The Hibiscus Bud Weevil: Biological Control & Sanitation Practices

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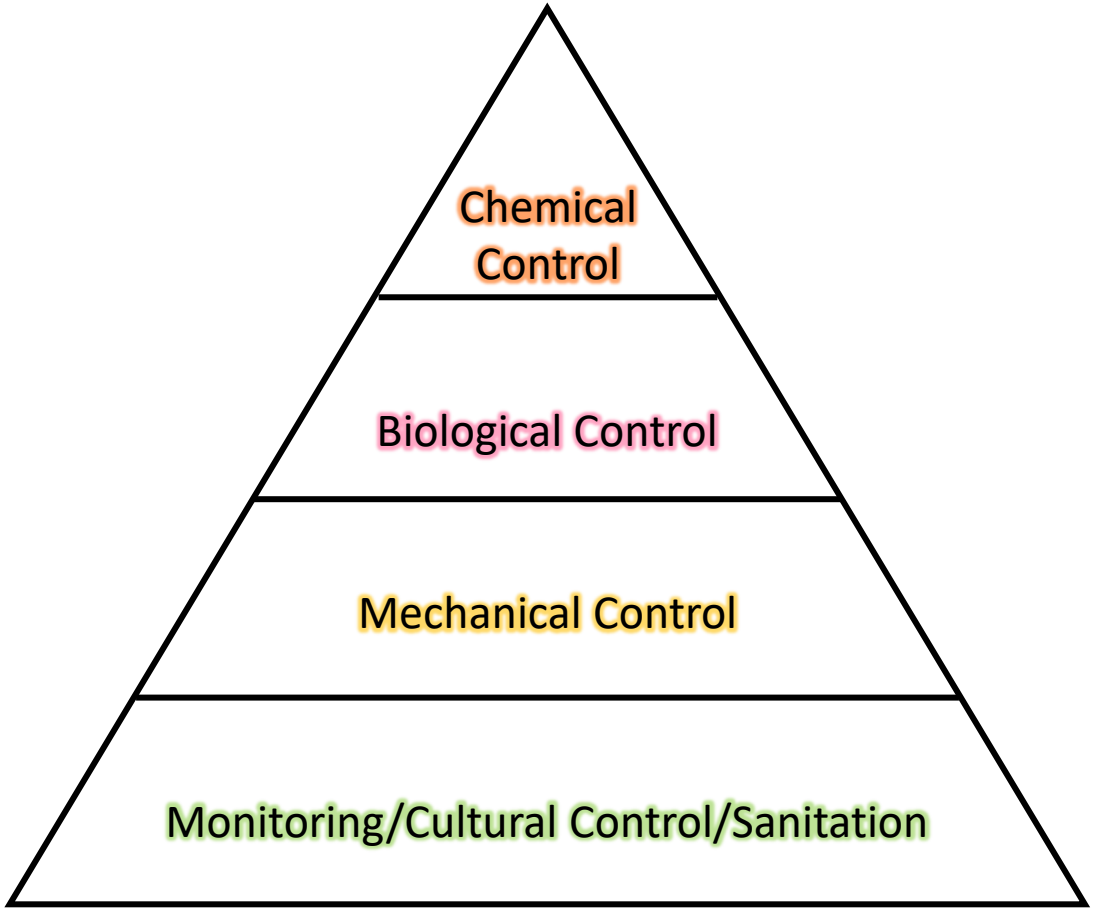
Integrated Pest Management



Chemical Control Against HBW- Contact Insecticides

- No use of neonicotinoids (4A)
- We evaluated 17 insecticides and 4 oils
- The most efficacious were:

Product	Active Ingredient	Group	Rate
Dimilin 25 W	diflubenzuron	15	16 oz/100 gal
Xxpire	sulfoxaflor+spinetoram	4C + 5	0.08 oz/3 gal
Pyganic EC	pyrethrins	3A	15.61 fl oz/100 gal
Kontos	spirotetramat	23	0.1 fl oz/3 gal

Greene et al., 2023, Insects: 14, 544

Chemical Control Against HBW- Systemic Insecticides

- No use of neonicotinoids (4A)
- We evaluated 4 insecticides in a prophylactic and curative manner

Product	Active Ingredient	Group	Rate
Altus	flupyradifurone	4D	28 fl oz/750 gal
Mainspring	cyantraniliprole	28	12.2 fl oz/100 gal
Acelepryn	chlorantraniliprole	28	16 fl oz/100 gal
Kontos	spirotetramat	23	0.1 fl oz/3 gal

Vargas et al., 2023, Agriculture: 13, 1879

Biological Control of the HBW

- Entomopathogenic:
  - Nematodes (EPNs)
  - Fungi
  - Bacteria

- Parasitoids

Biological Control of HBW - EPNs

Tested entomopathogenic nematodes (EPNs) in lab assays against L1, L2 and L3

- *Heterorhabditis bacteriophora*
- *Steinernema carpocapsae*
- *S. kraussei*
- *S. feltiae*
- *S. riobrave*

Rate:
500 IJ/bud approx. on top of naturally infested buds

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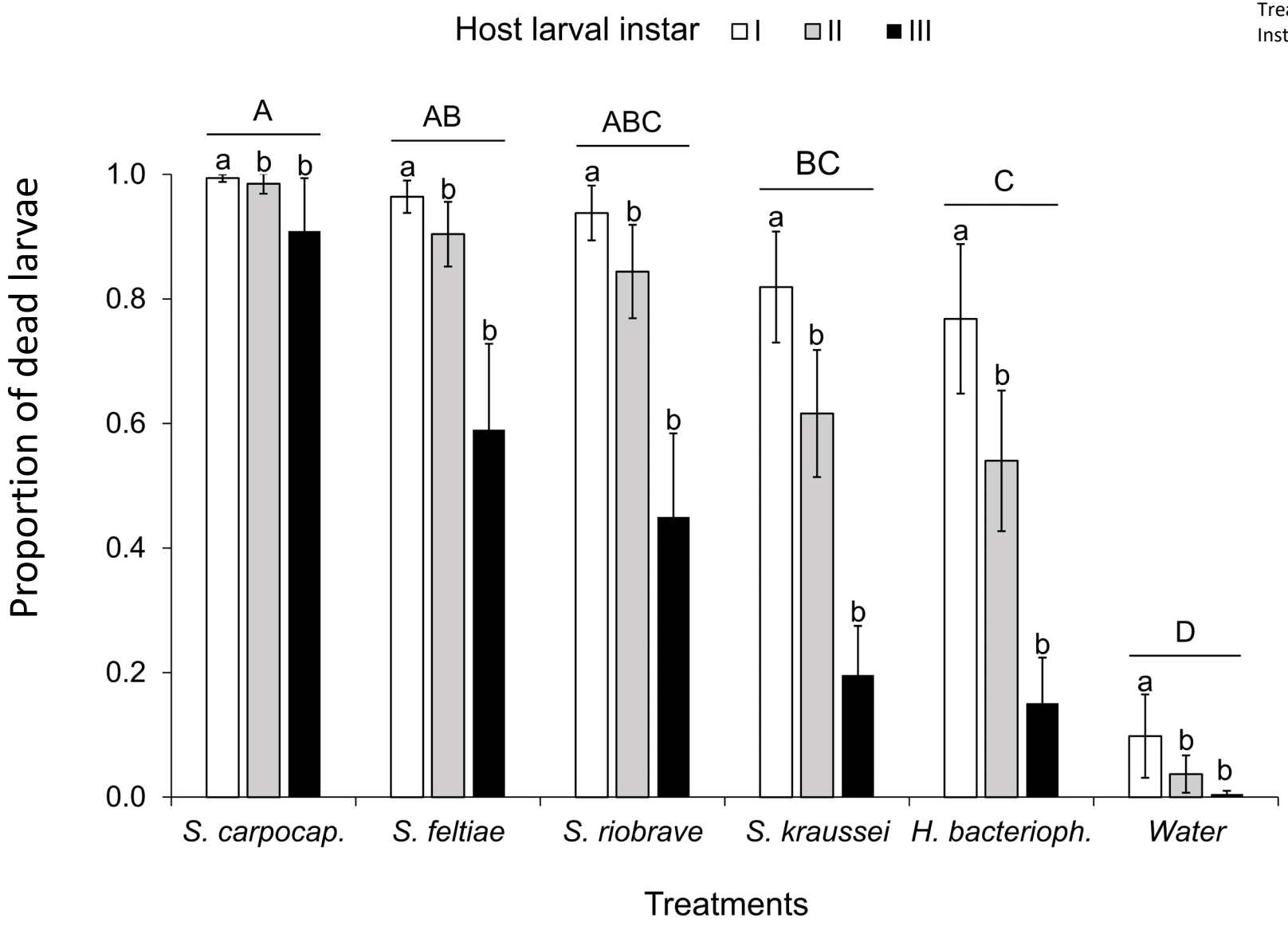
Laboratory Evaluations - EPNs

Treatment: ($\chi^2 = 44.20$; df = 5; $P < 0.001$)
Instar: ($\chi^2 = 22.50$; df = 2; $P < 0.001$)



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Vargas et al., *in press*

Greenhouse Evaluations

Infestation: 2 pairs of HBW

- *Steinernema carpocapsae*
- *S. feltiae*
- Water control
- w/ and w/o Barricade® (0.3%)

Dosage:
500,000 IJ/m^2 approx. sprayed at the foliage until runoff

N =6 plants per treatment and nematode combination

Observations: 5 actively growing buds and 5 fallen buds were dissected 1wk after the application

