Suppression of the sugarcane aphid by parasitoids on aphid susceptible and partially resistant sorghum

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INTRODUCTION

Sugarcane aphid outbreaks were detected on sorghum in 2013 in South Texas. Sugarcane aphid outbreaks since have been detected throughout nineteen US states spanning north into Kansas, as well as Mexico and the Caribbean islands (Bowling et al. 2016). Sugarcane aphid overwinters on ratoon sorghum and Johnson grass in Mexico and South Texas so that populations can survive until the next sorghum growing season. Their rapid expansion over a season is possible due to wind aided movement of alates coming from maturing sorghum in Mexico and South Texas. South Texas is responsible for ~15% of US sorghum production. Recent work has identified predators (coccinellids, chrysopids, hemerobiids, and syrphids) and two parasitoid species that parasitize sugarcane aphid in South Texas: *Apehlinus nigritus* Howard (Hymenoptera: Aphelinidae) which results in black mummies and *Lysiphlebus testaceipes* (Cresson) (Hymenoptera: Braconidae) which results in brown mummies (Bowling et al. 2016, Maxson et al. 2019) (Figure 1). Additionally, a secondary parasitoid has been identified, *Syrphophagus aphidivorus* (Mayr) (Hymenoptera: Encyrtidae), which develops in *A. nigritus* regardless of host being a larva in a living aphid or a pupa in an aphid mummy. Although the natural enemies of the sugarcane aphid in South Texas are known, their efficiency in controlling the sugarcane aphid is not known.

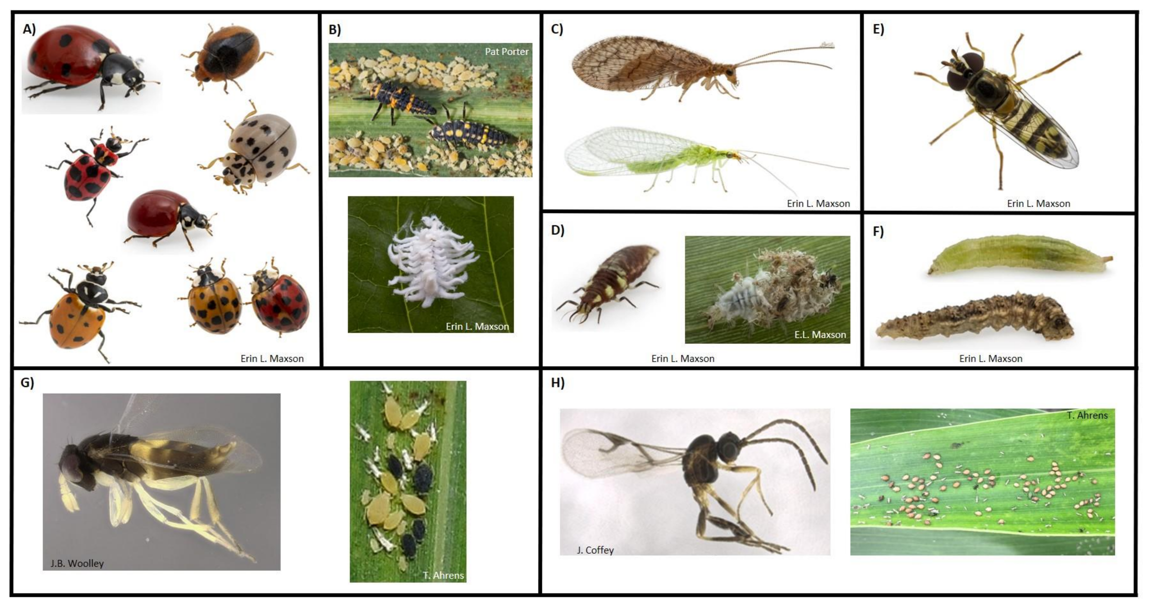


Figure 1. Natural enemies of the sugarcane aphid in South Texas. A) Coccinellid adults, B) Coccinellid larvae, C) Hemerobiid and chrysopid adults (do not feed on aphids), D) Hemerobiid and chrysopid larvae, E) Syrphid fly adults (do not feed on aphids), F) Syrphid fly larvae, G) *Aphelinus nigritus* and the black mummies they produce, H) *Lysiphlebus testaceipes* and the brown mummies they produce.

