How to Breed for Behavioral Resistance to Varroa Destructor

Krispn Given, Purdue University

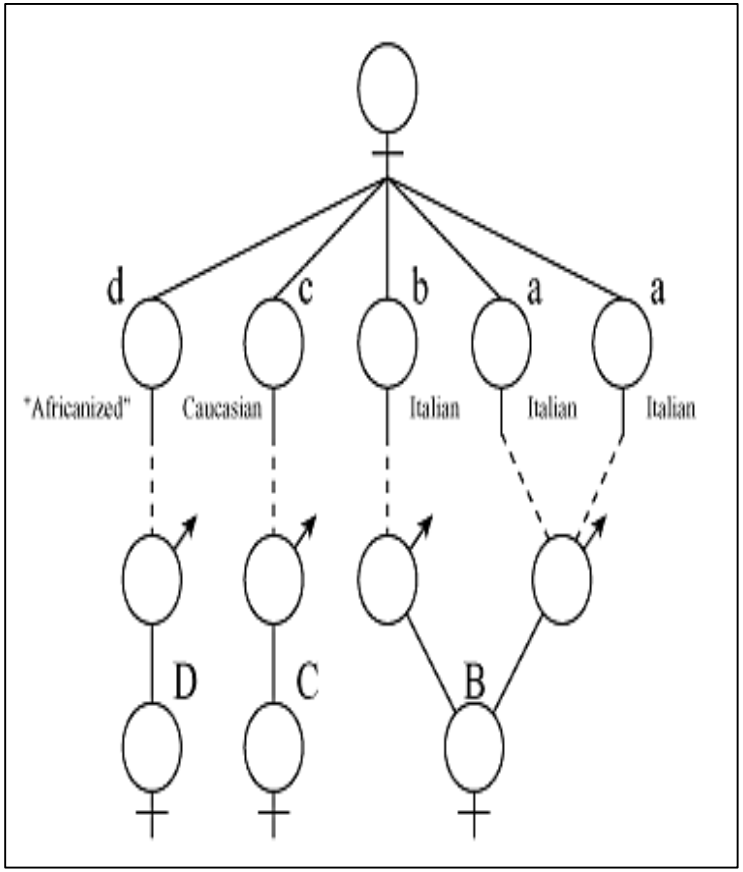
https://extension.entm.purdue.edu/beehive/

PURDUE
UNIVERSITY

Why **breed** bees?

- **Increase honey Production**
- **Improve overwintering ability**
- **Decrease defensive behavior**
- **Reduce swarming**
- **Reduce or increase use of propolis**
- **Change color**
- **Decrease incidence of diseases**
- **Improve defense against varroa destructor***
- **Other personal reasons**

Breeding versus queen rearing



Most important part of a breeding program

Steps in Breeding

- Decide on a trait (phenotype)
- Develop a assay
- Measure the foundation population
- Select parents
- Control mating using a design
- Evaluate, document, and verify
- Select parents

Bee Genetics + Breeding

Mendel's bee house

Honey Bees

16 CHROMOSOMES

~260 million bases (Mb
LOW REPETIVE DNA

HAPLOID MALES

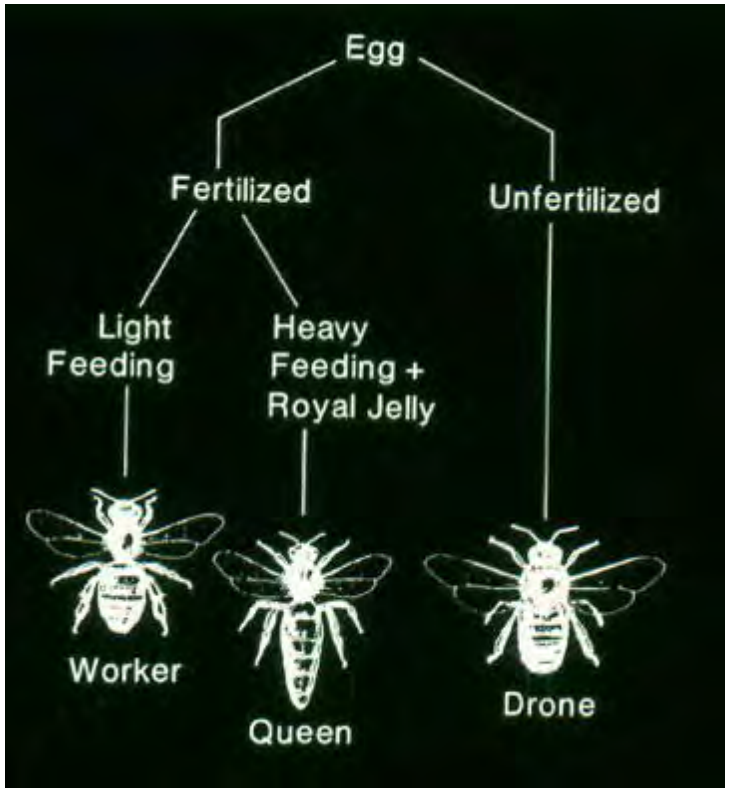
HIGH RECOMBINATION RATES!

CHROMOSOMES

- Composed of coiled, twisted DNA and coated with proteins
- Each species has a specific number
- They are organized in pairs

(one comes from the mother and the other from the father)

Genetic gender and caste



- Queens lay two types of eggs
- Males develop from unfertilized eggs
- Females develop from fertilized eggs

HONEY BEE GENETICS

Bees have 16 paired chromosomes.

Haplodiploidy

- Males honey bees have one of each chromosome (haploid 16)
- Females have two of each chromosome (diploid 32)

Polyandry

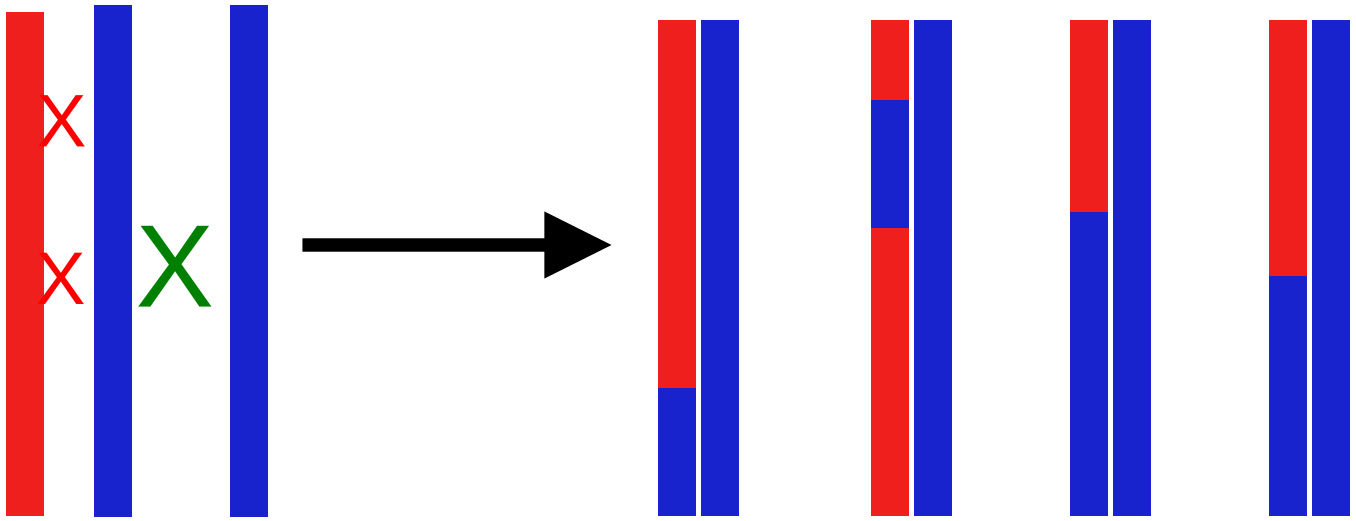
- The queen mates with 10 to 15 males, resulting in many sub-families within the hive's family.

Many important behaviors are influenced by genes!

- stinging
- pollen foraging
- undertaking
- hygienic behavior
- brood rearing traits
- swarming tendency
- propolis collection
- honey production
- even learning!

