

# Contrasting the behavior of three bee species in alfalfa to predict their impact on gene flow risk

Johanne Brunet  
USDA-ARS VCRU  
Dept. of Entomology  
University of Wisconsin-Madison



# Outline

- Conceptual approach: Linking Pollinator foraging behavior to gene flow
- Field observations of pollinator foraging behavior for 3 bee species on alfalfa
- Comparing the three bee species with their potential impact on gene flow risk



# Acknowledgements

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- Graduate School- UW Madison
- USDA-ARS



# Pollinator foraging behavior and gene flow risk

- Pollinator movement
  - The distance traveled between plants
  - Directionality in pollinator movement



# Directionality of movement



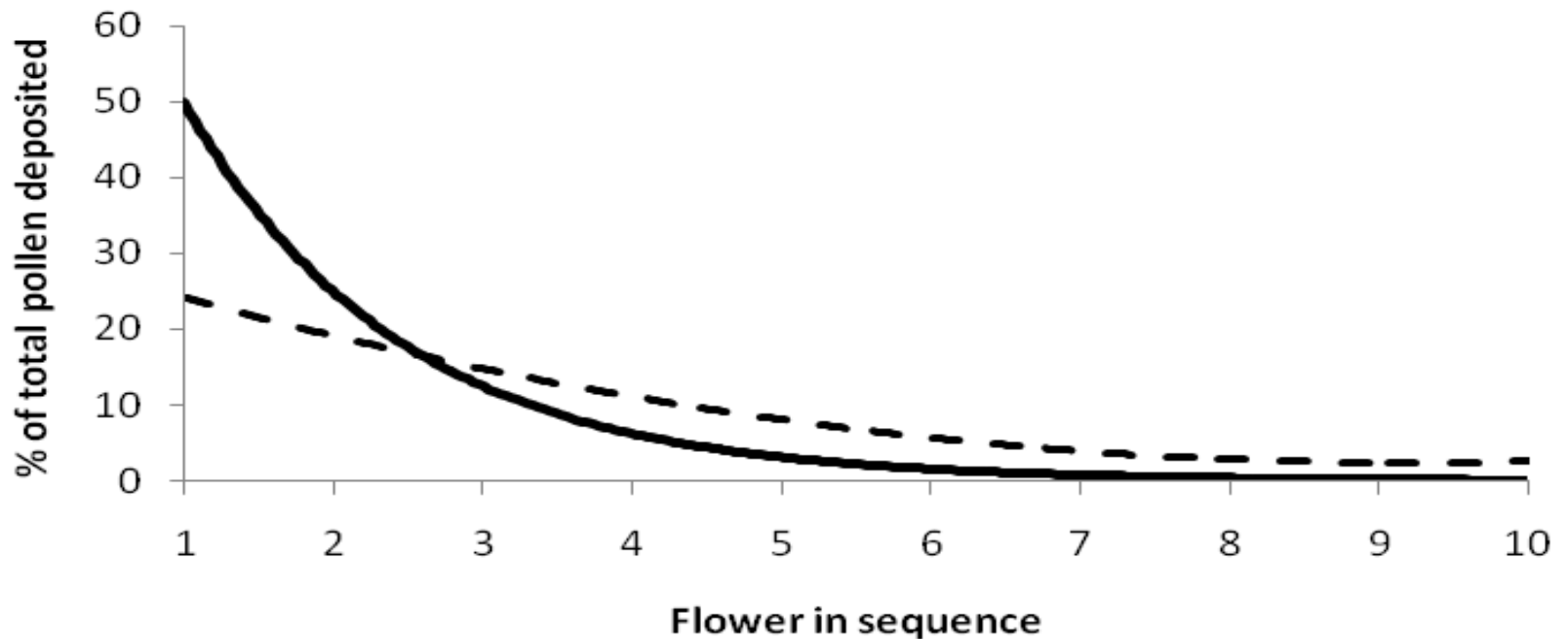
# Pollinator foraging behavior and gene flow risk

- The distance traveled between plants
- Directionality in pollinator movement
- The pollen deposition curve
- Residence or number of flowers visited in a foraging bout



# Pollen deposition curves

Fig. 4 Example of pollen carryover curves resulting in shorter (solid line) and longer (dashed line) pollen dispersal



# Pollen deposition and pollinator movement





# Pollinators and risk of transgene escape

- When coming from a transgenic to a conventional field the distance traveled by the transgenic pollen depends on the shape of the pollen deposition curve
- The more flowers visited during a foraging bout within a field, the less likely transgenic pollen will move to the next field, thus limiting gene flow
- Residence



# Pollinator foraging behavior and gene flow risk

- The distance traveled between plants
- Directionality in pollinator movement
- The pollen deposition curve
- Residence or number of flowers visited in a foraging bout
- **Tripping rate**
- Pollinator foraging behavior will affect gene flow risk and influence the coexistence of the different alfalfa markets

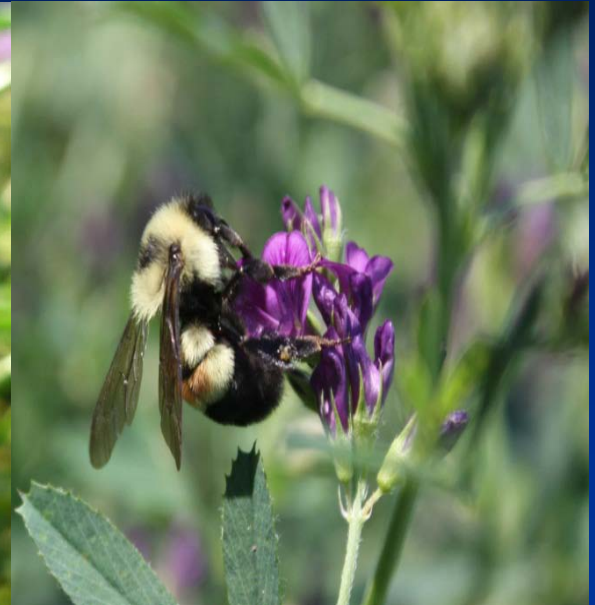
# Bees on alfalfa



Leaf cutting bee



Honey bee



Bumble bee

# Flowering alfalfa



# Bumble bees and leafcutting bees



# Pollinator observations

- 3- 6 observers
- When we see a bee in a patch
- Record bee type and follow it throughout the patch until it leaves the patch
- Mark each raceme visited in order and record number of flowers visited per raceme



# Observations (cont.)

- Record plant number
- Measured distance and direction between consecutive racemes
- Directions: N, S, E, W, NE, NW, SE, SW
- Patches with 169 plants ( $13 * 13$ ) with each plant at 0.90 m of one another.