METHODS

Split-plot Design (Figure 2)**:**

- 0.47 ha (38.6m X 54.85m) field
- 2 sorghum treatments:
  - DKS3888 Susceptible
  - DKS3707 Resistant
- Pyrethrin at 4-5 leaf stage to remove natural enemies
- Artificially infested with 50 colony-reared aphids

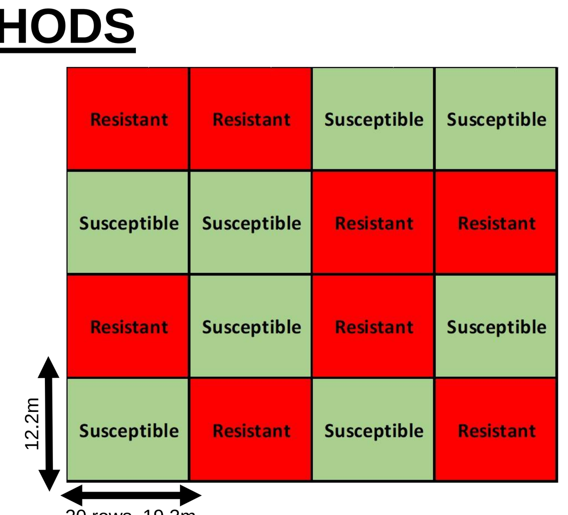


Figure 2. Experiment design for study. Split plot design with eight complete randomized blocks of susceptible and semi-resistant hybrids. Fields were planted in mid-April 2018 and 2019.

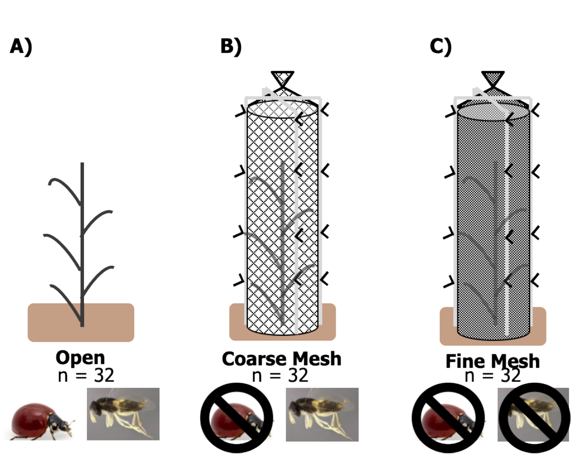


Figure 3. Natural enemy treatments used for experiment (Lee et al. 2005). A) Open to allow predator and parasitoid access. B) Coarse mesh to exclude predators but allow parasitoid access. C) Fine mesh to exclude predators and parasitoids.

Natural Enemy Treatments:

- Individual plants caged = 96 experimental units
- 4 cages/natural enemy treatment/block
- 3 natural enemy treatments

Sampling Regime:

- 1 & 3 weeks after aphid infestation
- 48 plants sampled/time point
- Whole plant counts recorded:
  - SCA alates
  - SCA apterates
  - Predators
  - Mummies reared to parasitoids

STUDY OBJECTIVE

Compare parasitoid and predator suppression of sugarcane aphid on resistant and susceptible hybrids across the sorghum growing season.

