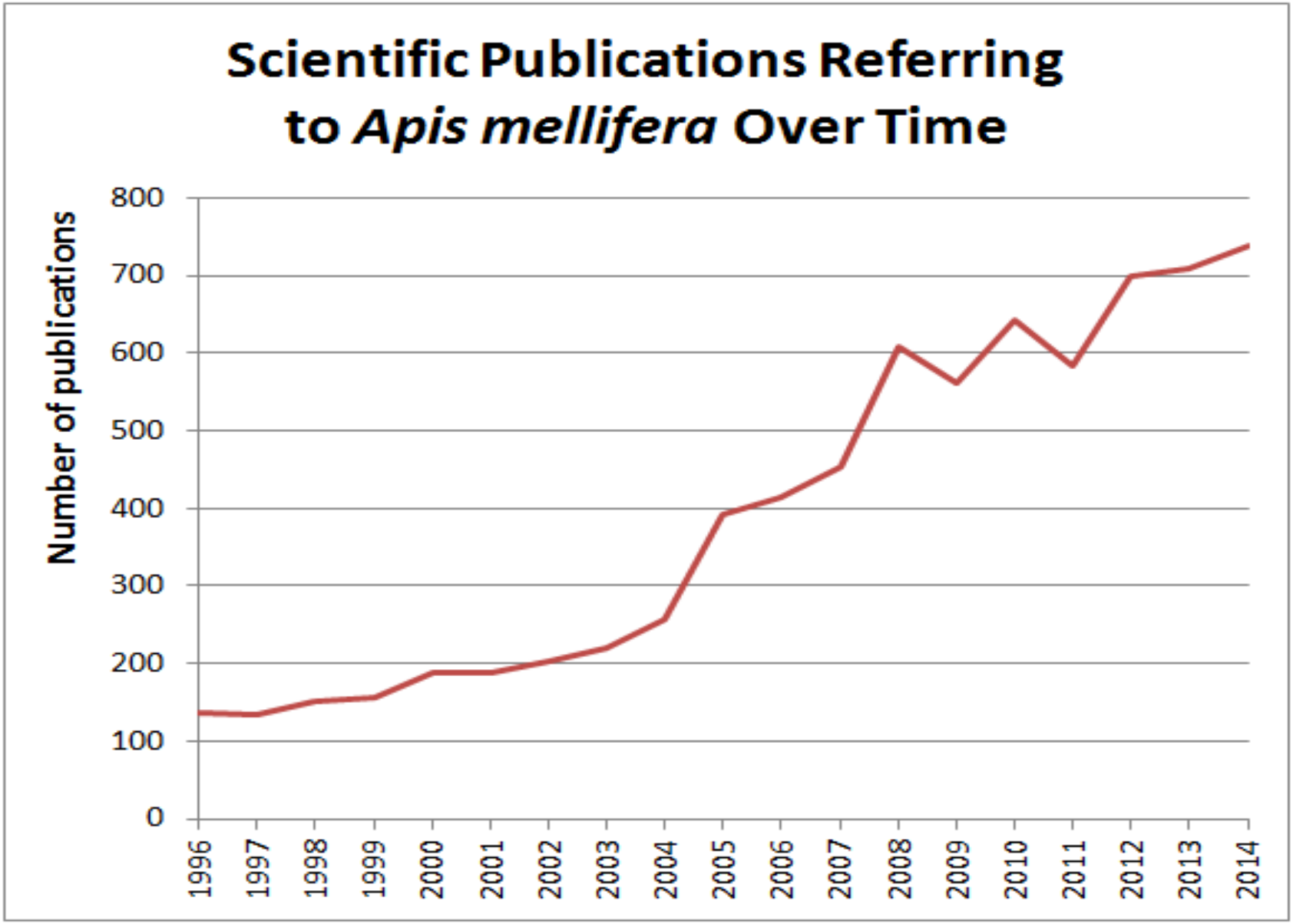
Applying science to the practice of beekeeping



But most are laboratory studies or reviews that have little direct application to colony management.

Beekeepers themselves can perform "applied" scientific research in order to answer practical questions.

But any "research" needs to be planned and executed using scientific logic.

Types of research:

- **Observational *studies*.**
- **Exploratory *investigations*.**
- **Confirmatory *testing*.**
- **Comparative *experimental trials*.**

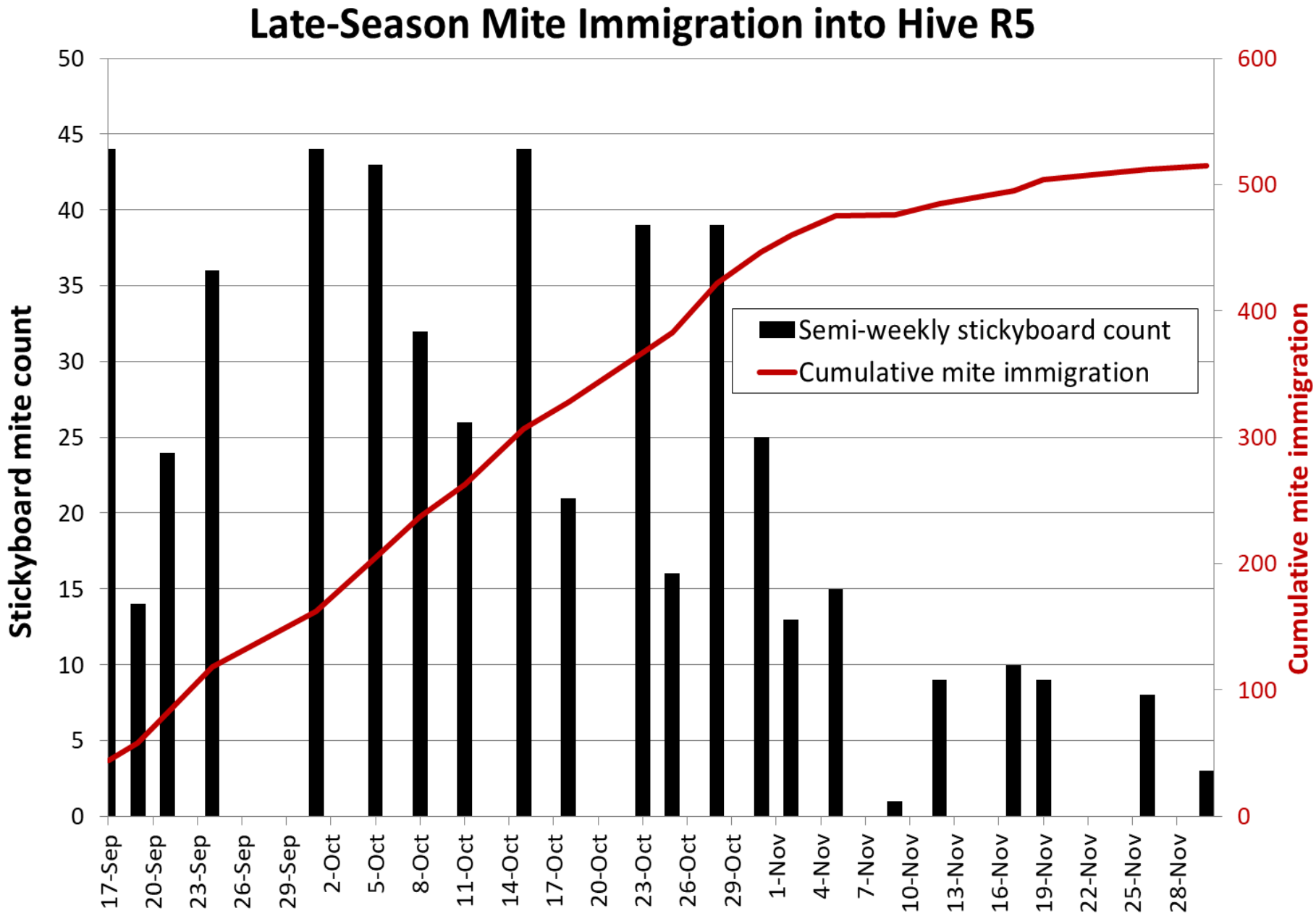
Observational Study:

What is the amount of mite immigration into my hives in late summer?

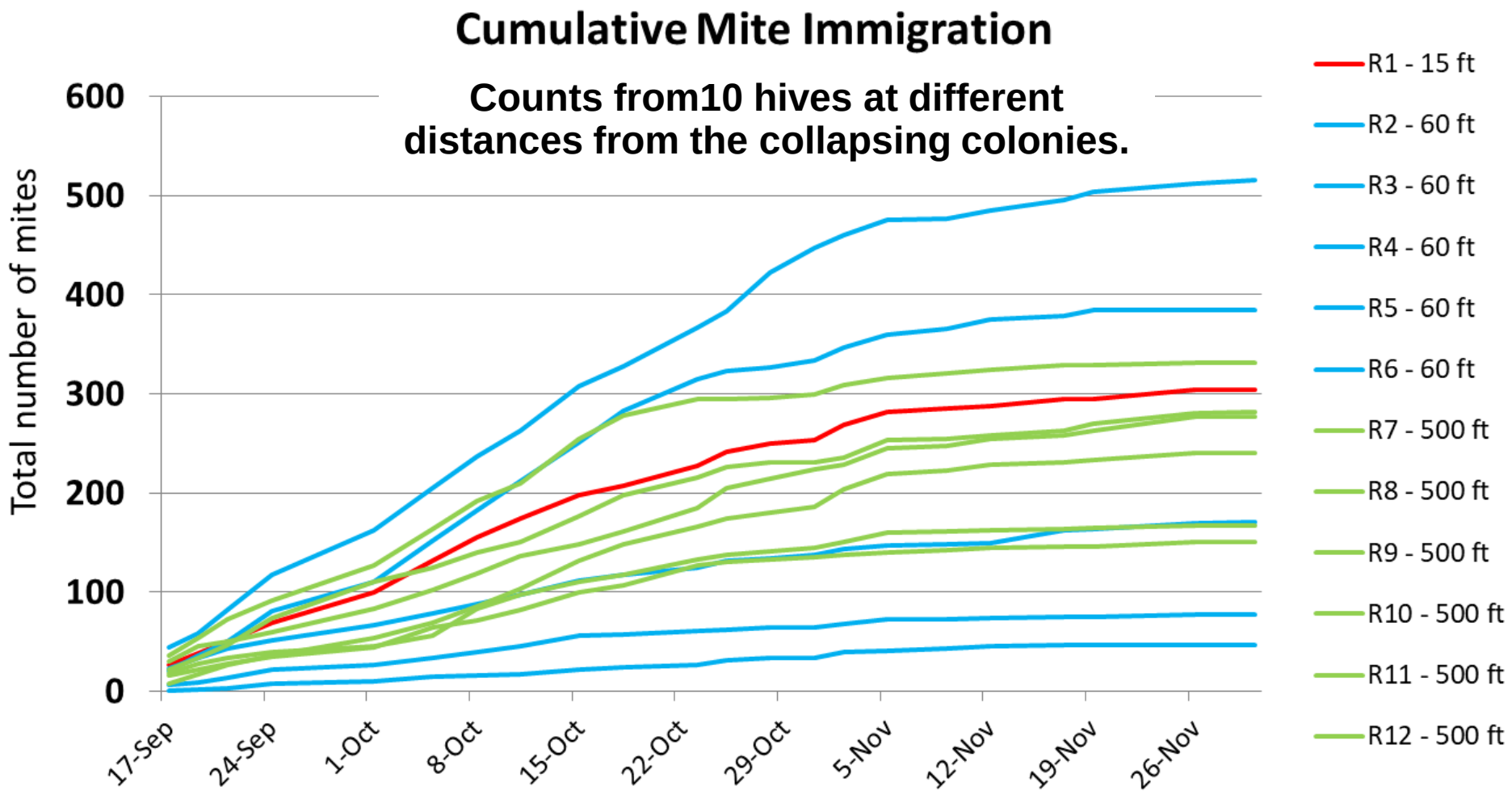
Eliminate every mite in “receiver” hives

Insert stickyboards to catch any “immigrated” mites.

Count the fallen mites twice a week.



Graph your data: Yes, substantial immigration!



Findings: there was a median varroa immigration of 258 mites per hive between mid Sept through end of November.

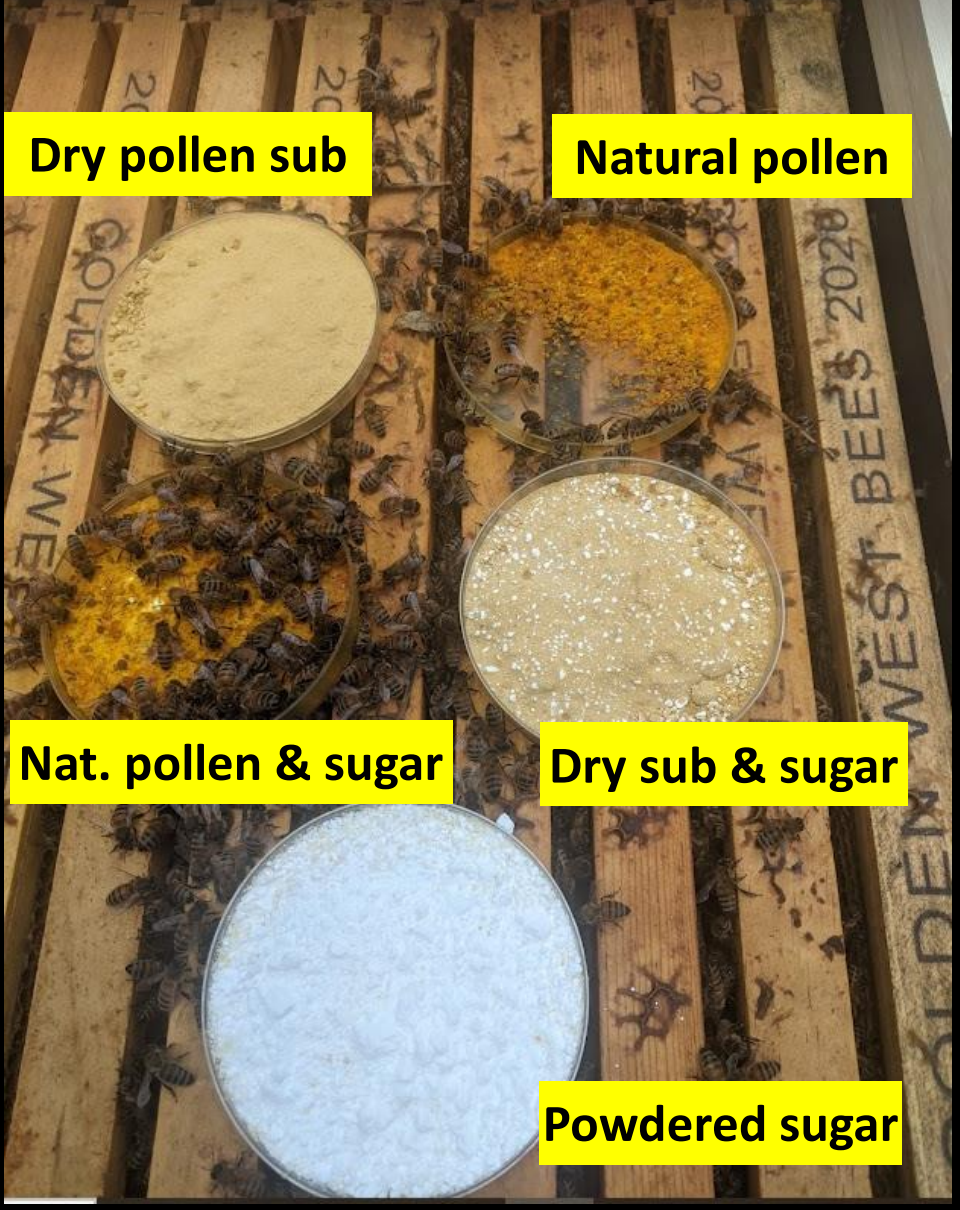
But it was not correlated with distance between hives.

Exploratory investigations

Exploratory	Confirmatory
If I place mint leaves in a hive every day, what will I observe?	**I expect that placing mint leaves in a hive will decrease the varroa infestation.**
Look for any changes, but understand that an apparent correlation does not confirm causality.	**Test to confirm the hypothesis against the "null hypothesis" of no effect.**
Measure every metric you can think of, and then look for possible correlations.	**Compare the change in mite counts between the mint Test group and the Control group.**

Exploratory preliminary research:

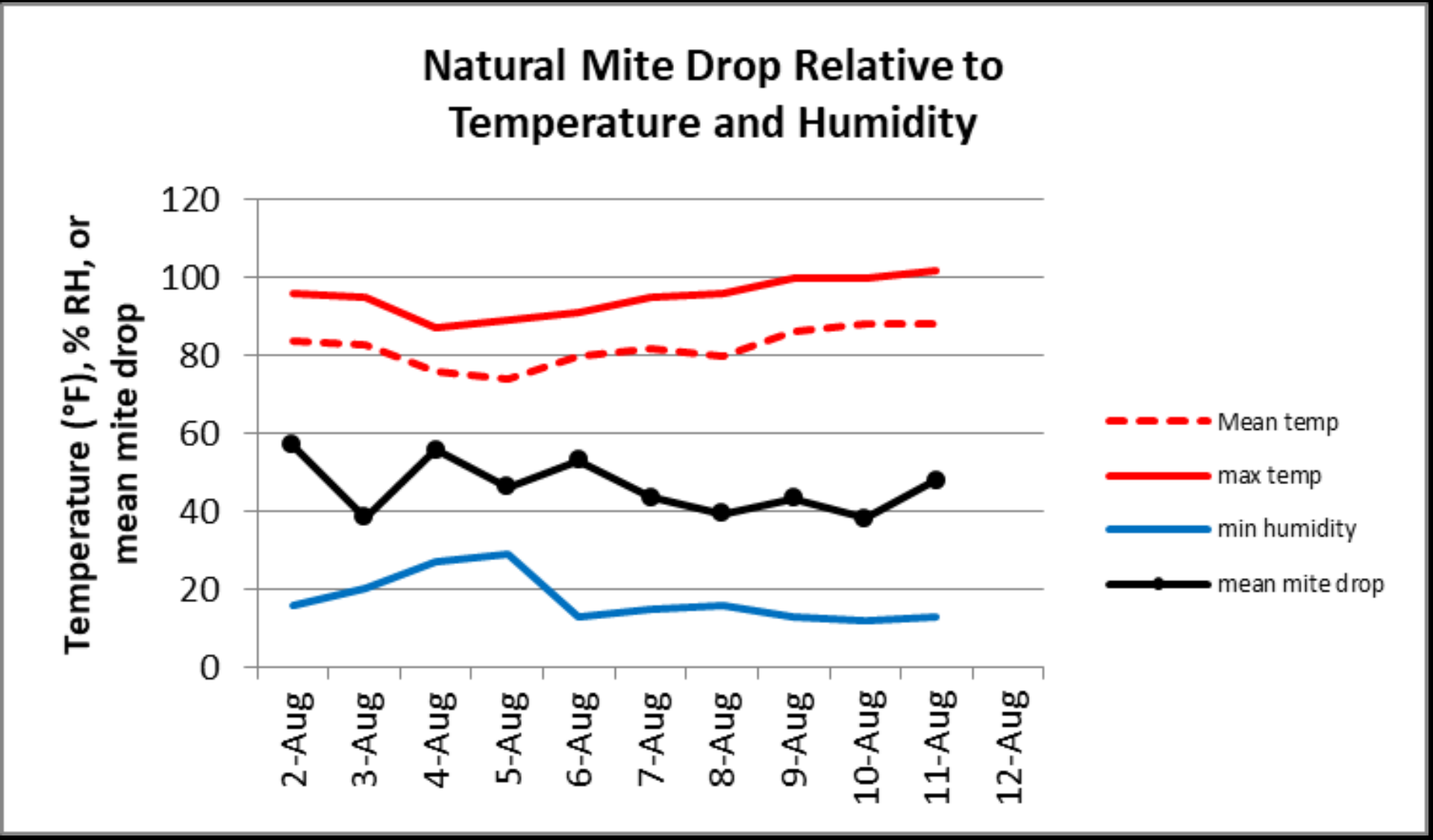
How do bees respond to dry powdered diets offered under the hive cover?



Observe through a glass cover, which of five offered feeds bees preferentially consume or carry off on their legs.

Exploratory preliminary research:

Is natural mite drop onto a sticky board affected by temperature or humidity?

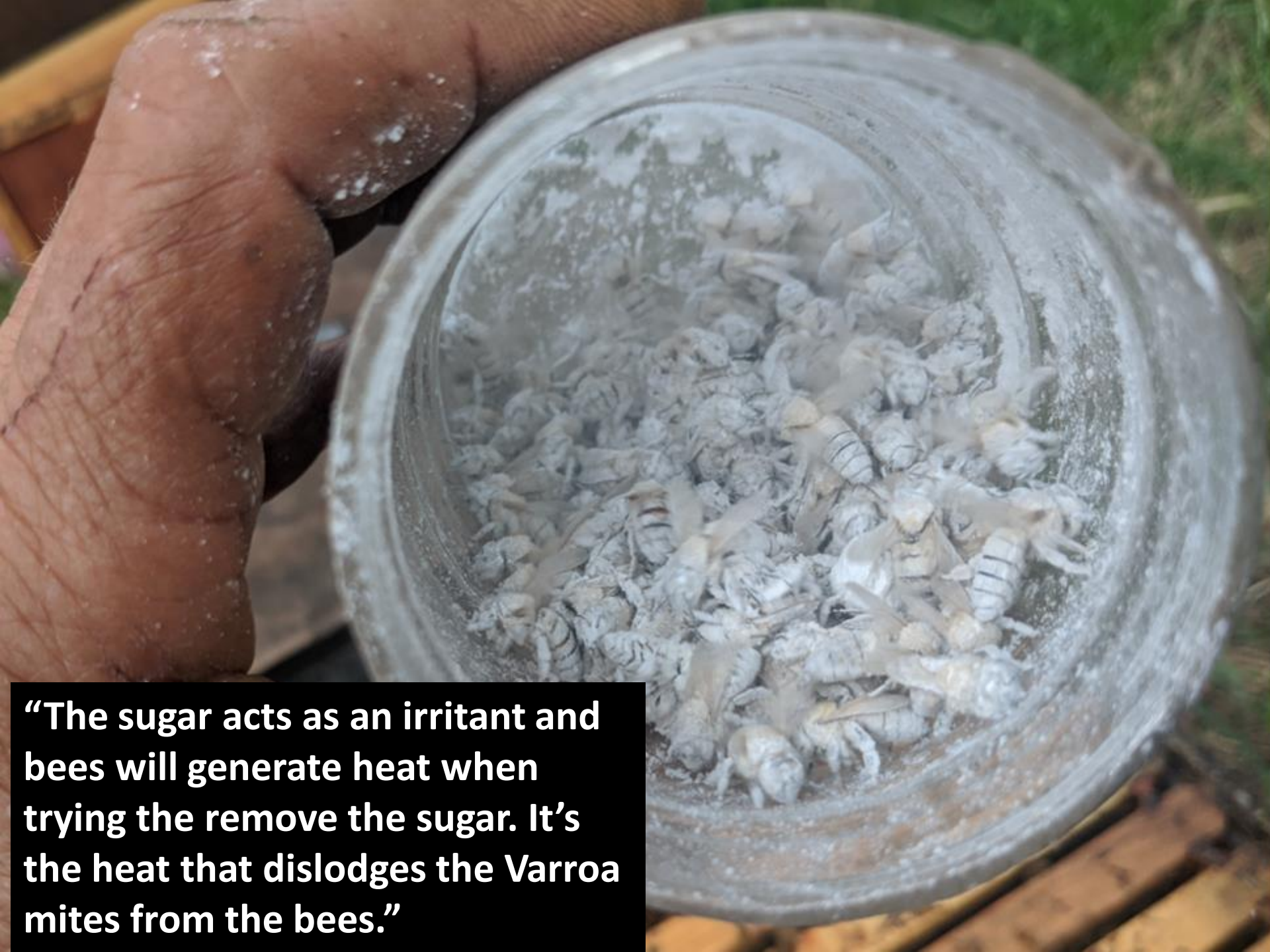


No obvious correlations.

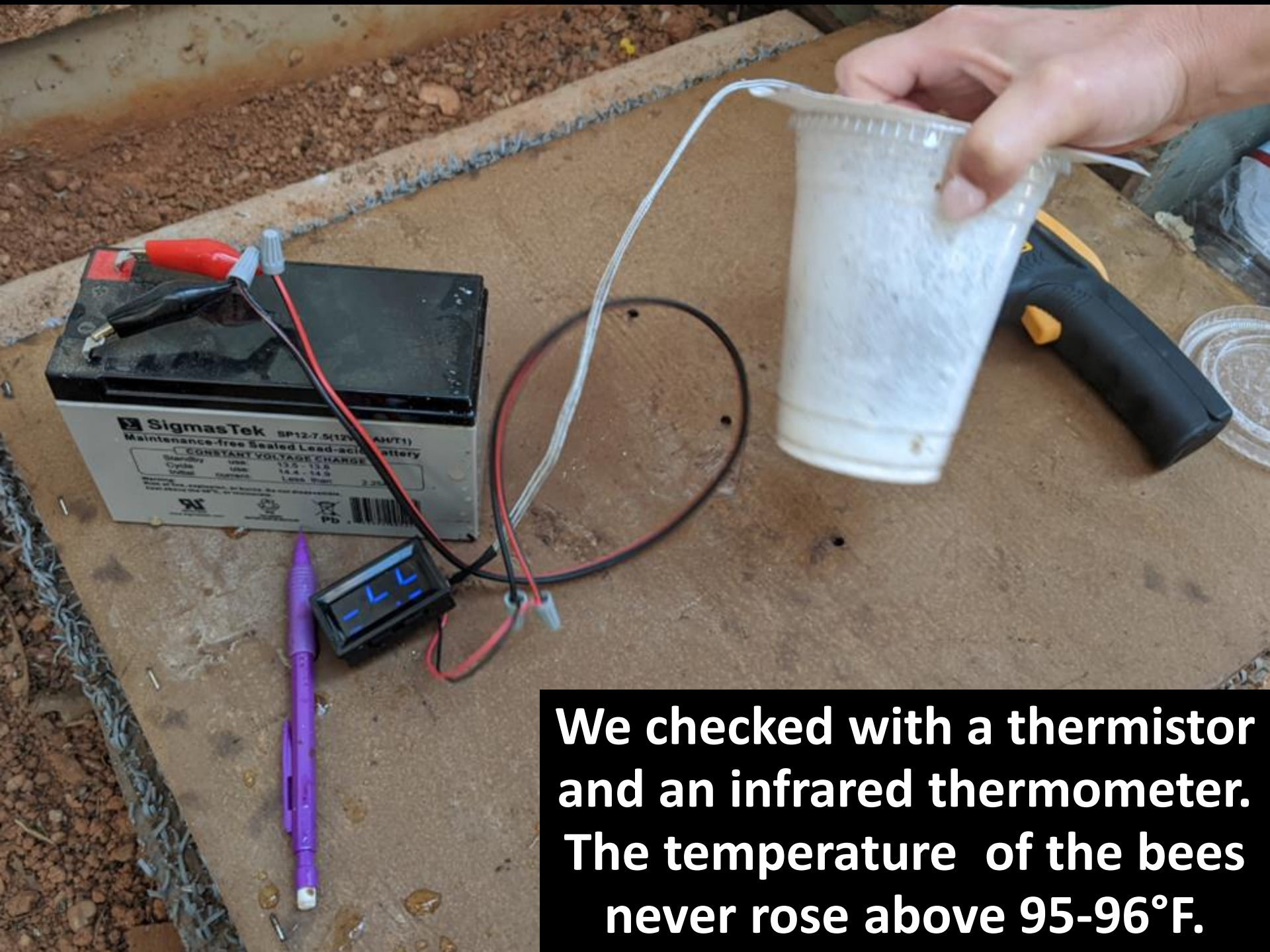
Confirmatory testing of a claim

The claim: The reason that a sugar roll works is due to the bees heating up.