# Data (cont)

- Number of flowers visited per raceme in succession
- Distance and direction traveled between consecutive racemes

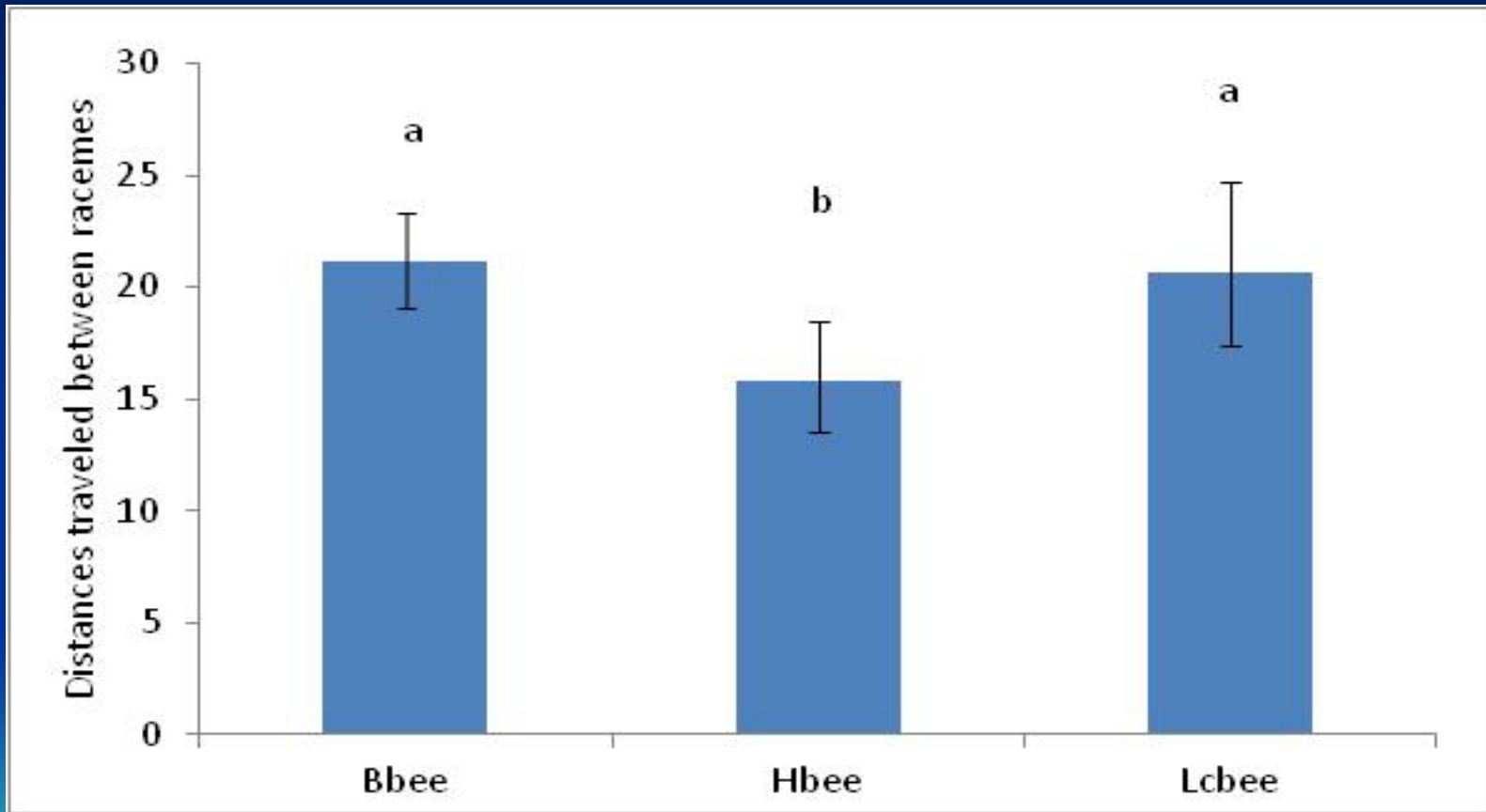
## Plant level

- Distance traveled between plants
- Number of racemes and flowers visited per plant

