APIMONDIA SCANDINAVIA 2025
SWEDEN | DENMARK | NORWAY

PP-016 [Bee Health]

UBeeO: A Novel Tool for Selecting Pest- and Disease-Resistant Honey Bees

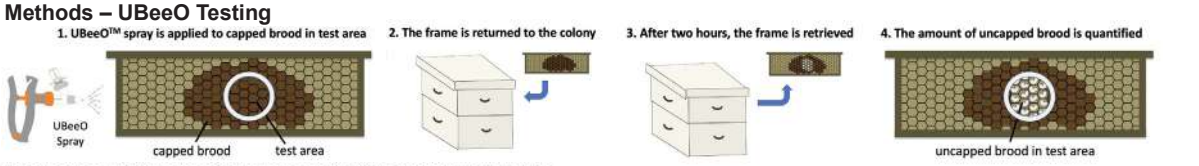
Kaira Wagoner[1], Samantha Alger[2], Sydney Miller[2], Alexander Burnham[3], Corinne Jordan[4], Yosef Hamba Tola[5], Esmaeil Amiri[6]

[1] Biology Department, University of North Carolina, Greensboro, NC, United States; [2] Agriculture, Landscape, and Environment Department, University of Vermont, Burlington, VT, United States; [3] Biology Department, University of Vermont, Burlington, VT, United States; [4] Bee Lady Apiaries, Carbrook, QLD, Australia; [5] Department of Applied Ecology, North Carolina State University, Raleigh, NC, United States; [6] Delta Research and Extension Center, Mississippi State University, Stoneville, MS, United States.

Introduction

- The health of the honey bee *(Apis mellifera)* is declining and sustainable solutions are needed to address the primary threat, the parasitic mite *Varroa destructor* (*Varroa*)
- To be sustainable, solutions must meet the needs of both bees and beekeepers; they must be long-term, low-cost, and capable of generating healthy and productive honey bee colonies
- One of the most important *Varroa* and disease resistance traits is ***hygienic behavior***, the ability to detect and remove *Varroa*-infested and diseased brood from the colony
- The selective breeding of truly *Varroa*-resistant hygienic stock is a promising long-term, low-cost, and effective solution to the current honey bee health crisis
- Numerous hygiene selection methods exist to aid in the identification of mite- and disease-resistant colonies, however these selection methods vary in their utility and sensitivity
  - Measuring suppression of mite reproduction is highly effective for ID of resistant colonies, but is labor intensive & most accurate late-season when mite & virus loads are already high
  - In contrast, brood-kill selection methods are relatively rapid, but less effective at IDing mite-resistant colonies, likely because they rely on removal of dead rather than unhealthy brood
- ***UBeeO is a heritable, predictive, practical tool*** for measuring honey bee colony hygiene, providing new opportunities for rapid and reliable selection of pest and disease-resistant bees

Methods – UBeeO Testing



(Detailed methods for studies described below can be found in corresponding publications or obtained by contacting Kaira Wagoner: kmwagone@uncg.edu)

Results

UBeeO scores are negatively correlated with mite, viral, *Vairimorpha*, and chalkbrood loads.

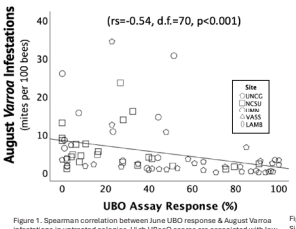


Figure 1. Spearman correlation between June UBO response & August Varroa infestations in untreated colonies. High UBeeO scores are associated with low colony mite loads. Figure published in *Wagoner et al. 2021.*

