



Varroa Feed on Hemolymph and Two Other Alternative Facts

Samuel Ramsey, Dennis vanEngelsdorp, Ronald Ochoa, Gary Baughan, Connor Gulbranson, Joe Mowery, Allen Cohen, Joseph Cicero, James Ellis

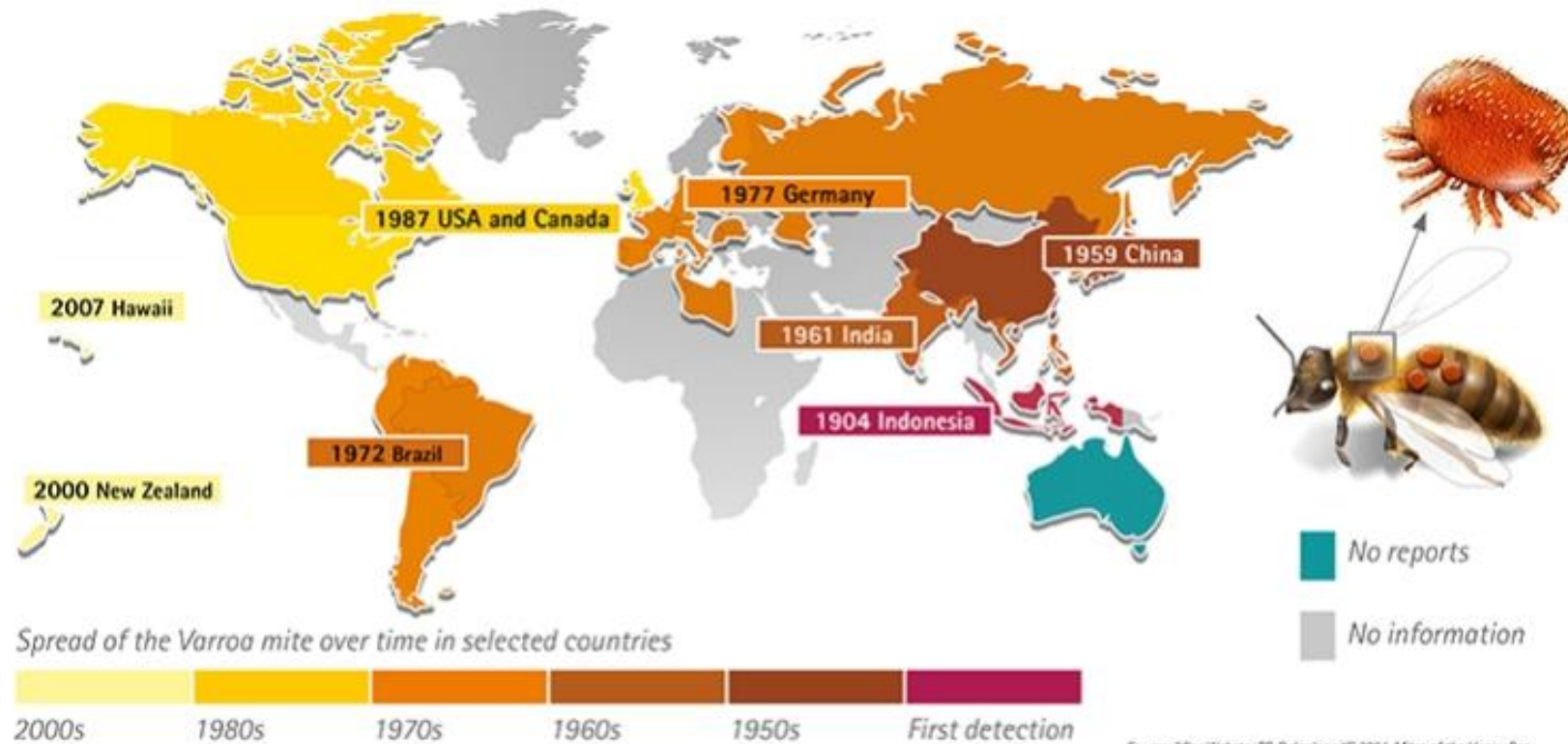
Varroa destructor

- ◆ Considered agent of primary concern in trend of colony losses (Annoscia 2012)
- ◆ First Found in the US in 1987
- ◆ Wiped out feral colonies by 1997



Gilles San Martin

Varroa Mite Distribution



Source: *research* – the Bayer Scientific Magazine

Feeding Behavior

- Food source not confirmed by experimental data
- Feeding behavior is difficult to observe



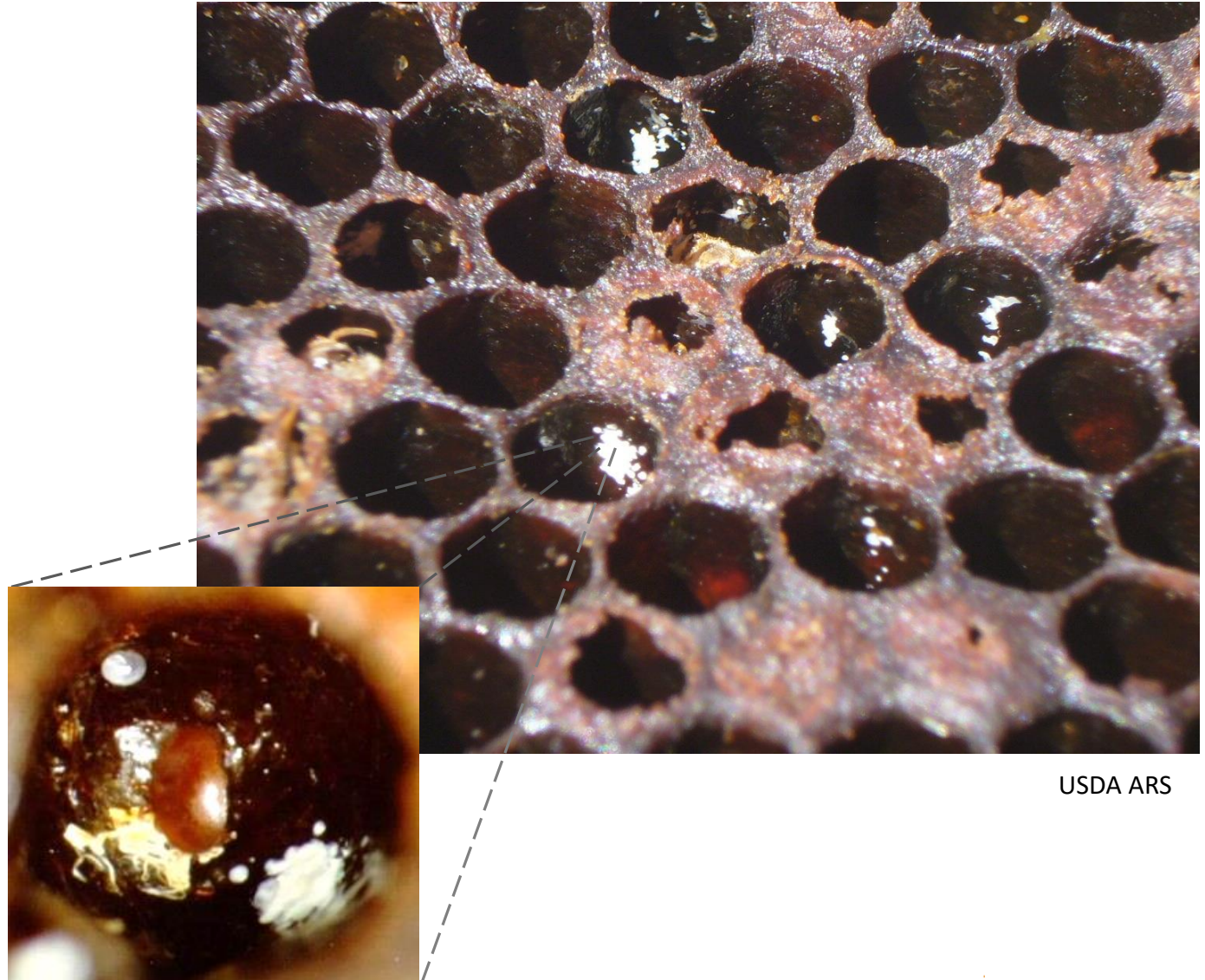
Ramsey, UMD

Expectations

- 1. Mite digestive system and excrement shows similarities to other hemolymph or fluid feeding arthropods**
2. Mite lineage shows *Varroa* are closely related to other lymph feeders
3. Mites observed feeding wherever hemolymph can be drawn from host

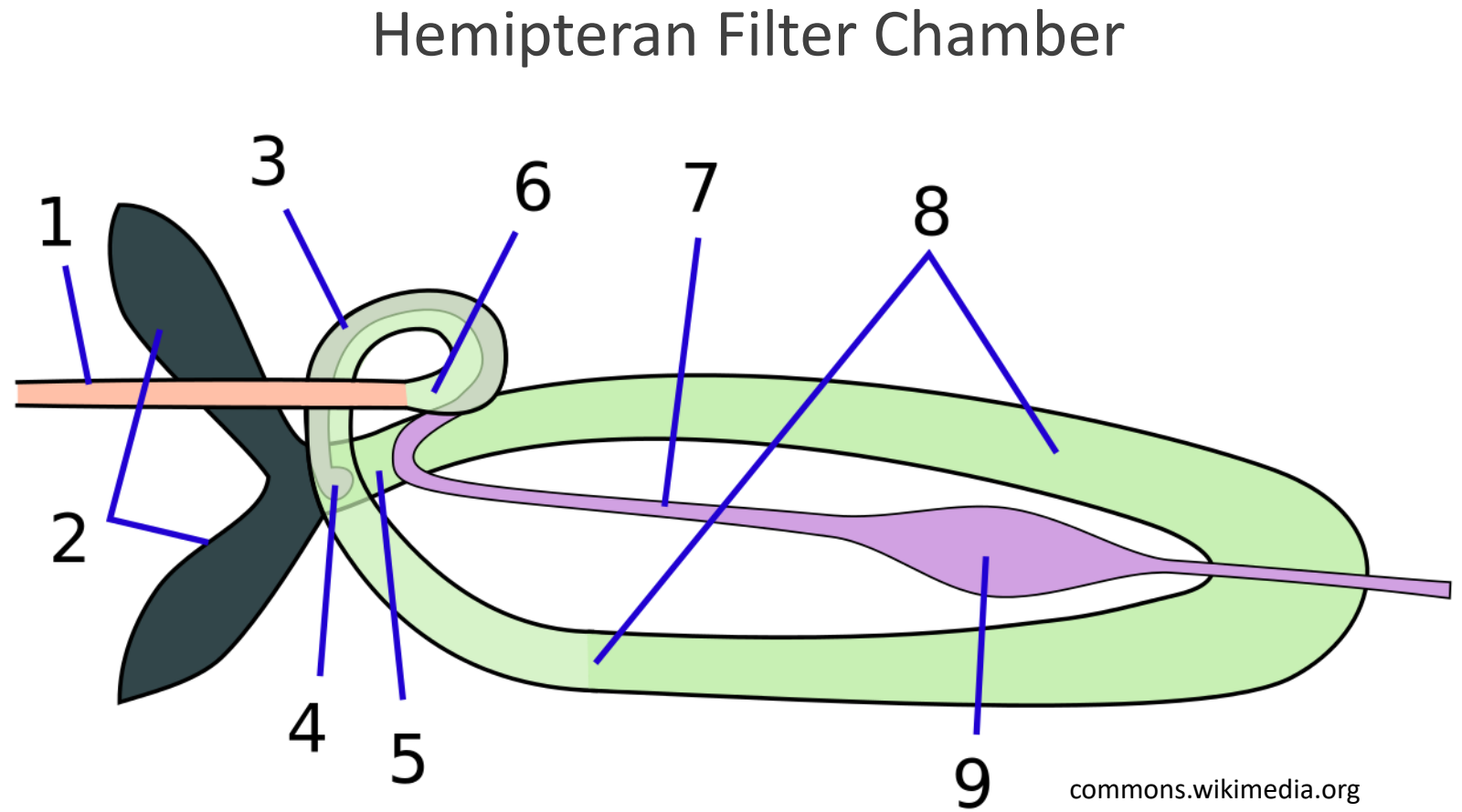
Mite Frass

- Expected: Insoluble waste product based on proposed life history
- Observed: >95% guanine (Cohen 1994)
- Very little water content (Cohen 1995)



Digestive System Modifications

- Expected: filter chamber-like modification
- Observed: No modifications to shunt excess water away from midgut (Akimov 1988)



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Video credit: Dr. Allen Cohen

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Mite Phylogeny

- Expected: *Varroa* closely allied with other dilute fluid-feeding mites
- Observed: Closely allied with predatory mites feeding through extra-oral digestion (Klompken 2006)
- Share similar digestive system structuring (Ruijter 1983)