RESULTS

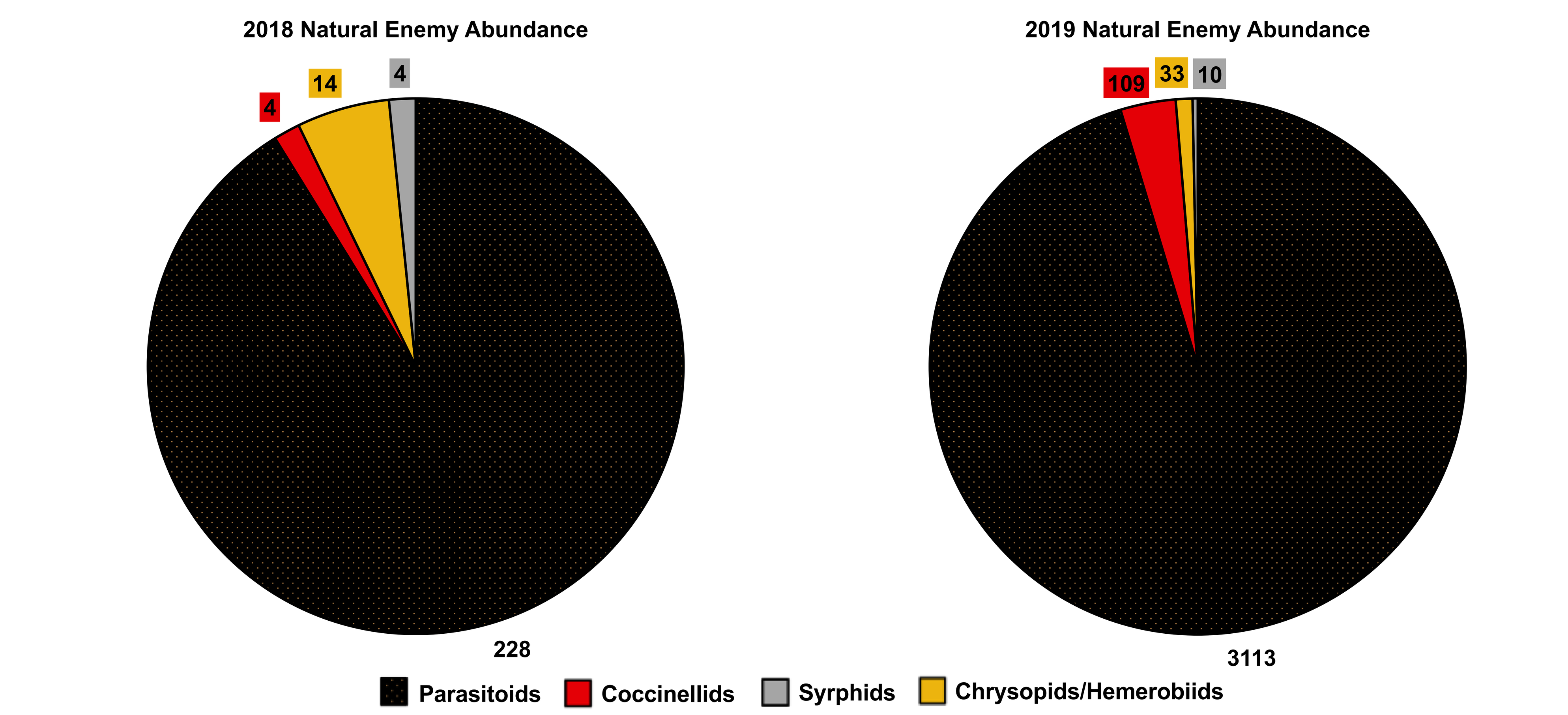


Figure 4. Natural enemy abundance. Overall abundance of natural enemies collected from susceptible and resistant sorghum treatments and all natural enemy treatments in 2018 and 2019. A total of 96 individual plants served as experimental units in both years. Parasitoids were the most abundant natural enemy in both years based on the equality test of proportions (χ^2 = 48.94; df = 3; P = <0.0001).