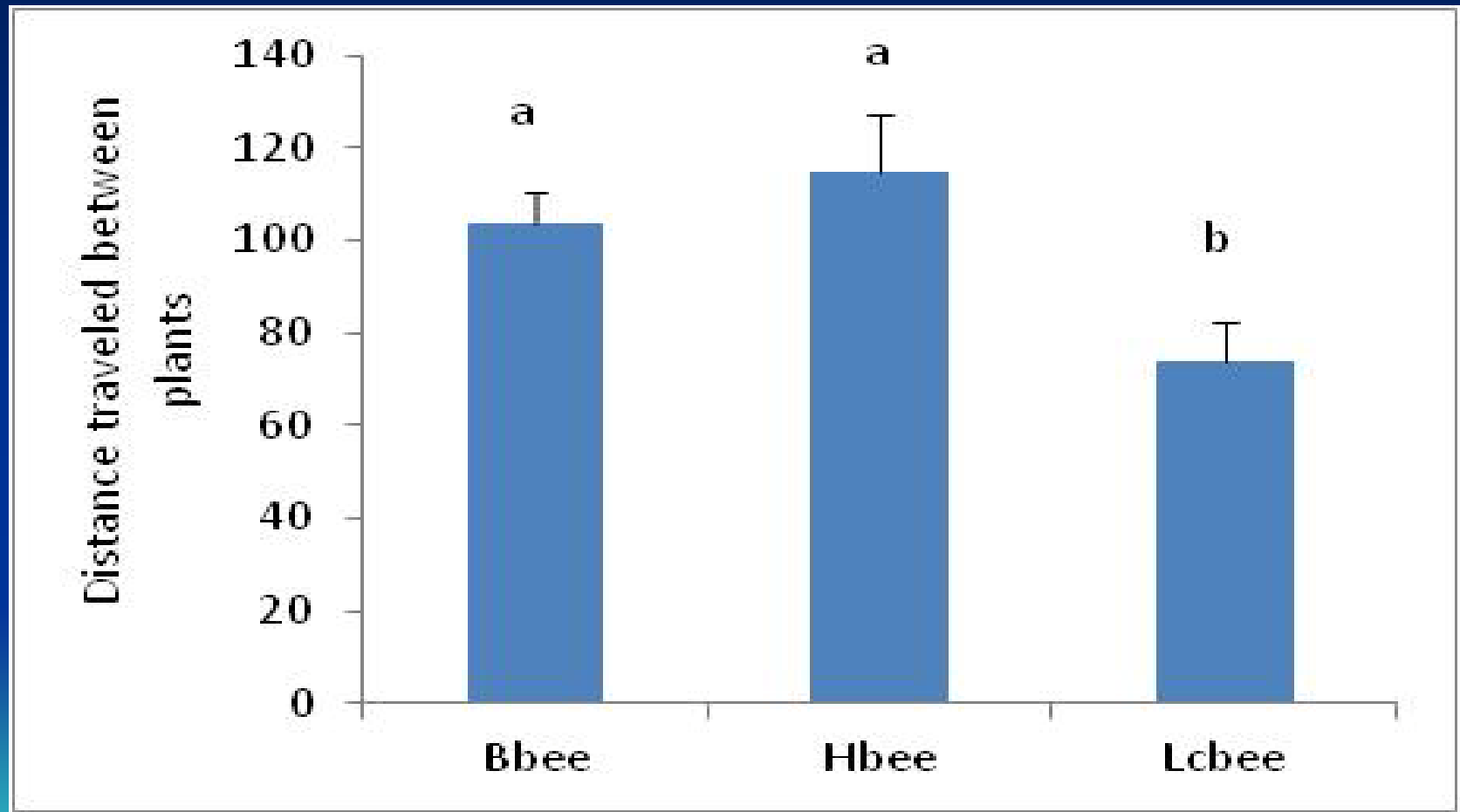




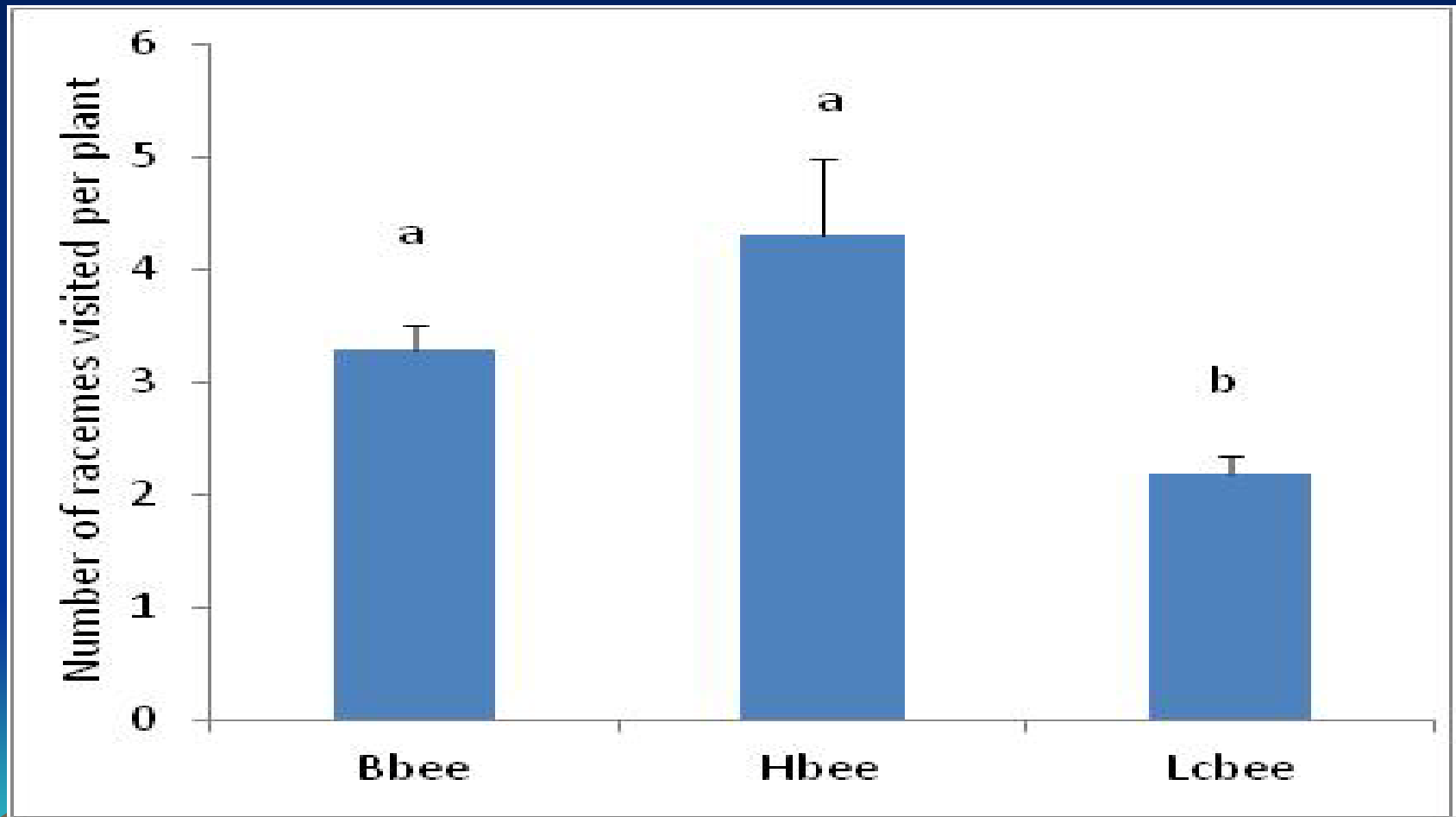
# Distance traveled between racemes



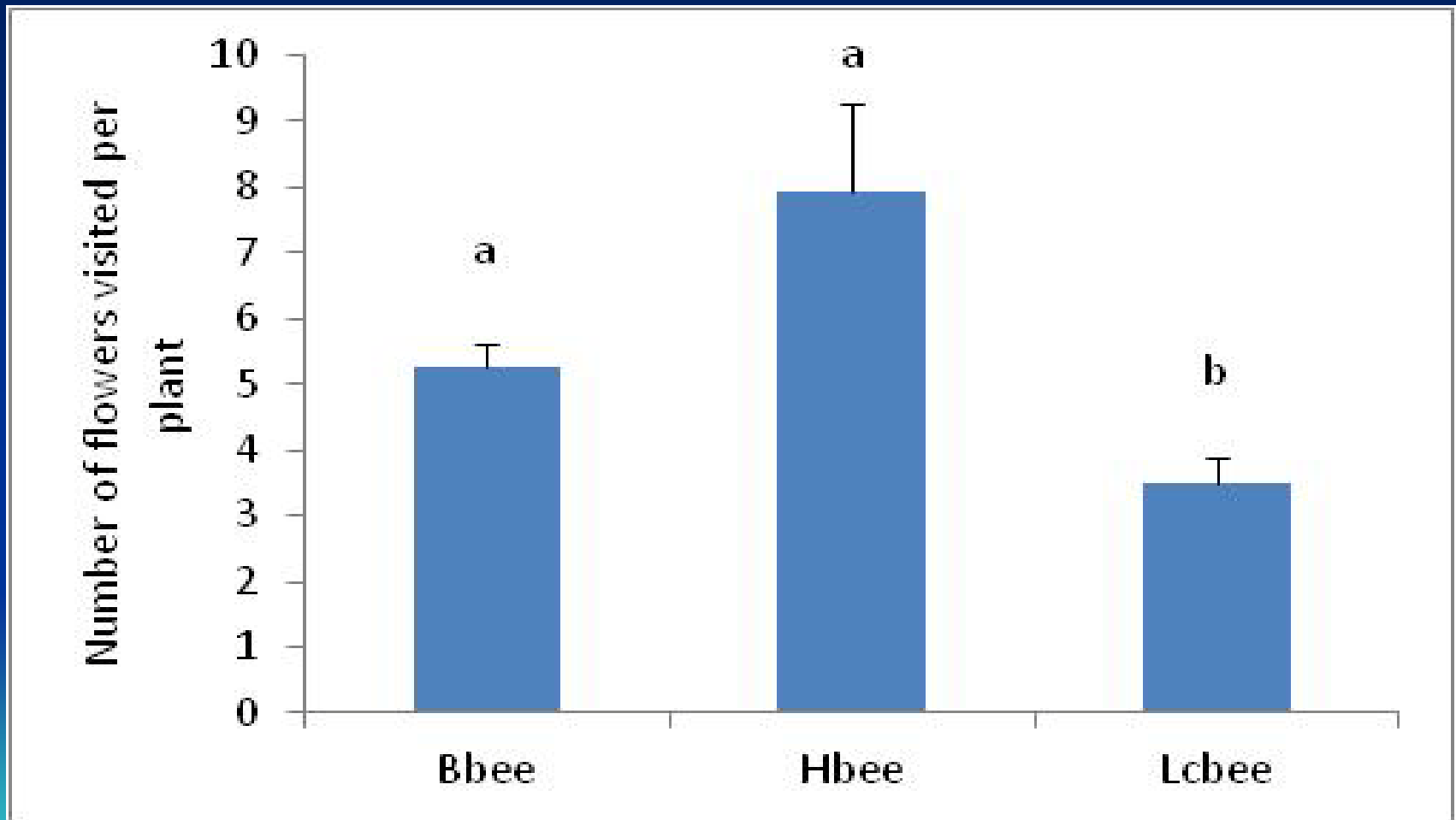
# Distance traveled between plants



# Number of racemes per plant



# Number of flowers per plant



# Directionality within bouts

- Serial angular correlations were used to determine whether the directions of successive flight segments were correlated.
- Significant for Bbee and Hbee but not for Lcbee