FEMALES

crossing-over

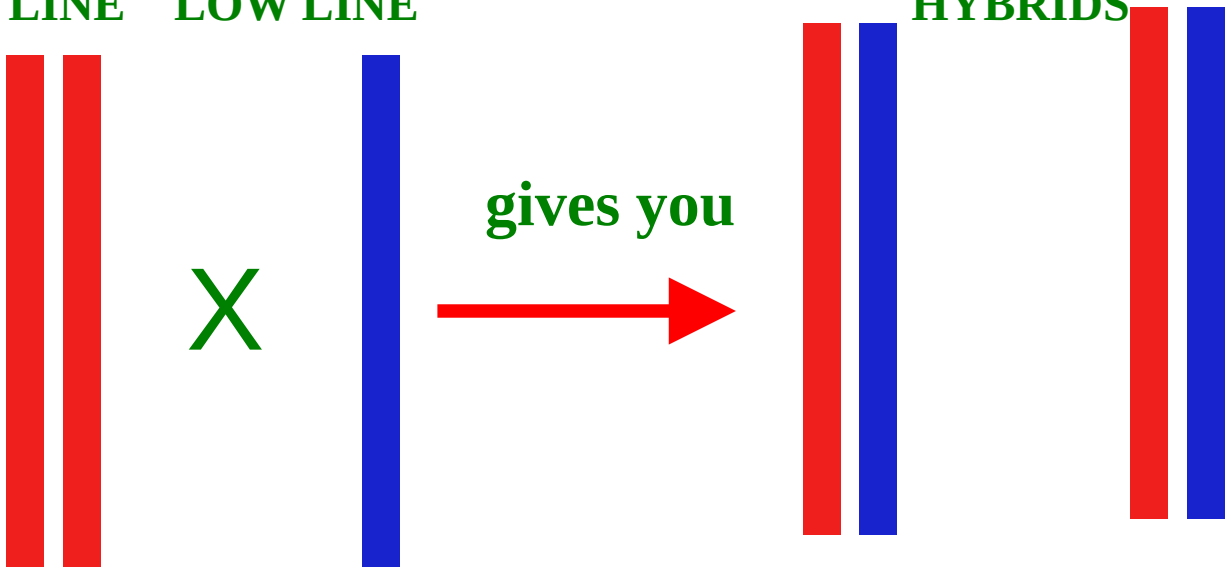


WHAT HAPPENS WHEN YOU CROSS TWO DIFFERENT STOCKS OF BEES



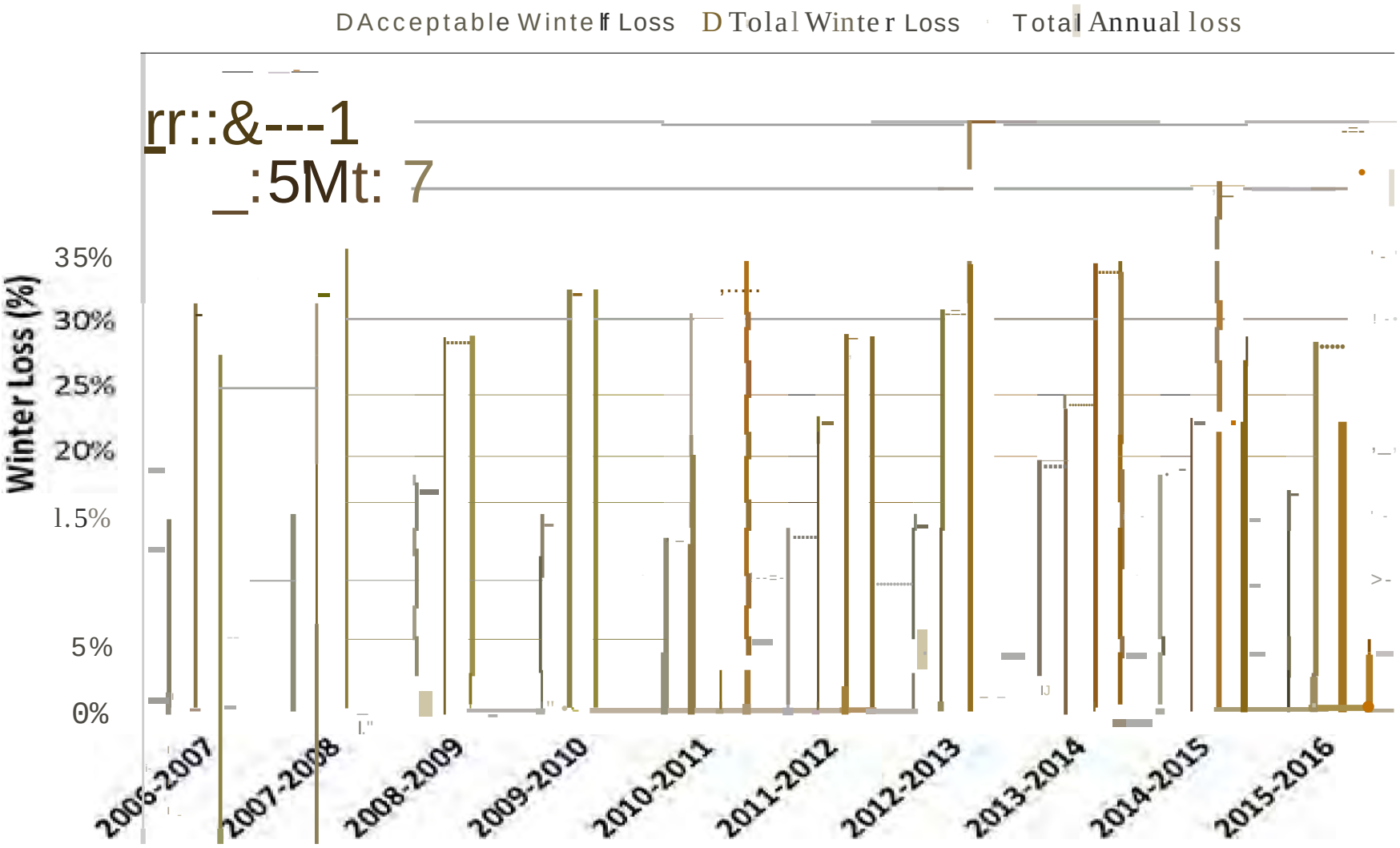

or


HIGH LINE **LOW LINE** **HYBRIDS**



HYBRID CROSS

Tota US managed honey bee colonies Loss Estimates

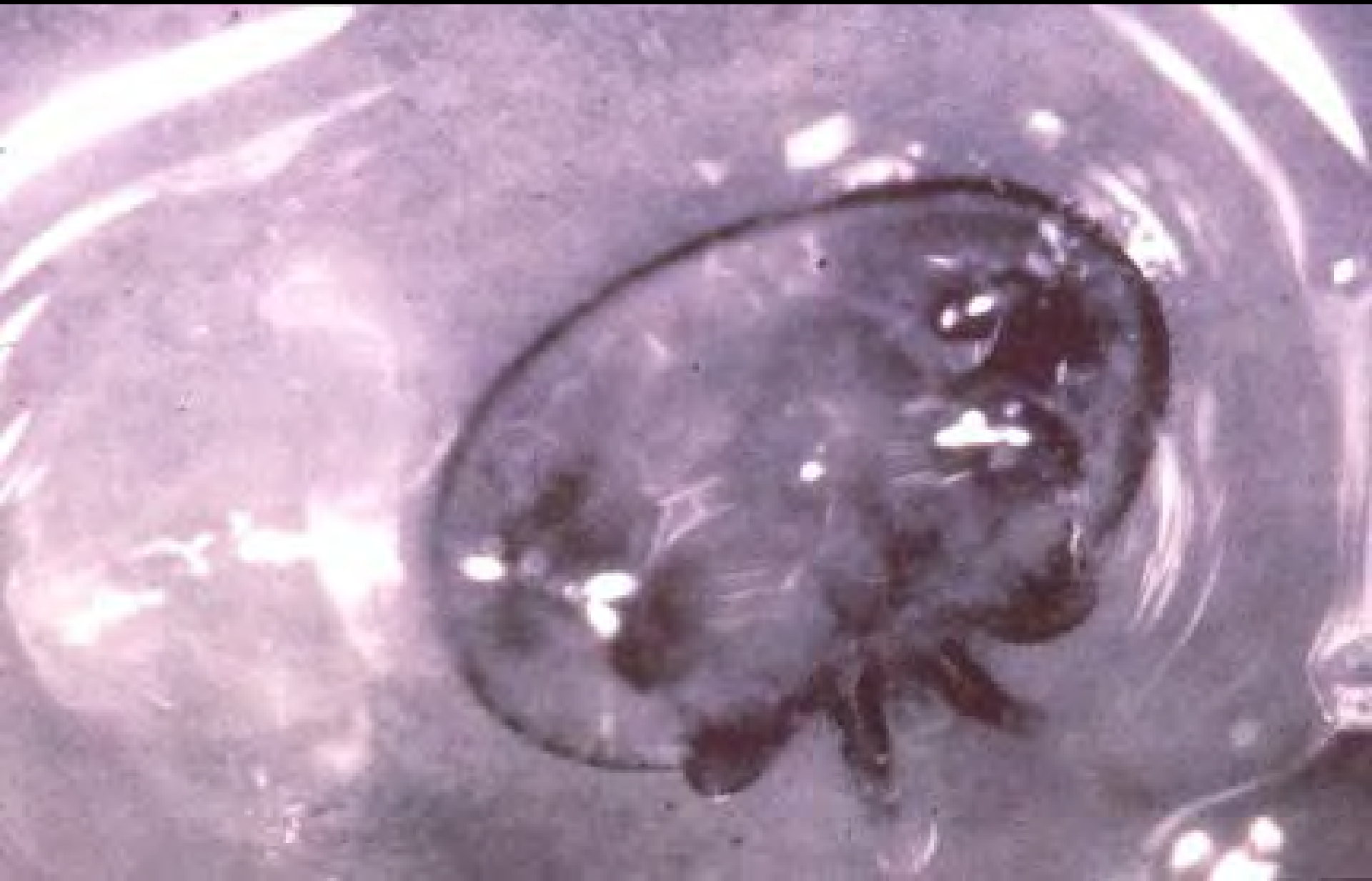


Registration #	Product Name	Active Ingredient
2724-406	ZOECON RF-318 APISTAN STRP	Fluvalinate (10.25%)
2724-406-62042	AP STAN ANTI-VARROA MITE STR PS	
61671-3	FOR-MITE	Formic acid (65.9%)
70950-2	AVACHEM SUCROSE OCTANOATE (40.0%)	Sucrose octanoate (40%)
70950-2-2205	SUCROCIDE	
70950-2-84710	SUCRASHIELD	
73291-1	API LIFE VAR	Thymol (74.09%), Oil of eucalyptus (16%), Menthol (3.73%)
75710-2	MITE-AWAY QUICK STRIPS	Formic acid (46.7%)
79671-1	APIGUARD	Thymol (25%)
83623-2	HOPGUARD II	Hop beta acids resin (16%)
87243-1	Apivar	Amitraz (3.33%)
91266-1	OXALIC ACID DIHYDRATE	Oxalic acid (100%)
91266-1-73291	OXALIC ACID DIHYDRATE	
91266-1-91832	OXALIC ACID DIHYDRATE	
11556-138	CHECKMITE+ BEE HIVE PEST CONTROL STRIP	Coumaphos (10%)
11556-138-61671	CHECKMITE+ BEE HIVE PEST CONTROL STRIP	

Adult female invades cell before its sealed

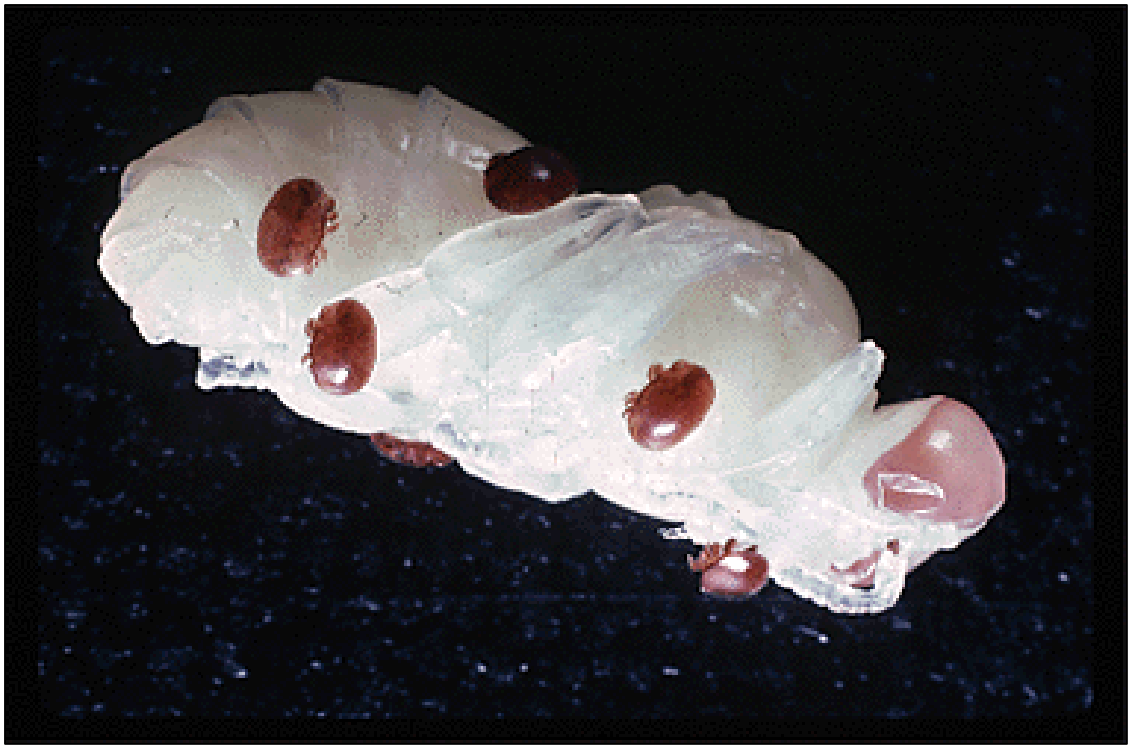
Dr. Harry Laidlaw

female immerses herself in brood food,
lays first egg after about 72 hours.



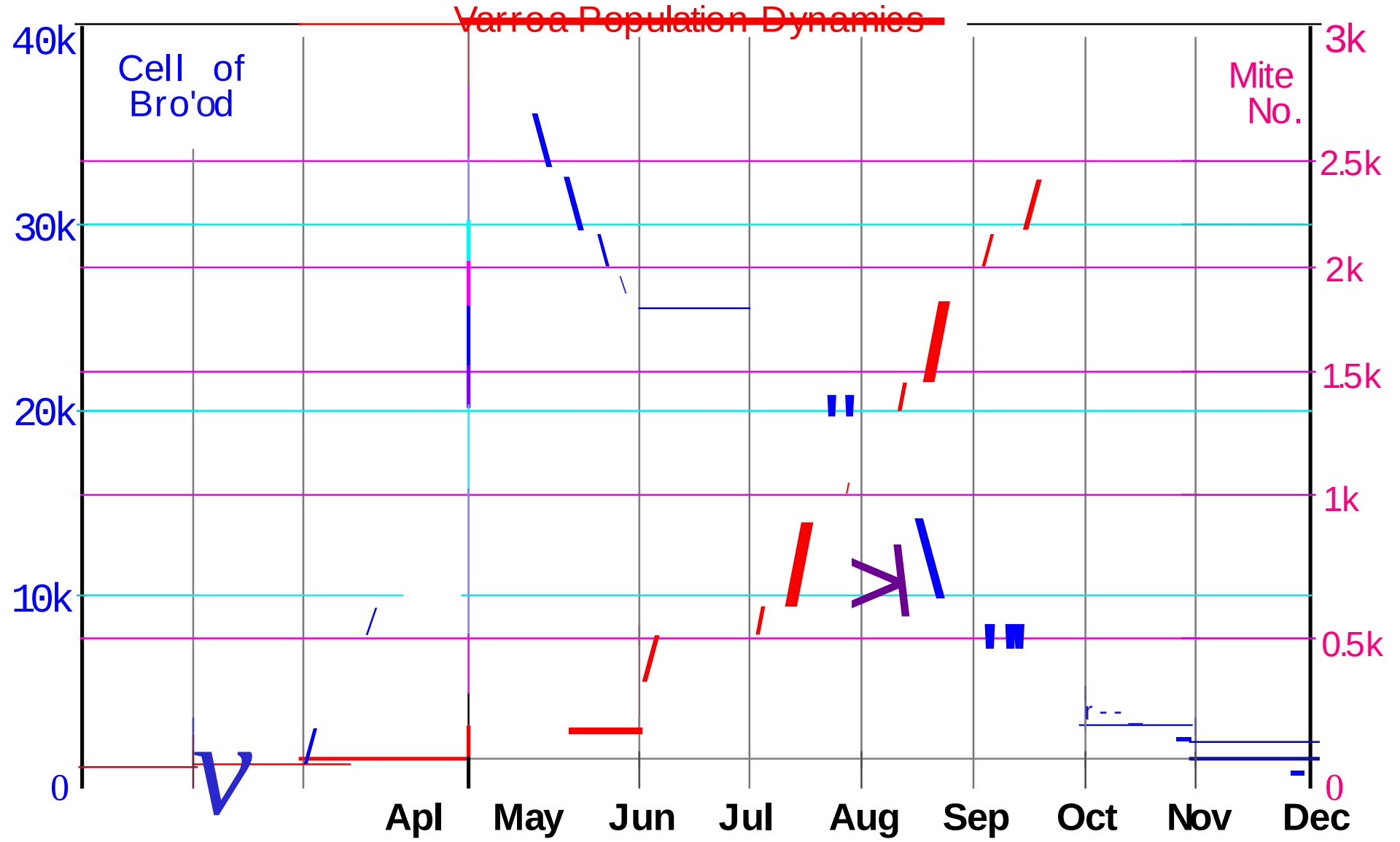
First egg laid is a haploid male, then mites mate in cell and must mature before the bee emerges (usually about 4 females emerge).

Varroa mites prefer drone brood but also invade worker cells. Most mites (80%) will be in the sealed drone and worker brood

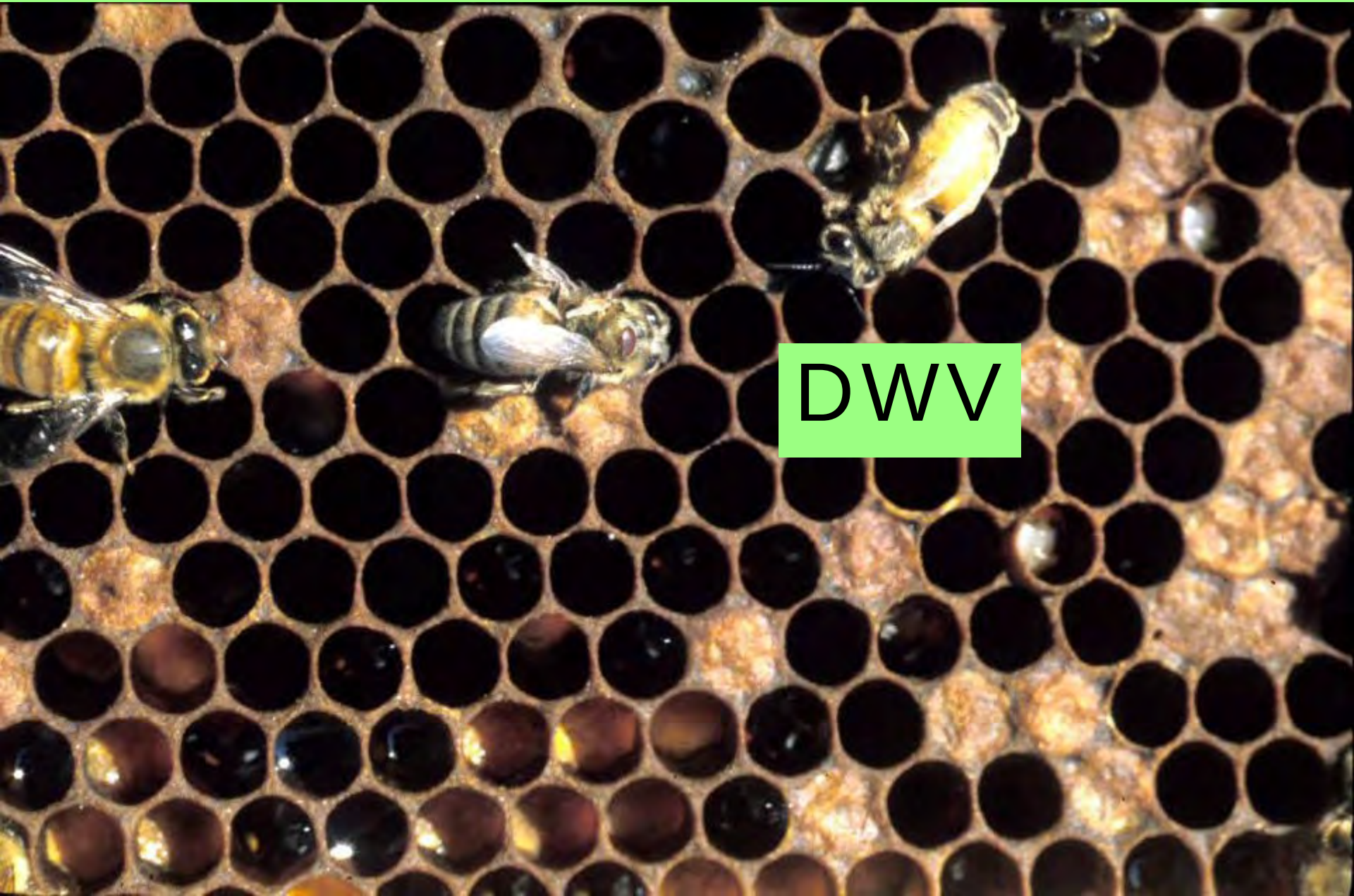


THEY CAME FROM ASIAN HONEY BEES

In Apis cerana Varroa only reproduces in drone brood

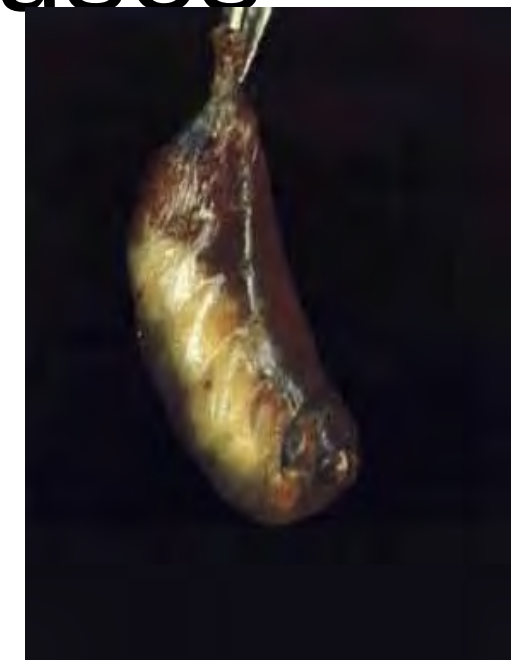

Varroa Population Dynamics
Cell of Bro'od
Mite No.
40k
30k
20k
10k
0
3k
2.5k
2k
1.5k
1k
0.5k
0
Apl
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar

PARASITIC MITE SYNDROME




Virus and brood diseases appear

some vectored viruses from varroa



- Acute bee paralysis (ABPV)
- Israel acute bee virus (IAPV)
- Kashmir bee virus (KBV)
- Black queen cell virus (BQCV)
- Deformed wing virus (DWV)

