OP-099 [Bee Health]
Tracking the evolution of viral titers in colony sub-populations throughout the season and in response to varroa treatment strategies

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Varroa destructor vectors numerous economically important honey bee viruses; however, the full details of the varroa-virus-honey bee dynamic remain to be elucidated. For example, varroa preferentially parasitize drone larvae and adults, yet the role played by the shifting production of drones across the season with respect to viral loads in the functionally crucial worker population is currently unexplored. Additionally, the consequence of varying type and timing of varroa treatments on viral titers in drones and workers, and ultimately on colony productivity, has not been determined. We received funding from the North Dakota Department of Agriculture to conduct a two-year project in southern Ontario, Canada to assess viral titers (DWV-A, DWV-B, and DWV-C) in colony sub-populations across the season and subjected to varying varroa treatment regimes. We tracked colony health, productivity, and varroa infestation parameters, and conducted operculated brood biopsies on worker and drone brood monthly. In addition to characterizing and quantifying mite levels in biopsied brood, we sampled purple-eyed worker and drone pupae from cells that were or were not infested with varroa, as well as adult workers and drones. All samples were blinded and sent to the National Agricultural Genotyping Center in Fargo, North Dakota, for high-throughput qPCR viral analysis. Our results highlight the role of drones in the varroa-virus-honey bee system, and underscore the importance of appropriate varroa treatment and timing.

Tracking the Evolution of Viral Titers in Colony Sub-Populations Throughout the Season and In Response to Varroa Treatment Strategies

September 26, 2025

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BACKGROUND

Deformed Wing Virus

- Major economic significance (e.g., Morfin et al., 2023; Piou et al., 2022; Ryabov et al., 2022)
- Predates varroa, but evidence varroa-mediated infection may be worse (e.g., Mockel et al., 2011)
- Varroa treatments:
  - ⬇ DWV (e.g., Locke et al., 2017; Martin et al., 2010)
  - ⬆ or 〓 DWV (e.g., Bubnič et al., 2024; Locke et al., 2012)
- DWV-A thought to be more virulent (e.g., Ryabov et al, 2015)
  - But see Brettell et al., 2017; Ray et al., 2023
- DWV-B more closely associated with varroa than DWV-A (e.g., Moore et al., 2011; Zhang et al., 2024)
  - Can replicate in varroa (e.g., Ryabov, 2022)
- DWV-B replacing DWV-A (e.g., Grindrod et al., 2021)
  - But also depends on where you are (e.g., Haddad et al., 2017)
- At least 4 master strains and many recombinants now identified (e.g., Dobelmann et al., 2025; Zhang et al., 2024)