Was that claim based upon data/observation, or was it an unfounded assumption?



“The sugar acts as an irritant and bees will generate heat when trying the remove the sugar. It’s the heat that dislodges the Varroa mites from the bees.”

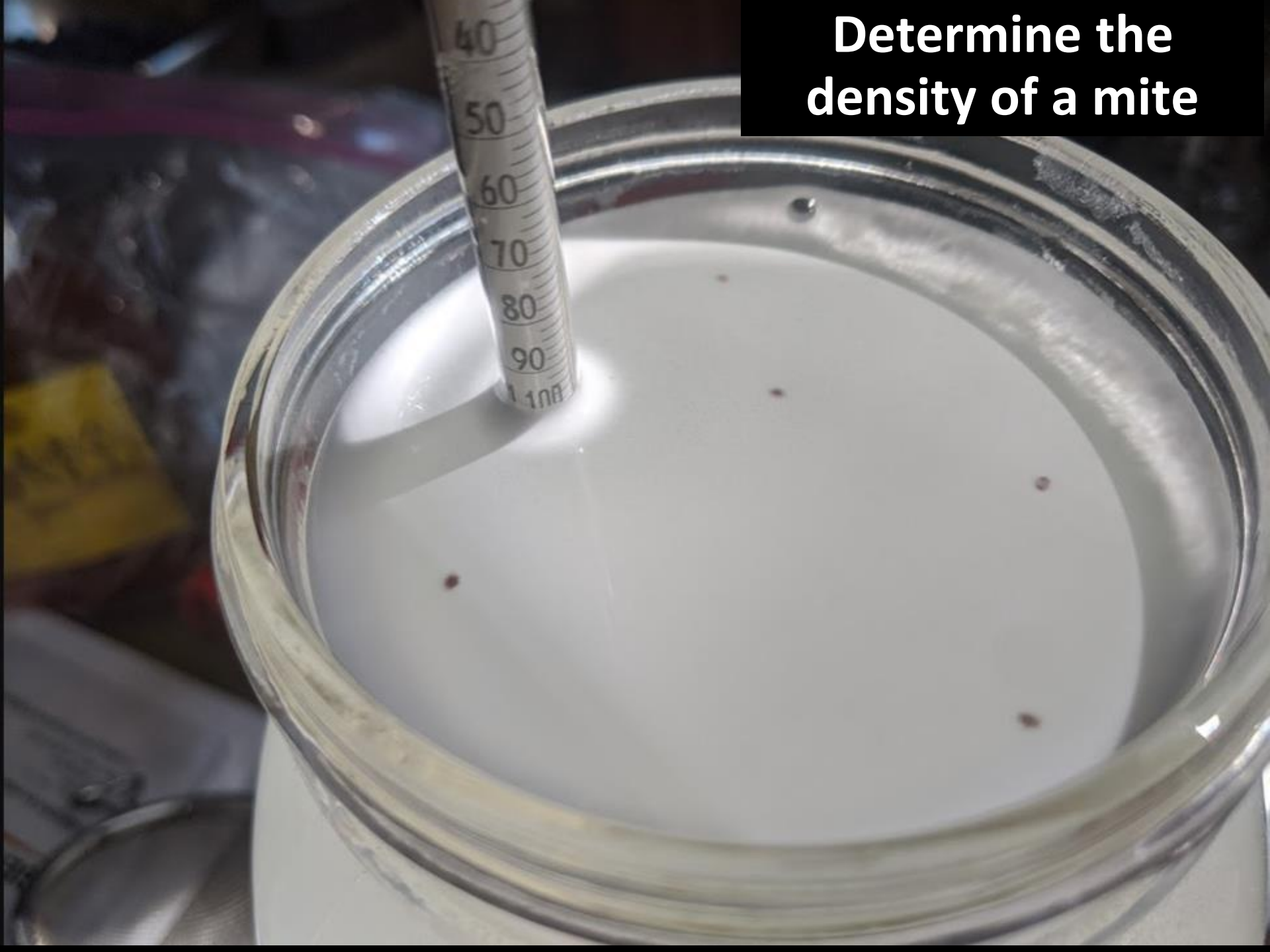


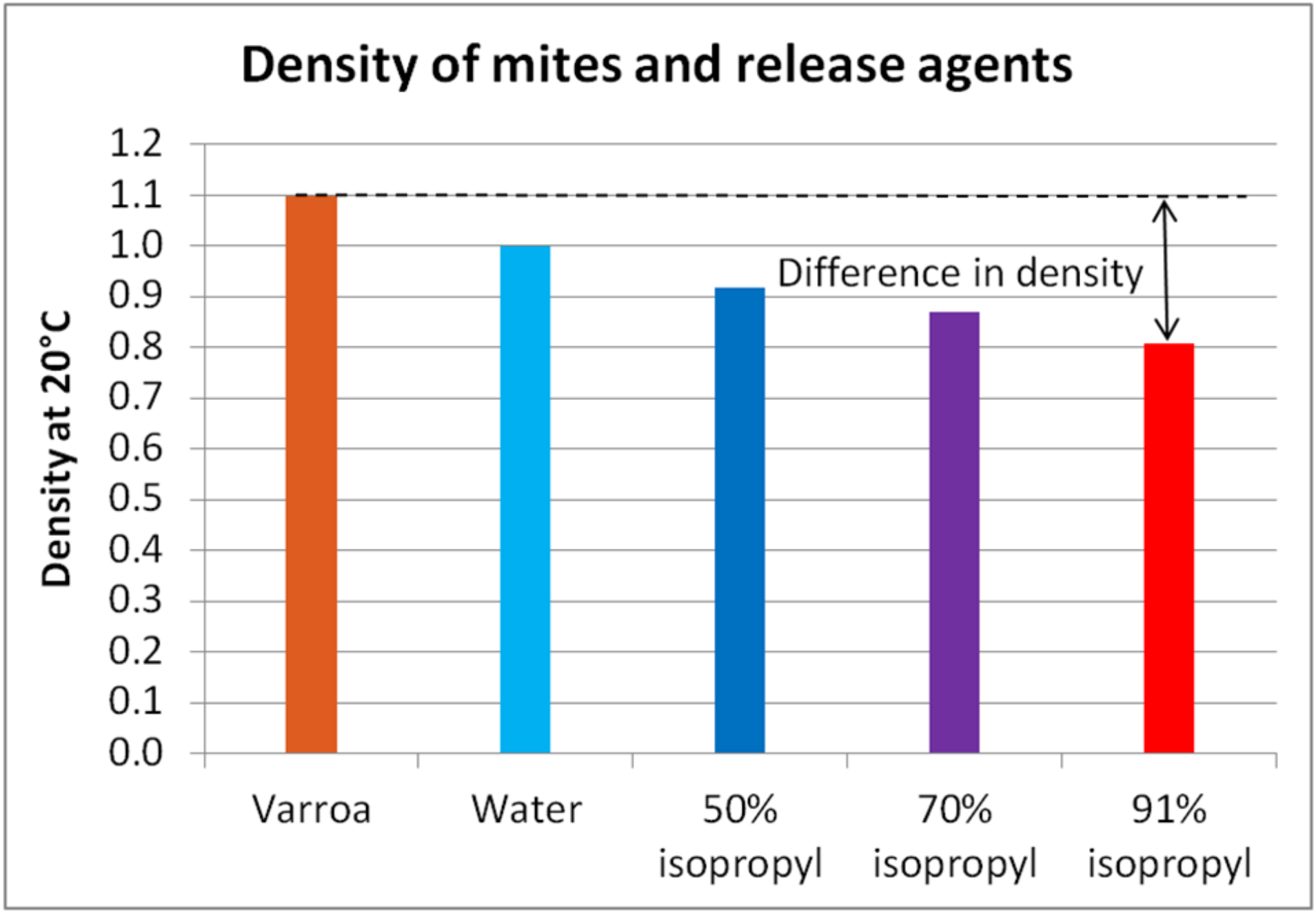
We checked with a thermistor and an infrared thermometer. The temperature of the bees never rose above 95-96°F.

Confirmatory testing:

Hypothesis: In an alcohol wash, the mite sink rate will be relative to alcohol concentration.

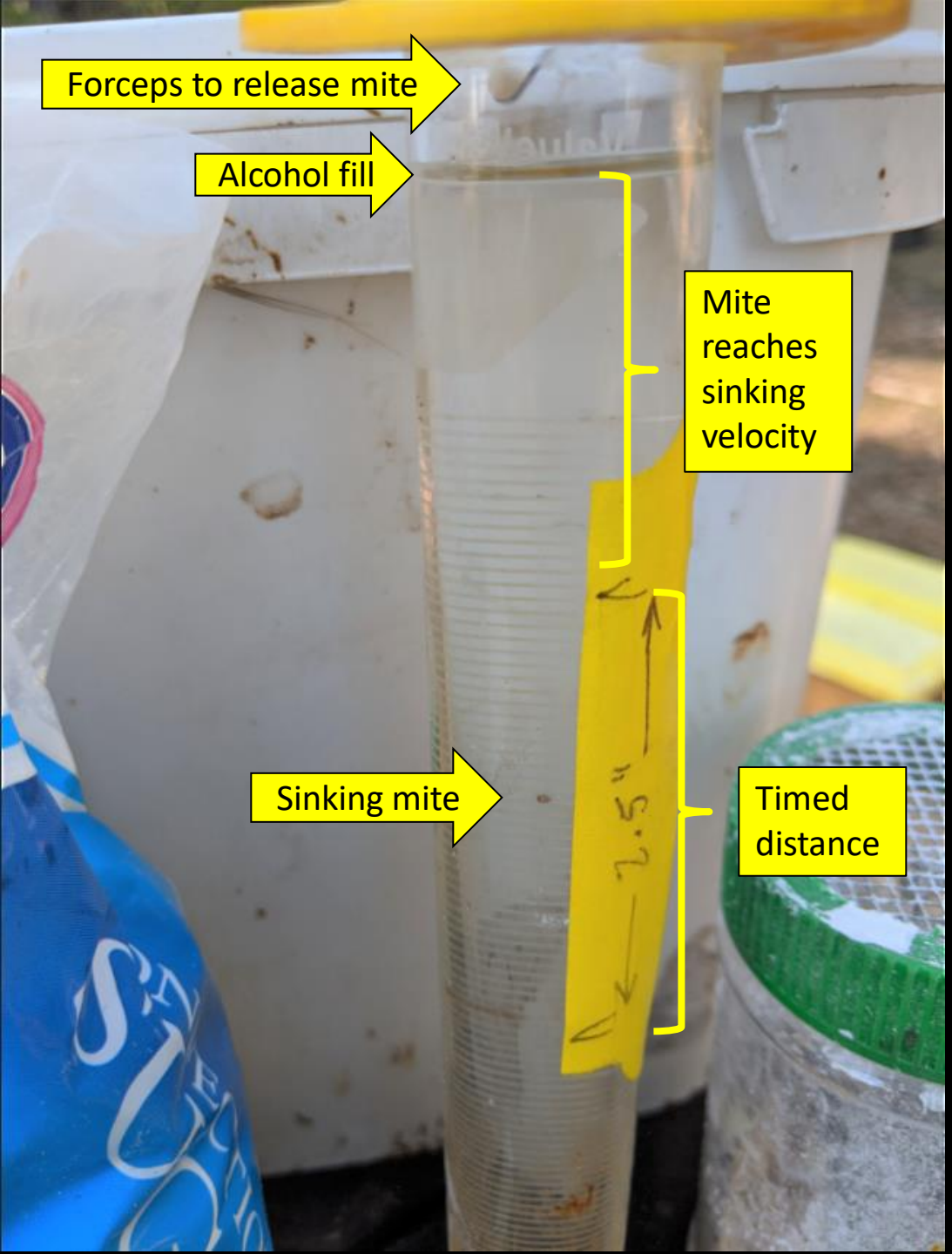
Determine the density of a mite



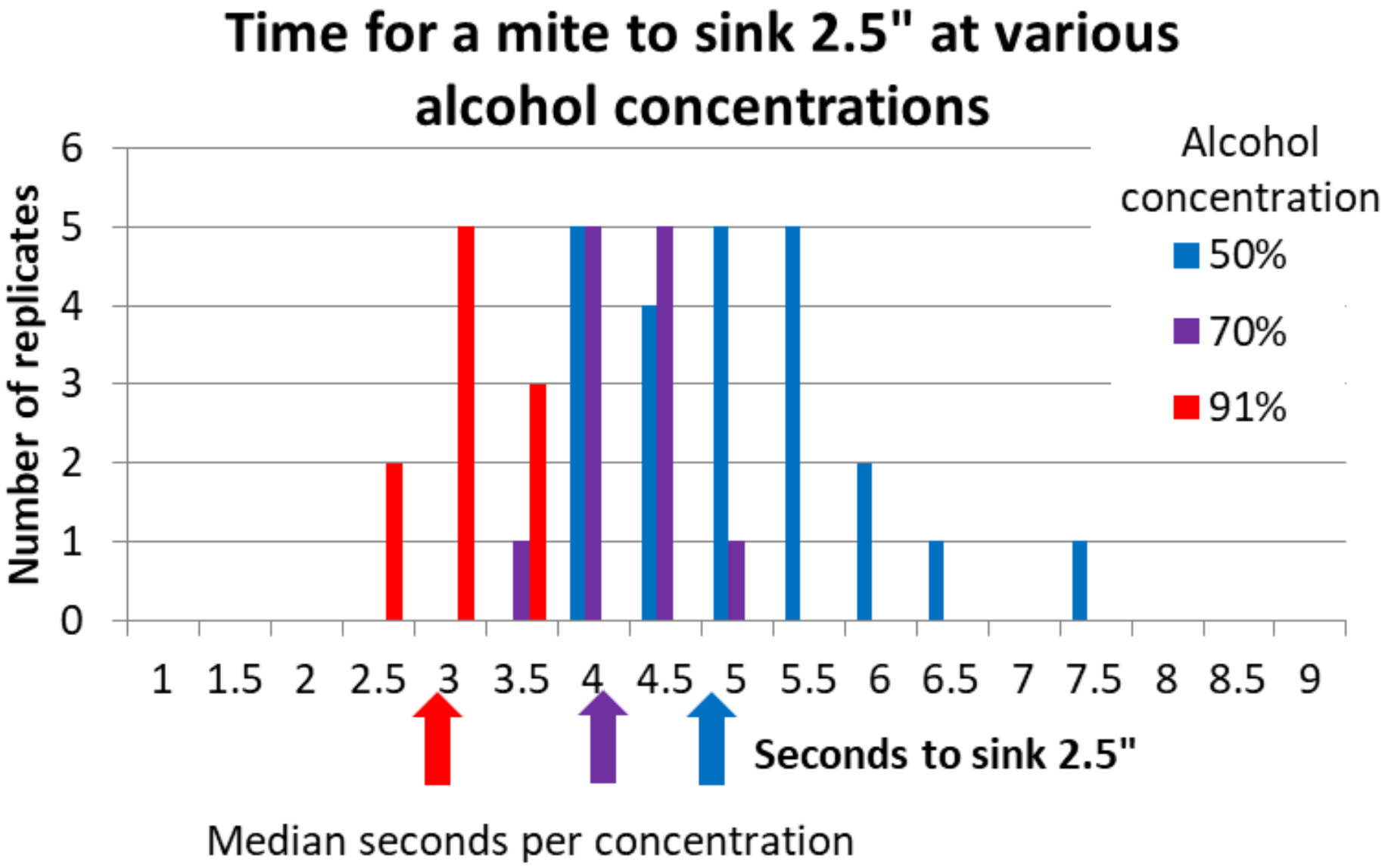


Compare to densities of water and various alcohol solutions.

Measure the distance that a mite must sink.



Time how long it takes for a mite to sink 2 ½ inches.



Plot out the results: The higher the alcohol proof, the faster the sink rate confirmed.

Applied research: Field experiments and trials.

What’s the biggest mistake that beekeepers make when they run an “experiment”?

Example: our queen cells were dying from Black Queen Cell Virus

It was recommended that we treat them with oxytet and/or fumagillin to solve the problem. So I fed them a mix.

After a few days of treatment, the problem went away. What did we learn?

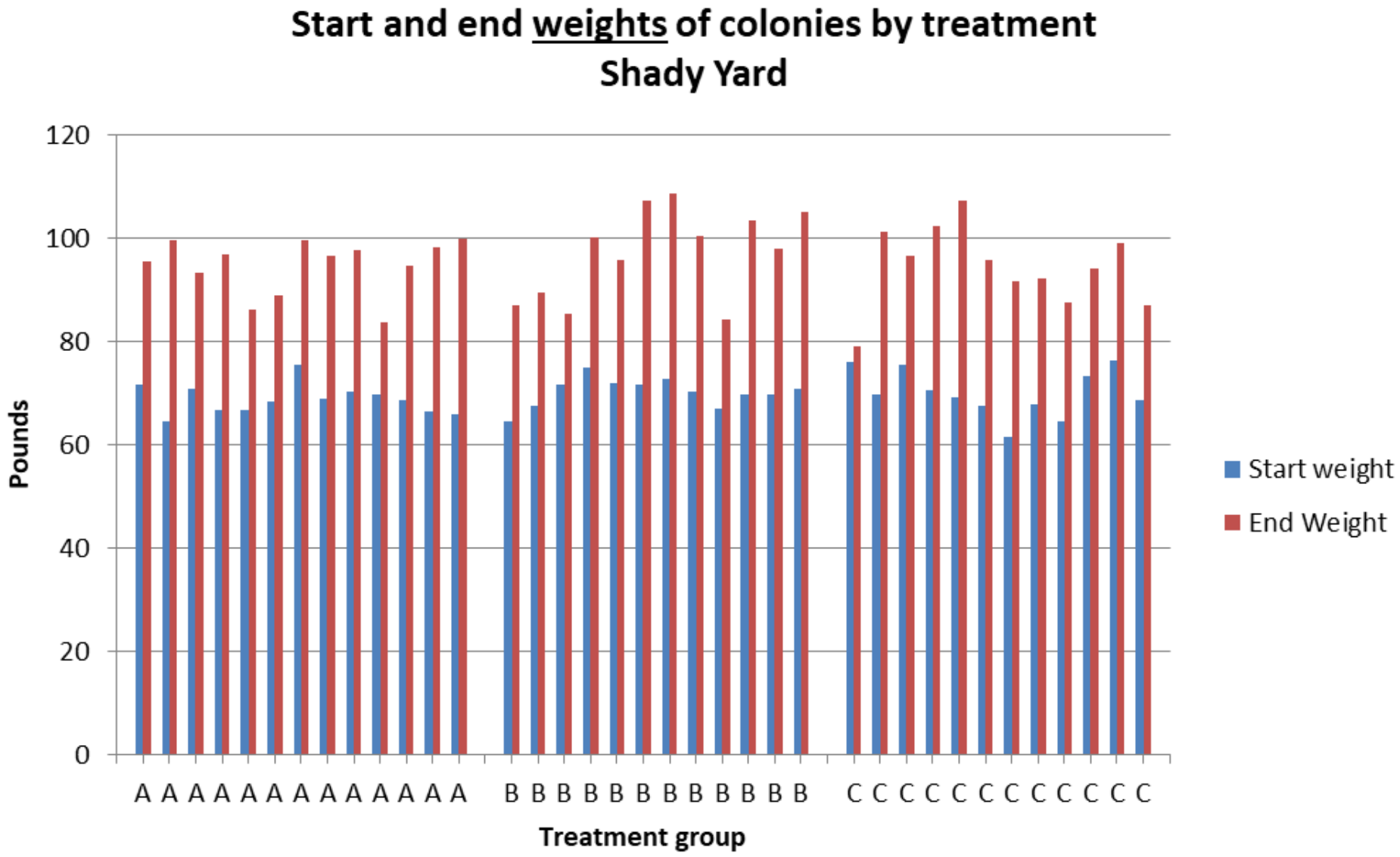
What was the result in your control group?

The main error that beekeepers make when running an “experiment”:

Lack of a Control Group to compare to.

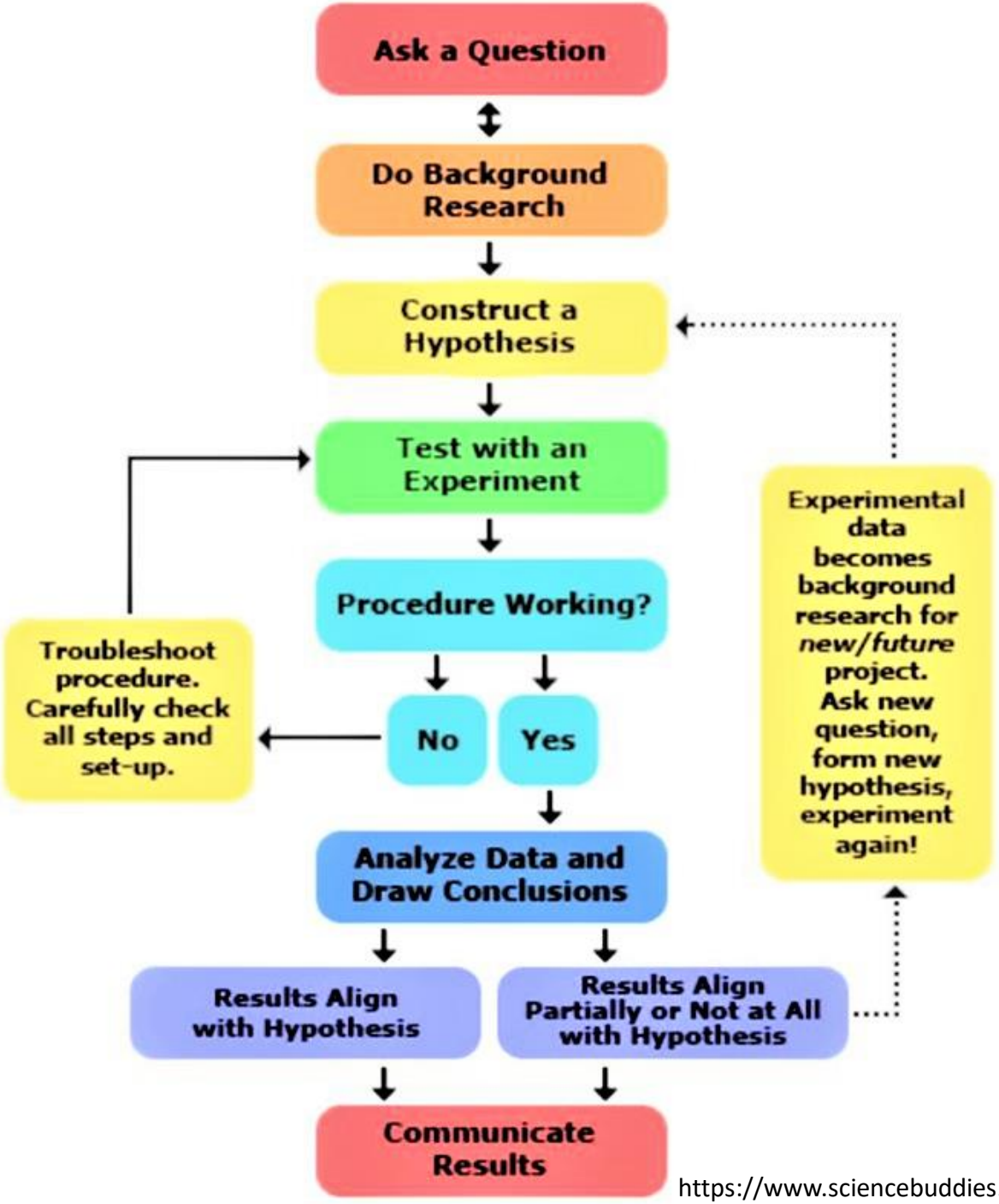
Bill tried treating all his hives with “x.”
They made the best honey crop ever!
What did he learn about the benefit of “x”?

Absolutely nothing!



Unless you run a Control group, you can't compare the result to that of a group not given "x"!

The Scientific Method



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Beekeeping Through the Eyes of a Biologist

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Tips for Citizen Scientists

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Tips for Designing Bee Research Projects

Randy Oliver ScientificBeekeeping.com

Revised 26 Feb 2017

Beekeepers are known for being of curious and experimental minds. Since factors affecting beekeeping are continually changing, new unanswered questions are bound to arise; the beekeeper "citizen scientist" can often answer them himself by performing a well-designed experiment, and then share those results to the benefit of everyone. But for the results of any experiment to be meaningful, it is important that the experiment follow certain scientific principles. I've written up a sheet of tips for the citizen scientist. You can download it at: **BEE RESEARCH M&M TIPS pdf**

Share:

Test Group vs. Control Group

<u>Differ by only a single variable.</u>

Positive Controls (compare to treatment with known effect).