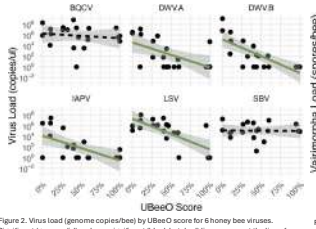


Figure 2. Virus load (genome copies/bee) by UBeeO score for 6 honey bee viruses. Significant (green solid) and non-significant (black hatched) lines represent the line of best fit generated by a linear model. For four viruses, pathogen load decreased significantly with increasing UBeeO score (DWVA (p = 0.011); DWV-B (p = 0.0002); IAPV (p = 0.007); LSV (p = 0.0004)). Figure published in *Alger et al. 2025.*

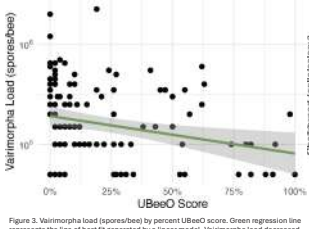


Figure 3. Vairimorpha load (spores/bee) by percent UBeeO score. Green regression line represents the line of best fit generated by a linear model. Vairimorpha load decreased significantly as UBeeO score increased (p < 0.0001). Figure published in *Alger et al. 2025*

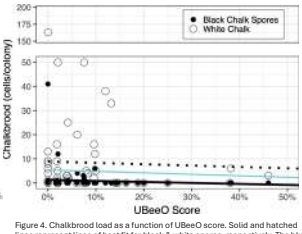


Figure 4. Chalkbrood load as a function of UBeeO score. Solid and hatched lines represent lines of best fit for black & white spores, respectively. The blue line represents all spores. Chalkbrood decreased significantly as UBeeO score increased (p = 0.01). Black spores were significantly less numerous in high UBeeO colonies (p < 0.0001). Figure published in *Alger et al. 2025.*

Disease brood virulence and UBeeO resistance thresholds are inversely related

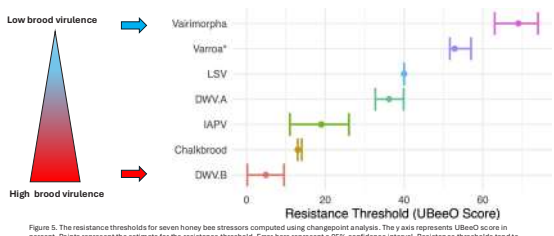


Figure 5. The resistance thresholds for seven honey bee stressors computed using changepoint analysis. The y axis represents UBeeO score in percent. Points represent the estimate for the resistance threshold. Error bars represent a 95% confidence interval. Resistance thresholds tend to be higher for stressors with lower brood virulence. Figure adapted from *Alger et al. 2025.*

High UBeeO scores are linked to low viral loads in *mites*

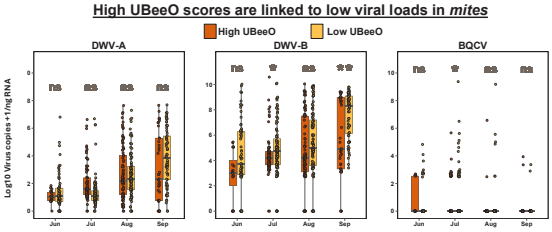


Figure 6. Temporal pattern of viral titers in *Varroa* mites from high and low UBeeO colonies. Sampling took place from July to September, and samples were tested for 7 viruses including: DWV-A, DWV-B, BQCV, LSVs, SBV, BRV-1, and VDV-2. Statistically significant differences were assessed using Bayesian posterior distributions p < 0.05 (*), p < 0.01 (**), p < 0.001 (***), and ns= not significant as estimated via Bayesian pairwise comparisons. Figure submitted for publication in *Amiri et al. 2025.*

UBeeO-linked hygiene is heritable

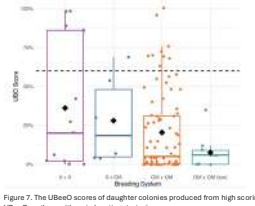


Figure 7. The UBeeO scores of daughter colonies produced from high scoring UBeeO mothers with varied mating strategies:
II+II: both mother and daughter queens instrumentally inseminated (II)
II+OM: open mated daughter queens from II mothers
OM+OM: both the mother and daughter queens were open mated (OM)
OM+OM (low): OM daughter queens from low UBeeO, OM mothers
Figure published online by University of Vermont, 2024.