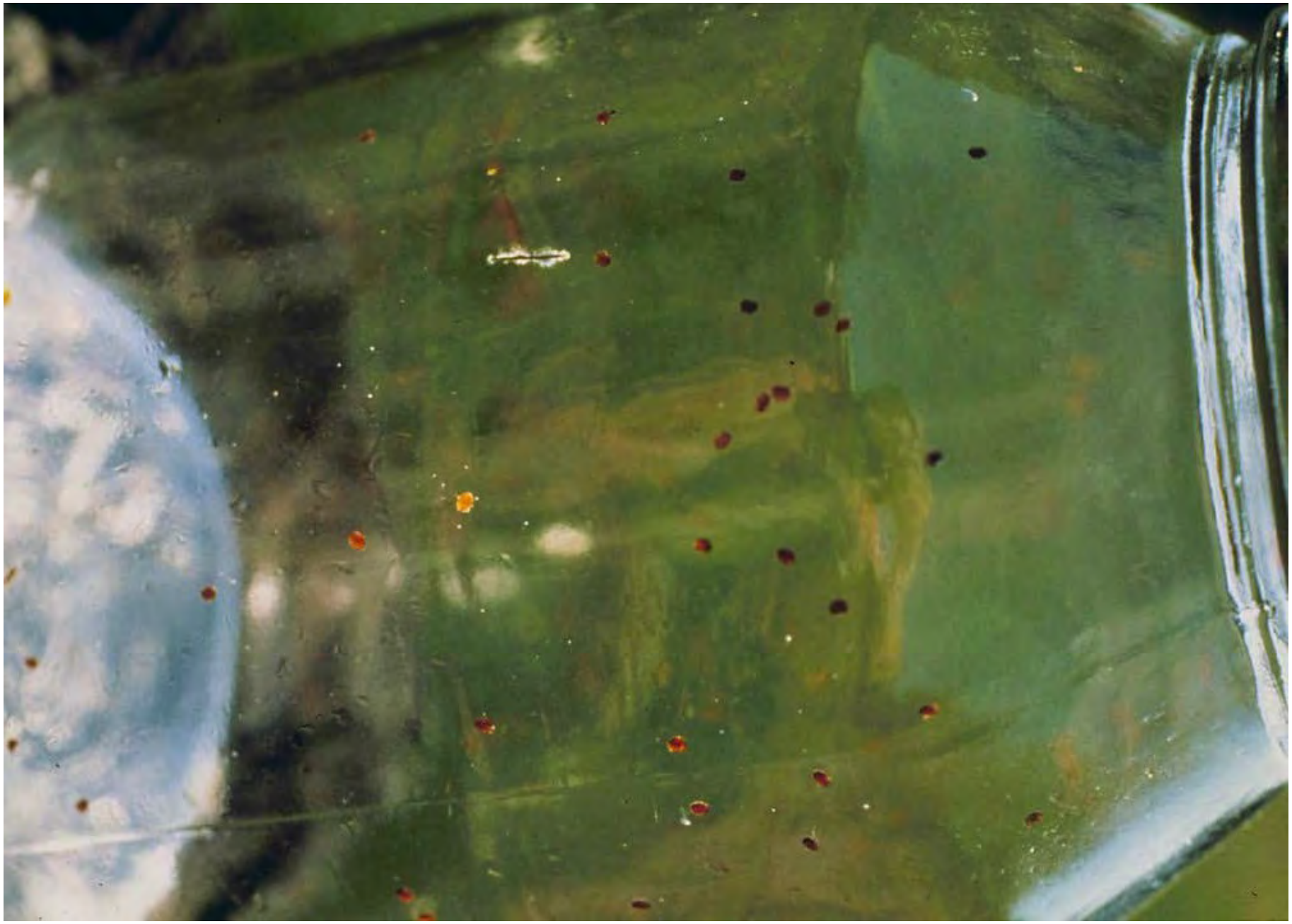
- 22 known viruses!

Monitoring Mites in Your Hive

- Uncapping drone brood
- Ether Roll
- Ethanol wash
- Sugar Roll
- Sticky Boards

Looking for mites in drone brood

Looking for mites on adults



WHAT TRAIT WILL YOU MEASURE AND HOW TO MEASURE IT?

1)How do you choose the parents? (need to evaluate and keep good records)

2)how do you control mating's?
(need to do I.I. or have drone source flooding in your mating yard)

PRACTICAL WAY TO SELECT FOR VARROA RESISTANCE:

GRAFT FROM STRONG HIVES THAT DON’T GROW MITES


To select for traits: You need enough colonies (at least 100 would be sufficient)

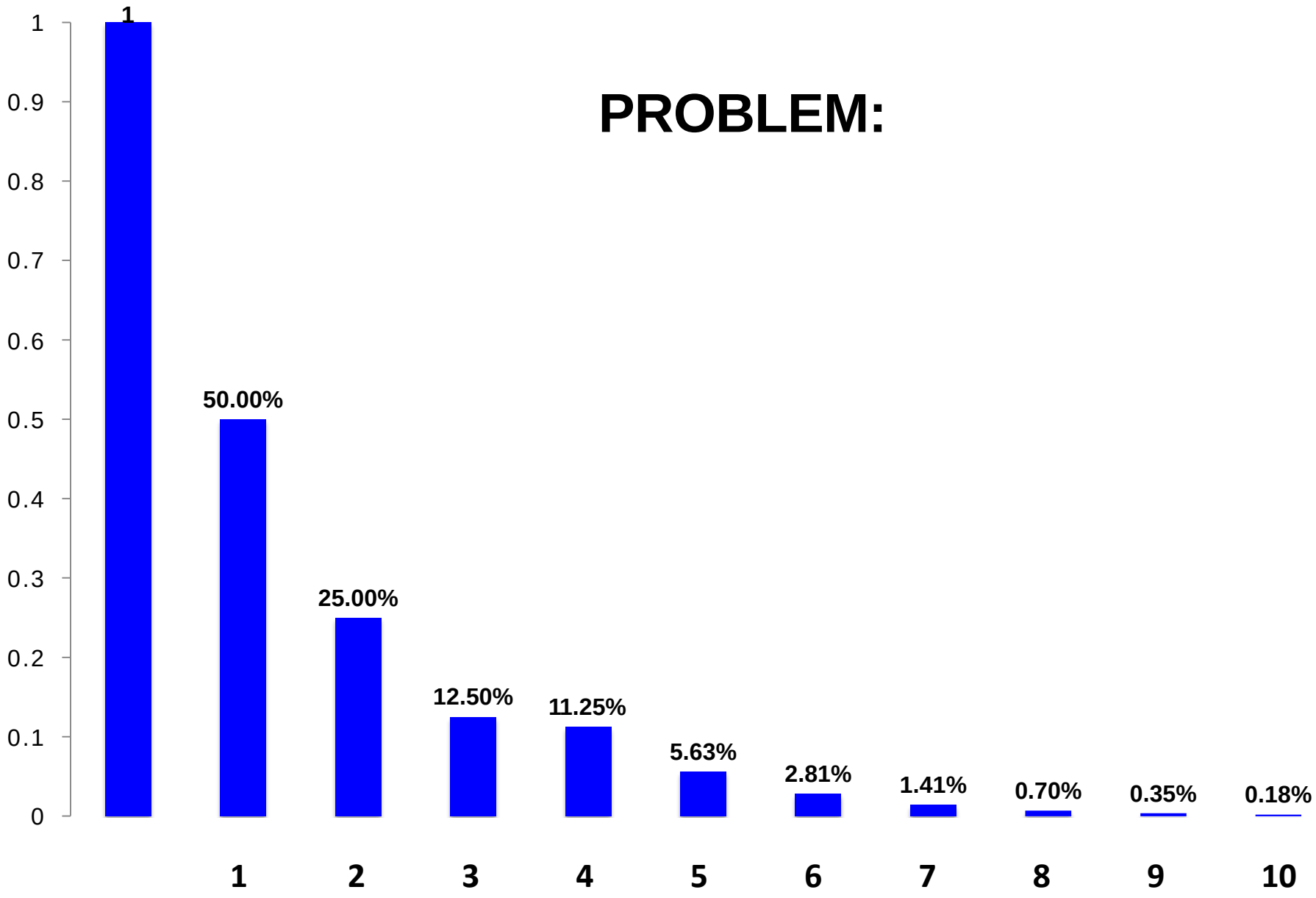
You need try to control mating's

Try to have good colonies with drones in the mating yard.

You need a trait you can evaluate, something that is beneficial, and that is heritable.

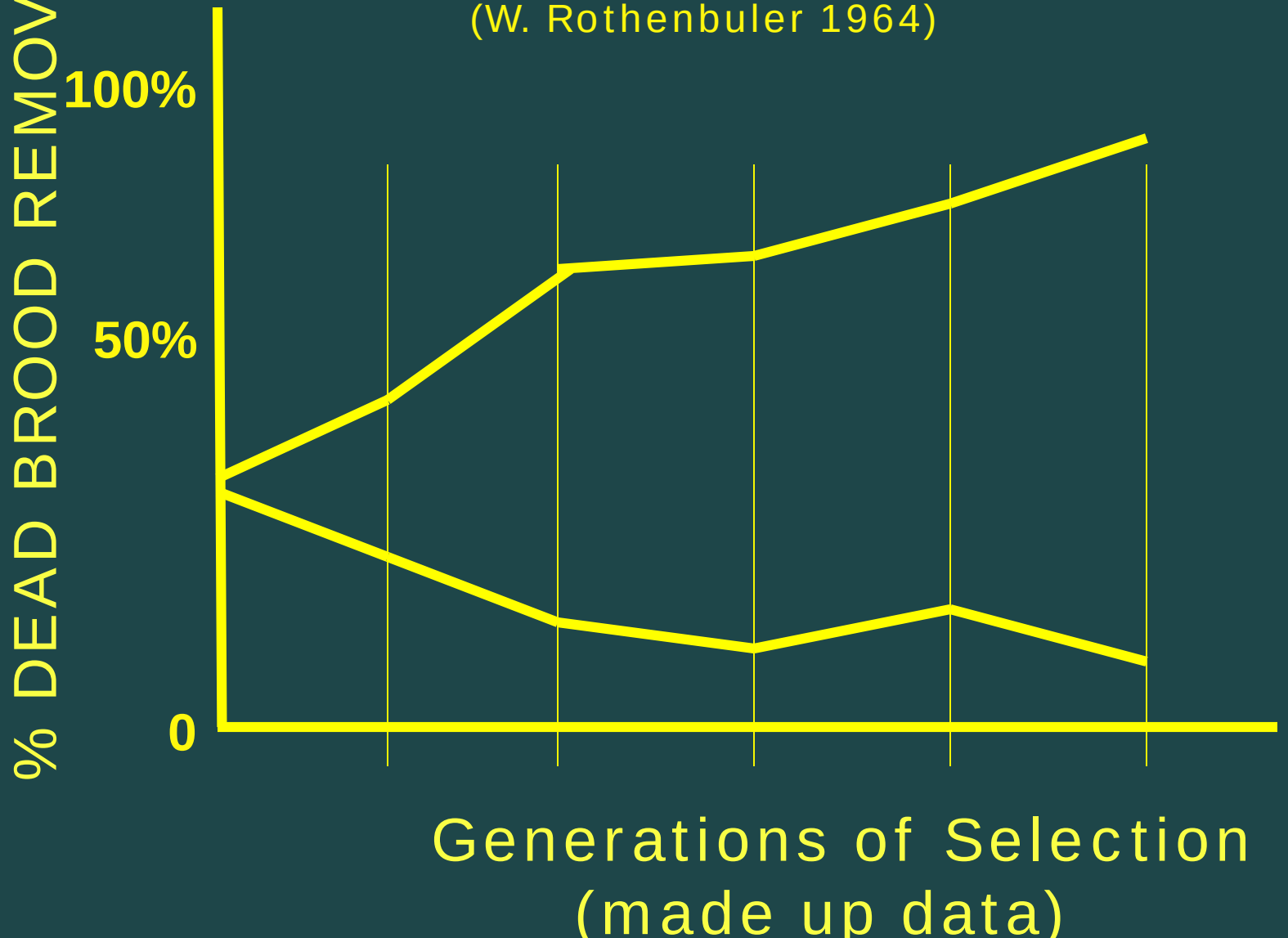
Start with bees that have good traits for your area!

PROBLEM:

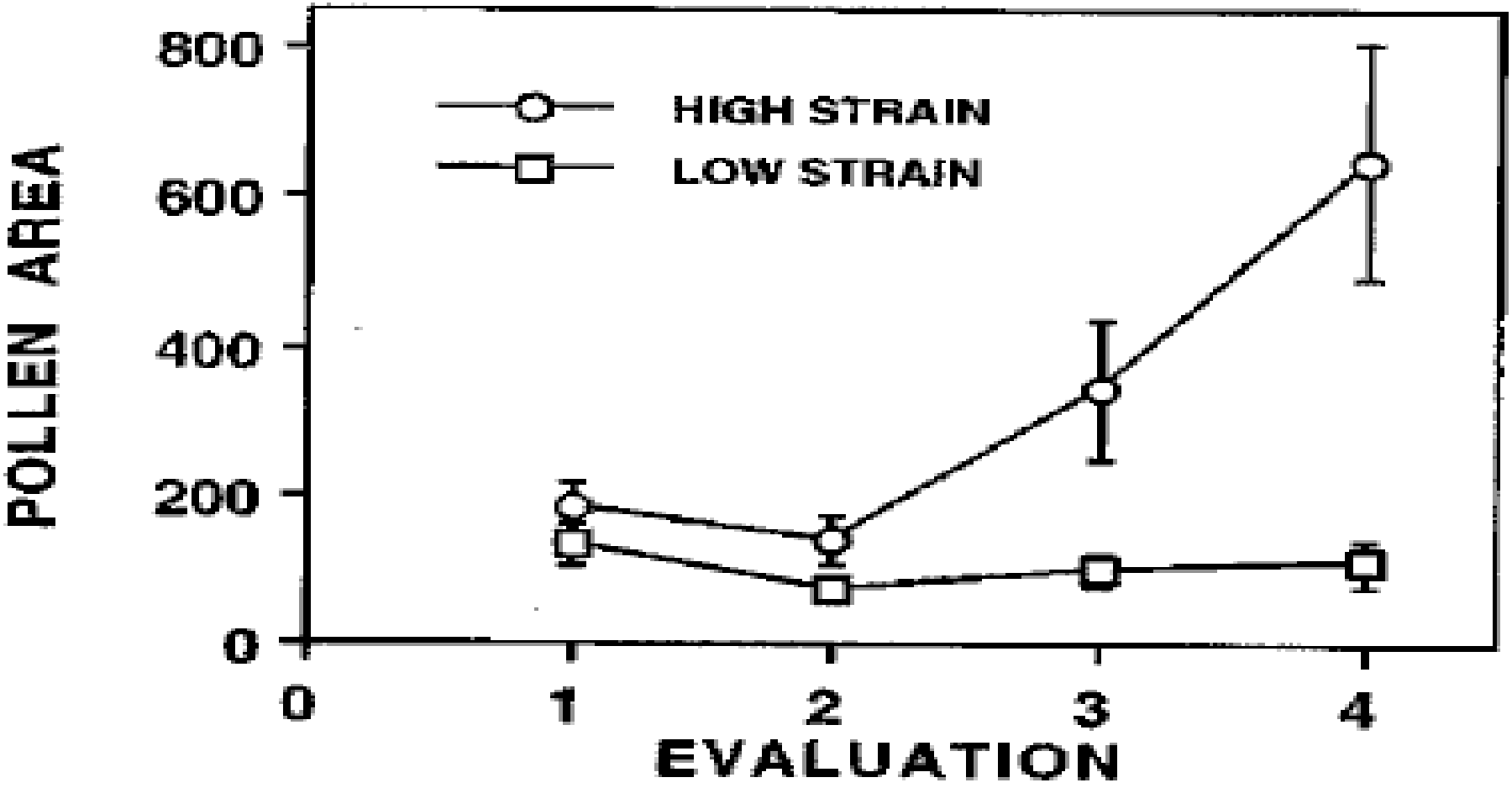

1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
1
50.00%
25.00%
12.50%
11.25%
5.63%
2.81%
1.41%
0.70%
0.35%
0.18%
1
2
3
4
5
6
7
8
9
10

Hygienic Behavior is Heritable

(W. Rothenbuler 1964)



