




Photo by Natalia Nowakowski


INVESTIGATING THE EFFECTS OF A COMMON APICULTURE ANTIBIOTIC ON HONEYBEE COLONIES

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2025 Graduate Student Seminar
February 20th, 2025

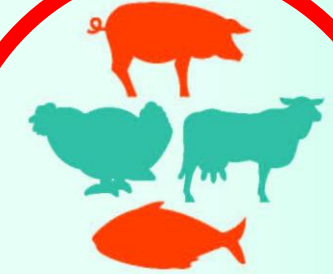
CAUSES OF ANTIBIOTIC RESISTANCE




Over-prescribing of antibiotics




Patients not taking antibiotics as prescribed




Unnecessary antibiotics used in agriculture



Poor infection control in hospitals and clinics




Poor hygiene and sanitation practices




Lack of rapid laboratory tests


6 of the 18 most alarming **antibiotic resistance threats** cost the U.S. more than **\$4.6 billion annually**




Vancomycin-resistant *Enterococcus* (VRE)




Carbapenem-resistant *Acinetobacter* species (CRAsp)




Methicillin-resistant *Staphylococcus aureus* (MRSA)



Carbapenem-resistant Enterobacterales (CRE)



Extended-spectrum cephalosporin resistance in Enterobacterales suggestive of extended-spectrum β -lactamase (ESBL) production



Multidrug-resistant (MDR) *Pseudomonas aeruginosa*

www.cdc.gov/DrugResistance



ANTIBIOTIC RESISTANCE IS A PUBLIC HEALTH CRISIS



Centers for Disease Control and Prevention
National Center for Emerging and Zoonotic Infectious Diseases

Learn More
<http://www.cdc.gov/getsmart>
<http://www.cdc.gov/drugresistance>

#AntibioticResistance
www.who.int/drugresistance

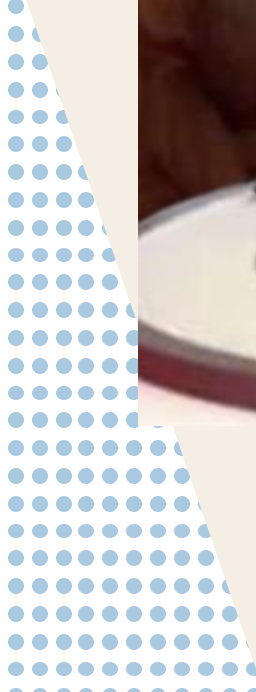


AGRICULTURE IS ONE OF THE LARGEST CONSUMERS OF ANTIBIOTICS

Lipstitch et al. 2002; Cheng et al. 2014



Photos taken from Wikimedia Commons



ANTIBIOTICS IN APICULTURE

- Honeybees are **managed livestock**!
- Beekeepers use antibiotics to **prevent** or **treat** colony diseases
- FDA recommended dosage for oxytetracycline = **200mg** per **colony**
- Commonly administered by
 - **Direct dusting**
 - **Dietary supplement** in pollen patties



Photo by Trevor Bawden

ANTIBIOTICS BAD FOR BEES?

- Antibiotics **negatively affects** honeybee **health** (Raymann et al. 2017; 2018; Deng et al. 2022)
- Antibiotics **negatively affects** honeybee **behavior** (Ortiz-Alvarado 2020;2022), **notably, thermoregulatory behavior** (Nguyen & Cook, *accepted*)
- **Antibiotic resistance genes** detected in gut microbial community (Evans 2003)
- **Misuse** led to FDA's Veterinary Feed Directive in 2017



ANTIBIOTICS BAD FOR BEES?

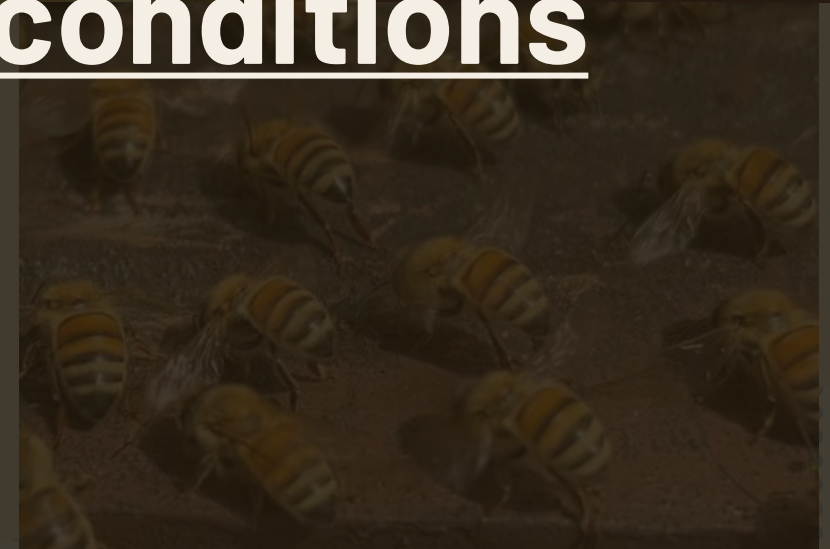
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- Research informing legislation
were all done in the lab and
not in field realistic conditions

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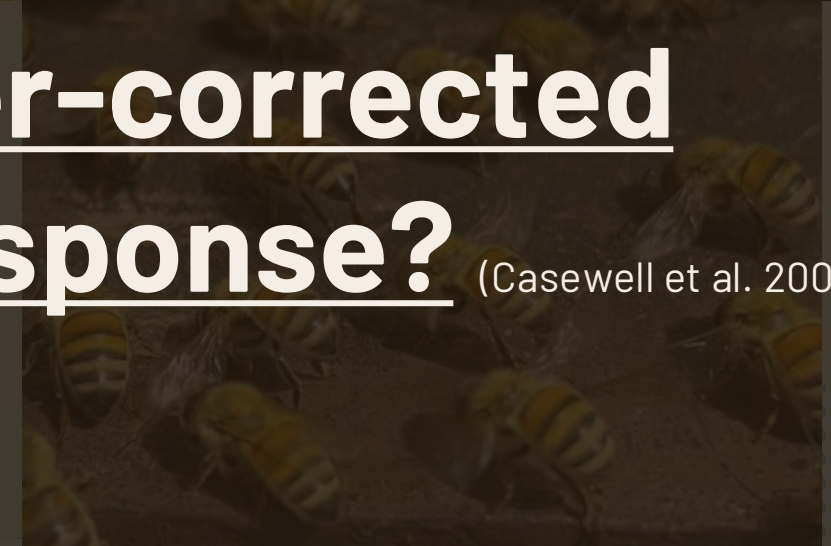
- Antibiotic **resistance** **non-detectable** in gut microbial community (Evans 2003)

Have we possibly over-corrected

- with an all-or-nothing response? (Casewell et al. 2003)
- **Misuse** led to FDA's Veterinary Feed Directive in 2017



Photo by Natalia Nowakowski



**HOW DOES PROPHYLACTIC,
COLONY-WIDE ANTIBIOTIC
TREATMENT AFFECT COLONIES
IN A FIELD-REALISTIC SETTING?**



HOW DOES PROPHYLACTIC, COLONY-WIDE ANTIBIOTIC TREATMENT AFFECT COLONIES?

HYPOTHESIS

Prophylactic colony-wide antibiotic treatment **disrupts** colony dynamics



PREDICTIONS

Antibiotic treated colonies will...

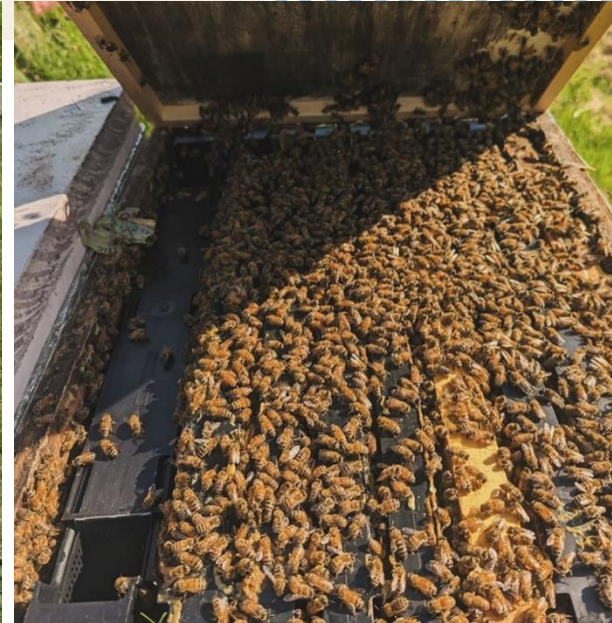
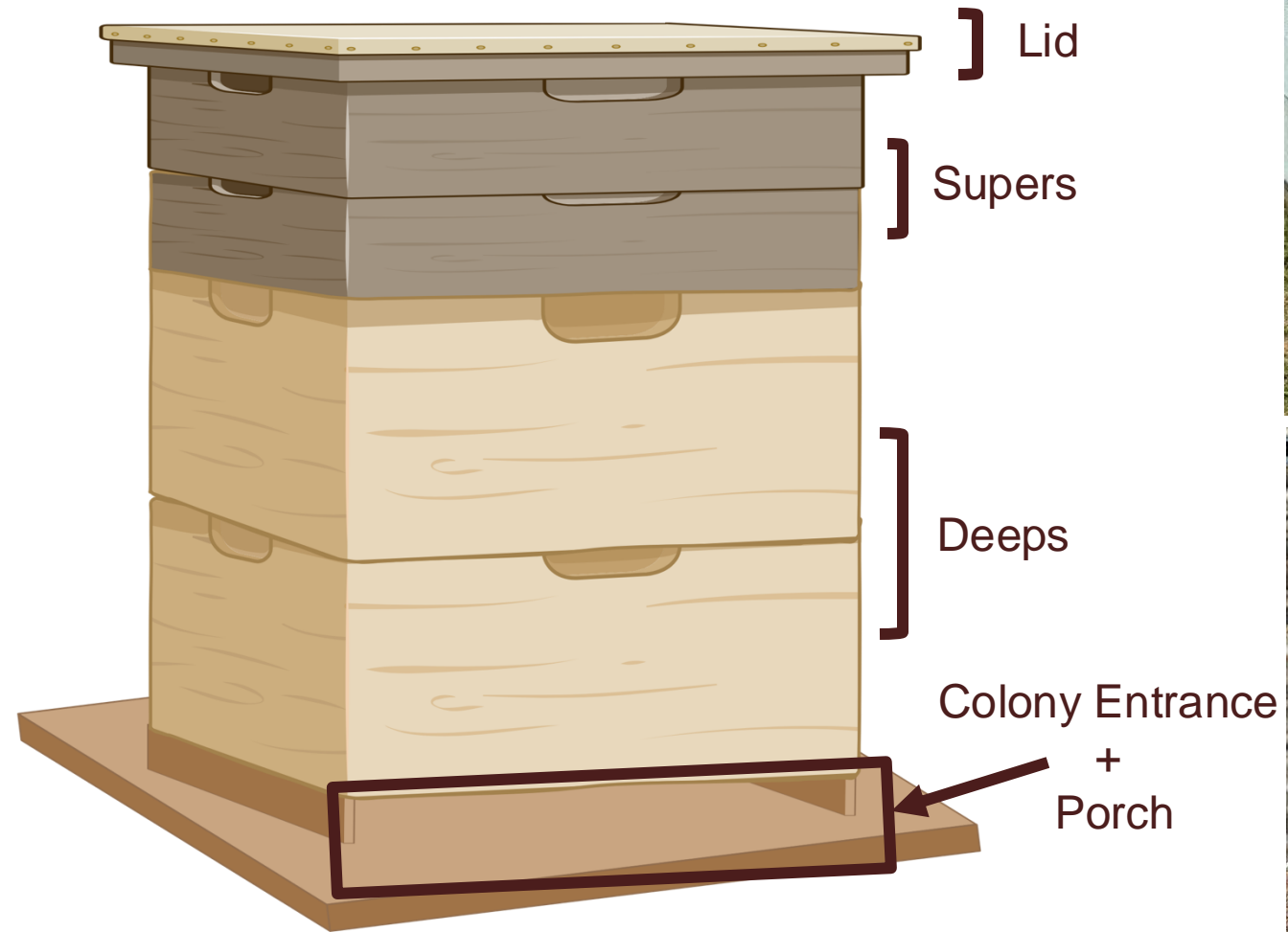
- 1) **Weigh less**
- 2) Have **less resources** collected
- 3) Have **less offspring** reared
- 4) Have **disrupted** colony **thermoregulation**
 - Less** fanners

Methodology





BEEKEEPING TERMS 101





METHODOLOGY – SET UP & LOCATION



Photo by Natalia Nowakowski



- Oconomowoc, Wisconsin
- 24 total colonies from Concord Farms
- Installed Broodminder temperature sensors in 20 colonies



METHODOLOGY - TREATMENT



Photo by Trevor Bawden

- Colonies given treatment regimen in June & September, following FDA instructions
 - **Antibiotic:** 200mg oxytetracycline + powdered sugar
 - **Sugar:** Powdered sugar
- Treatment sprinkled at edges of top deep
- Treatment regimen = 3 dosages with 5 days in-between



METHODOLOGY – FANNING OBSERVATIONS



- Measured ambient temperature & surface temperatures ($^{\circ}\text{C}$) of different areas of porch
- Measured ambient light (lux)
- Observed number of fanners at entrance of colony in set areas of porch
- Repeated 3 times per week



METHODOLOGY – HIVE INSPECTIONS



- Weighed colonies & supers
- Proportion of resources on all **frames**
 - Bee coverage
 - Offspring
 - Pollen
 - Honey
- Repeated 2 times per month



Photos by Alyssa Rada

ALL THE DATA WE COLLECTED!



COLONY WEIGHT

How much weight did the colonies gain?



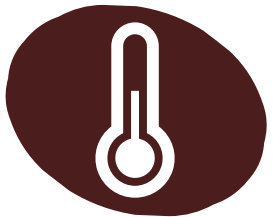
SUPER WEIGHT

How much honey did the colonies produce?



NUMBER OF FANNERS

How many fanners did the colony have during hot days?



COLONY TEMP

How well did colonies thermoregulate their internal temperatures?



HIVE INSPECTIONS

How much resources did the colony collect/produce?

