for *Varroa* since 2008
- Colonies have developed "*Varroa* tolerance" and keep mite numbers low

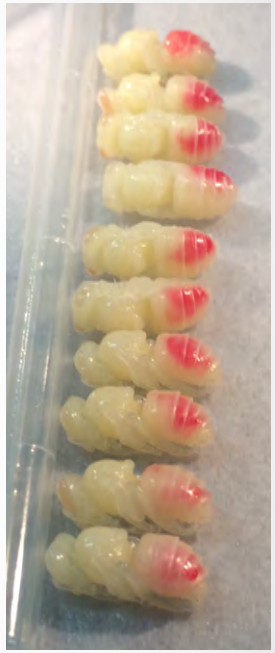
Investigating DWV strain replication and competition in *Varroa*-naïve pupae

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

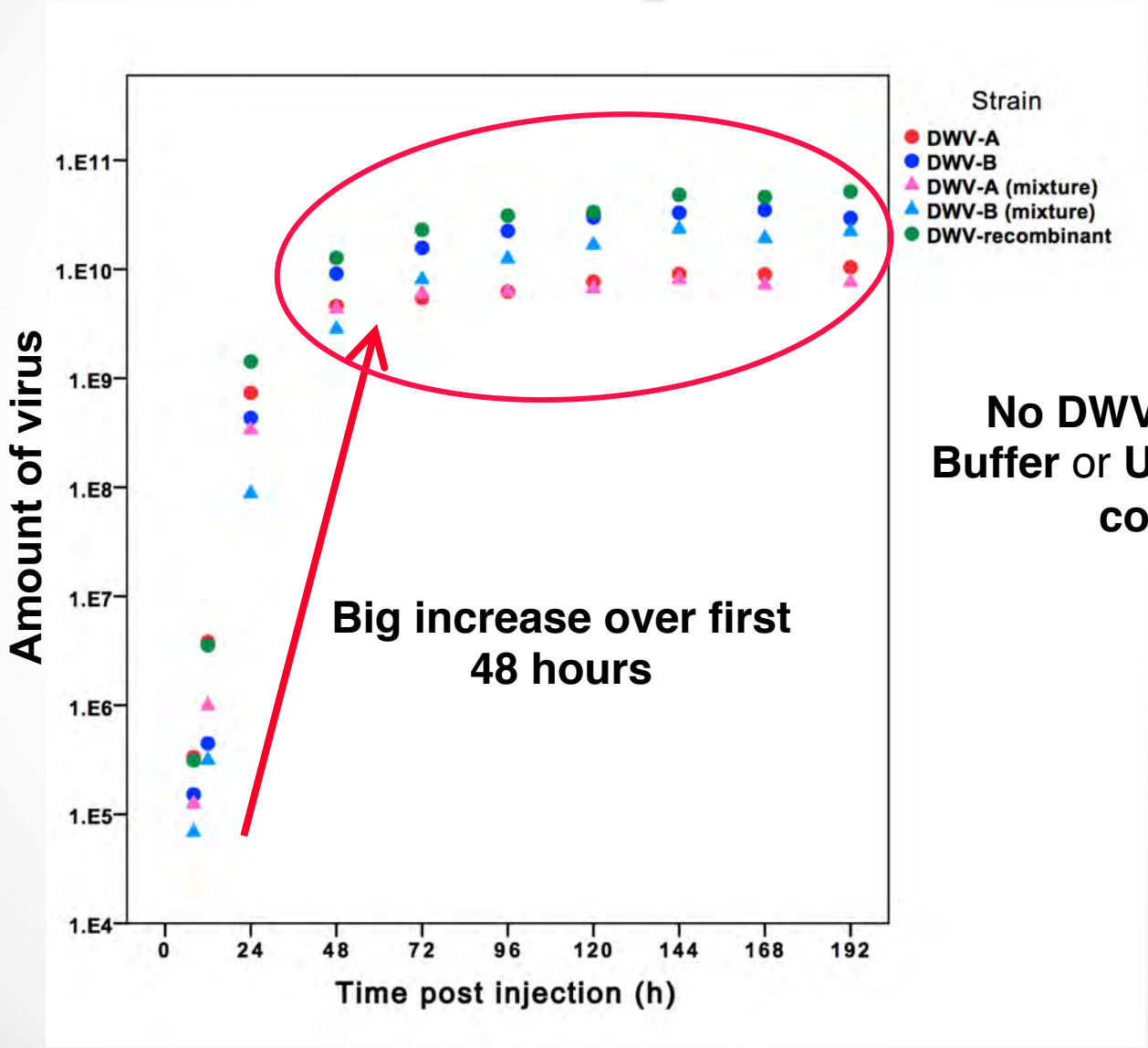
- Permit to import and administer DWV to local honey bee pupae (0000917783), within our quarantine approved laboratory (N2083)