Another example:
Response to Selection for Pollen Hoarding



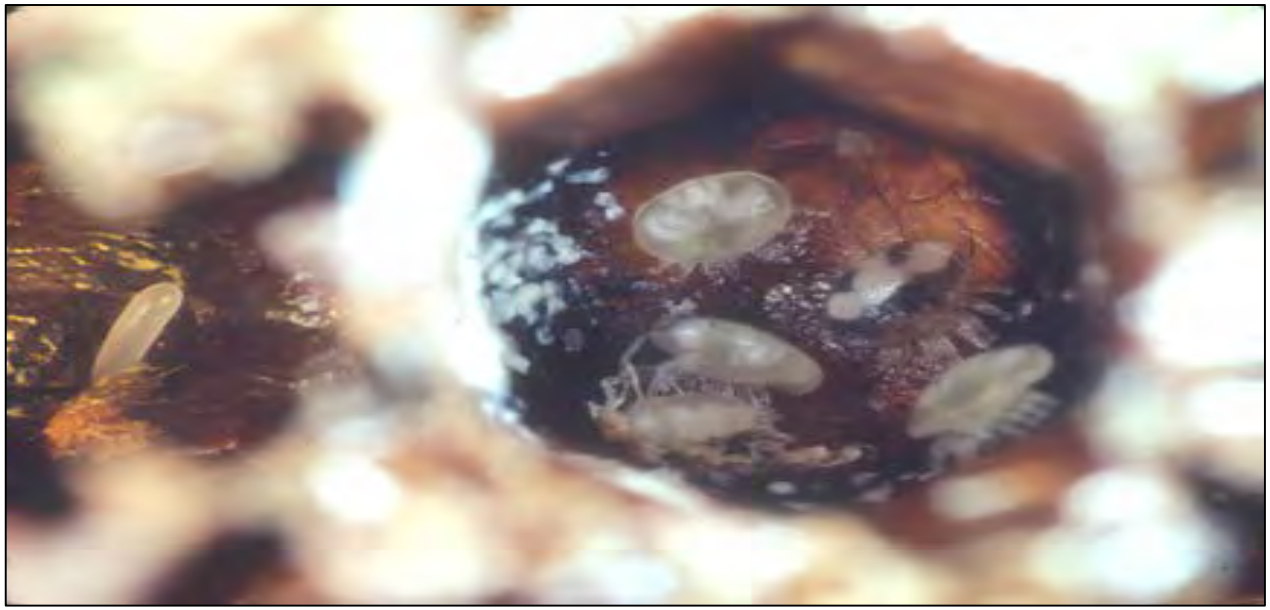
USDA Baton Rouge bee lab

VSH BEHAVIOR

- **Varroa-sensitive hygienic behavior (VSH)**
- **Detection and removal of varroa infested brood**

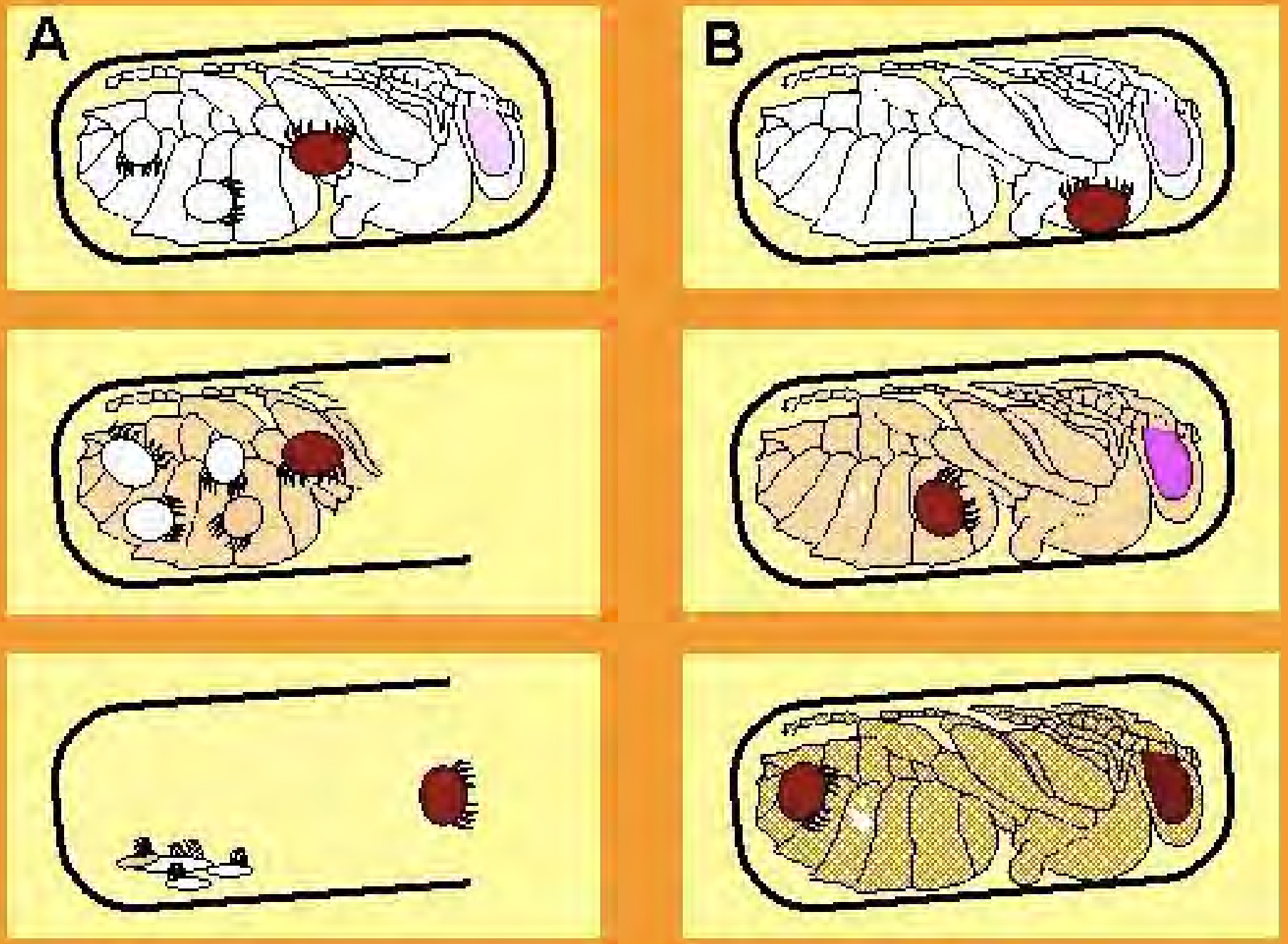
Making uniform colonies

VARROA MITES INSIDE THE CELL



Good age to check for reproductive mites

VSH is an indirect attack on Varroa



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Selecting for Varroa Sensitive Hygiene

Bee Health November 12, 2010 Print

For a description of the VSH trait in honey bees, please see Varroa Sensitive Hygiene and Mite Reproduction.

The USDA-ARS Baton Rouge Bee Lab has bred bees that express Varroa Sensitive Hygiene, and we would like to offer a simple technique that queen breeders could use to select for VSH. However, there is no method at this time that is both easy and accurate. We have developed several types of measurement, but the most accurate require significant time at a microscope to evaluate colony performance (Fig. 1).

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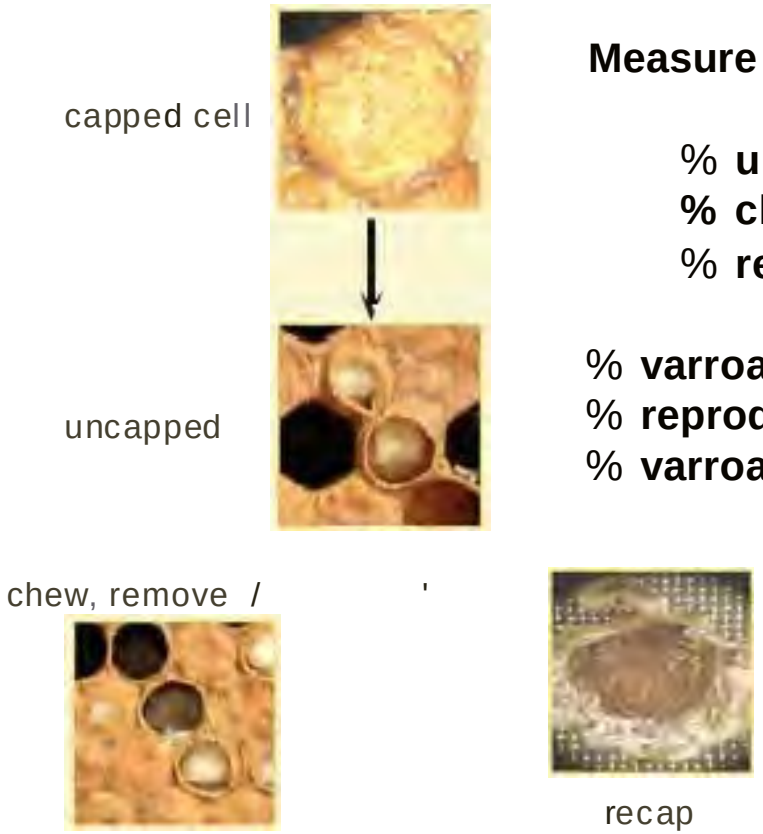


Measure changes in:

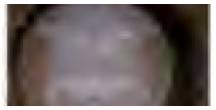
- % **uncapped**
- **% chewed**
- % **recapped**

Visible w/o magnification. but imprecise

- % **varroa infestation**
- % **reproductive varroa**
- % **varroa with no progeny**

Precise, but require magnification

Figure 1. - Types of changes in brood combs that can be measured without and with a stereo microscope. For example, the percentage of pupae uncapped during a certain period of time could potentially be used to breed for varroa resistance. Uncapped pupae are visible without a microscope, but measuring the % uncapped pupae is highly variable and does not always predict VSH behavior. On the other hand, measuring the percentage of infertile mites (those without progeny) predicts strong varroa resistance, but requires detailed microscopic examinations of brood to measure.

Days past capping	Brood stage	Eldest offspring in normally reproducing mites
3	 prepupa	 Varroa egg
4	 pupa, white eyes	 first proto nymphe (male)
5-6	 pupa, pnk eyes	 second proto-ny1mph (female}
7-9	 pupal purp1e eyes	 first female deu1onymph
10-11	pupat, brown head. black eyes	 first adult daughter

Uncapping of mite-infested cells due to VSH

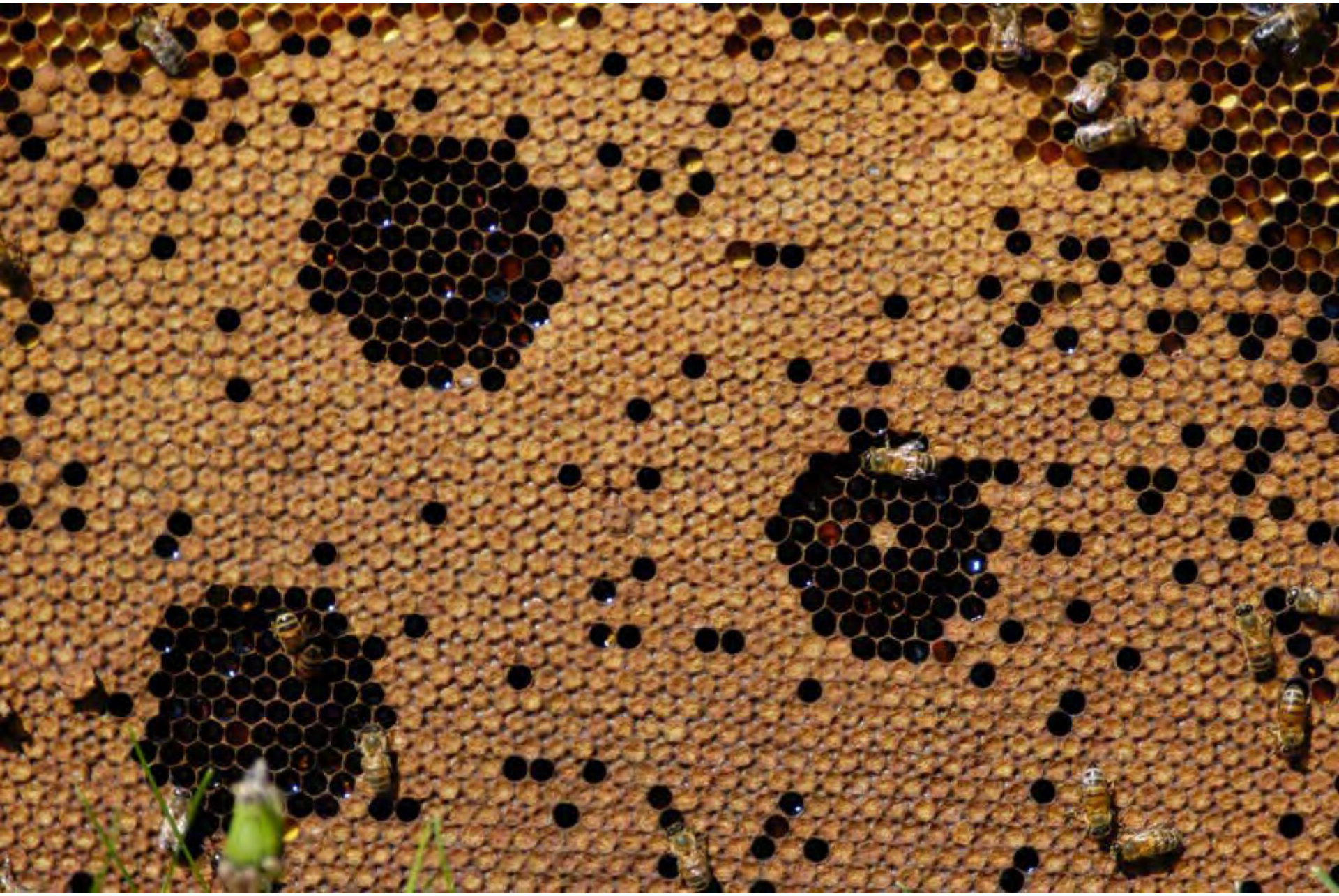

24hrs LATER!