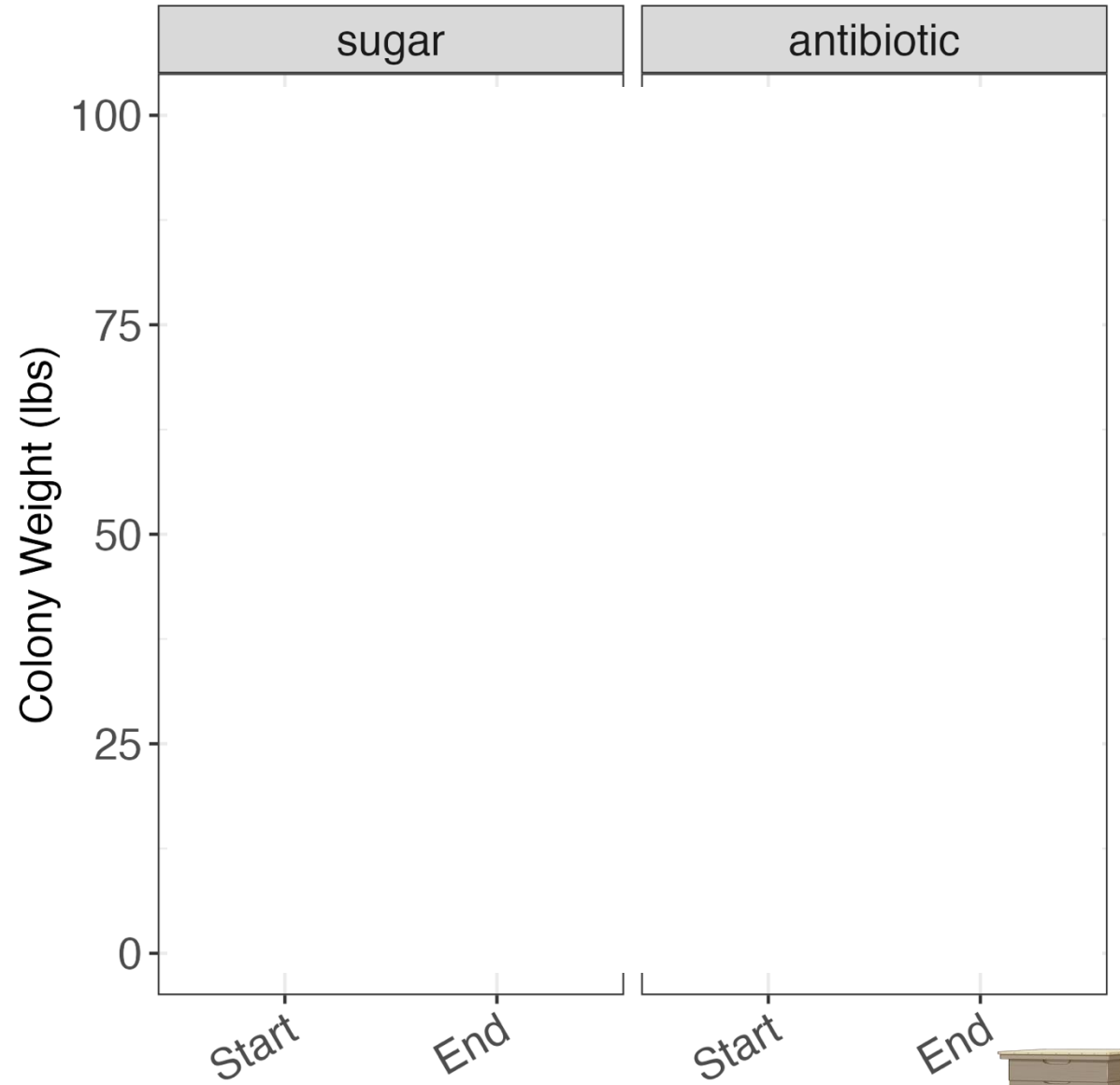
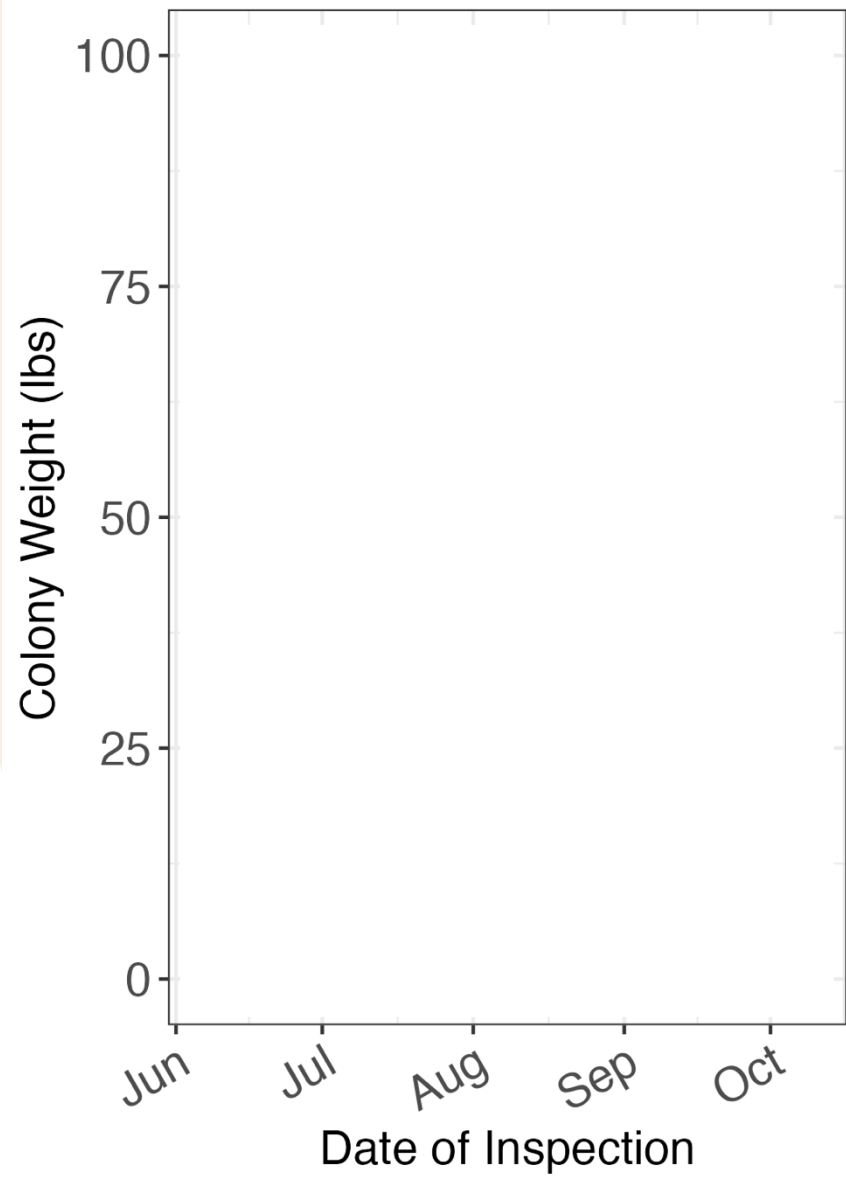


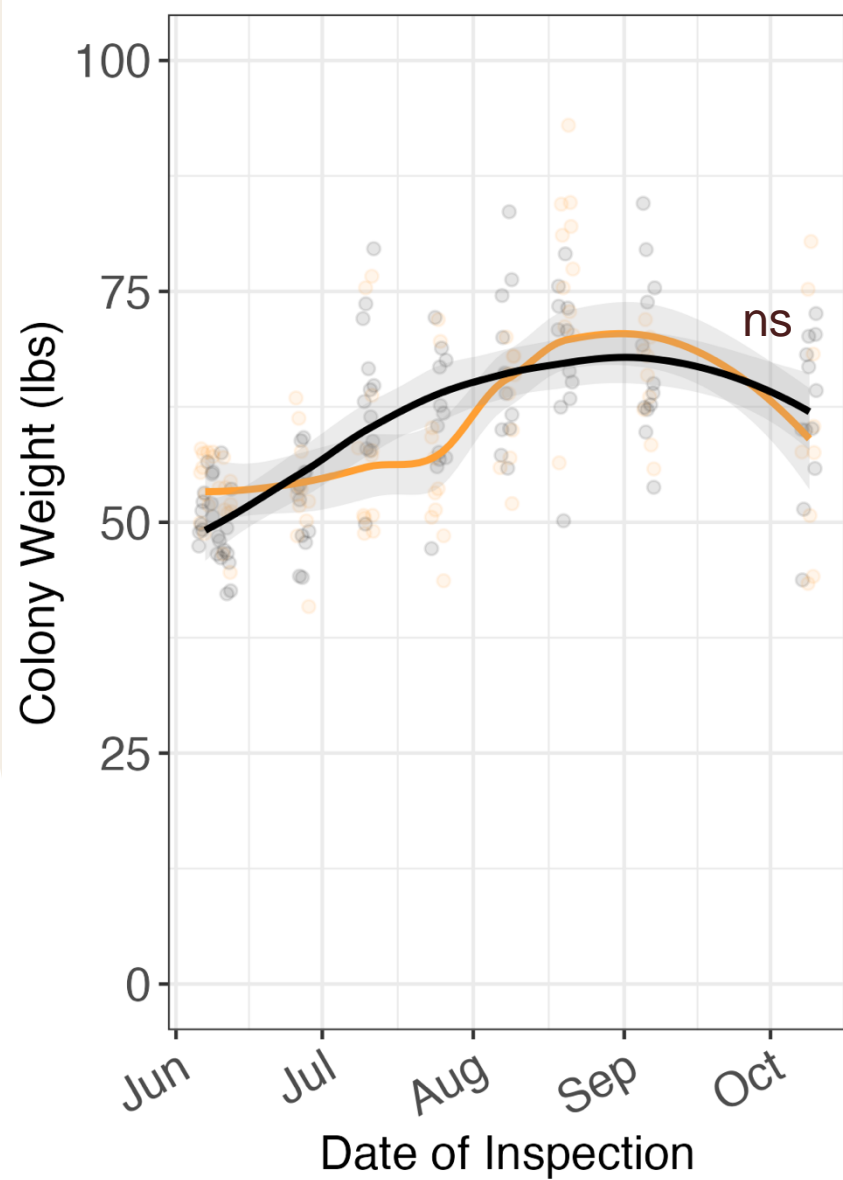
WHOLE BEE SAMPLES

How did the gut microbiome change? What about antibiotic resistance genes?