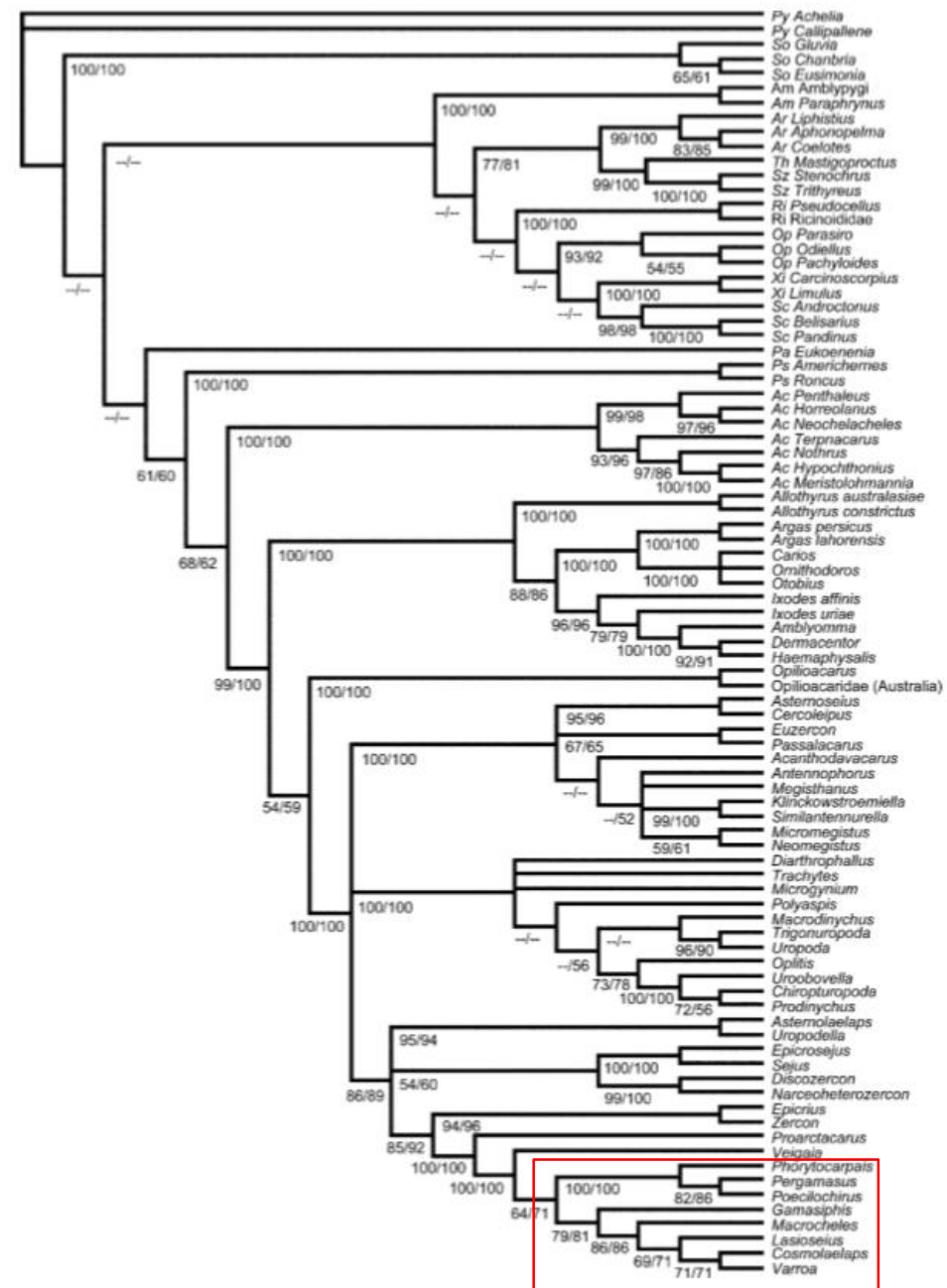
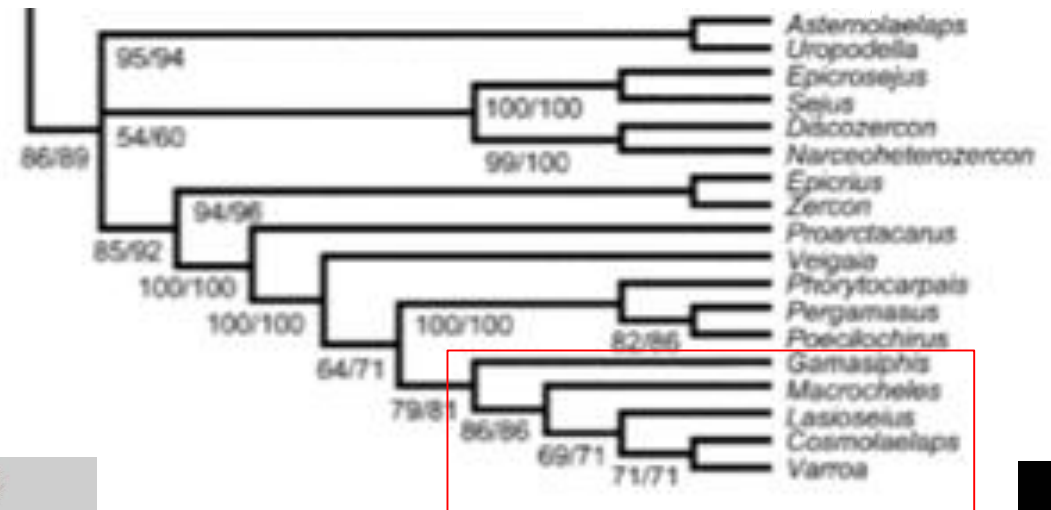


Fig. 2. Strict consensus of eight equally most parsimonious trees based on 18S rRNA data only (gaps = missing). Values below branches indicate Jackknife support (gaps = missing/gaps = fifth state). Order abbreviations for outgroups: Ac: Acariformes; Am: Amblypygi; Ar: Araneae; Op: Opiliones; Pa: Palpigradi; Ps: Pseudoscorpiones; Py: Pycnogonida; Ri: Ricinuli; Sc: Scorpiones; So: Solifugae; Sz: Schizomida; Th: Thelyphonida; Xi: Xiphosura.

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Methods

- ◆ Data taken onsite immediately after removing frame
- ◆ Bees pulled directly from frame
- ◆ Data not taken before or after inclement weather



Expectations

- Expected: Mites able to feed from a variety of locations

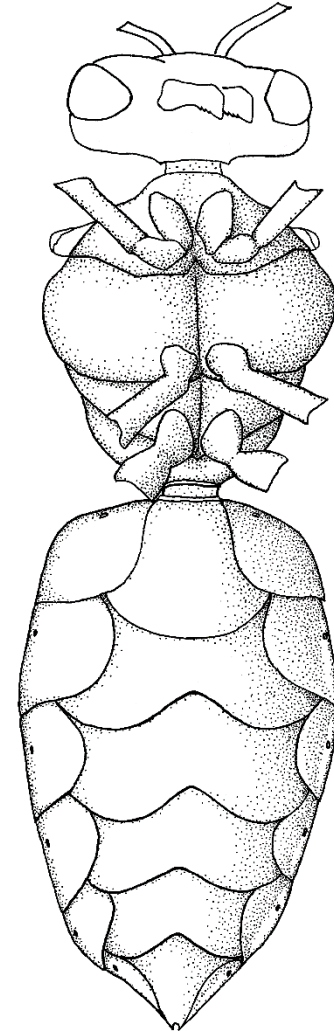
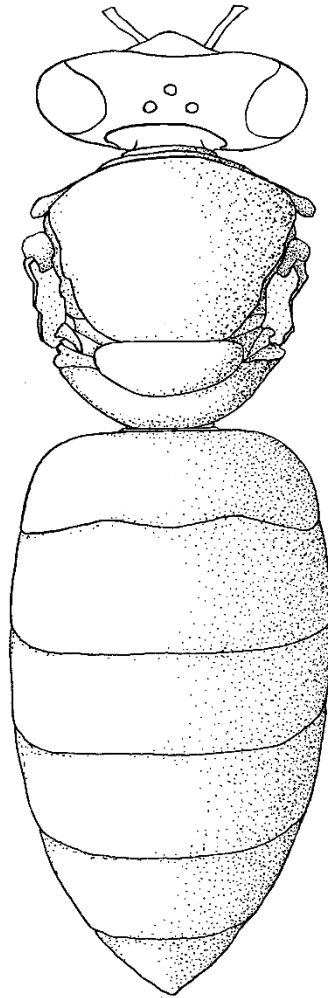
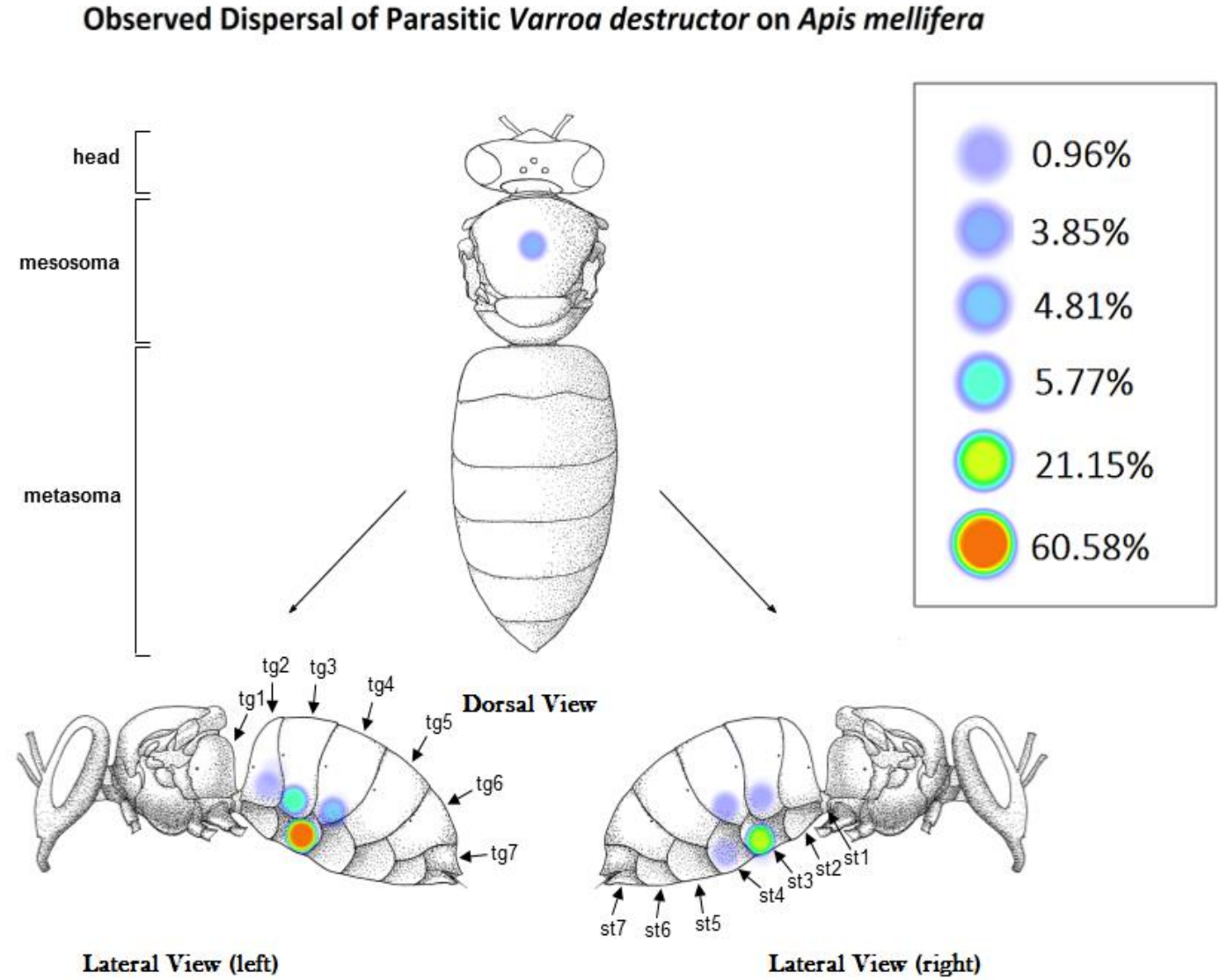


Illustration by Todd Waters

Results

- H_0 : Mites show no preference for any location on host
- H_a : Mites show preference for specific location on host
- $\chi^2 (7, N=104) = 353.3205$
- $p < .01$
- Rejected null hypothesis



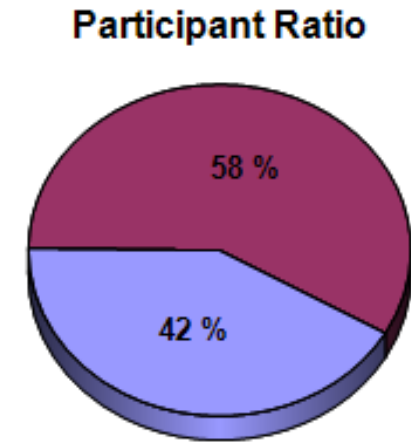
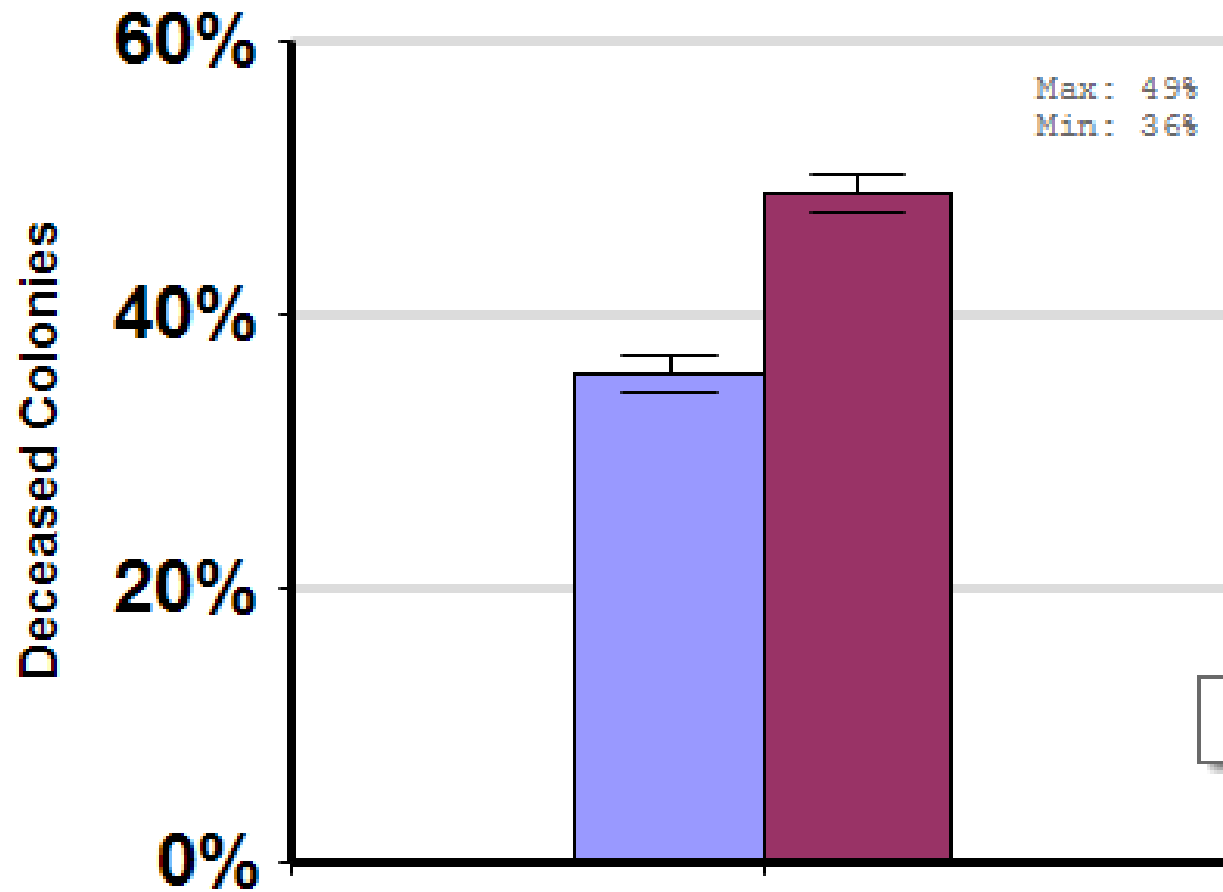
Mite Dispersal

- Mites strongly prefer underside of the metasoma
- Apparently the primary feeding site
- 95.2% of mites found under metasomal sternites/tergites
- Statistically significant preference for left side of hosts body





Chemical *Varroa* Control



4 consecutive years illustrating that **beekeepers who treat for *Varroa*** lost significantly fewer colonies than **those who did not use any product**.