Negative Controls (compare to no treatment).

#1 point—Ask yourself, what is the <u>single specific question</u> that you are trying to answer with this experiment?

(and make sure that your experimental design will unambiguously answer the question). Fill in the following blanks before you go further (take some time to think them through):

Your question:

Which pollen sub will cause my colonies to grow more for almond pollination – Global 4% or Global 15%?

Your hypothesis:

That the 15% of natural pollen will allow for greater colony growth.

The treatment (variable) to be tested:

The percent of natural pollen in the pollen sub.

The predicted effect:

Ending colony strength of the will be greater in the colonies fed the 15% pollen sub.

SOMETIMES YOU'LL HAVE MORE THAN ONE QUESTION

Write the <u>specific</u> question that you wish to answer on the wall.

Write the <u>specific</u> question that you wish to answer on the wall.

Then make sure that your design collects the necessary data to answer the question.

Write the <u>specific</u> question that you wish to answer on the wall.

Then make sure that your design collects the necessary data to answer the question.

Eliminate anything from your experimental design on that doesn't have to do with specifically answering the question!

Q: Which pollen sub will cause my colonies to grow more for almond pollination – Global 4% or Global 15%?

- ***Should I run a Control group fed another brand of sub not containing natural pollen?***

Q: Which pollen sub will cause my colonies to grow more for almond pollination – Global 4% or Global 15%?

- ***Should I run a Positive control of natural pollen?***

Q: Which pollen sub will cause my colonies to grow more for almond pollination – Global 4% or Global 15%?

- ***Should I run a Negative Control of sugar patty?***

Q: Which pollen sub will cause my colonies to grow more for almond pollination – Global 4% or Global 15%?

- ***Should I run a Negative Control group fed nothing?***

Q: Which pollen sub will cause my colonies to grow more for almond pollination – Global 4% or Global 15%?

- ***Should I measure the amount of brood?***

Q: Which pollen sub will cause my colonies to grow more for almond pollination – Global 4% or Global 15%?

- ***Should I pull every frame to measure colony strength, or use simple cluster size grading?***

Q: Which pollen sub will cause my colonies to grow more for almond pollination – Global 4% or Global 15%?

- ***Should I feed strong colonies more sub than the weak colonies?***

Q: Which pollen sub will cause my colonies to grow more for almond pollination – Global 4% or Global 15%?

- ***How should I assign treatments?***

INTRODUCTION AND YOUR OBJECTIVE

Trial Log

Pollen supp during bloom trial 2014

Principal Investigator: Randy Oliver, assisted by Eric and Ian Oliver

Funding sources: beekeeper donations to ScientificBeekeeping.com.

Introduction

The results of the 2013/14 Pollen Supp Trial indicated that there was no apparent benefit in colony buildup from supplemental protein feeding while alder pollen was abundant in January/February. I was curious as to whether this held true later in the spring.

EXPERIMENTAL OBJECTIVES

To determine whether it is of benefit to feed pollen supplement to growing nucs during the normal spring pollen flow.

BE REALISTIC – DON'T BITE OFF MORE THAN YOU CAN CHEW!

The three metrics with the most practical application to beekeepers are:

- **Colony strength (number of frames covered with bees).**
- **Weight gain (the final calculus of colony performance).**
- **Varroa infestation rate (or freedom from disease).**

Variable to test: the feeding of pollen sub.
Outcome variable to measure: change in colony strength.
Null hypothesis: it won't make any difference.

I'm only going to measure colony frame strength.

BACKGROUND RESEARCH

- Perform an internet (e.g. Google Scholar) literature search.
- Speak to researchers familiar with this topic.

I'll read every paper written on the subject -- many questions were answered years ago, but forgotten! But I'd still like to run this experiment in my environment.

Your Experimental Design

PLAN AHEAD AND WORK BACKWARDS

First run the experiment backwards in your head, and then on paper.

Begin by imagining <u>exactly</u> how you plan to present the results to an audience
(in a manner so that they can fully understand the significance of your experimental findings).

I will show the results in a line graph to compare the gains in strength of the Test and Control groups.

WRITE YOUR EXPERIMENTAL DESIGN AND PROTOCOL
IN DETAIL
BEFORE YOU BEGIN!

The Materials and Methods section should include sufficient technical information to allow the experiments to be repeated.

EXPERIMENTAL DESIGN:

Set up 30 5-frame nucs with freshly-mated tested queens, equalized for strength, in pairs.

Randomly assign 1 hive in each pair to be given pollen supplement patties on a regular basis (Treatment); feed the other a patty of fondant containing the same amount of sugar as the pollen supp. patties in order to eliminate any difference in sugar feeding as a variable (Controls).

Grade colonies for strength (cluster size) until their populations max around mid July.

Define your independent vs. dependent variable(s)

Independent variable	Dependent variable(s)
Miticide(s) applied	Change in mite infestation? Adverse effect upon colony?
Miticide application method	Change in colony setback?
Feeding of pollen sub types	Differences in colony growth?
Application of OA dribble	Change in mite infestation, colony strength, weight gain?
Insulate hive	Winter survival rate? Amount of honey consumption?
Feed “bee health” product	Colony performance? Nosema prevalence?
Feed ag fungicide	Change in brood production?

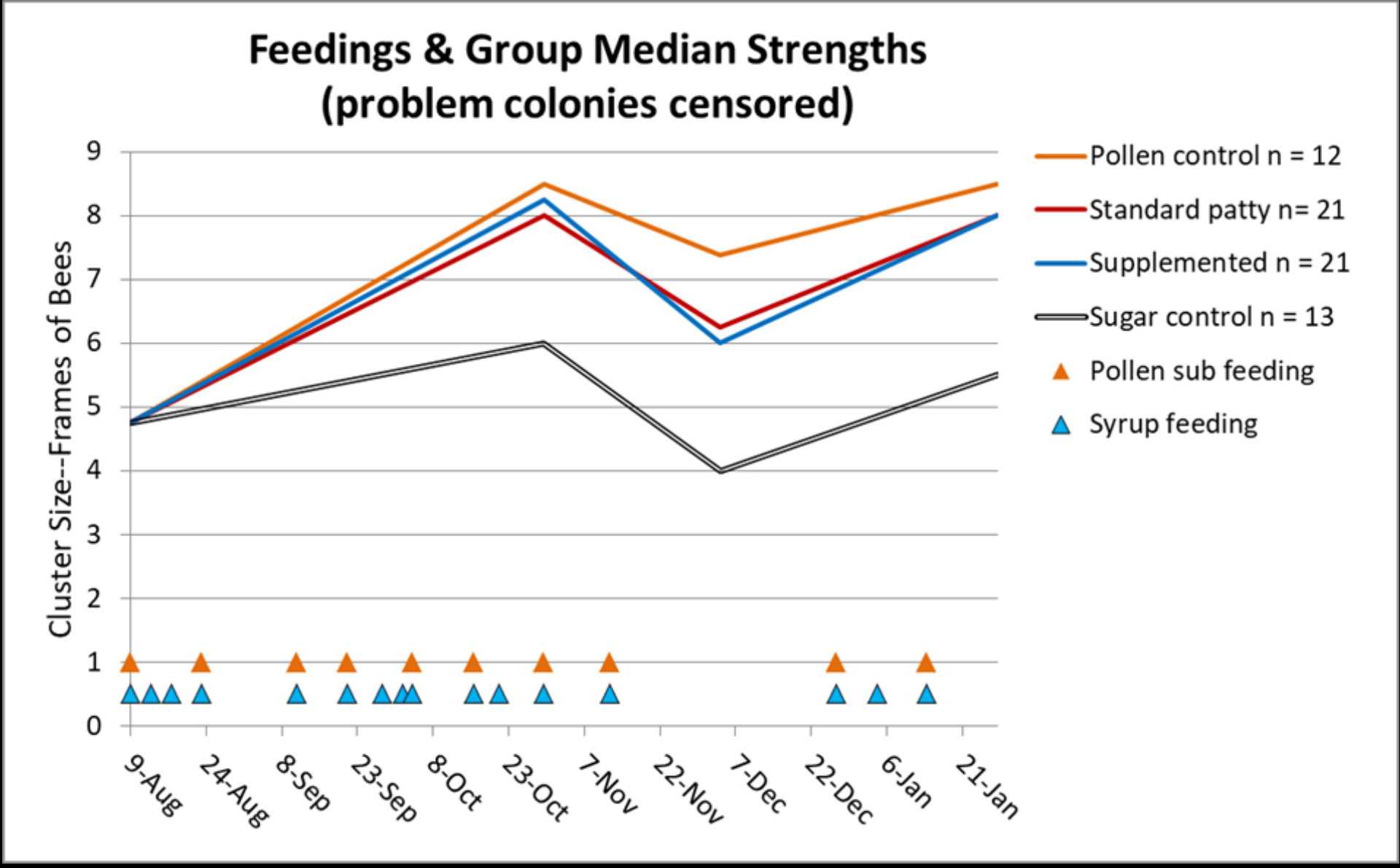
If the ***independent variable*** is the artificial diet type.

The "Test" groups get fed protein patties.

The "Negative Control" group gets fed an equal amount of sugar alone.

A "Positive Control" would be fed equal protein in patties of natural pollen.

The ***dependent variable*** would be the change in colony strength.



The test hives all fell between the positive and negative controls. This validates the experimental design.

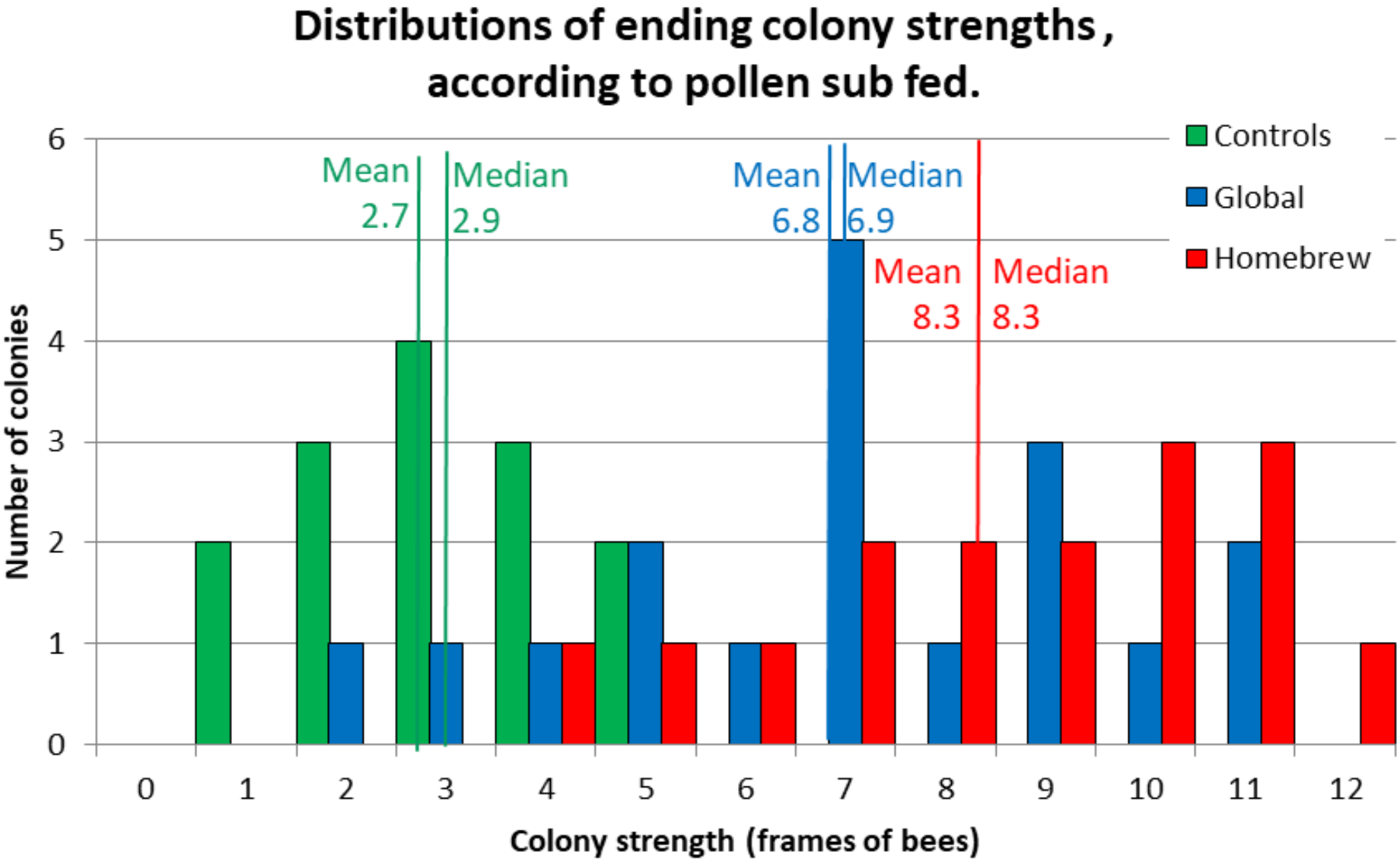
Teasing out a signal from the noise

The problem:

- **Within-group variability vs.**
- **Size of the effect due to treatment**

The larger the number of replicates, the smaller an effect you can detect.

Run a large enough "n" of replicates!
(With colonies, a minimum of 12 per test group)



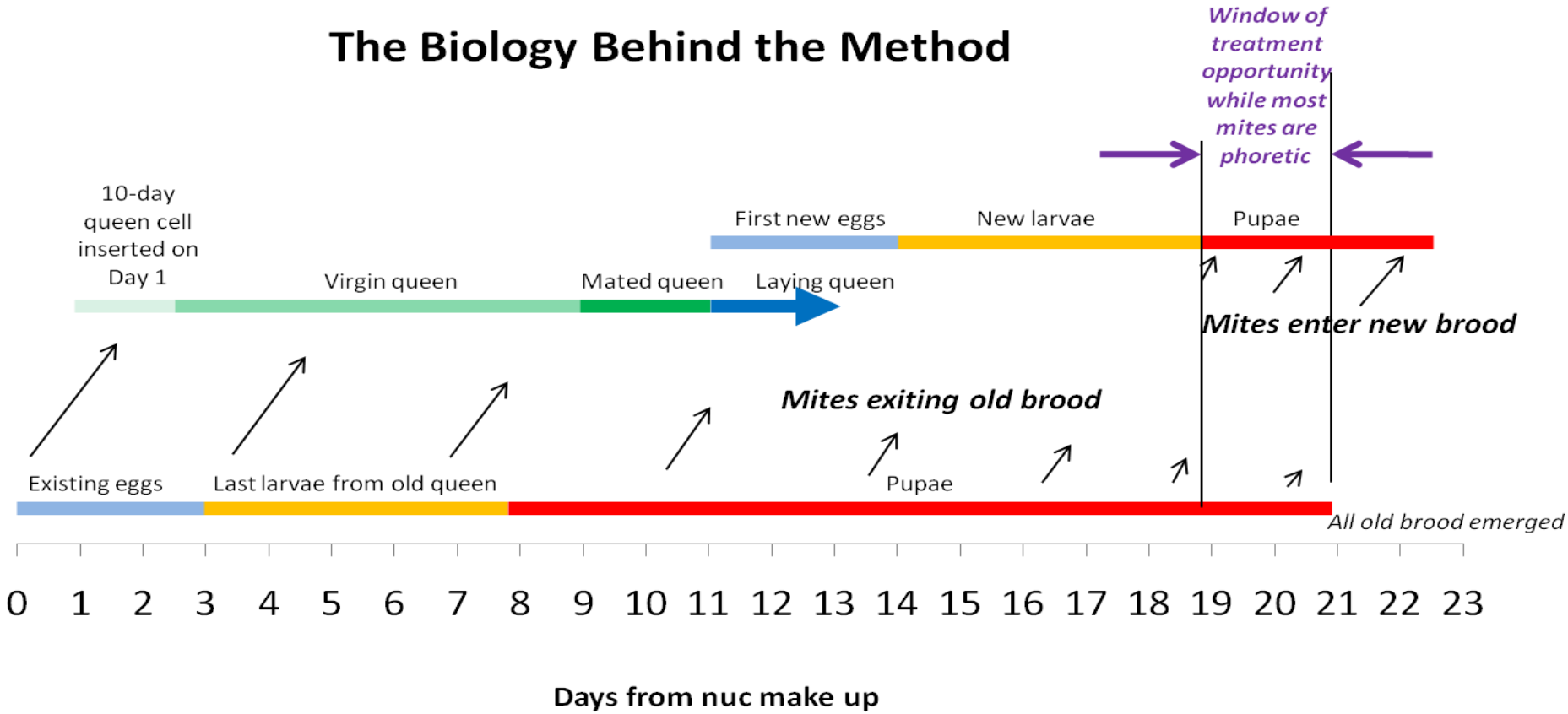
Compare the histograms of the test groups.
Sometimes "normal distributions," sometimes not.

SOME SIMPLE FIELD TRIALS

Does Oxalic Acid Treatment of Nucs Affect:

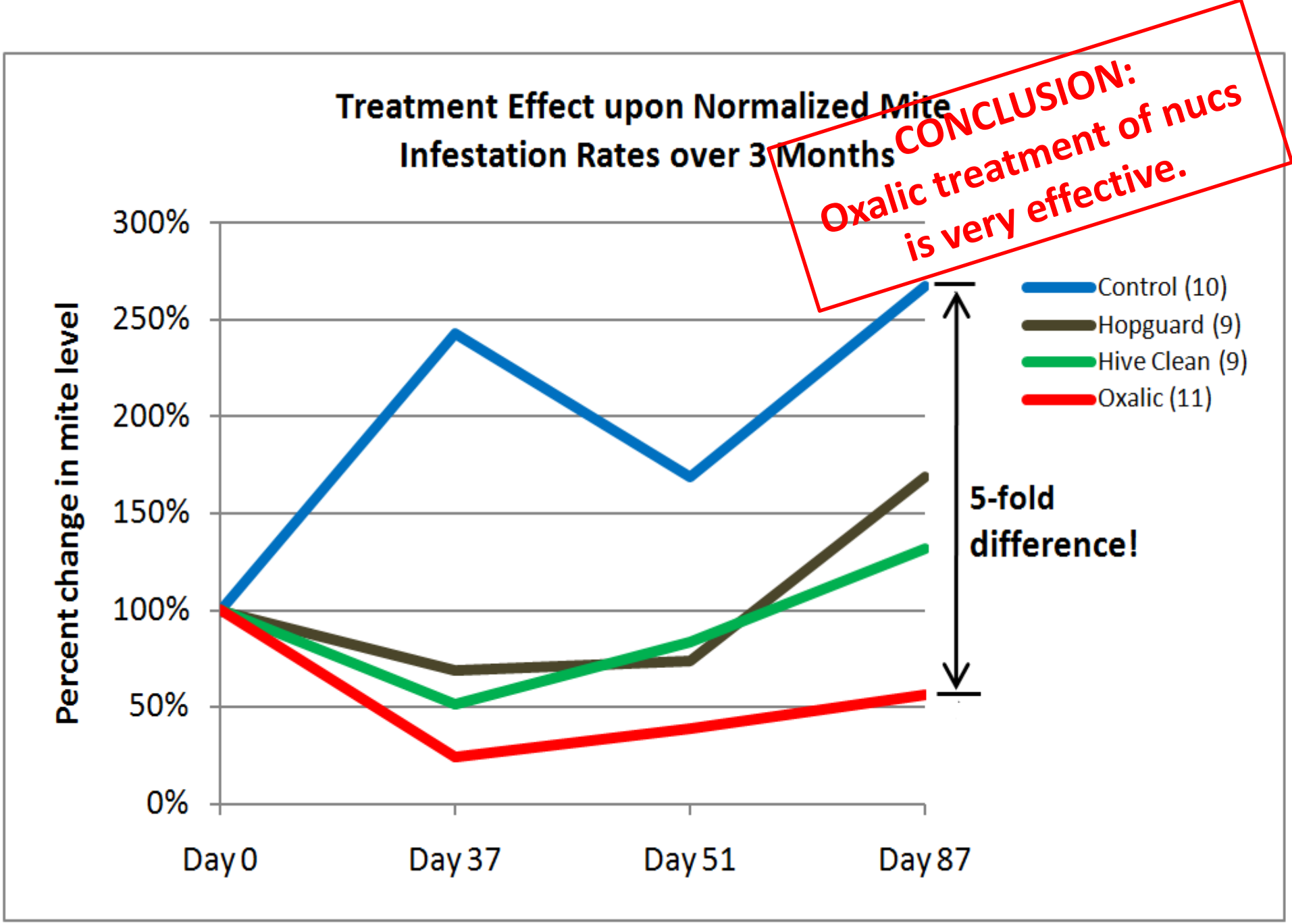
Mite Buildup?

Nucs made with queen cells, dribbled with OA on Day 19




Apply OA to Test group,
plain syrup to Control group

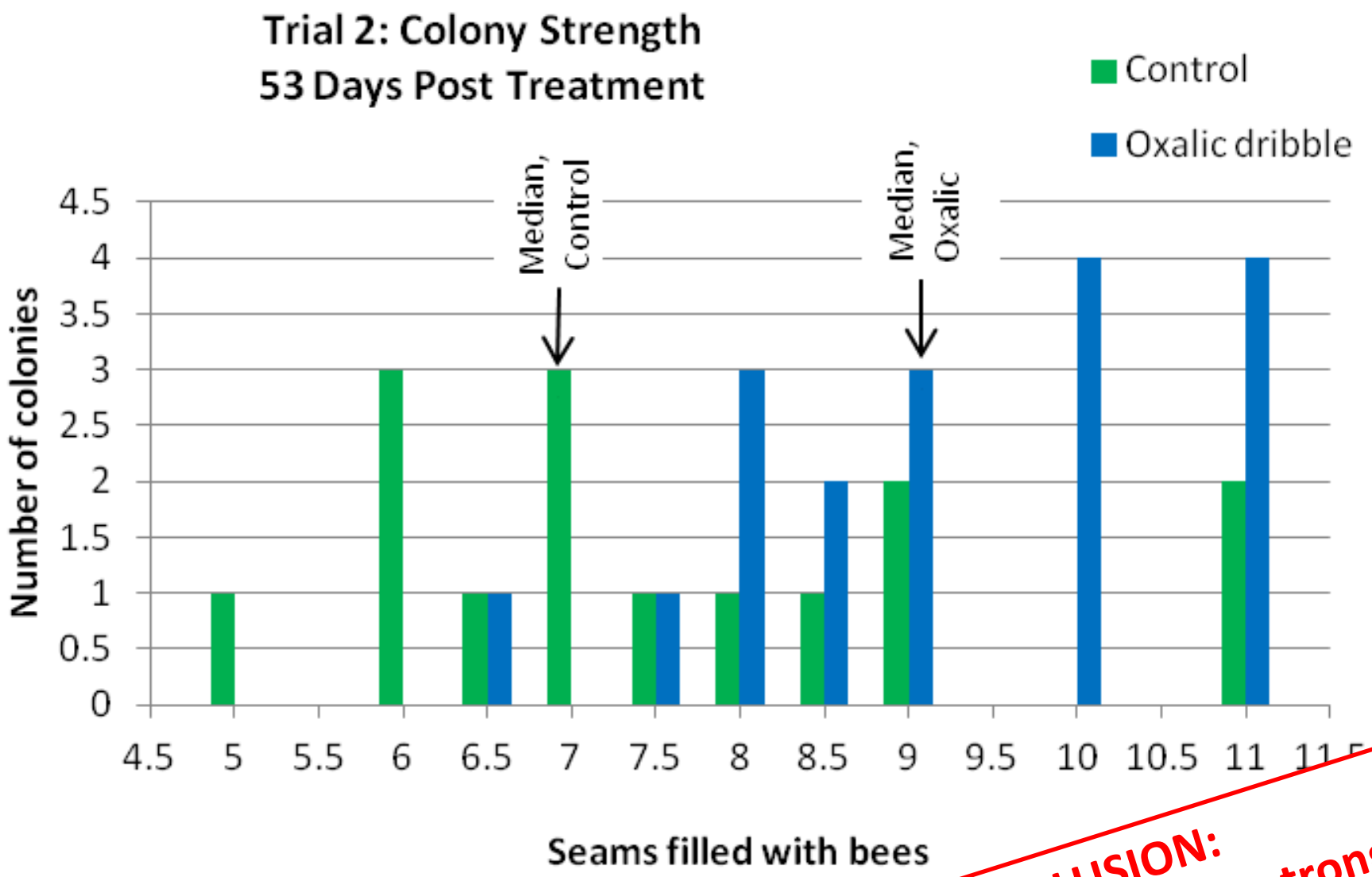
Perform mite wash counts at four time points


Treatment Effect upon Normalized Mite Infestation Rates over 3 Months
CONCLUSION: Oxalic treatment of nucs is very effective.
Percent change in mite level
300%
250%
200%
150%
100%
50%
0%
Day 0
Day 37
Day 51
Day 87
Control (10)
Hopguard (9)
Hive Clean (9)
Oxalic (11)
5-fold difference!

Does Oxalic Acid Treatment of Nucs Affect:

Colony Buildup?

Cluster grade



CONCLUSION:
Oxalic-treated nucs grew stronger.