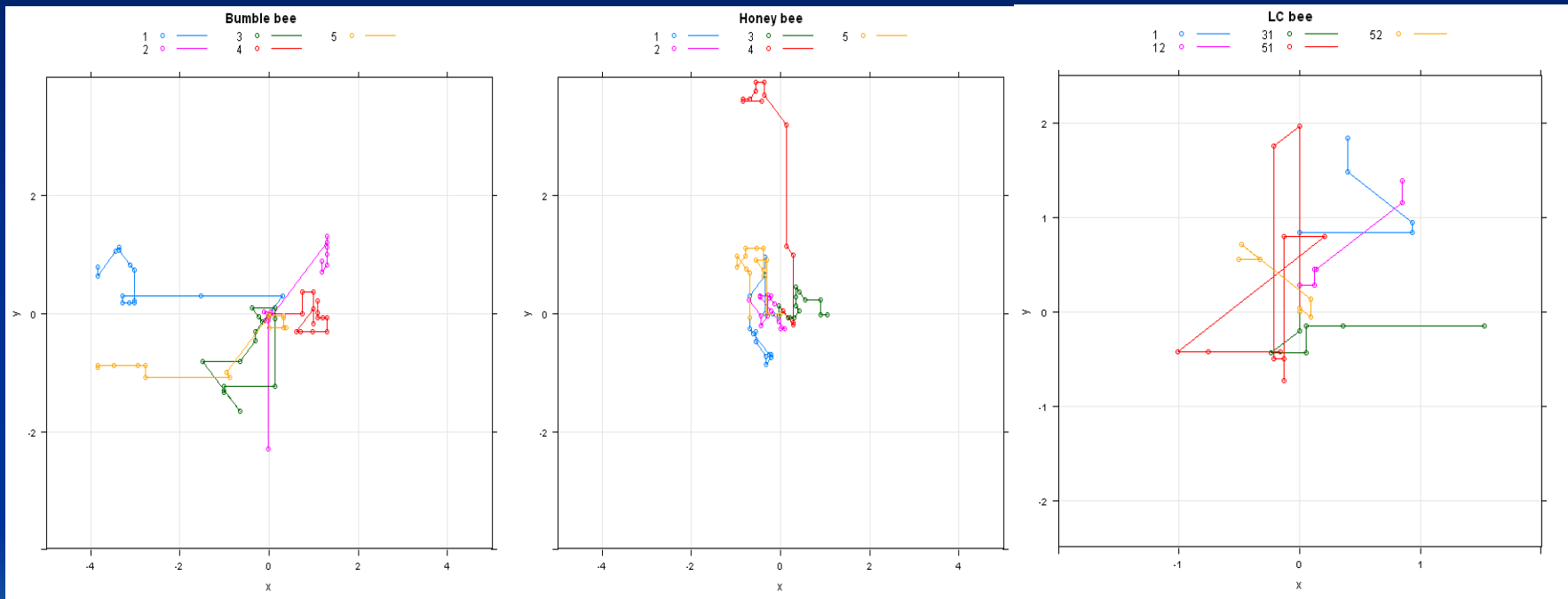


# Directionality in Foraging bouts

## Bumble bee

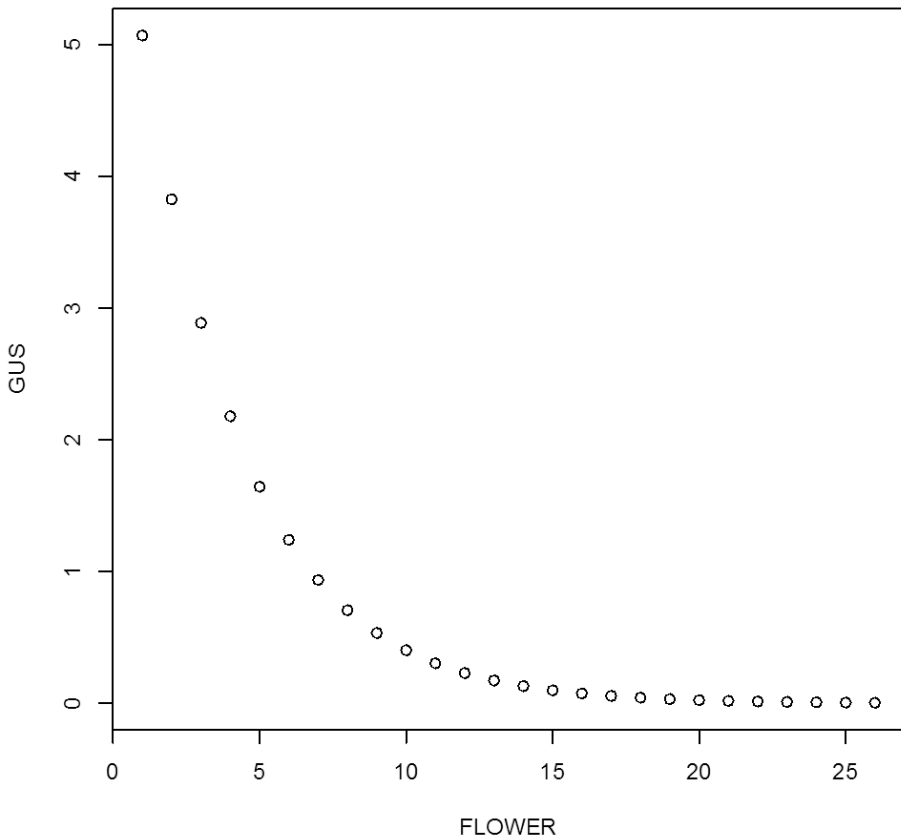
## Honey bee

## Leaf cutter bee

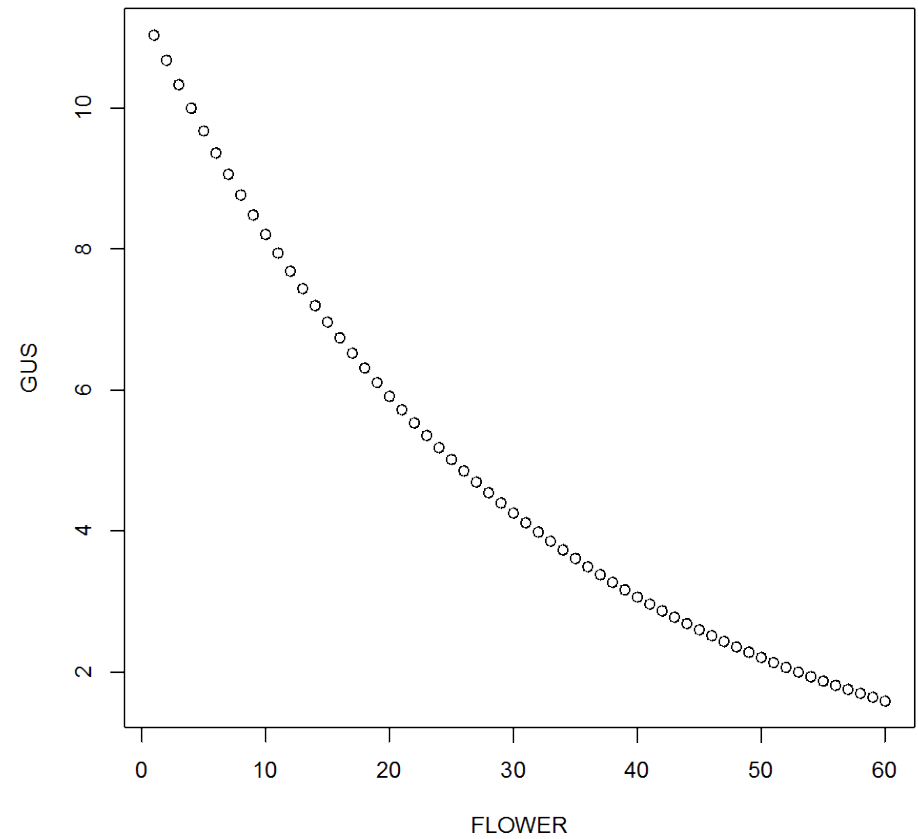


# Pollen deposition curves- Flower

Leafcutting bee



Bumble bee



# Foraging bouts

- Bee observed entering a patch
- Followed until it left the patch
- Only complete foraging bouts
- Recorded number of flowers visited on each raceme, plant number and foraging bout duration (sec).
- Number of plants, racemes and flowers visited per foraging bout; duration



