

## Introduction

Most eusocial and primitively eusocial insects demonstrate a degree of specialization within the colony, varying from responsibilities in rearing a brood to foraging in the field to sustain the colony. This foraging specialization has been noted in strictly eusocial organisms such as honey bees (Page and Amdam, 2007) but has been scarcely documented in less elaborate social systems such as the bumble bee. Such species have been anecdotally observed to retain evolutionarily ancestral mechanisms for regulating reproduction, and co-opting these mechanisms to regulate the division of labor amongst workers.

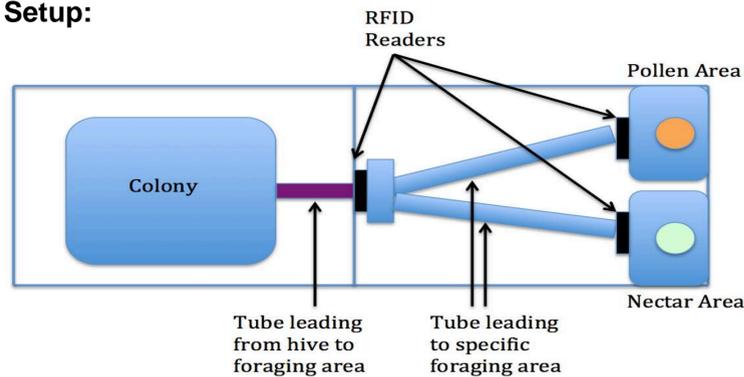
### Prior Observations:

- Honey bee workers who forage for pollen develop larger ovaries and higher vitellogenin titers than workers foraging for nectar, despite both groups remaining non-reproductive.
- The ground-plan hypothesis states that ancestral mechanisms once used to regulate foraging patterns remain, where pollen (protein) is used to produce eggs, and nectar (carbohydrates) is used for self-maintenance (Page and Amdam, 2007).
- The related (and largely unstudied) bumble bee does have specialists and generalists within a colony.
- Typically only the queen lays eggs during the season, but individuals still may express measures of reproductive fitness.

### Research Goals:

- The primary question of this project asks whether through the course of social development, do any solitary tendencies remain within the behaviors of bumble bee specialists?
  - If so, can these tendencies be quantitatively measured through physical manifestations, such as ovary development, ovary size, bee size, and haemolymph composition?
- The current hypothesis in this experiment states that these measures of reproductive fitness will be significantly greater (e.g., more developed and larger ovaries, larger head size) for pollen specialists when compared to nectar specialists and generalists.

### Experimental Setup:



## Methods

- Radio Frequency Identification Tagging and Logging
- Physical Measurements and Dissections
- Micro-capillary Haemolymph Extractions
- Gel Electrophoresis
- *Note:* Specialists were defined using an exact binomial test with a confidence value of 90 percent based on foraging patterns. Any bee that did not meet these criteria was assumed to be a generalist. A minimum of 10 foraging trips was needed for an individual bee to be considered.

## Results

### Dissection Samples of Ovary Development After 8 Days Ad

#### *Libitum* Feeding



Fig. 1 Ovary development scale based on the Michener and Wille (1961) framework.