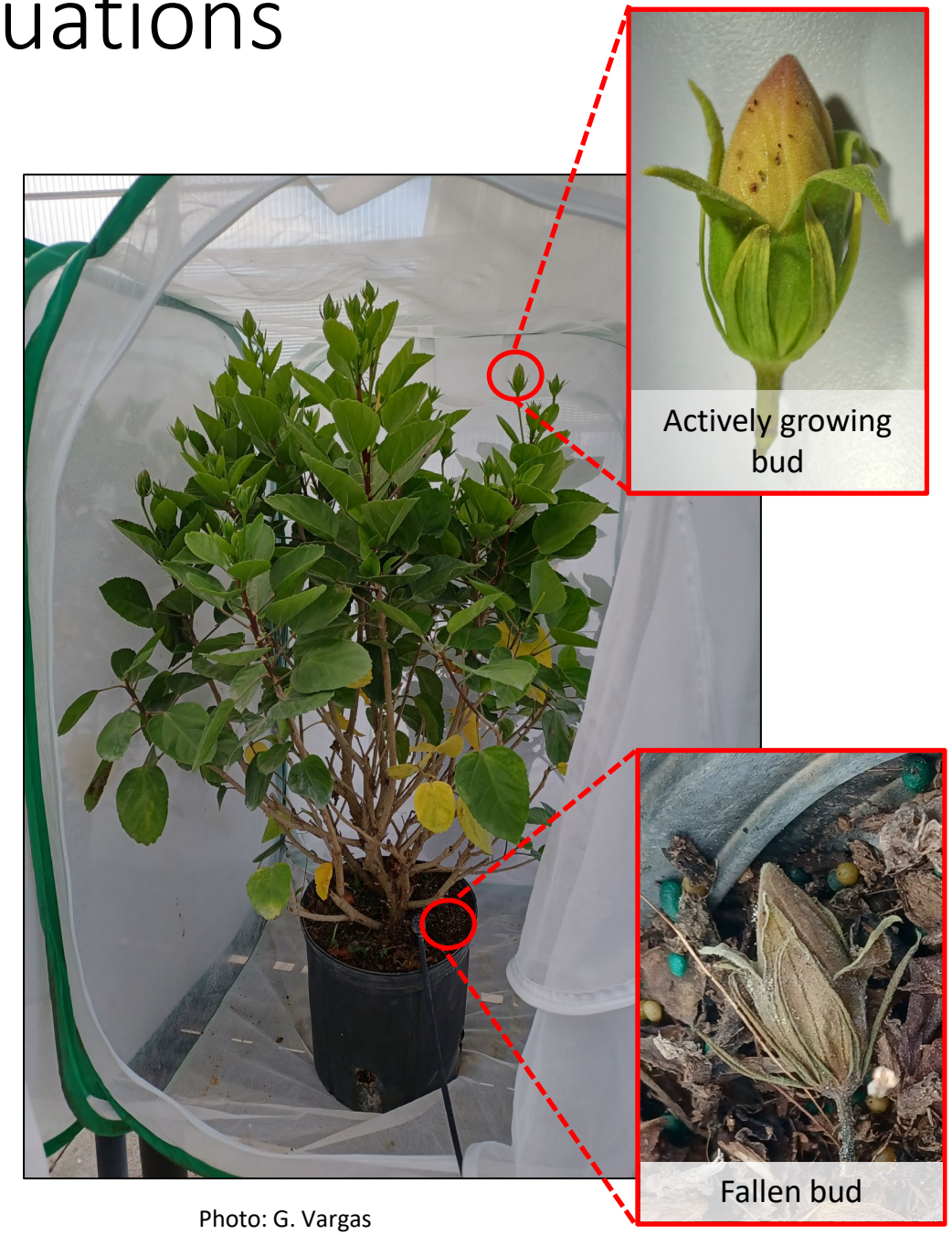

Photo: G. Vargas

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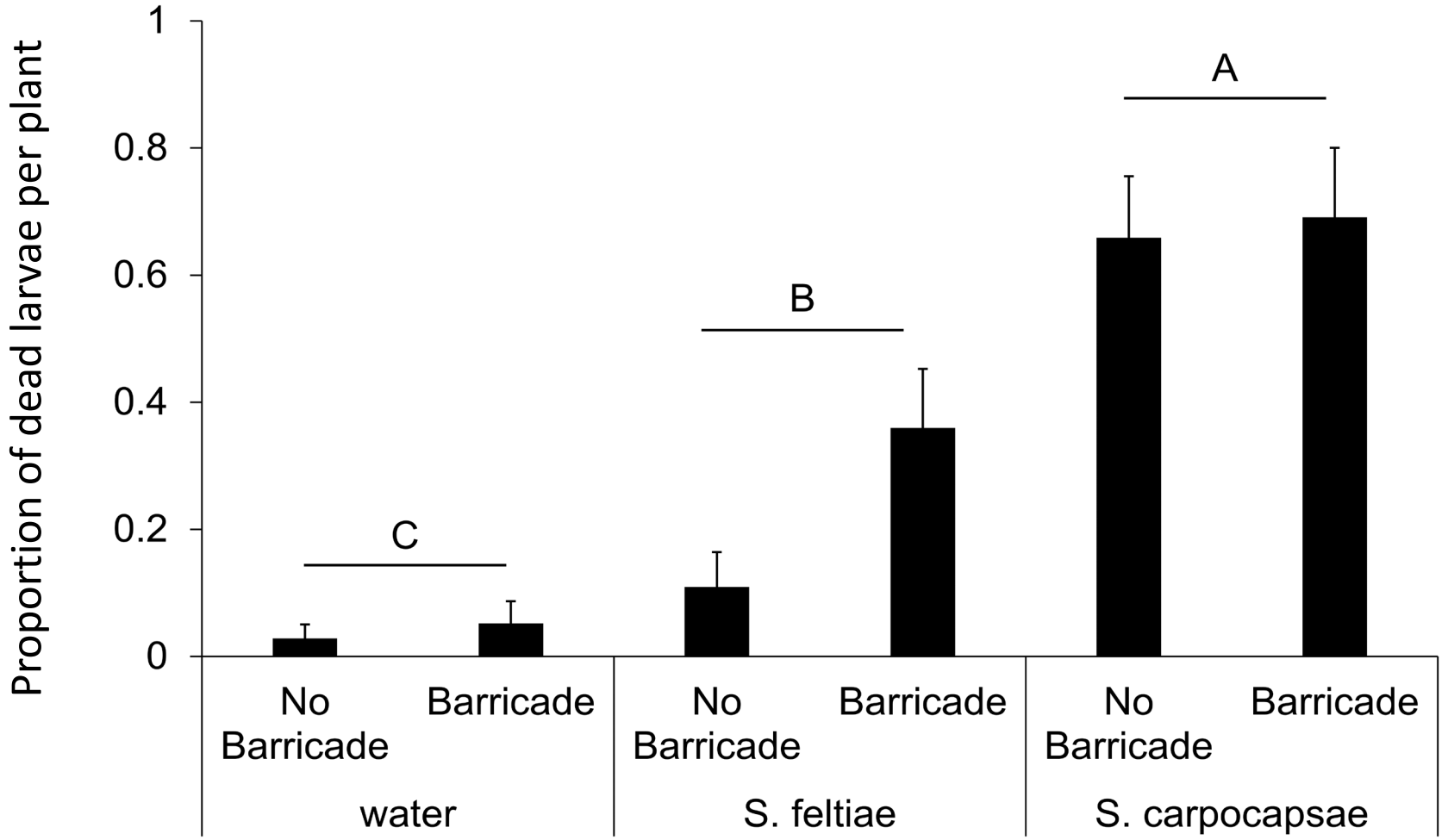
Greenhouse Evaluations- Actively Growing Buds

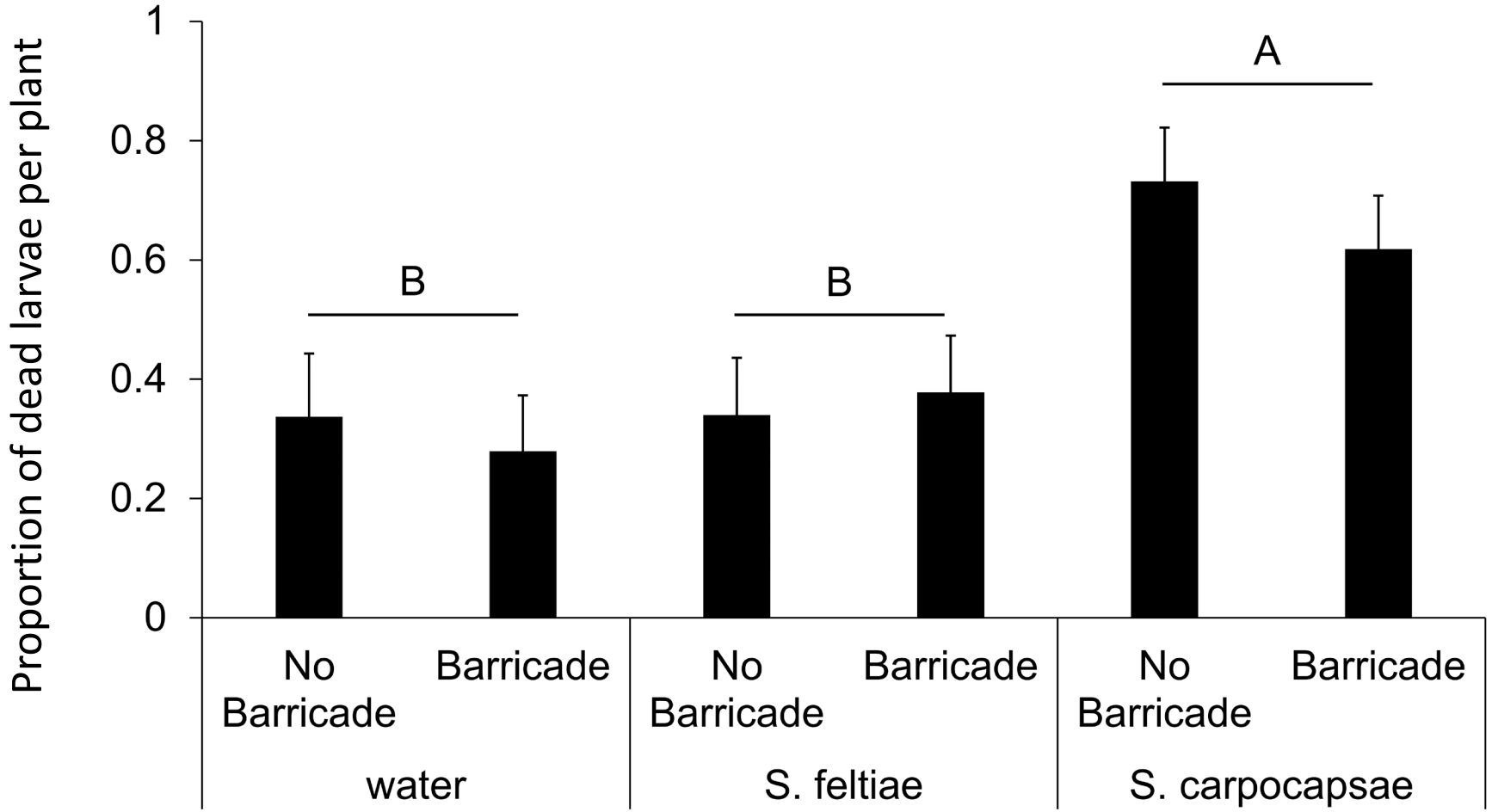
EPN: ($\chi^2 = 44.53$; df = 2; $P < 0.001$)
Barricade: ($\chi^2 = 3.7$; df = 1; $P = 0.054$)



Vargas et al., *in press*

Greenhouse Evaluations- Fallen Buds

EPN: ($\chi^2 = 15.39$; df = 2; $P < 0.001$)
Barricade: ($\chi^2 = 0.393$; df = 1; $P = 0.564$)



Vargas et al., *in press*

Steinernema carpocapsae

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Photos: German Vargas

Greenhouse Evaluations – Refined Rates

Infestation: 2 pairs of HBW

Steinernema carpocapsae

Rates:

- 428,525 IJ/m^2 approx. (full rate)
- 75% of the full rate
- 50% of the full rate
- 25% of the full rate

sprayed at the foliage until runoff

N = 7 plants per treatment

Observations: 5 actively growing buds and 5 fallen buds were dissected 1wk after the application

Photo: G. Vargas

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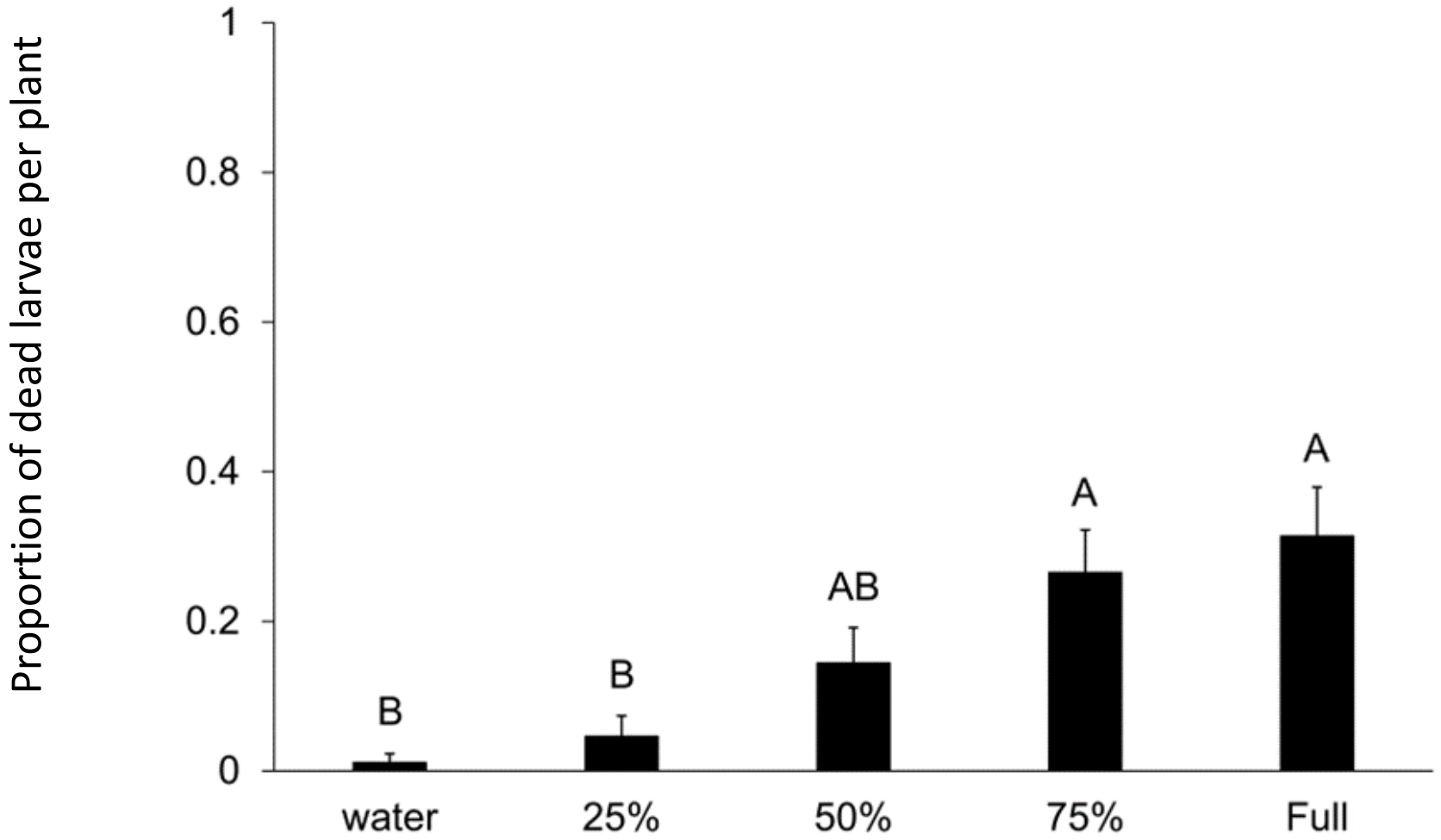
Refined Rates of *S. carpocapsae* - Actively Growing Buds