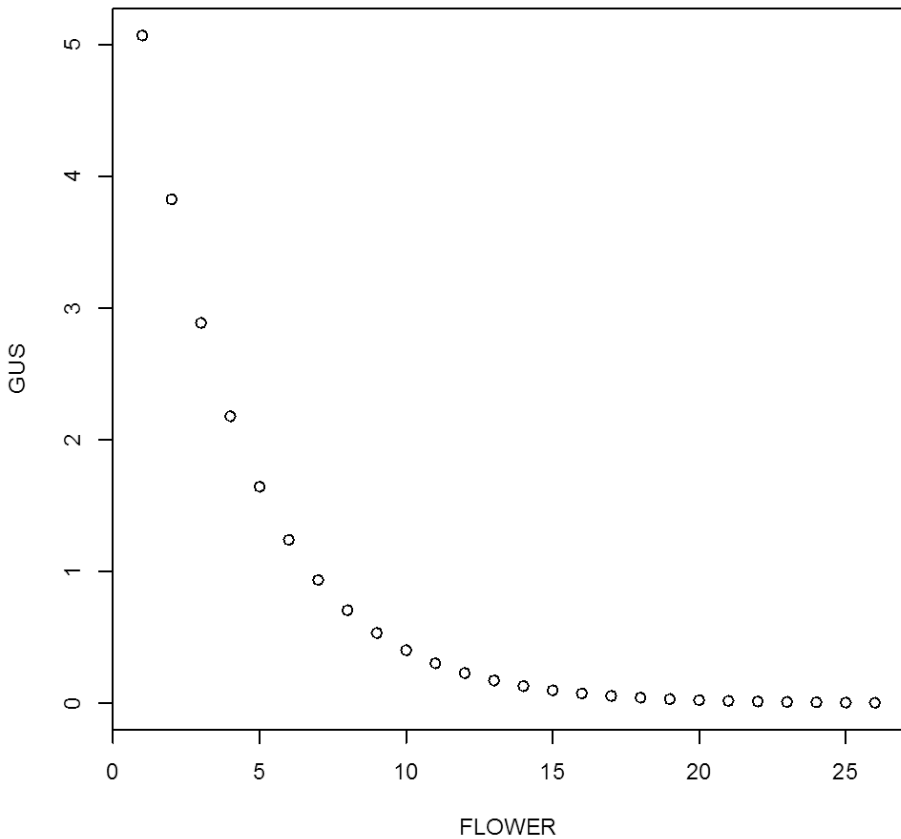


# Foraging bouts

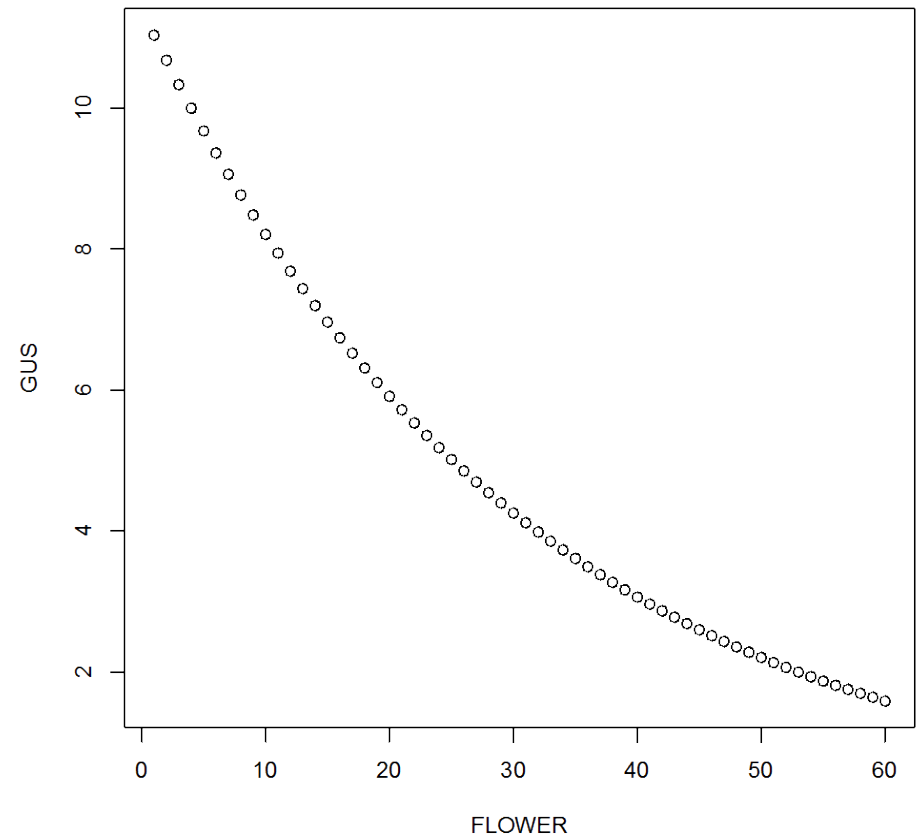
	Bumble bee	Honey bee	Statistics
Residence (flowers)	53.9 +/- 8.1	48.2 +/- 9.5	P= 0.24
Racemes	29.5 +/- 4.0	26.1 +/- 4.4	P= 0.32
Plants	5.8 +/- 0.6	5.4 +/- 0.72	P= 0.93
Duration (sec)	235.6 +/- 33.5	202.3 +/- 33.0	P= 0.56

