Benefits of Insect Pollination to Confection Sunflowers: Comparisons across two years, three states, and multiple hybrids

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Benefits of pollinators to sunflower production

- Wild sunflowers: self-incompatible
- Domesticated sunflowers
  - Seed production: require pollinators
  - Confection and oilseed production: require pollinators?
    - Breeding for self-fertility
    - Potential yield increase with insect pollination

Benefits of pollinators to sunflower production

- Variation across plant genotypes
  - Self-compatibility: complex, allelic variation, multiple loci (Gandhi et al 2005, Sun et al 2012)
  - Selfing rates vary with plant morphology (Gandhi et al 2005, Griffiths and Erickson 1983)
- Variation across environments
  - Selfing rates vary with growing conditions (DeGrandi-Hoffman and Chambers 2006, Vaknin et al 2008)
  - Pollinator abundance and diversity vary across locations (DeGrandi-Hoffman and Chambers 2006)

Sunflower Pollinators

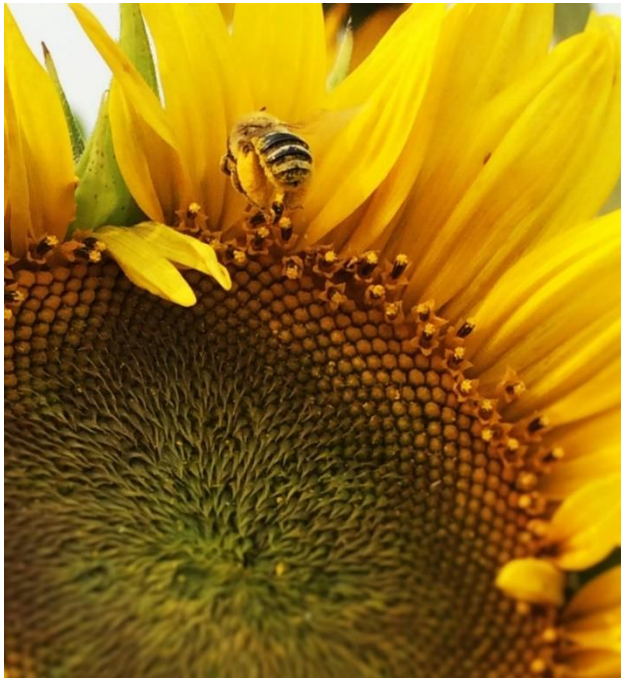
- Managed honey bees
  - Non-native generalists
- Wild bees
  - ~4,000 species in NA
  - 400+ species on sunflowers
  - Specialists of sunflower
- Best pollinators depends on:
  - Abundance
  - Visitation rates
  - Bee body size
  - Foraging behavior

Research Goals

1. Pollinator benefits to confection sunflowers
   - Variation across 10 hybrids
   - Variation across 3 states
2. Which pollinators are the most effective?