Preliminary Results



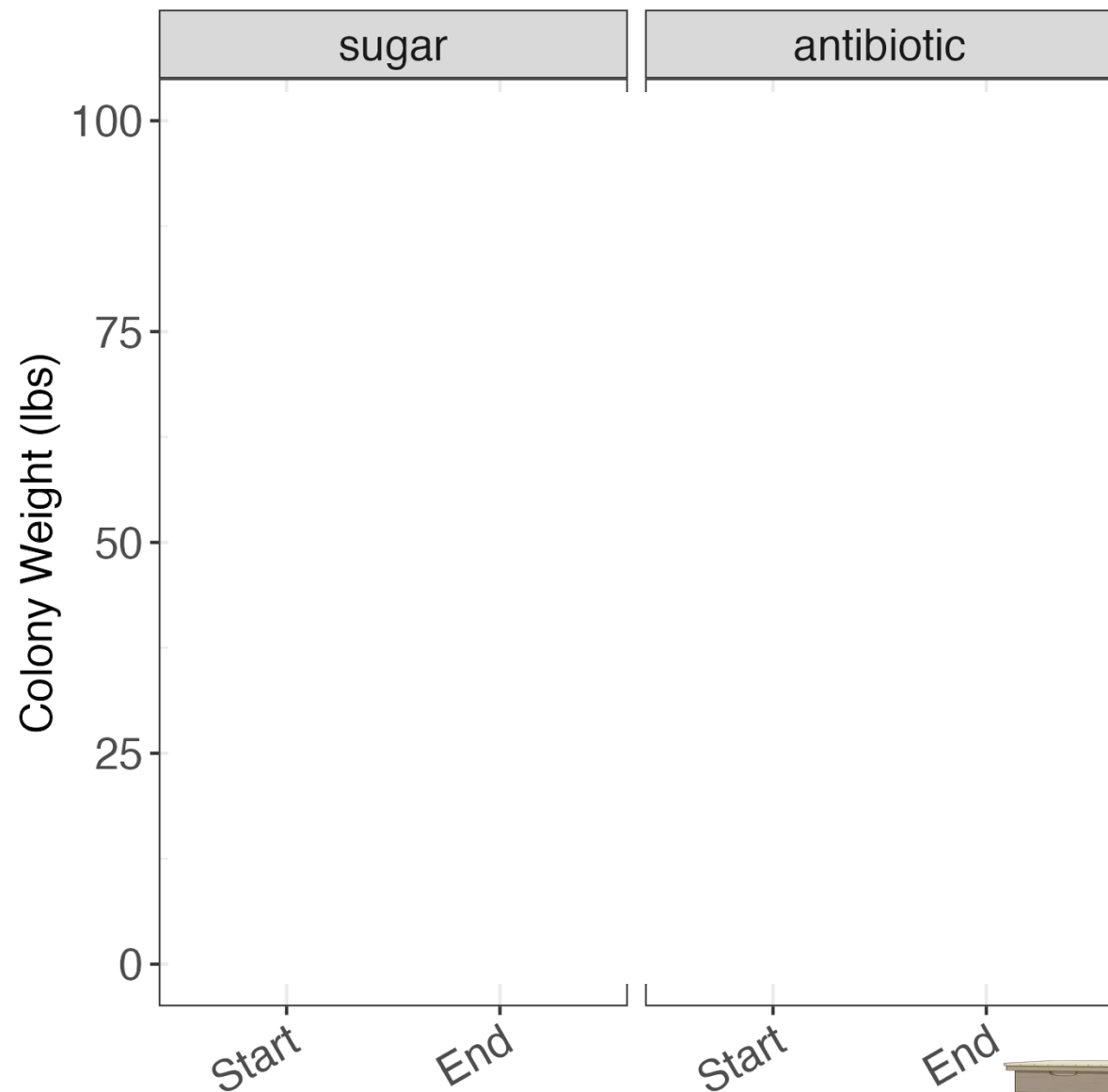




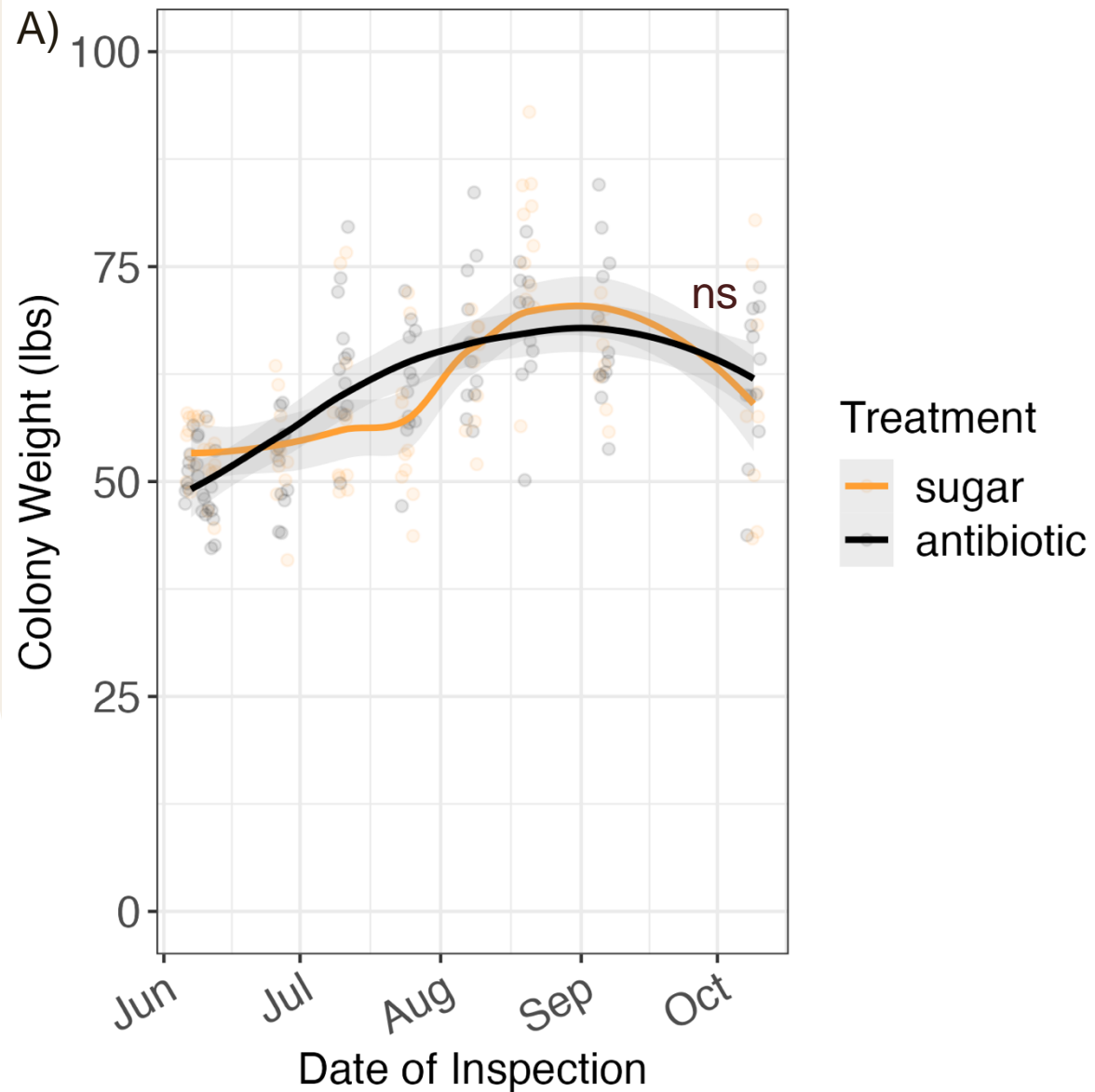
Treatment

- sugar
- antibiotic

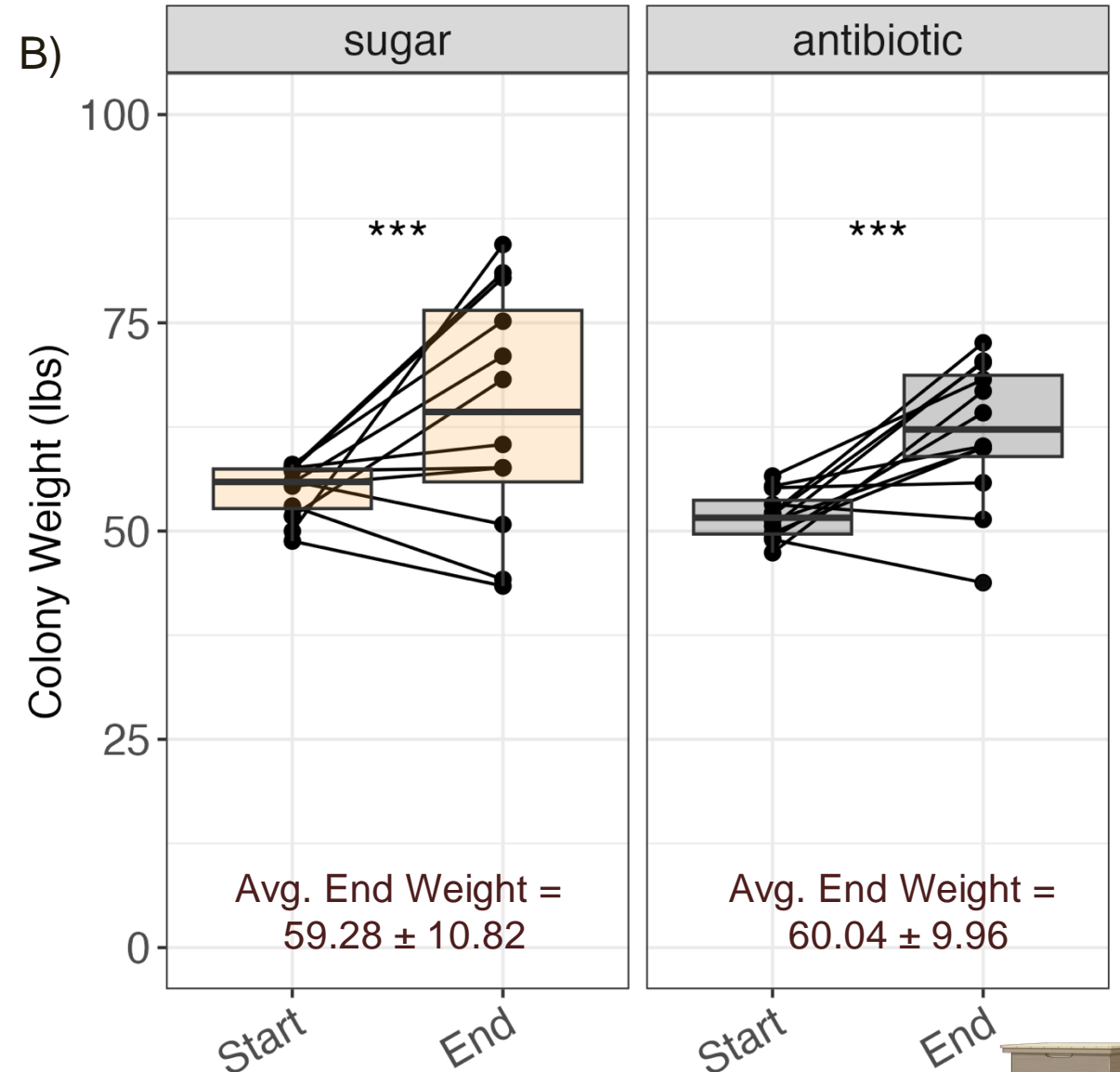
Wilcoxon rank sum test, $W = 5069$, $p\text{-value} = 0.4413$



TREATMENT HAD LITTLE EFFECT ON COLONY WEIGHT GAIN

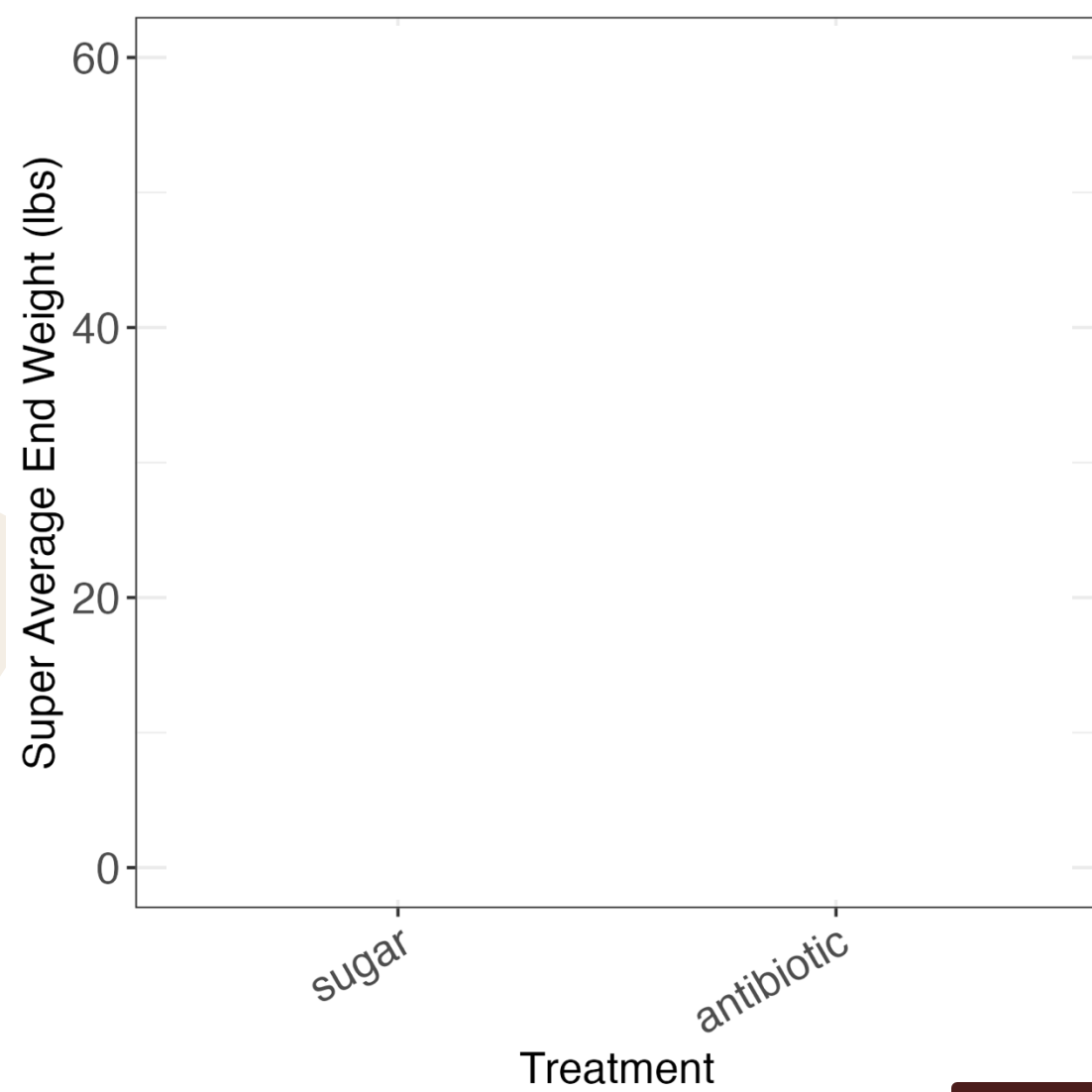
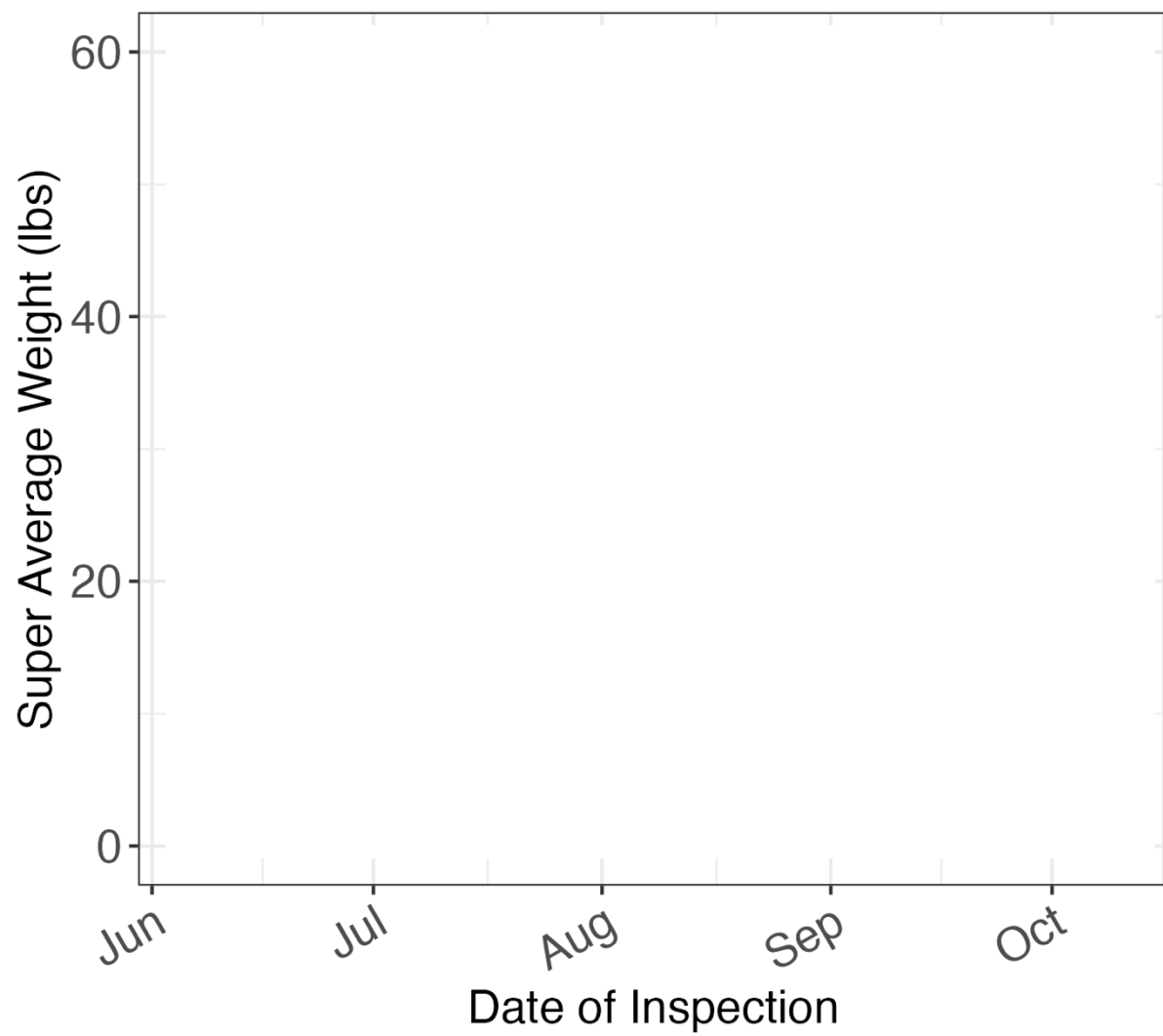