GENERAL HYGIENIC BEHAVIOR

Freezing capped brood with liquid nitrogen (250 ml)

OR PIN PRICK METHOD

Greg Hunt



GROOMING BEHAVIOR

MIGUEL AND ERNESTO'S STUDY

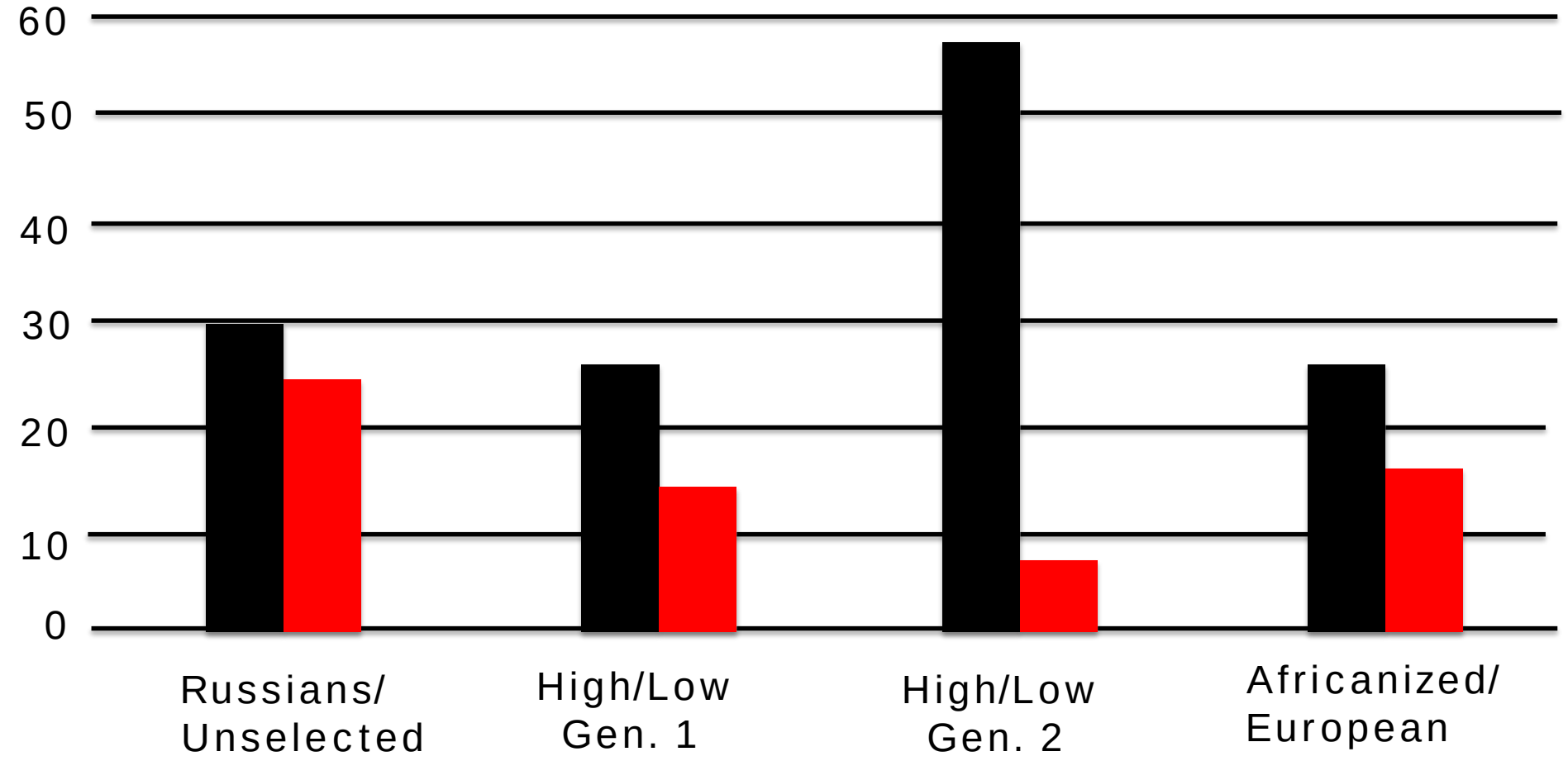
In Mexico

Found that grooming behavior was important

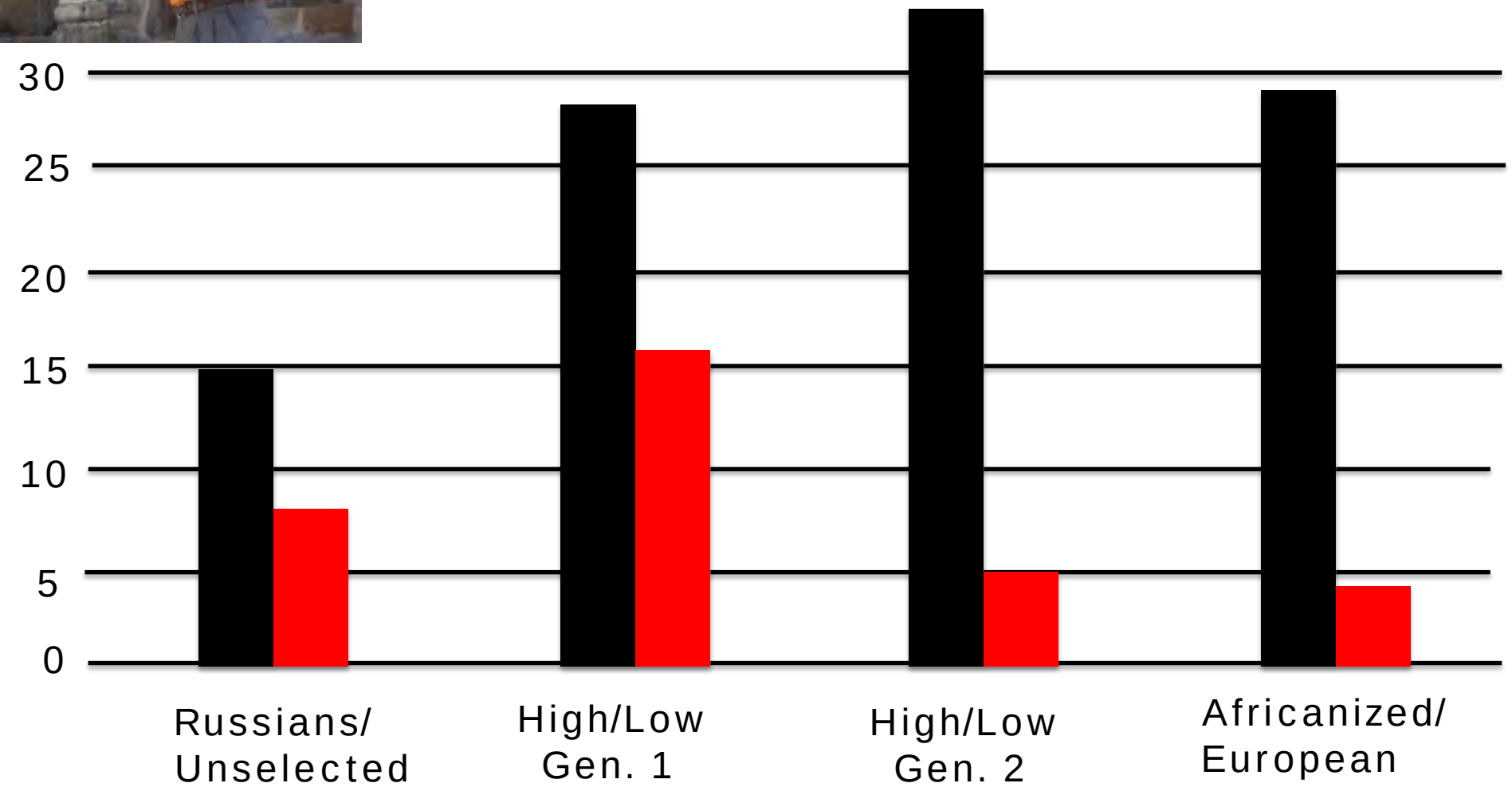
Those with the lowest infestation overall had low adult infestation show highest mite drop !

They also had the most chewed mites on board, and also in the lab assay.

% Mites Chewed in Hives



% Mites Removed in Assay

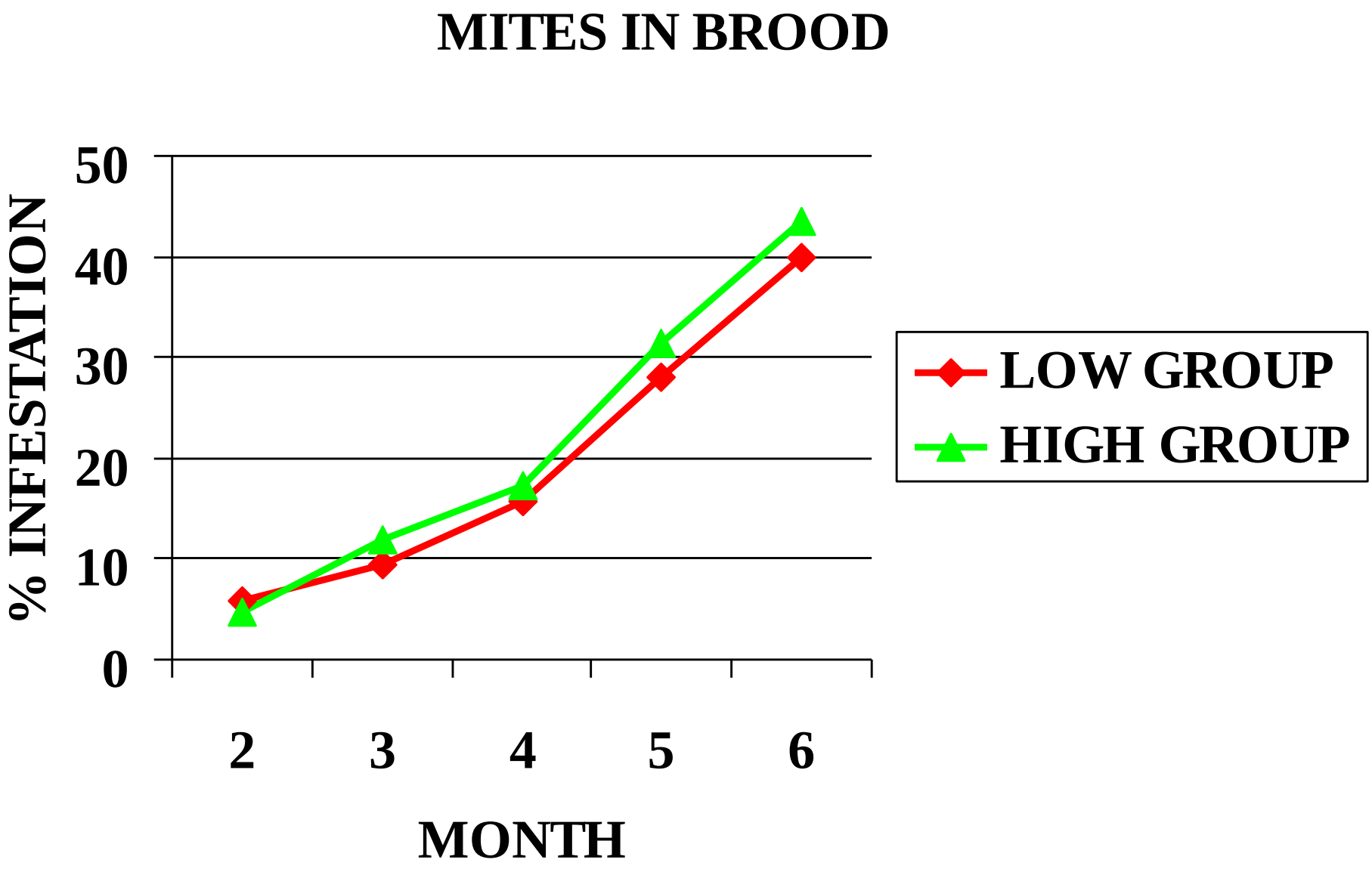


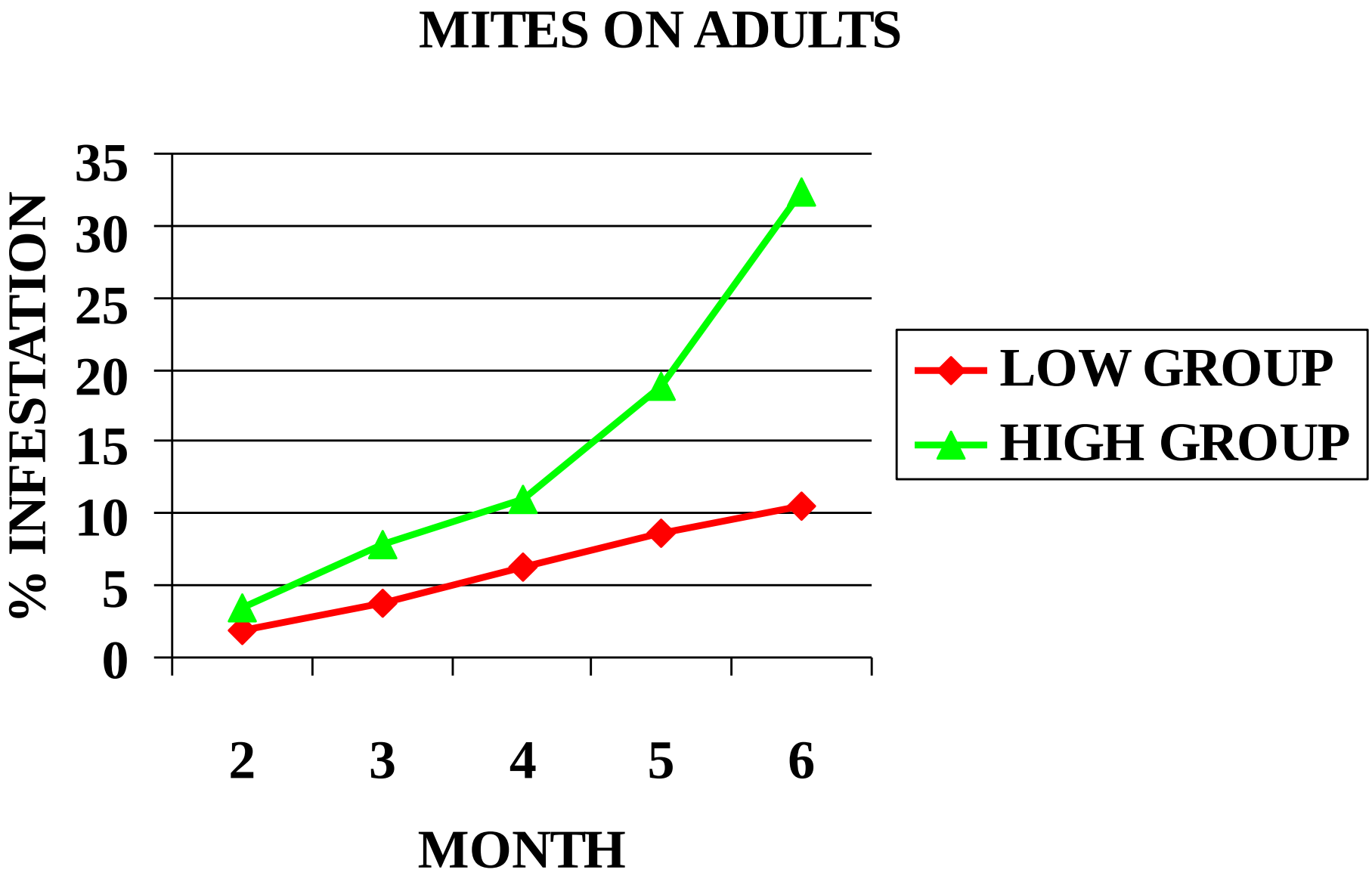
What is responsible for behavioral traits?

- Genotype of queens and workers

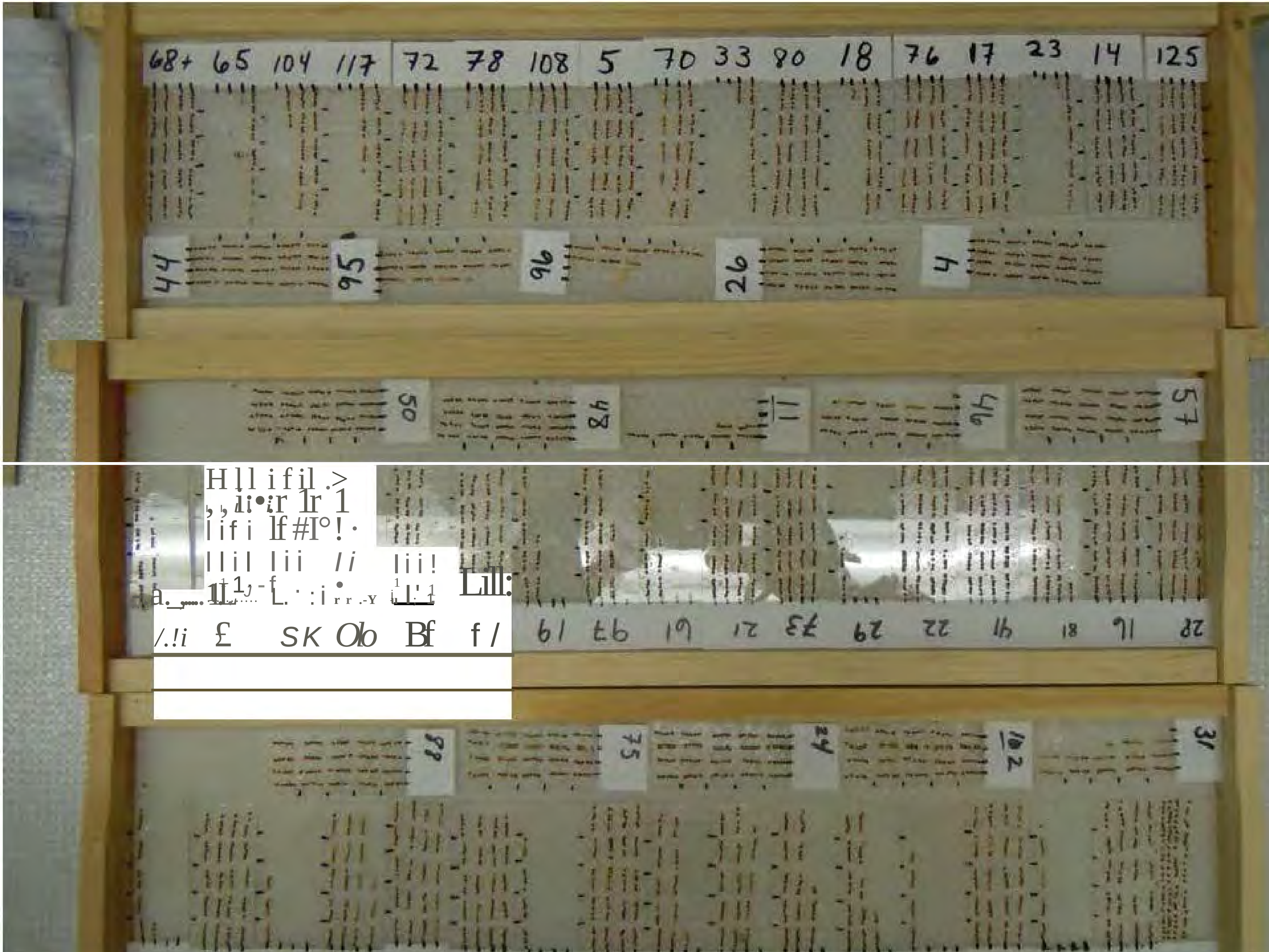
- Environmental factors

Grooming Behavior


MITES IN BROOD
% INFESTATION
50
40
30
20
10
0
2
3
4
5
6
MONTH
LOW GROUP
HIGH GROUP


MITES ON ADULTS
% INFESTATION
35
30
25
20
15
10
5
0
2
3
4
5
6
MONTH
LOW GROUP
HIGH GROUP

Selecting for chewed mites is sticky business!