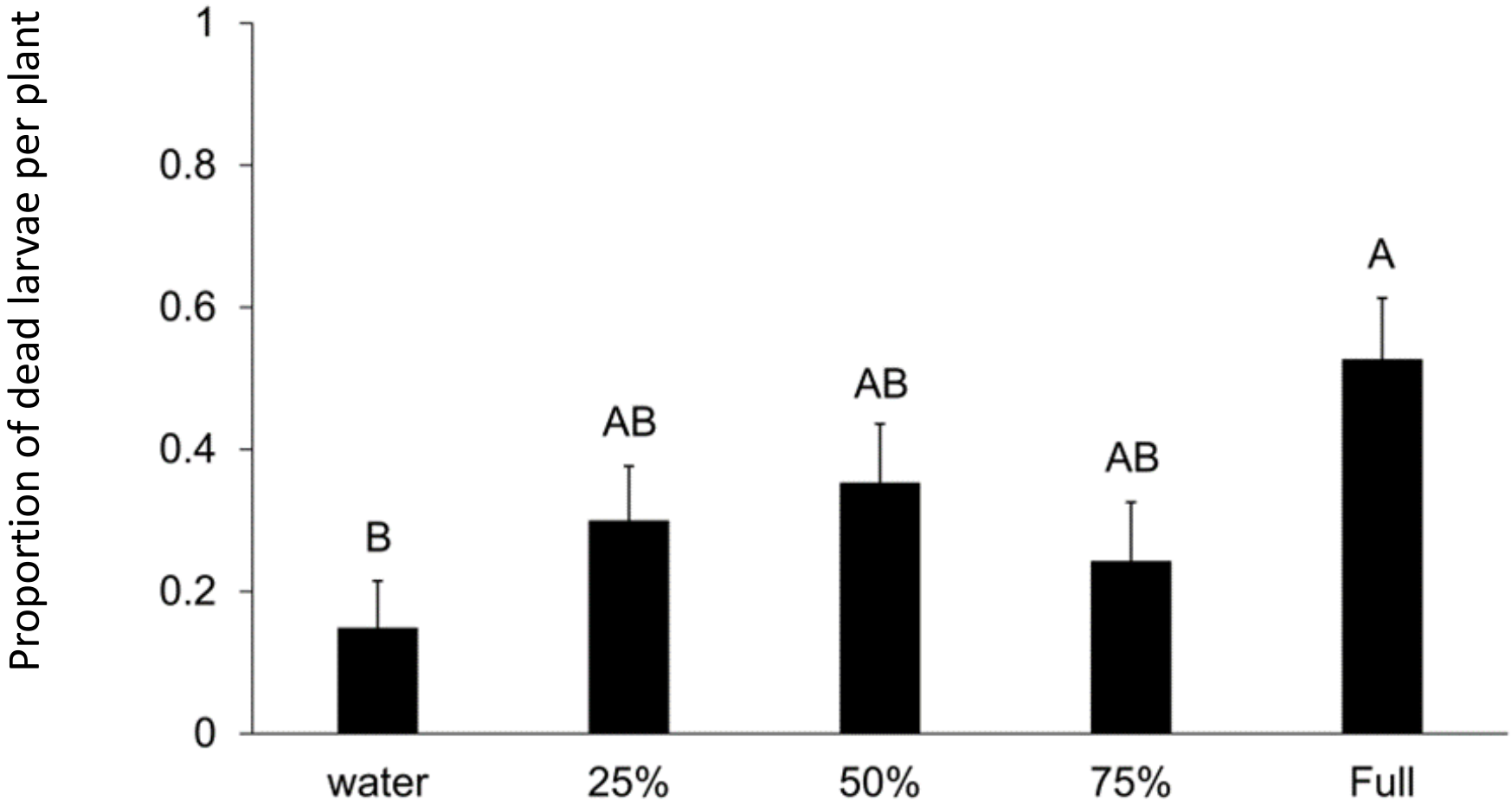
Treatment: ($\chi^2 = 23.09$; df = 4; $P < 0.001$)



Vargas et al., *in press*

Refined Rates of *S. carpocapsae* - Fallen Buds

Treatment: (χ^2 = 11.33; df = 4; P = 0.023)



Vargas et al., *in press*

EPNs- Conclusions

- *Steinernema carpocapsae* and *S. feltiae* → best HBW control
- *Steinernema carpocapsae* greater efficacy → canopy and soil surface
- A 25% reduction in *S. carpocapsae* rate did not significantly decrease the efficacy of controlling larvae at the canopy
- EPN application can target HBW larvae in fallen infested buds

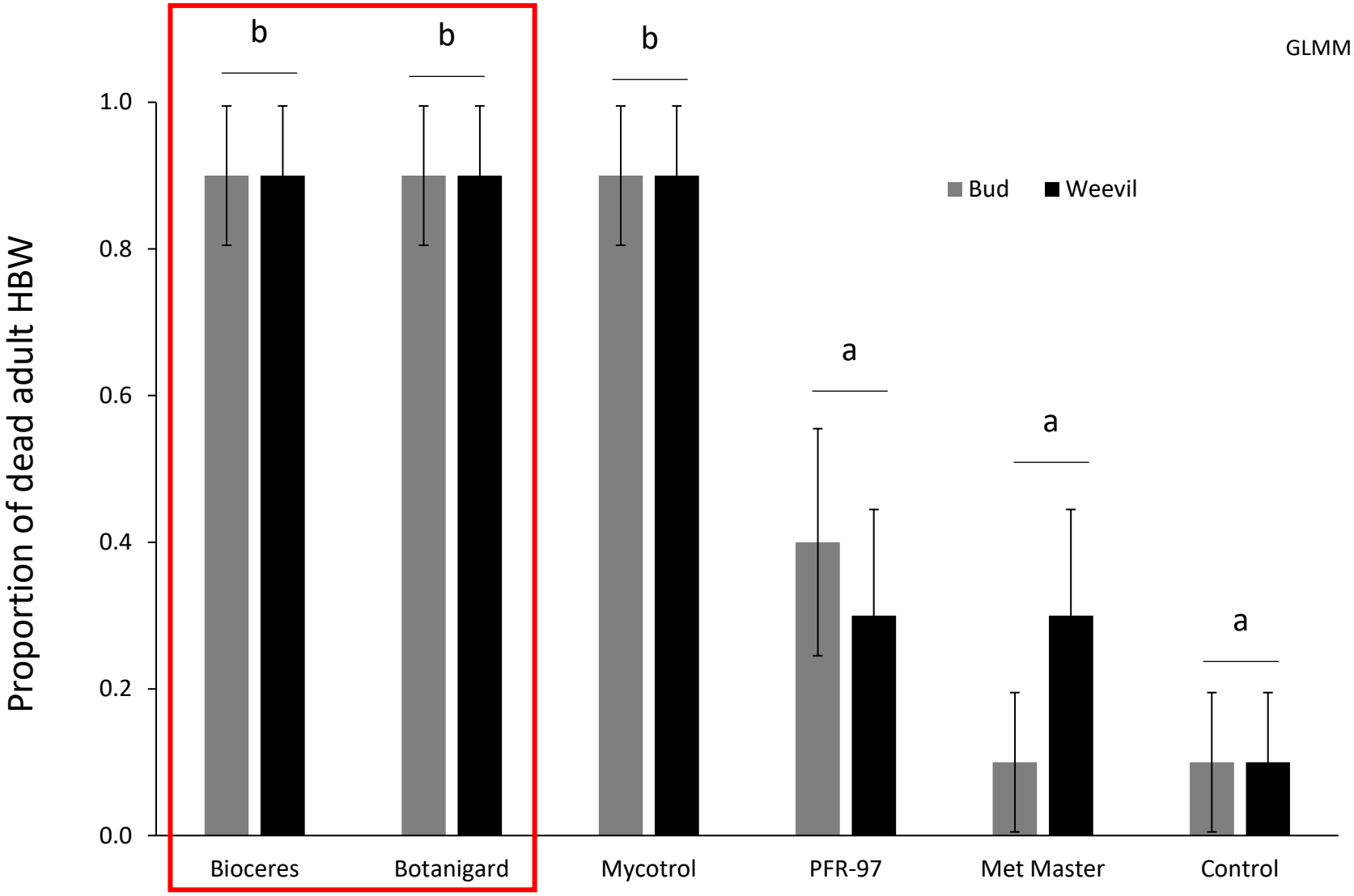
Photo: G. Vargas

Biological Control of HBW - Entomopathogenic Fungi

- Tested entomopathogenic fungi in lab assays against adult weevils
- Exposure through direct contact or treated buds
- Observation: 3-, 7-, 10-, and 14-days post treatment

Product	Active Ingredient	Rate
Bioceres WP	*Beauveria bassiana*, Strain ANT-03	4.8 x 10^7 spores/ml
Botanigard 22WP	*Beauveria bassiana*, Strain GHA	3.4 x 10^7 spores/ml
Mycotrol WPO	*Beauveria bassiana*, Strain GHA	4.1 x 10^7 spores/ml
PFR-97 20% WDG	*Isaria fumosorosea* Apopka Strain 97	4.1 x 10^7 spores/ml
Met52 EC	*Metarhizium anisopliae* Strain F52	3.7 x 10^7 spores/ml
Control	Water	NA

Laboratory Evaluations - Entomopathogenic Fungi



Vargas et al., *in prep.*

Beauveria bassiana ANT-03
(BioCeres WP)

Beauveria bassiana Strain GHA
(BotaniGard 22WP)

Isaria fumosorosea
(PRF-97 ®WDG)

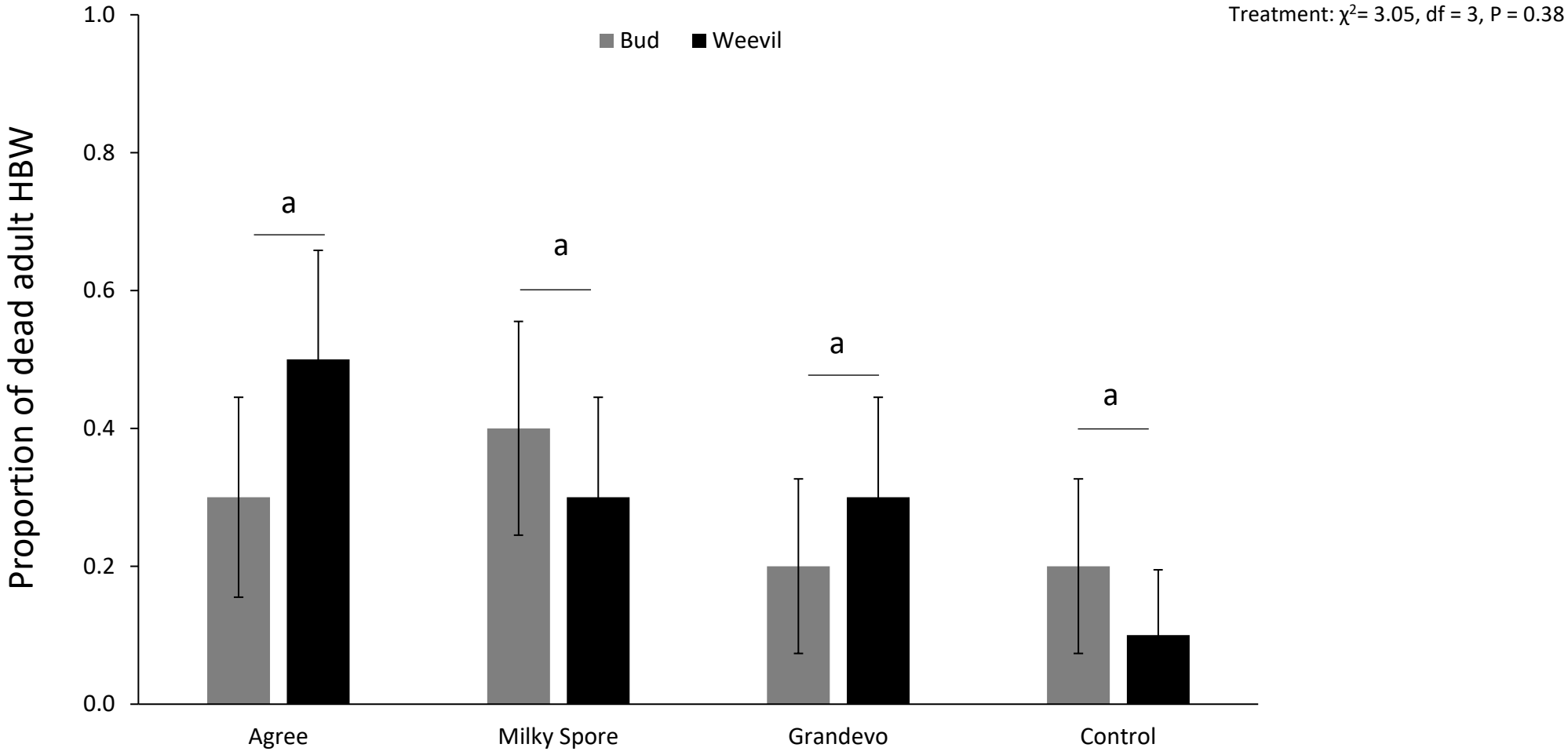
Beauveria bassiana Strain GHA
(Mycotrol WPO)