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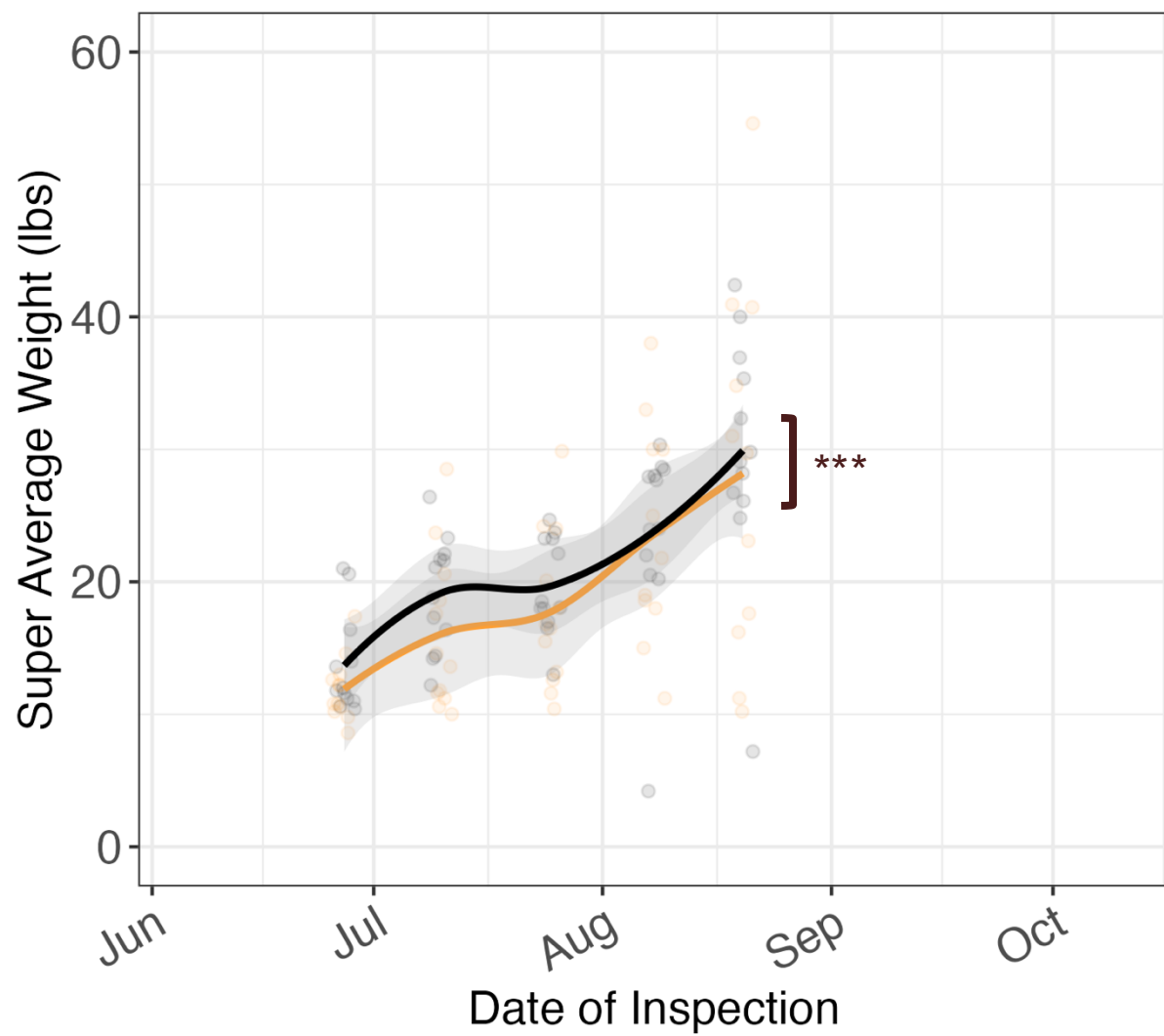
Friedman Test, $X^2 = 8.17$, $p\text{-value} = 0.00427$



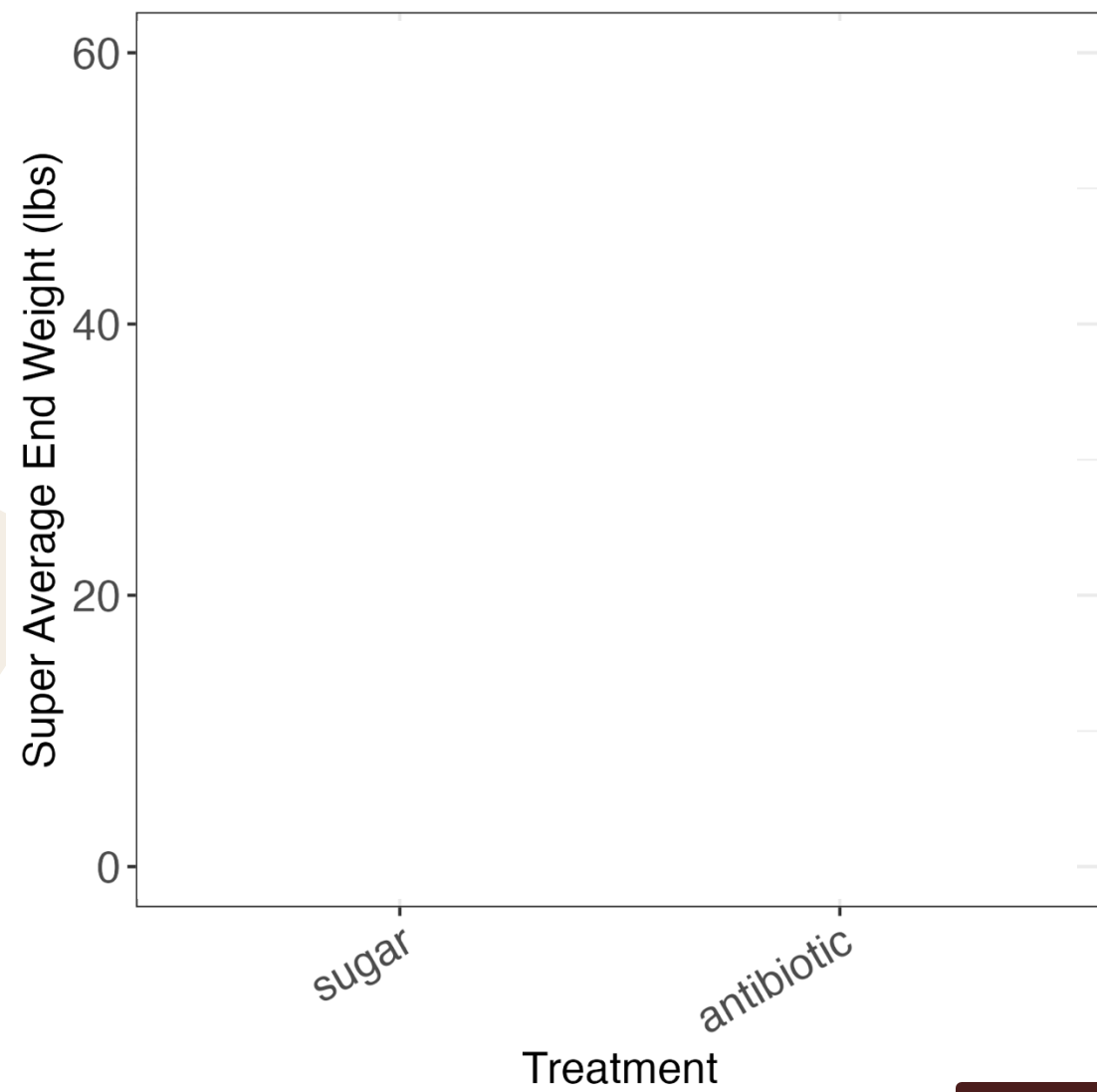


Treatment  sugar  antibiotic





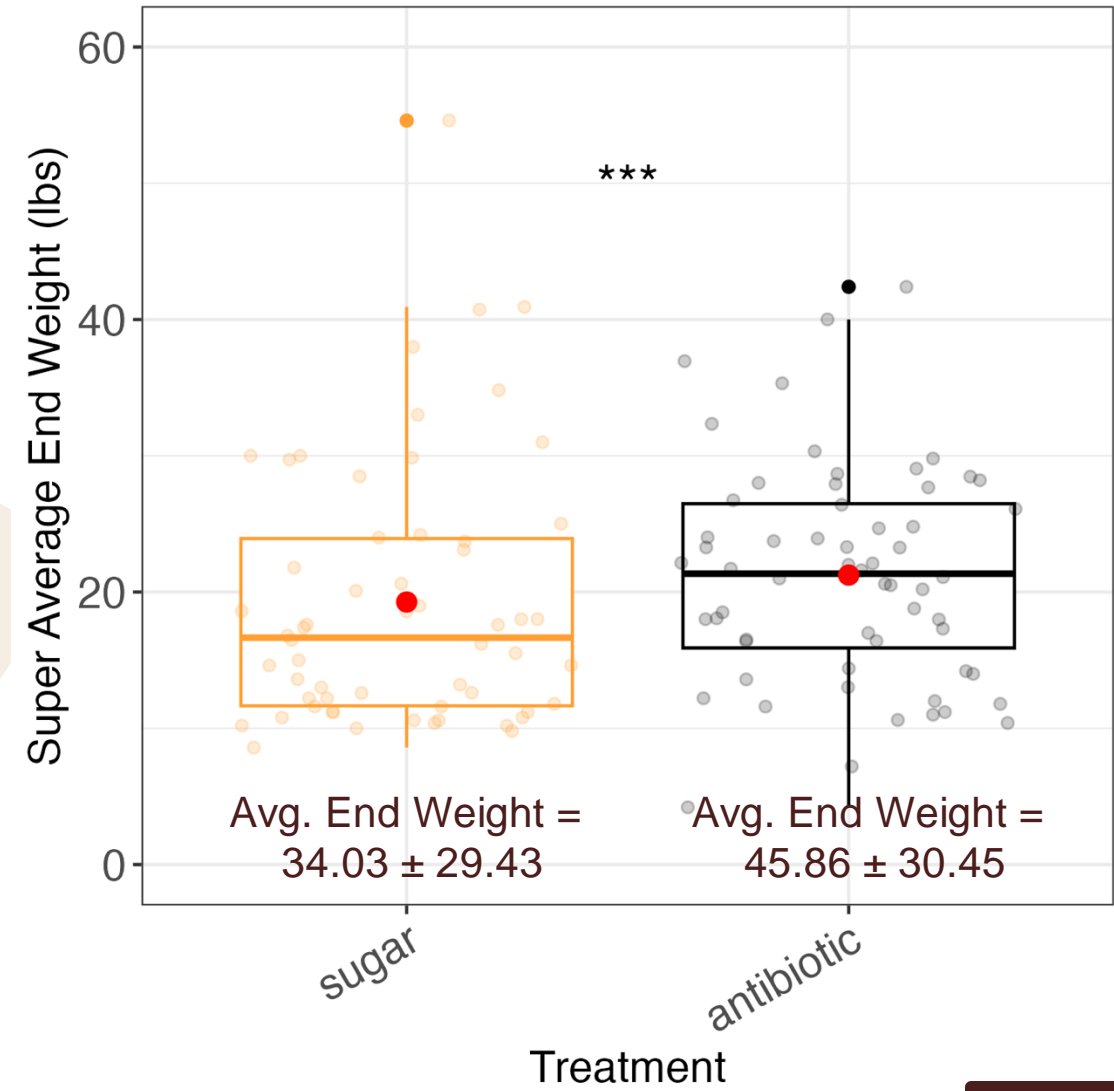
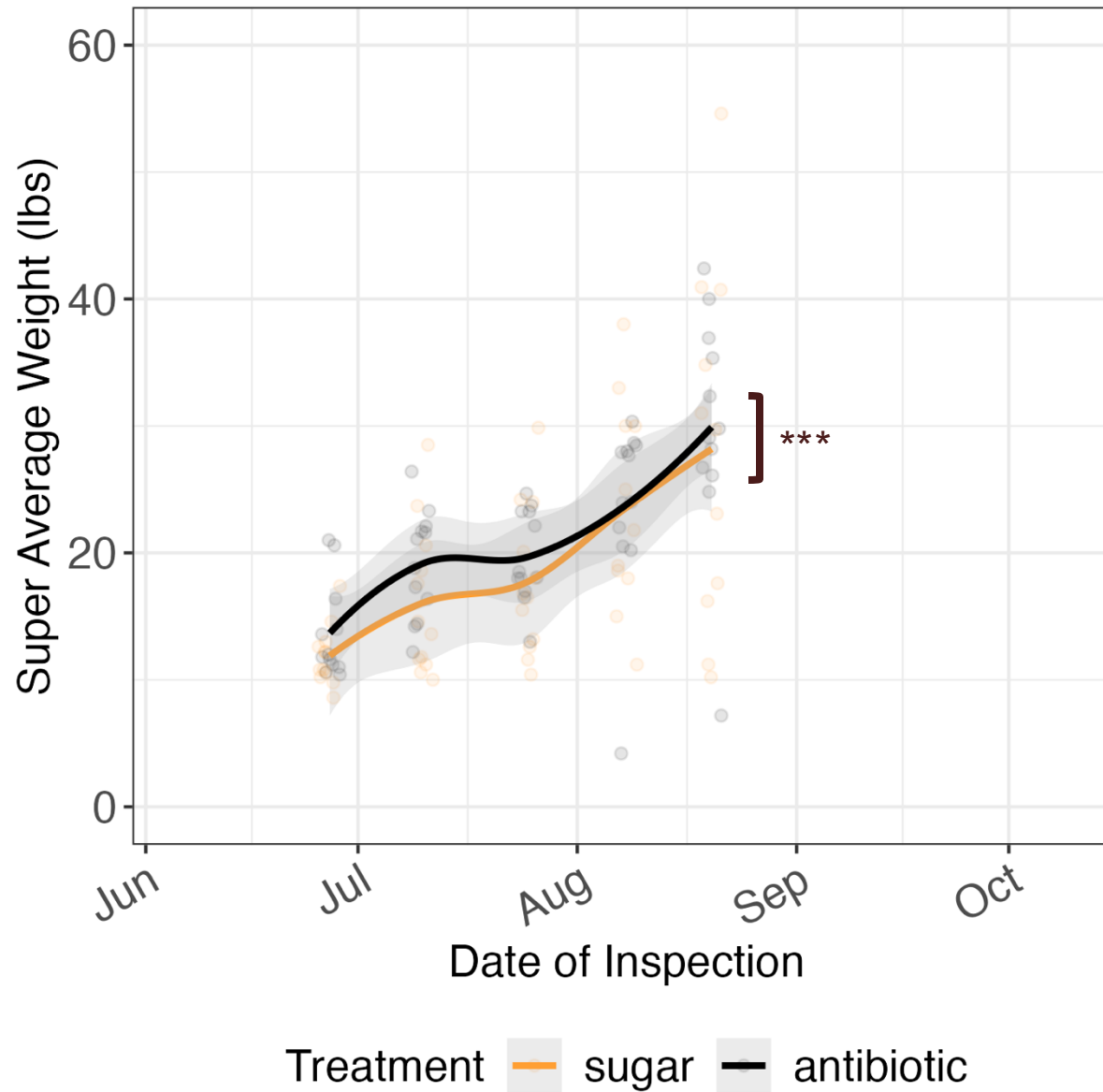
Treatment — sugar — antibiotic