Alternative Fact #2



- ~~1. *Varroa* feed exclusively on the hemolymph of adult and immature Bees~~
- 2. You'll usually find *Varroa* on top of worker bee's thorax**

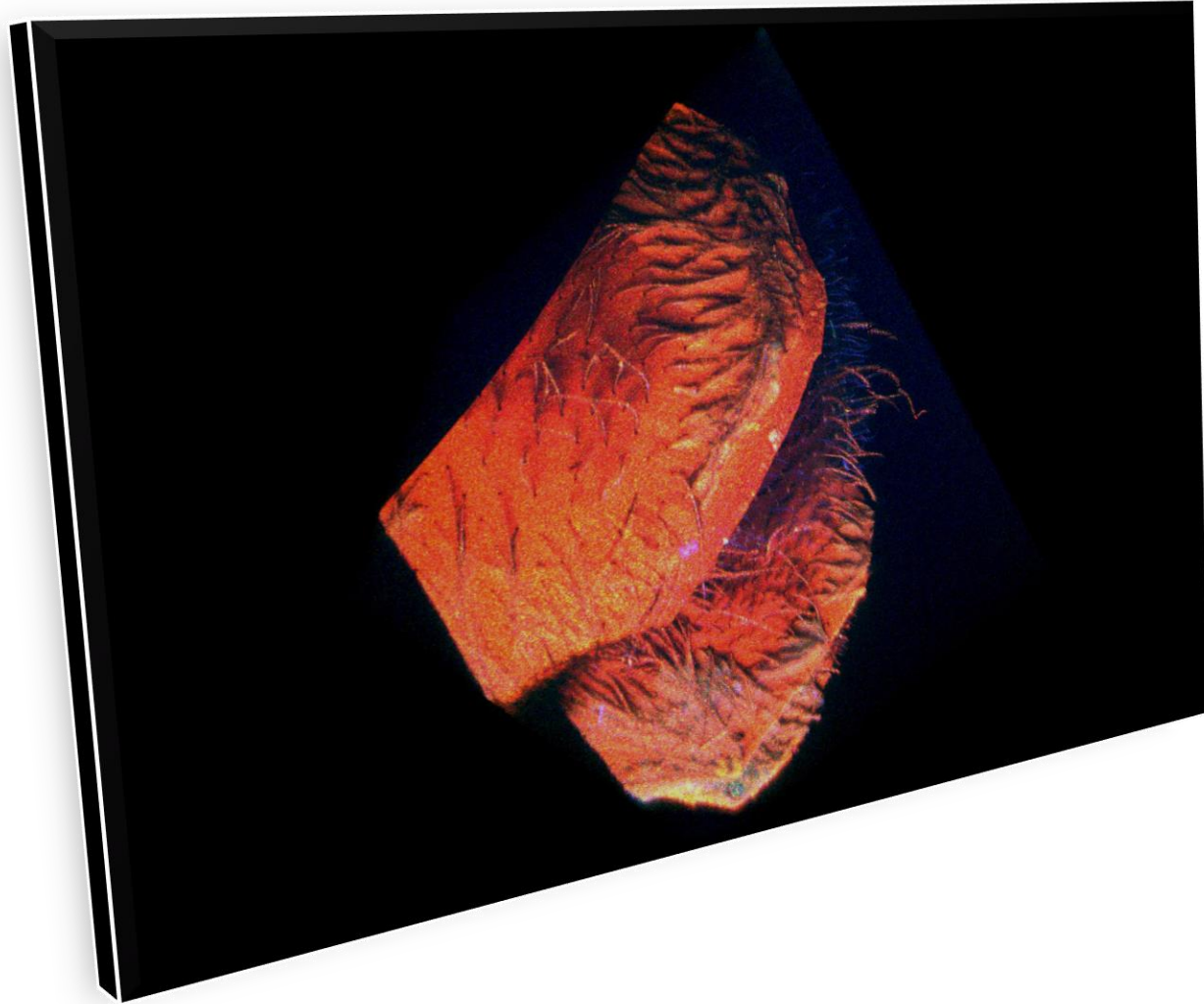
Mite Dispersal

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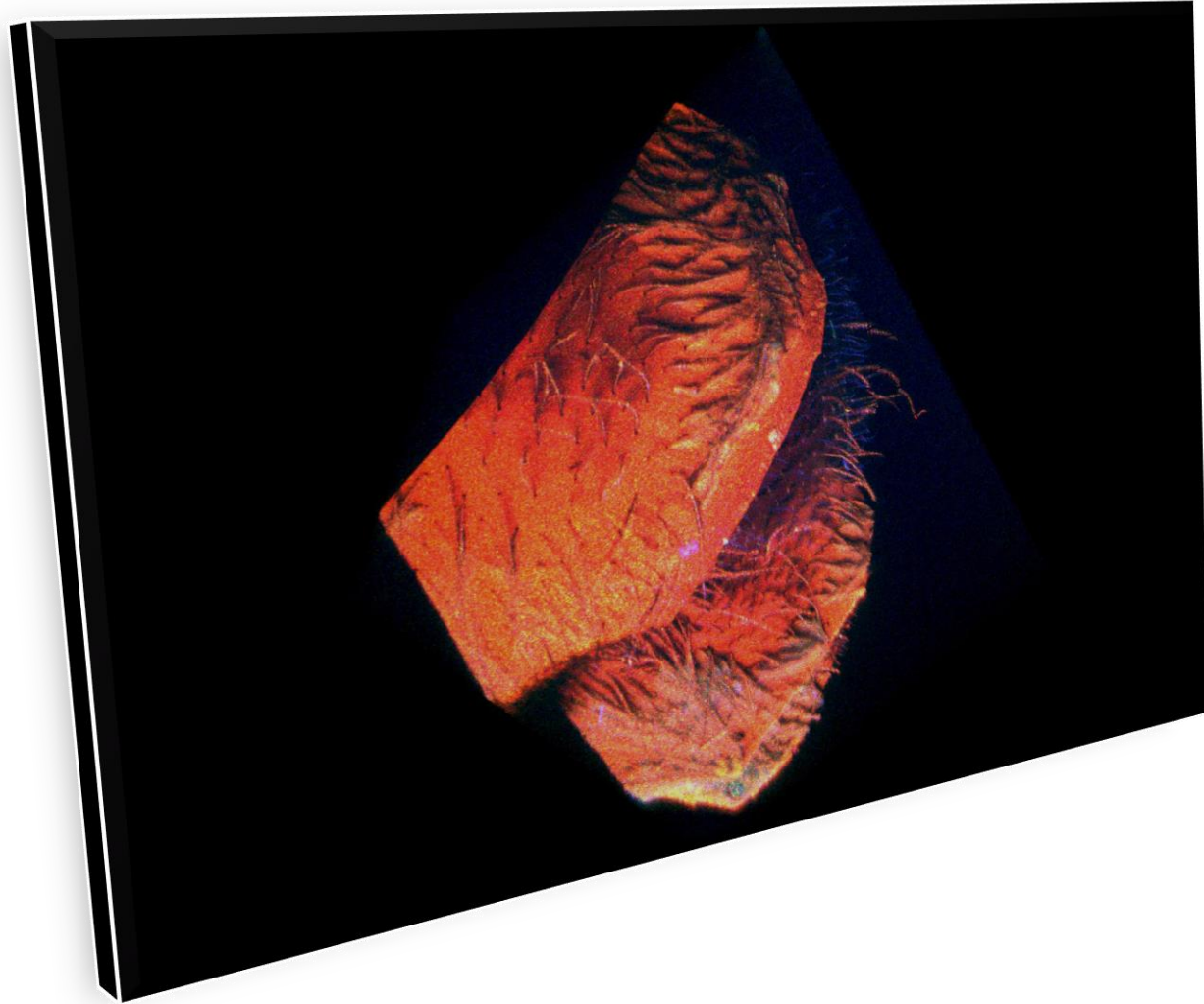
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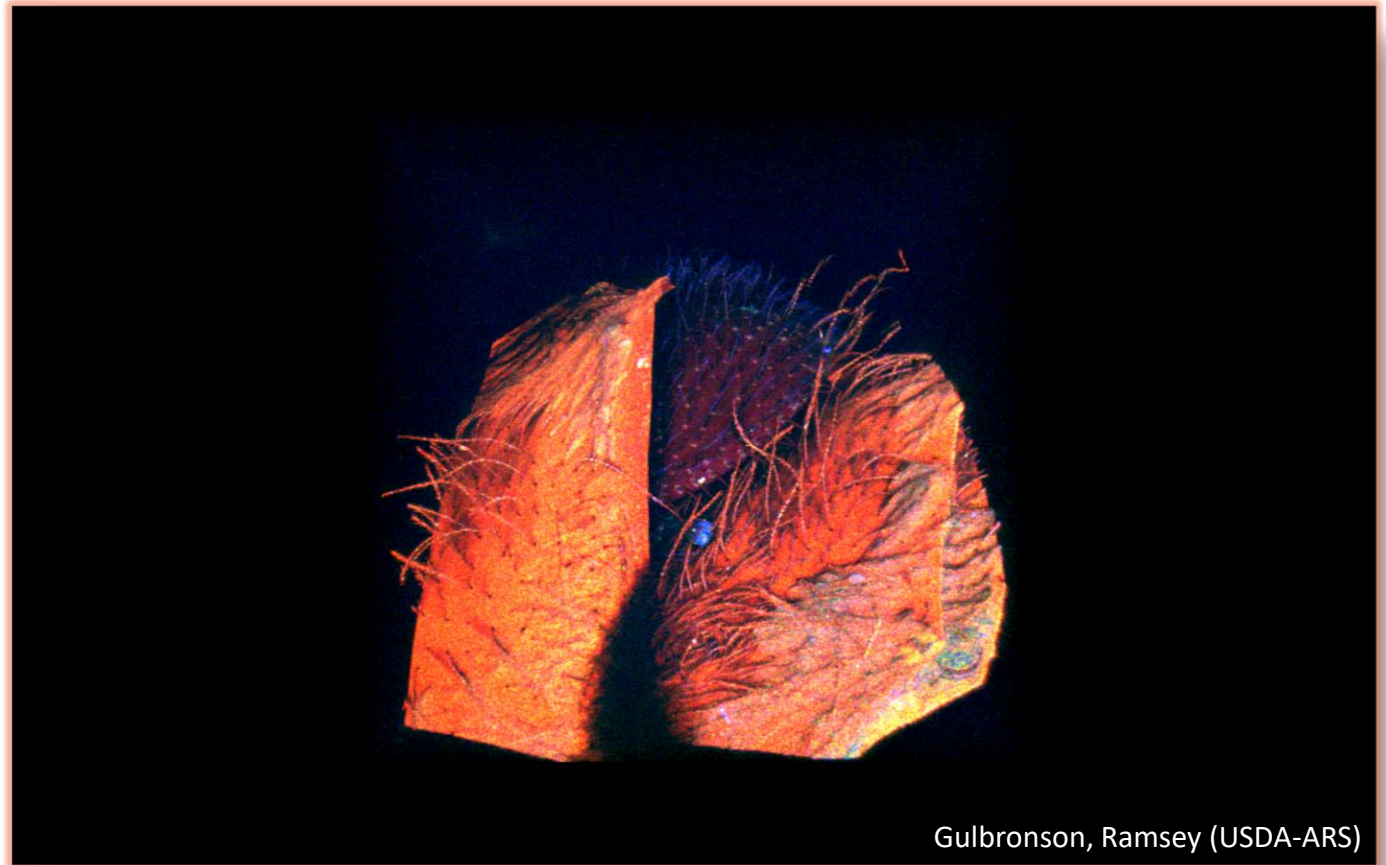
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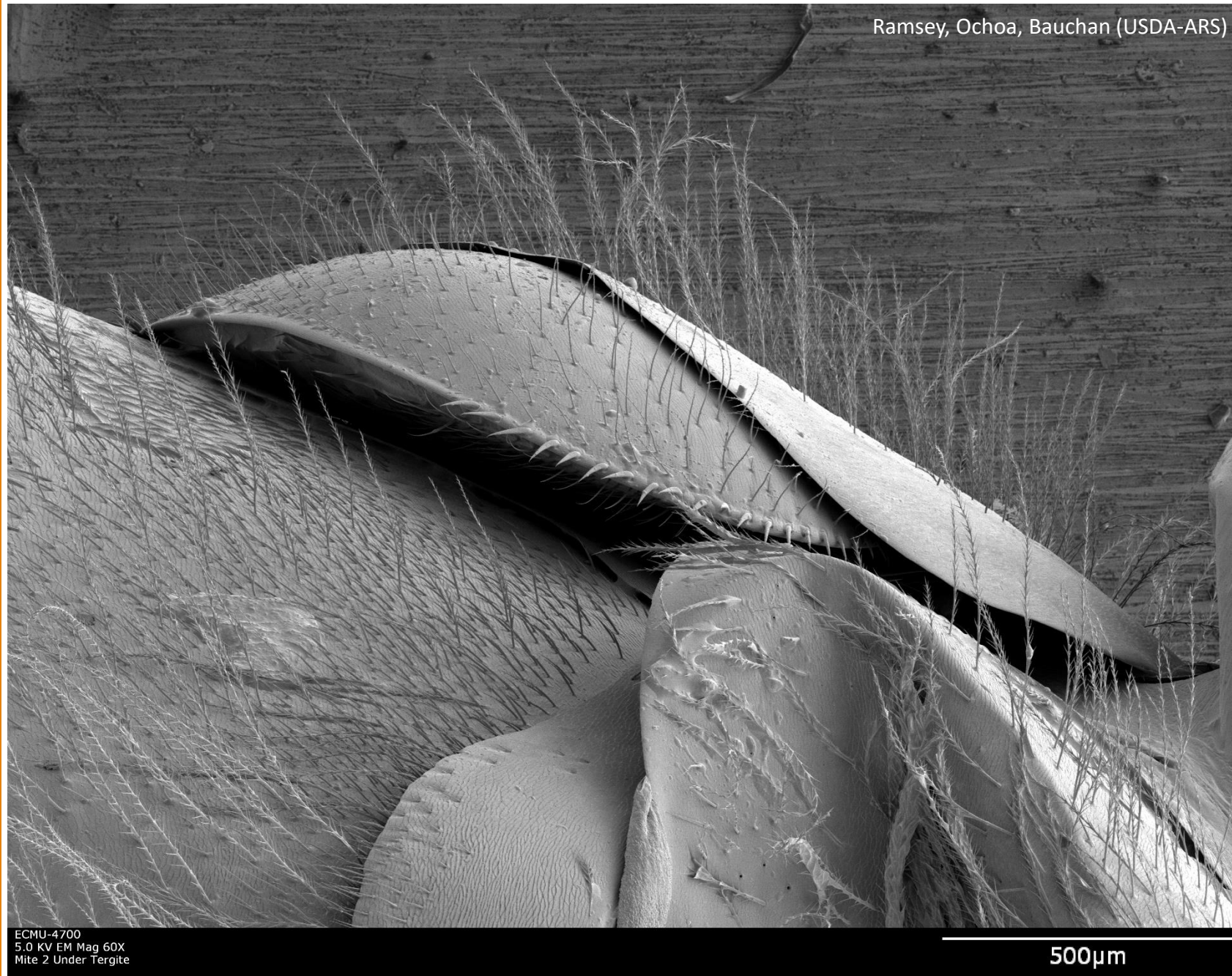
Gulbranson, Ramsey (USDA-ARS)