- All methods strictly adhere to quarantine protocol

- Pupae frozen @ -80°C prior to eclosion

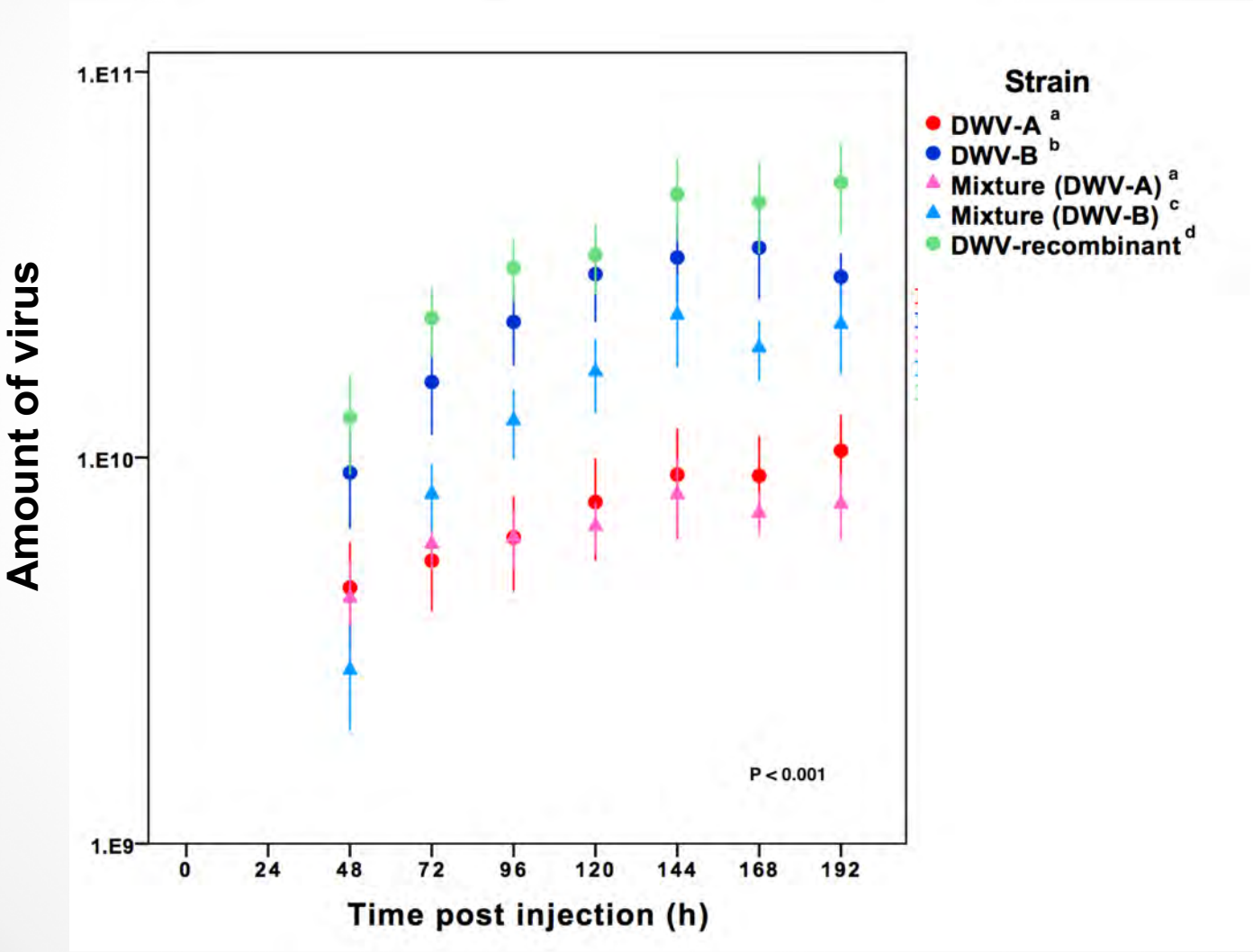
Approved premises: N2083

DWV replication