68+
65
104
117
72
78
108
5
70
33
80
18
76
17
23
14
125

Current Selection Program: Grooming and Biting Behavior

Hierarchical Selection:

Measure proportion chewed mites.

↓

Eliminate those that show disease or did not control mite population growth.

↓

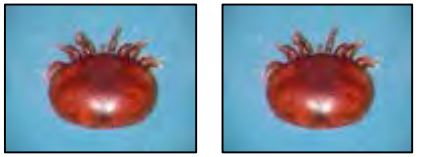
Eliminate those that do not pass freeze-killed hygienic test.

↓

Select breeder colonies.

- **Started with SURVIVORS, VSH + Russians**
- **Method for the first 7 years:**
- **Measure mite drop (and strength) multiple times**
- **Measure honey yield**
- **Test best sources for (VSH) hygienic behavior**
- **Use instrumental insemination.**

Response to selection at the colony level is also at the individual



Initiating grooming dance*

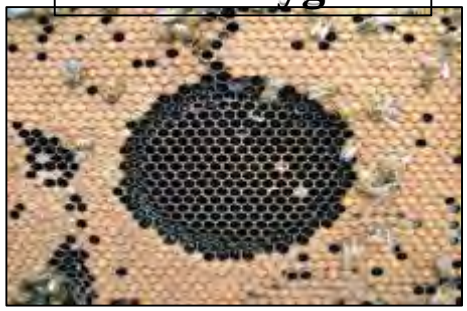
grooming

Biting

VSH

General hygiene

Undertaker

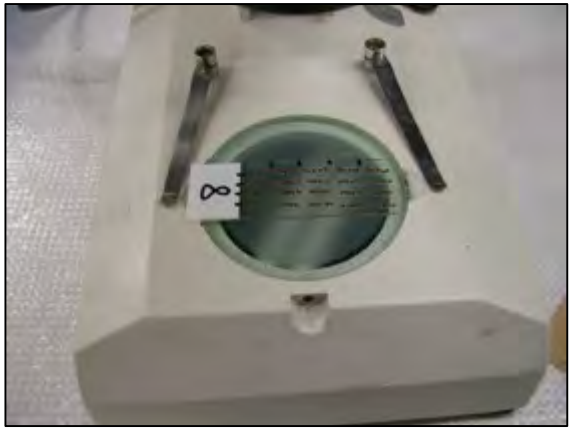


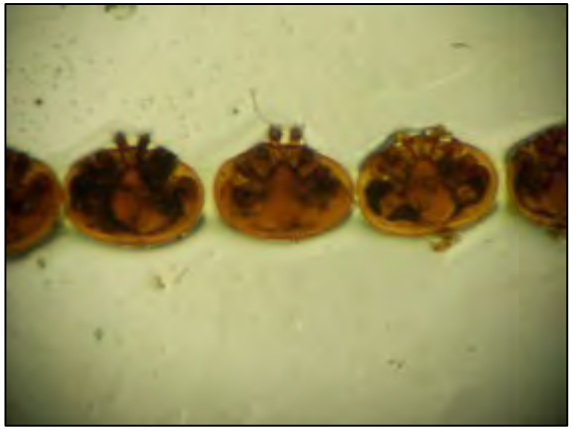
Instrumental Insemination

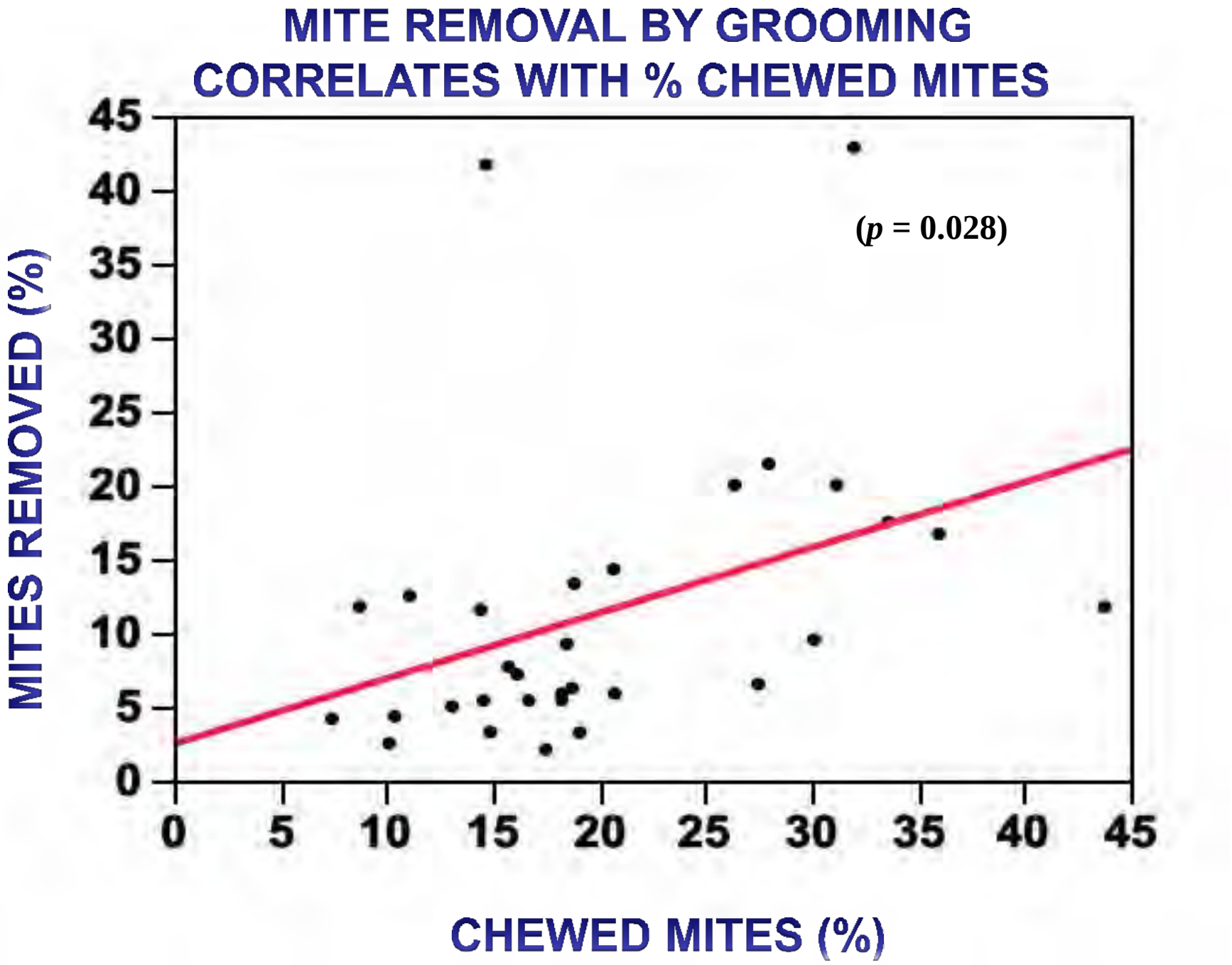
High x high chewers are crossed and monitored
For more response to selection

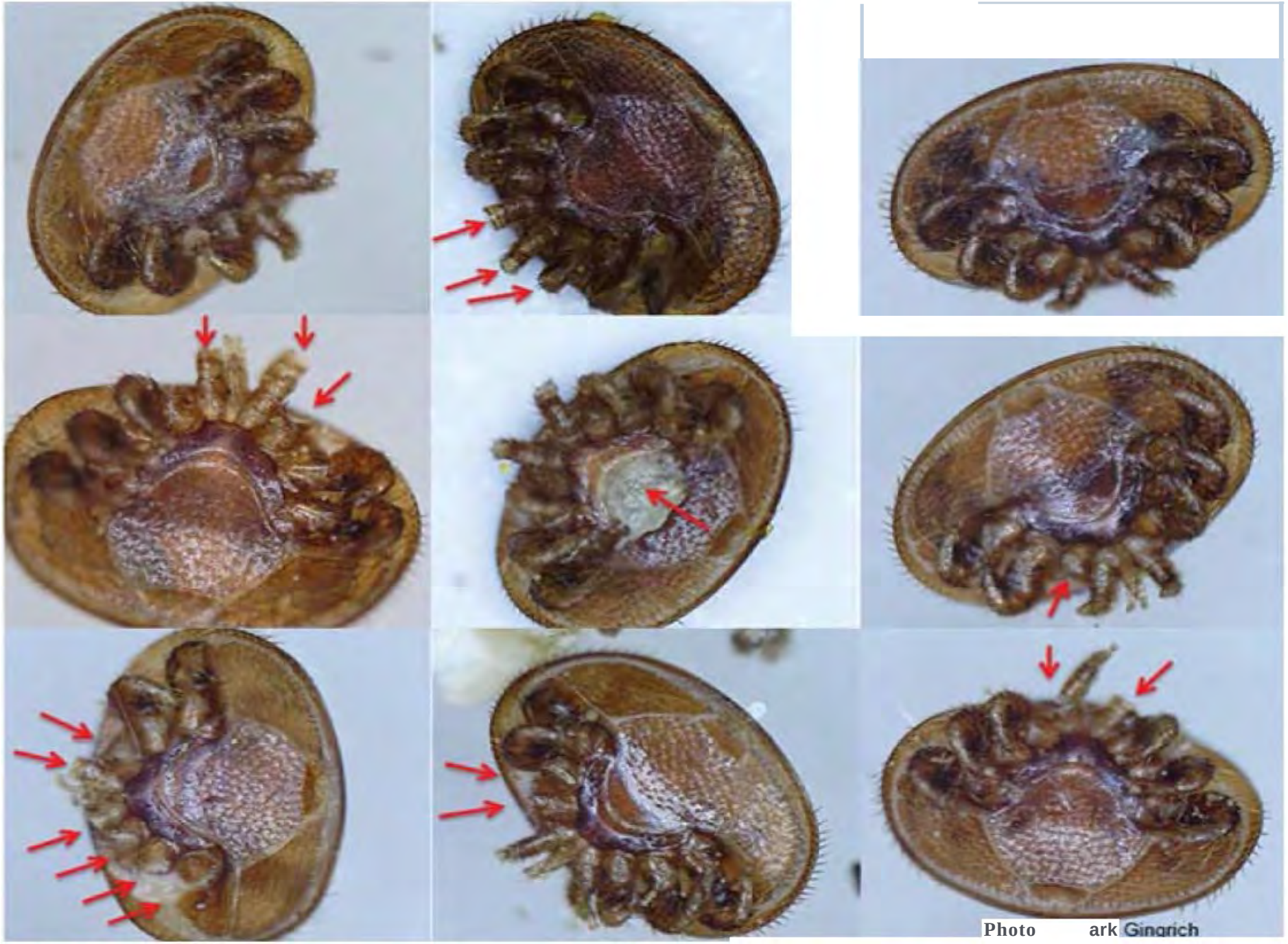
Daughter queens are then grafted from these*