1. Pollinator benefits to confections

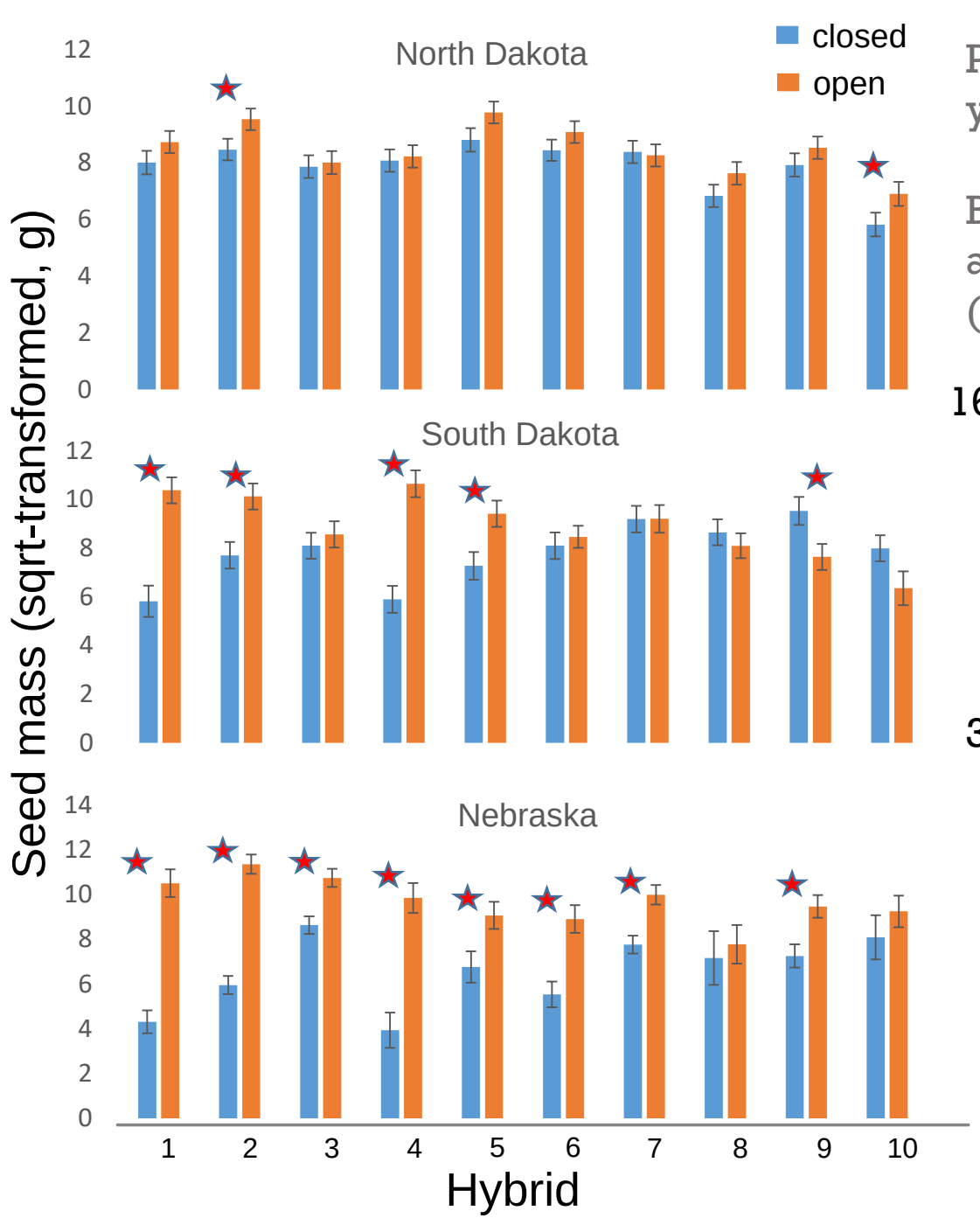
- 10 commercial hybrids in ND, NE, and SD
- 2 years: 2016 and 2017
- Insect-exclusion treatments (bagged, open-pollination)
- Seed mass per flower head (yield)
  - Closed heads (self-fertility)
  - Differences between open/closed heads (pollinator benefits)
- Pollinator visitation rates
  - Do more visits result in greater yield?



2016 results

Pollinators significantly increased yields (T: $P < 0.001$)

But variation across hybrids and environments
(T*H: $P < 0.001$, T*S: $P < 0.001$)



Pollinators significantly increased yields (T: P <0.001)

But variation across plant varieties and environments
(T*V: P< 0.001, T*S: P < 0.001)