# Pollen deposition curves- Flower

Leafcutting bee



Bumble bee

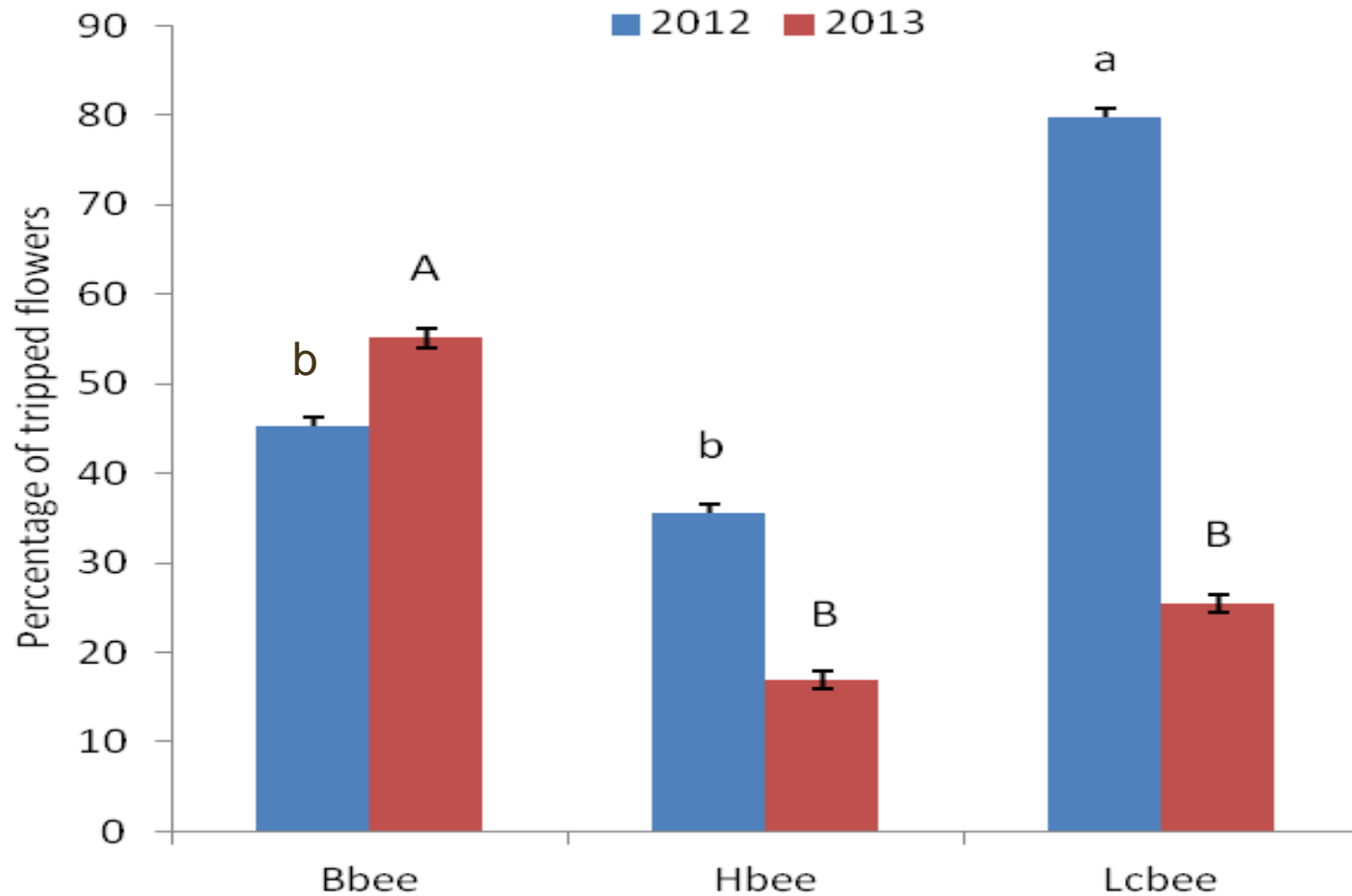


# Tripping rate

- Bee type
- Number of flowers visited on a raceme
- Number of flowers tripped on a raceme
- Proportion of visited flowers that were tripped

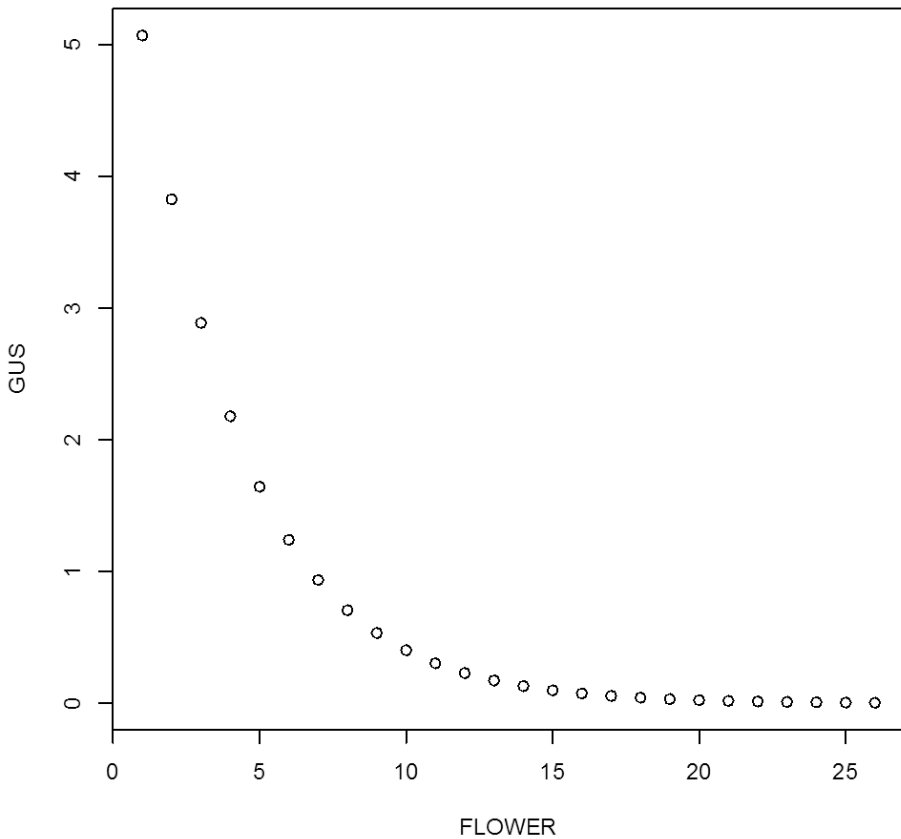


# Percentage of tripped flowers

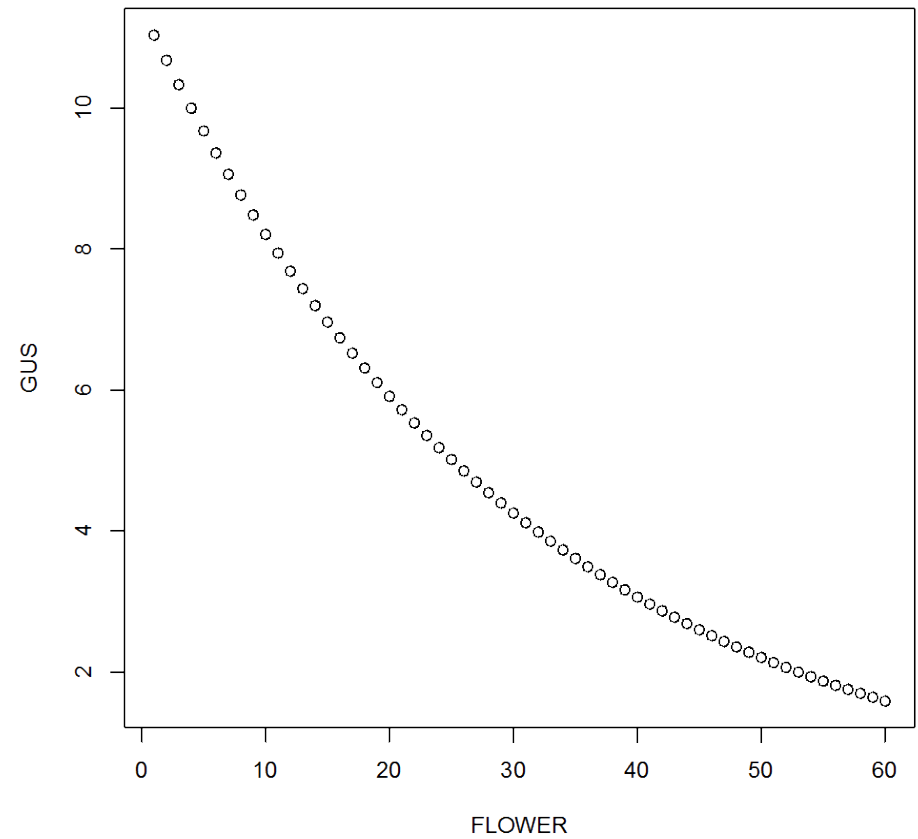


# Pollen deposition curves- Flower

Leafcutting bee



Bumble bee



# Gene flow

## Leafcutting bees

- Smaller distance between plants
- No directionality within foraging bout
- Steep Pollen dispersal curve



# Gene flow

## Honey bee

- greater distance between plants
- directionality within foraging bout
- large number of flowers per patch
- pollen dispersal curve
- **low tripping rate** (increase gene flow risk)



# Future work

- Model of gene flow by insect pollinators: pollinator movement within and among patches
- Pollen deposition curve superimposed to pollinator movement to obtain a pollen dispersal curve
- Integrate data on pollen viability to obtain a seed dispersal curve (gene flow)





QUESTIONS?