Does Oxalic Acid Treatment of Nucs Affect:

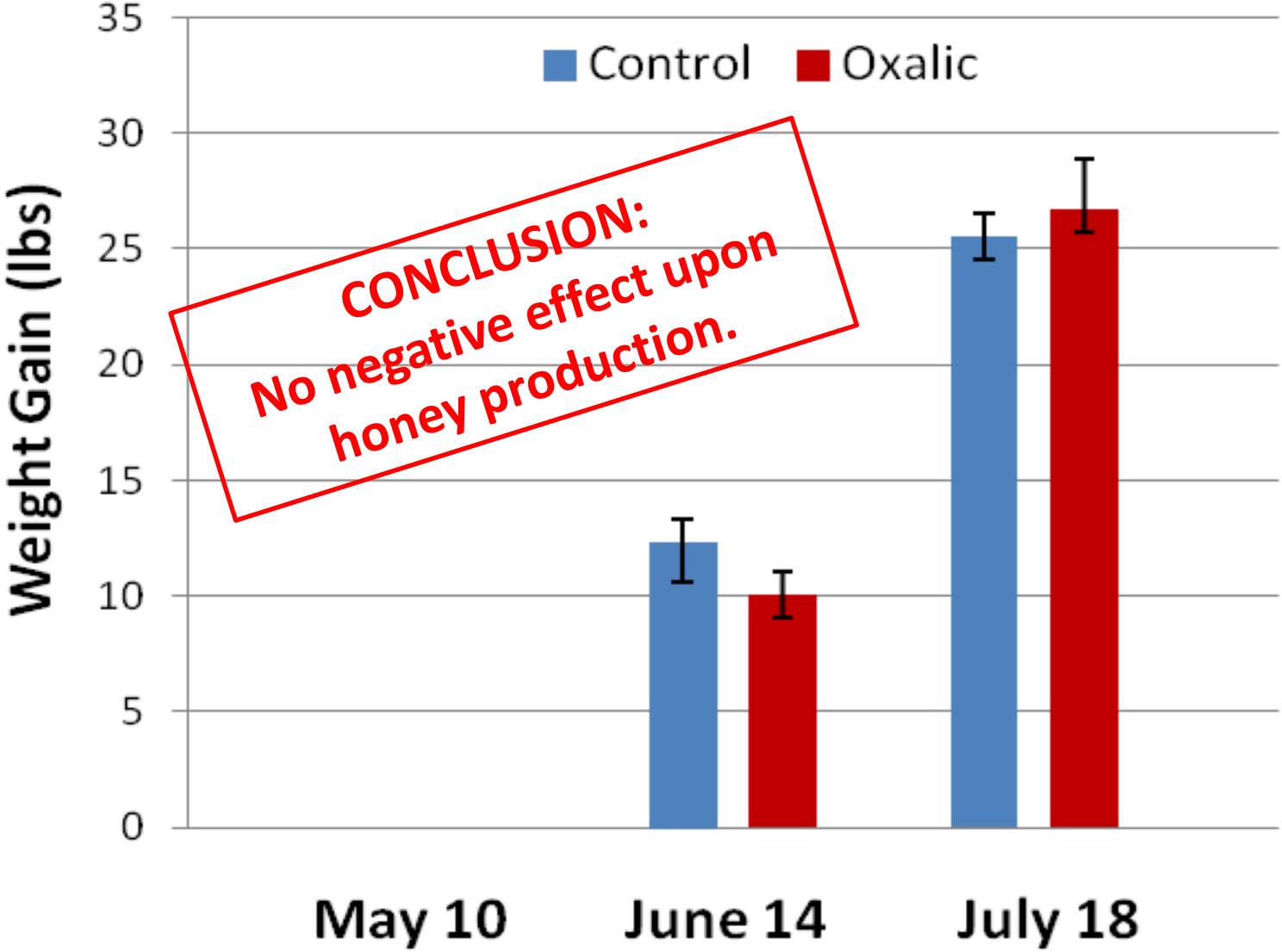
Honey Production?

BUT DOES OXALIC TREATMENT AFFECT HONEY PRODUCTION?
2013 TRIAL: 38 hives, sister queens.

Record hive weights over time, calculate net gain

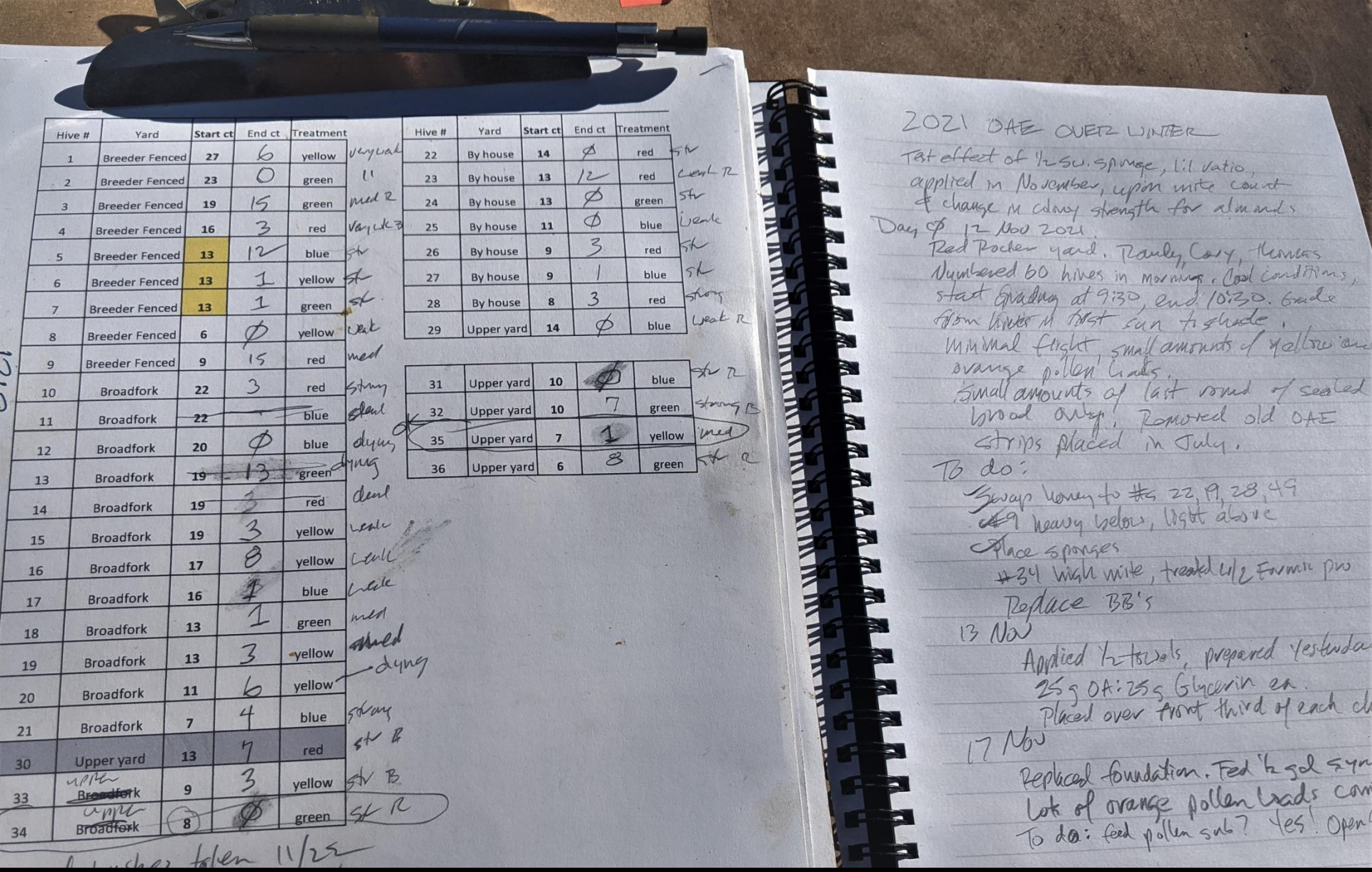
Hive	T/C	Init wt 5/10	2nd box wt 5/20	Total wt 5/20	Total wt 6/14	Net gain	Total wt 7/18	Net gain #2
1	C	42.2	17.6	59.8	68.4	8.6	71.4	3.0
2	T	45.2	17.8	63.0	75.6	12.6	95.0	19.4
3	C	47.8	17.2	65.0	72.4	7.4	92.8	20.4
4	C	41.8	17.2	59.0	70.4	11.4	87.0	16.6
5	C	41.0	17.8	58.8	76.4	17.6	96.2	19.8
6	C	46.4	18.4	64.8	79.4	14.6	92.4	13.0
7	T	40.6	17.2	57.8	69.8	12.0	77.2	7.4
8	T	43.6	17.4	61.0	73.2	12.2	89.2	16.0
9	T	50.2	17.4	67.6	73.4	5.8	71.8	-1.6
10	C	47.0	18.6	65.6	72.4	6.8	84.0	11.6
11	C	47.2	17.8	65.0	75.0	10.0	78.8	3.8
12	T	46.0	17.0	63.0	75.8	12.8	97.0	21.2
14	C	47.6	17.4	65.0	76.2	11.2	78.4	2.2
15	T	50.6	17.2	67.8	81.4	13.6	106.2	24.8
16	T	47.4	17.4	64.8	75.6	10.8	86.4	10.8
17	T	45.8	17.8	63.6	73.0	9.4	86.8	13.8
18	C	43.8	17.0	60.8	70.6	9.8	77.4	6.8
19	C	50.0	17.6	67.6	80.0	12.4	96.0	16.0
20	T	45.2	16.8	62.0	72.6	10.6	89.2	16.6
21	T	47.6	17.8	65.4	81.6	16.2	91.0	9.4
22	C	47.0	16.8	63.8	75.0	11.2	69.6	
23	C	42.0	17.4	59.4	77.4	18.0	97.0	19.6
24	C	47.0	17.6	64.6	80.0	15.4	100.6	20.6
25	C	49.4	18.0	67.4	82.4	15.0	101.8	19.4
26	T	43.2	17.4	60.6	74.6	14.0	85.6	11.0
27	C	40.4	18.8	59.2	75.0	15.8	81.2	6.2
28	C	49.2	17.0	66.2	70.8	4.6	94.4	23.6
29	T	41.2	17.8	59.0	63.8	4.8	80.2	16.4
30	T	48.6	18.0	66.6	73.2	6.6	100.8	27.6
31	T	41.0	17.0	58.0	67.0	9.0	85.8	18.8
32	T	45.2	17.2	62.4	70.2	7.8	87.6	17.4
33	C	44.2	17.6	61.8	77.8	16.0	91.4	13.6
34	T	48.6	17.2	65.8	74.0	8.2	98.6	24.6
35	T	45.4	17.6	63.0	68.6	5.6	73.8	5.2
36	T	46.0	17.8	63.8	73.0	9.2	92.8	19.8
37	C	49.2	17.8	67.0	83.0	16.0	112.8	29.8
						11.2		15.0

Hive weight gain after oxalic treatment



CONCLUSION:
No negative effect upon honey production.

Keep a Written Log,
Record all field notes, *in the field*
(don't trust your memory!)
(not even for a moment!)



Hive #	Yard	Start ct	End ct	Treatment	
1	Breeder Fenced	27	6	yellow	very weak
2	Breeder Fenced	23	0	green	"
3	Breeder Fenced	19	15	green	med R
4	Breeder Fenced	16	3	red	very weak B
5	Breeder Fenced	13	12	blue	str
6	Breeder Fenced	13	1	yellow	str
7	Breeder Fenced	13	1	green	str
8	Breeder Fenced	6	Ø	yellow	weak
9	Breeder Fenced	9	15	red	med
10	Broadfork	22	3	red	strong
11	Broadfork	22	1	blue	dead
12	Broadfork	20	Ø	blue	dying
13	Broadfork	19	13	green	dying
14	Broadfork	19	3	red	dead
15	Broadfork	19	3	yellow	weak
16	Broadfork	17	8	yellow	weak
17	Broadfork	16	4	blue	weak
18	Broadfork	13	1	green	med
19	Broadfork	13	3	yellow	~~med~~ dying
20	Broadfork	11	6	yellow	
21	Broadfork	7	4	blue	strong
30	Upper yard	13	7	red	str R
33	~~Broadfork~~ upper	9	3	yellow	str B
34	~~Broadfork~~ upper	8	Ø	green	str R

Hive #	Yard	Start ct	End ct	Treatment	
22	By house	14	Ø	red	str
23	By house	13	12	red	weak R
24	By house	13	Ø	green	str
25	By house	11	Ø	blue	weak
26	By house	9	3	red	str
27	By house	9	1	blue	str
28	By house	8	3	red	strong
29	Upper yard	14	Ø	blue	weak R

31	Upper yard	10	Ø	blue	str R
32	Upper yard	10	7	green	strong B
35	Upper yard	7	1	yellow	med
36	Upper yard	6	8	green	str R

2021 OAE OVER WINTER

Test effect of ½ su. sponge, 1:1 ratio, applied in November, upon mite count & change in colony strength for almonds

Day Ø 12 Nov 2021

Red Rocker yard. Rauly, Cory, Thomas

Numbered 60 hives in morning. Cool conditions, start grading at 9:30, end 10:30. Grade from hives in first sun to shade.

Minimal flight, small amounts of yellow and orange pollen loads.

Small amounts of last round of sealed brood only. Removed old OAE strips placed in July.

To do:

Swap honey to #s 22, 19, 28, 49

#9 heavy below, light above

Place sponges

#34 high mite, treated w/ Formic pro

Replace BB's

13 Nov

Applied ½ towels, prepared yesterday

25 g OA : 25 g Glycerin ea.

Placed over front third of each cl

17 Nov

Replaced foundation. Fed ½ gal syr

Lots of orange pollen loads com

To do: feed pollen sub? Yes! Open

Print off data sheets for entering field data (cardstock or WP paper). Keep a detailed logbook.

TRIAL LOG

May 14, 2014 Moved 30 nucs to Lower Colfax yard, set in three rows, worked into pairs of singles with entrances spread. All newly-mated tested queens from the same graft from the same mother, mated in the same yard. All nucs oxalic'd at Day 19; all checked for good patterns of worker brood.

May 17 Equalized all into 5-frames in a single. Three frames of brood in center (typ. 2 sealed, 1 open); one frame of honey/pollen and one drawn comb to either side. Shook bees to equalize coverage to one full layer of bees on the outside combs. Need approx. 4 lbs of shook bees tomorrow to fully equalize for strength.

May 19 Full 5-frame nucs drawing comb from lids. Boosted colonies with shook bees, need more? Treated all with a drench of ½ cup 1:1 sugar syrup containing 95 mg fumagillin and 100 mg OTC.

May 21 Added shook bees to weaker colonies.

I type it up from my handwritten field notes in the Log Book.

Tips


Cluster grading


Boom loader and crane scale
016RAZ

Weighing

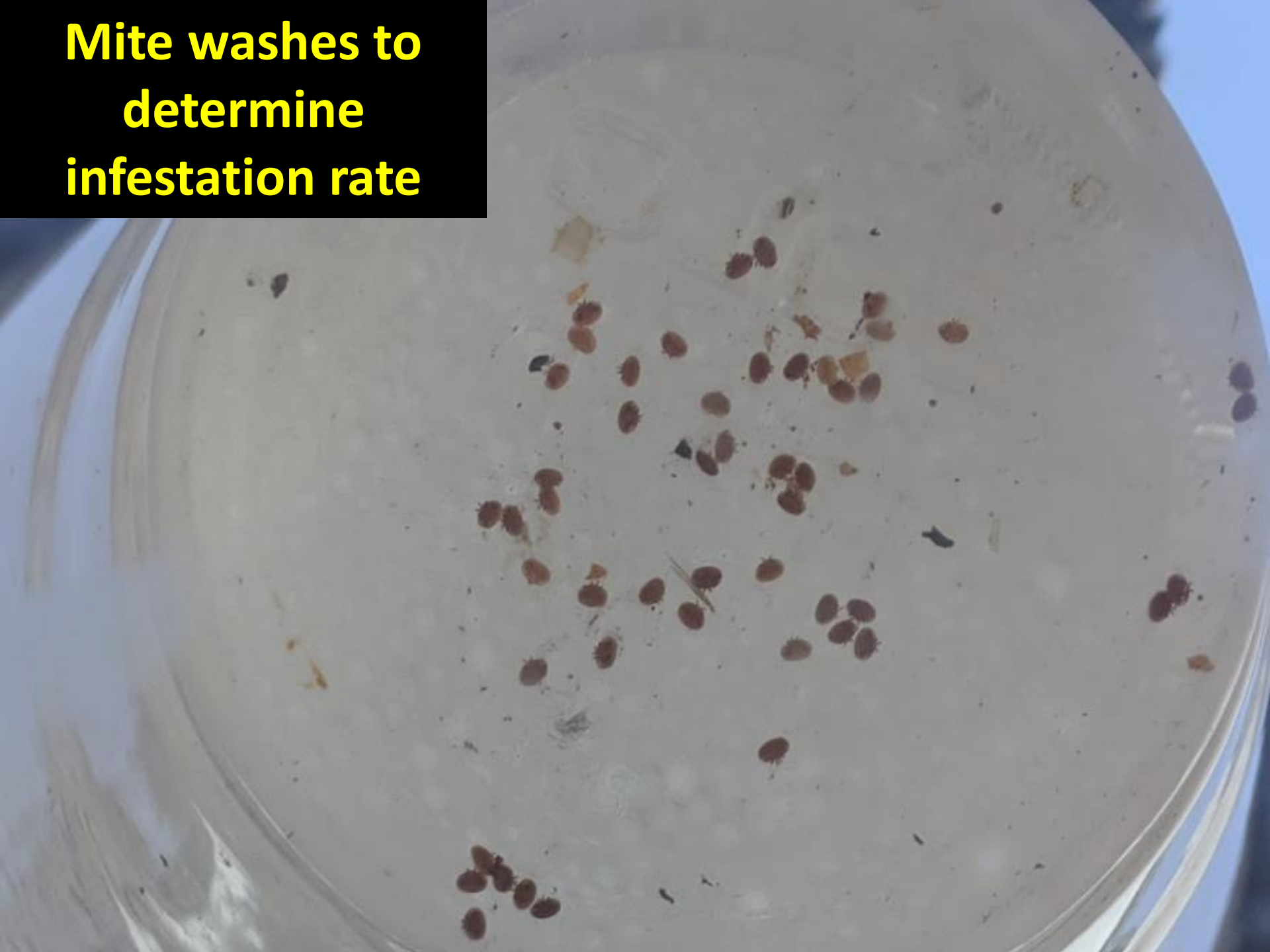
I often build custom devices

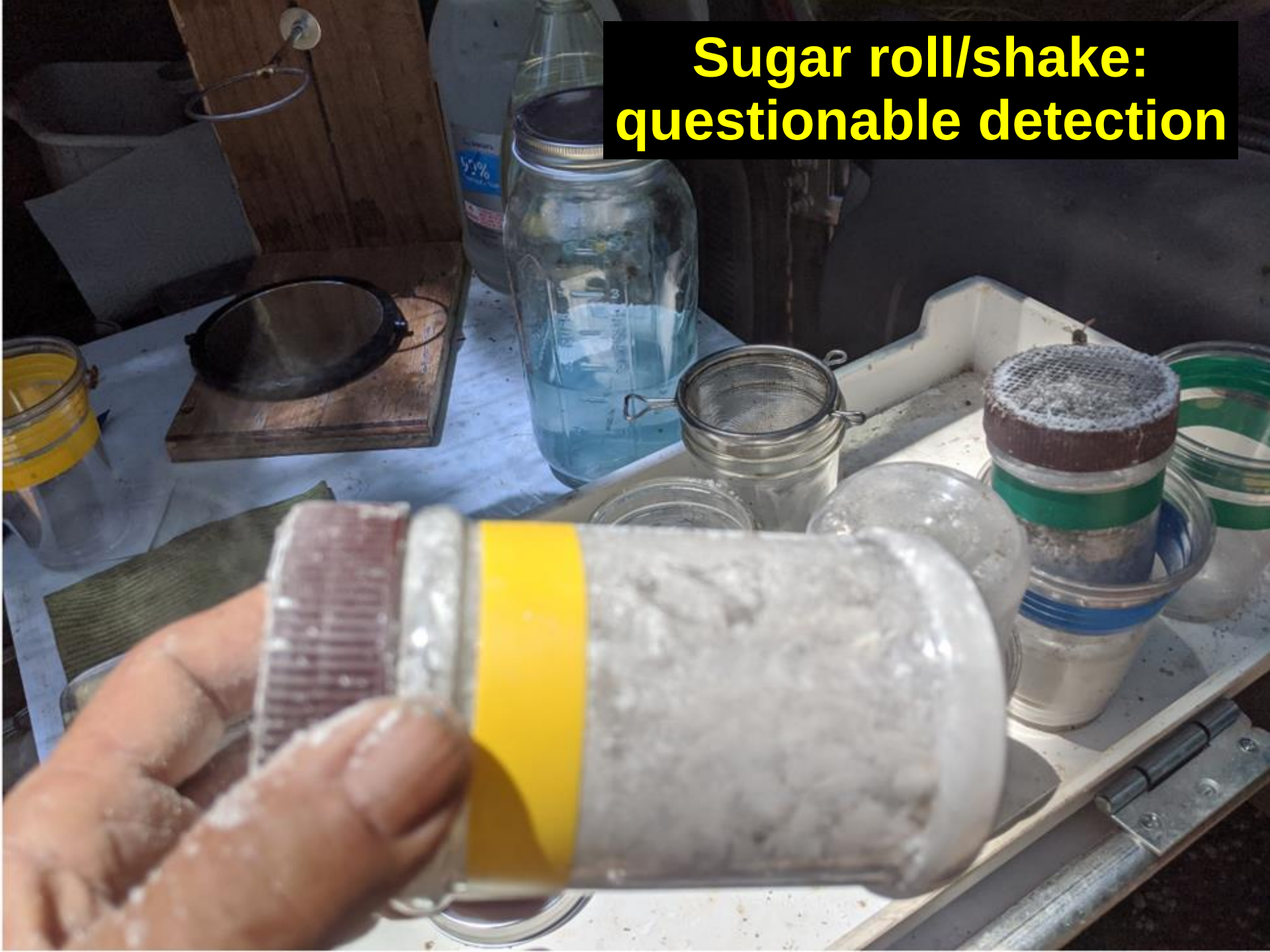

Mike Palmer
balancing hive
on floor scale


Varroa mite drop:
Stickyboards

13-oz container of Vaseline dissolved in 1 pint of mineral oil. Use drywall knife to quickly scrape clean.

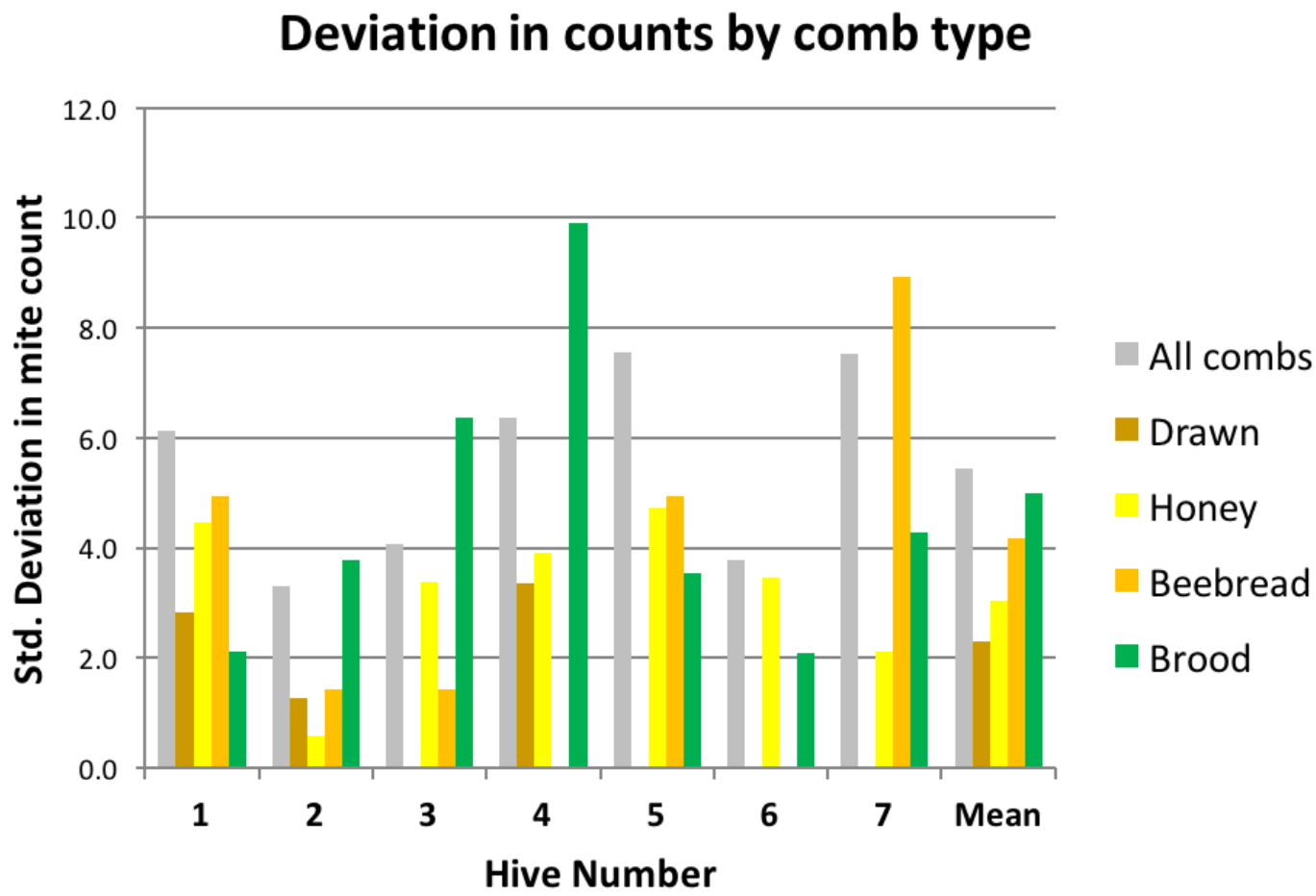
Mite washes to determine infestation rate




Sugar roll/shake:
questionable detection

Best mite release with 91% alcohol or Dawn detergent.

To avoid peering through foam to count mites, use a 10x magnifying mirror (6-inch diameter) placed about 4 inches below the bottom of the cup.



Take bee sample from a frame adjacent to brood.

If you want to find the highest infestation rate, take a bee sample from a brood comb with young larvae, but be prepared for wide variability. Otherwise, if your goal is to obtain a *consistent and representative* sample of the adult bee infestation rate, shake it from a drawn or honey comb free of brood, but adjacent to the broodnest. Doing so has the huge added advantage of greatly reducing your chance of inadvertently harming the queen.


Shake bees into an
18-qt dish tub, and
let the flyers fly off


Record number of mites per *level* ½ cup of bees, unless you want to count the bees!