UBeeO scores are heavily influenced by environment

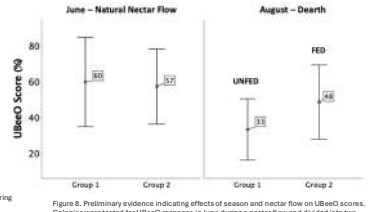


Figure 8. Preliminary evidence indicating effects of season and nectar flow on UBeeO scores. Colonies were tested for UBeeO response in June during a nectar flow and divided into two groups of roughly equivalent UBeeO scores. All scores were lower when colonies were retested during August dearth, however scores from colonies fed a 1:1 sugar solution prior to testing (Group 1) more closely resembled those from the natural June nectar flow.

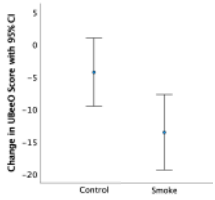


Figure 9. Preliminary evidence indicating the effects of smoker use on UBeeO scores. Colonies UBeeO tested twice consecutively tended to score lower if a smoker was used during the second UBeeO test. Smoke was applied directly to area from which experimental frame was removed and returned, and fuel type impacted the extend of the effect (fuel type data not shown).

Gut microbiota differs in hygiene performers

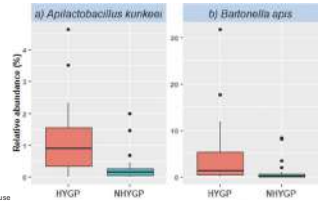


Figure 10. Relative abundance of three bacterial species was significantly higher in hygiene performers (HYGP) than nonhygiene performers (NHYGP).
a. Apilactobacillus kunkeei (p = 0.0439), b. Bartonella apis (p = 0.0338), and c. Frischella perrara (p = 0.0438 – not shown here). Figure adapted from Tola et al 2025.

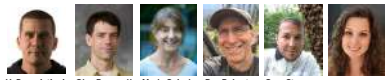
Conclusions and Way Forward

- UBeeO can predict colony-level resistance to mites, viruses and fungal diseases, and thus serves as a promising new tool for selective breeding of pest- and disease-resistant honey bees
- The UBeeO score associated with disease resistance (the resistance threshold) varies with pest and pathogen virulence, underscoring the importance of brood stress and brood signal detection in colony hygiene, and indicating that honey bee disease resistance can be achieved by targeting disease-specific responses to UBeeO
- UBeeO-linked hygiene is heritable, however UBeeO scores are heavily influenced by environmental factors such as food availability and beekeeper smoker use
- Hygienic behavior of honey bees is associated with changes in the abundance of several other species, including virus loads in *Varroa* mites and microbial communities in honey bee guts
- More research is needed to understand colony virus dynamics & how environmental variables like nutrition & climate influence hygiene performance & related pest- and disease-resistance
- Work is underway to better understand impacts of nectar flow on hygiene, to simplify & standardize UBeeO scoring, & to determine the role of gut microbes in colony pest & disease resistance

Acknowledgements

FIELD & LAB TECHS: Francisco Belinchon, Daniel Smith, Quinton Irby, Samantha Mcpherson, Babak Yousefi, Dominick Defelice, Taylor Reams, Chris Reid, Emily Jordan, Shaun Pitts, Zachary Bunch, Natalie Sabiston, Jordan Reimers, Sydney Jones, **TRIAD MS LAB:** Daniel Todd, Brandie Ehrmann, Reynaldo Diaz

SPECIAL THANKS TO:



Works Cited

Alger, S. A., Burnham, P. A., Miller, M. S., Amiri, E., Jordan, C., & Wagoner, K. (2025). Unhealthy brood odor scores predict pathogen loads of several important honey bee diseases. *Frontiers in Bee Science*, *3*, 1509871.