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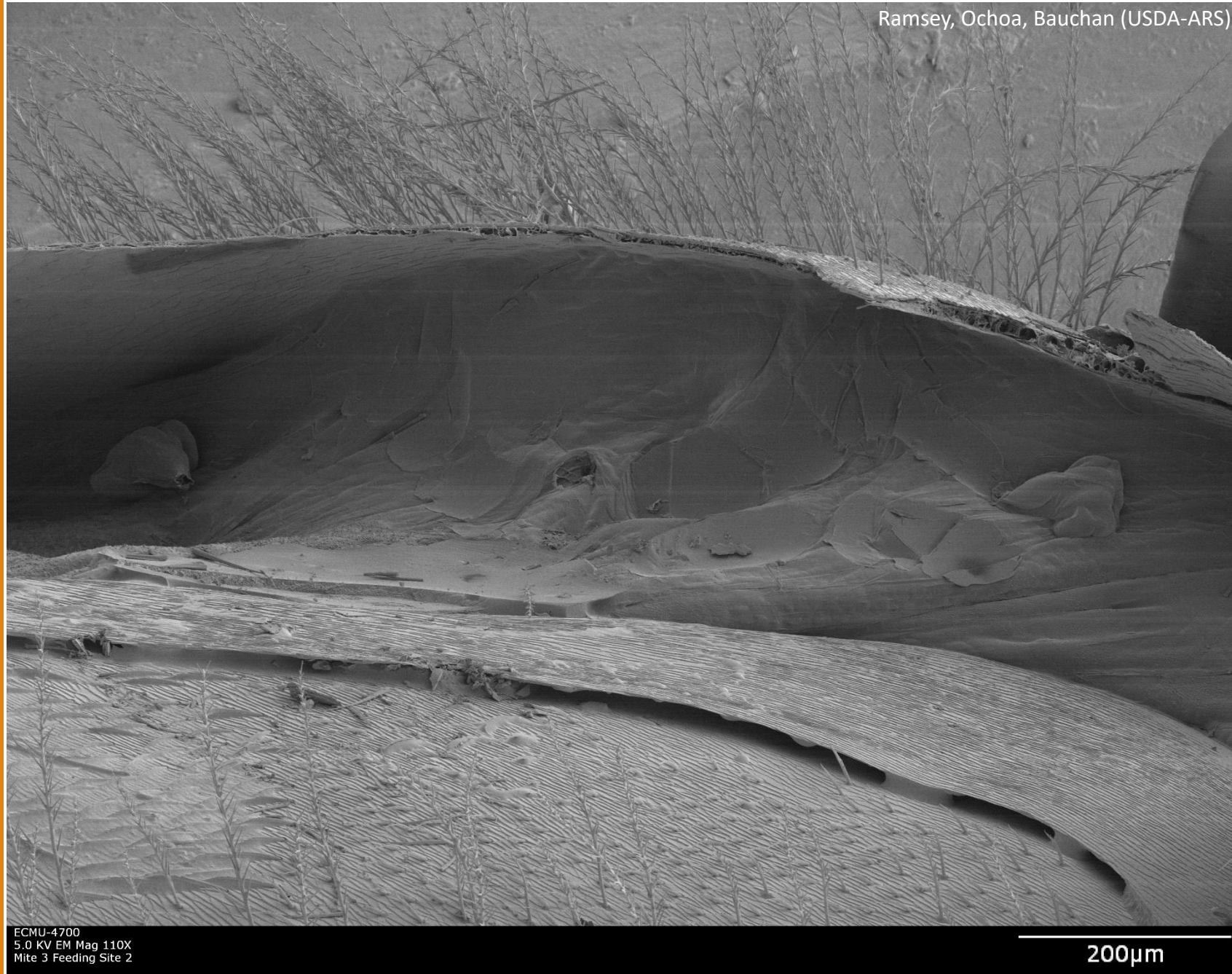
Phoretic or Not?

- ◆ Phoretic: parasite using host as a vehicle not a food resource
- ◆ LT-SEM study undertaken to verify feeding site hypothesis



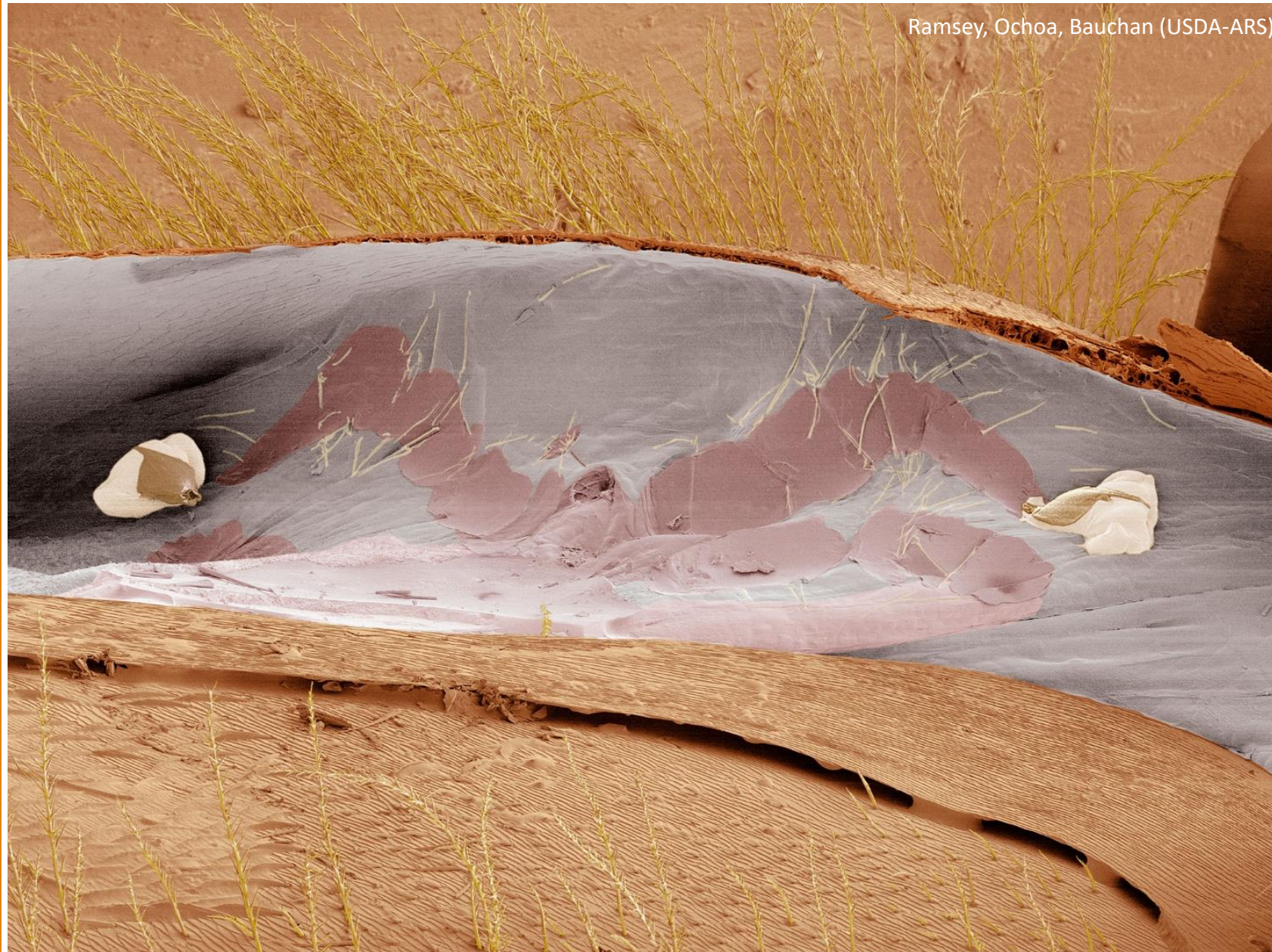
Mite Feeding Wound

- Pierces multiple layers of soft tissue
- Found in membrane between sternites/tergites



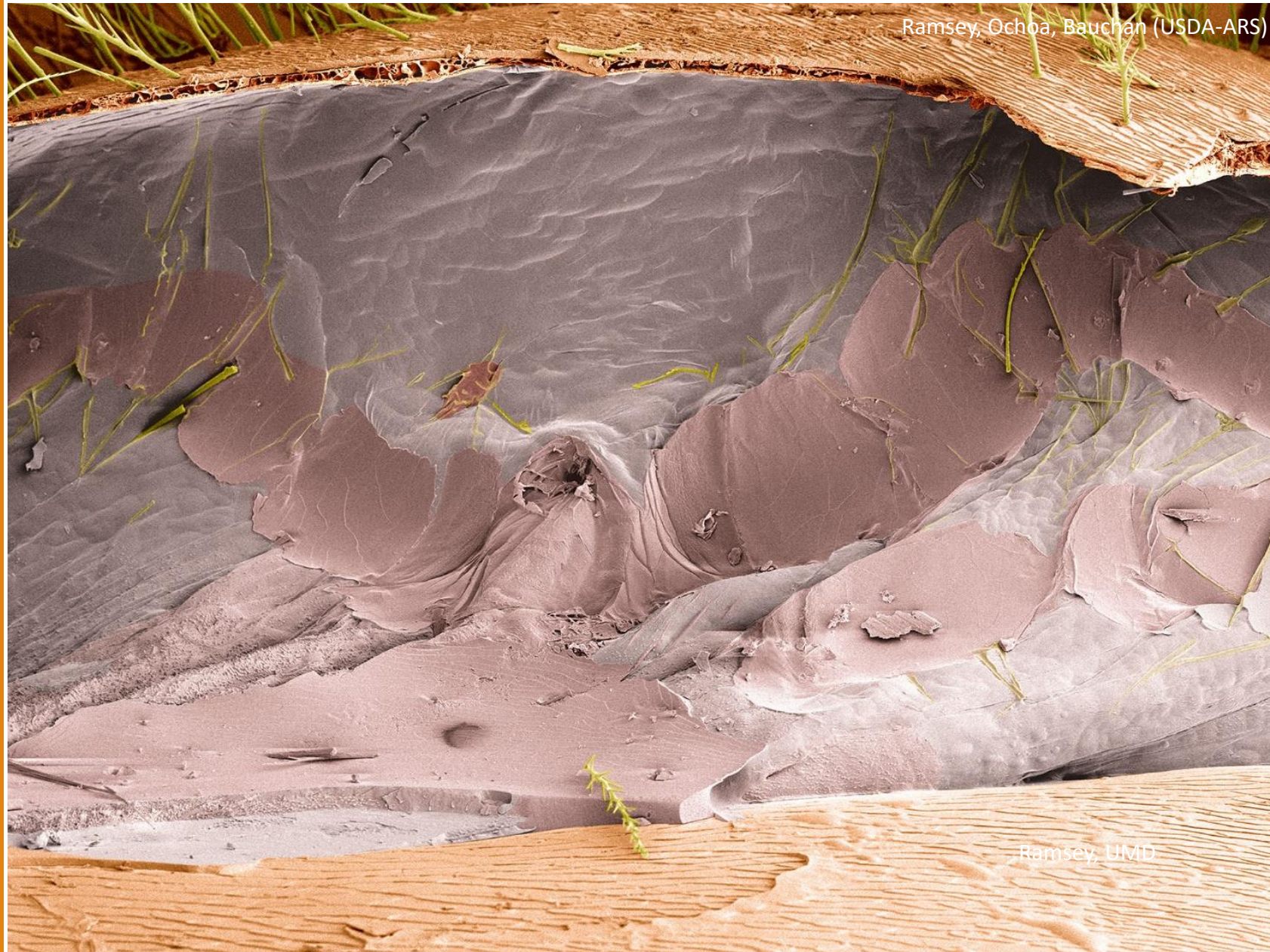
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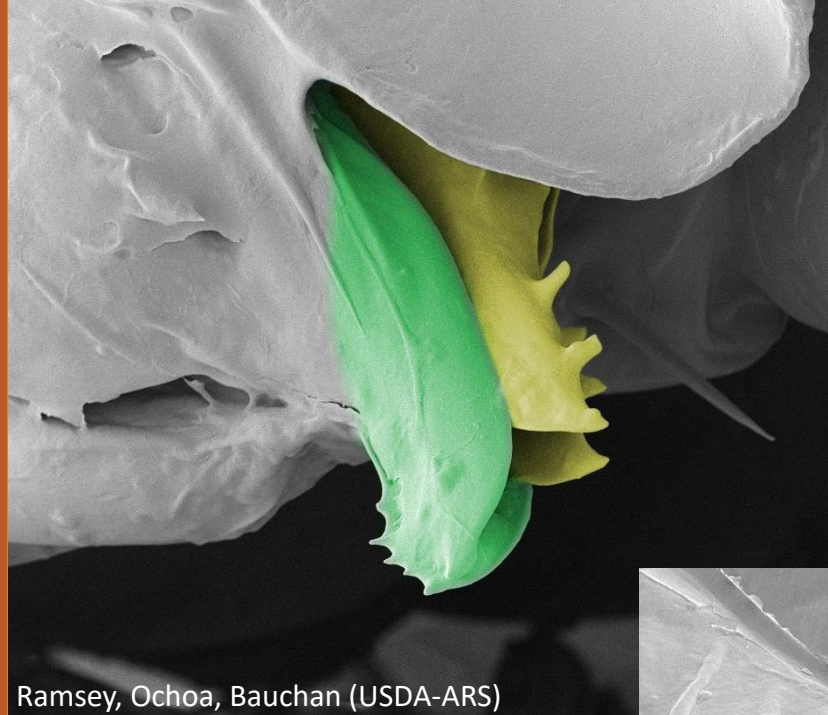
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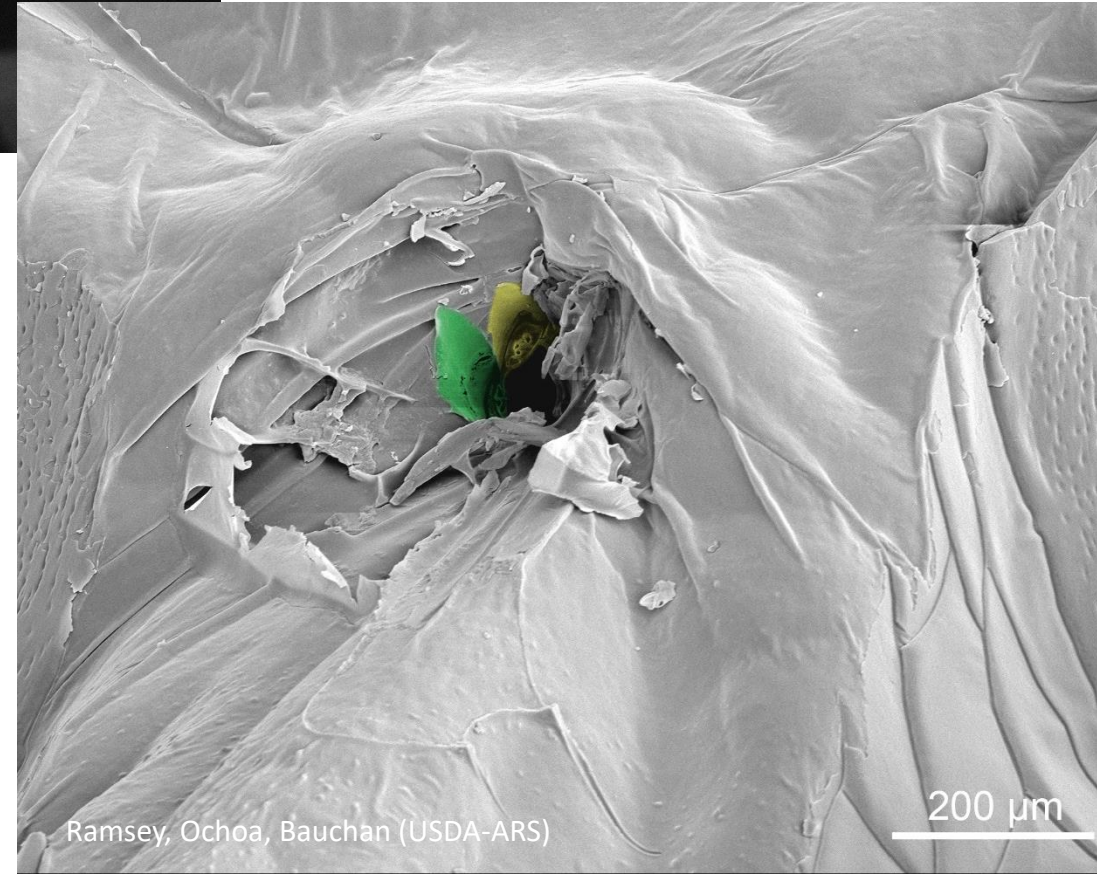


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Ramsey, Ochoa, Bauchan (USDA-ARS)



Ramsey, Ochoa, Bauchan (USDA-ARS)

Is Varroa Phoretic?