We standardize with timed mechanical agitators
DIRTY

Department of Pesticide Regulation
Pesticide Research Authorization
PR-REG-027a (Est. 12/12)
See Instructions on Reverse

DPR Use ONLY
#1702050

Pesticide Research Authorization

1. Researcher

Researcher	Randy Oliver	Phone #	
Firm Name	ScientificBeekeeping.com	Cell Phone #	530 277 4450
Address	14744 Meadow Dr	E-mail Address	randy@randyoliver.com
City, State Zip	Grass Valley, CA 95945	Type or print address information for use as a mailing label.	

Pesticide

	2. Product Name	3. U.S. EPA Reg. or EUP No (if any)	4. Pesticide Reg. Type (check one)	5. Fumigant
1	Oxalic acid dihydrate	91266-1	■ Fed ☐ CA ☐ Both ☐ Unreg	☐ Yes ■ No

6. Active Ingredient(s)	7. Maximum Rate (A.I.)	8. Method of Application (check one or more)
Oxalic acid dihydrate	24 g / hive	☐ Aerial ☐ Handheld
		☐ Ground ☐ Chemigation
		■ in hive on shop towel

9. Type of Pesticide (check one or more)

☐ Insecticide ☐ Herbicide ☐ Defoliant ☐ Rodenticide ☐ Plant Growth Regulator ☐ Pheromone
☐ Spray Adjuvant ☐ Fungicide ☐ Desiccant ☐ Nematicide ■ miticide on bees

10. Formulation	11. Residue Tolerance (check one)	12. Multiple Applications	13. Max Size of Each Trial	14. Max # of Trials	15. Total Area or Units
OA dissolved in glycerin	☐Yes ☐No ■Exempt	■Yes ☐No	100 hives	6	600 hives

16. Stage of Growth (check one or more – Pre- and Post-harvest cannot both be selected on one

☐ Seeds ☐ Pre-plant ☐ Pre-emergent ■ Growing season ☐ Pre-harvest ☐ Post-harvest

	17. Commodity, Crop Group or Site to be Treated	18. D
A	honey bee hives	☐ H
B		☐ H
C		☐ H

To add additional pesticides or commodities, please use form PR-REG-027b.

Research Detail

Get a pesticide research permit if necessary

Photos are often better than words – take them at every step!

Identify hives clearly.
(I like plastic restaurant place tags)

For colony growth trials, first equalize nucs with only 5 frames in the box.

Recording your Data

Experiment Name

_____

Date_____

Yard_____

Investigator

_____

Time point _____

Type of data (measurement)

_____

Field Notes:

Hive	Date	Date	Date	Date
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				
11				
12				

PRINT DATA SHEETS ON HEAVY CARDSTOCK

TRANSFER DATA TO EXCEL

Hive	T/C	Init wt 5/10	2nd box wt 5/20	Total wt 5/20	Total wt 6/14	Net gain	Total wt 7/18	Net gain #2
1	C	42.2	17.6	59.8	68.4	8.6	71.4	3.0
2	T	45.2	17.8	63.0	75.6	12.6	95.0	19.4
3	C	47.8	17.2	65.0	72.4	7.4	92.8	20.4
4	C	41.8	17.2	59.0	70.4	11.4	87.0	16.6
5	C	41.0	17.8	58.8	76.4	17.6	96.2	19.8
6	C	46.4	18.4	64.8	79.4	14.6	92.4	13.0
7	T	40.6	17.2	57.8	69.8	12.0	77.2	7.4
8	T	43.6	17.4	61.0	73.2	12.2	89.2	16.0
9	T	50.2	17.4	67.6	73.4	5.8	71.8	-1.6
10	C	47.0	18.6	65.6	72.4	6.8	84.0	11.6
11	C	47.2	17.8	65.0	75.0	10.0	78.8	3.8
12	T	46.0	17.0	63.0	75.8	12.8	97.0	21.2
14	C	47.6	17.4	65.0	76.2	11.2	78.4	2.2
15	T	50.6	17.2	67.8	81.4	13.6	106.2	24.8
16	T	47.4	17.4	64.8	75.6	10.8	86.4	10.8
17	T	45.8	17.8	63.6	73.0	9.4	86.8	13.8
18	C	43.8	17.0	60.8	70.6	9.8	77.4	6.8
19	C	50.0	17.6	67.6	80.0	12.4	96.0	16.0
20	T	45.2	16.8	62.0	72.6	10.6	89.2	16.6
21	T	47.6	17.8	65.4	81.6	16.2	91.0	9.4
22	C	47.0	16.8	63.8	75.0	11.2	69.6	
23	C	42.0	17.4	59.4	77.4	18.0	97.0	19.6
24	C	47.0	17.6	64.6	80.0	15.4	100.6	20.6
25	C	49.4	18.0	67.4	82.4	15.0	101.8	19.4
26	T	43.2	17.4	60.6	74.6	14.0	85.6	11.0
27	C	40.4	18.8	59.2	75.0	15.8	81.2	6.2
28	C	49.2	17.0	66.2	70.8	4.6	94.4	23.6
29	T	41.2	17.8	59.0	63.8	4.8	80.2	16.4
30	T	48.6	18.0	66.6	73.2	6.6	100.8	27.6
31	T	41.0	17.0	58.0	67.0	9.0	85.8	18.8
32	T	45.2	17.2	62.4	70.2	7.8	87.6	17.4
33	C	44.2	17.6	61.8	77.8	16.0	91.4	13.6
34	T	48.6	17.2	65.8	74.0	8.2	98.6	24.6
35	T	45.4	17.6	63.0	68.6	5.6	73.8	5.2
36	T	46.0	17.8	63.8	73.0	9.2	92.8	19.8
37	C	49.2	17.8	67.0	83.0	16.0	112.8	29.8
						11.2		15.0

Presenting your Data:
Tables and types of Charts

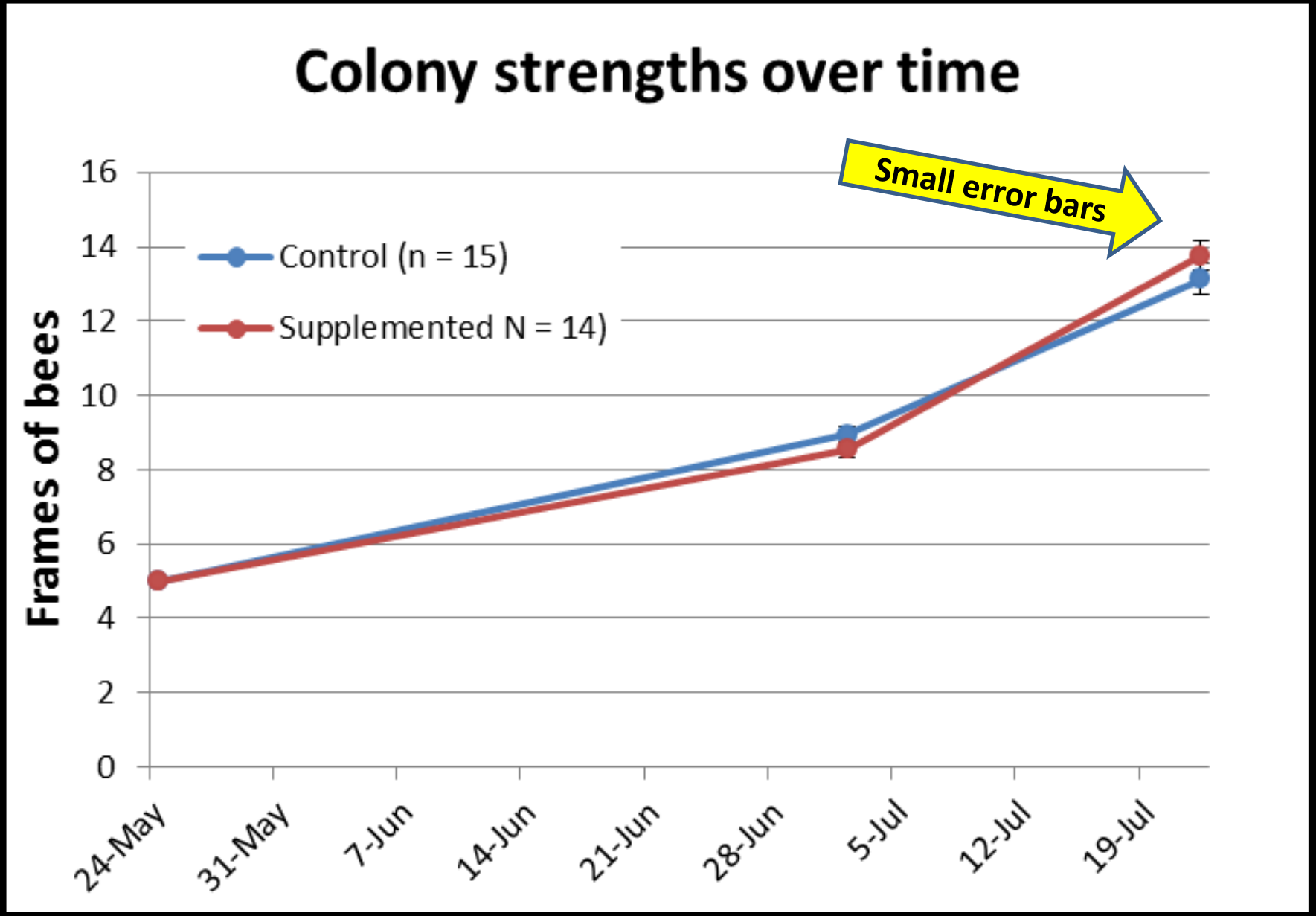
Helping your eyes and brain to tease out meaning.

Analyze data and show results.

Have mercy on your audience.
Avoid showing results in tables!

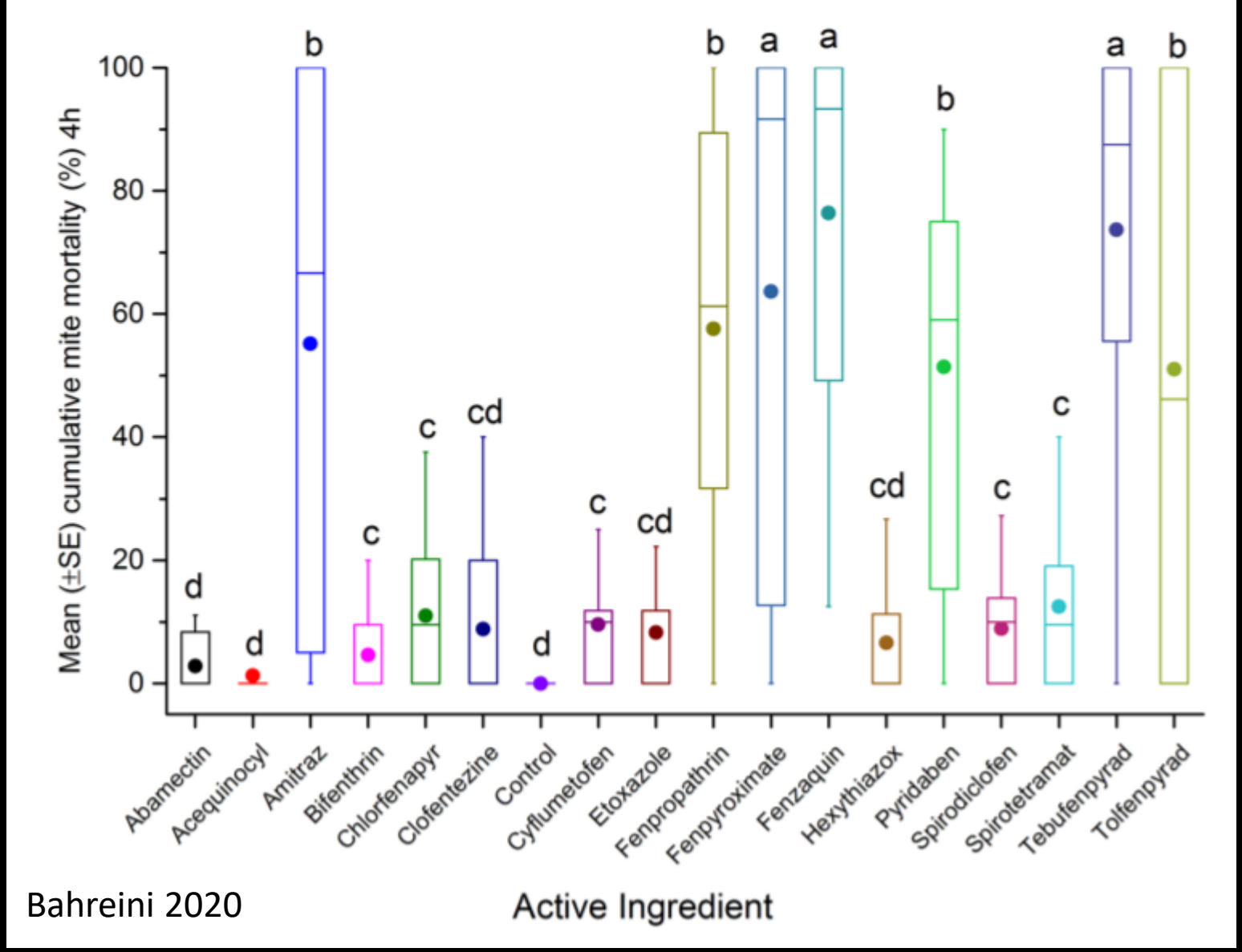
Table 1. Mean colony strengths over time				
		24-May	2-Jul	22-Jul
	n	Mean frames of bees (SEM)		
Unfed	15	5 (0.0)	8.5 (0.20)	13.8 (0.40)
Fed	14	5 (0.0)	8.9 (0.22)	13.1 (0.42)
No significant difference, p = 0.08 Student's t test				

A bunch of numbers are difficult to interpret!



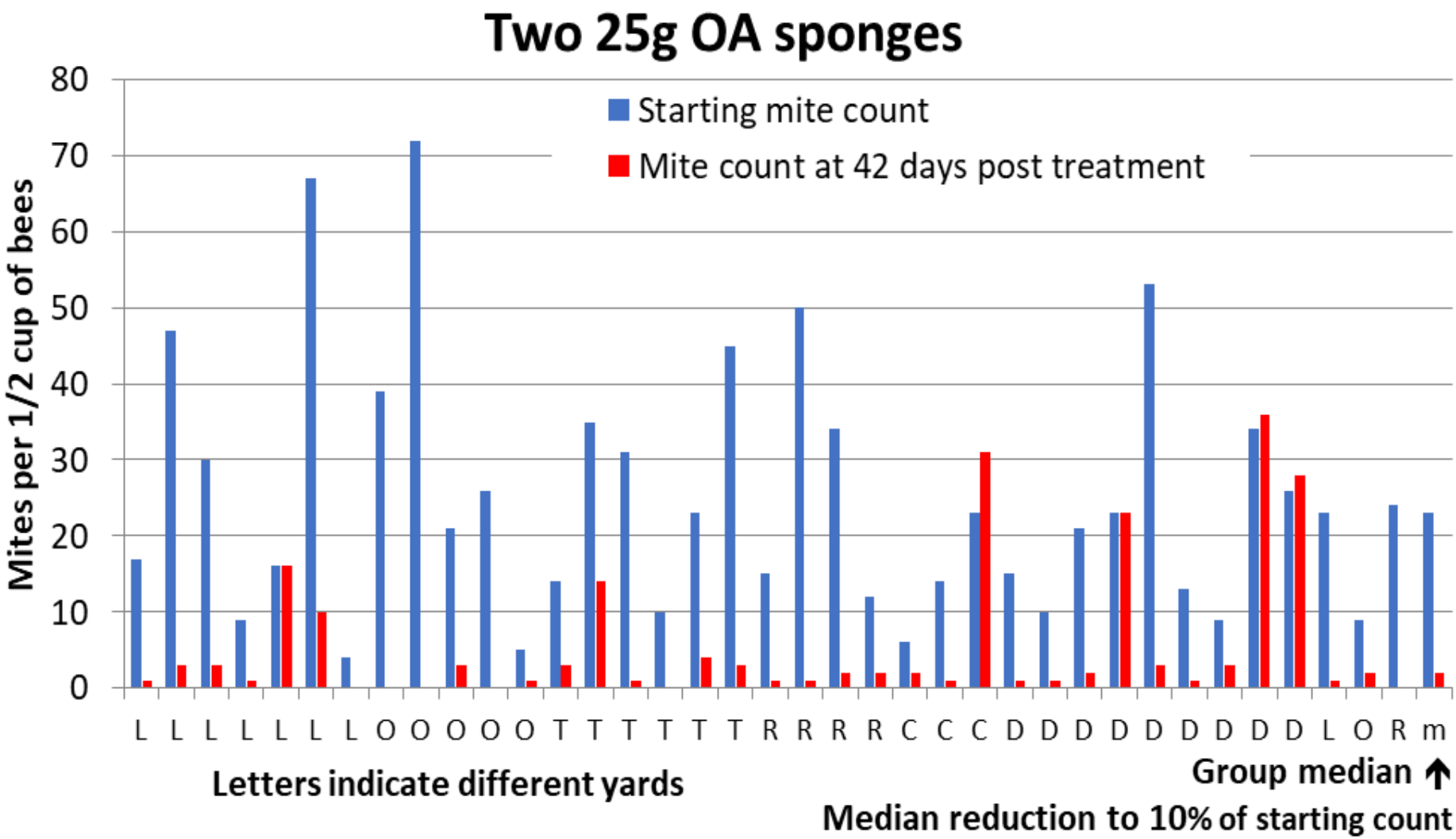
Same data. The human brain prefers pictures.

Instant interpretation: no difference between test groups !

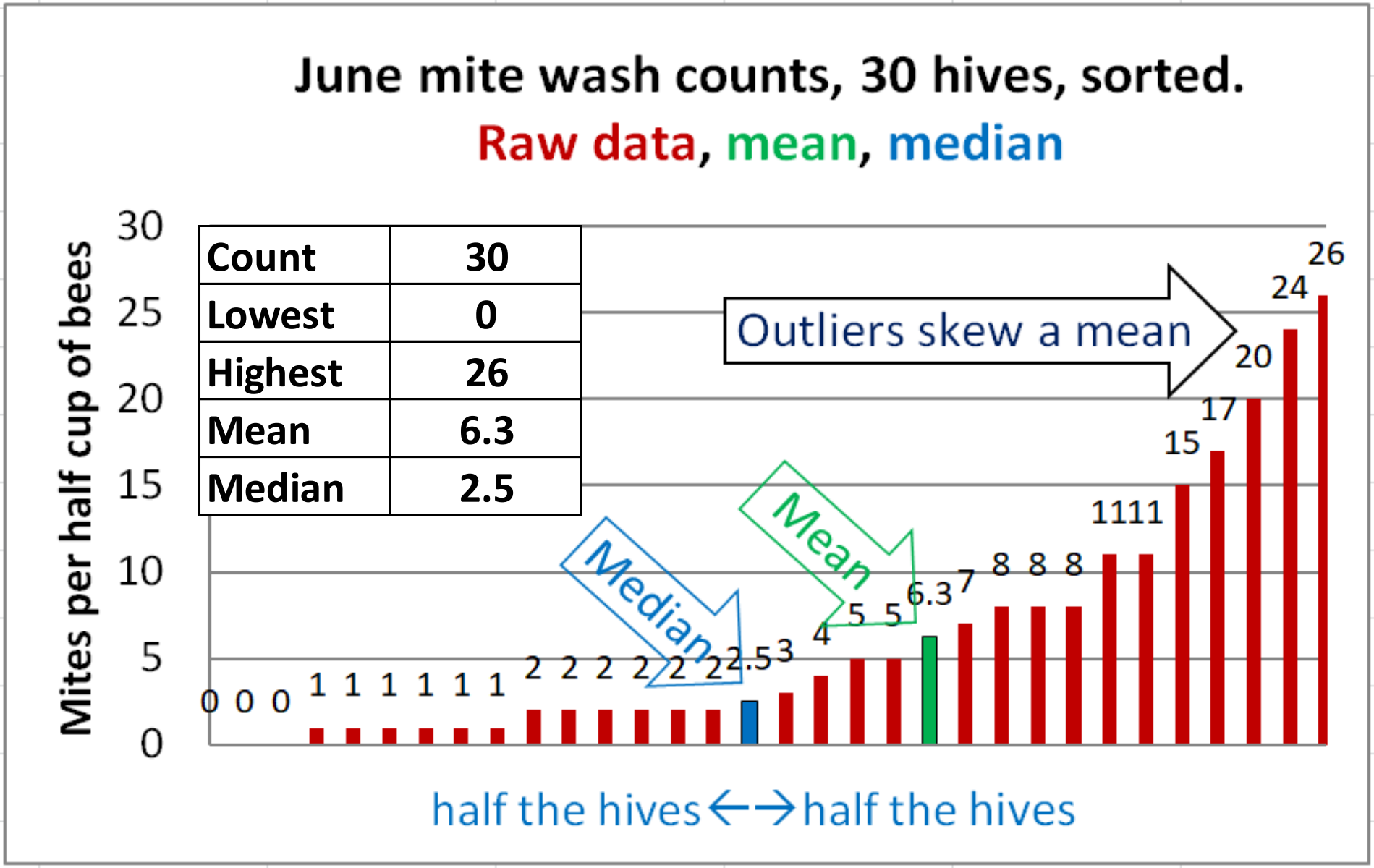


Bahreini 2020

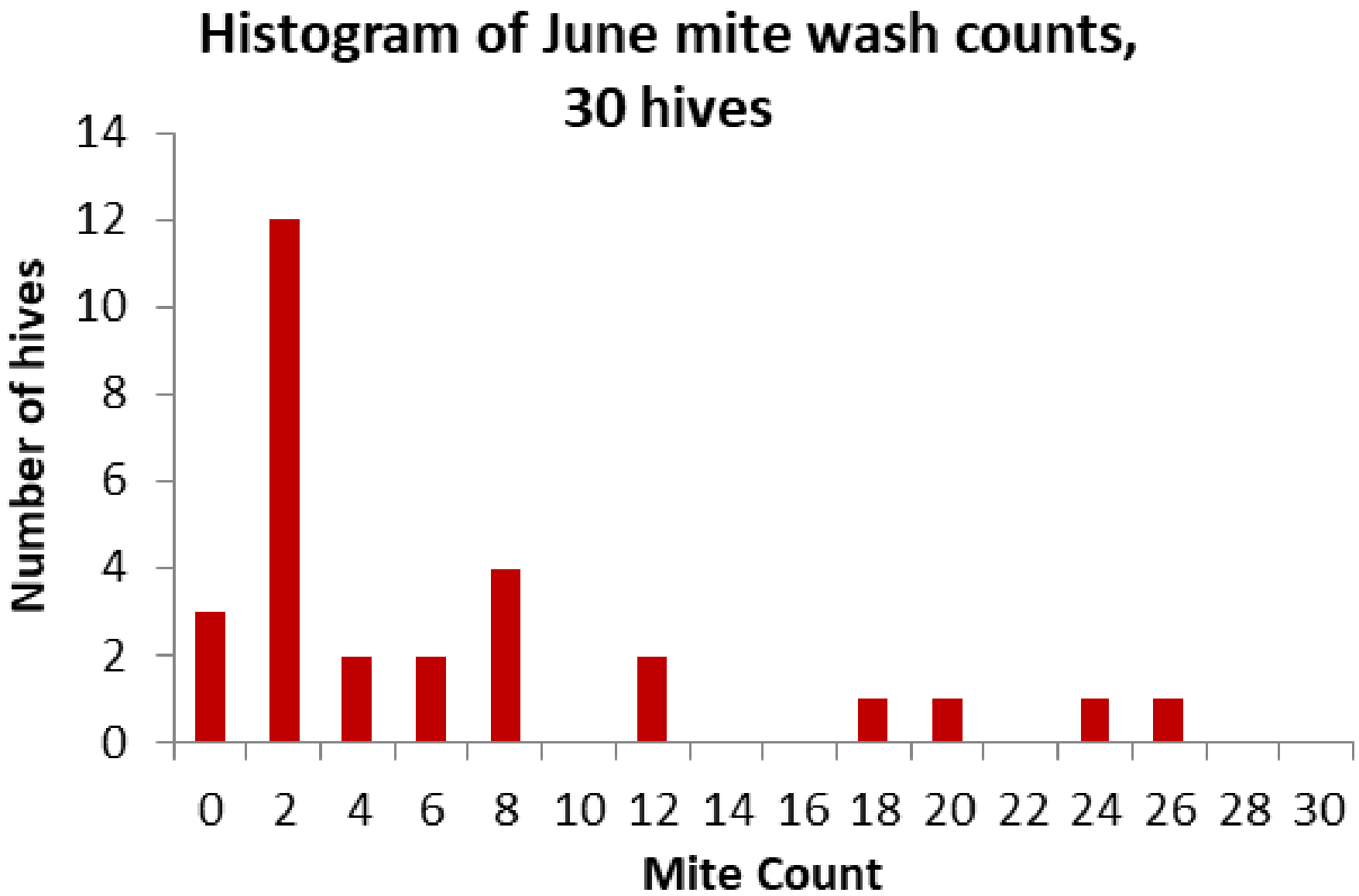
Means, boxplots, and statistics don't tell the whole story. *And don't resonate with beekeepers!*



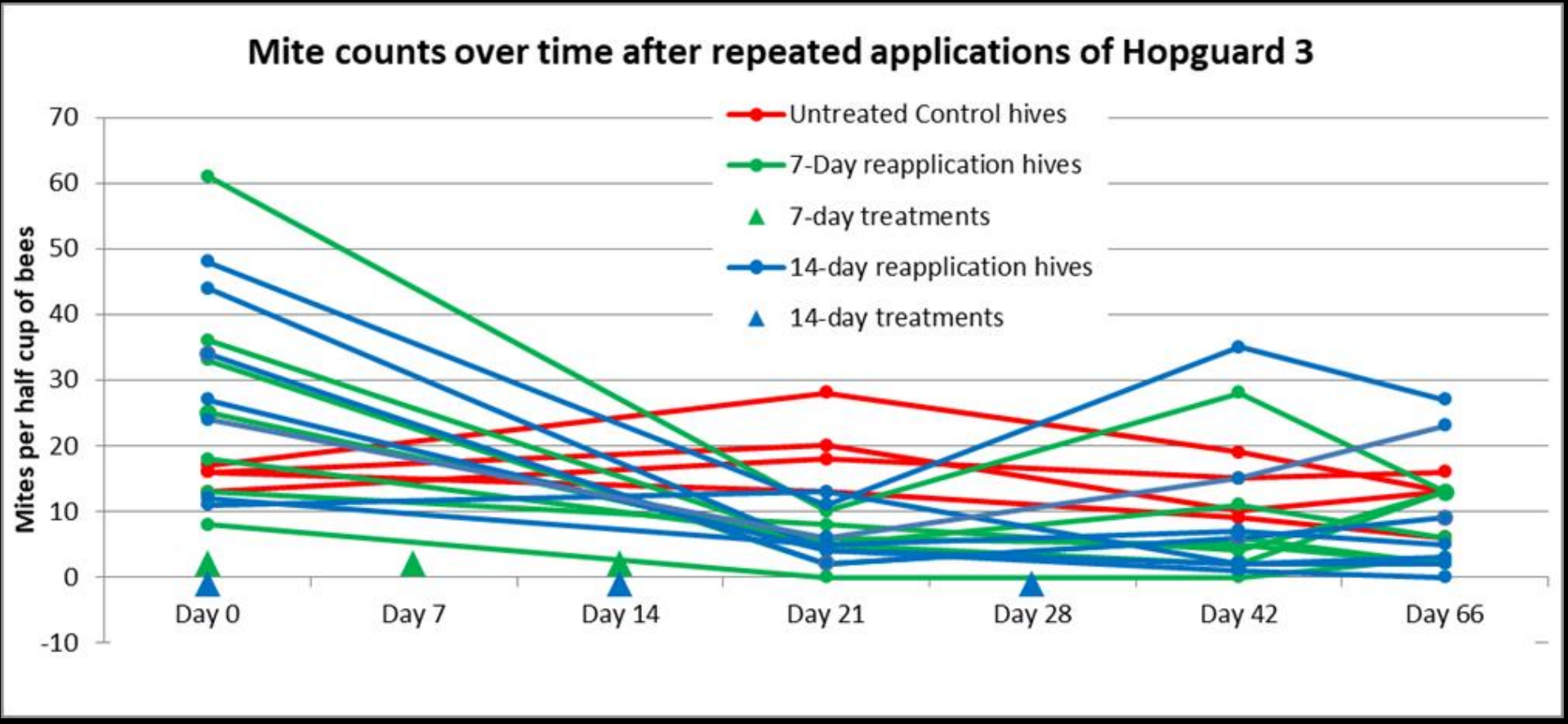
Simple presentation of raw data may be best!