Biological Control of HBW - Entomopathogenic Bacteria

- Tested entomopathogenic bacteria in lab assays against adult weevils
- Exposure through direct contact or treated buds

Product	Active Ingredient	Rate
Agree WG	*Bacillus thuringiensis* subspecies *aizawai* strain GC-91	
Milky Spore	*Bacillus popilliae*	1 gr/200 ml
Grandevo	*Chromobacterium subtsugae* strain PRAA4-1^{T}	
Control	Water	NA

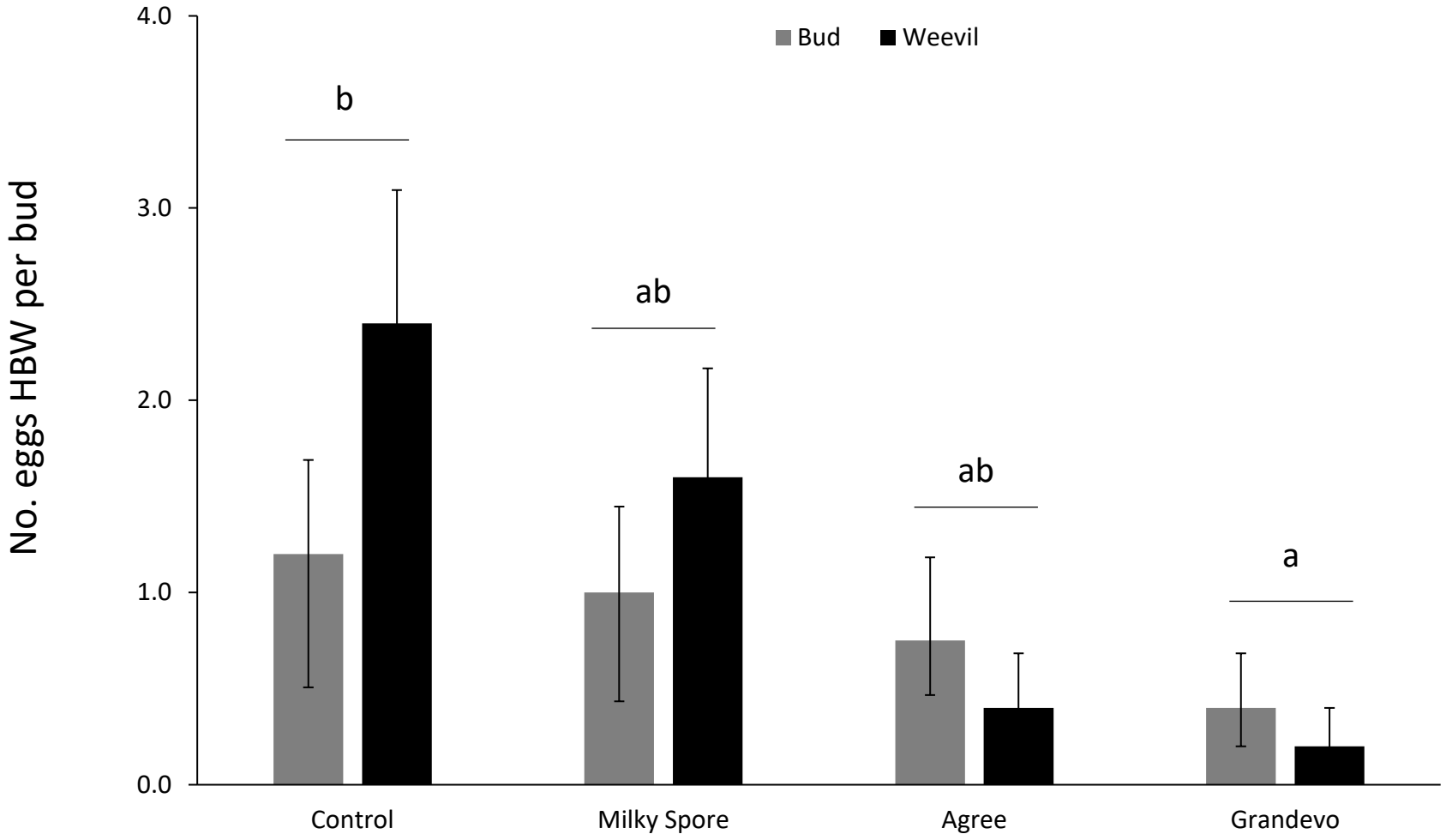
Laboratory Evaluations - Entomopathogenic Bacteria



Vargas et al., *in prep.*

Laboratory Evaluations - Entomopathogenic Bacteria

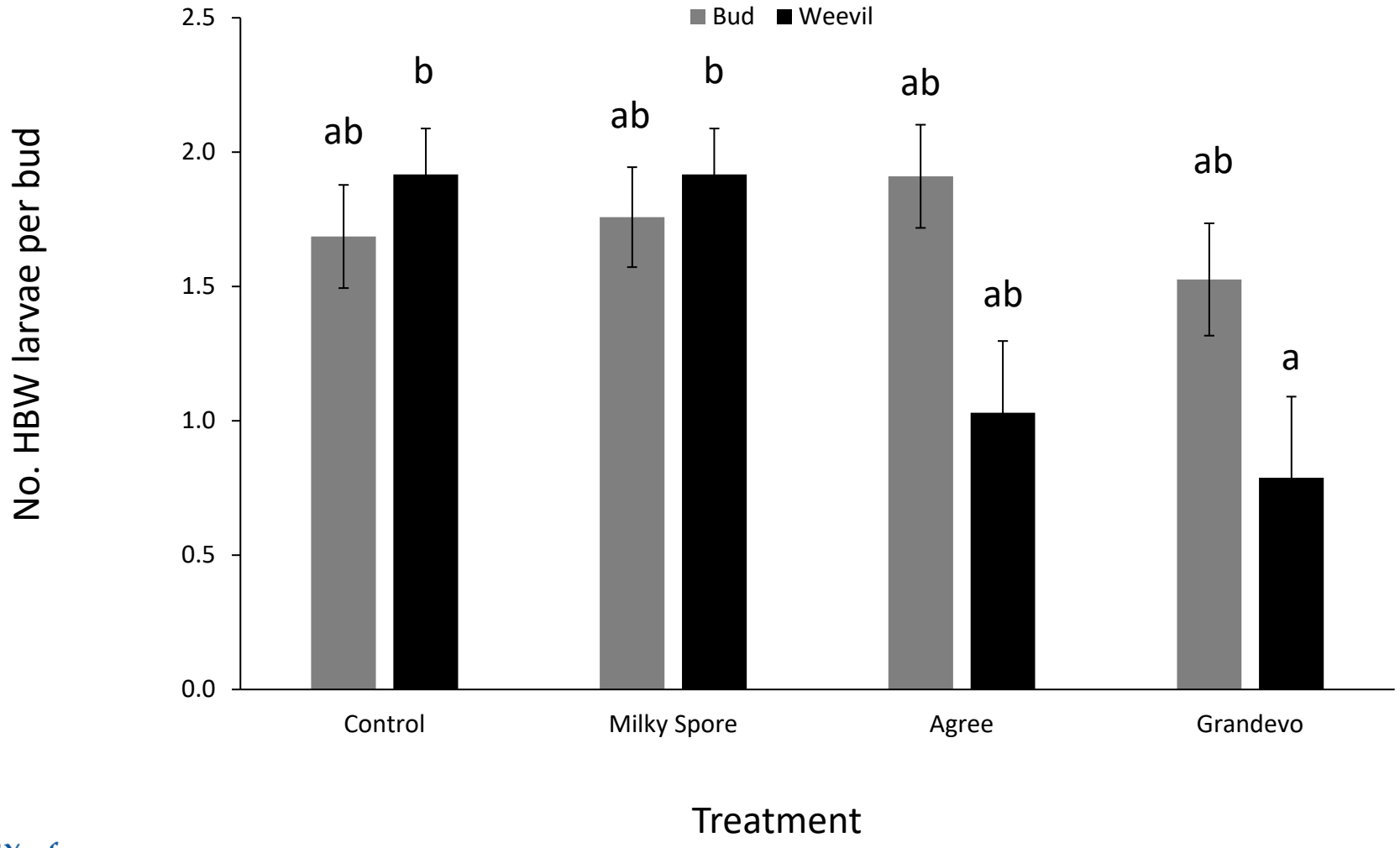
Treatment: χ^2= 9.71, df = 3, P = 0.02



Vargas et al., *in prep.*

Laboratory Evaluations - Entomopathogenic Bacteria

Treatment*Contact:
χ^2= 9.14, df = 3, P = 0.03



Vargas et al., *in prep.*

Greenhouse Evaluations- Entomopathogenic Fungi & Bacteria

- Infestation: 2 HBW pairs/plant
- N = 9 plants/treatment
- Observation: 2 wks post application
- Collection of all buds (actively growing and fallen)
- 2 Blocks

Product	Active Ingredient	Rate
Bioceres WP	*Beauveria bassiana*, Strain ANT-03	3.59 gr/L
Botanigard 22 WP	*Beauveria bassiana*, Strain GHA	2.37 gr/L
Grandevo	*Chromobacterium subtsugae* strain PRAA4-1^{T}	20.7 gr/L
Control	Water	NA

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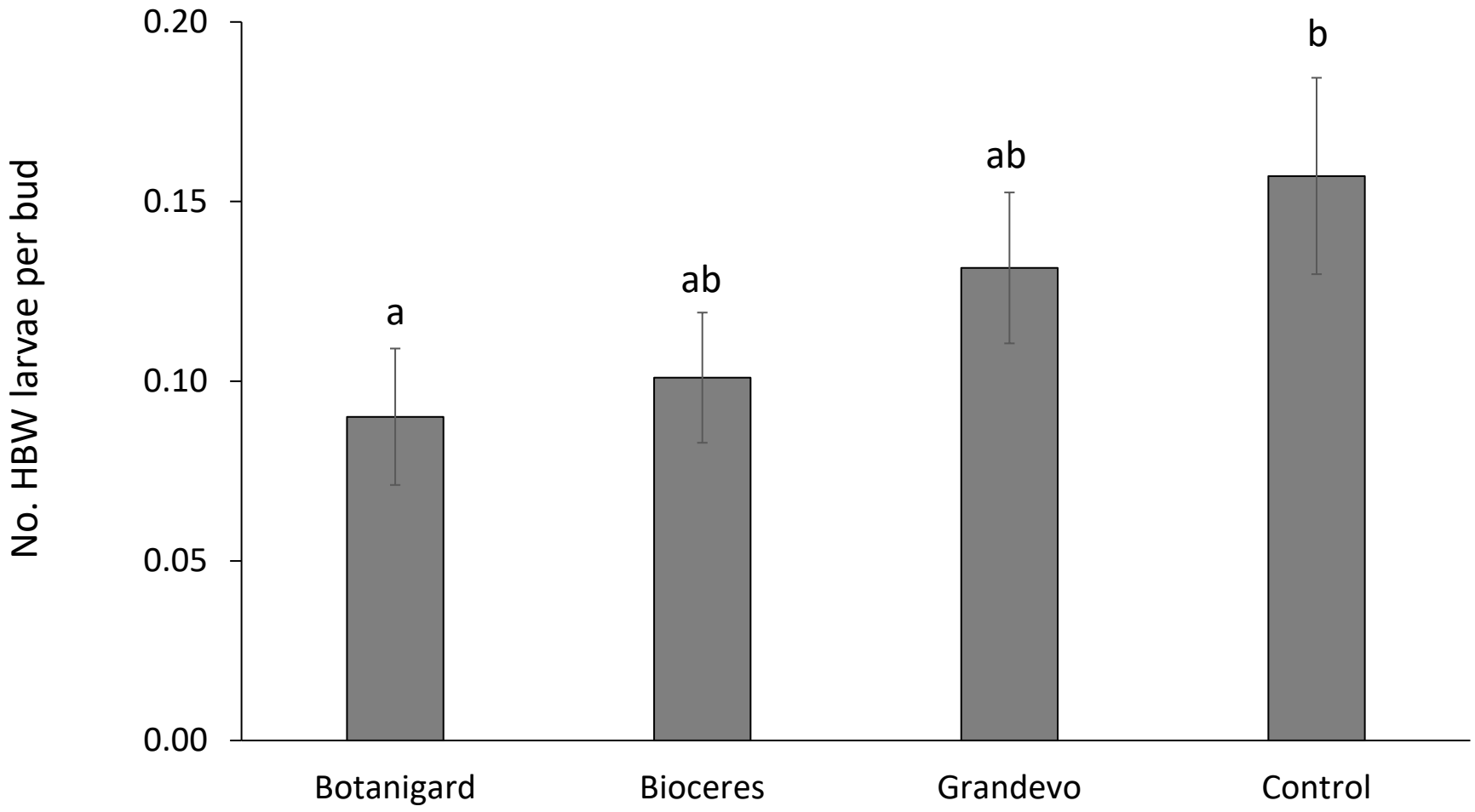
Greenhouse Evaluations- Actively Growing Buds