Amiri, E., Mehrparvar, S., Wagoner, K. Honey bee hygienic selection impacts virus dynamics of both bees and Varroa mites. *SUBMITTED to Journal of Pest Science*, August 2025.

Tola, Y., Wagoner, K., Strand, M., Rueppell, O. & Tarpy, D. The gut microbiome differs between hygiene-performing and non-hygiene-performing worker honey bees. *Insectes Sociaux*, 1-8 (2025).

UBeeO Factsheet: What we know about UBeeO. Published online by University of Vermont with contributions from BetterBee and Optera LLC, 2024: https://vermontbeelab.com/resources/UBO-Factsheet-Producers-Final-2.pdf.

Wagoner, K., Millar, J. G., Keller, J., Bello, J., Waiker, P., Schal, C., Spivak, M. & Rueppell, O. (2021). Hygiene-eliciting brood semiochemicals as a tool for assaying honey bee (Hymenoptera: Apidae) colony resistance to Varroa (Mesostigmata: Varroidae). *Journal of Insect Science*, *21*(6), 4.

Want to learn more about UBeeO?
Visit optera-bees.com for more information, including links to full publications.

SCAN ME

PP-016 [Bee Health]
UBeeO: A Novel Tool for Selecting Pest- and Disease-Resistant Honey Bees

Kaira Wagoner[1], Samantha Alger[2], Alexander Burnham[2], Sydney Miller[2], Esmaeil Amiri[3], Corinne Jordan[4], Yosef Hamba Tola[5]
[1]University of North Carolina Greensboro, Greensboro North Carolina, USA
[2]University of Vermont, Burlington Vermont USA
[3]Mississippi State University, Stoneville Mississippi, USA
[4]Bee Lady Apiaries, Carbrook Queensland, Australia
[5]North Carolina State University, Raleigh North Carolina USA

The health of the honey bee (Apis mellifera) is declining, and sustainable solutions are needed to address their primary threat, the parasitic mite Varroa destructor (Varroa). To be sustainable, solutions must meet the needs of both bees and beekeepers, meaning that they must be long-term, low-cost, and capable of generating healthy and productive honey bee colonies. One of the most important Varroa and disease resistance traits in honey bees is hygienic behavior. Hygienic bees detect and remove Varroa-infested and diseased brood from colonies proactively, preventing and mediating the negative effects of mites and the pathogens they vector. The selective breeding of truly Varroa-resistant honey bee stock is a promising long-term, low-cost, and effective solution to the current honey bee health crisis. Large-scale breeding programs have successfully bred hygienic stock using freeze-killed brood (FKB), pin-killed brood (PKB), and Harbo (SMR) assays. Though useful, these assays vary in their utility and sensitivity. For example, while more mite-resistant colonies can be identified through SMR selection than FKB, the SMR method is labor intensive, and most accurate late in the bee season when mite populations are high, and viruses have already spread through non-resistant colonies. In contrast, FKB is faster and more accessible to beekeepers, but is less effective at identifying mite-resistant bees, likely because it relies on removal of dead brood (necrophoresis) rather than removal of living-but-unhealthy brood. UBeeO is a novel pheromone-based tool that measures colony response to unhealthy brood odors, providing new opportunities for rapid and reliable selection of pest and disease-resistant honey bees. Compared to low-scoring colonies, high UBeeO colonies exhibit better winter survival and have significantly lower mite, virus, Vairimorpha, and chalkbrood loads. UBeeO responsive bees also have better long-term memory of diseased brood odors and exhibit different gut microbiome compositions than bees that do not respond to UBeeO. Here we will review the latest findings related to UBeeO technology, and discuss the potential implications of UBeeO-based selection for honey bee health, colony productivity, pollination services, and the spillover of diseases from honey bees to other pollinator species.