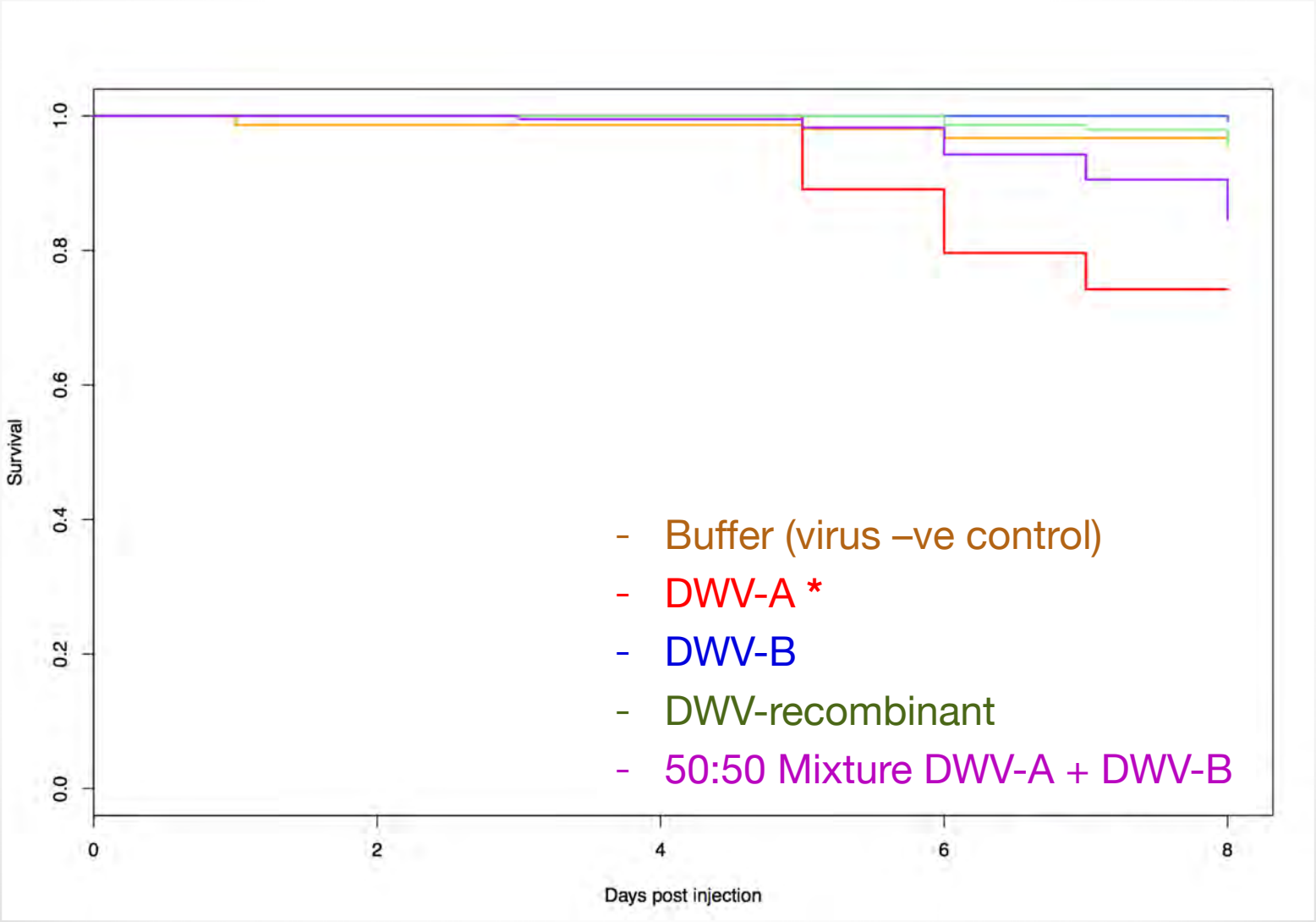


No DWV detected in **Buffer** or **Unmanipulated controls**

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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