Treatment: *(χ^2 = 9.16; df = 3; P = 0.027)*



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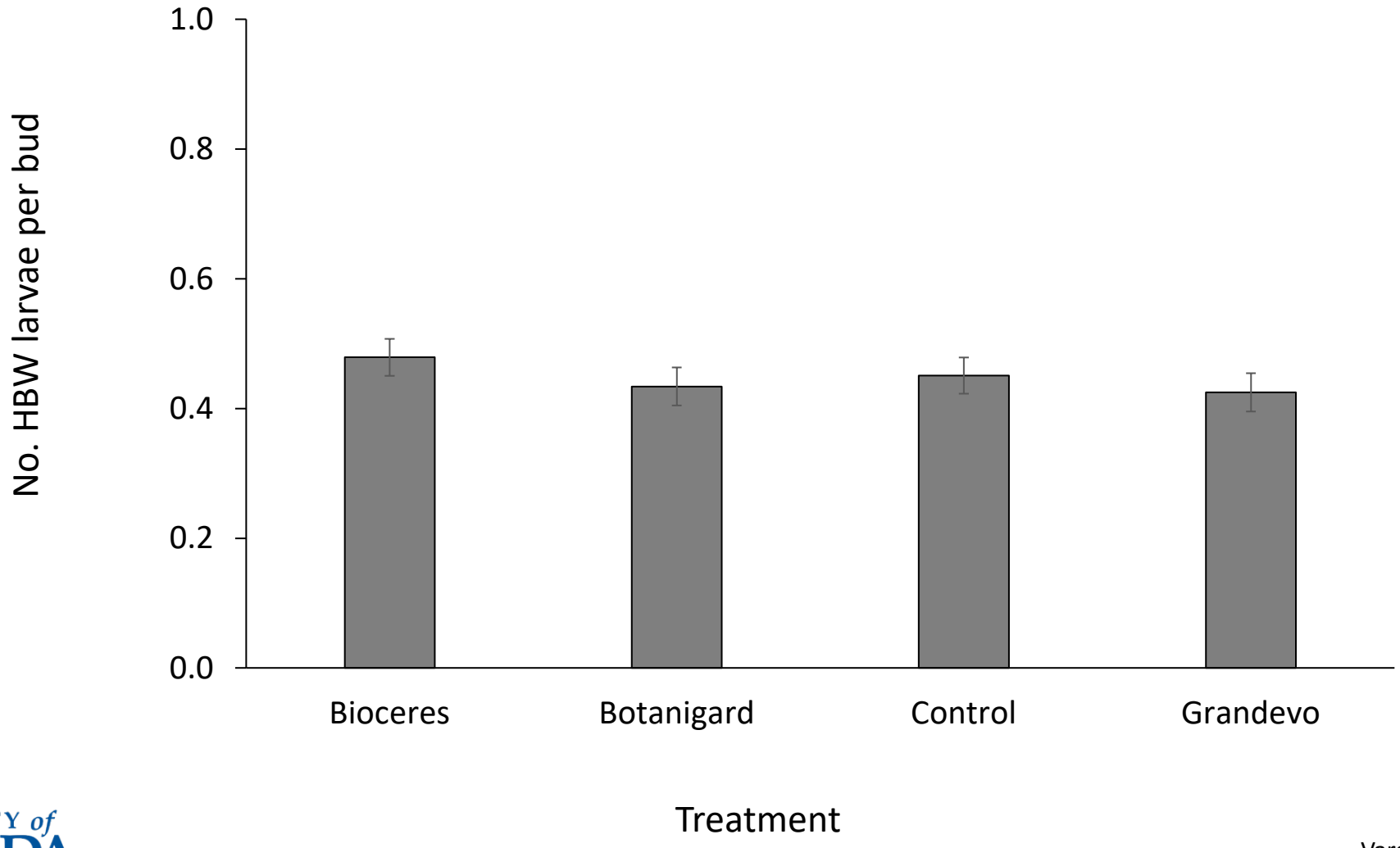
Vargas et al., *in prep.*

Greenhouse Evaluations- Fallen Buds

Treatment: *(χ^2 = 5.38; df = 3; P = 0.15)*



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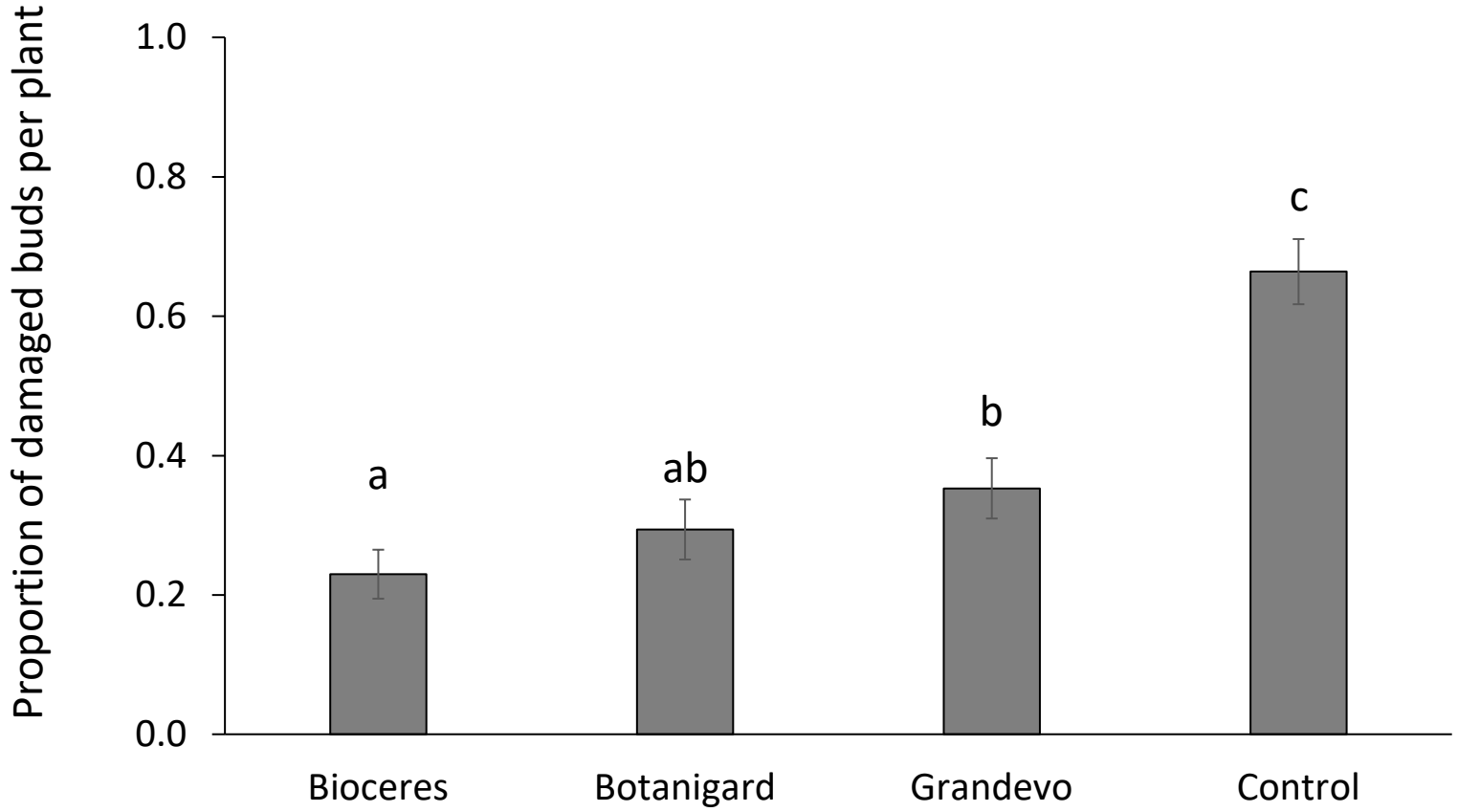
Vargas et al., *in prep.*

Greenhouse Evaluations- Damage on Actively Growing Buds

Treatment: *(χ^2 = 121.07; df = 3; P < 0.001)*



Vargas et al., *in prep.*

Entomopathogenic Fungi & Bacteria- Conclusions

- *Both B. bassiana* strains → efficacious against the HBW
- Grandevo → possible antifeeding and anti-oviposition effects
- All products resulted in greater number of actively growing buds

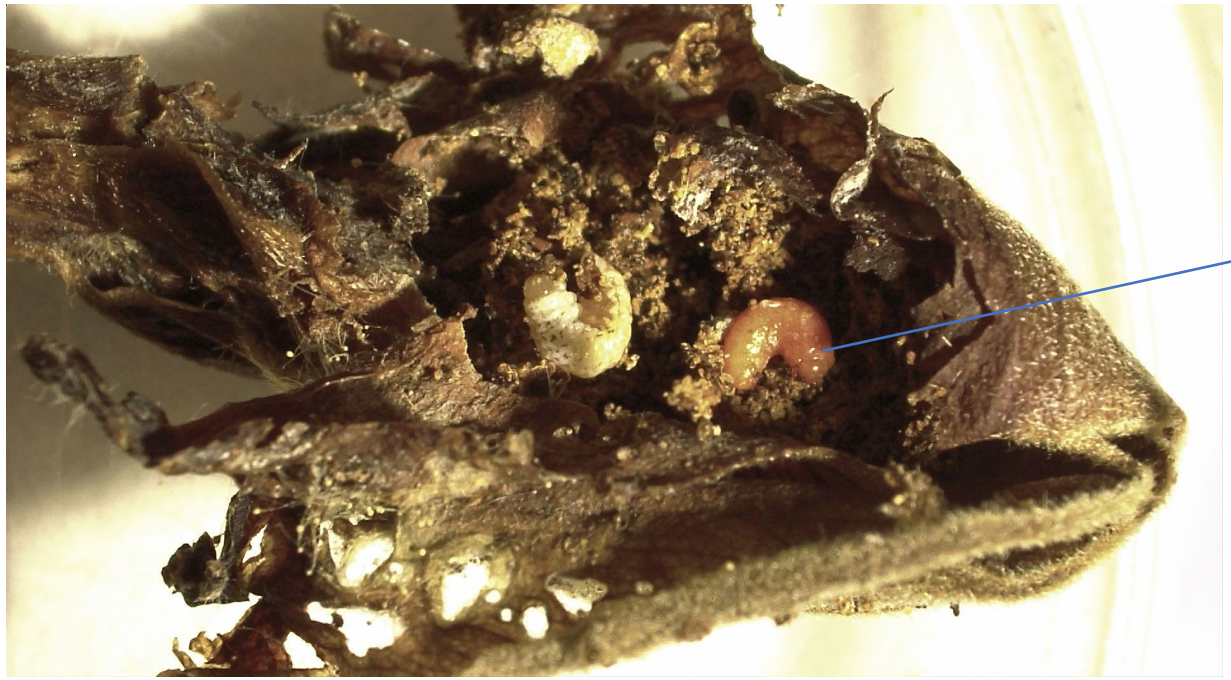
Photo: G. Vargas

Biological Control of HBW - Parasitoids

- *Catolaccus hunteri* (Hymenoptera: Pteromalidae)
- Polyphagous ectoparasitoid
- Parasitoid of several species of *Anthonomus* sp.
  - cotton boll weevil
  - pepper weevil
- It is now available in the US market

Larvae of *C. hunteri* attached to a HBW pupa (Y. Hernandez-Velazquez)

Catolaccus hunteri



Parasitized larva

Photo: Y. Velazquez Hernandez

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Catolaccus hunteri

Parasitized Pupa

Photo: Y. Velazquez Hernandez

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Which is the most appropriate HBW developmental stage for *C. hunteri?*

- Lab evaluations
- 5 buds with:
  - Eggs
  - L1-L3
  - Pupa
- N = 10 per stage
- 1 parasitoid pair released for 24h