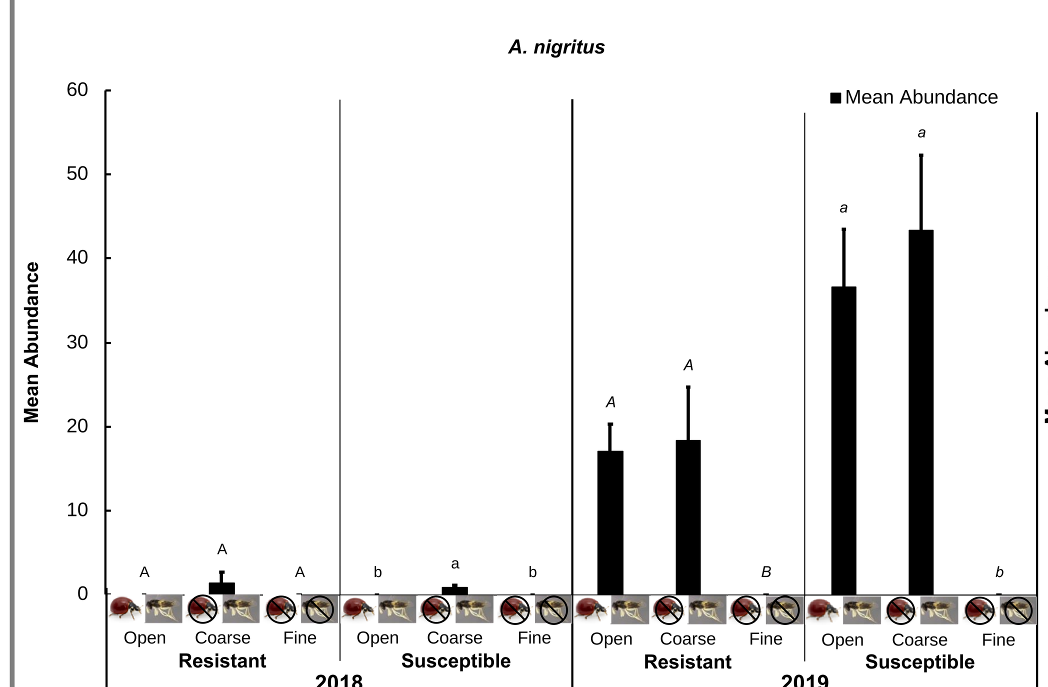


Figure 5. Mean abundance for *A. nigritus* across the resistant and susceptible sorghum and natural enemy treatments in 2018 and 2019. *A. nigritus* was collected more frequently from the coarse cage treatments, with a significant difference in the number of *A. nigritus* collected from the susceptible versus the resistant hybrid. Please note Tukey's comparisons are across natural enemy treatments for each resistant and susceptible hybrid for each year.

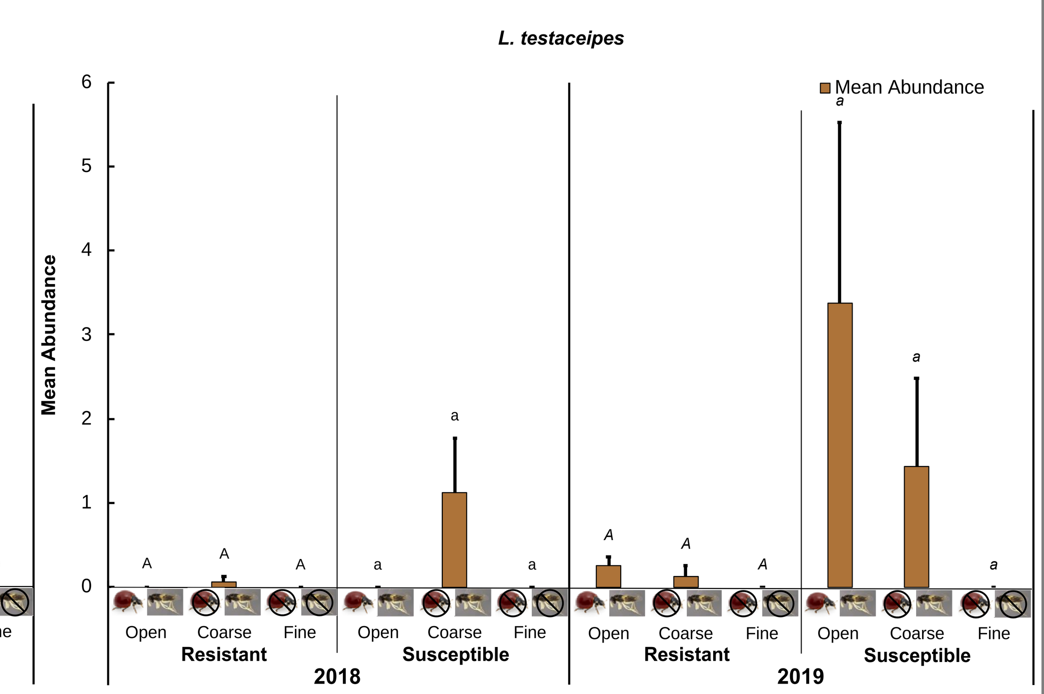


Figure 6. Mean abundance for *L. testaceipes* across the resistant and susceptible sorghum and natural enemy treatments in 2018 and 2019. *L. testaceipes* was collected more frequently from the coarse and open cage treatments, with a significant difference in the number of *L. testaceipes* collected from the susceptible versus the resistant hybrid. Please note Tukey's comparisons are across natural enemy treatments for each resistant and susceptible hybrid for each year.