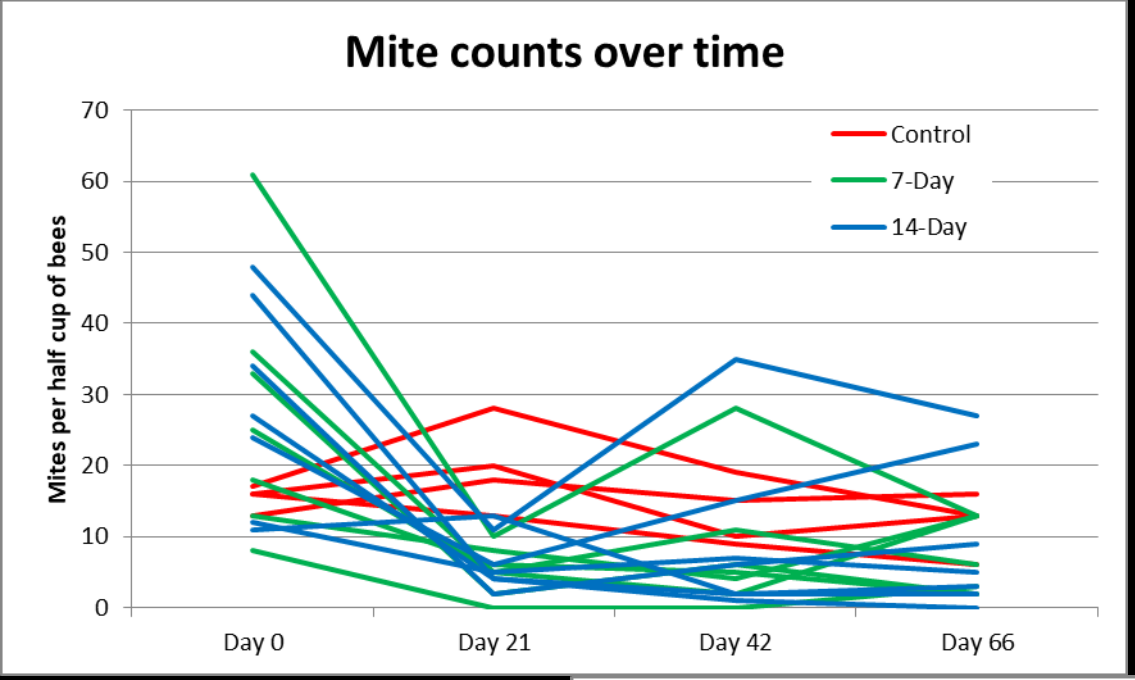
Averages: means (numerical average) or medians (half above, half lower)?



Same data: A histogram give a better picture!

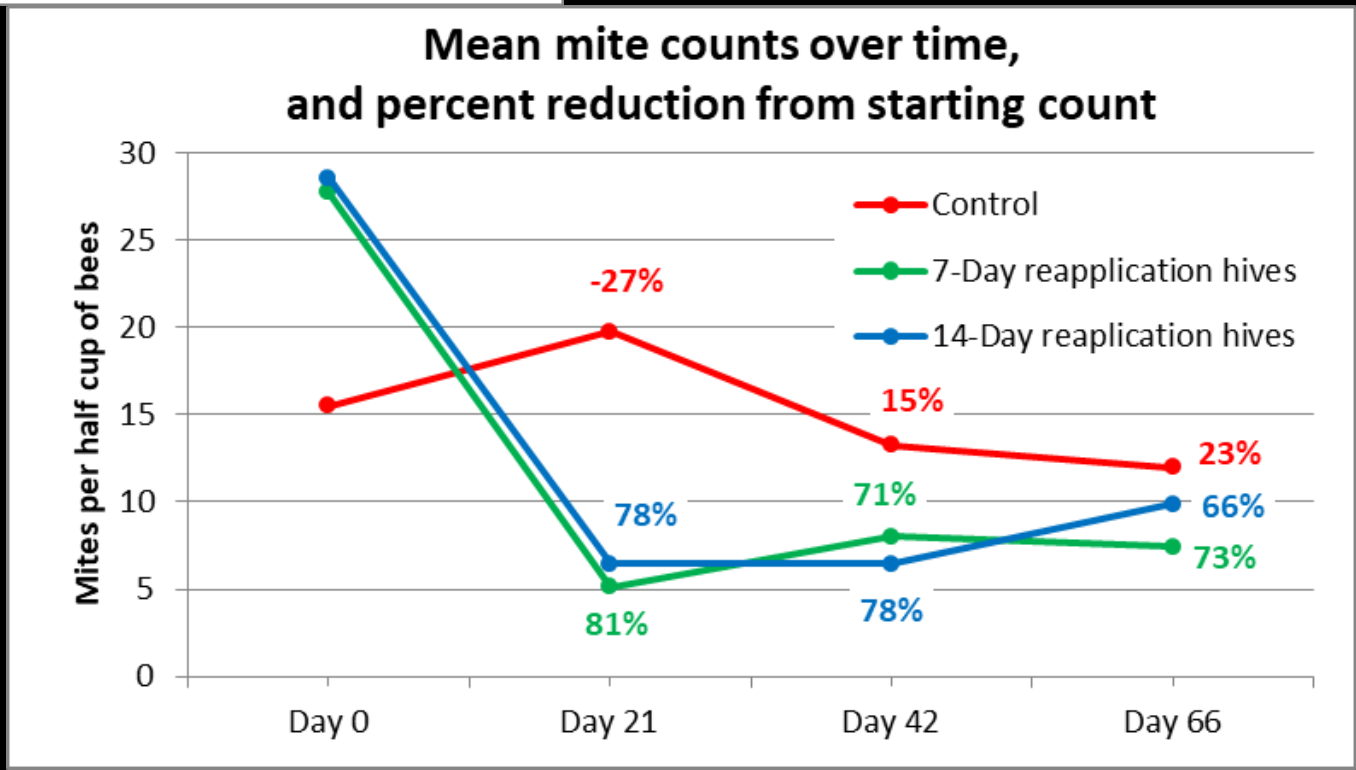


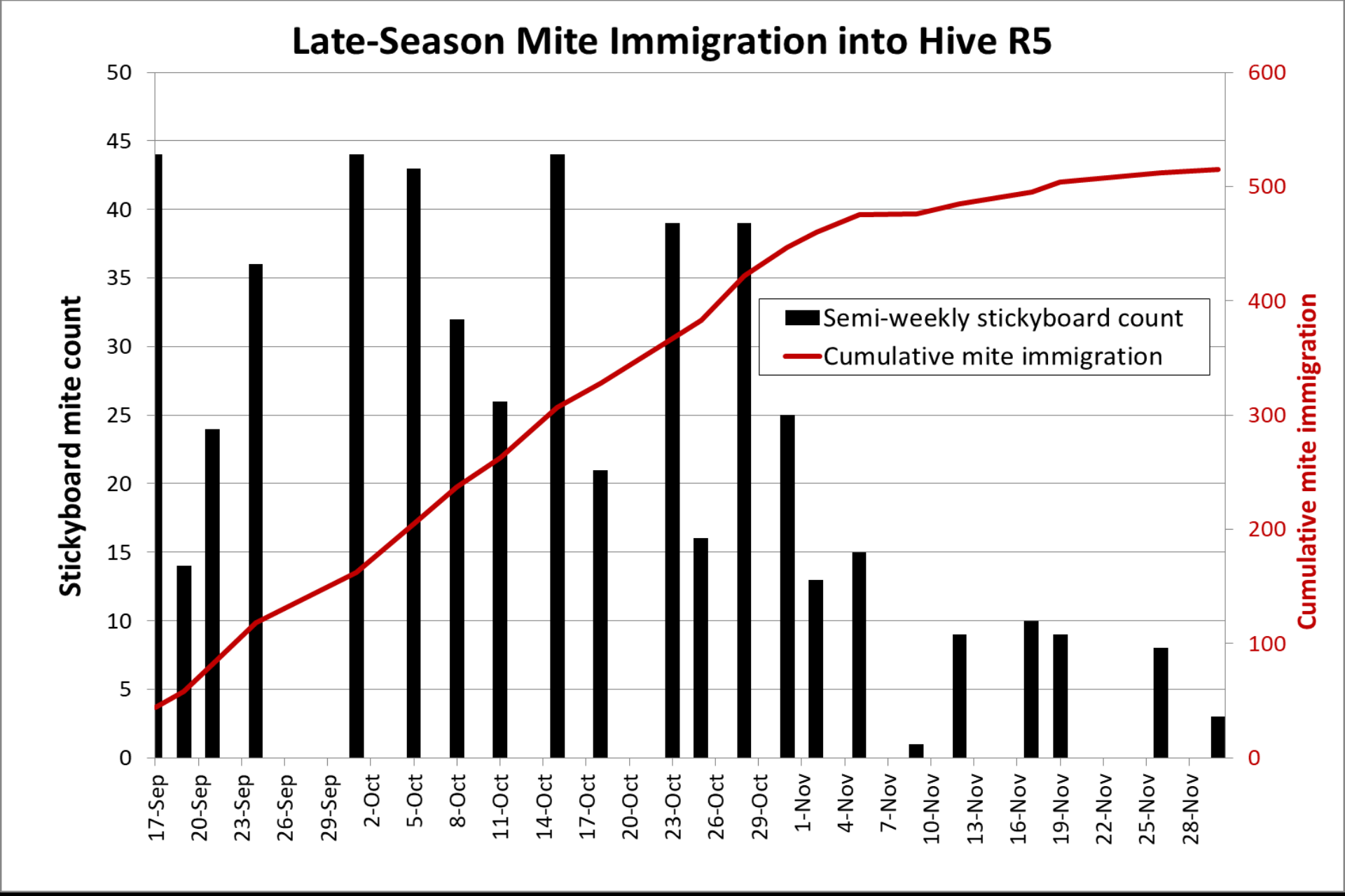
Make your graphs self-explanatory.
Show treatment dates.
Find someone proficient in Excel.



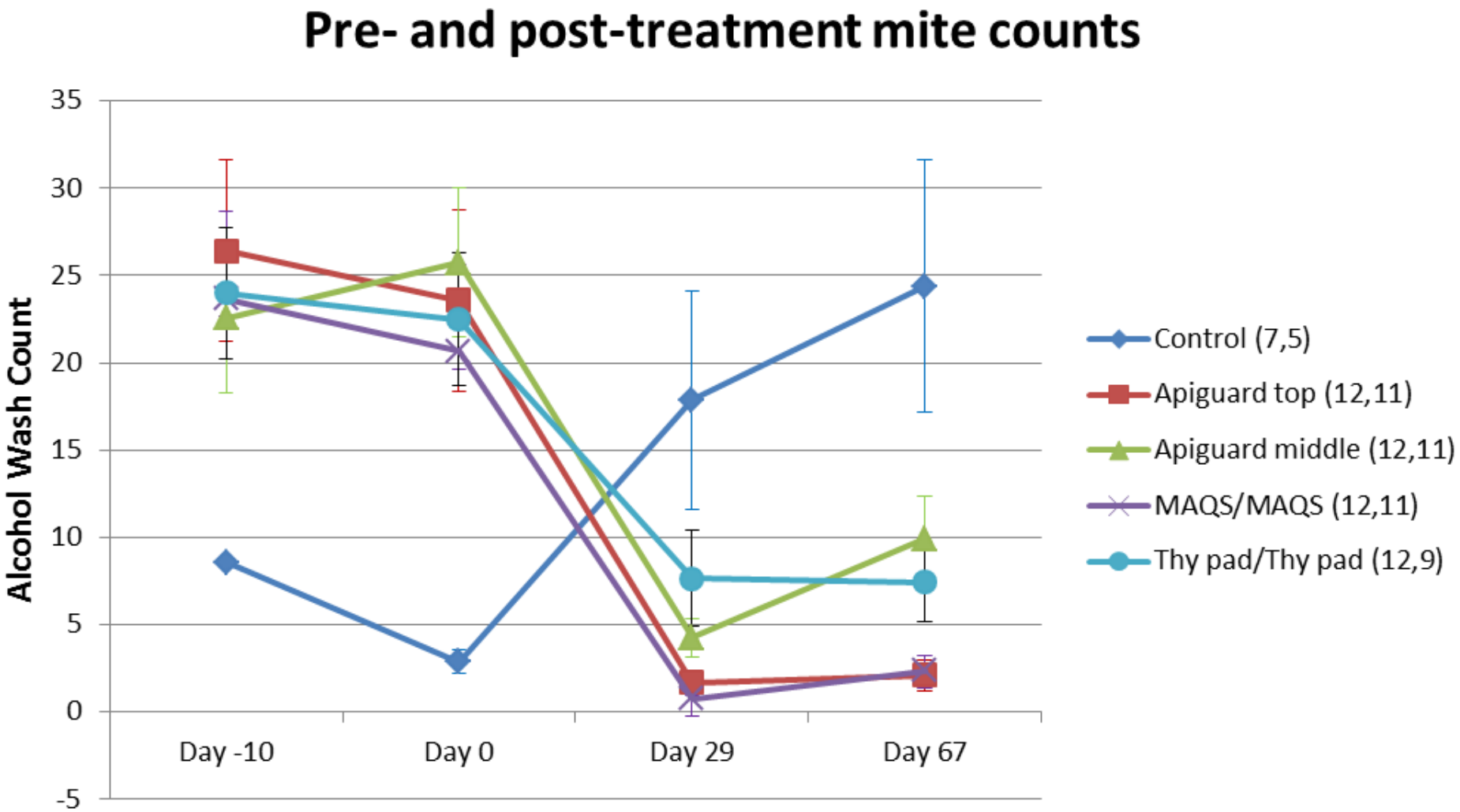
Line chart, raw data

Same data, means with percentage reductions indicated



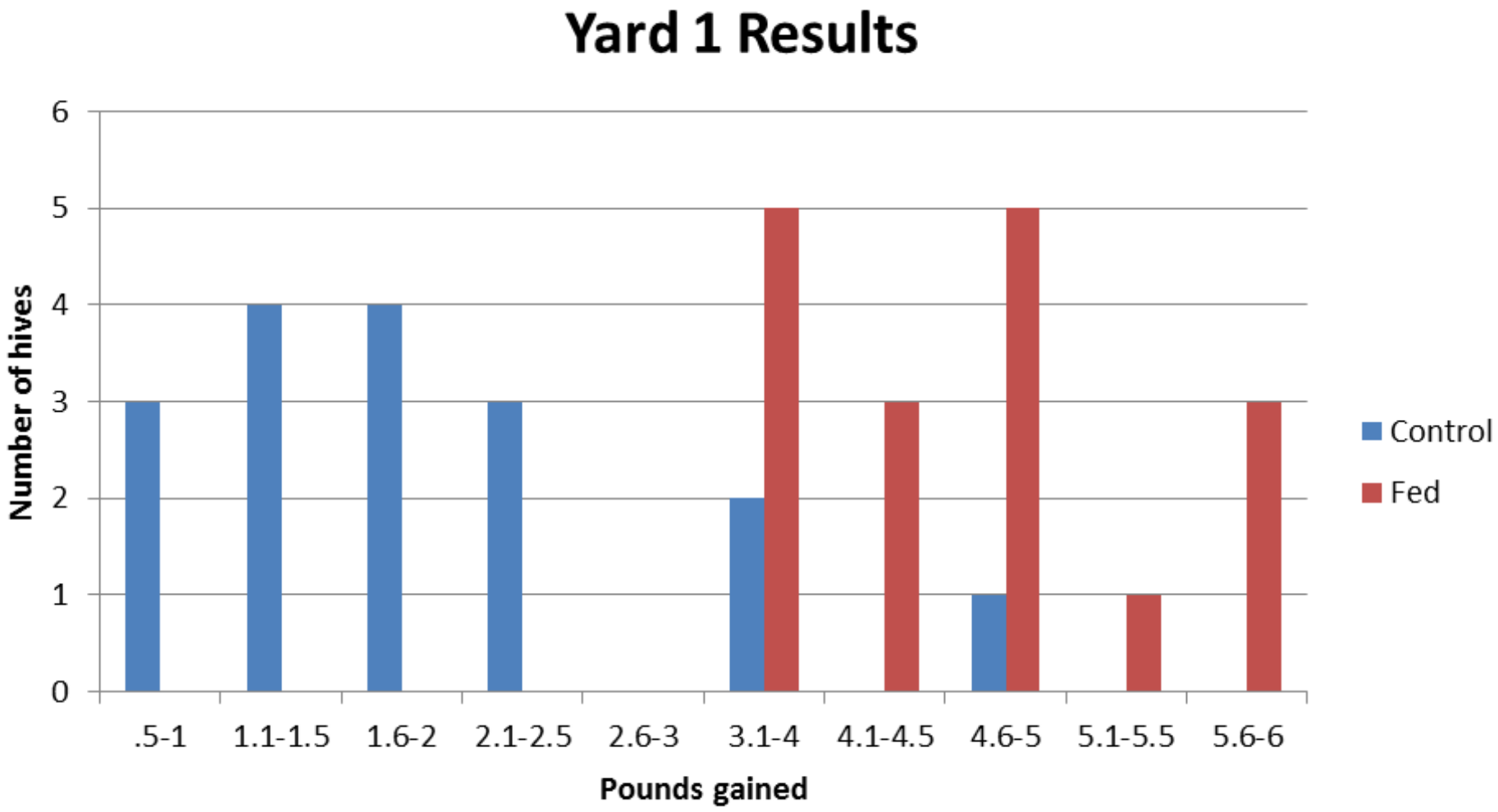


Combination of column and line graphs



Line Graph of means with error bars.

(Wide error bars mean lots of variability)

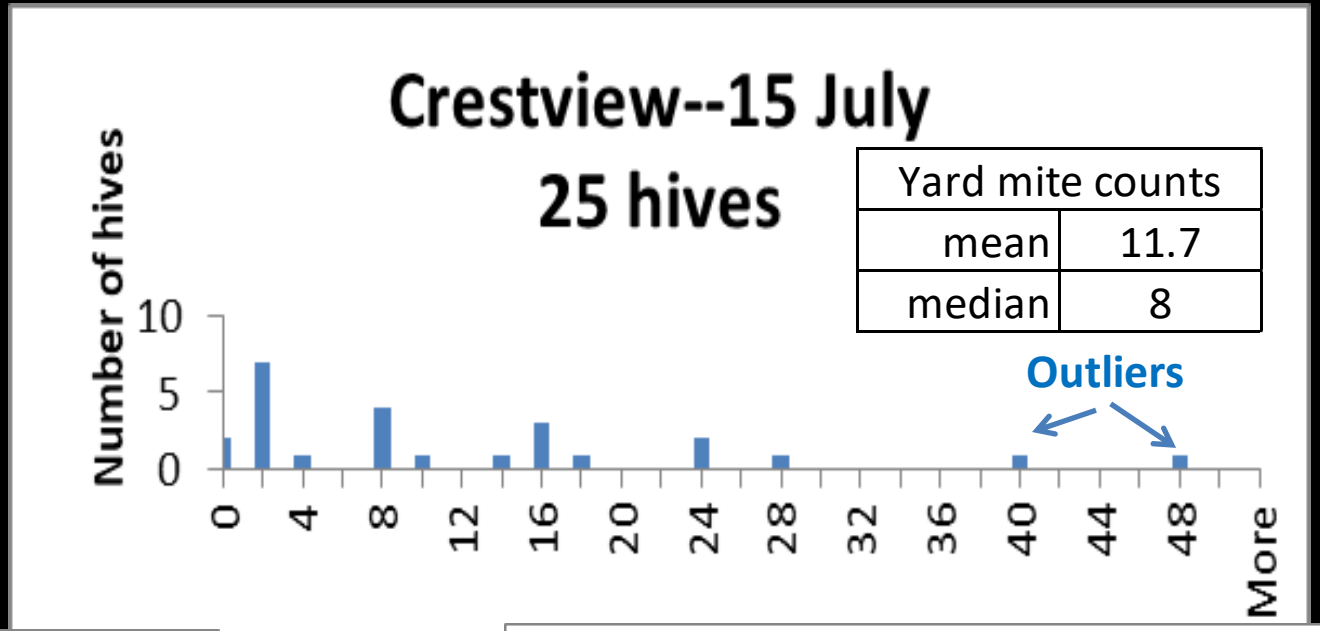


Histogram

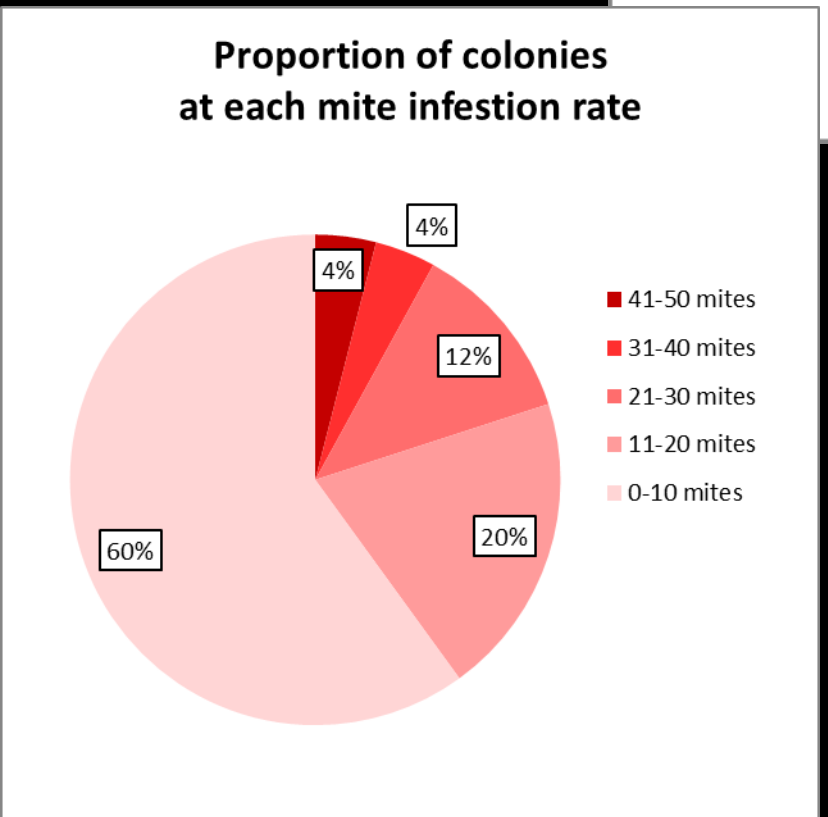
The fed *colony group* (red) clearly gained more weight!