16 % increase, 2 hybrids sig

30 % increase, 5 hybrids sig

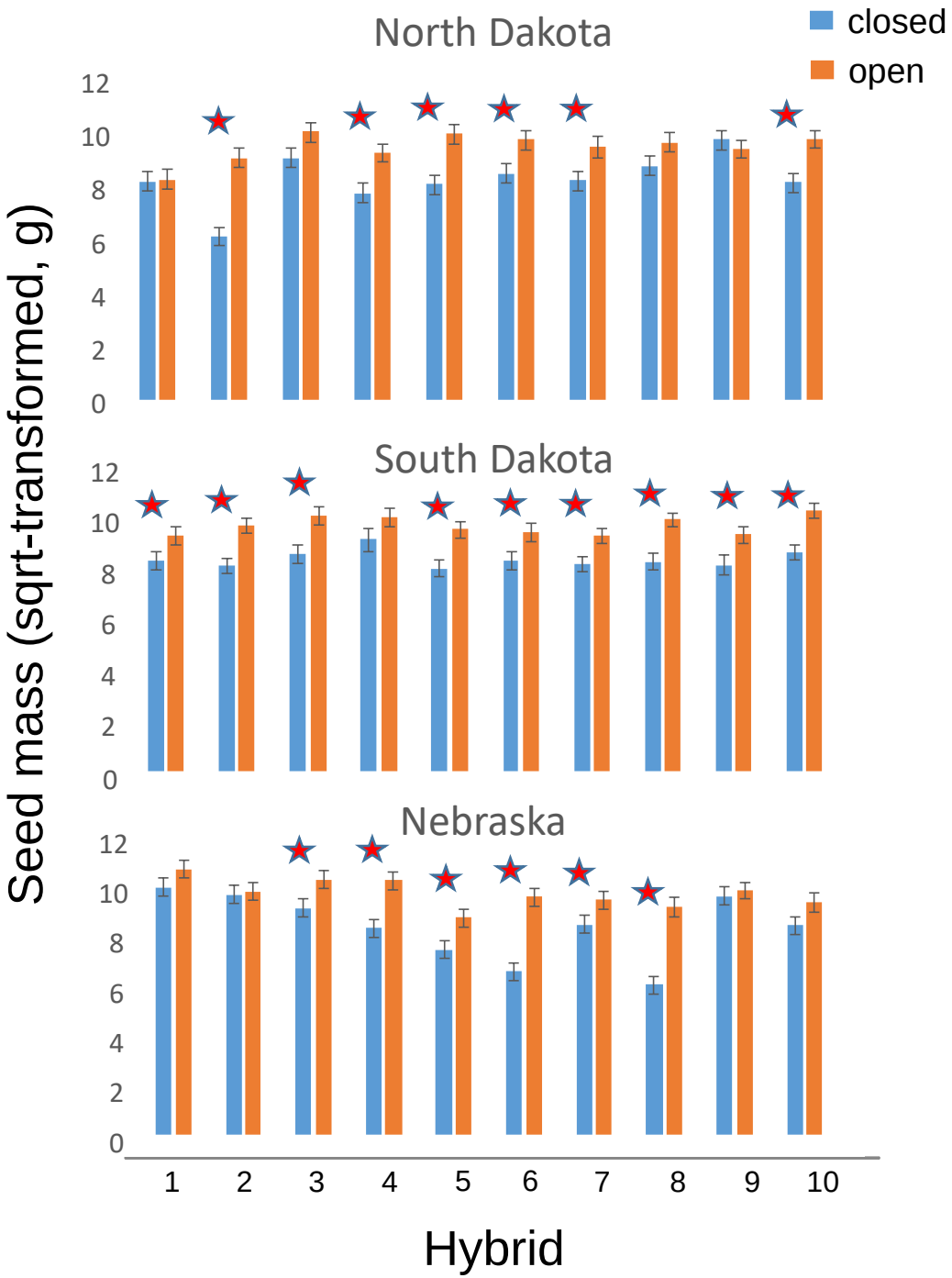
120 % increase, 8 hybrids sig

2017 results

Pollinators significantly increased yields (T: P <0.001)

Sig variation across hybrids (T*H: P = 0.001)

No sig variation across states (T*S: P = 0.52)



Pollinators significantly increased yields (Treat: P <0.001)

But variation across plant varieties (Treat*Var: P = 0.001)

No sig variation across states (Treat*State: P = 0.52)