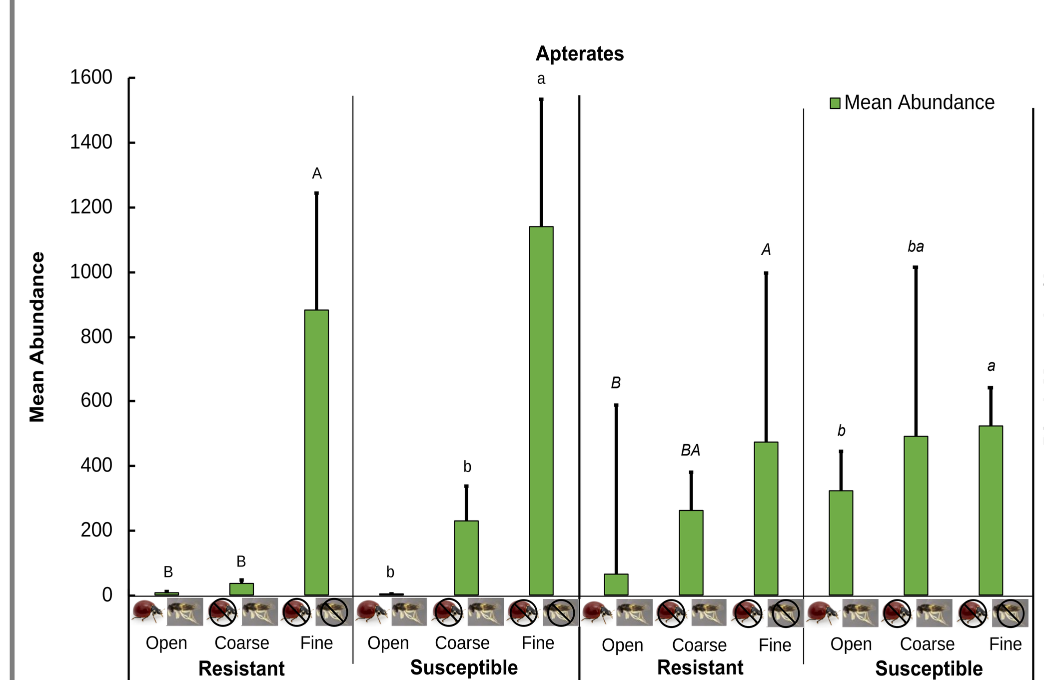


Figure 7. Mean abundance for apterate sugarcane aphids across the resistant and susceptible sorghum and natural enemy treatments in 2018 and 2019. A similar response for apterates was observed for the susceptible and the resistant hybrids. Please note Tukey's comparisons are across natural enemy treatments for each resistant and susceptible hybrid for each year.