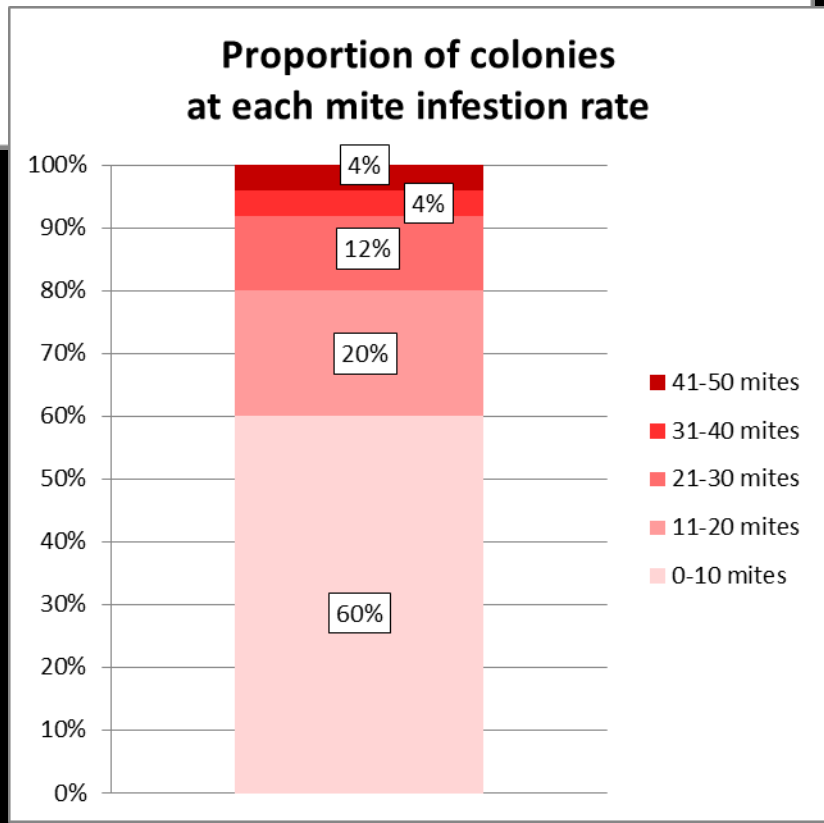
Proportional charts, same data

- Histogram
- Pie chart
- Stacked column



Yard mite counts	
mean	11.7
median	8



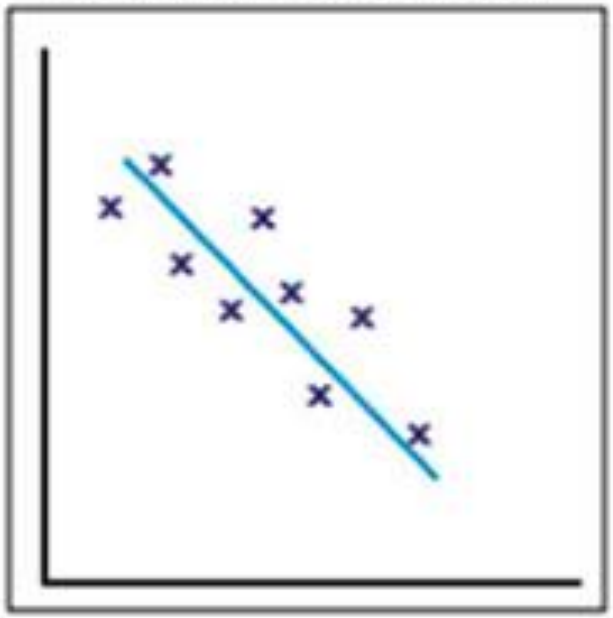


Positive correlation

The points lie close to a straight line, which has a positive gradient.

This shows that as one variable **increases** the other **increases**.

Negative correlation



The points lie close to a straight line, which has a negative gradient.

This shows that as one variable **increases**, the other **decreases**.

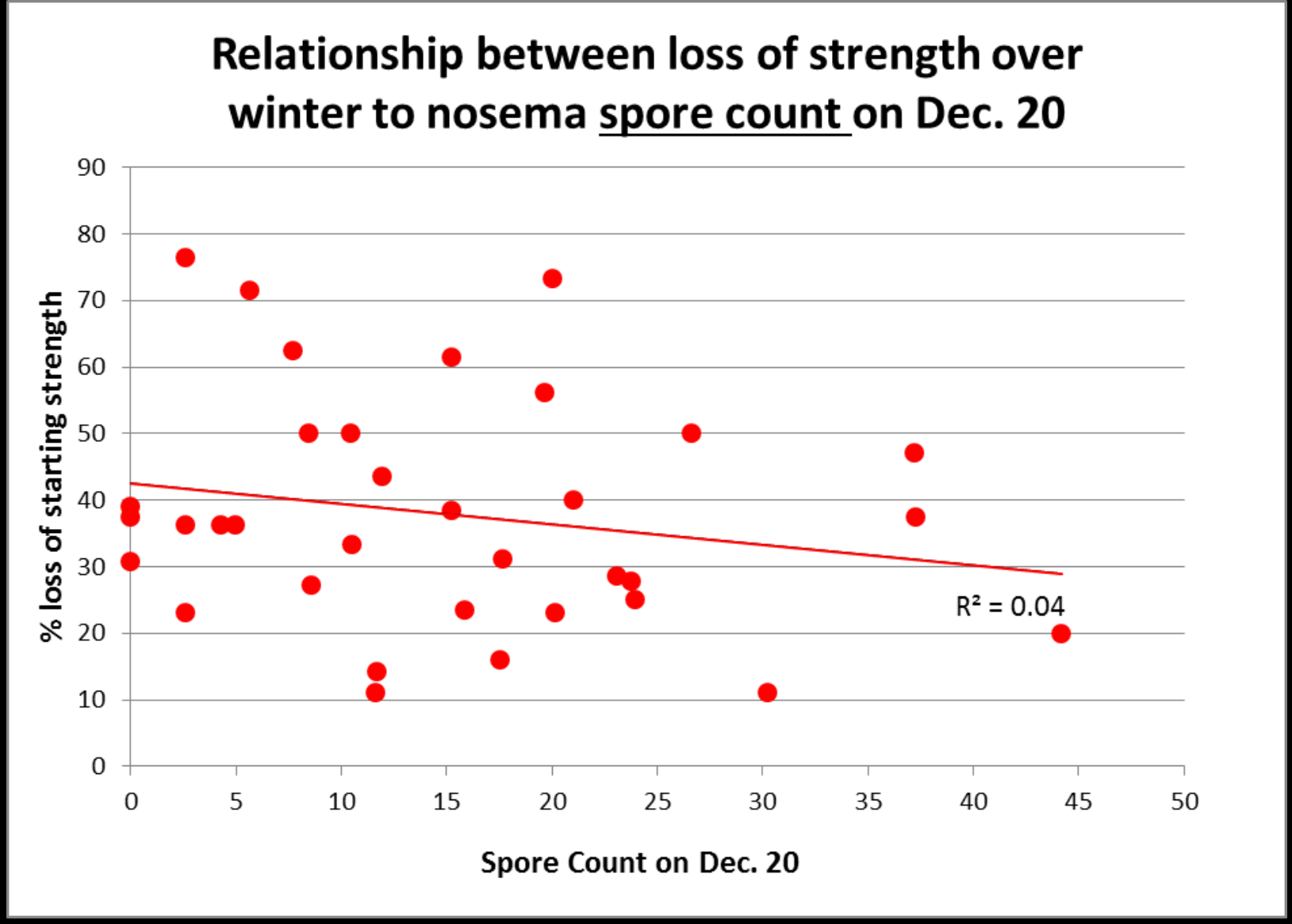
No correlation

There is no pattern to the points.

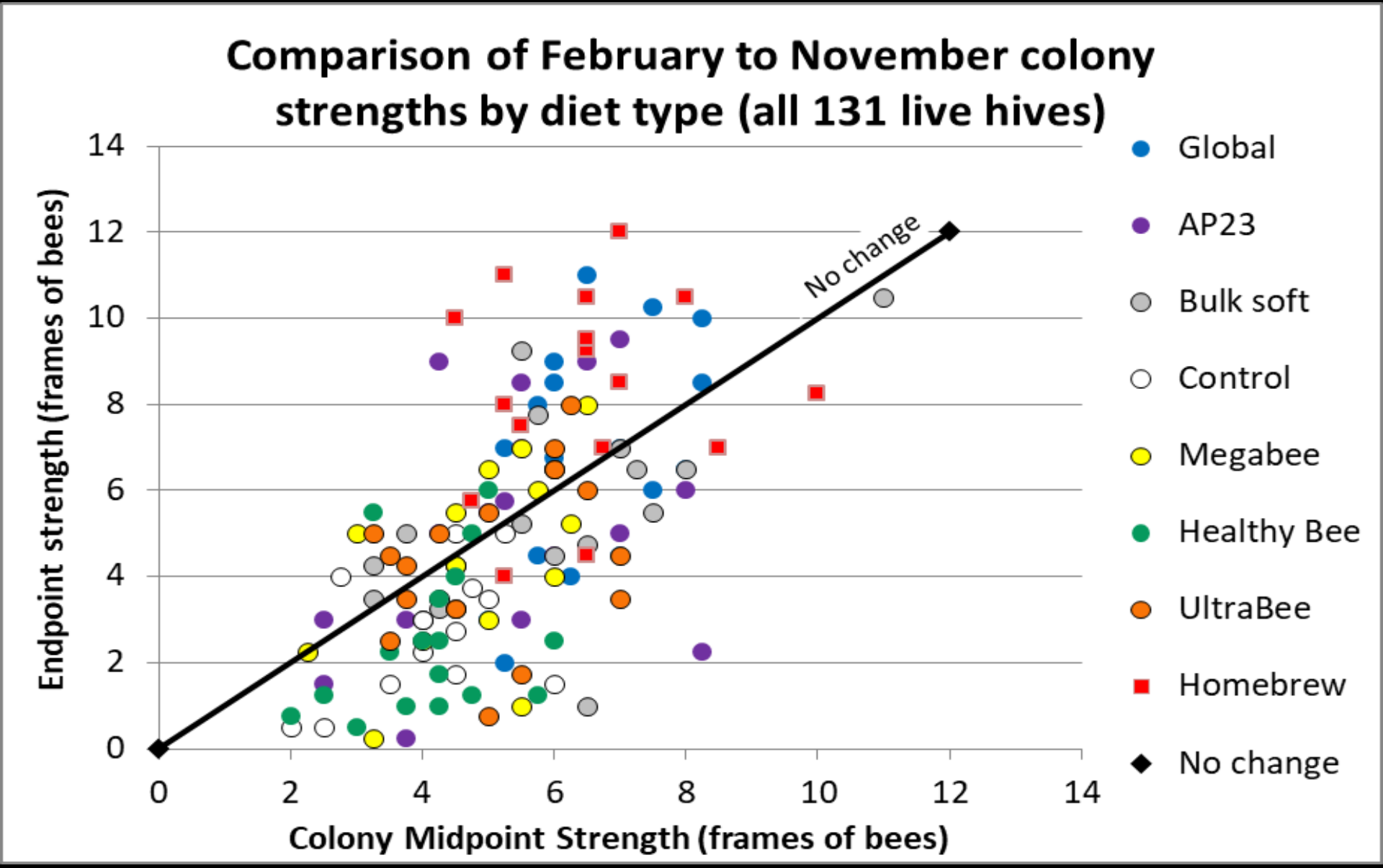
This shows that there is **no connection** between the two variables.

Scatter Plots

Look for correlations and R^2 (R-squared) value



Scatter plot with trend line. Correlation coefficient (R^2 value) indicates minimal correlation



Lots of visual information in one chart!
Which diet groups (by color) grew most or least?

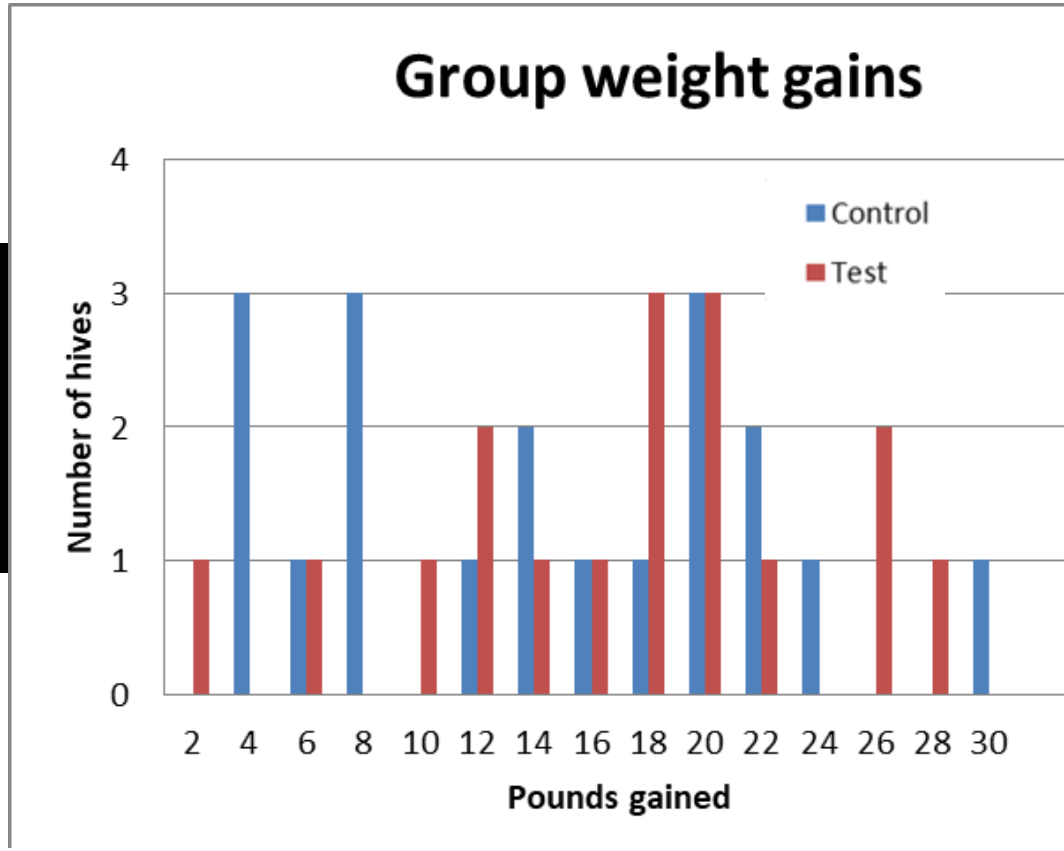
Statistics

"Lies, damned lies, and statistics"

RUN SOME STATS???

Hive	T/C	Init wt 5/10	2nd box wt 5/20	Total wt 5/20	Total wt 6/14	Net gain	Total wt 7/18	Net gain #2
1	C	42.2	17.6	59.8	68.4	8.6	71.4	3.0
2	T	45.2	17.8	63.0	75.6	12.6	95.0	19.4
3	C	47.8	17.2	65.0	72.4	7.4	92.8	20.4
4	C	41.8	17.2	59.0	70.4	11.4	87.0	16.6
5	C	41.0	17.8	58.8	76.4	17.6	96.2	19.8
6	C	46.4	18.4	64.8	79.4	14.6	92.4	13.0
7	T	40.6	17.2	57.8	69.8	12.0	77.2	7.4
8	T	43.6	17.4	61.0	73.2	12.2	89.2	16.0
9	T	50.2	17.4	67.6	73.4	5.8	71.8	-1.6
10	C	47.0	18.6	65.6	72.4	6.8	84.0	11.6
29	T	41.2	17.8	59.0	65.8	4.8	80.2	16.4
30	T	48.6	18.0	66.6	73.2	6.6	100.8	27.6
31	T	41.0	17.0	58.0	67.0	9.0	85.8	18.8
32	T	45.2	17.2	62.4	70.2	7.8	87.6	17.4
33	C	44.2	17.6	61.8	77.8	16.0	91.4	13.6
34	T	48.6	17.2	65.8	74.0	8.2	98.6	24.6
35	T	45.4	17.6	63.0	68.6	5.6	73.8	5.2
36	T	46.0	17.8	63.8	73.0	9.2	92.8	19.8
37	C	49.2	17.8	67.0	83.0	16.0	112.8	29.8
						11.2		15.0

Means, medians, "non-normal" distributions – was there a difference between the two groups?



Pounds gained		
	Control group	Test group
mean	13.6	16.0
median	13.6	16.6

Mann-Whitney U Test Calculator

The value of U is 134.

You'll notice below that we have calculated a c
hypothesis is one or two tailed. We have also c
blue reach significance. Results in red do not.

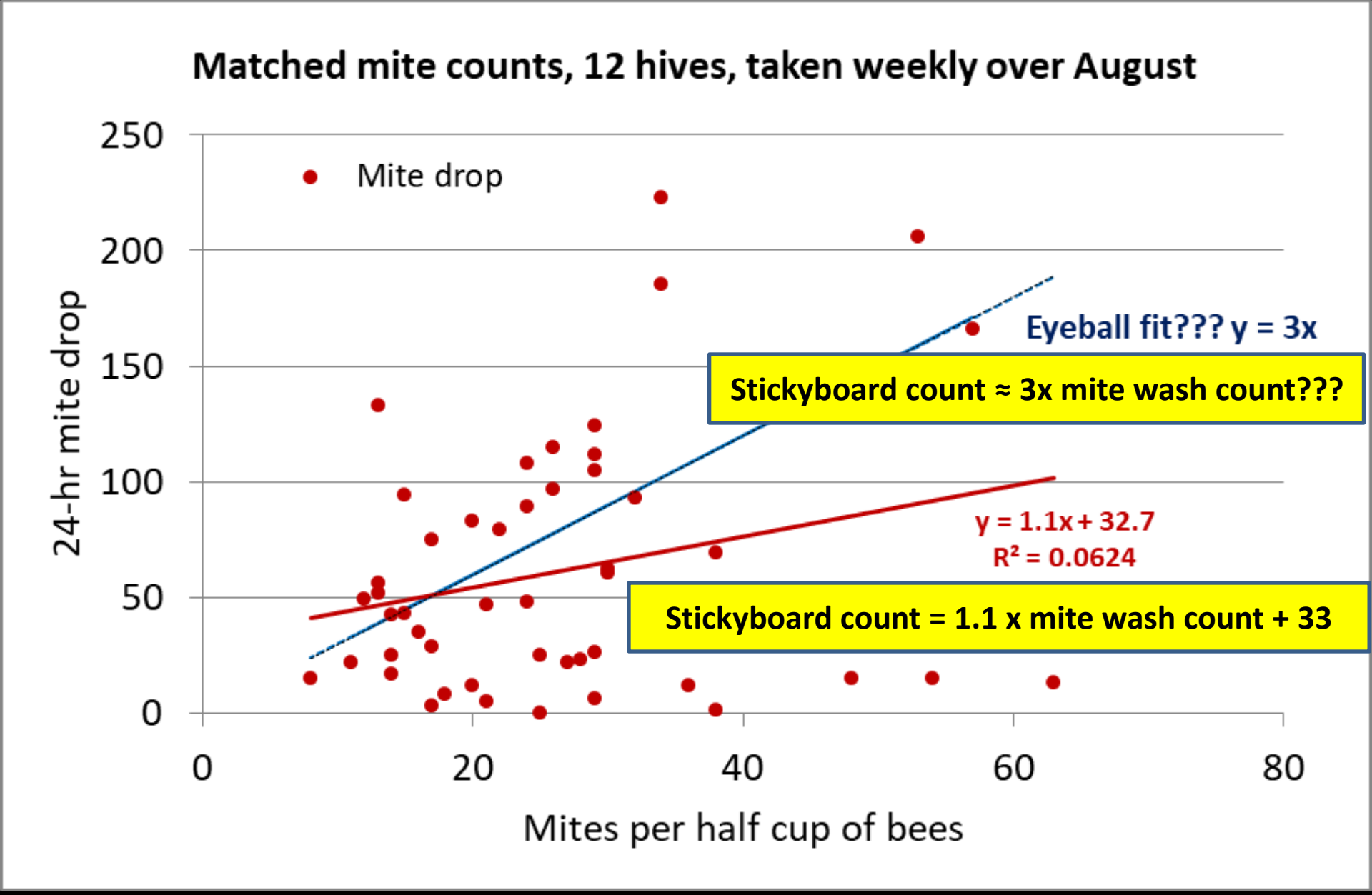
Sample 1

```
3
20.4
16.6
19.8
13
7.4
```

Sample 2

```
19.4
16
-1.6
21.2
24.8
10.8
```

The p-value is .38978. The result is not significant at p < .05. The null hypothesis asserts that the *medians* of the two samples are identical.



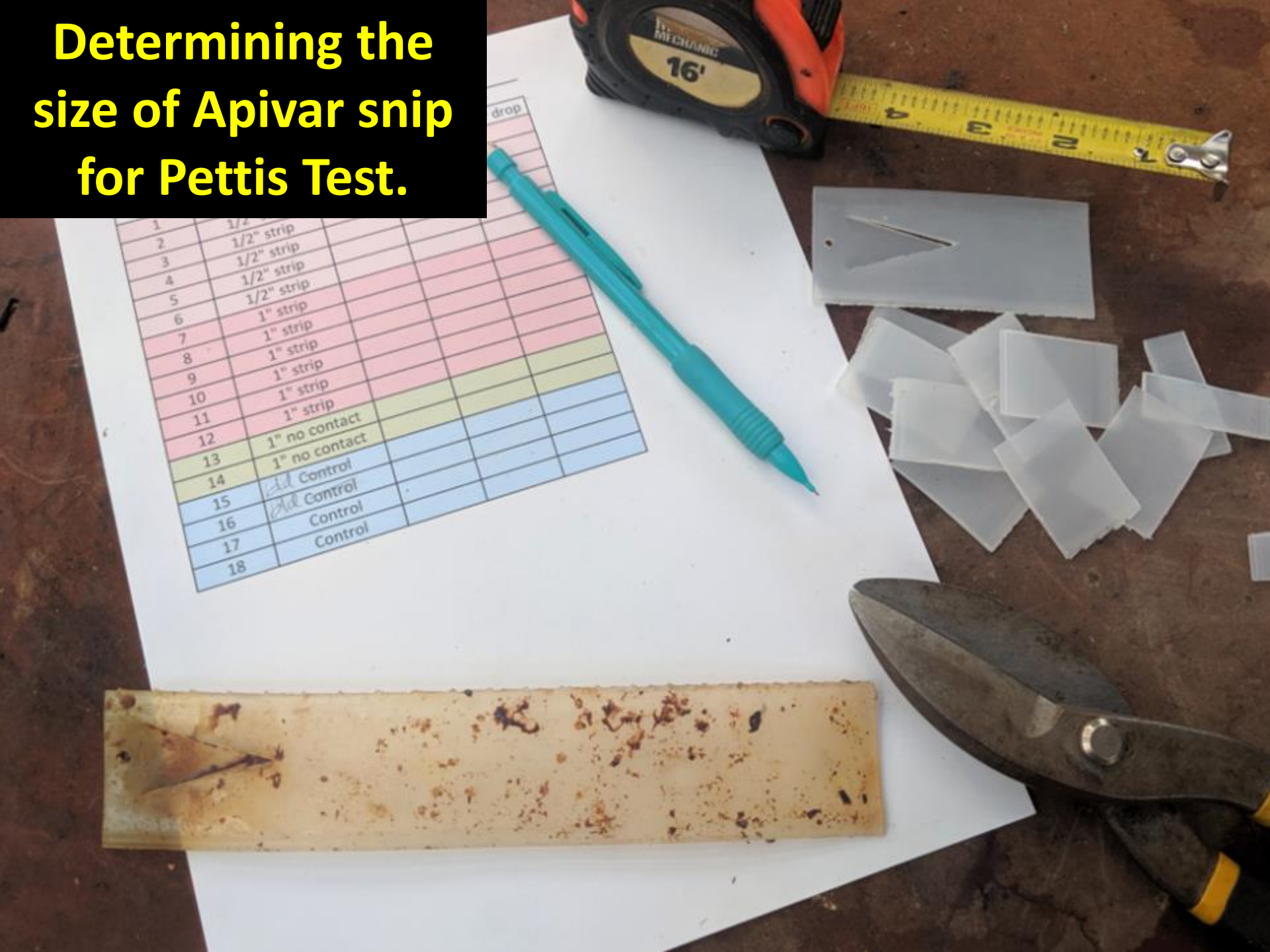
Regression equations may have little predictive value!

INCUBATOR (CAGED BEE) TRIALS

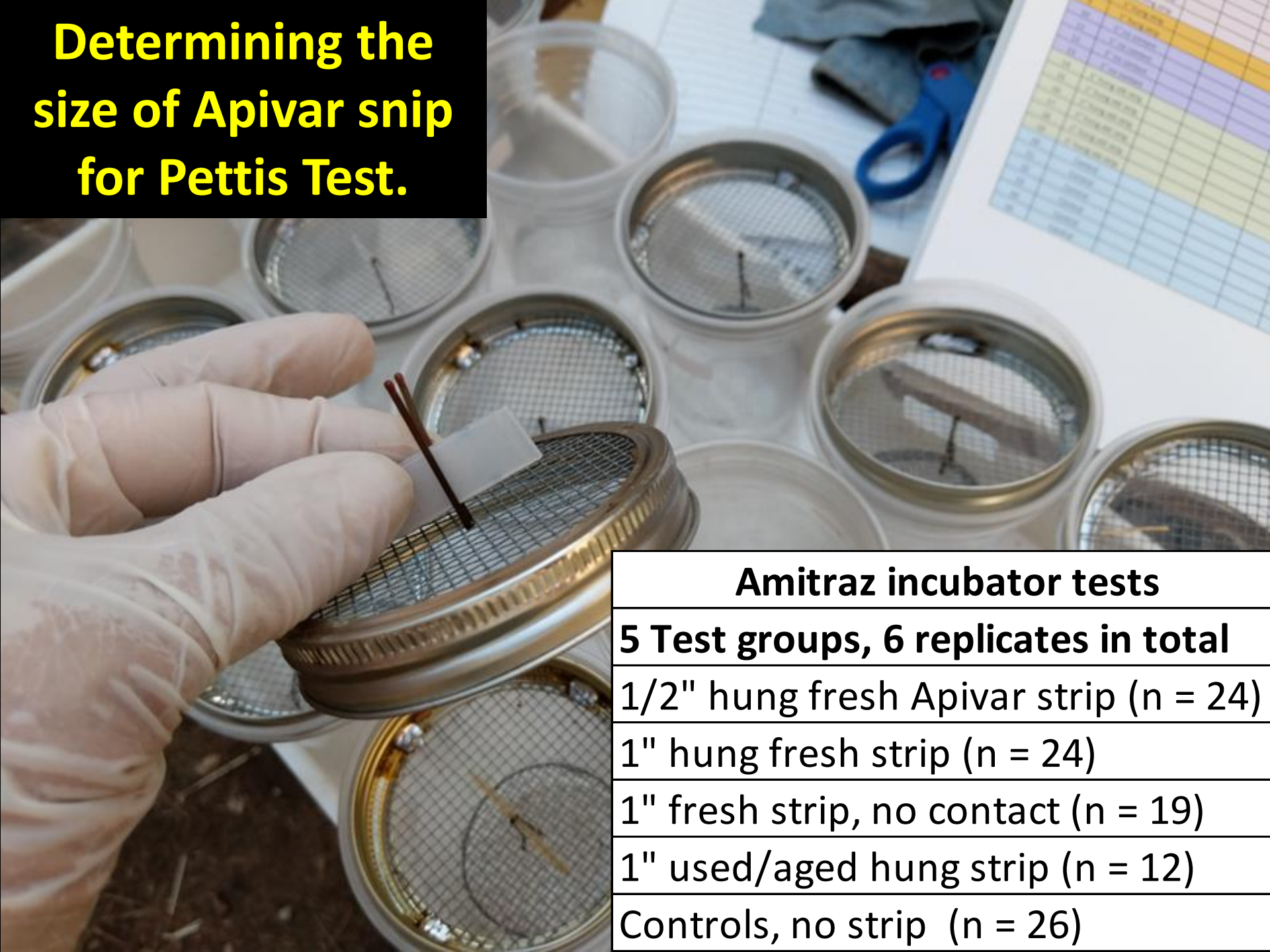

Home-made incubator
from upright freezer


Cup cages

Determining the size of Apivar snip for Pettis Test.