35 % increase, 6 hybrids sig

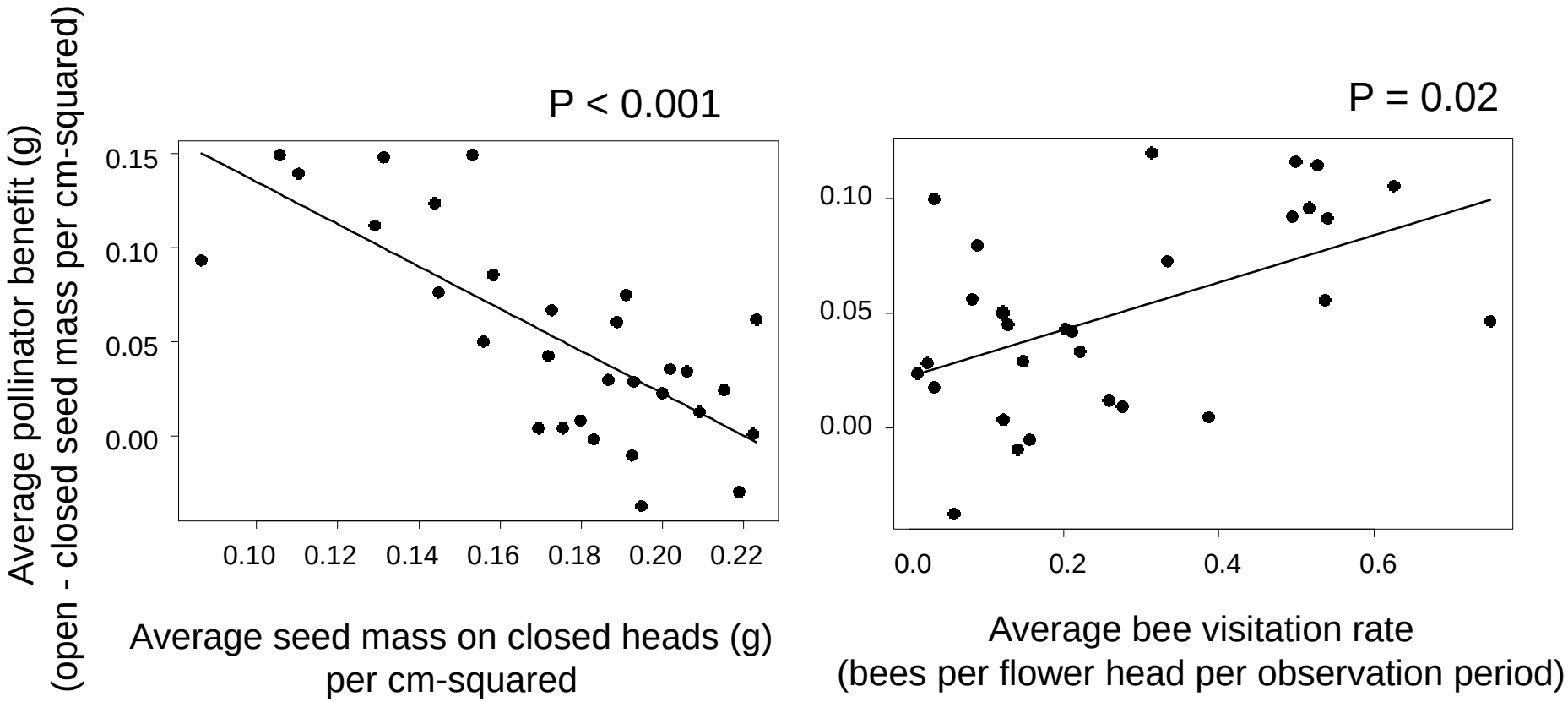
34 % increase, 9 hybrids sig

31 % increase, 6 hybrids sig

What explains variation in pollinator benefits?