Collecting and counting chewed mites

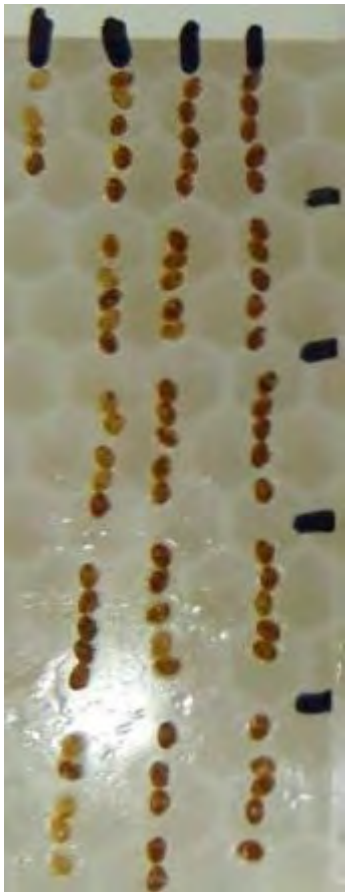


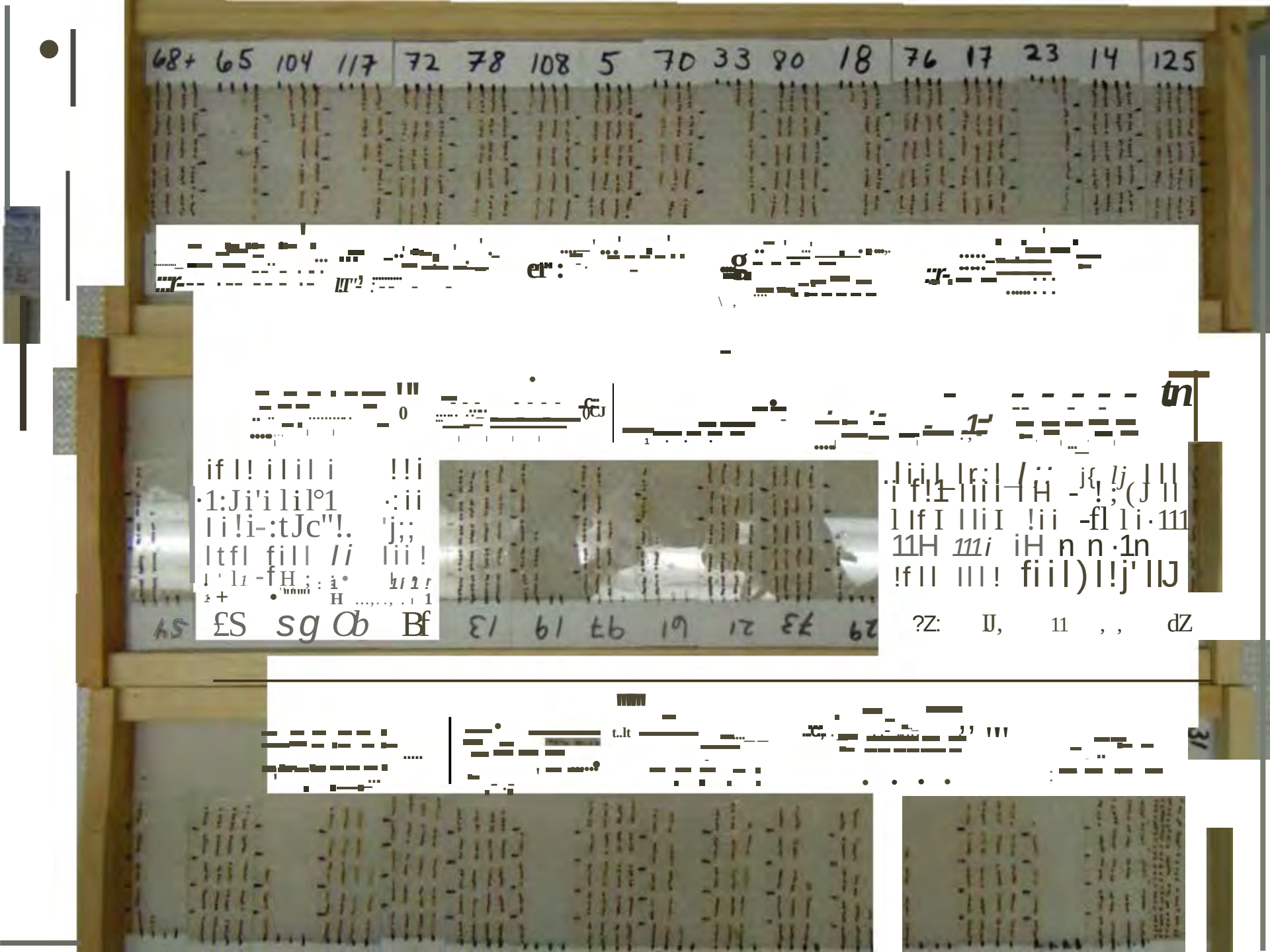


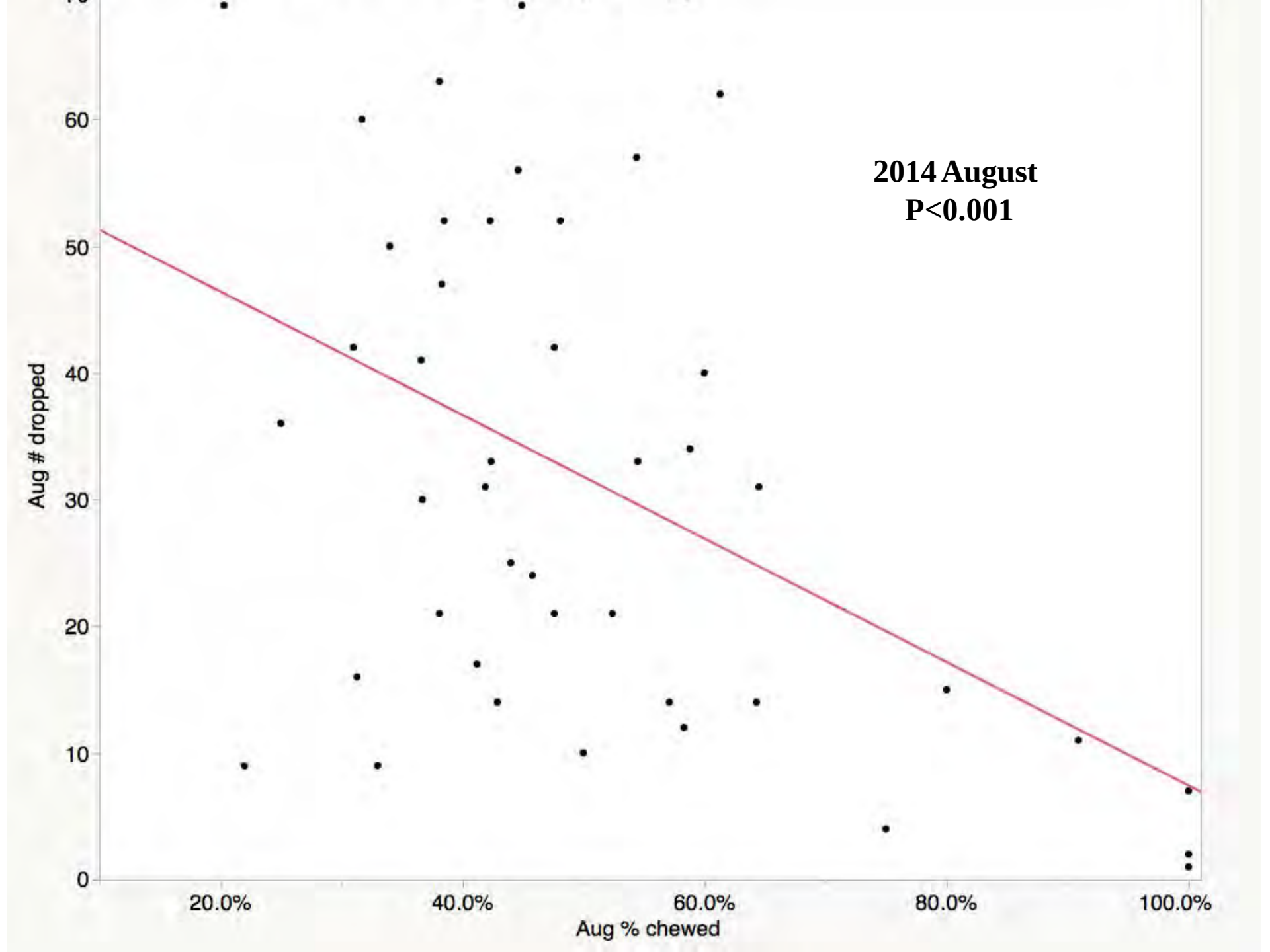

MITE REMOVAL BY GROOMING
CORRELATES WITH % CHEWED MITES
(p = 0.028)
MITES REMOVED (%)
CHEWED MITES (%)
0
5
10
15
20
25
30
35
40
45



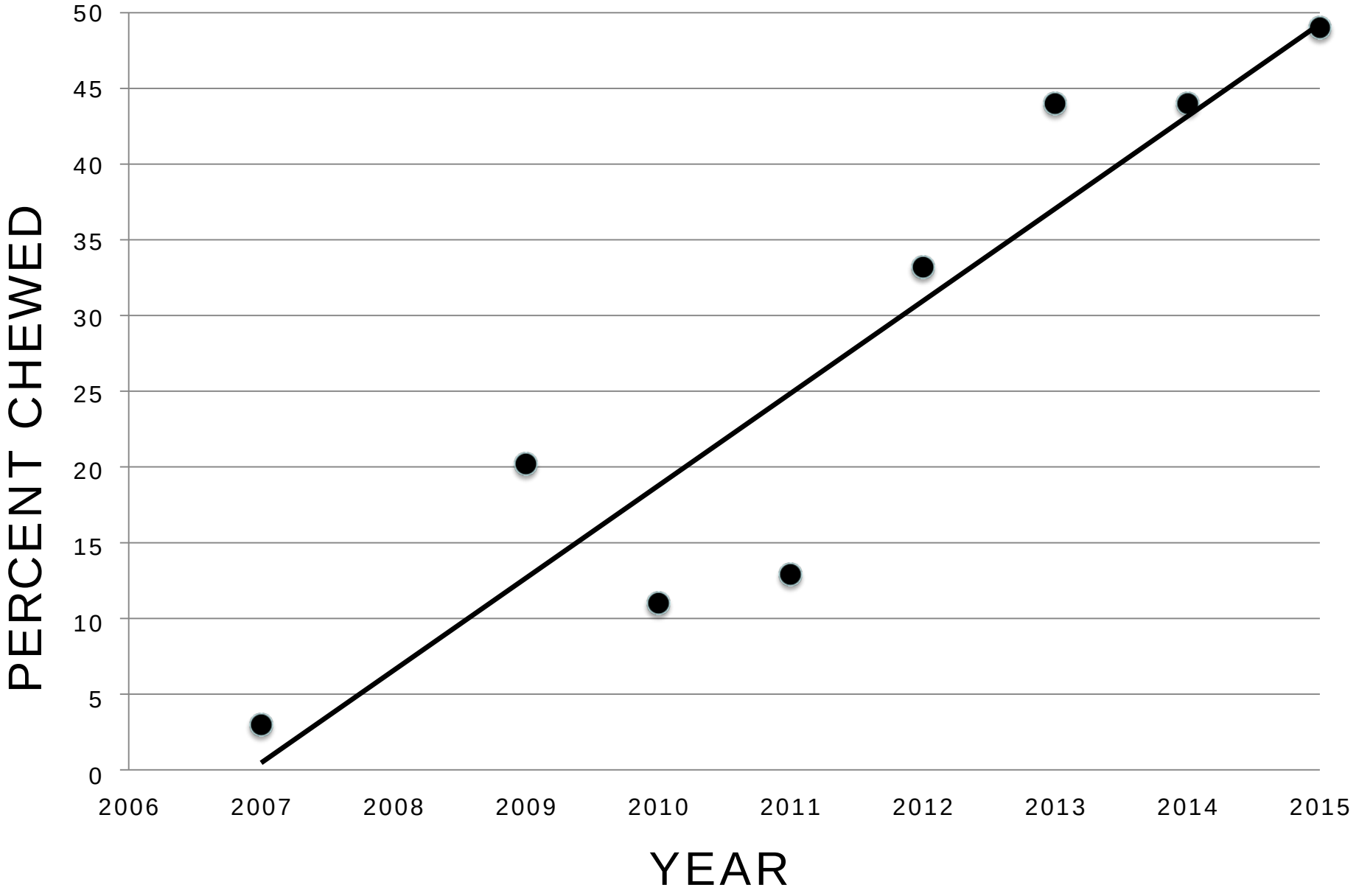
Mites that have been chewed by the mite-biters



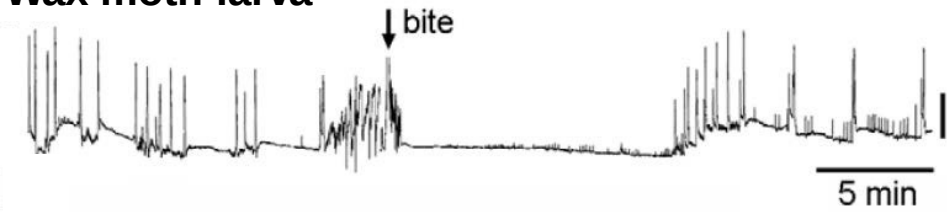



2014 August
P<0.001
Aug # dropped
0
10
20
30
40
50
60
Aug % chewed
20.0%
40.0%
60.0%
80.0%
100.0%

MITE-BITING IS A HERITABLE TRAIT.

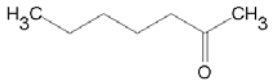


Wax moth larva

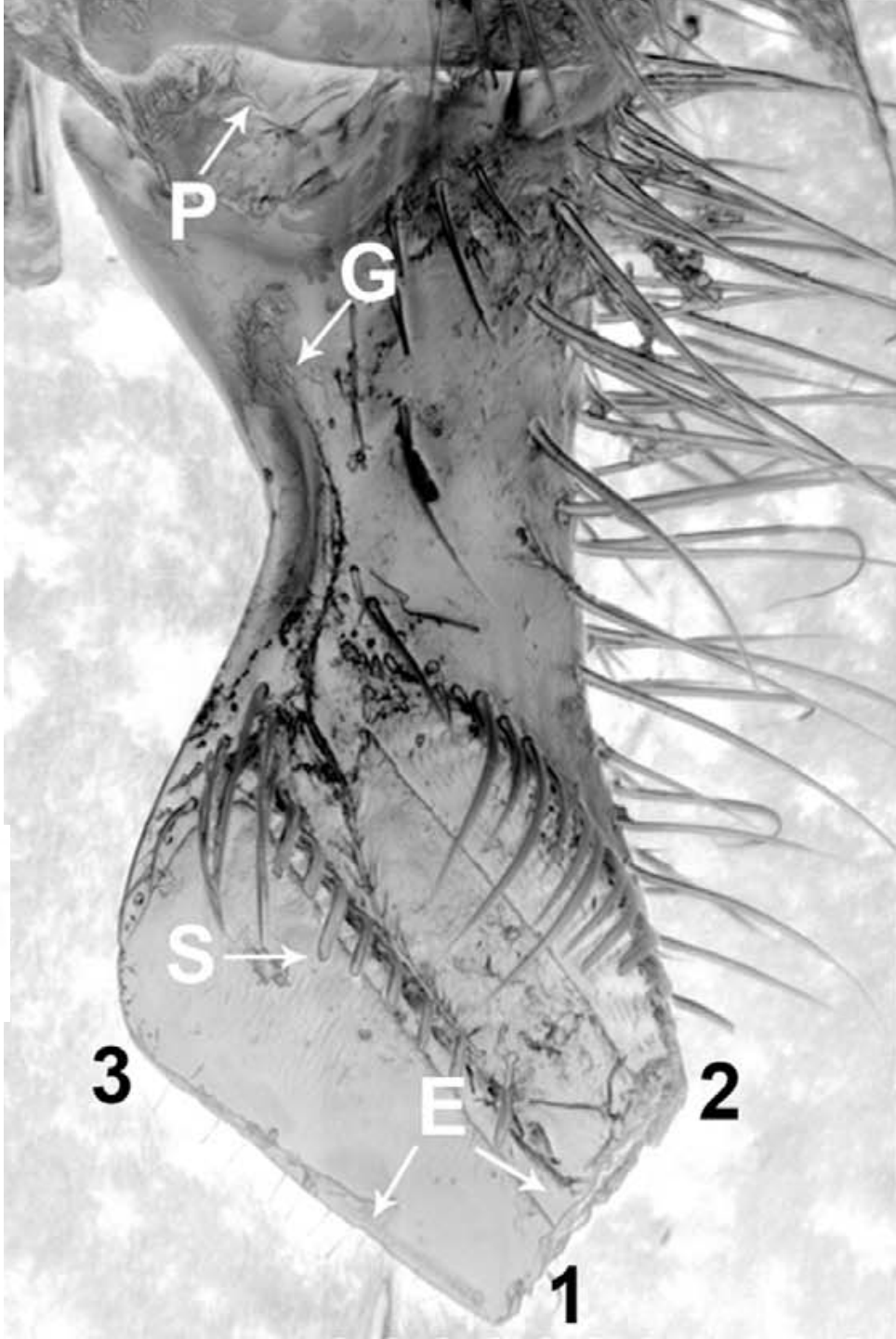


The bite of the bee

contains 2-heptanone



Varroa



How to select for bees that bite varroa mites and groom them from their bodies

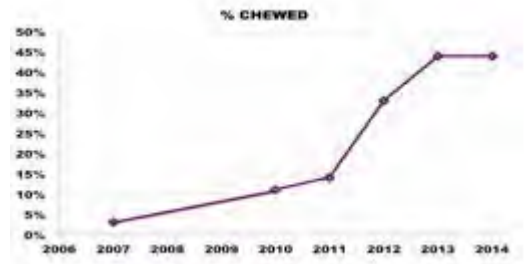
Krispn J. Given, Greg J. Hunt, David M. Shenefield, Ginger D. Davidson Dwight C. Wells
and Dan P. O'Hanlon

Abstract

Grooming behavior is one of the key mechanism honey bees (*Apis Melifera*) execute to kill and remove *Varroa destructor* from their bodies. Two of the grooming behaviors identified with chewing and mite removal are responsible. Through selection with instrumental insemination we have seen *Varroa Destructor* chewing levels go from 3% to 43%. The [illegible] and dissemination of northern mite-resistant stocks.

Grooming behavior is one of the mechanism of defense against *Varroa destructor*. Mite grooming behavior is the ability to remove mites and is associated with chewed mites.

Mites are placed on there idiosoma and inspected for damage.



This shows a a response to our selection. We may be near the peak for grooming behavior but need make sure every colony has a high levels as possible by requeening the low chewers. We are working on a better measure for grooming behavior, and have a better correlation between % chewed mites and reduced mite populations in 2014 than we did in 2013, in 2013 the mite populations were higher and more variable between colonies.

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Inaugural HHBBC at the Purdue University bee laboratory, where 75 queens were in distributed. Breeders from PA, WV, OH, attended the three day

Annual queen rearing classes taught at the Purdue bee lab, in 2014 we had 34 students.