Wilcoxon rank sum test, $W = 1245.5$, $p\text{-value} = 0.007828$

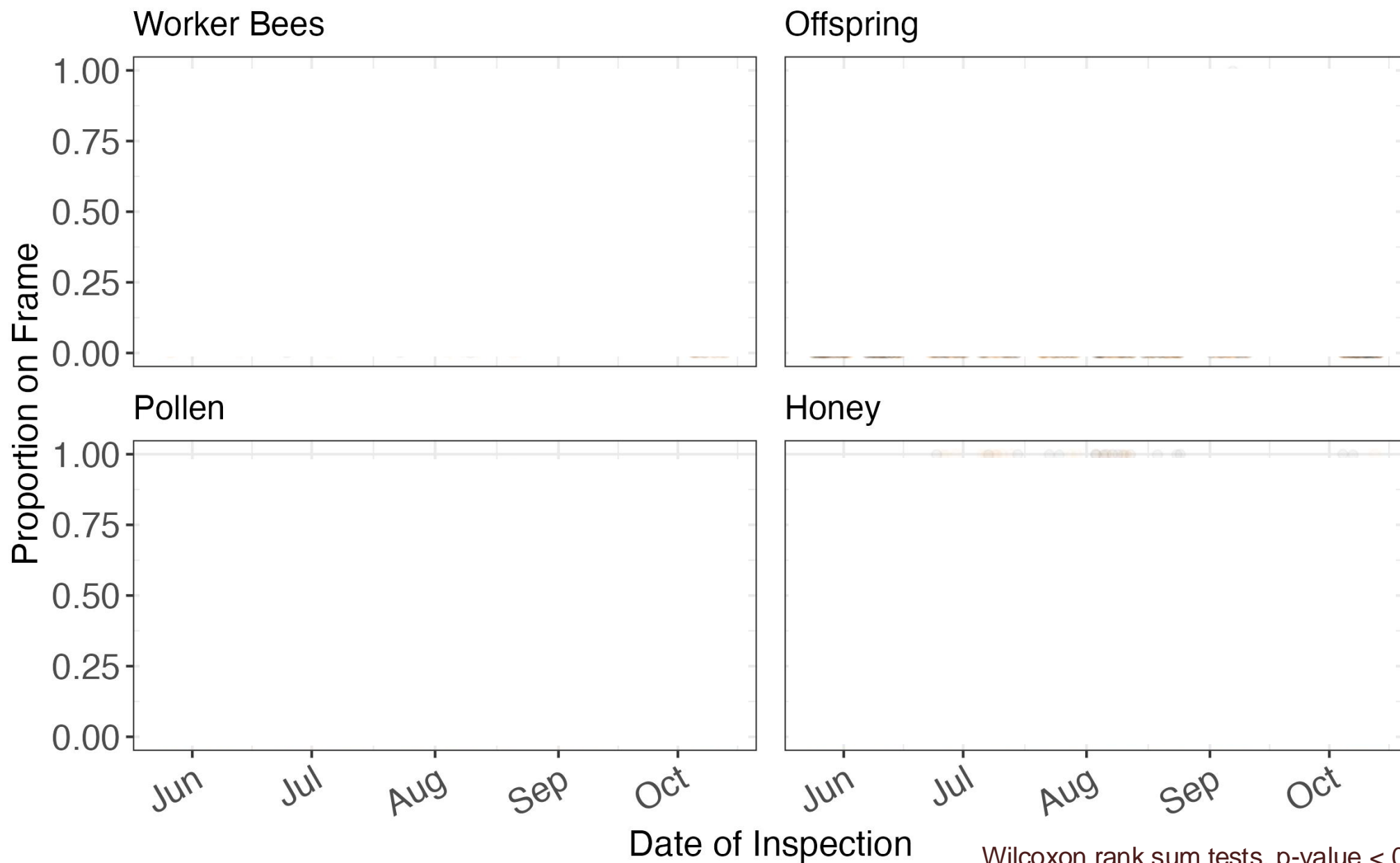


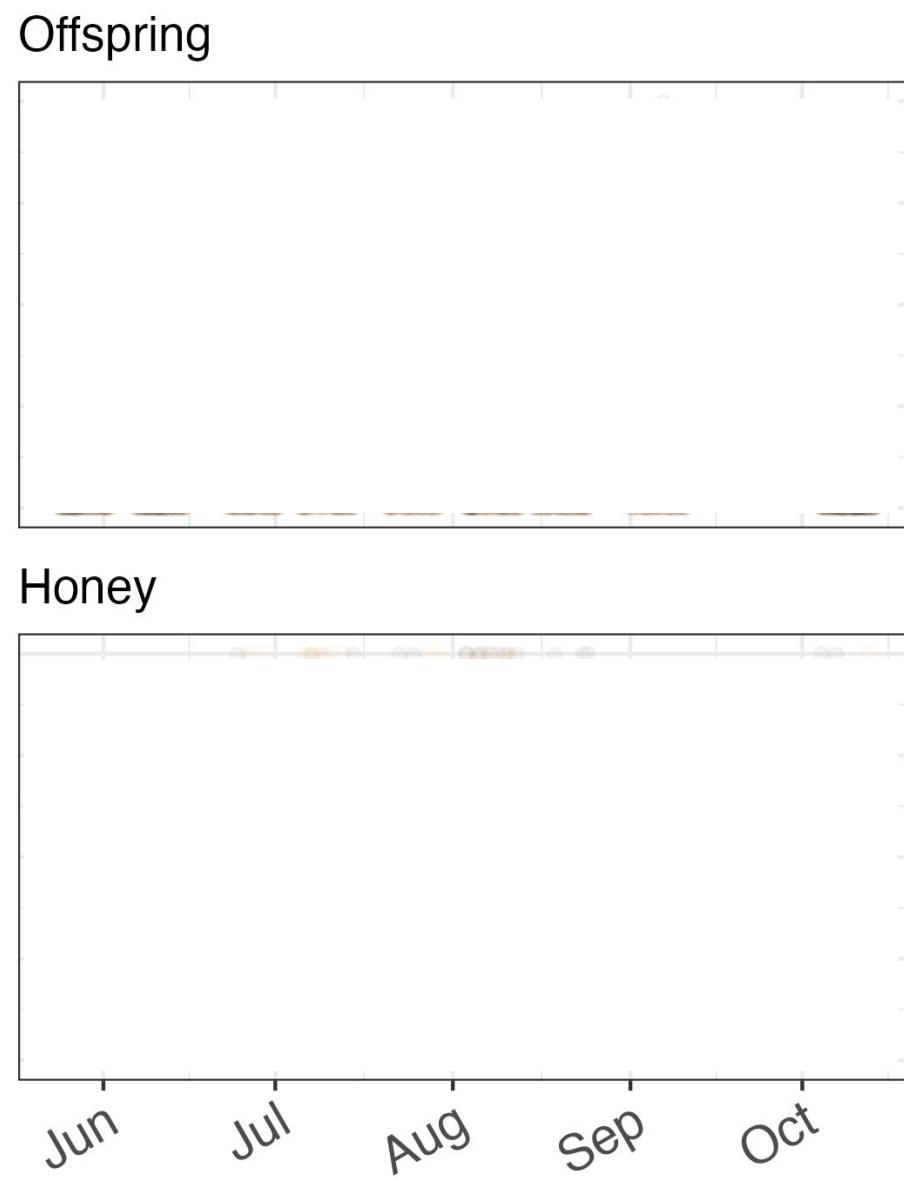
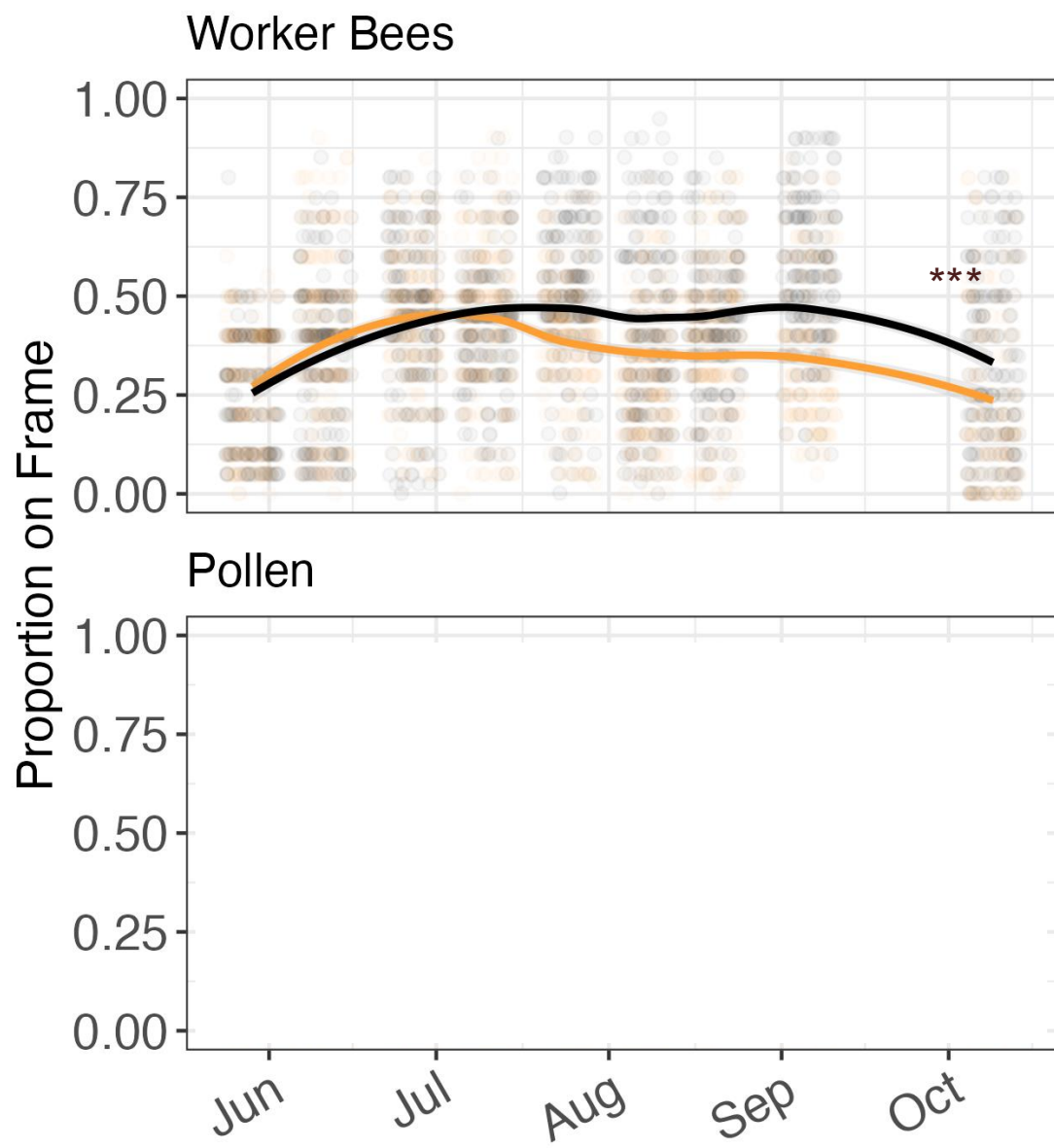
ANTIBIOTIC TREATED COLONIES PRODUCED MORE HONEY



Wilcoxon rank sum test, $W = 1245.5$, $p\text{-value} = 0.007828$







Treatment

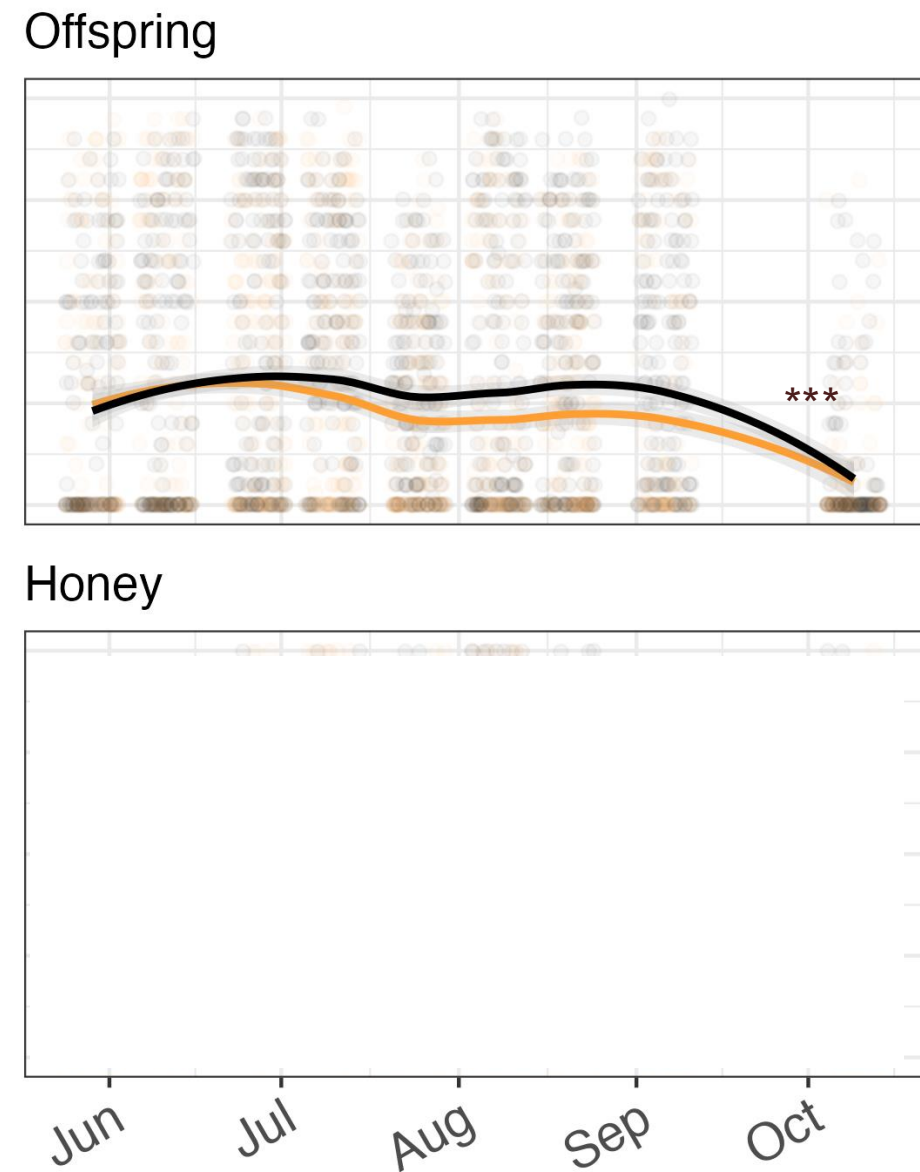
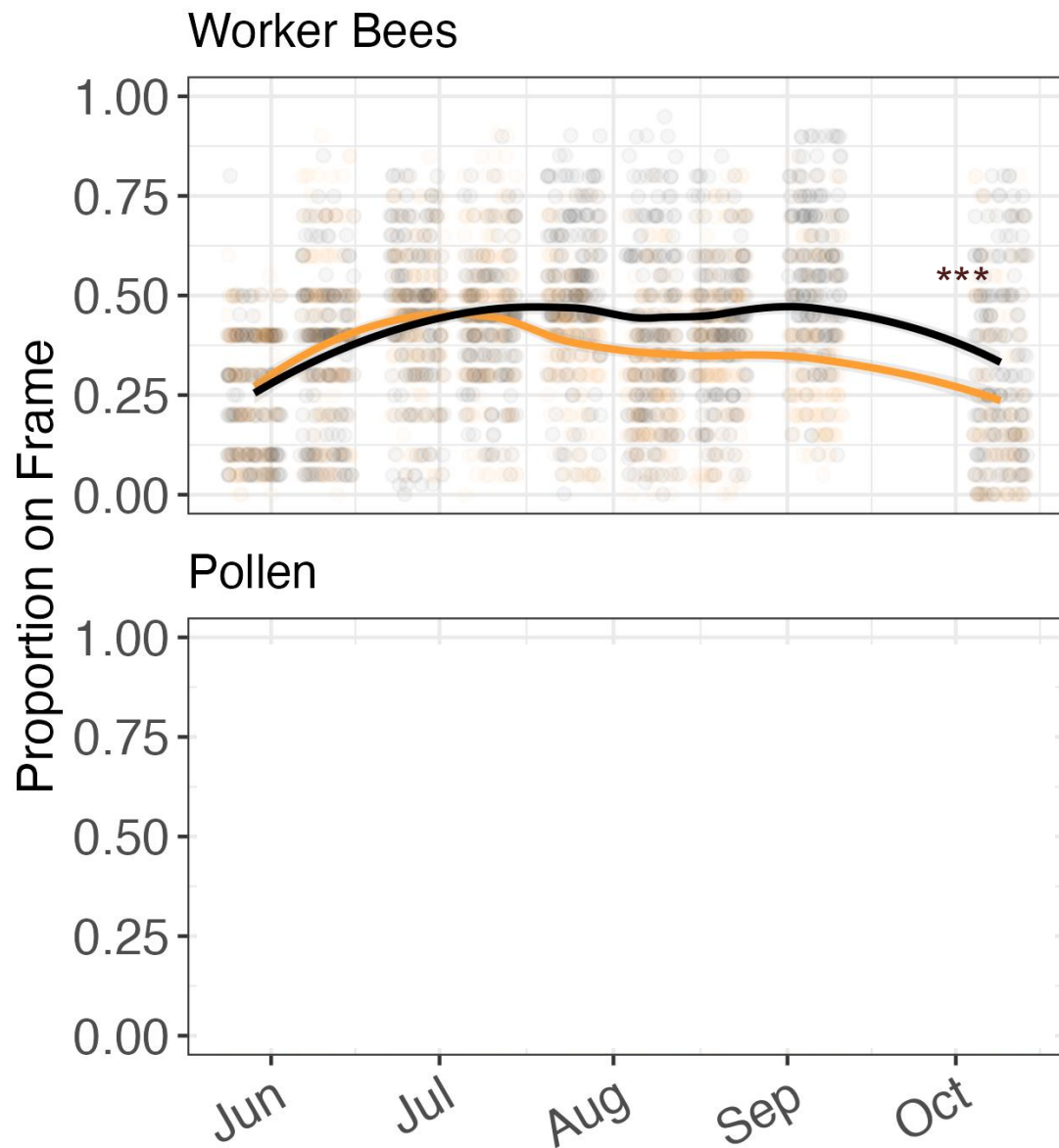
— sugar