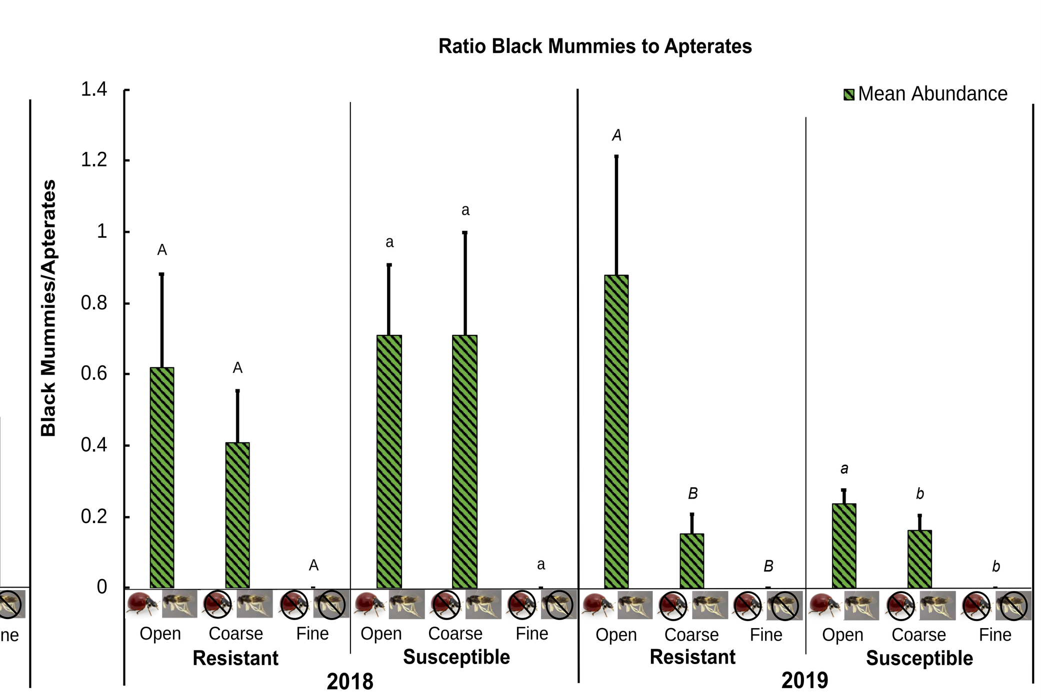
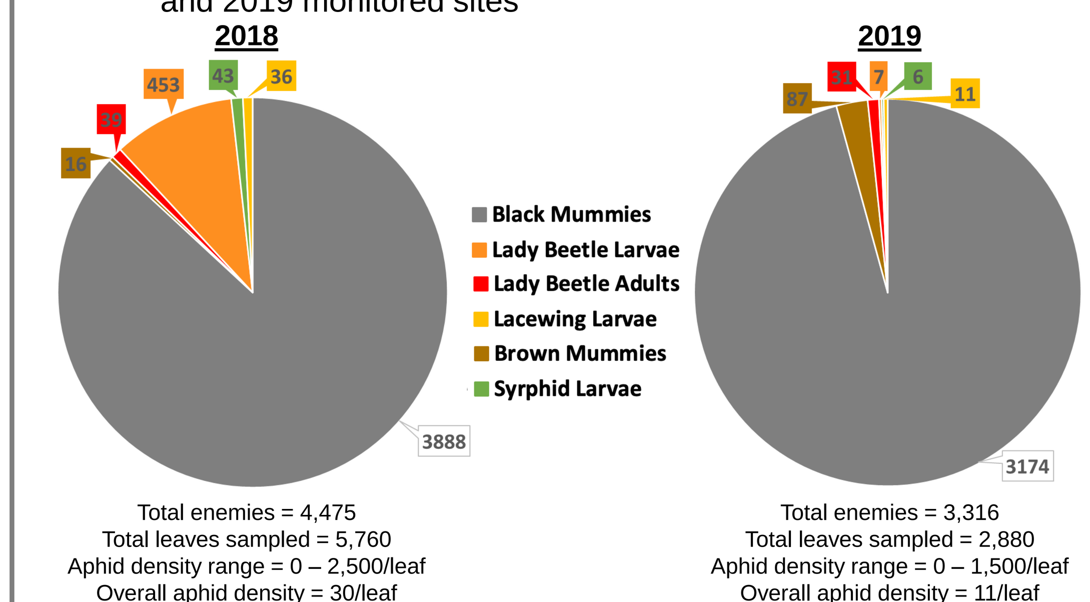