Definition

- a phenomenon in which one animal attaches to the outer surface of another animal for a limited time during which the attached animal (termed phoretic) ceases both feeding and reproduction, such attachment resulting in dispersal from areas unsuited for further development, either of the individual or its progeny





Phoresy

IS VARROA PHORETIC?

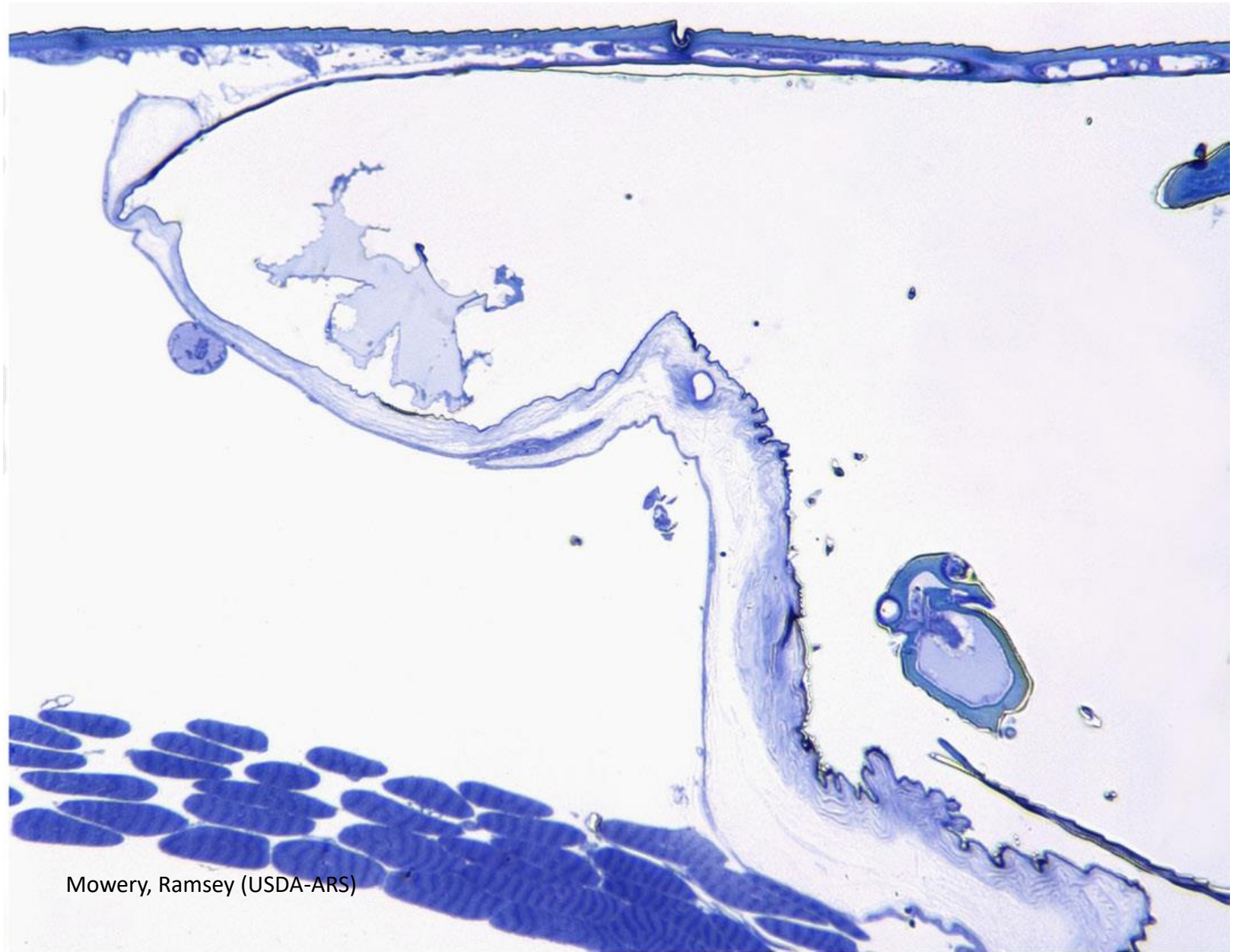
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Not Phoretic

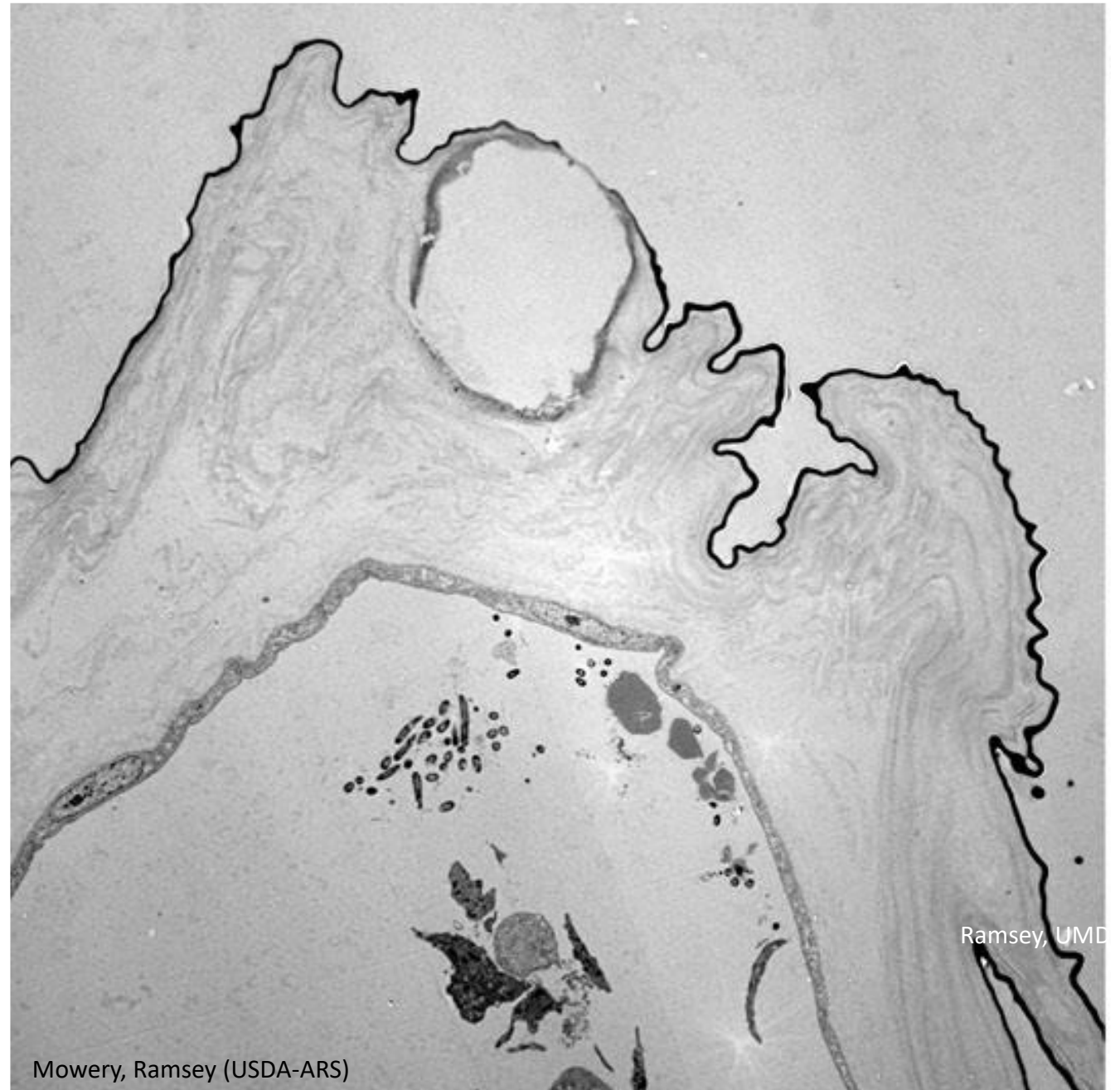
- Evidence of extra oral digestion
- Mite consumes host tissue from adult bees
- Uses host as a trophic resource in addition to a vehicle



Mowery, Ramsey (USDA-ARS)

Feeding Damage

- Two morphologically distinct groups of bacteria present in wound
- Partially digested cell components present



Alternative Fact #3



- ~~1. *Varroa* feed exclusively on the hemolymph of adult and immature Bees~~
- ~~2. You'll usually find *Varroa* on top of worker bee's thorax~~
3. *Varroa* have a phoretic phase





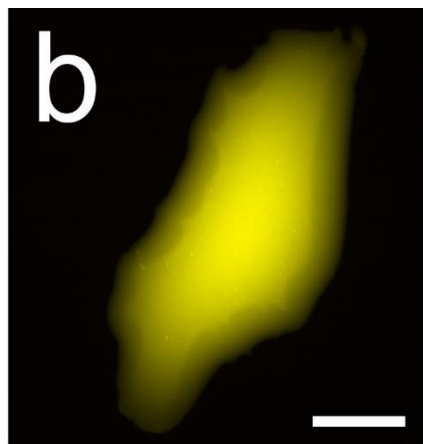
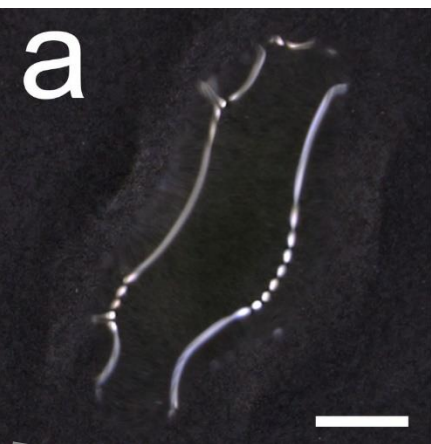
Fat Body

- ◆ Varroa fed only where fat body was accessible

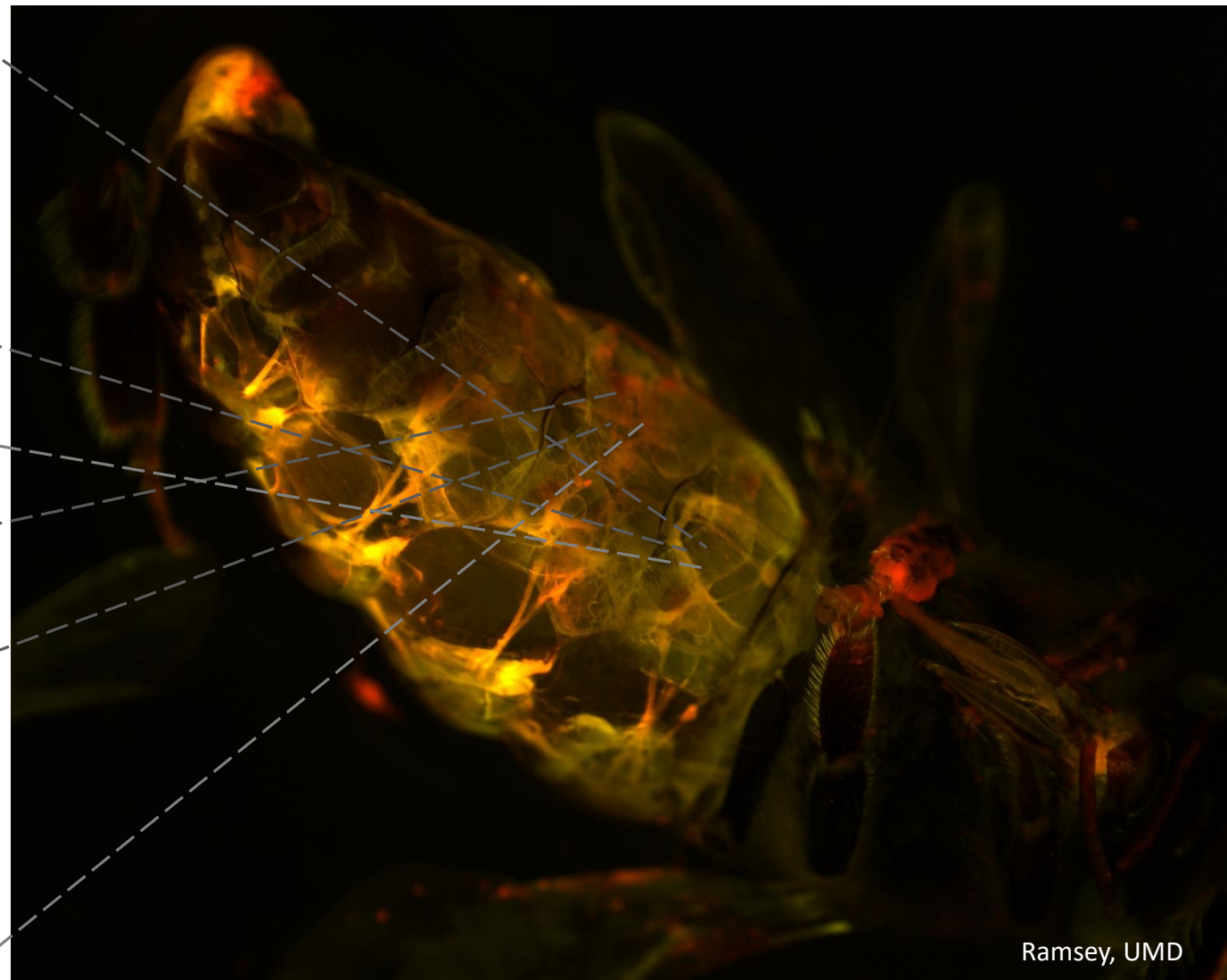
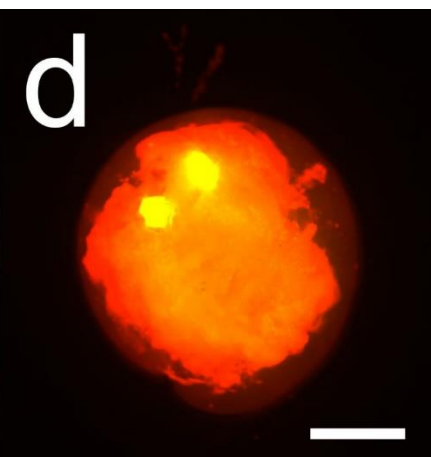
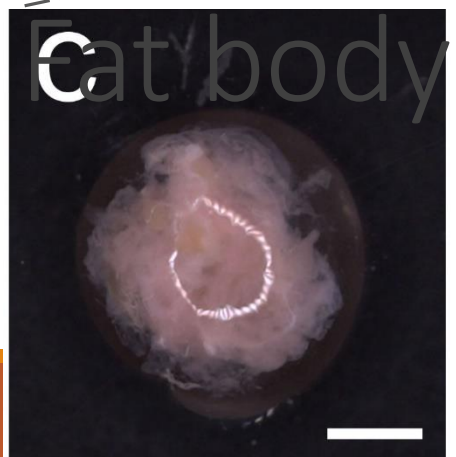
Methods