— antibiotic

Date of Inspection

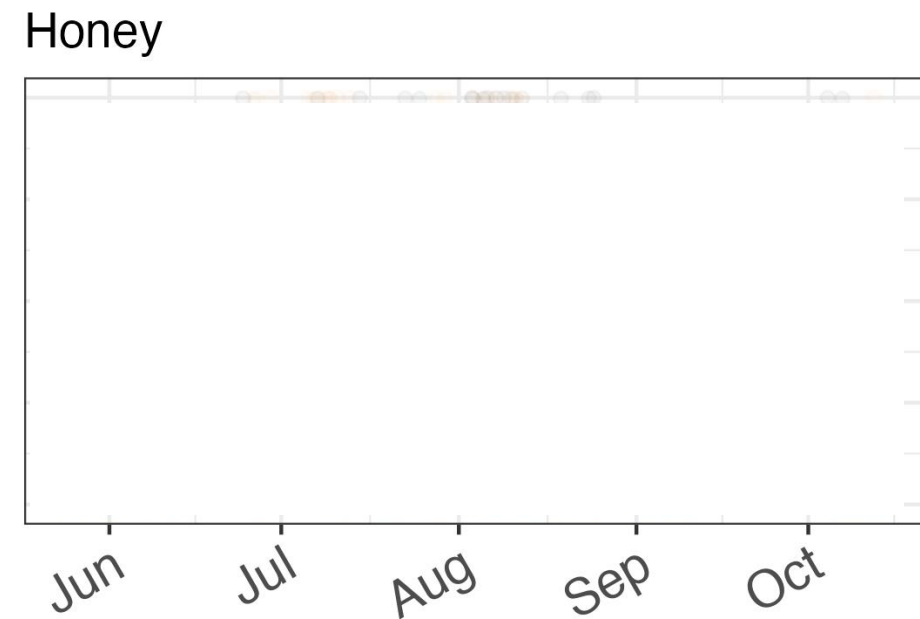
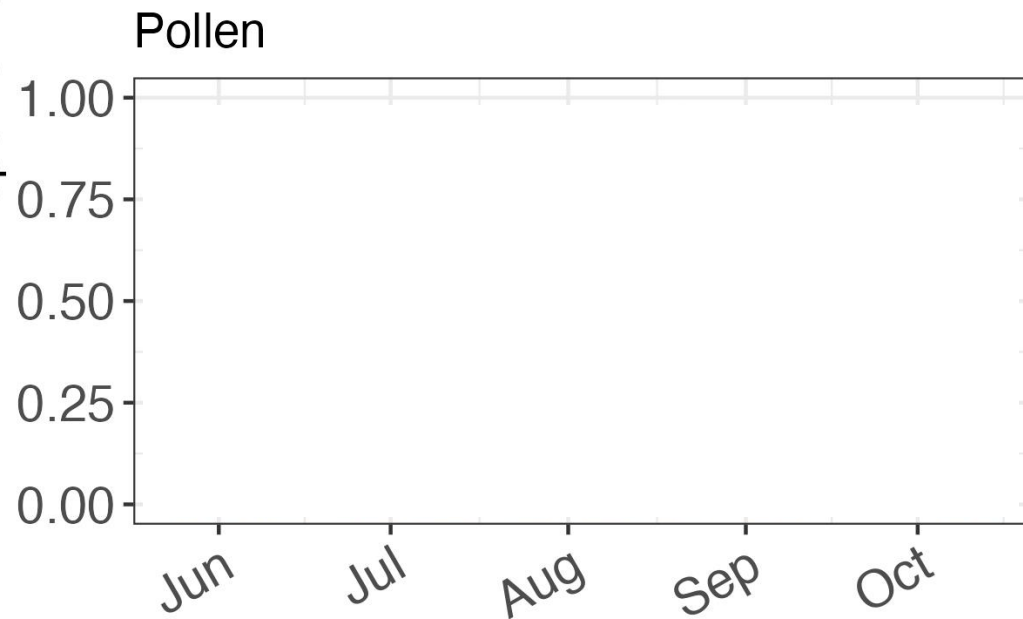
Wilcoxon rank sum tests, $p\text{-value} < 0.05$





Treatment

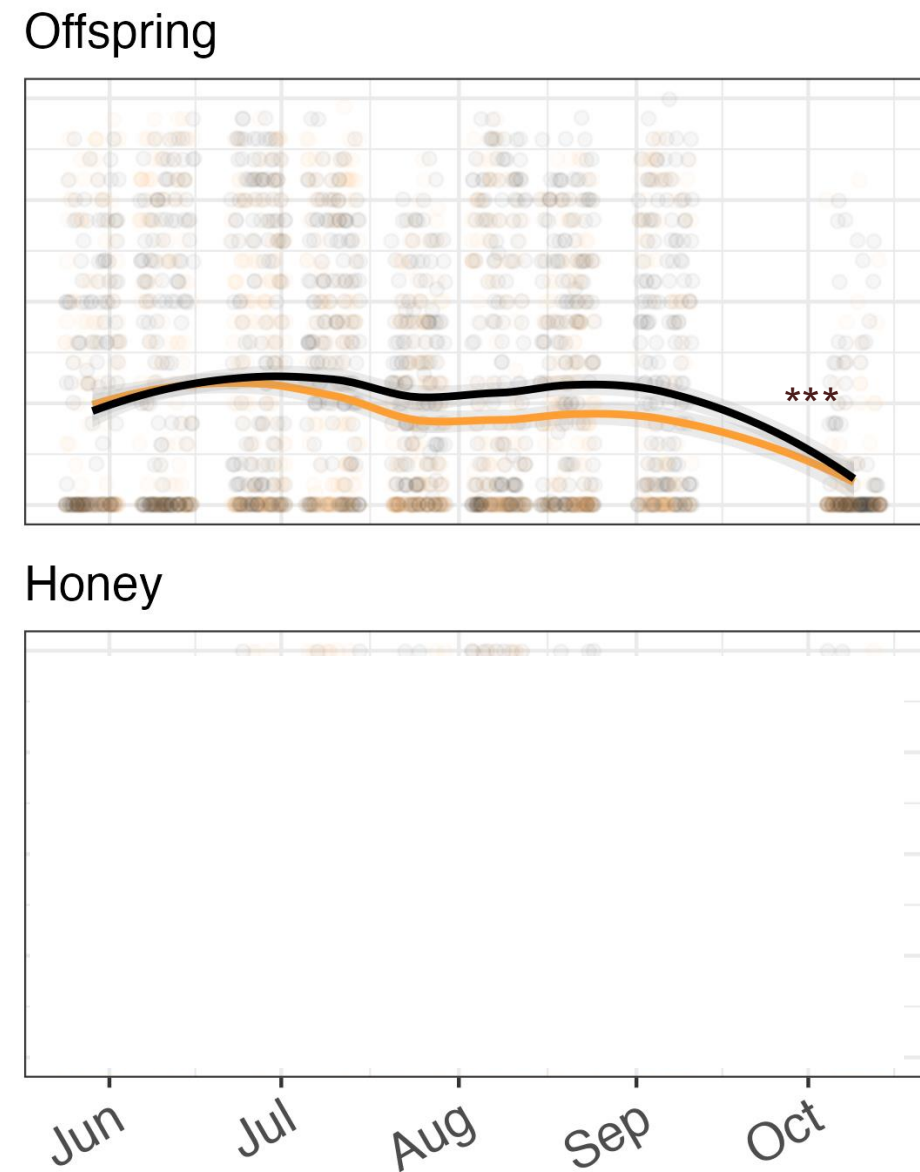
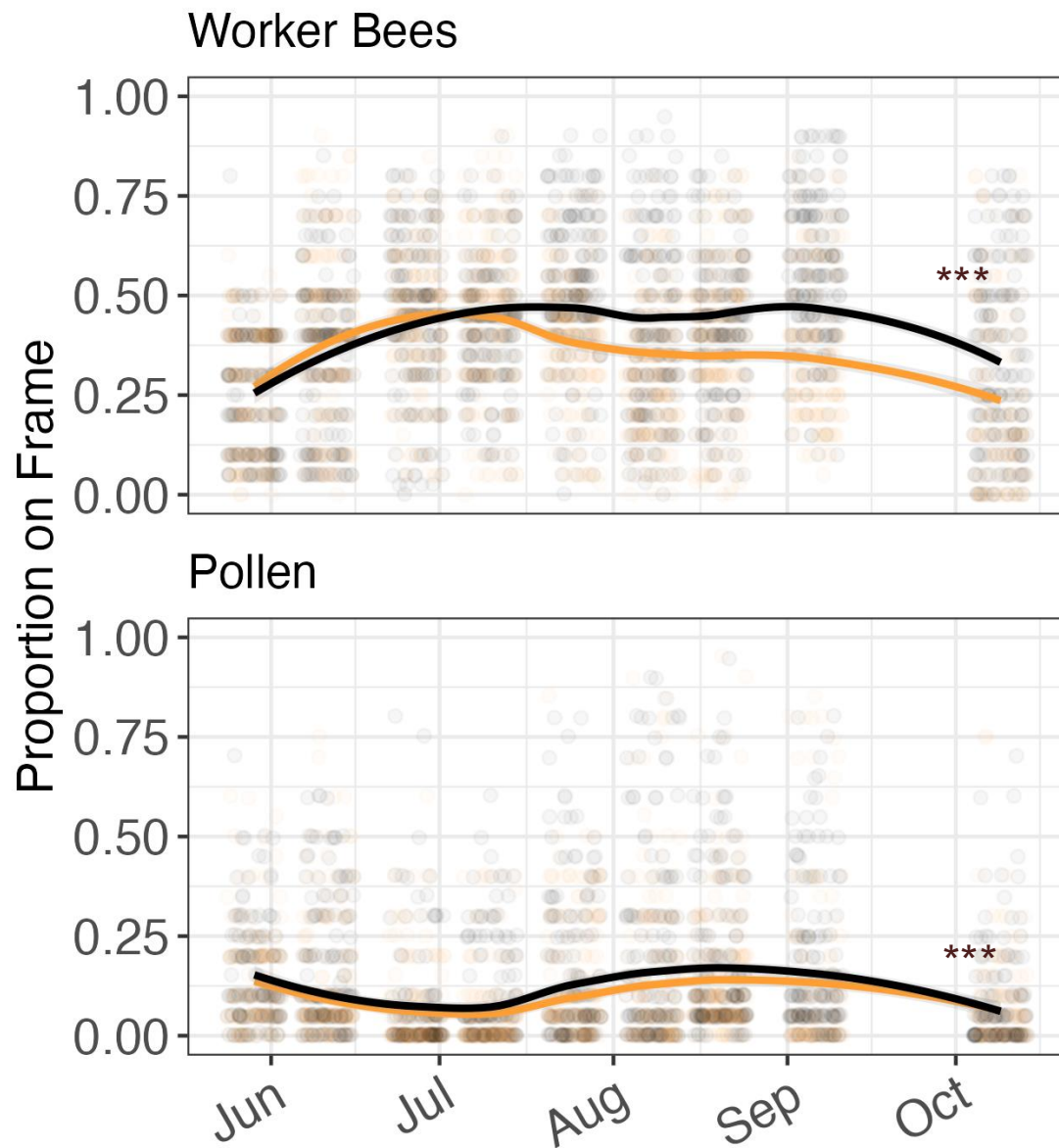
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- antibiotic



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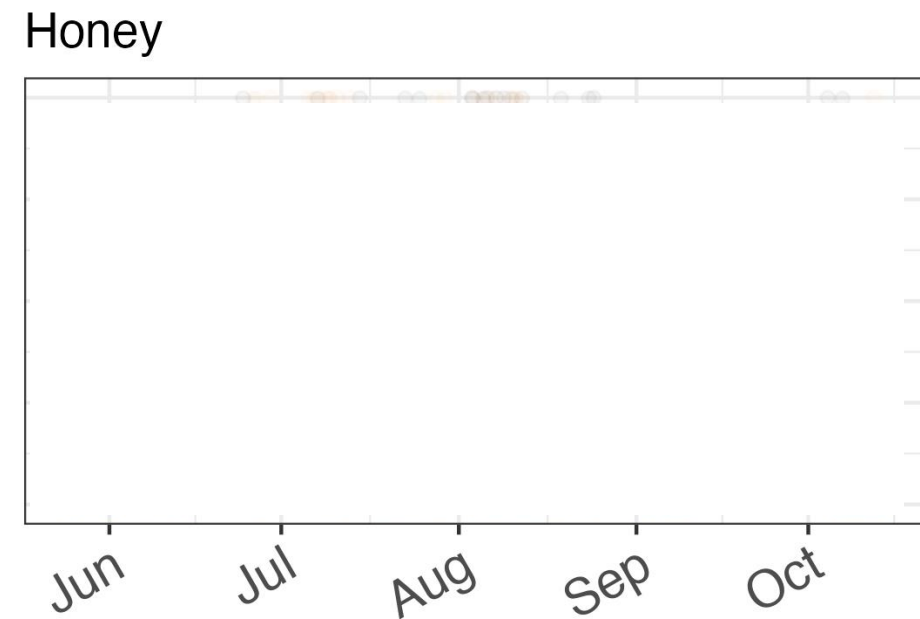
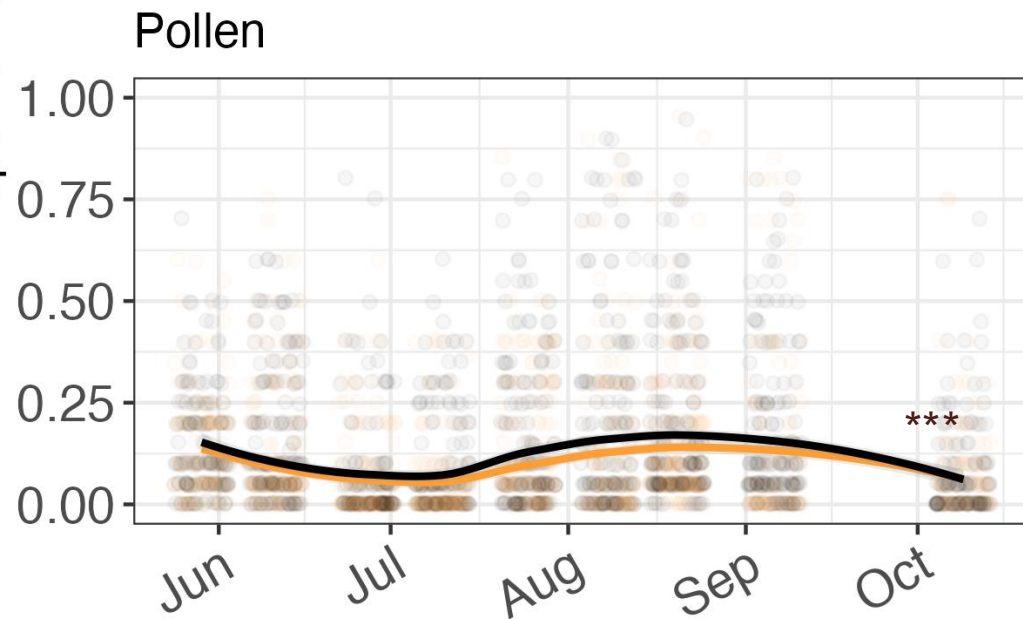
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Treatment