Instrumental insemination classes have also been a good resource for breeders to learn more about the importance of selection at the Purdue Bee Lab.

2016 Insemination Fest

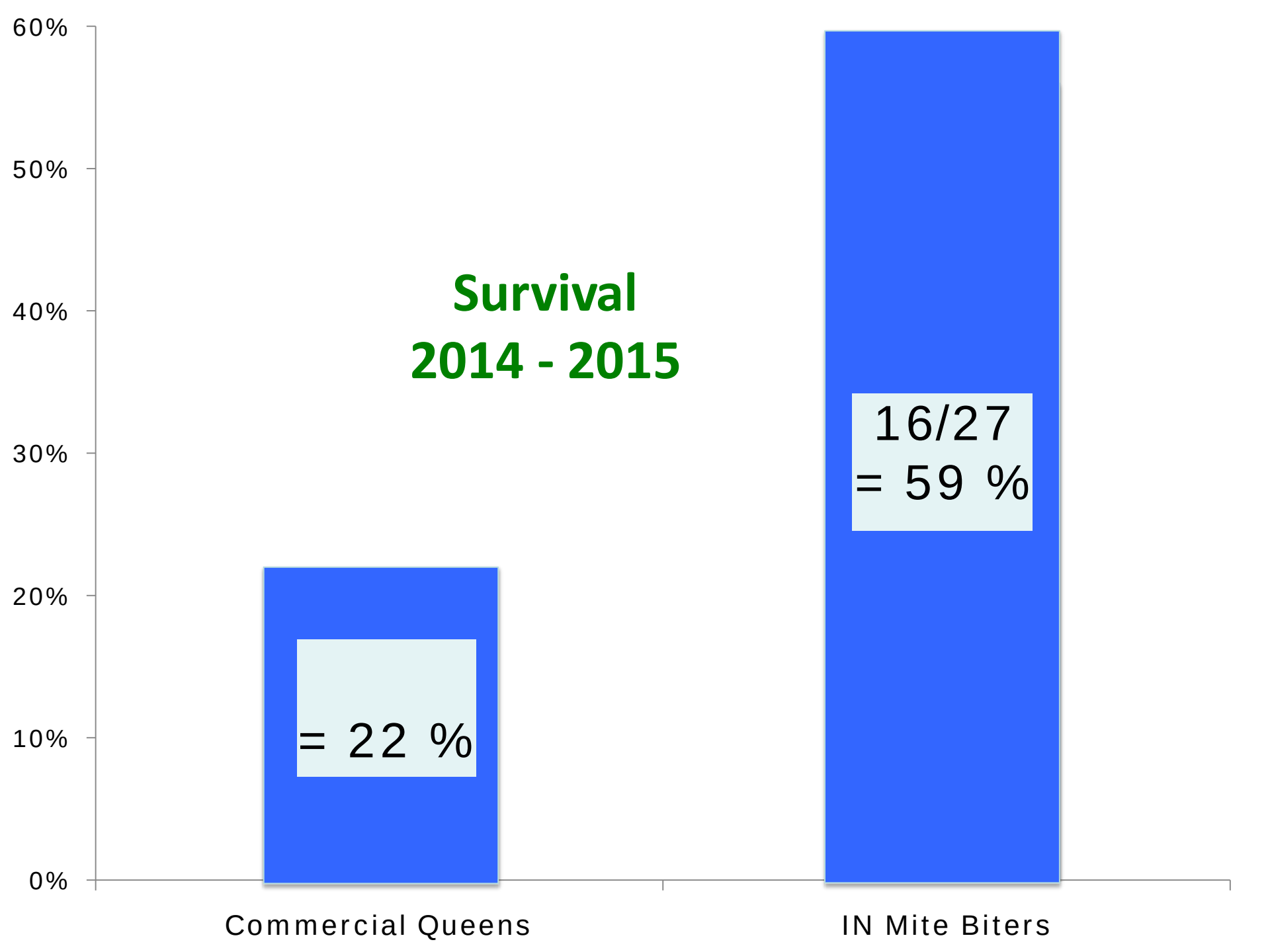
PA, OH, WV, MI, IN, IL, KY, TN

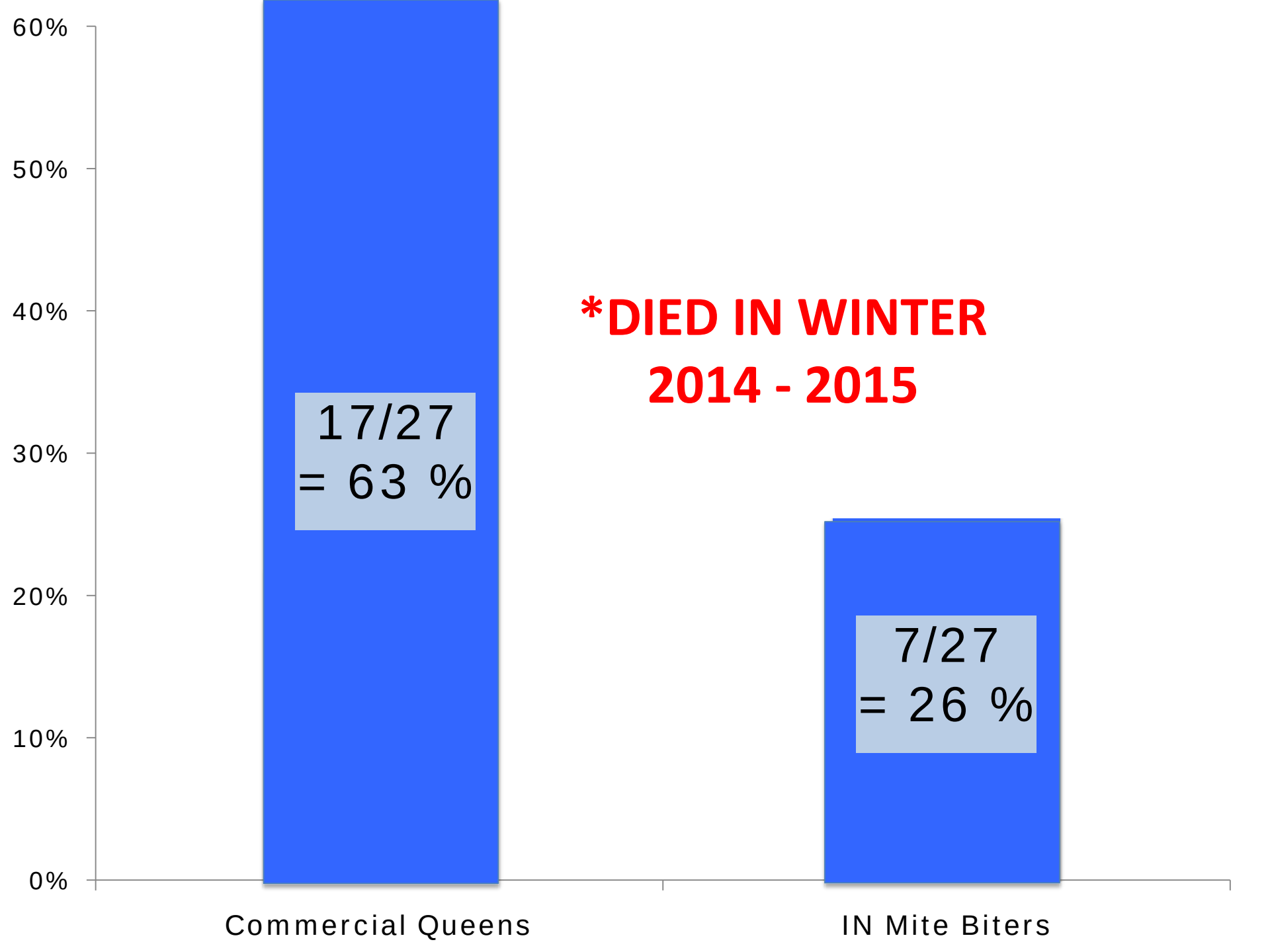
130 queens inseminated

COMMUNITY STOCK EVALUATION
IN 2014-2015
54 queens, 23 beekeepers,
3 commercial sources,
2 Purdue sources.

Commercial hives had 3X more mites

PHOTO: RATNA THAPA


60%
50%
40%
30%
20%
10%
0%
Survival
2014 - 2015
= 22 %
16/27
= 59 %
Commercial Queens
IN Mite Biters


60%
50%
40%
30%
20%
10%
0%
17/27
= 63 %
7/27
= 26 %
*DIED IN WINTER
2014 - 2015
Commercial Queens
IN Mite Biters

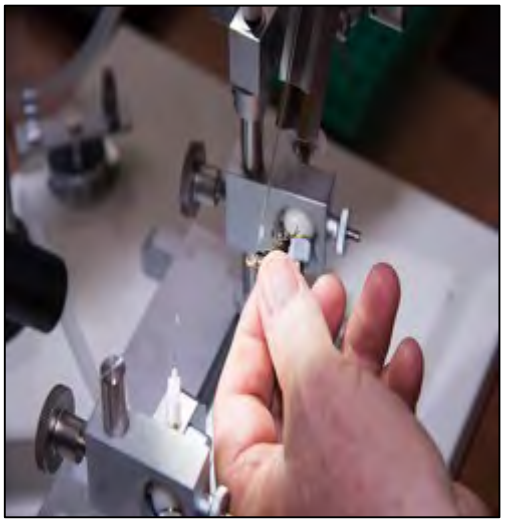
IN QUEENS MADE 40 LB MORE HONEY

Ten of eleven beekeepers preferred IN mite biters

HAS July 13-15, 2017
Evansville, IN

July 13

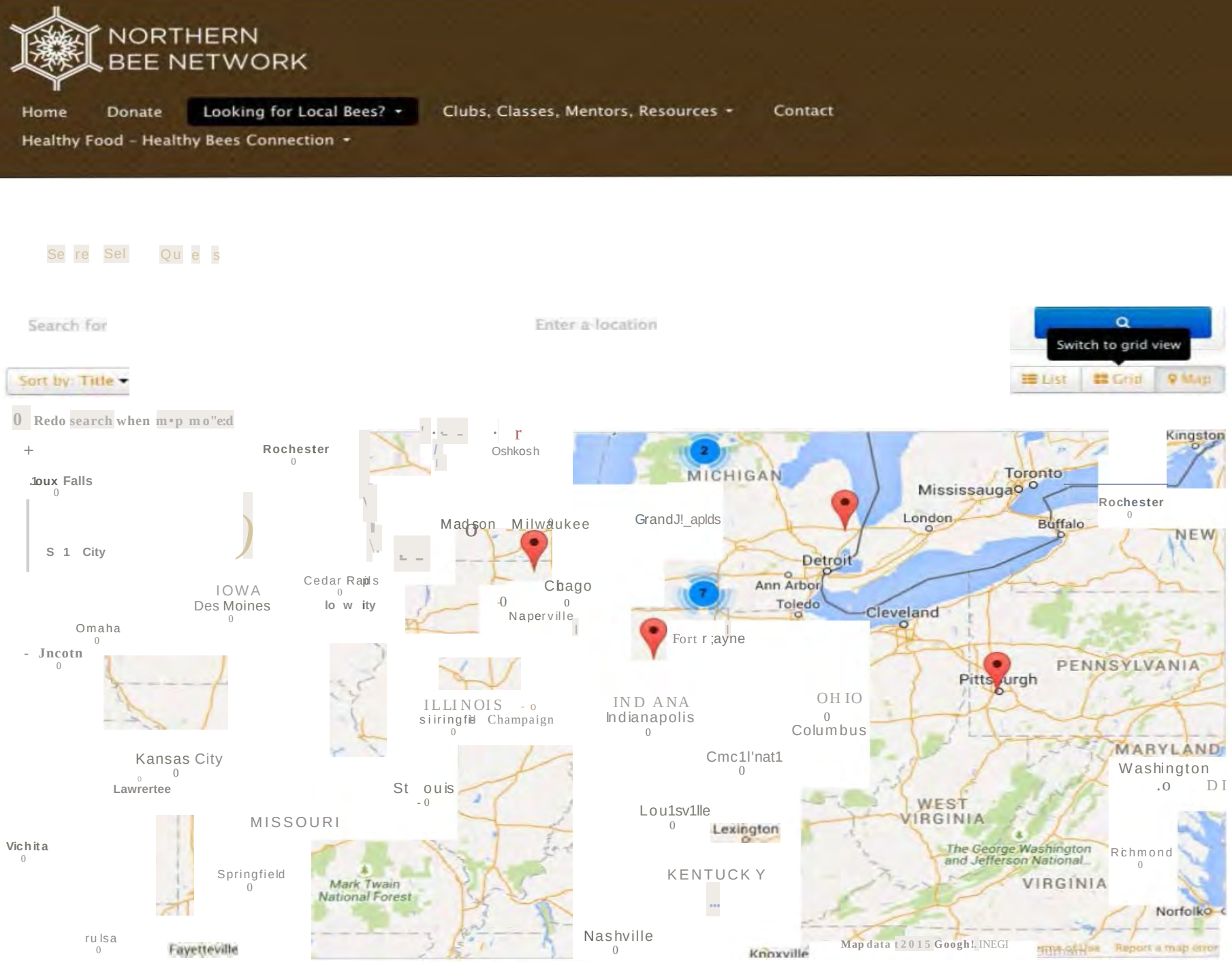
2016 I.I. Class




PROPERTY OF
17 ★ 76

Future plans:

Cage bee assays for grooming!


NORTHERN
BEE NETWORK
Home
Donate
Looking for Local Bees?
Clubs, Classes, Mentors, Resources
Contact
Healthy Food – Healthy Bees Connection
Search for
Enter a location
Switch to grid view
List
Grid
Map
Sort by: Title
Redo search when map moved
Rochester
Oshkosh
Madison
Milwaukee
Chicago
Naperville
Cedar Rapids
IOWA
Des Moines
Omaha
Kansas City
Lawrence
ILLINOIS
Champaign
Springfield
MISSOURI
St. Louis
Wichita
Tulsa
Fayetteville
Mark Twain National Forest
MICHIGAN
Grand Rapids
Detroit
Ann Arbor
Toledo
Cleveland
Fort Wayne
Indianapolis
INDIANA
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Buffalo
Kingston
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NEW
PENNSYLVANIA
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Washington
WEST VIRGINIA
VIRGINIA
The George Washington and Jefferson National...
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Norfolk
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The Bee Hive

Welcome to the Hunt lab's Bee Hive. We are involved in honey bee research and education.

July 9-11, 2015

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heartlandbees.org

14TH ANNUAL H.A.S. CONFERENCE

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Dennis vanEngetsdO<J>, Sue Cob<ty. Larry Connor, Joe Traynor, Clanmce Collison
Kim Flottum, Renata Borba, Roger Hoopln11a ner Ken Schramm, ghan Milbrath

conference sponsored by:
Bee Culture
MANN LAKE

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adv. wort.shop,.,
b<JildJng nucs splts,
q-ueen rai.sing.
drone catch tng.
new propotis d scoveries
honey tasting
bnng 3jars to swap!

CHILDREN'S PROGRAMMING:
candle-making, murals, seed bombs

EGISTER NOW!
www.heartlandbees.org

Events

Do you have a swarm to pick up? Find a local swarm catcher here:
http://www.in.gov/dnr/entomolo/S755.htm.

When bees swarm the queen and most of the hive bees leave after filling up on honey. Bees in a swarm are usually very gentle but leave them alone! With all those bees flying one could get stuck in your hair. The swarm sends out scout bees to find a new cavity to nest in. They usualy stay for a few days and then they are off to their new home.

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Website developed by the Entomology Department at Purdue University

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Thank you

Heartland Honey Bee Breeders Coop

National Honey Board Funding

NEW USDA Funding !!!

Greg Hunt

Jennifer Tsuruda

Gladys Andino

Jeff Berta - PA
Matt Evans – IN
Tammy Horn - KY
Joe Kovalevski – OH
Scott Martin - IL
Megan Milbraith - MI
Dan O'Hanlon - WV
Dave Shenefield - IN
Dwight Wells - OH