BACKGROUND

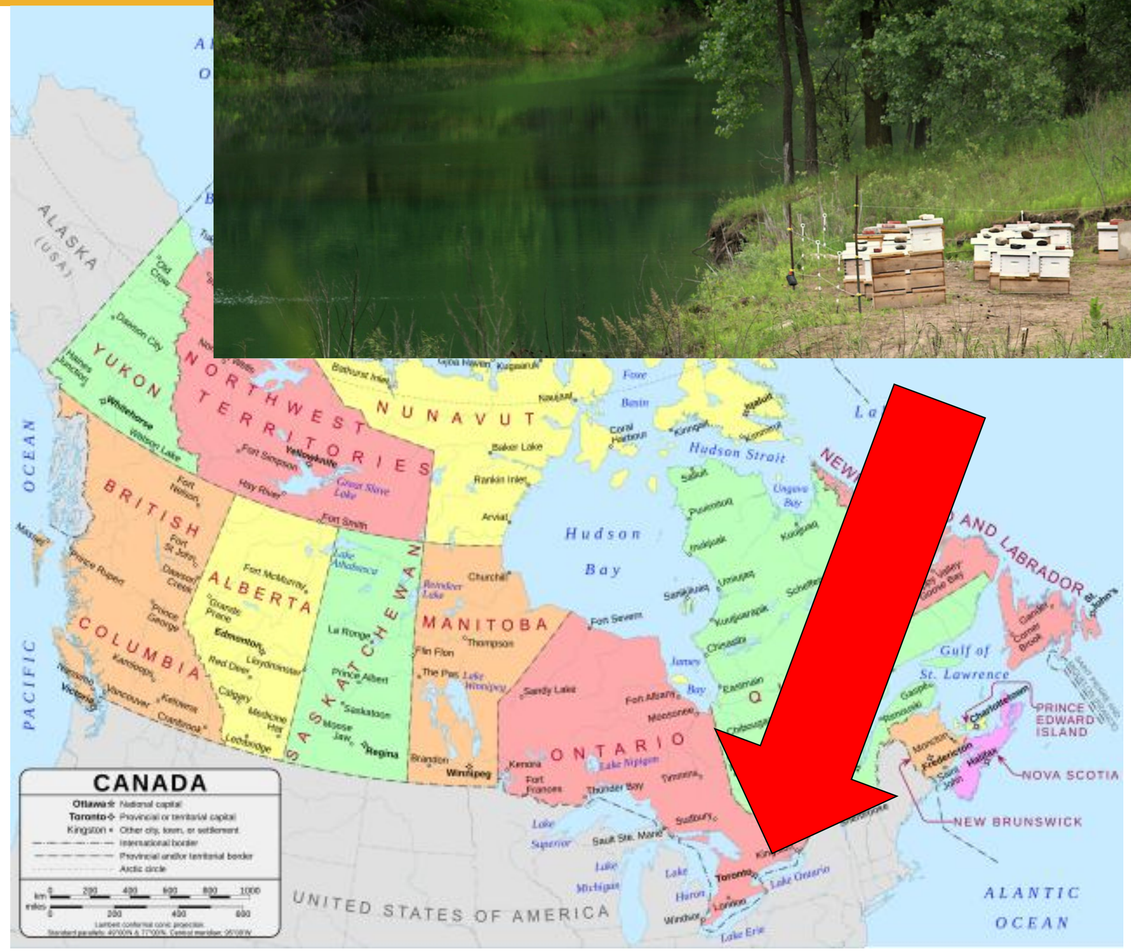
Research Questions

- How are mites, viruses, and mite treatments related?
- How do mite and viral loads evolve over the season and under different varroa treatment regimes?
- How are virus and mite loads related to colony performance?
- Do drones act as a “reservoir” and/or “buffer” for virus?

METHOD

Location

- Quinte West, Ontario, Canada (44°11’N 77°34’W)
- USDA plant hardiness zone 6b: humid continental climate
- Lake effects
- Hot, humid summers + moderate – cold winters
- Temperature Averages
    - July: 28 °C (high)
    - January: -9 °C (low)
- First pollen = mid April
- First honey harvest = July
- Second honey harvest = September



METHOD

Treatment Groups

2 strips Formic Pro (*n* = 6)

1+1 strip Formic Pro (*n* = 6)

2 g oxalic acid vapour
3x, 4 days apart (*n* = 6)

No treatment control (*n* = 6)

METHOD

Assays

Monthly:

1) Alcohol wash
2) Liebefeld population, resources, brood
3) Queen status and ID
4) Operculated brood biopsy (worker + drone)
5) Samples for PCR (6 of each per colony):
    1) Adult foragers
    2) Adult drones
    3) Purple eyed drone pupae (+varroa)
    4) Purple eyed drone pupae (-varroa)
    5) Purple eyed worker pupae (+varroa)
    6) Purple eyed worker pupae (-varroa)

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Weekly:

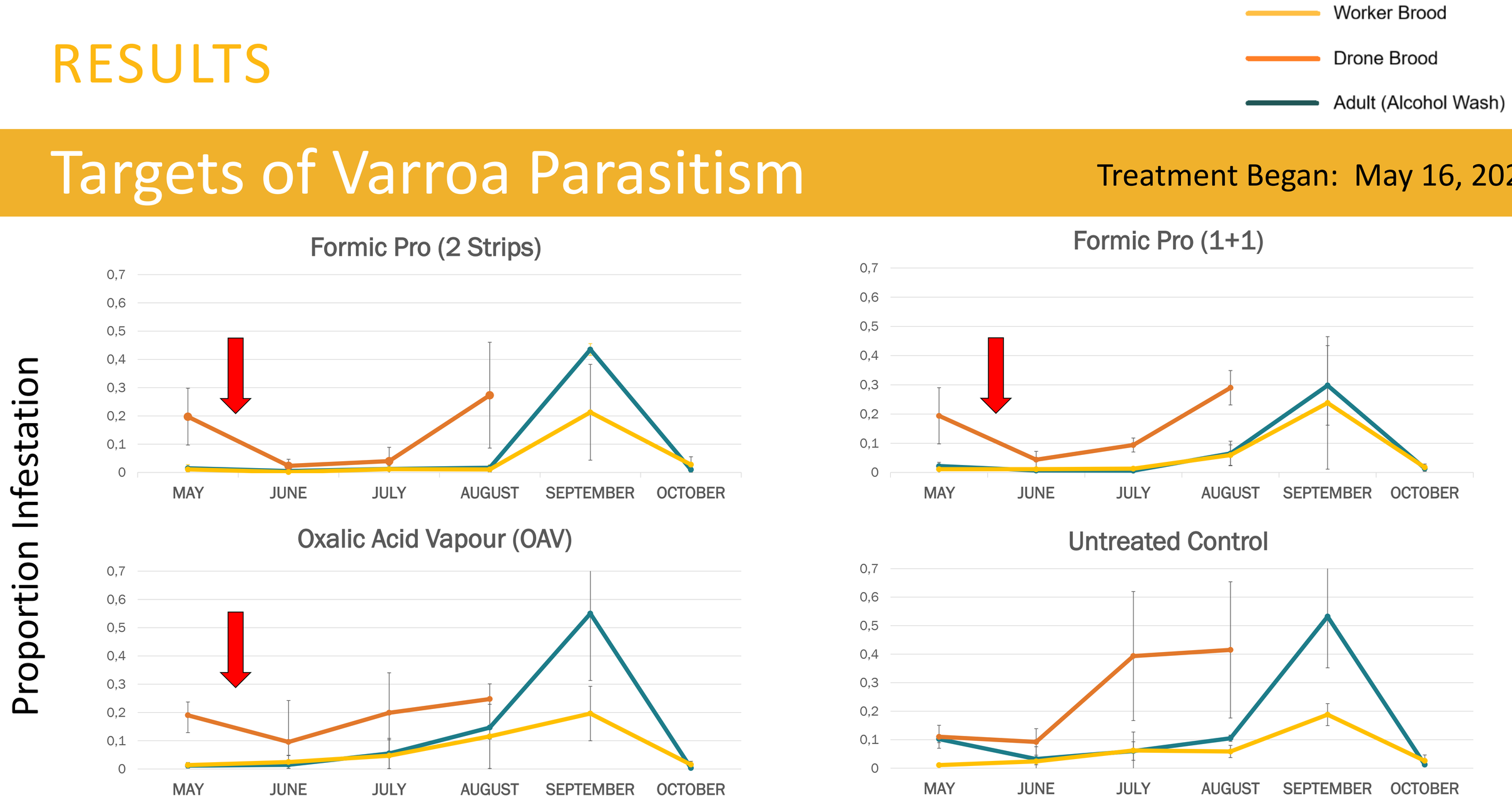
HIVETRONICS

1) Hive weights
2) Sticky boards (2x per week)