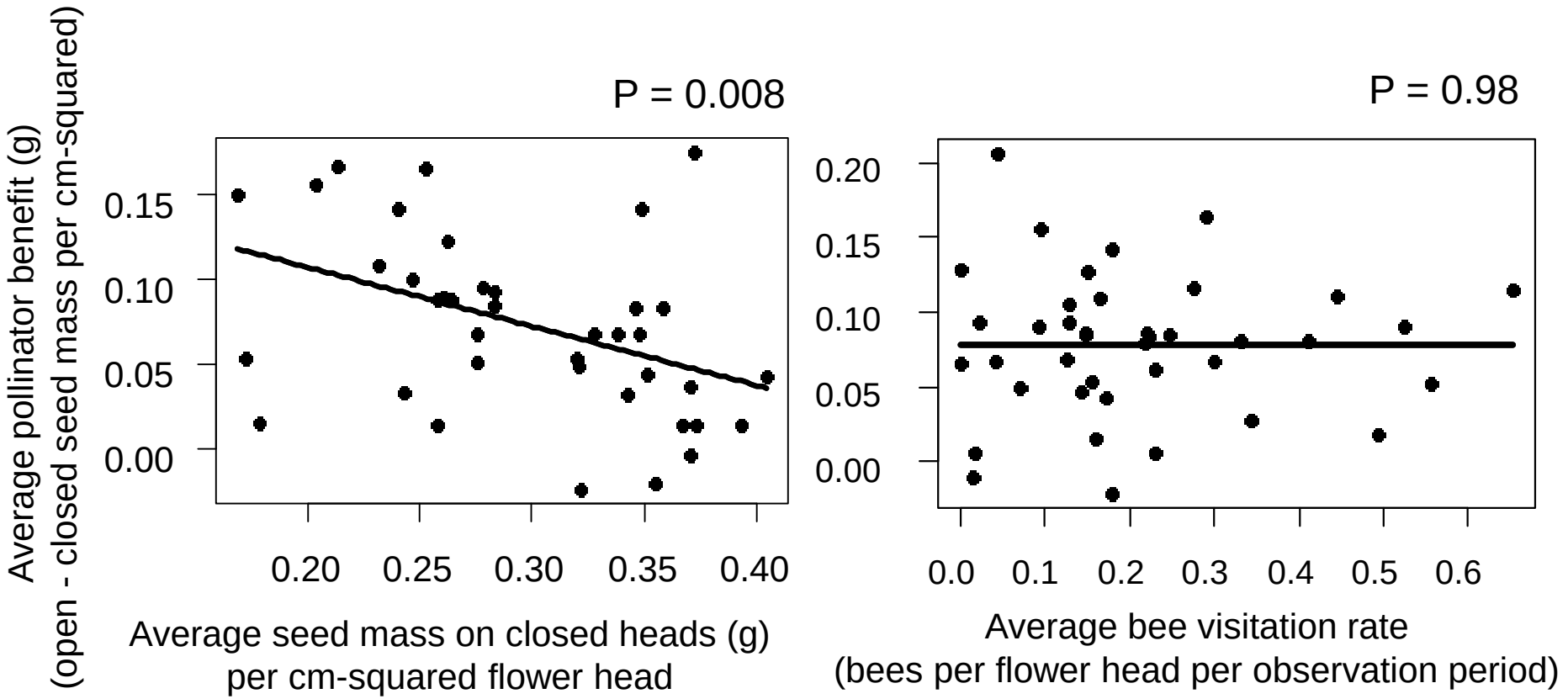
1. Plant self-fertility
   - Maximum seed set with self-pollination alone
2. Pollinator visitation rates

Pollinator benefits decrease with self-fertility and increase with bee visitation rates in 2016



** Best-fit model contains both variables

Pollinator benefits decrease with self-fertility but not affected by bee visitation rates in 2017