- Each honey bee exposed to treatment solution immediately upon emergence
- Honey bees allowed to feed ad libitum on 30% sugar solution containing dye
- After feeding for 10 days, each bee separated into cup with two mites





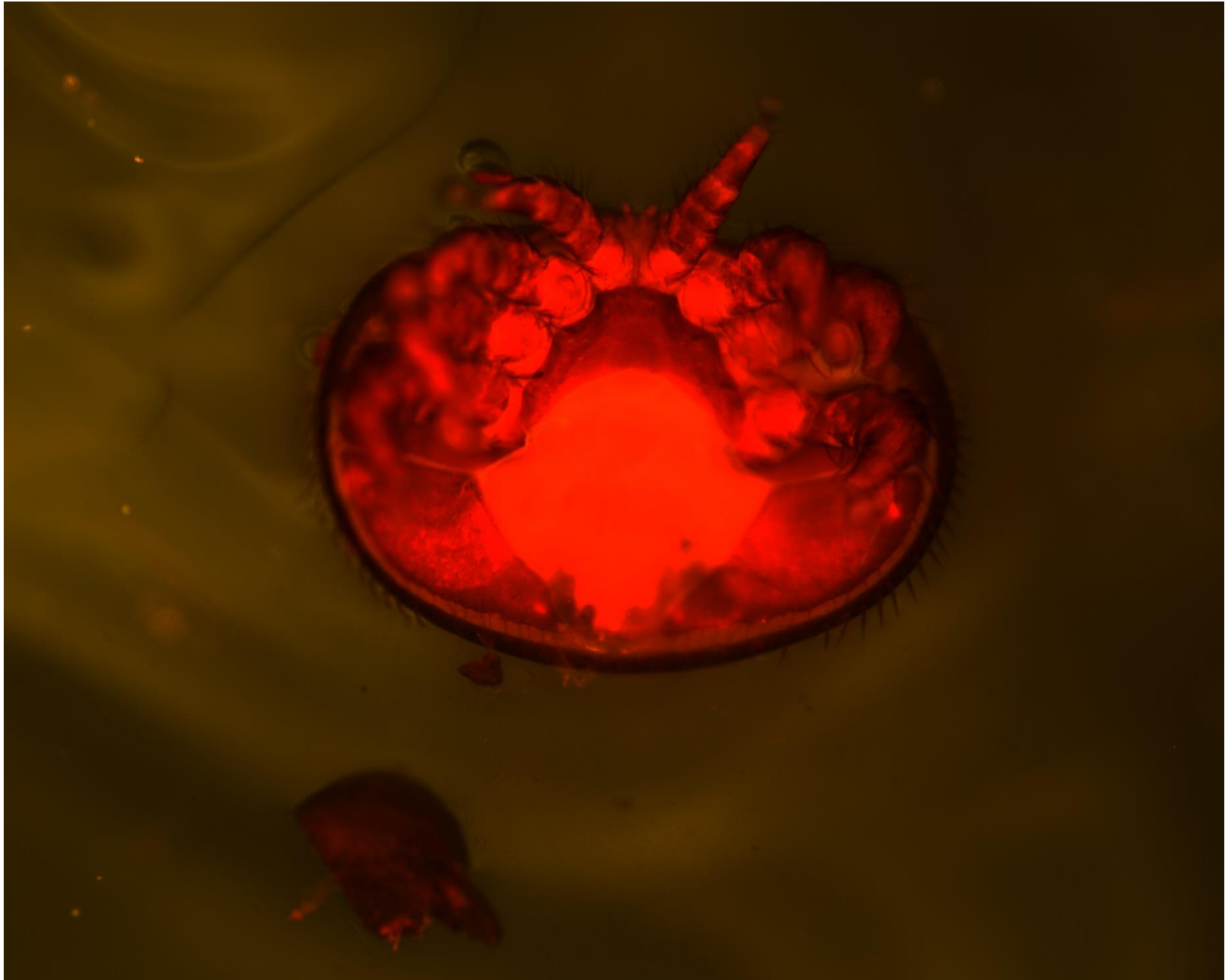
Honey Bee with
Fluorescently
labeled (hydrophilic
stain)
Hemolymph and
Fat body



Ramsey, UMD

Results

- Varroa after feeding for 24 hours
- Magnification: 40x
- 1s exposure



Results

- Nile Red (Fat Biostain)



Fat Body

- Growth & Metamorphosis
- Storage & Energy/Nutrient Mobilization
- Pesticide Detoxification
- Water Loss/Osmoregulation
- Immune Function
- Temperature Regulation
- Metabolic Activity
- Protein & Fat Synthesis
- Vitellogenesis



Growth & Development

(Bowen-Walker 2001; Amdam 2004; Nilsen 2011; Rosenkrantz 2010)

Metamorphosis

(Bowen-Walker 2001; Le Conte 2010; Annoscia 2012)



Nutrient Storage & Mobilization

(Bowen-Walker 2001; Doormalen 2013)

Metabolic Activity

(Bowen-Walker 2001; Doormalen 2013)



Water Loss & Osmoregulation

(Bowen-Walker 2001; Salvy 2001; Annoscia 2012)

Temperature Regulation

(Amdam 2004)



Pesticide Detoxification

(Gregorc et al. 2012; Blanken et al. 2015;)

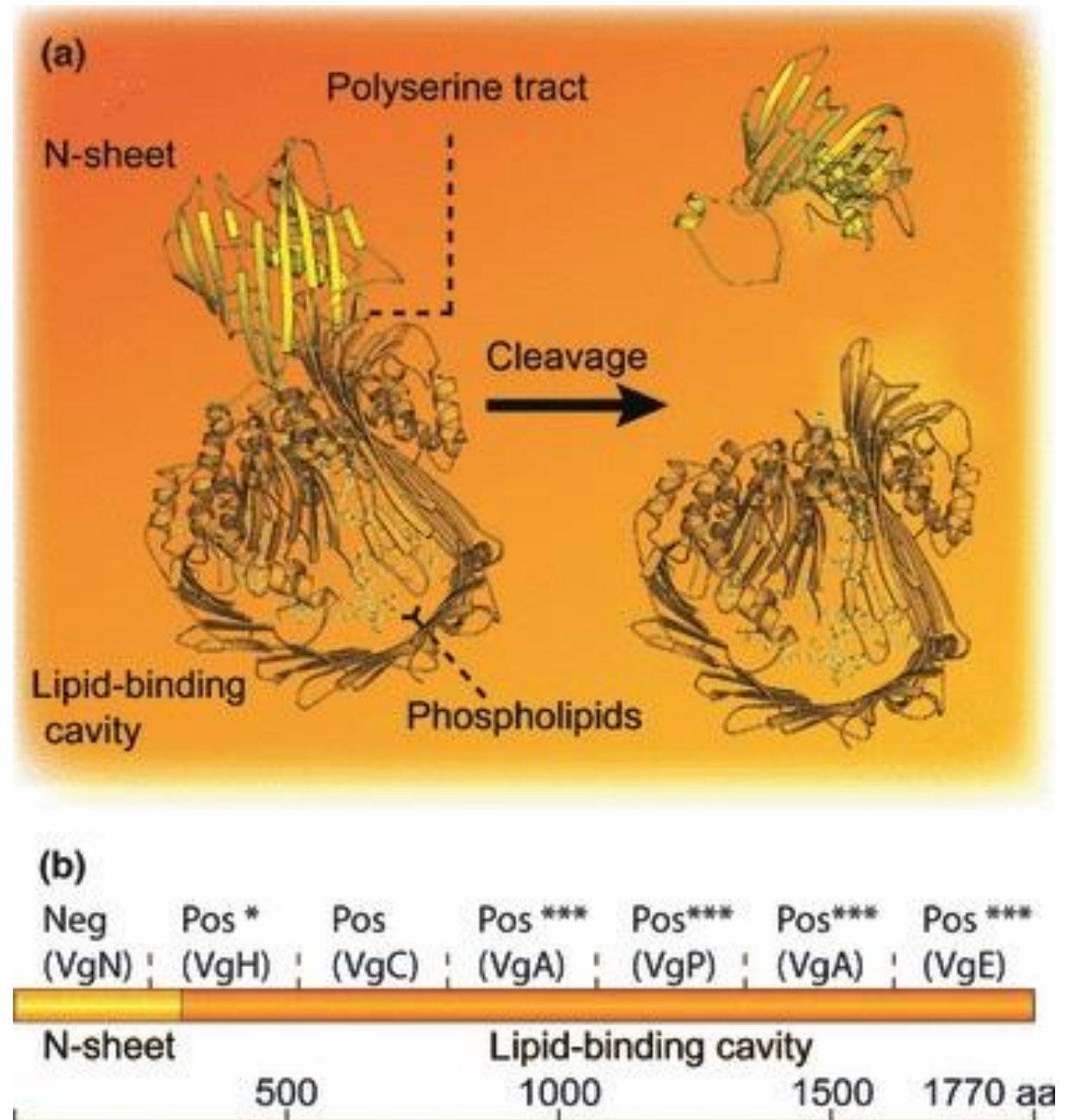


Protein Synthesis

(Tewarson 1983; Glinski 1984; Weinberg 1985; Bowen-Walker 2001; Amdam 2004; Doormalen 2013)

Immune Function

(Yang 2005; Yang 2007)



Vitellogenesis

(Tewarson 1983; Amdam 2003; Amdam 2004)



Host Tissue Feeding Experiment

- ◆ Foundress mite introduced into artificial cell
- ◆ Allowed to feed on a controlled diet composed of:
 - $\frac{1}{4}$ fat body to $\frac{3}{4}$ hemolymph by volume
 - $\frac{1}{4}$ hemolymph to $\frac{3}{4}$ fat body by volume
 - $\frac{1}{2}$ fat body to $\frac{1}{2}$ hemolymph
 - entirely hemolymph
 - entirely fat body tissue (in phosphate buffered saline)

Methods

- Created artificial cells from wax queen cups
- Foundress mites collected from brood
- Introduced into cell



Methods

- “Decoy pupa” fashioned from size 5 pill
- Pill rubbed against pre-pupa to obtain brood smell
- Pill injected with honey bee tissue



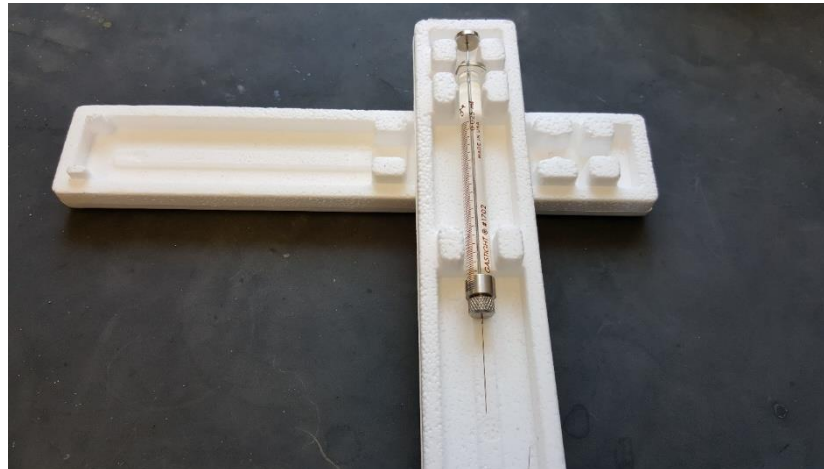
Methods

- Trough cut into underside of pill
- Then layer of stretched parafilm spread over trough