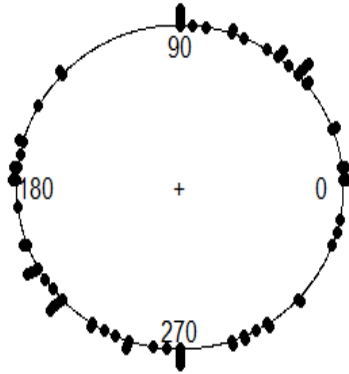
# Overall preference for a direction

To determine whether an overall direction was preferred by each of the three pollinator types, bumble bees, honey bees or leafcutting bees, we used the Watson Uniformity test.

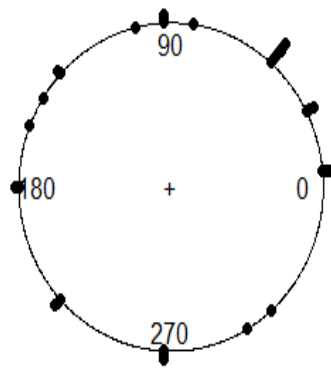
Directions were first transformed into angles with east representing  $0^\circ$  and north  $90^\circ$ . We used mean direction per foraging bouts that had at least 5 racemes visited.

# Overall preference for a direction

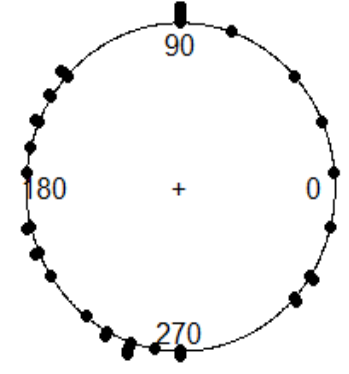
2012 B only (using ave dir for each b



2012 LC only (using ave dir for each bee )



2012 HB only (using ave dir for each bee

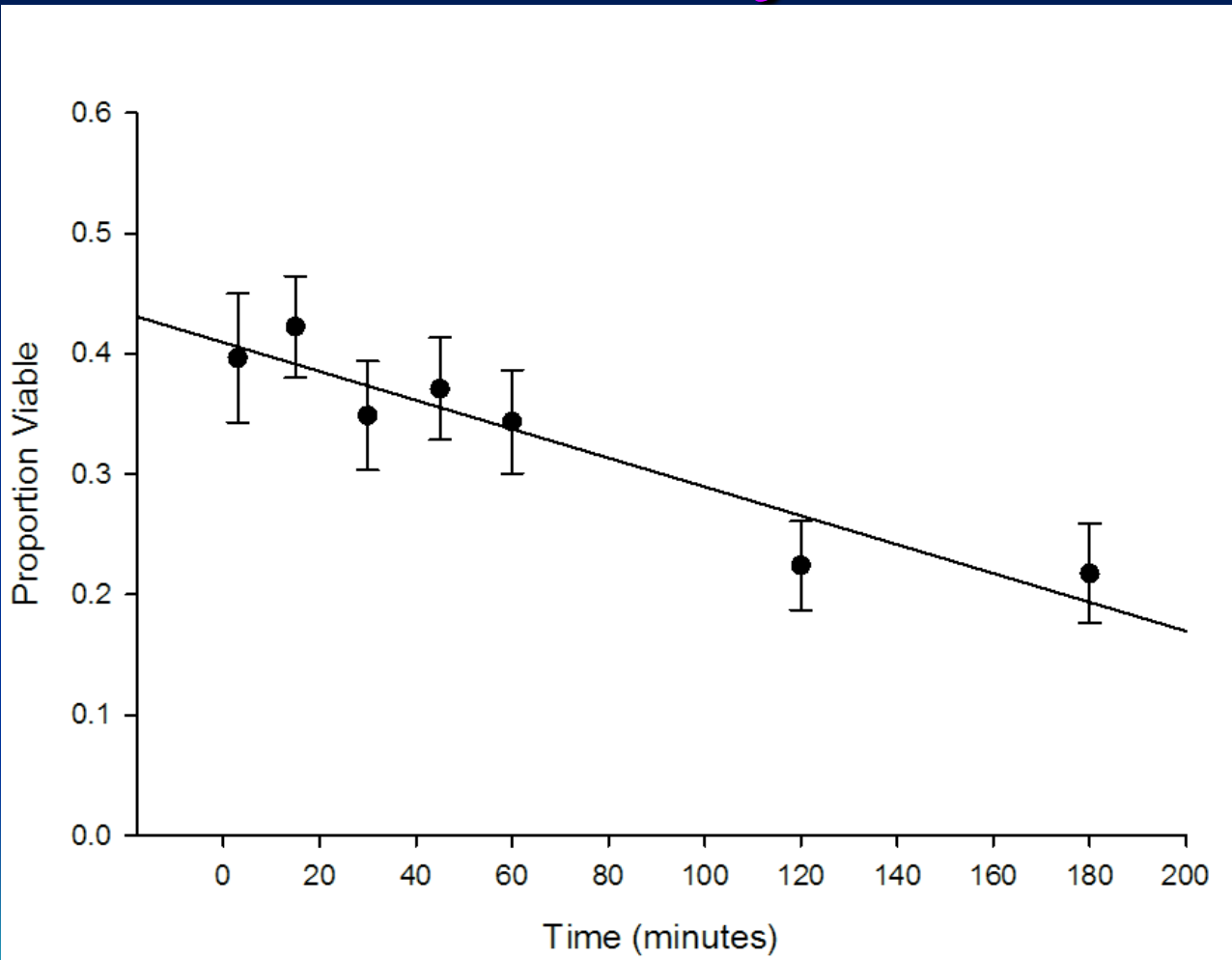


Bumble bee

Leaf cutting bee

Honey bee

# Pollen viability over time



# Statistical analyses

- To determine the impact of bee type, year, and their interaction on the distance traveled between consecutive racemes, we used a mixed linear model (Proc Mixed SAS 9.3). Distances were log transformed prior to analyses.
- Foraging bout was used as a random effect and bee type and year were fixed effects. Multiple comparisons were performed to examine differences among bee types.