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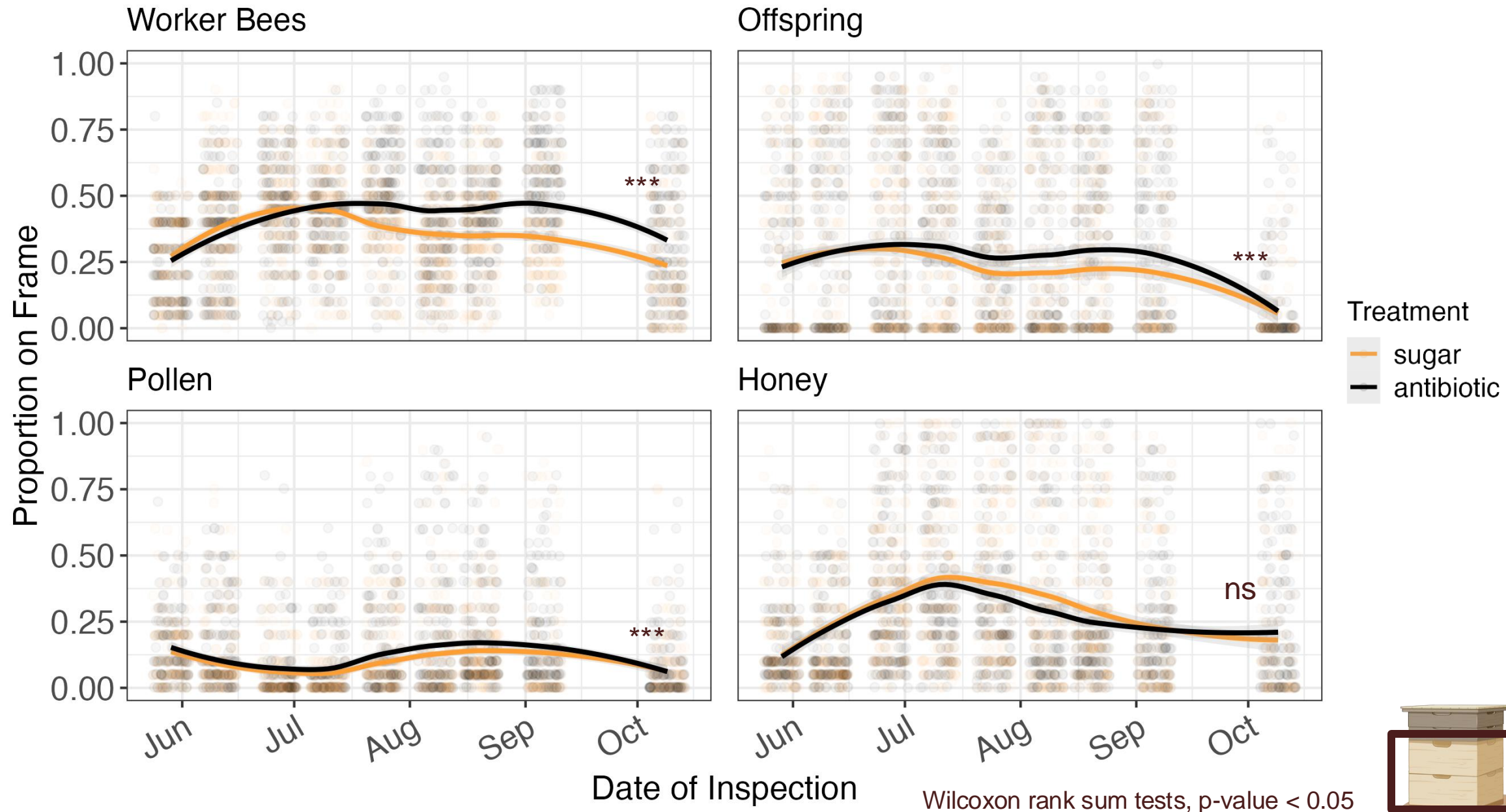


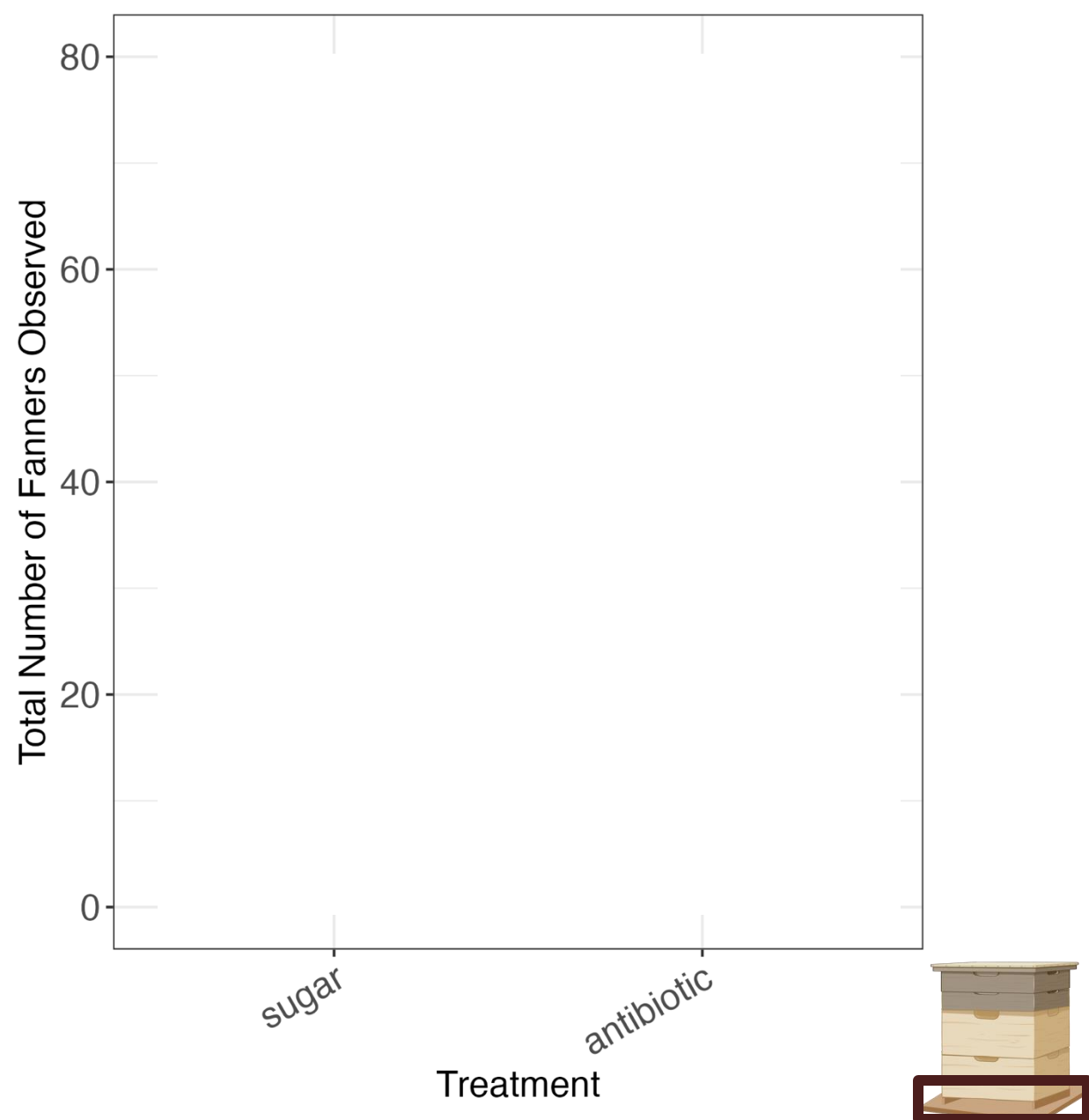
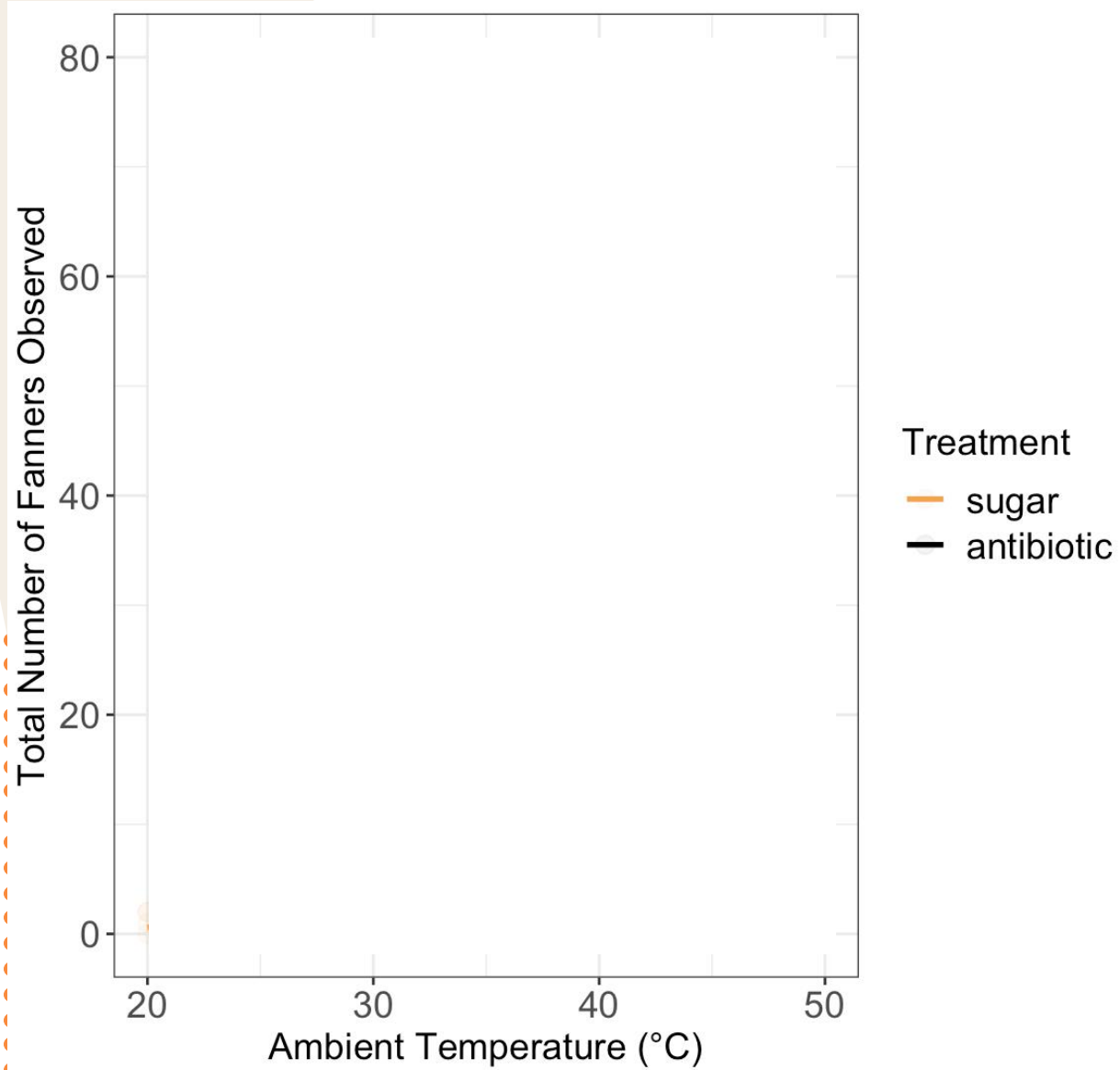
Date of Inspection

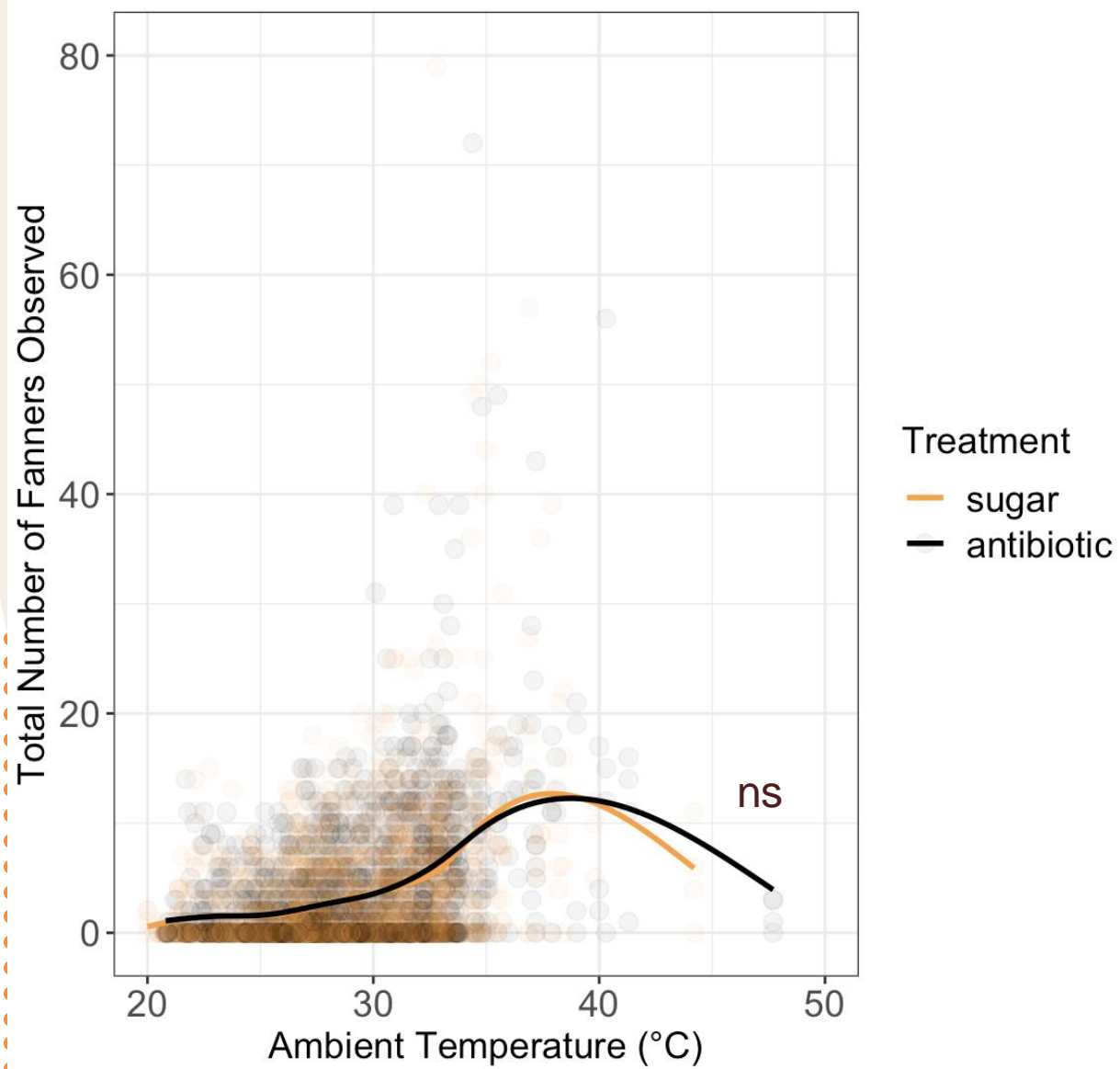
Wilcoxon rank sum tests, $p\text{-value} < 0.05$