RESULTS

Targets of Varroa Parasitism

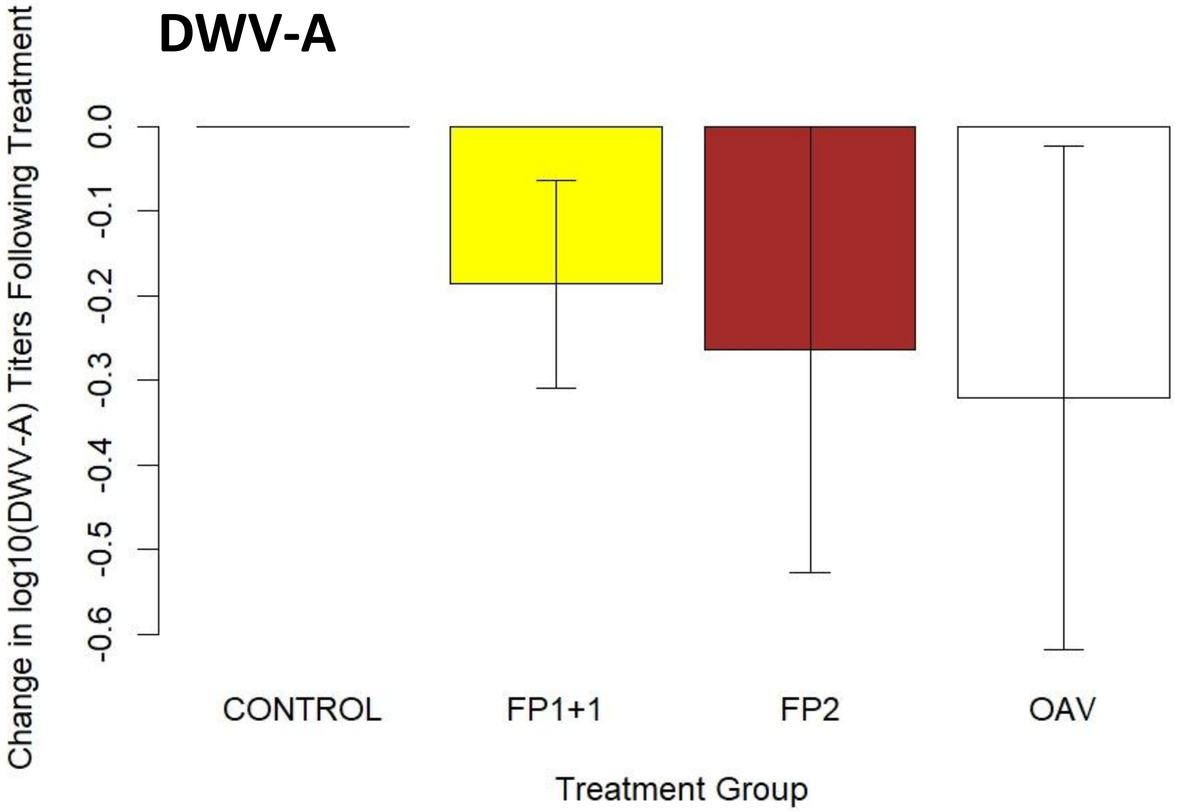
Treatment Began: May 16, 2024

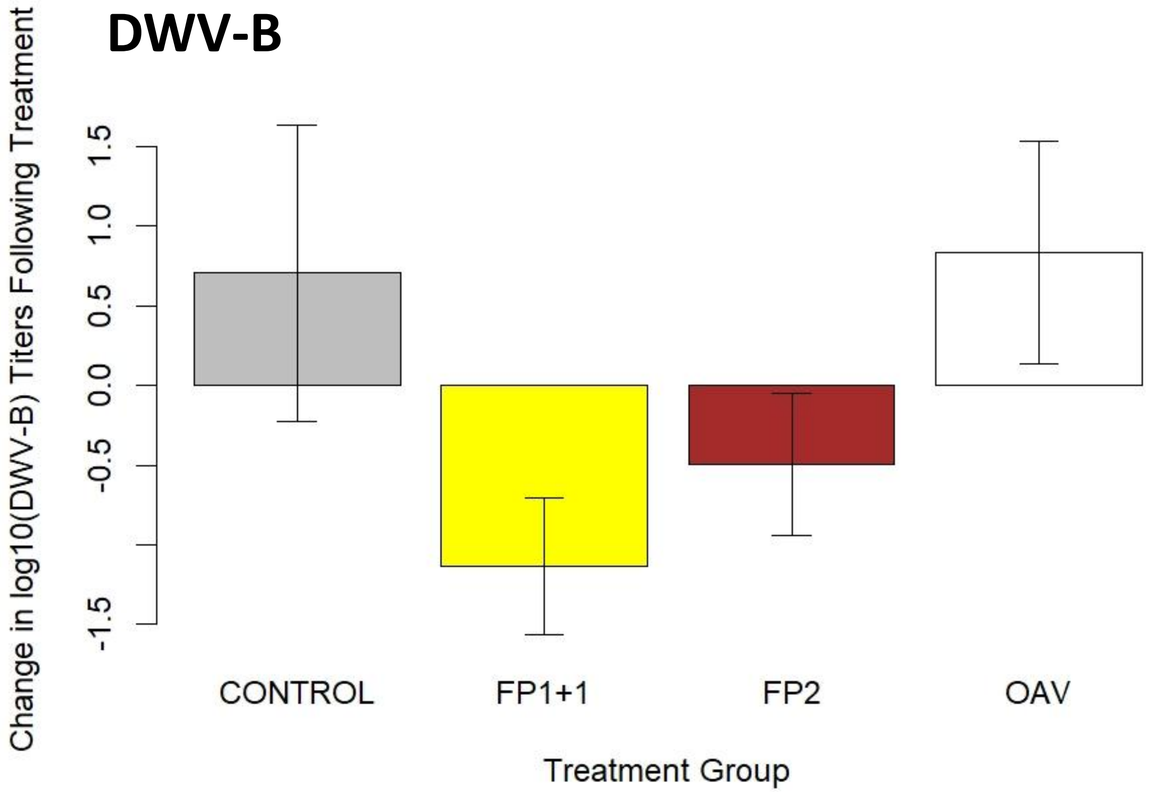


Broccard-Bell et al., in prep. Error bars are 95% confidence intervals

RESULTS

Change in Viral Loads Following Treatment



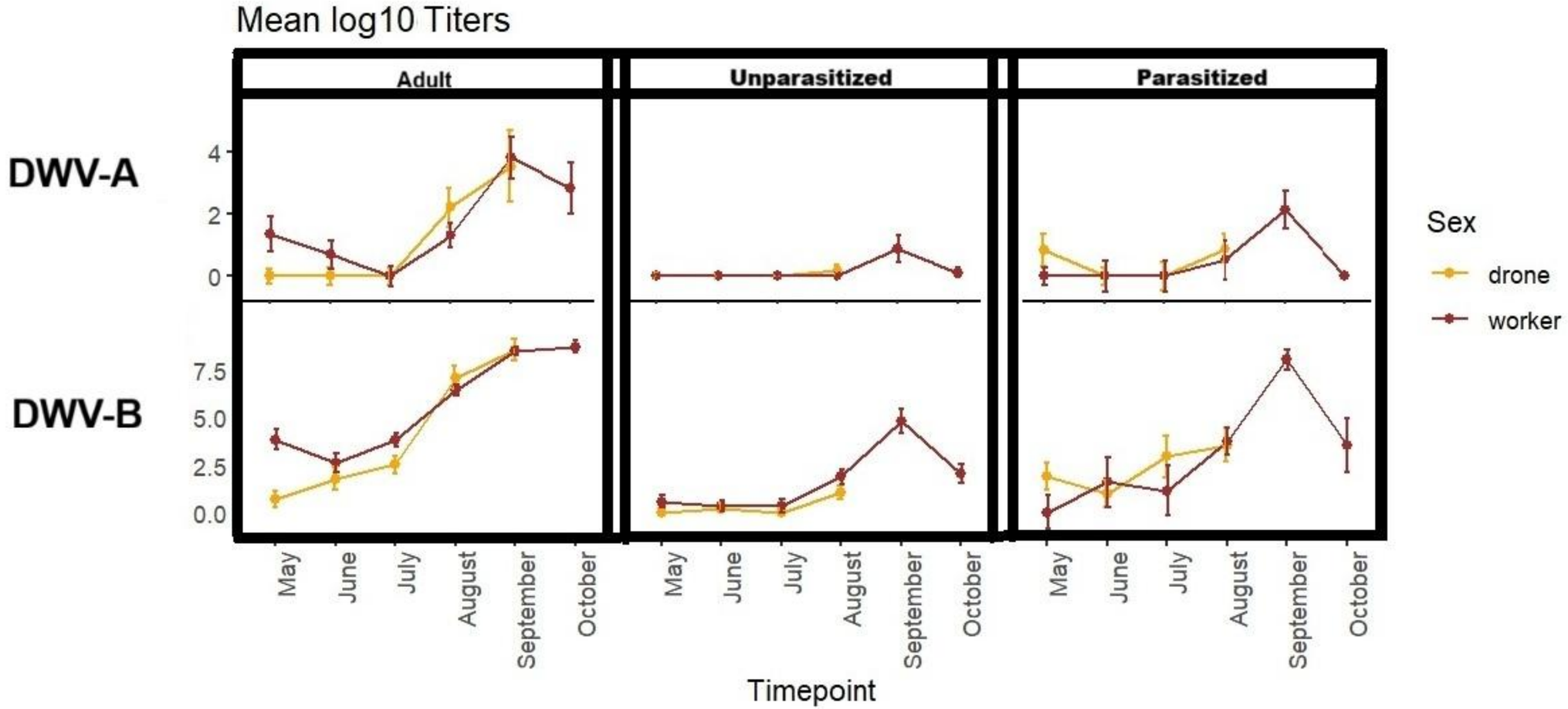


Broccard-Bell et al., in prep. Error bars are 95% confidence intervals

No significant differences at $p = 0.05$

RESULTS: DRONES VS. WORKERS

DWV Across the Year



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RESULTS: DRONES VS. WORKERS

Proportion of Detections

DWV-A	Adults		Unparasitized Pupae		Parasitized Pupae	
	F	*p*	*F*	*p*	*F*	*p*
Month	14.66	<0.001	1.37	0.25	1.15	0.33
Sex	4.69	0.03	1.40	0.24	1.12	0.29
Sex:Month	0.68	0.6	1.38	0.25	0.44	0.72

DWV-B	Adults		Unparasitized Pupae		Parasitized Pupae	
	F	*p*	*F*	*p*	*F*	*p*
Month	22.62	<0.001	10.13	<0.001	7.34	<0.001
Sex	22.97	<0.001	5.03	0.03	0.34	0.56