** Best-fit model contains only self-fertility indicator

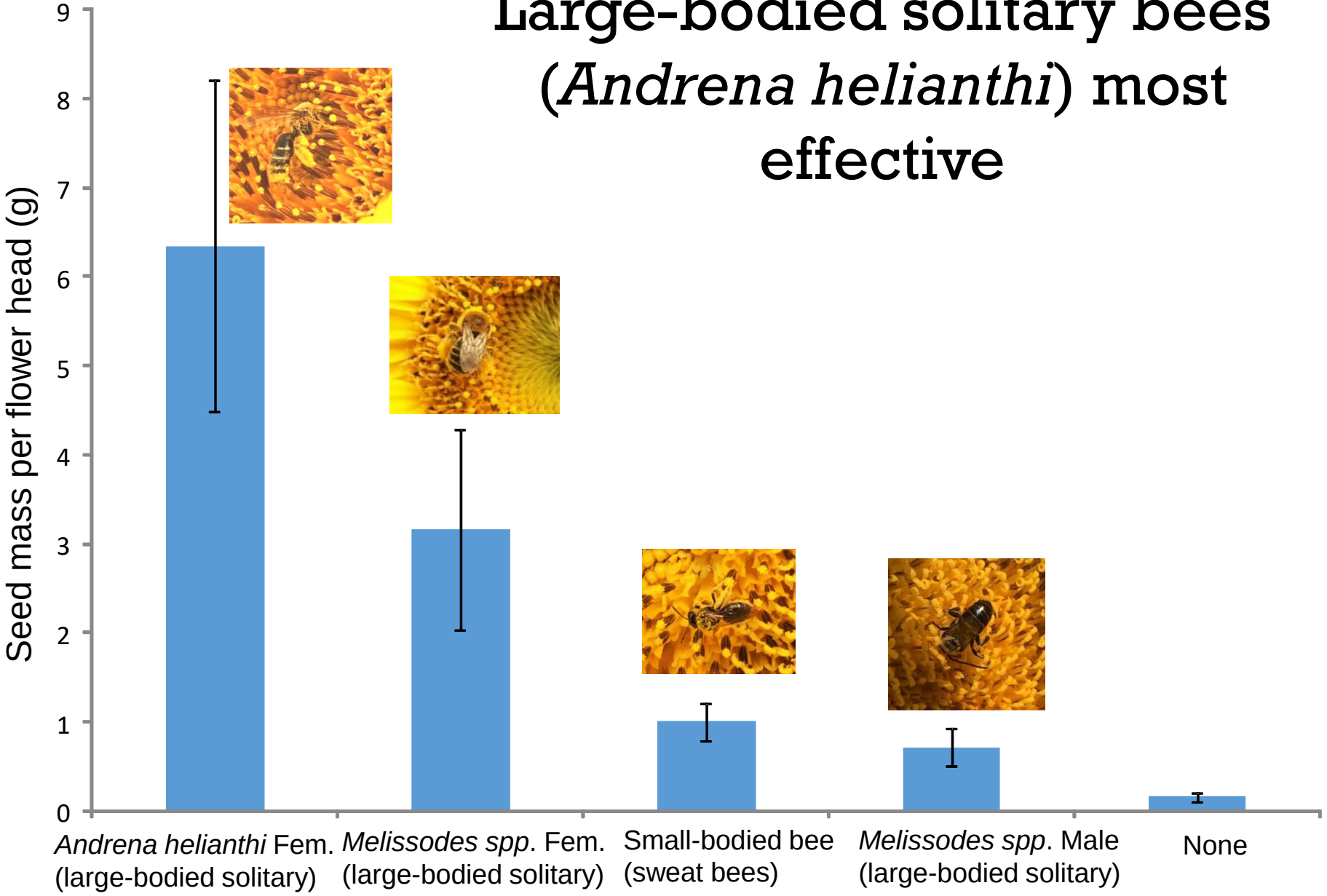
2. Which pollinators are the most effective?

- Efficacy = frequency*per-visit efficacy
- Frequency = Pollinator visitation rates
- Per-visit efficacy = Seed mass per single visit to CMS flowers
  - Bagged heads
  - Remove bags and wait for a single visit
  - Re-bag heads, harvest, total seed mass
- 2016 and 2017, frequency (all states) and per-visit efficacy (ND)

Large-bodied solitary bees most frequent

1. Large-bodied solitary bees (n = 717)
    1. *Melissodes agilis, M. trinodis, Andrena helianthi, Svastra obliqua*
2. Bumble bees (n=83)
    1. *Bombus ternarius*, *B. griseocolis, B. impatiens*
3. Small-bodied bees (48)
    1. *Dufourea marginata*
4. Green sweat bees (7)
5. Honey bees (4)

Large-bodied solitary bees (*Andrena helianthi*) most effective



Conclusions

- Confection sunflowers benefit from insect pollination
- Pollinator benefits vary across genotypes and environments
  - Plant self-fertility
  - Different pollinator visitation rates
- Large-bodied solitary bees most effective pollinators
  - *Andrena helianthi*
  - Females more effective than males
  - Managed honey bees infrequent visitors

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