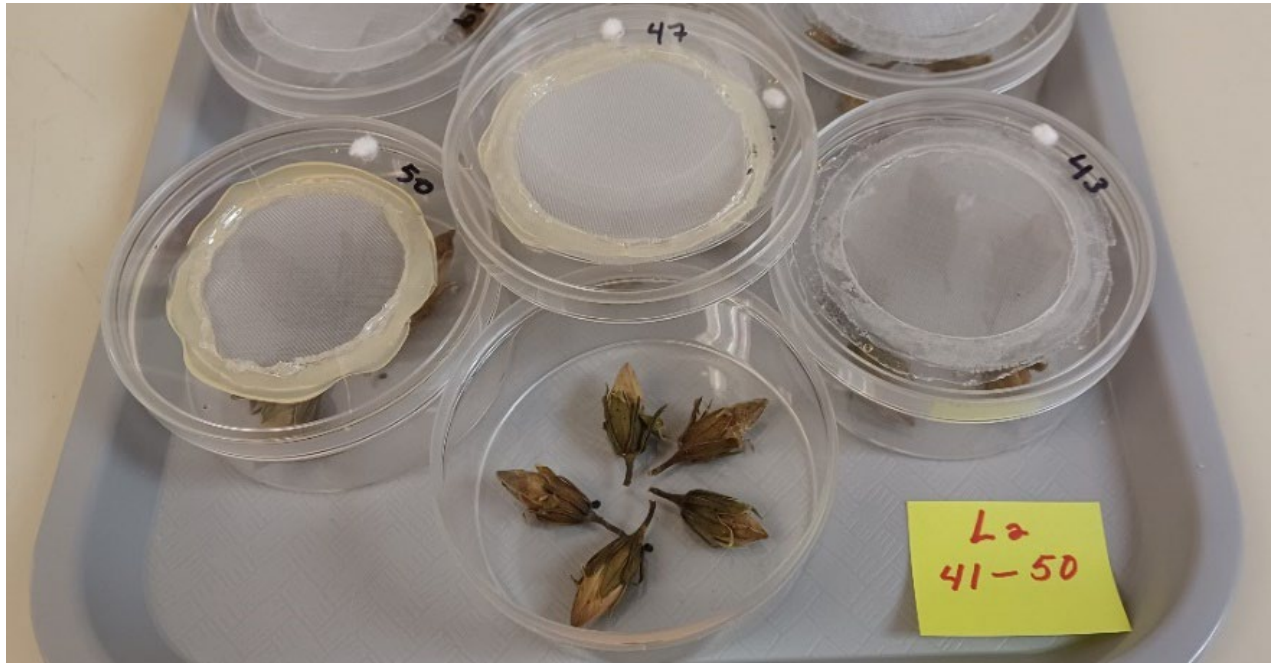
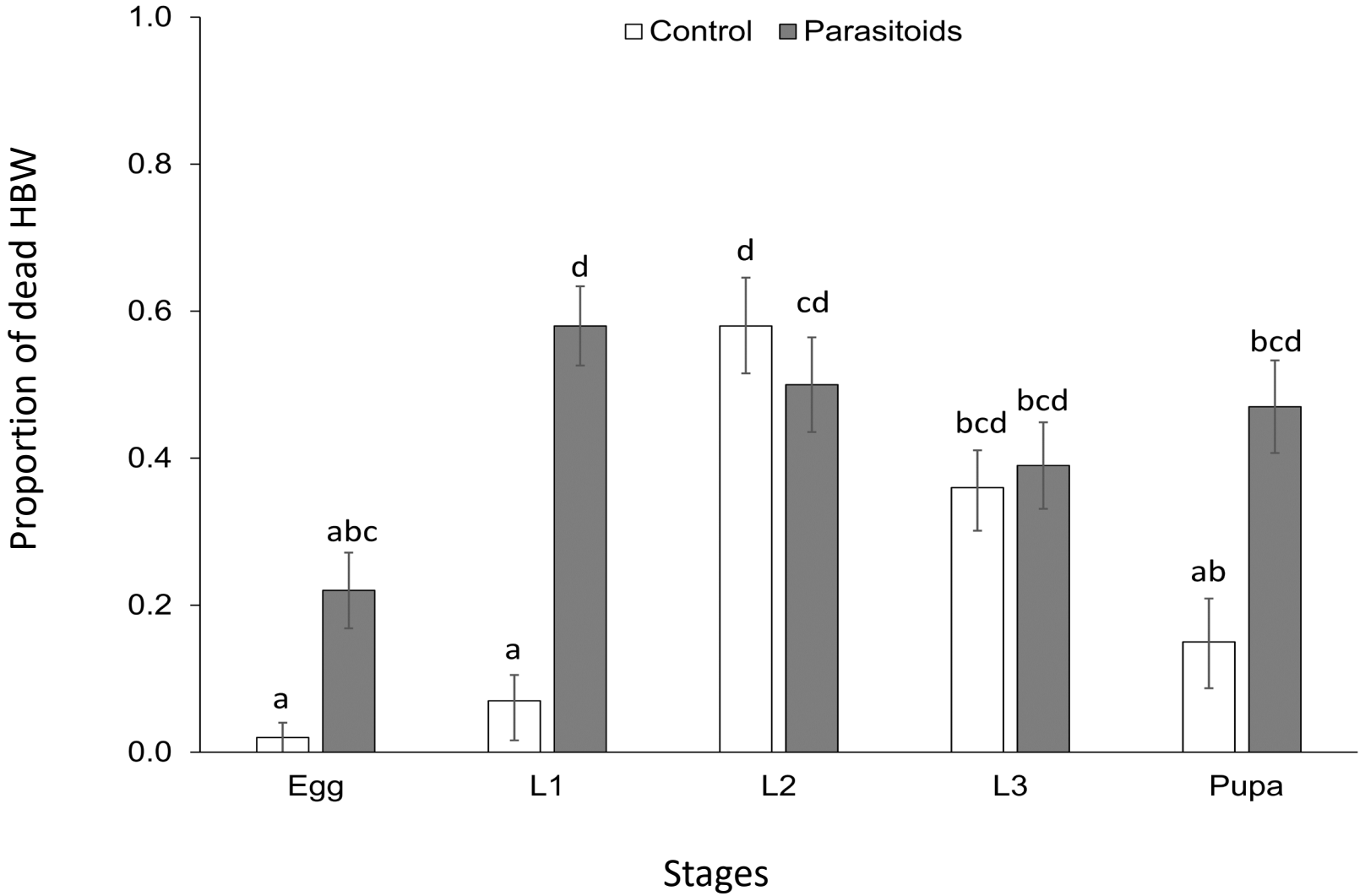


Photo: Y. Velazquez Hernandez

Laboratory Evaluations- Parasitoids

Treatment*Stage:
$\chi^2 = 32.99$; df = 4; $P < 0.001$



Is there an Optimum Release Rate for the *C. hunteri?*

- Lab evaluations
- 15 HBW infested buds plus:
  - 1
  - 2
  - 3 female parasitoids
- N = 4 per treatment
- Parasitoids remained in the cage for 4 days

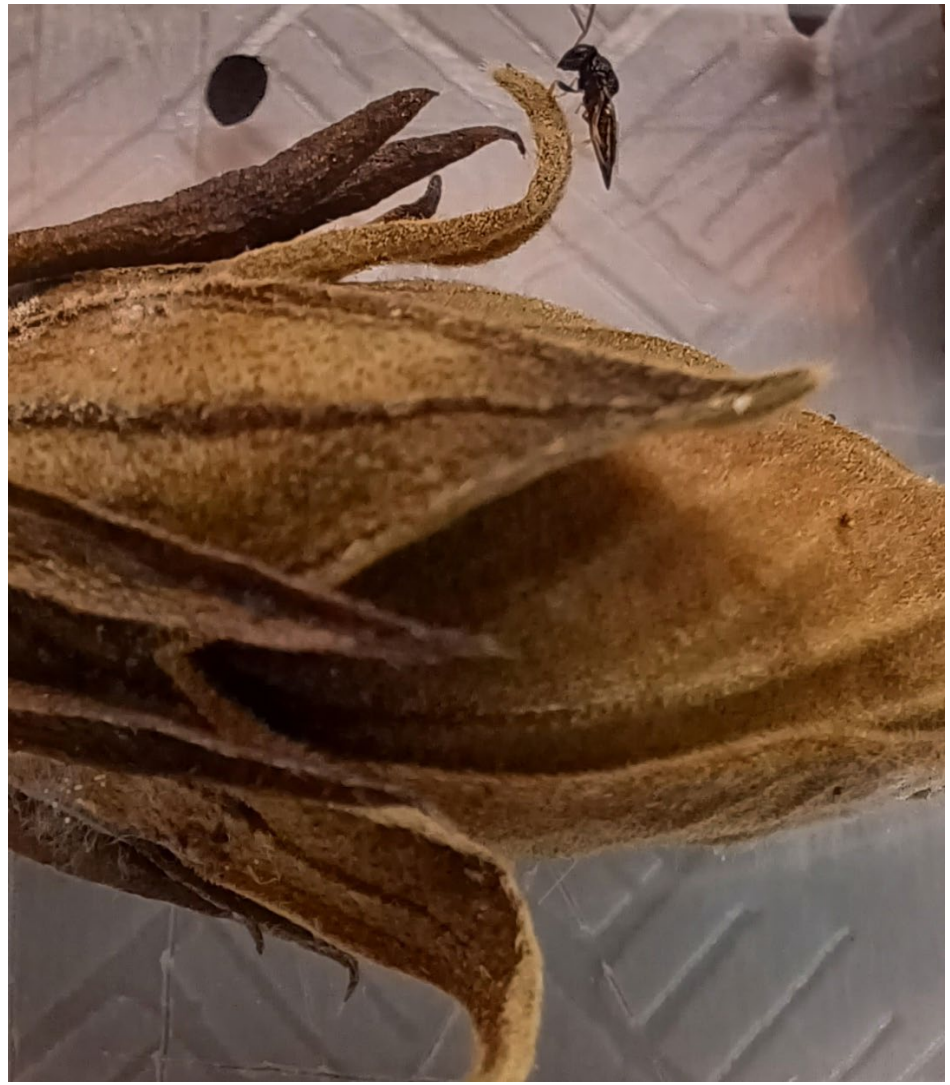
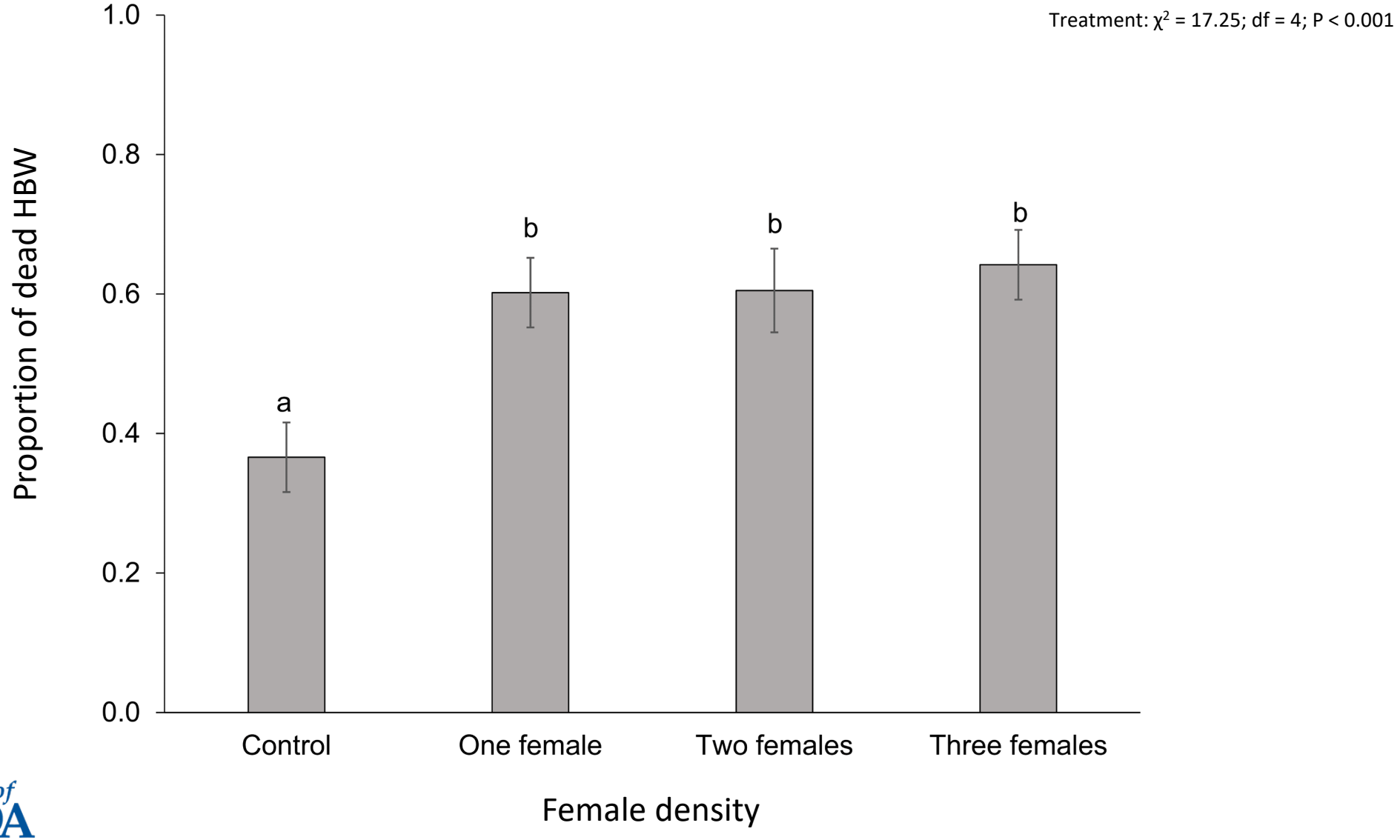