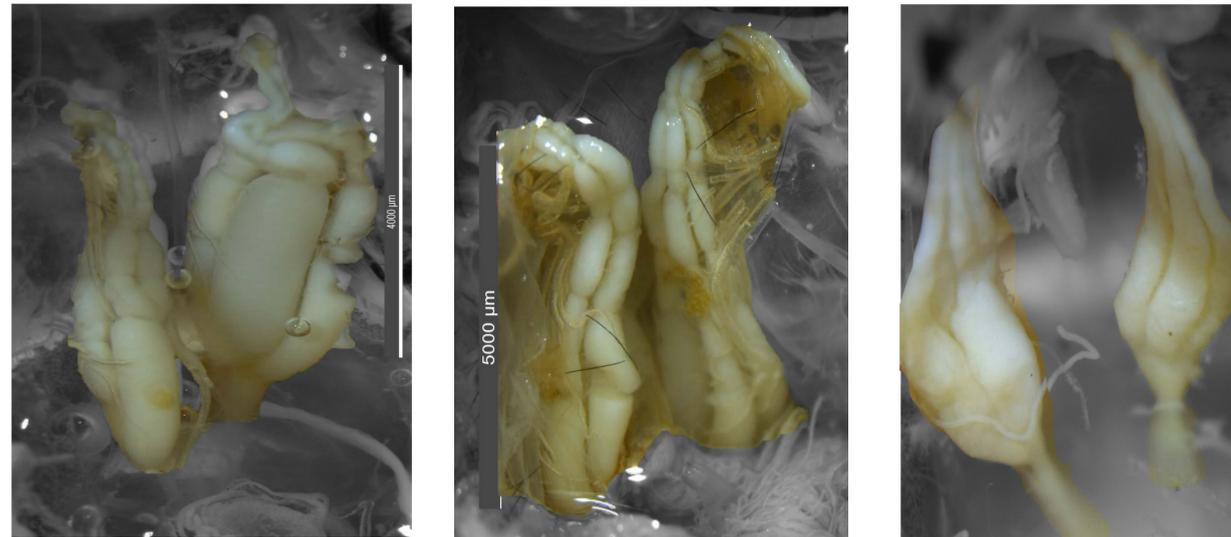


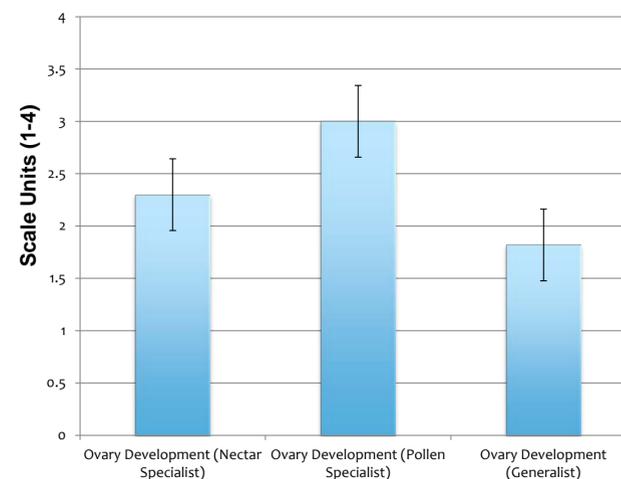
Fig. 2 All measurements taken at the conclusion of feeding period

Pollen Specialist (length ≈ 4 mm)  
Head size: 3.9 mm

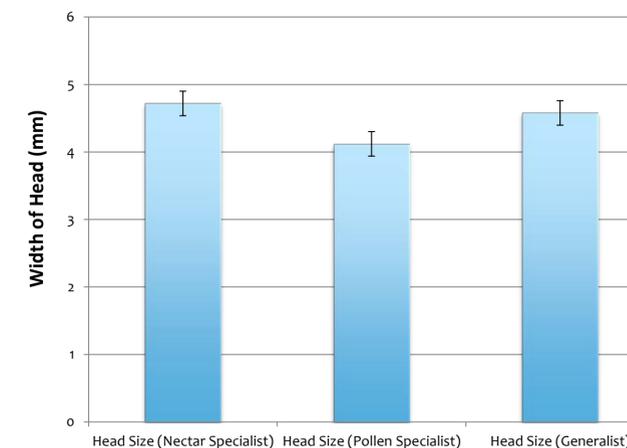
Nectar Specialist (length ≈ 5 mm)  
Head size: 5.2 mm

Generalist (length ≈ 2 mm)  
Head size: 3.6 mm

### Visual Scale of Ovary Development



### Head Size of Specialists/Generalists



## Conclusions

After conducting t-test comparisons between specialists as well as generalists, the following results were gathered:

- Ovary Development
  - Pollen to nectar specialists  $p = 0.10$
  - Nectar specialist to generalist  $p = 0.15$
  - Pollen specialist to generalist  $p = 0.03$
- Head Size
  - Pollen to nectar specialists  $p = 0.08$
  - Nectar specialist to generalist  $p = 0.50$
  - Pollen specialist to generalist  $p = 0.16$

The only statistically significant relationship appeared to be the comparison of ovary development between pollen and specialists and generalists, indicating a difference in ovary development between pollen specialists and average workers. Interestingly, head size appeared to be larger for nectar foragers, although not statistically significant.

## Future Research

- Using gel electrophoresis to further measure vitellogenin (egg precursor protein) concentration.
- Antibody staining and confocal microscopy to measure brain amine titers.
- Ether extractions to quantify the fat content (nutritional resources) of foraging specialists.
- Bumblebees offer the chance to compare worker foraging specialization with direct reproductive ability *in the same individuals* since at the end of the season queen control erodes and workers reproduce. Determine if pollen specialists are more reproductively developed at the end of the colony cycle.

## Acknowledgements

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References available upon request