Determining the size of Apivar snip for Pettis Test.



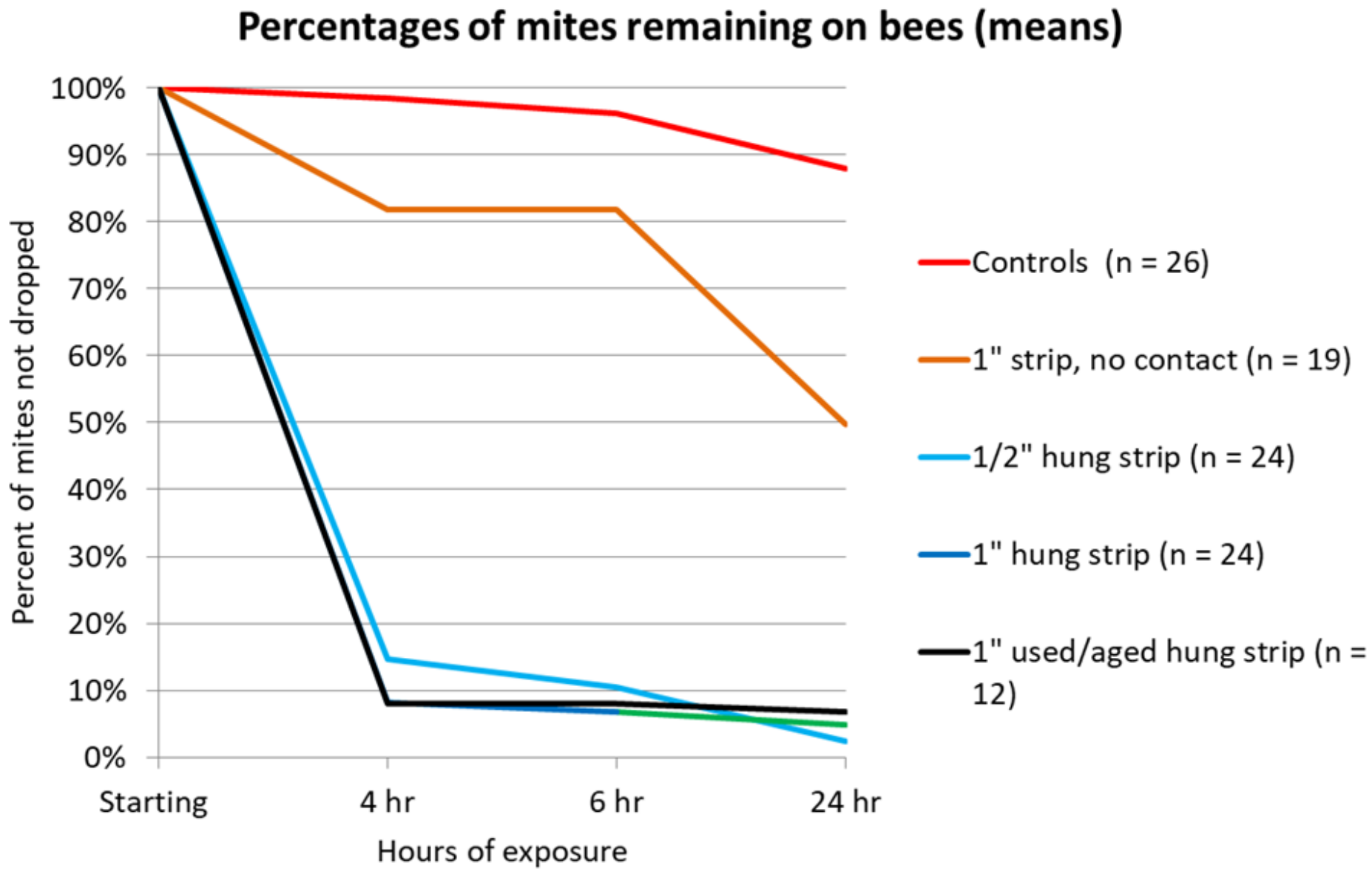
Amitraz incubator tests
5 Test groups, 6 replicates in total
1/2" hung fresh Apivar strip (n = 24)
1" hung fresh strip (n = 24)
1" fresh strip, no contact (n = 19)
1" used/aged hung strip (n = 12)
Controls, no strip (n = 26)

Scoop in 30 mL of mite-infested bees (~90 bees)

Feed syrup and leave them alone in darkness at 86°F, 60% RH.

Count fallen mites at 4, 6, and 24 hrs.

At 24 hrs, multiple wash any surviving mites off the bees



Findings: Slight vapor action; used strip still worked!

Applied Science Questions:

(Are there practical economic benefits to a treatment or management method?)

- Does it increase colony strength or survival?
- Does it increase colony weight gain?
- Does it decrease varroa counts?
- Does it decrease nosema prevalence?
- Does it save the beekeeper time or money?

Comparative Trials

(Applied research experiments)

“Consumer Reports” types of testing

A comparative trial of pollen subs

Replication/Repeatability/Reproducibility

The results of a single experimental run are questionable unless or until repeated under different circumstances.

I repeated this experiment in three different test yards, that intentionally differed in floral resources, running a number (n) of replicates of each treatment (patty type) at each yard.

Randomized block design.

Example: apply treatments randomly to groups of colonies "blocked" by starting strength.

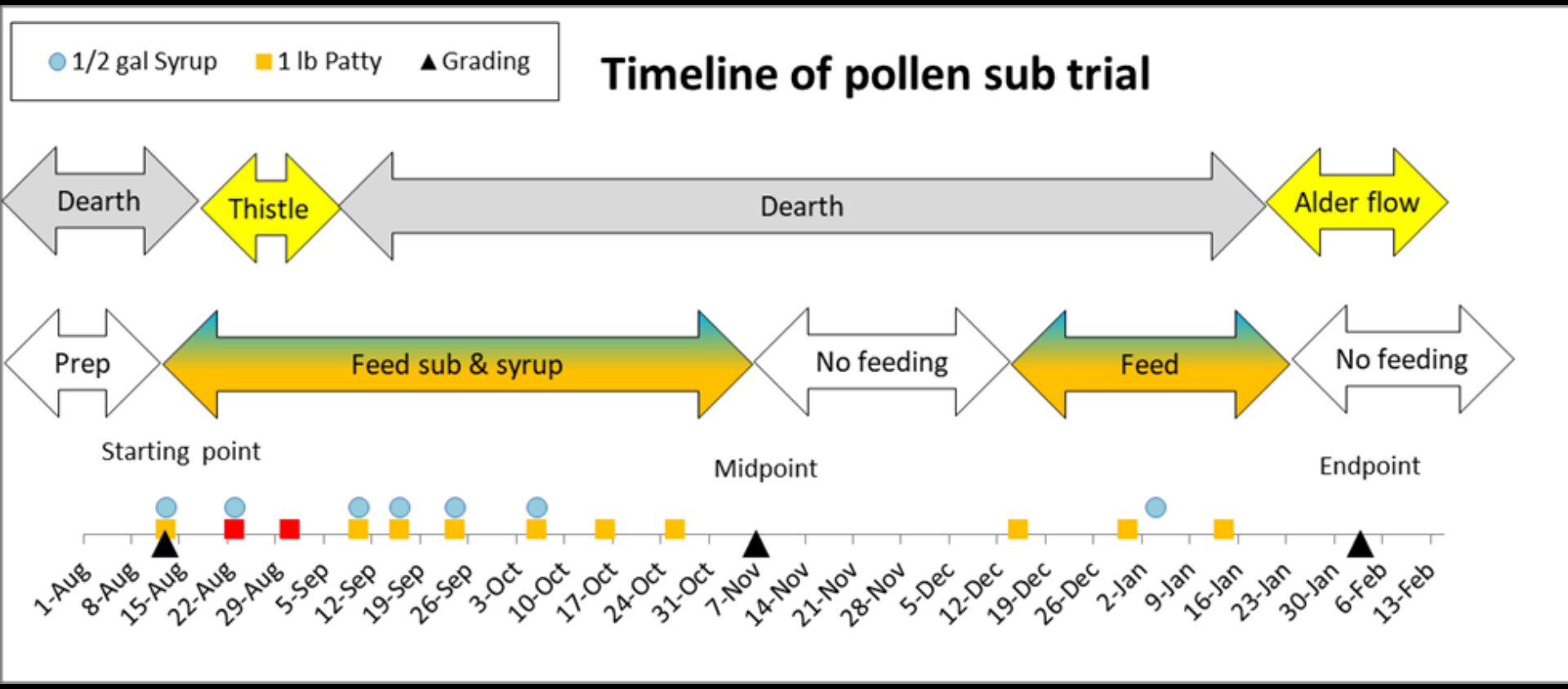
Block	1	2	3	4	5	6
Treatment	R	W	Y	W	S	S
	B	P	B	O	O	W
	G	R	O	R	Y	Y
	S	S	R	P	G	R
	W	O	P	B	B	P
	Y	B	G	G	R	B
	P	Y	S	S	W	G
	O	G	W	Y	P	O

Block	Hive No.	FOB	Trtmt
Block 1	8	10.5	R
	2	9.5	B
	9	9	G
	13	7.5	S
	1	7	W
	7	7	Y
	11	7	P
	14	7	O
Block 2	3	6.5	W
	4	6.5	P
	10	6.5	R
	16	6.5	S
	6	6	O
	5	5.5	B
	12	5.5	Y
	15	5.5	G

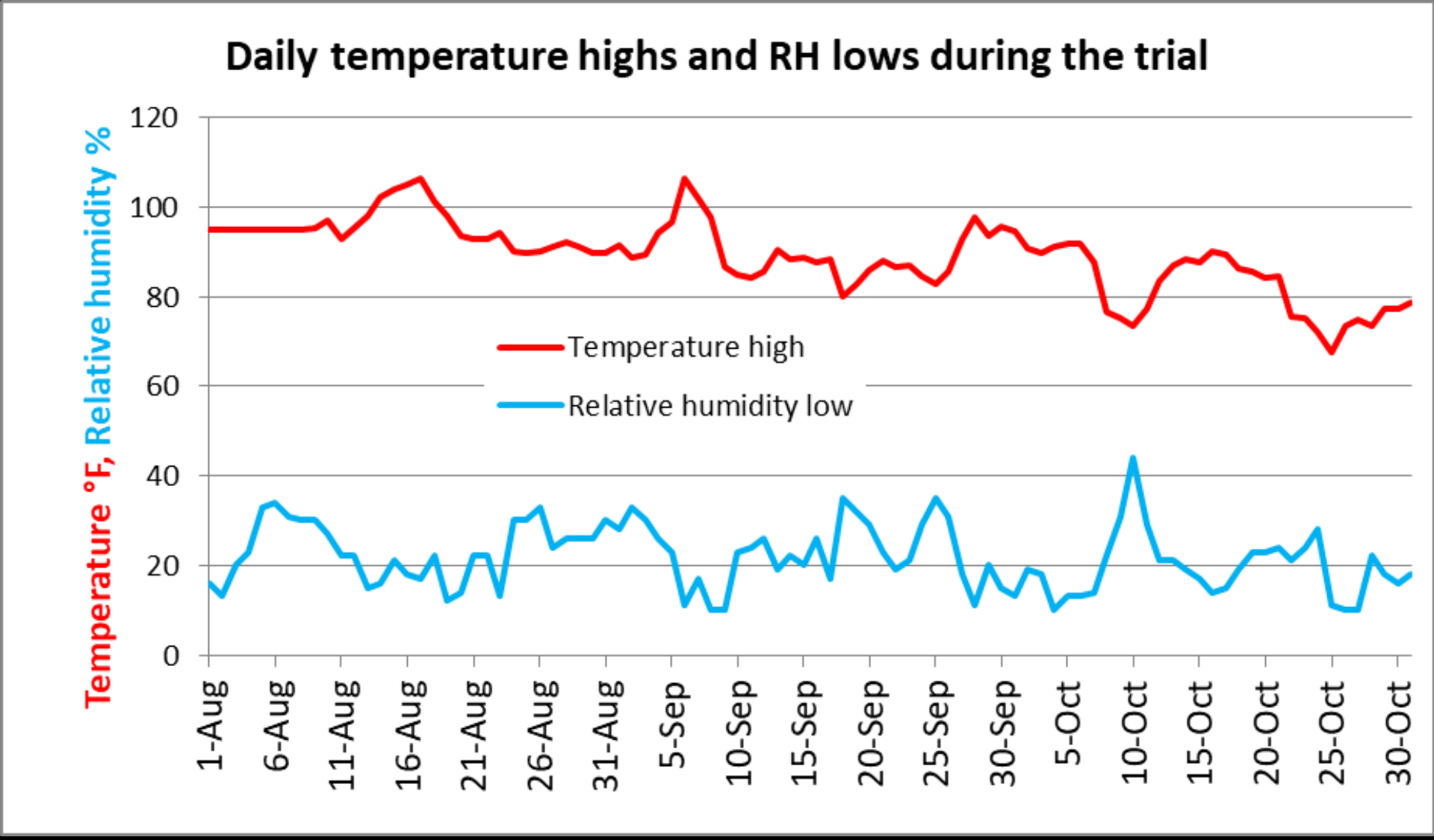
Use color-coded labeling

Replicate the trial in three different yards


Record field conditions, nectar or pollen flows.



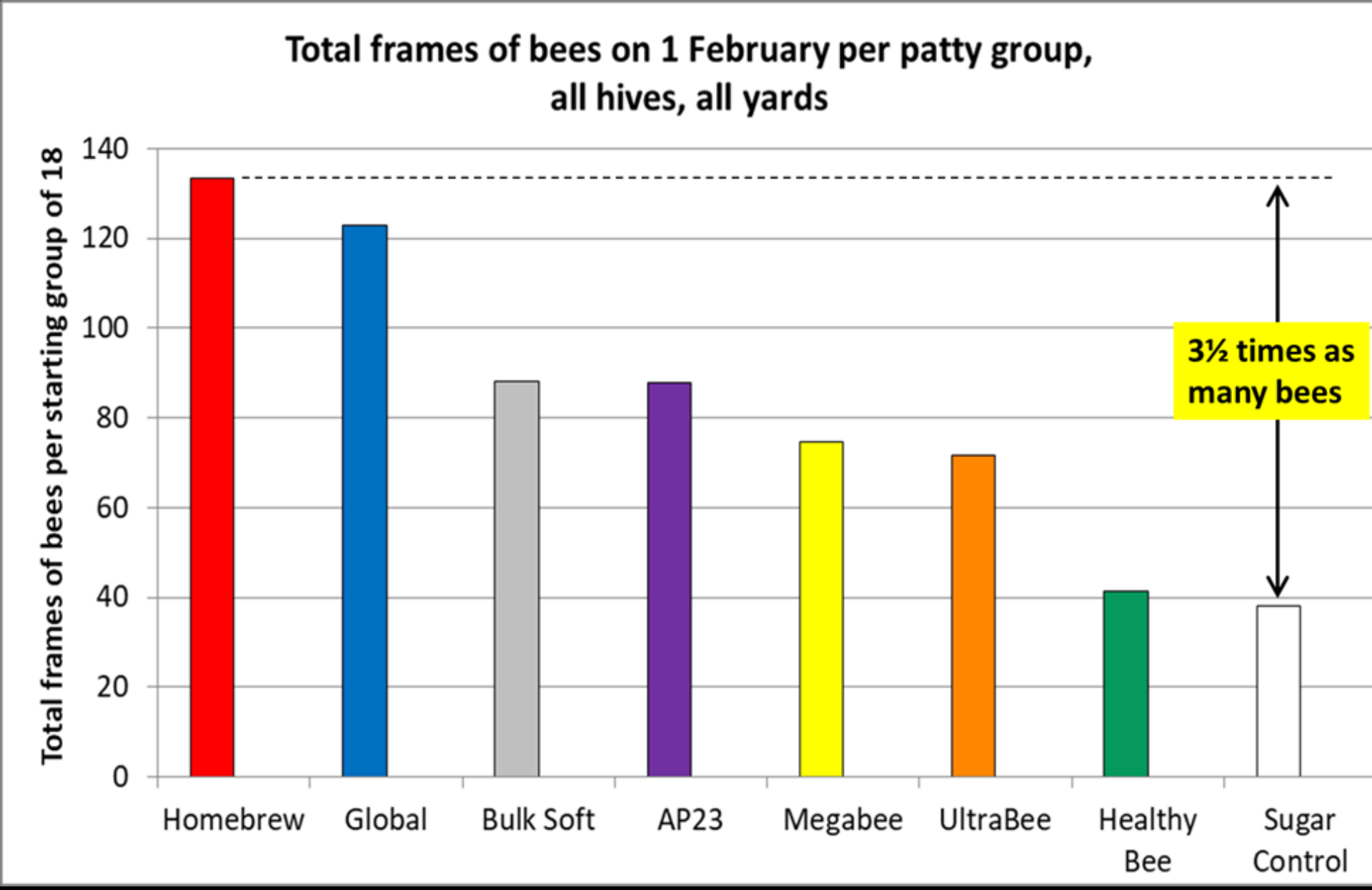
Show the timeline of events and data collection



Download weather data from a local personal weather station

Weigh uneaten patty

Cluster grading in cool weather



Some subs clearly outperformed others

MVTL

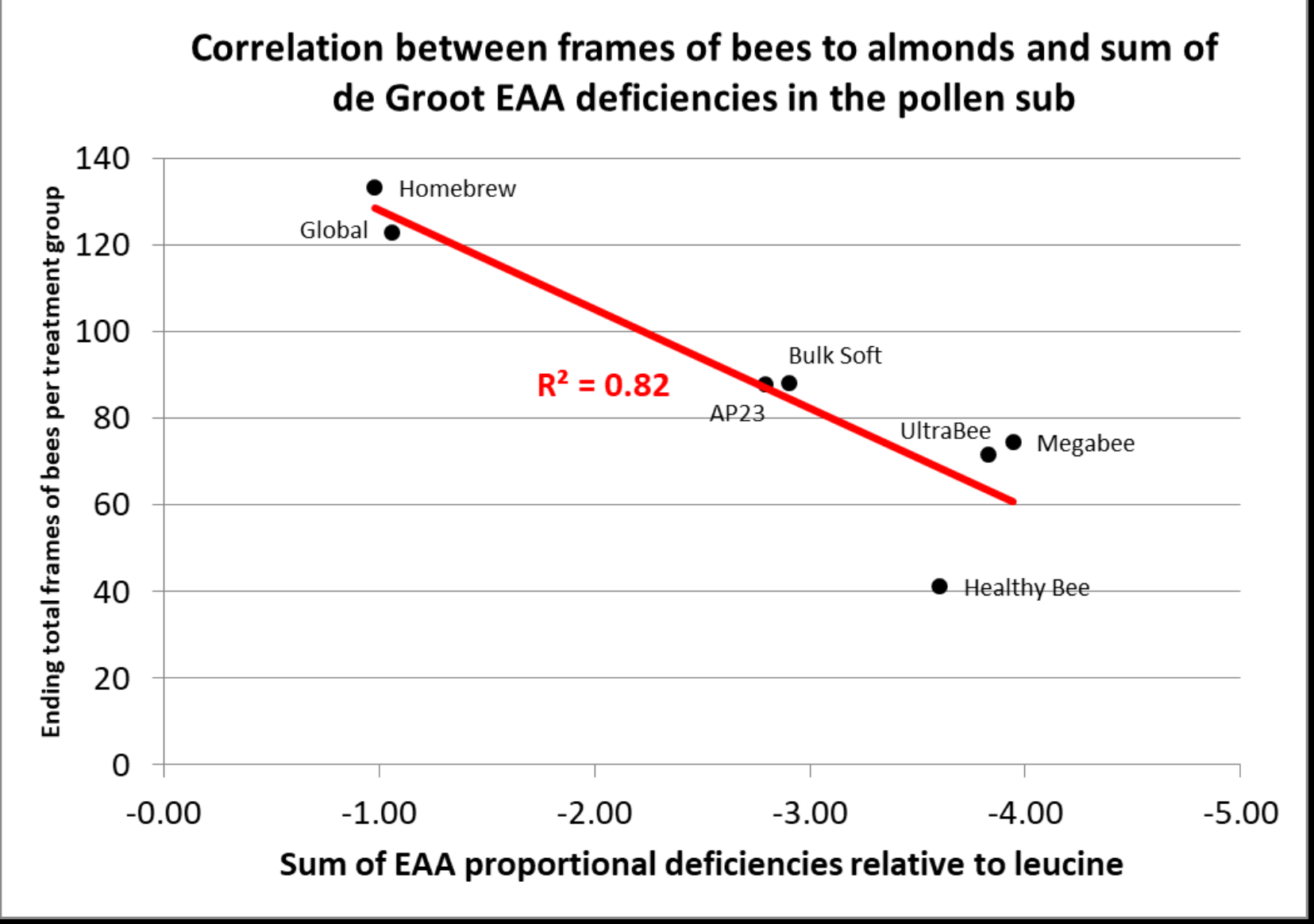
MINNESOTA VALLEY TESTING LABORATORIES, INC.

1126 N. Front St. ~ New Ulm, MN 56073 ~ 800-782-3557 ~ Fax 507-359-2890
2616 E. Broadway Ave. ~ Bismarck, ND 58501 ~ 800-279-6885 ~ Fax 701-258-9724
1201 Lincoln Highway ~ Nevada, IA 50201 ~ 800-362-0855 ~ Fax 515-382-3885
www.mvtl.com

MEMBER ACIL

ANALYTE	AS RECEIVED		METHOD	DATE ANALYZED
Sugar, Total	49.62	g/100 g		17 Sep 2020
Glucose	15.60	g/100 g	AACC 80-04 Modified	17 Sep 2020
Sucrose	11.20	g/100 g	AACC 80-04 Modified	17 Sep 2020
Lactose	< 0.2	g/100 g	AACC 80-04 Modified	17 Sep 2020
Maltose	0.32	g/100		
Fructose	22.50	g/100		
Alanine	1.527	%		
Arginine	0.7780	%		
Aspartic Acid	1.542	%		
Cysteine	0.3230	%		
Fat, Ethyl Ether	3.48	%	AOAC 2003.05	18 Sep 2020
Fiber, Crude	1.22	%	AOAC 978.10	16 Sep 2020
Glutamic Acid	3.944	%	AOAC 994.12	5 Oct 2020
Glycine	0.6570	%	AOAC 994.12	5 Oct 2020
Histidine	0.4440	%	AOAC 994.12	5 Oct 2020
Isoleucine	0.8350	%	AOAC 994.12	5 Oct 2020
Leucine	2.684	%	AOAC 994.12	5 Oct 2020
Lysine	1.975	%	AOAC 994.12	5 Oct 2020
Methionine	0.4010	%	AOAC 994.12	5 Oct 2020
Phenylalanine	1.163	%	AOAC 994.12	5 Oct 2020
Protein N x 6.25	22.00	%	AOAC 990.03	17 Sep 2020
Serine	0.8840	%	AOAC 994.12	5 Oct 2020
Taurine	< 0.01	%	AOAC 994.12	5 Oct 2020
Threonine	0.7270	%	AOAC 994.12	5 Oct 2020
Tryptophan	0.1610	%	MVTL R&D	5 Oct 2020
Tyrosine	0.5840	%	AOAC 994.12	5 Oct 2020
Valine	0.9630	%	AOAC 994.12	5 Oct 2020

Then dig deeper to figure out why???



R^2 indicates very strong correlation

ScientificBeekeeping.com

Beekeeping Through the Eyes of a Biologist

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What This Site Is About

This is not a "How You Should Keep Bees" site; rather, I'm a proponent of "Whatever Works for You" beekeeping.

I've visited beekeepers in many countries, and realize that there are as many ways to keep bees as there are beekeepers. The bees don't care whether you are a commercial or hobby beekeeper, nor whether your personal preference is Langstroth, Warre, top-bar, small cell, foundationless, "natural" or conventional beekeeping–***the same biology applies to all***. My goal is to provide any and all beekeepers with a resource of readable and straightforward information on how to practice good bee husbandry, and to exercise environmental and community responsibility.

This site is more or less a record of my learning process as I apply my formal training as a biologist to the practice of running a commercial beekeeping operation. I have no interest in offering advice (there are plenty of beekeepers more than eager to do that). Rather, what I do offer is ***evidence-based*** and ***scientifically-verified*** explanations of the biological processes occurring in the hive, as well as the effects of various management options. I then leave it to each beekeeper to use that information in order to make their own ***better-informed practical management decisions.***

If you are a beginning beekeeper looking for basic information, or an experienced beekeeper looking for a summary of mite treatment options, I suggest that you go directly to **Basic Beekeeping**. Otherwise, I suggest that you click on the blue categories to the right of each page to see which articles are available, or go to *Articles By Publication Date* (I suggest starting from the bottom up), or use the *Search* function at the top of each page to look for topics.

My Background

I started keeping bees as a hobbyist around 1966, and then went on to get university degrees in biological sciences, specializing in entomology. In 1980 I began to build a migratory beekeeping operation in California,

News and Blogs

In order to be notified by email of updates and additions to this website, please sign up at **ScientificBeekeeping Updates** (I will not share your email nor clog your inbox; I update once a month at best).

Update 24 Jan 2017.

Apologies for getting so far behind on updating the site. On New Year's Day I fulfilled a resolution and sent 17 articles off to my web tech Jane for posting to the site. Unfortunately, she's in the middle of a move, but I'll let you know as she gets them uploaded. Meanwhile, there has been huge interest in my article from the Jan ABJ on oxalic acid in glycerin. Please go to this link for updates: **http://scientificbeekeeping.com/oxalic-shop-towel-updates/**

Updates: Jan 29, 2016

California almond season is upon us! We've had it easy the past few seasons in almonds, since the lack of rain during our drought kept the orchards relatively dry. Not so this year! The orchards are a mess, and

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More examples