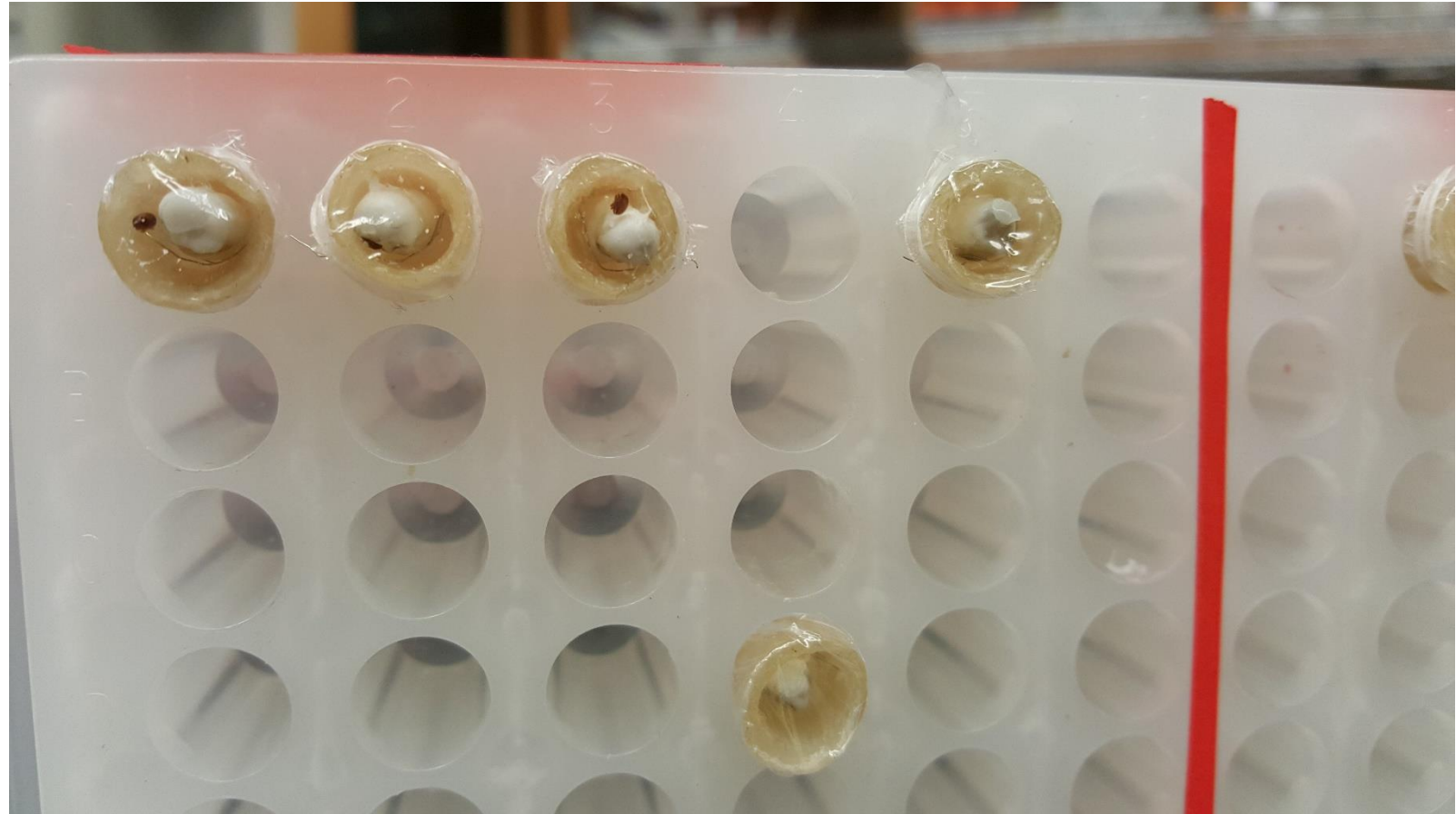
Methods

- Dissected Nurse bees to obtain fat body
- Hemolymph extracted via syringe

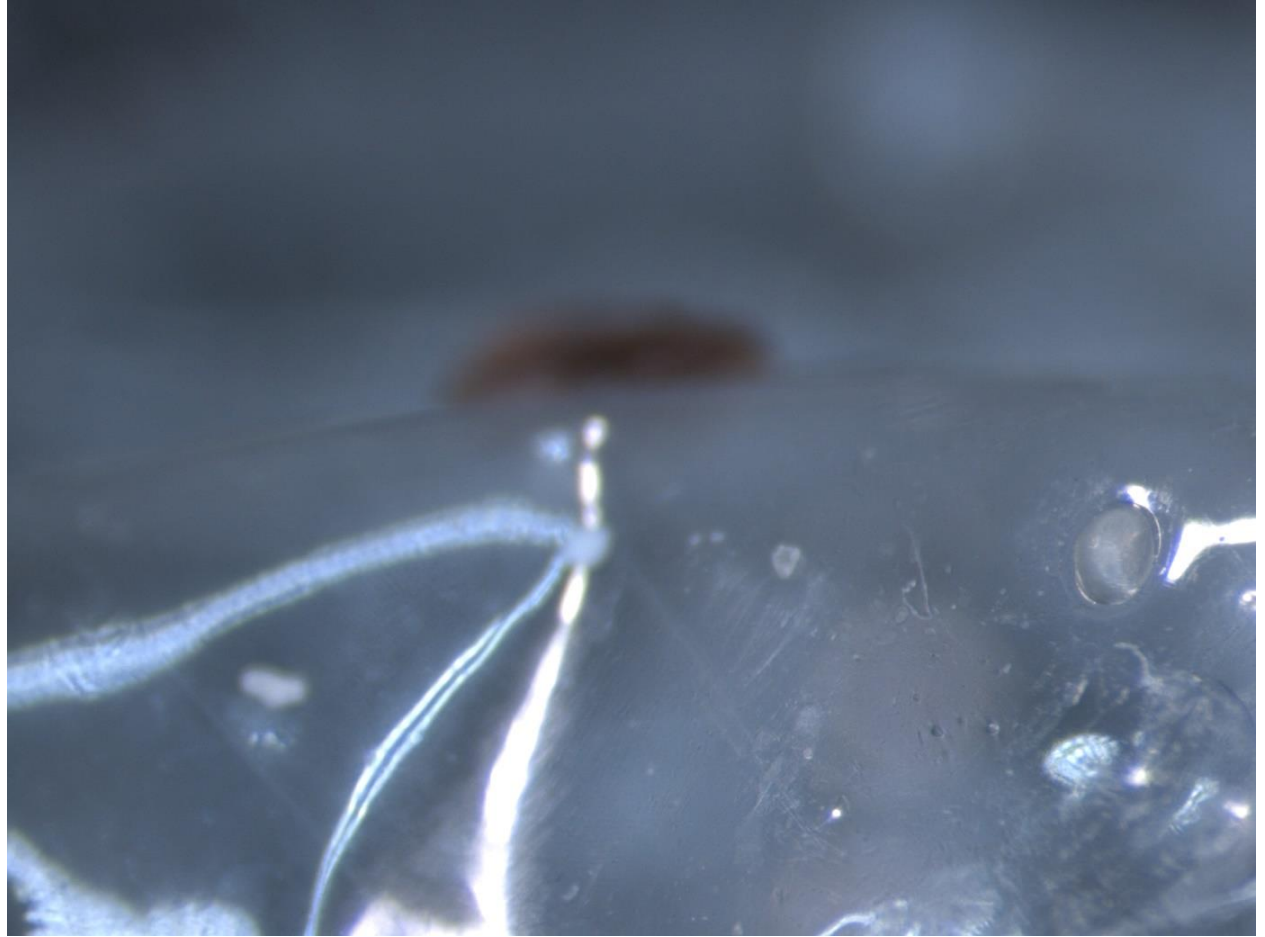


Methods

- 30 mites per trial
- Mites maintained at 33°C and 70% RH
- Survivorship and egg production measured every 24 hrs



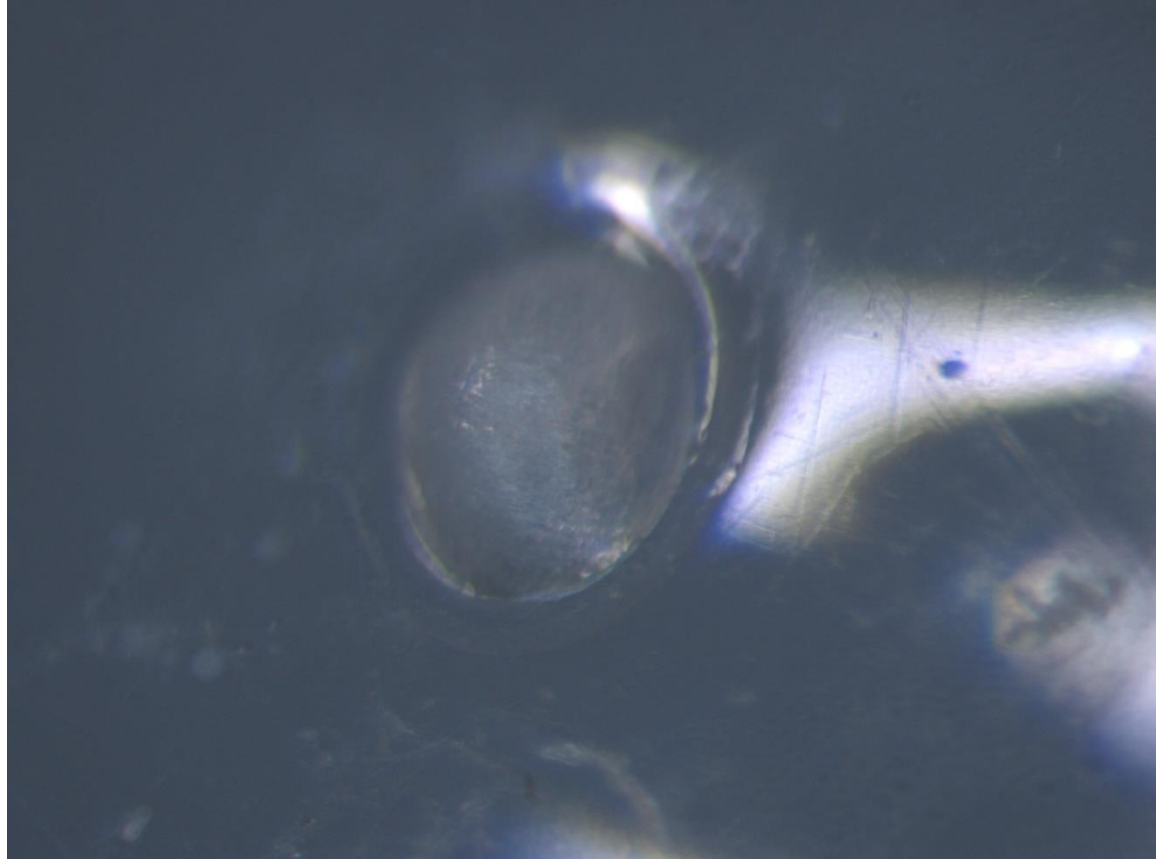
Results



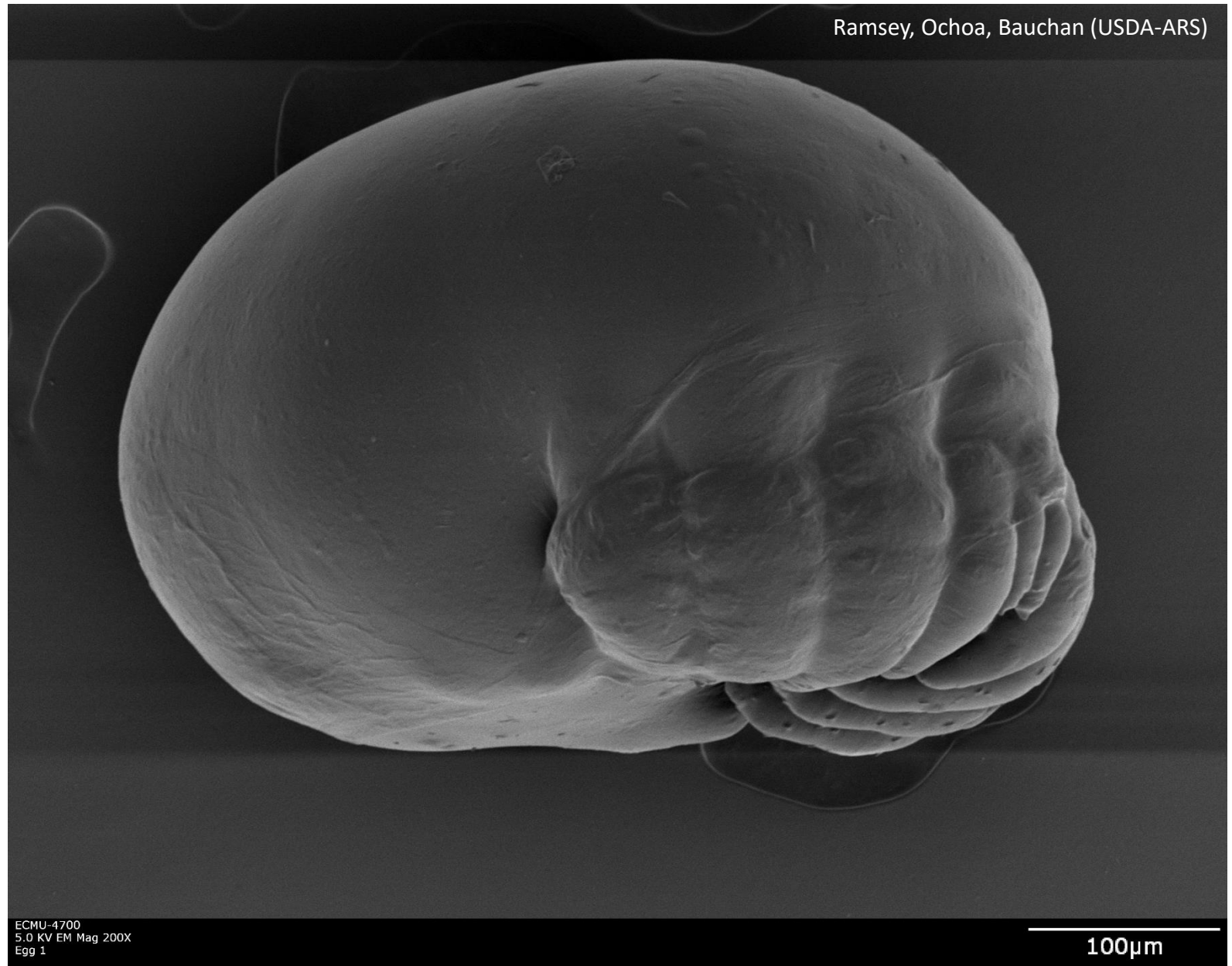
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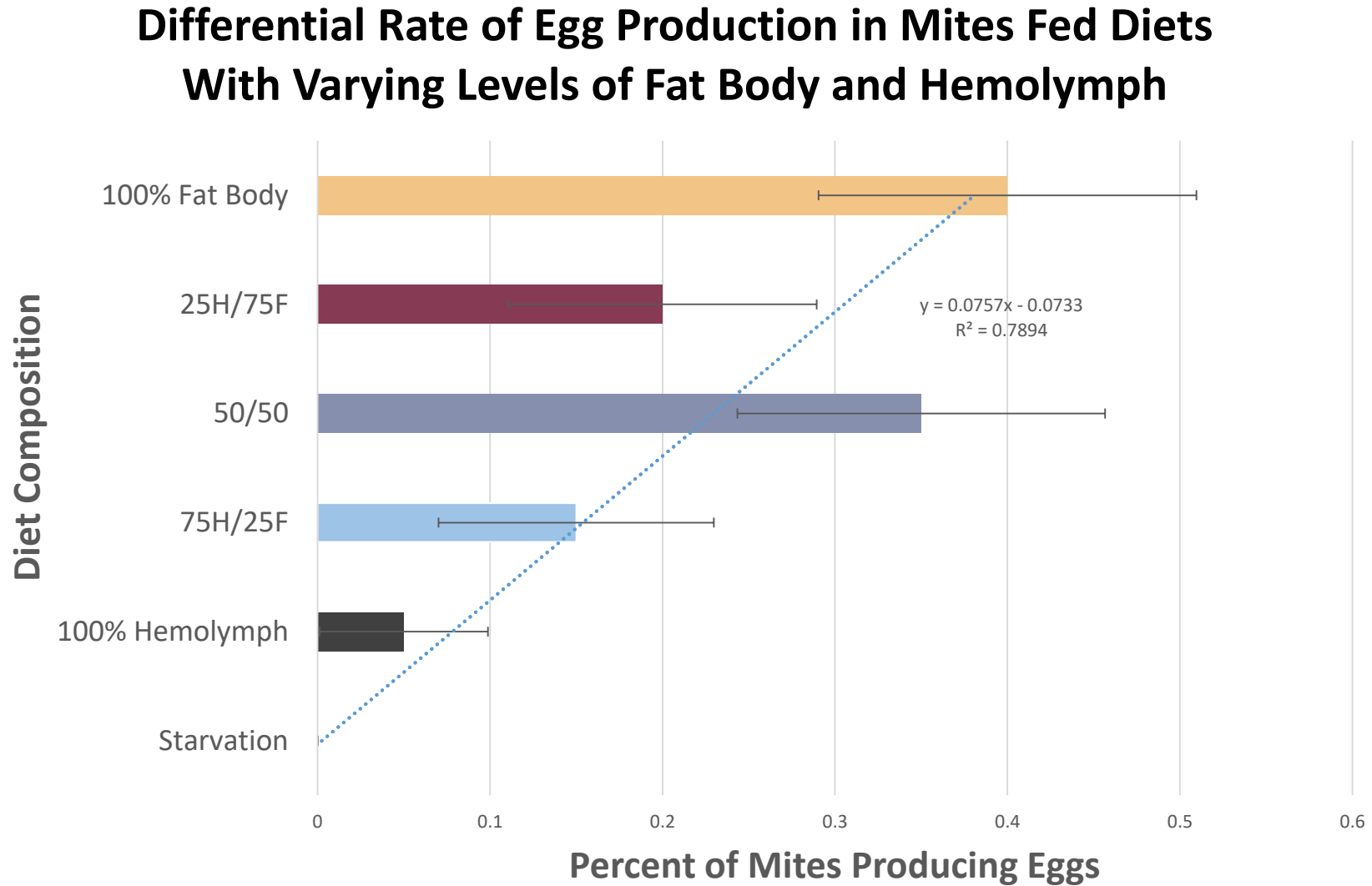
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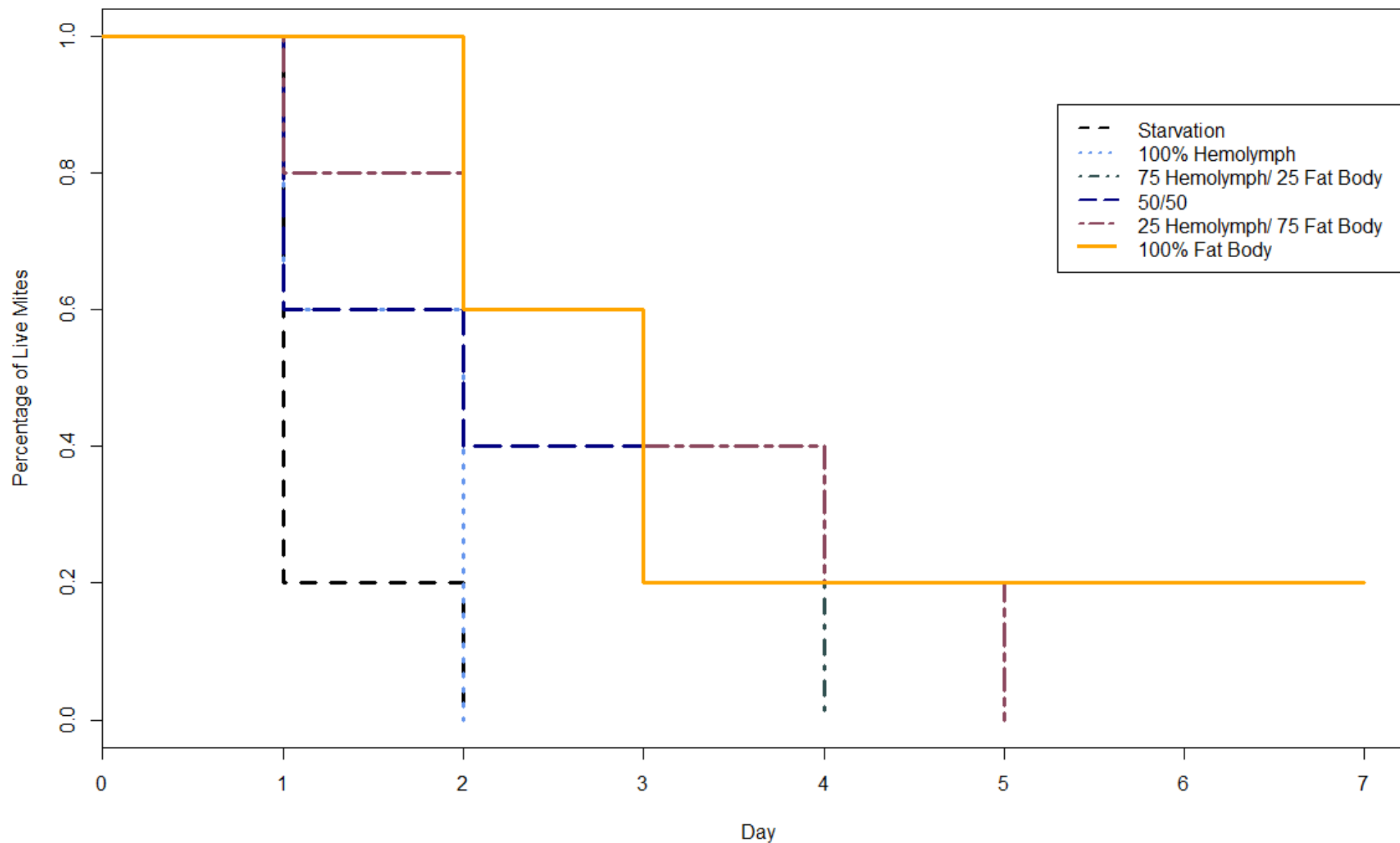
Results