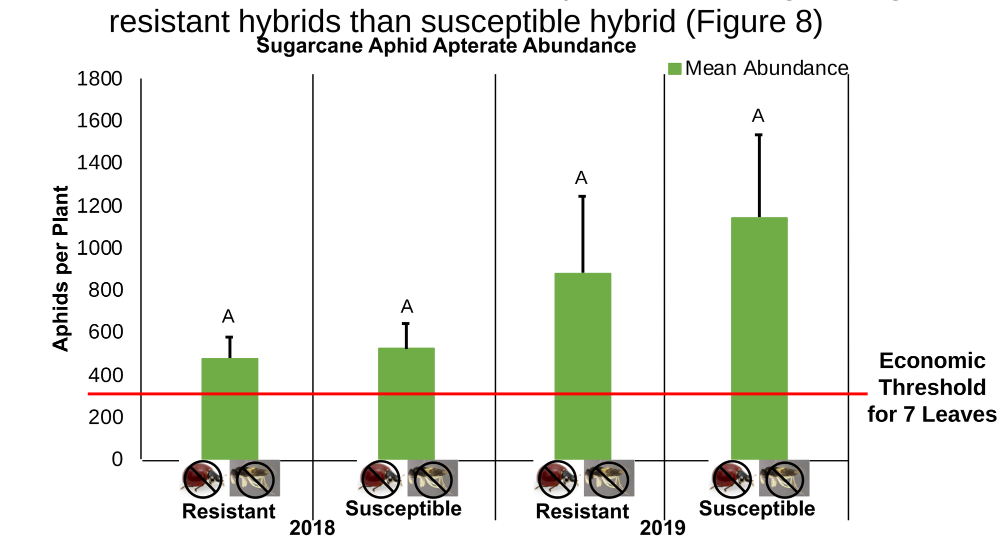
Figure 8. Ratio of black mummies (*A. nigritus*) to sugarcane aphids across the resistant and susceptible sorghum and natural enemy treatments in 2018 and 2019. The ratio was stable in 2018 on susceptible and resistant hybrids, in 2019 the ratio was stable for the coarse natural enemy treatments. Please note Tukey's comparisons are across natural enemy treatments for each resistant and susceptible hybrid for each year.

DISCUSSION

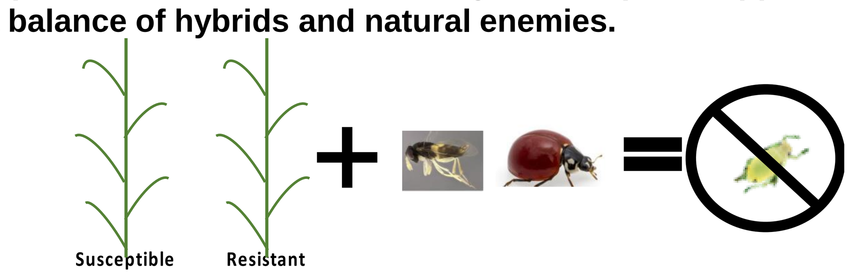
- **Which natural enemy was primarily responsible for sugarcane aphid suppression?**
  - *Aphelinus nigritus*
- **How do natural enemy abundances observed in this experiment compare to what we see in the field?**
  - Results from study were similar to relatively high abundance of *A. nigritus* (black mummies) and low predator numbers at local 2018 and 2019 monitored sites



- **Do resistant hybrids help suppress sugarcane aphids?**
  - South Texas Economic Threshold (E.T.) = 50 aphids/leaf (Gordy et al. 2019)
  - Plants sampled at 6-7 leaves
  - Number of aphids per leaf are more than double the E.T.
  - The number of aphids on resistant hybrids is not significantly different from susceptible hybrids
  - The ratio of black mummies to aphids was as high or higher on the resistant hybrids than susceptible hybrid (Figure 8)



  - Aphid population growth regardless of hybrid type highlights the importance of sugarcane aphid regulation by natural enemies
- **It appears that in South Texas, sugarcane aphid suppression is due to a balance of hybrids and natural enemies.**



FUTURE DIRECTIONS

- Experiment replication:
  - Results from replication in Stillwater, OK in the central Great Plains will be compared to results from this study conducted in the southern reaches of the Great Plains
- Simulation model parameterization:
  - An ecological model has been developed to explore sugarcane aphid migration events from South Texas and the probability of annual colonization in the north and potential for population increase and outbreaks (Wang et al. 2019)
  - Information from this experiment can be used to add a regulatory component of natural enemies and semi-resistant hybrids to this existing model

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