Sex:Month	5.13	<0.001	0.8	0.49	1.36	0.26

lmer() and anova() using Satterwaite's Type III Sums of Squares;
Only months both drones and workers were present included

RESULTS

Cox Proportional Hazards Regressions

Hazard Ratios							
Treatment Group	Alcohol Wash	Total Hive Weight	Adult Population	Capped Brood	DWV-A Categorical Levels in Adult workers	DWV-B Categorical Levels in Adult Workers	DWV-B Categorical Levels in Unparasitized Worker Brood
FP 1+1 = 1.5 FP 2 = 2.6 OAV = 1.2 all *p* = n.s.	35.17, *p* = 0.005	0.98, *p* = 0.24	0.04, *p* = 0.009	0.87, *p* = 0.009	zero = 1.05 low = 1.04 all *p* = n.s.	zero = 13.4, *p* = 0.02 low = 2.13, *p* = 0.27	zero = 0.07, *p* = 0.007 low = 0.11, *p* = 0.002

Broccard-Bell et al., in prep.

SUMMARY

- Varroa parasitism shifts throughout the year and under differing treatments
- Workers tend to harbour higher levels of virus than drones
  - Drones do not seem to act as a buffer or sink
- Varroa infestation was **negatively** correlated with colony survival
- Treatment may temporarily reduce viral levels
- DWV-B was the dominant strain in our colonies
- Only DWV-B levels were related to colony survival
  - **Negatively** correlated with unparasitized worker brood levels
  - **Positively** correlated with adult worker levels

Acknowledgements

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RESULTS

Correlations (Controls Only)

	Total Hive Weight	Adult Population	Capped Brood	Log10(DWV-A) Mean Titer	Log10(DWV-B) Mean Titer	Worker Brood Infestation Rate
Total Hive Weight		0.60***	0.43*	-0.04	0.08	-0.05
Adult Population			0.63***	-0.28	-0.24	0.08
Capped Brood				-0.43*	-0.46**	-0.30
Log10(DWV-A) Mean Titer					0.72***	0.74***
Log10(DWV-B) Mean Titer						0.81***
Worker Brood Infestation Rate						

Pearson product moment correlation coefficients, $df = 26$

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$

Broccard-Bell et al., in prep.