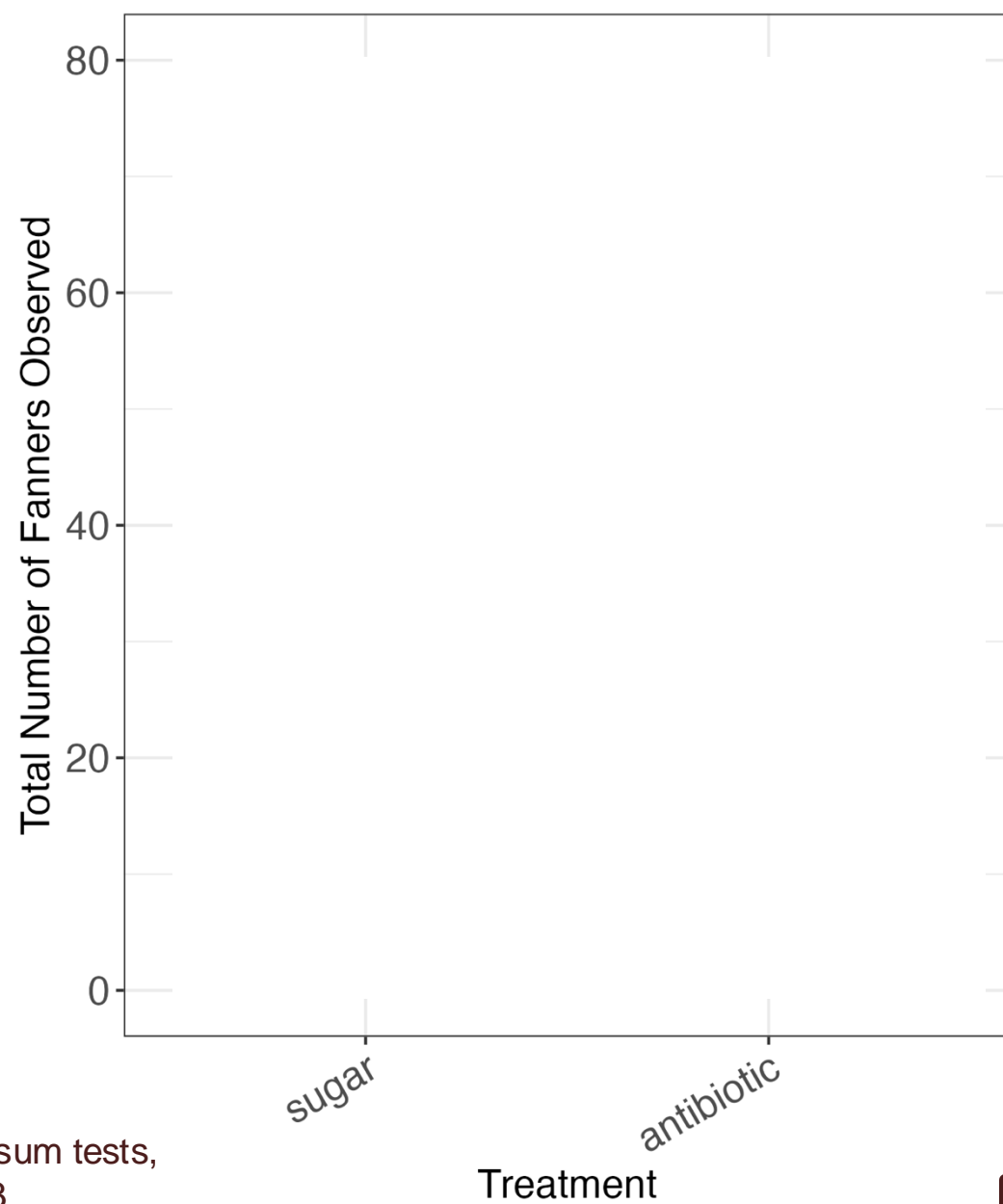
ANTIBIOTIC TREATMENT COLONIES HAD MORE BEES & RESOURCES



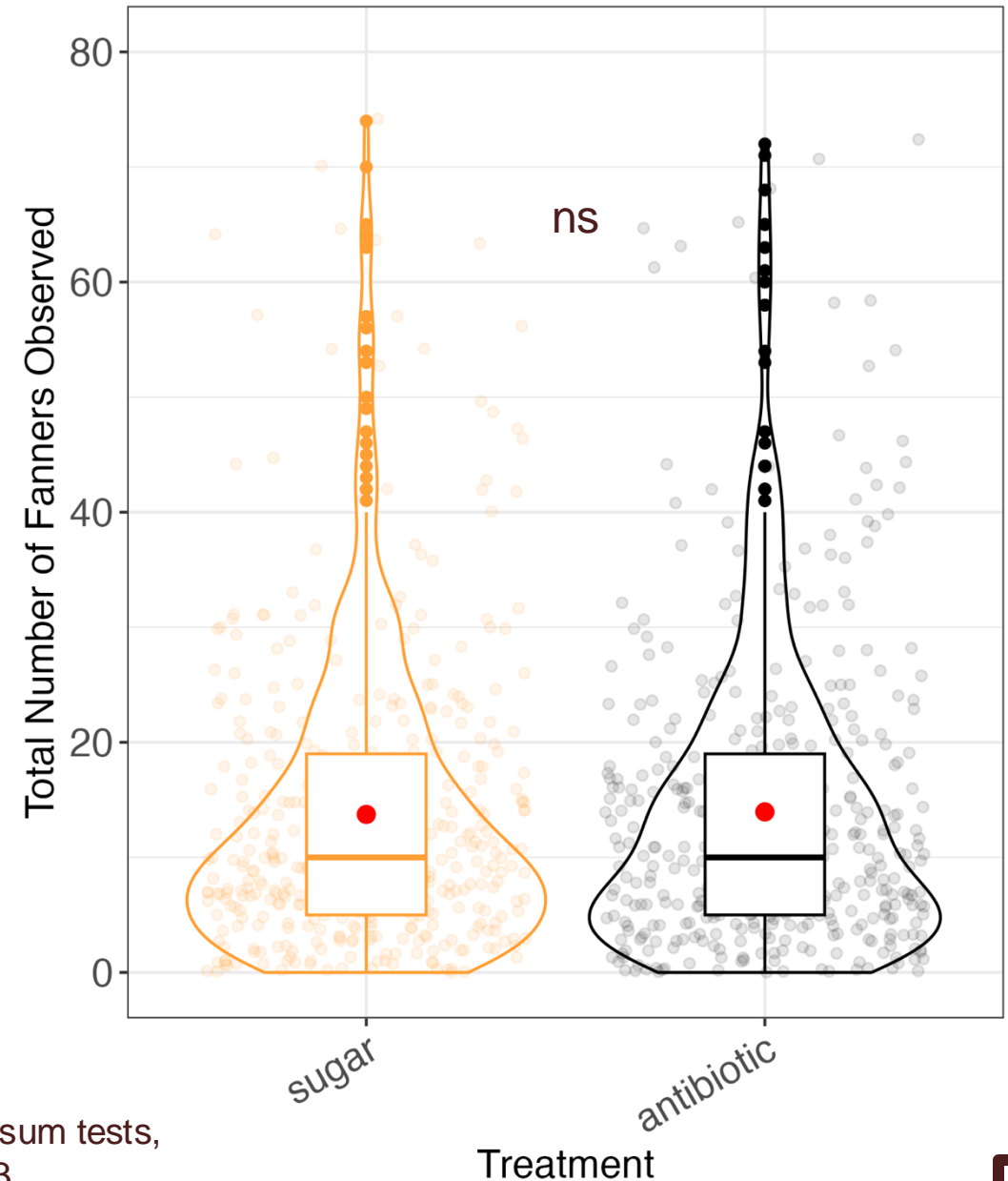
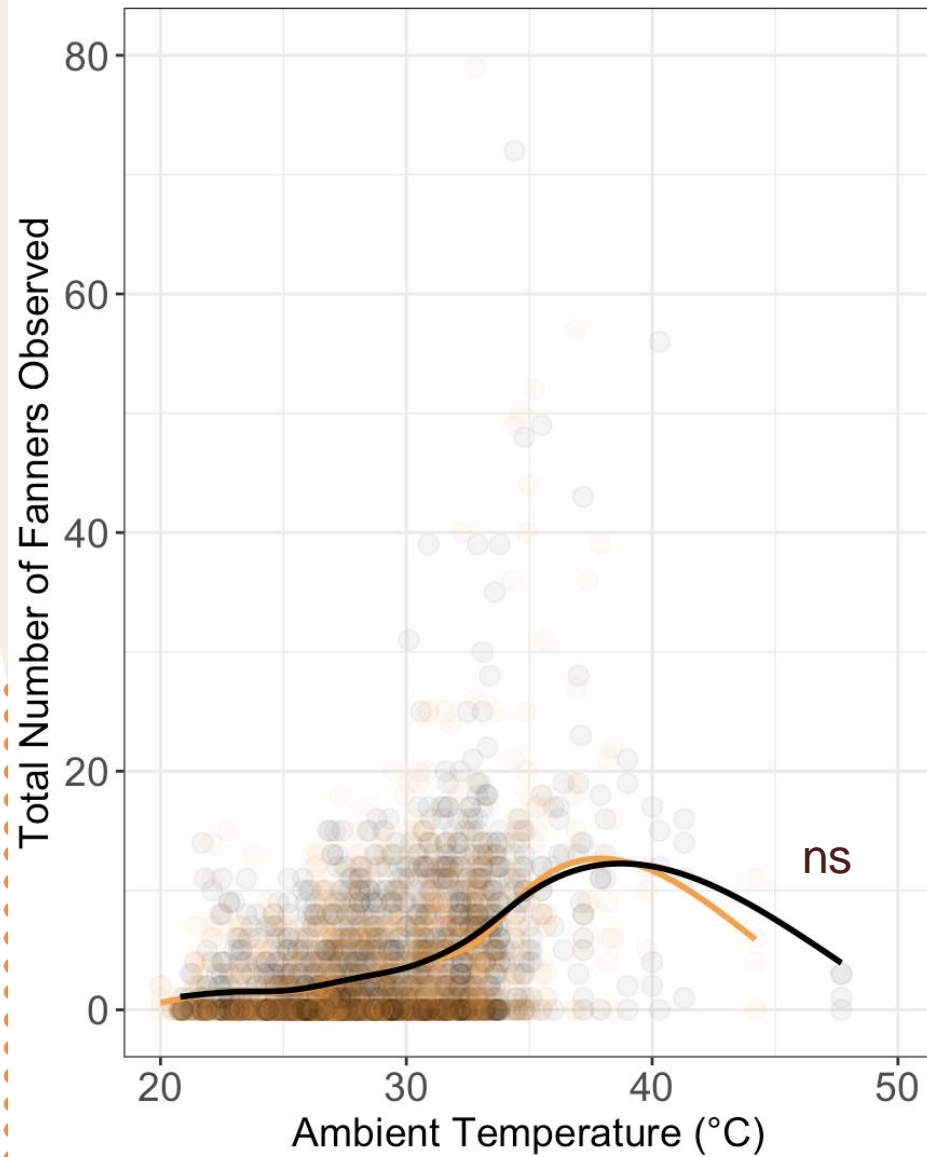




Wilcoxon rank sum tests,
p-value = 0.943



TREATMENT HAD LITTLE EFFECT ON FANNER OUTPUT



Wilcoxon rank sum tests,
p-value = 0.943



MAIN TAKEAWAYS



**PROPHYLACTIC ANTIBIOTIC
TREATMENT MAY PROTECT
COLONY HEALTH**



bees with
antibiotics



collect so much pollen
produce so much honey
produce so much babies

bees without
antibiotics



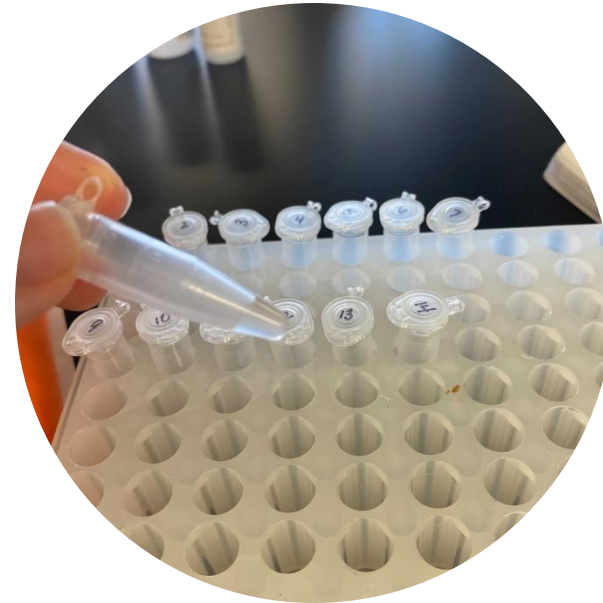
gets sick

**PROPHYLACTIC ANTIBIOTIC
TREATMENT MAY INCREASE
COLONY PRODUCTIVITY**

FUTURE DIRECTIONS



**CONTINUE TO ANALYZE DATA
(THERE'S SO MUCH)**



**GUT MICROBIOME ANALYSIS &
QPCR FOR ANTIBIOTIC RESISTANCE GENES**

ACKNOWLEDGEMENTS

Principle Investigator

Dr. Chelsea Cook



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Elma Peco

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AVERAGE INTERNAL COLONY TEMPERATURE BY TREATMENT