Photo: Y. Velazquez Hernandez

Laboratory Evaluations- Parasitoid Rate



Is there an Optimum Release Rate for the *C. hunteri?*

- Greenhouse evaluations
- Individual hibiscus infested plants plus:
  - 1
  - 2
  - 3 parasitoid pairs
- N = 4 per treatment
- Collection of all buds 2 wks post parasitoid release

Photo: Y. Velazquez Hernandez

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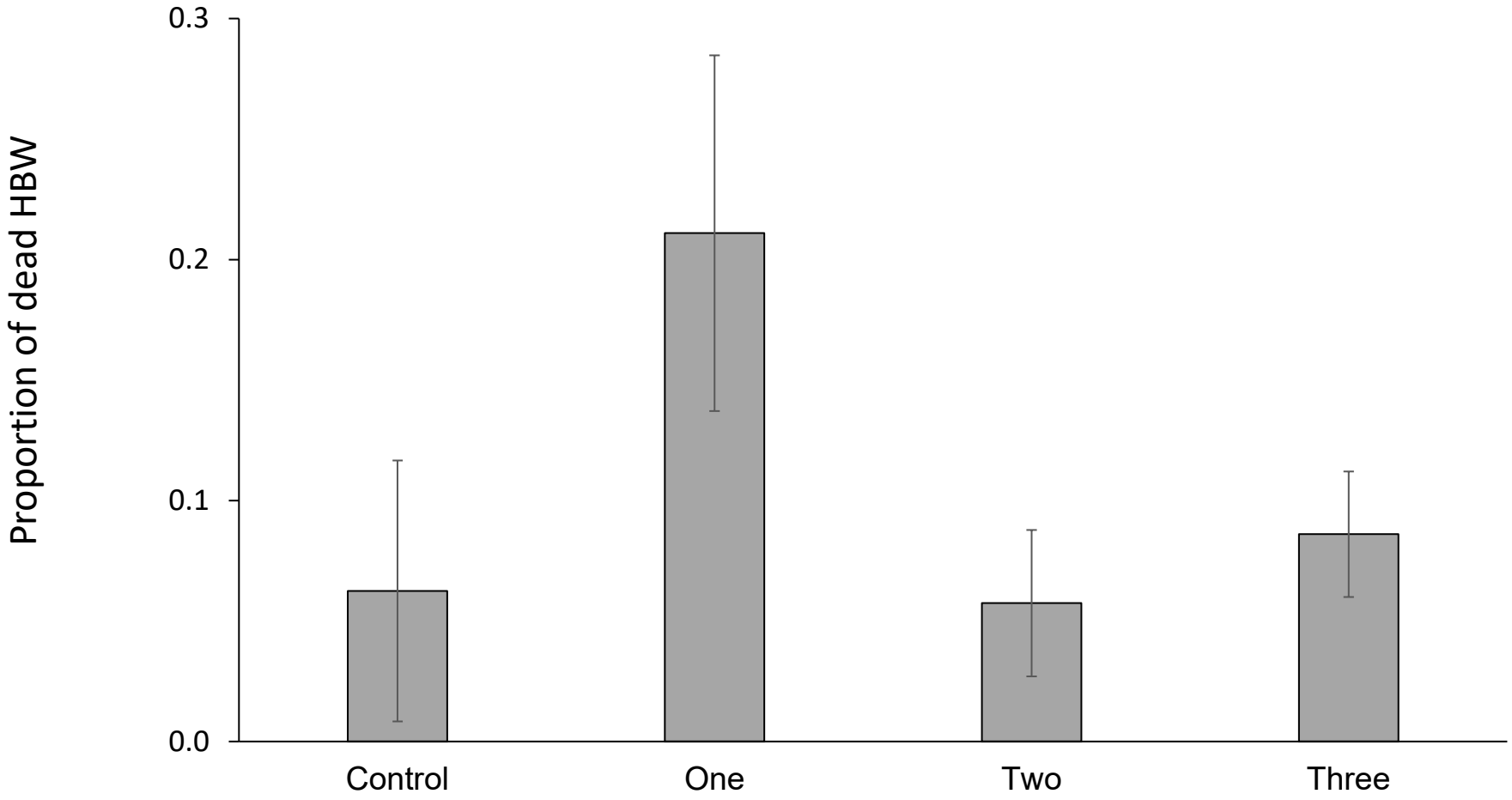
Greenhouse Evaluations- Parasitoid Rate



Parasitoids- Conclusions

- *Catolaccus hunteri* shows potential in controlling HBW larvae
- Releasing 1 female per 15 flower buds, did not differ significantly from releasing 2-3 individuals, but caused more mortality than the control, under lab conditions
- A released of a single parasitoid pair showed potential to control HBW under greenhouse conditions
- More research to define optimum sex ratio and its effects on female's reproductive performance

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Photo: Y. Velazquez Hernandez

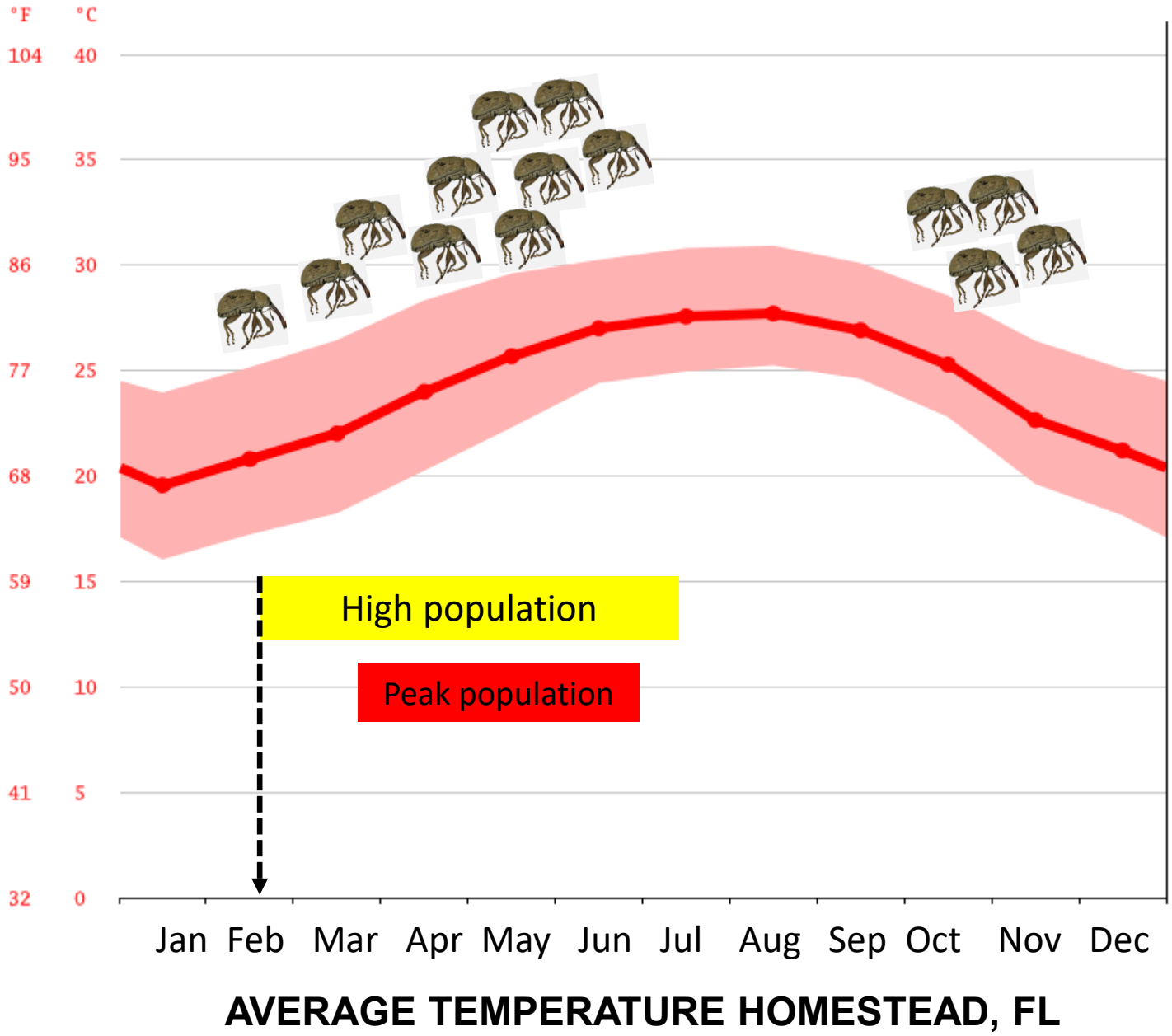
Considering phenology towards an IPM program

Monitor and sanitize throughout the year

Systemics under a prophylactic approach from February

Use of foliar entomopathogenic nematodes, fungi and bacteria can help in sustaining low populations

Use of contact insecticides before the shipping period



https://en.climate-data.org/north-america/united-states-of-america/florida/homestead-1632/#temperature-graph

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Biological Control of HBW – Take-home Messages

- *Steinernema carpocapsae* and *S. feltiae* → best HBW control
- *Beauveria bassiana* Strain ANT-03 and Strain GHA → efficacious against the HBW
- *Chromobacterium subtsugae* strain PRAA4-1^{T} → viable alternative
- *Catolaccus hunteri* → potential in controlling HBW larvae, more research is needed

Sanitation

- The collection and destruction of fallen buds
- Reduces HBW population
- Environmentally friendly strategy
- Labor intensive

Photo: A.D. Greene

Effect of Sanitation on HBW Populations

- 4 tents → Sanitation
- 4 tents → No Sanitation
- 10 hibiscus/tent
- Released 20 HBW (10F/10M)/tent
- Sampled 5 actively growing buds weekly for 9 weeks plus fallen buds (sanitation)

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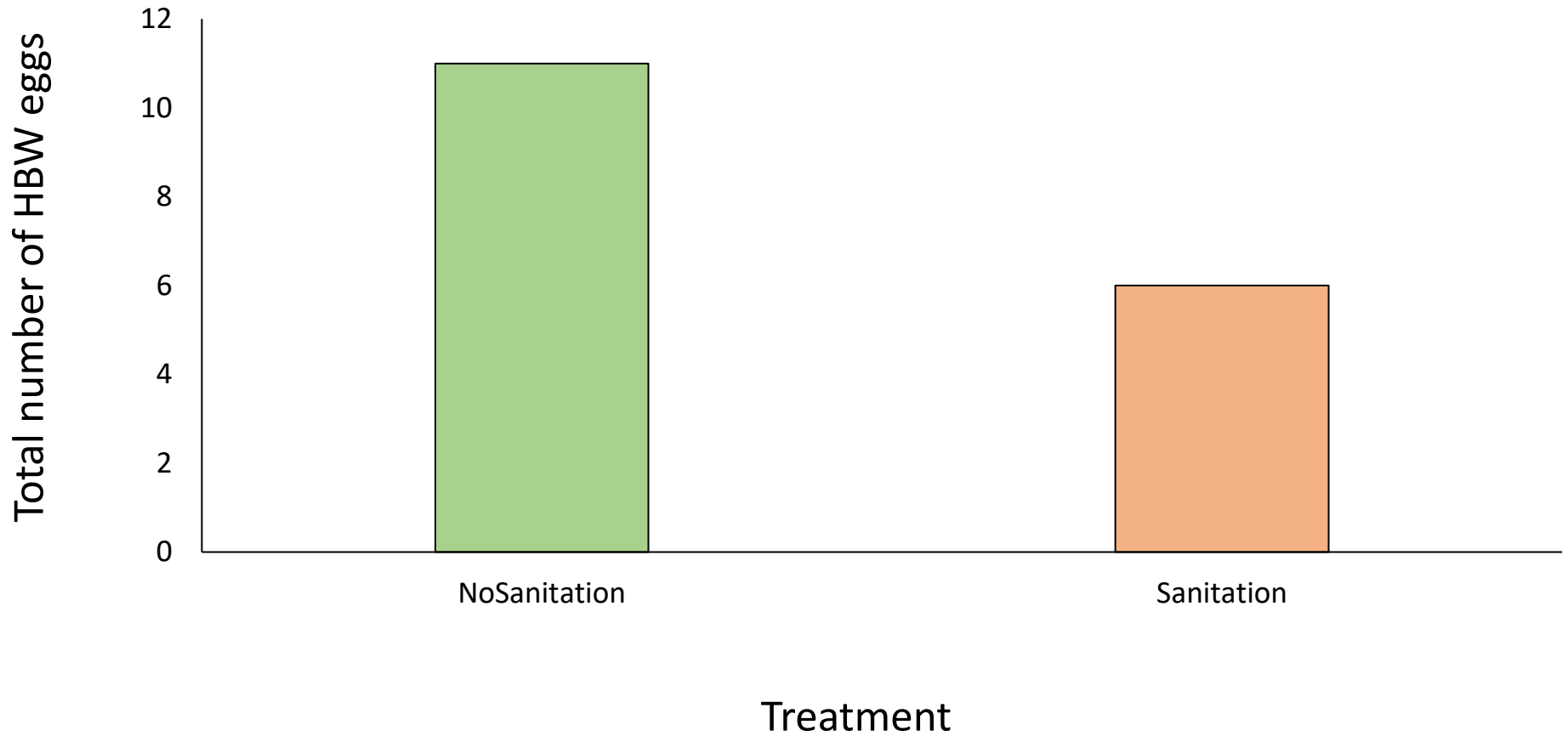
Photo: A.D. Greene