Results



Differential Survivorship of Foundress Varroa Fed Diets Composed of Honey Bee Tissue



$p < .001$, $n = 60$

NEW RESEARCH IN

Physical Sciences

Social Sciences

Biological Sciences

Varroa destructor feeds primarily on honey bee fat body tissue and not hemolymph

Samuel D. Ramsey, Ronald Ochoa, Gary Bauchan, Connor Gulbranson, Joseph D. Mowery, Allen Cohen, David Lim, Judith Joklik, Joseph M. Cicero, James D. Ellis, David Hawthorne, and Dennis vanEngelsdorp

PNAS published ahead of print January 15, 2019 <https://doi.org/10.1073/pnas.1818371116>

Edited by Gene E. Robinson, University of Illinois at Urbana-Champaign, Urbana, IL, and approved December 6, 2018 (received for review October 26, 2018)

Article

Figures & SI

Info & Metrics

PDF

Significance

Varroa destructor causes considerable damage to honey bees and subsequently the field of apiculture through just one process: feeding. For five decades, we have believed that these mites consume hemolymph like a tick consumes blood, and that *Varroa* cause harm primarily by vectoring viruses. Our work shows that they cause



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Parasitic mites and honey bee fat body



How mites affect honey bee colonies

Varroa destructor feeds primarily on honey bee fat body tissue and not hemolymph

Institutionalization and cognitive development

Available Open Access

Conclusions

- ◆ *Findings indicate that Varroa are not exploiting hemolymph as their primary host resource*
- ◆ Need to update recommendations for treatment timing
- ◆ Supplementing protein without controlling *Varroa* is not helpful
- ◆ Development of systemic pesticides for *Varroa* could be affected by these findings

Acknowledgements

The vanEngelsdorp Lab

Dennis vanEngelsdorp
Karen Rennich
Heather Eversole
Rachel Fahey
Dan Reynolds

Dr. Allen Cohen
Judy Joklik
David Lim
Dr. Pedro Barbosa
Nathalie Steinhauer



USDA-ARS

Electron & Confocal Microscopy Team

Andrew Ulsamer
Tim Zastrow
James Zastrow
Ashrafun Nessa
Andrew Ulsamer
Dr. Jay Evans
Dr. Kevin Hackett
Kathleen Hackett

Many Thanks!

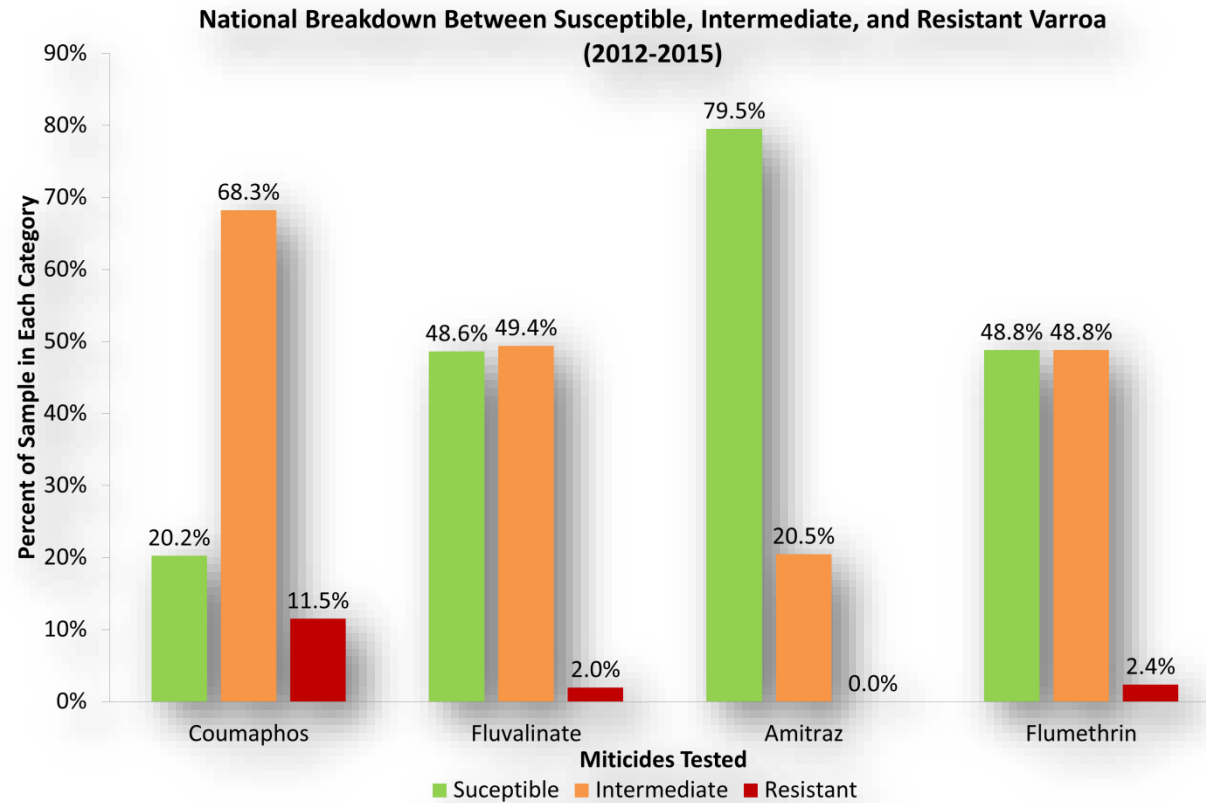
Questions?



Thank You For Your Time and Attention
I'd be Happy to Answer Any Questions?



Results



“Resistant” mites were categorized by $\leq 20\%$ mortality after treatment

“Susceptible” mites were categorized by $\geq 80\%$ mortality after treatment

“Intermediate” mites had between 21-79% mortality after treatment



Results



Tested mites populations show resistance to 3
miticides tested

Coumaphos resistance most prevalent
Amitraz showed no resistance

Amitraz may be more effective in reducing mite loads than
the other miticides

Varroa mite control options and considerations

Essential oil



Organic acid



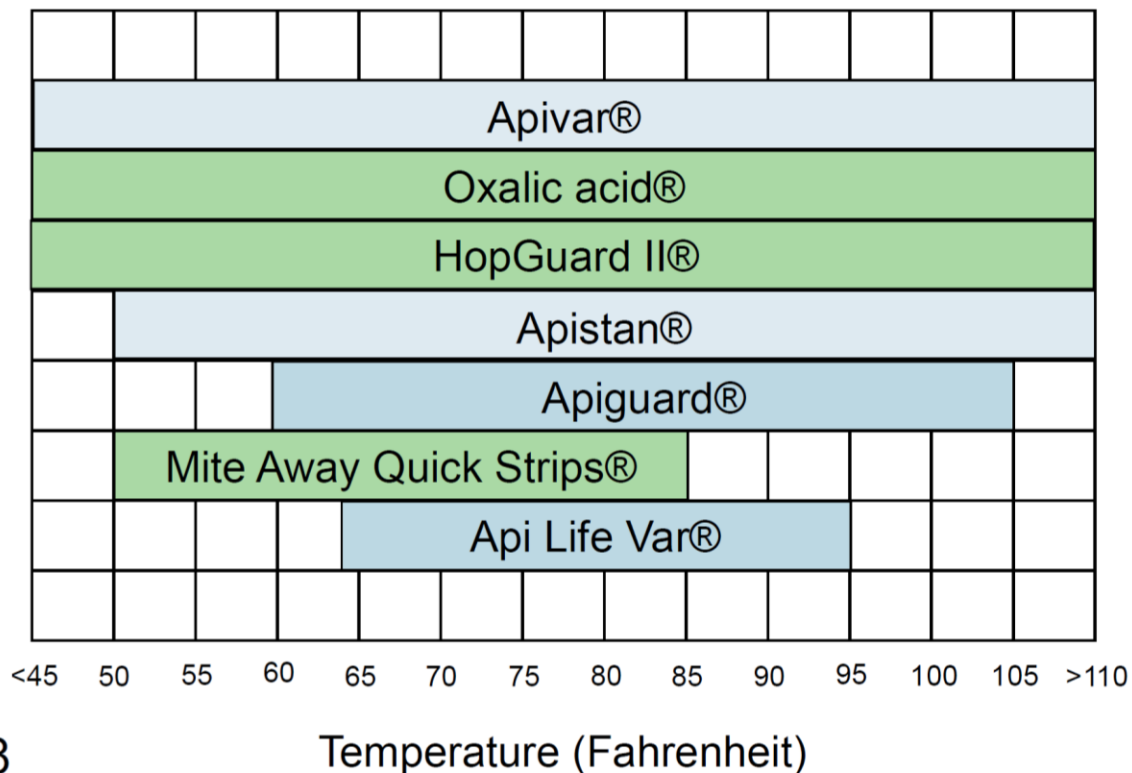
Synthetic chemical

Chemical	Active Ingredient	Method	Efficacy when used appropriately	Cost per colony (\$)	Treatment duration	Can you treat with supers on?	Time to wait after treatment ends before you can super
Apiguard®	Thymol	Tray with gel sits on brood frames	74-95%	3.30 - 6.80	28 days (2 times for 14 days each)	No	Can super immediately after treatment ends
Api Life Var®	Thymol, eucalyptus oil, menthol	Tablets placed on the corners of the brood nest	70-90%	4.48 – 7.12	21-30 days (3 times at 7-10 day intervals)	No	1 month
MiteAway Quick Strips®	Formic acid	Pads placed on brood nest	61-98%	4.40 – 7.25	7 days	Yes	Supers can be left on during treatment
Oxalic Acid	Oxalic acid dehydrate	Dribble brood nest or vaporize entrance	82-99%	0.25 – 0.37	10 minutes	No	2 weeks
Hop Guard II®	Hops beta acids	Strips inserted in brood nest	75-99%	3.33 – 3.80	28 days	Yes	Supers can be left on during treatment
Apivar®	Amitraz	Insert strips into brood nest	95%	5.00 – 6.90	42-56 days	No	2 weeks
Apistan®	<i>Tau</i> -fluvalinate (pyrethroid)	Insert strips into brood nest	95-99%	4.19 – 6.79	42 days	No	Can super immediately after treatment ends

Notes:

- There have been cases of resistance in Apistan®. Varroa mites can develop resistance to any treatment, therefore it is important to rotate treatments, remove treatment strips promptly, and practice Integrated Pest Management to reduce the likelihood of resistance developing. Make sure you monitor following treatment (or regularly every month) to determine efficacy.
- Efficacy levels are cited from **Honey Bee Health Coalition, 2017. Tools for Varroa management: a guide to effective Varroa sampling and control, 5th edition.**
- Treatment costs per colony vary depending on supply companies and order size.

Treatment Temperature Windows



Varroa mite control options and considerations

☐ Essential oil

☒ Organic acid

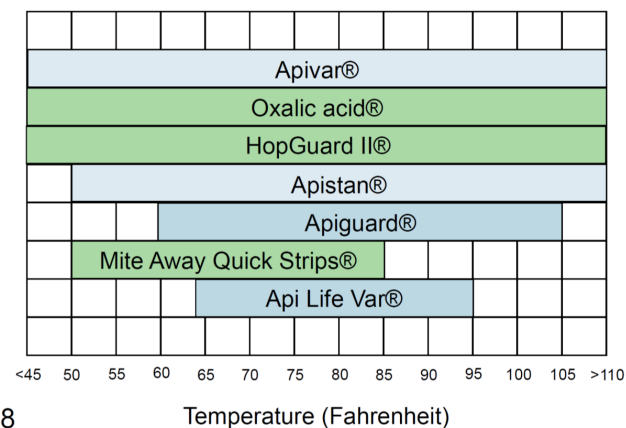
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Treatment Temperature Windows



38

Temperature (Fahrenheit)