Sanitation - HBW Eggs from Actively Growing Buds



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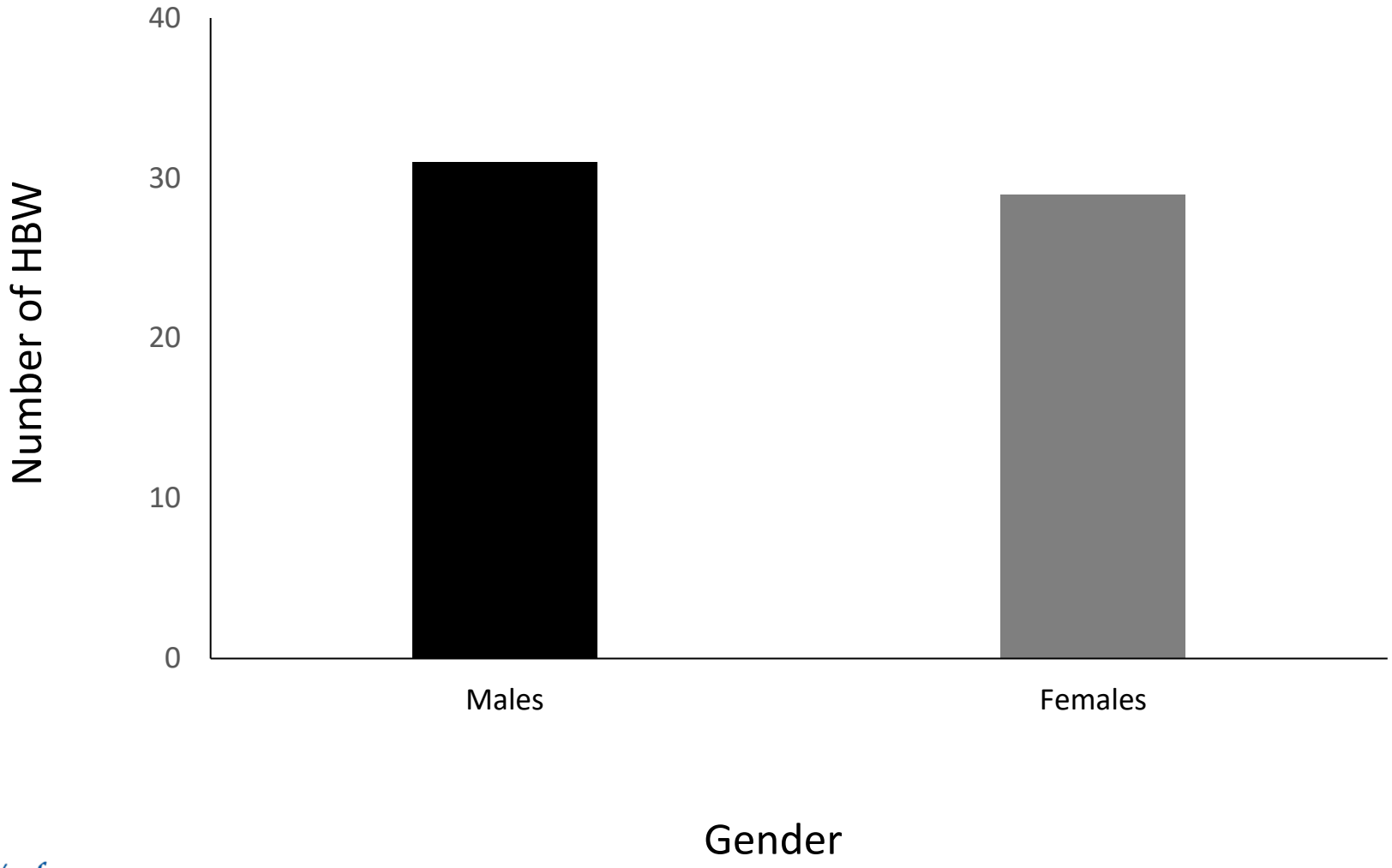
Sanitation - Emerging HBW from Fallen Buds



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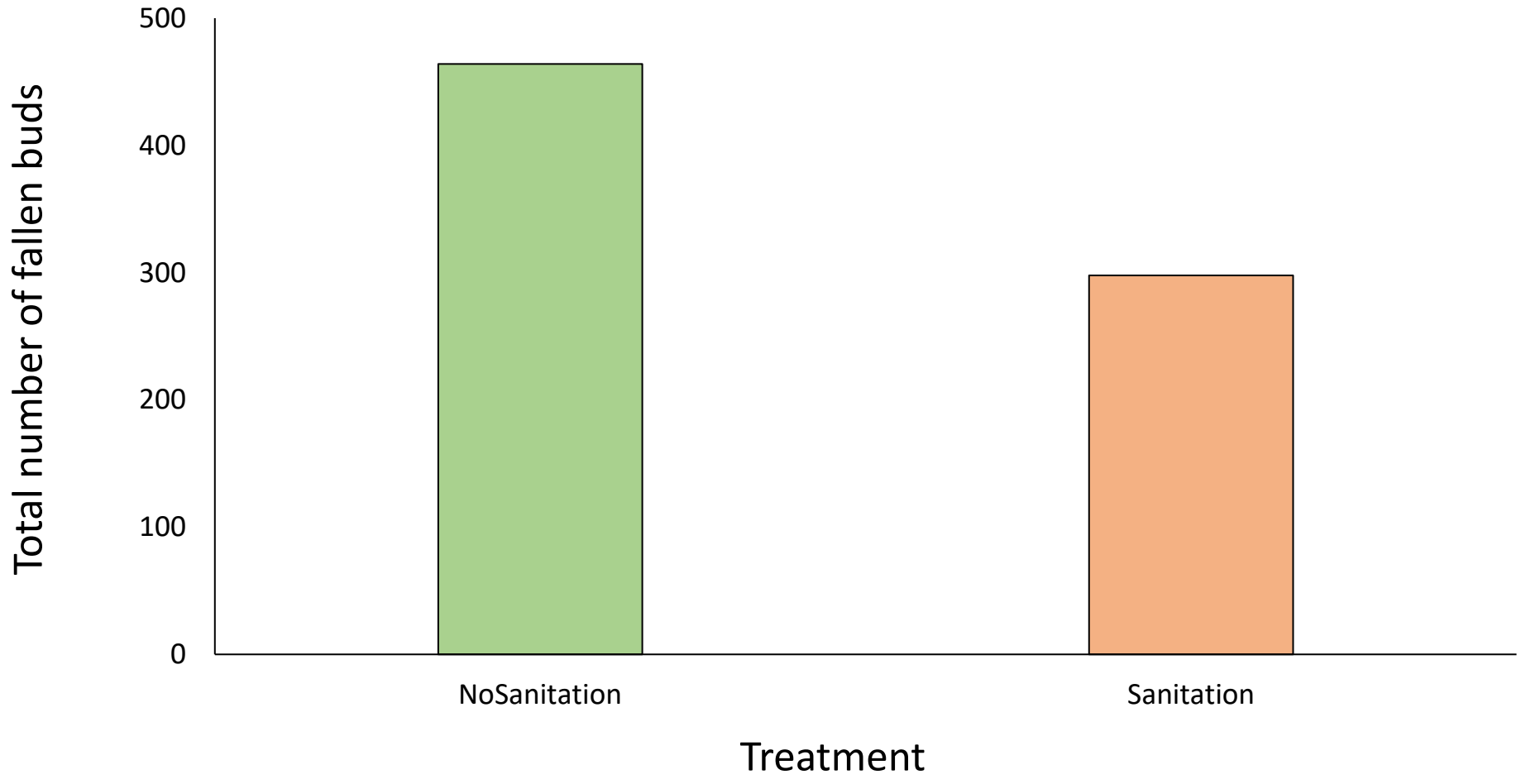
Sanitation - Number of Fallen Buds



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Can We Optimize Sanitation?

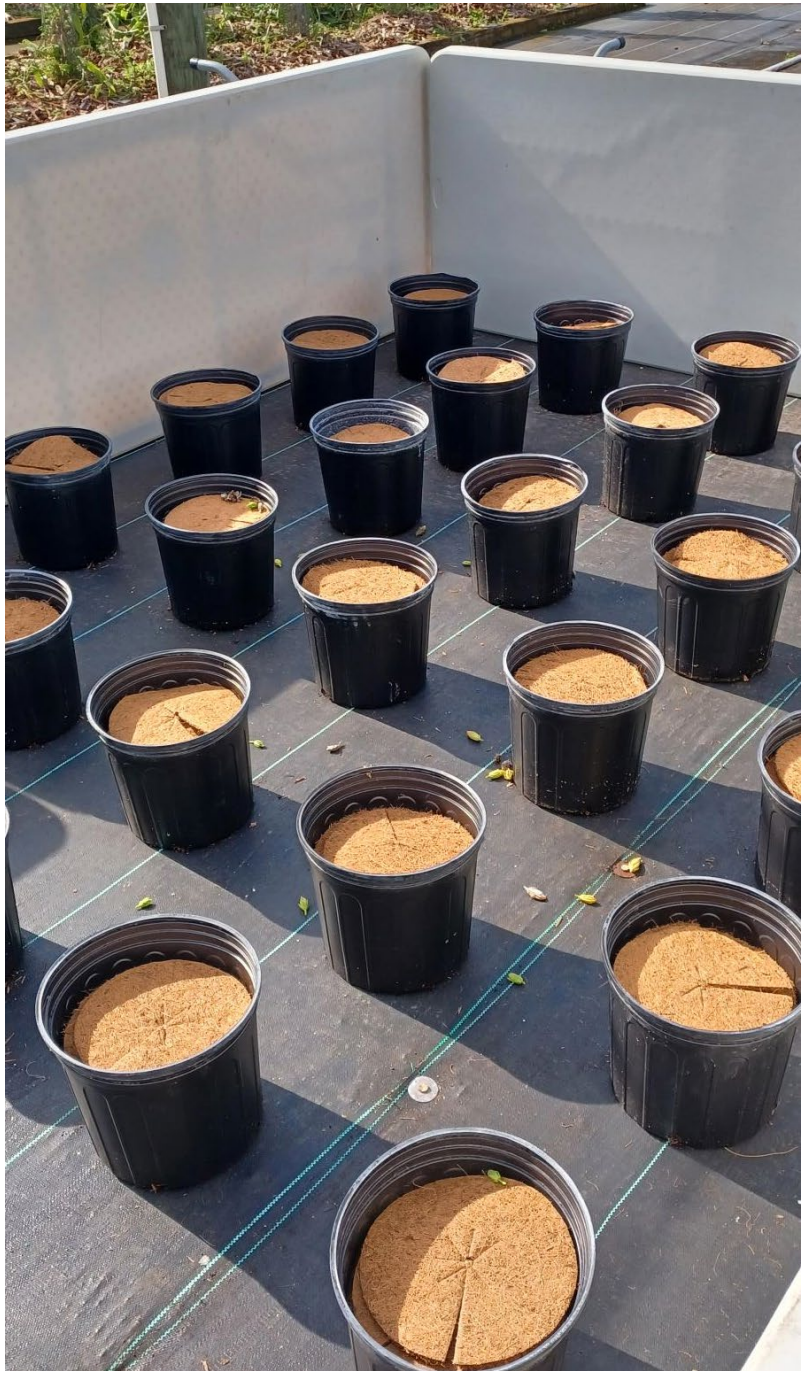
- Increase:
  1. Speed
  2. Number of collected buds

- Options:
  1. Manual sanitation
  2. Leaf blower
  3. Vacuum

Can We Optimize Sanitation?

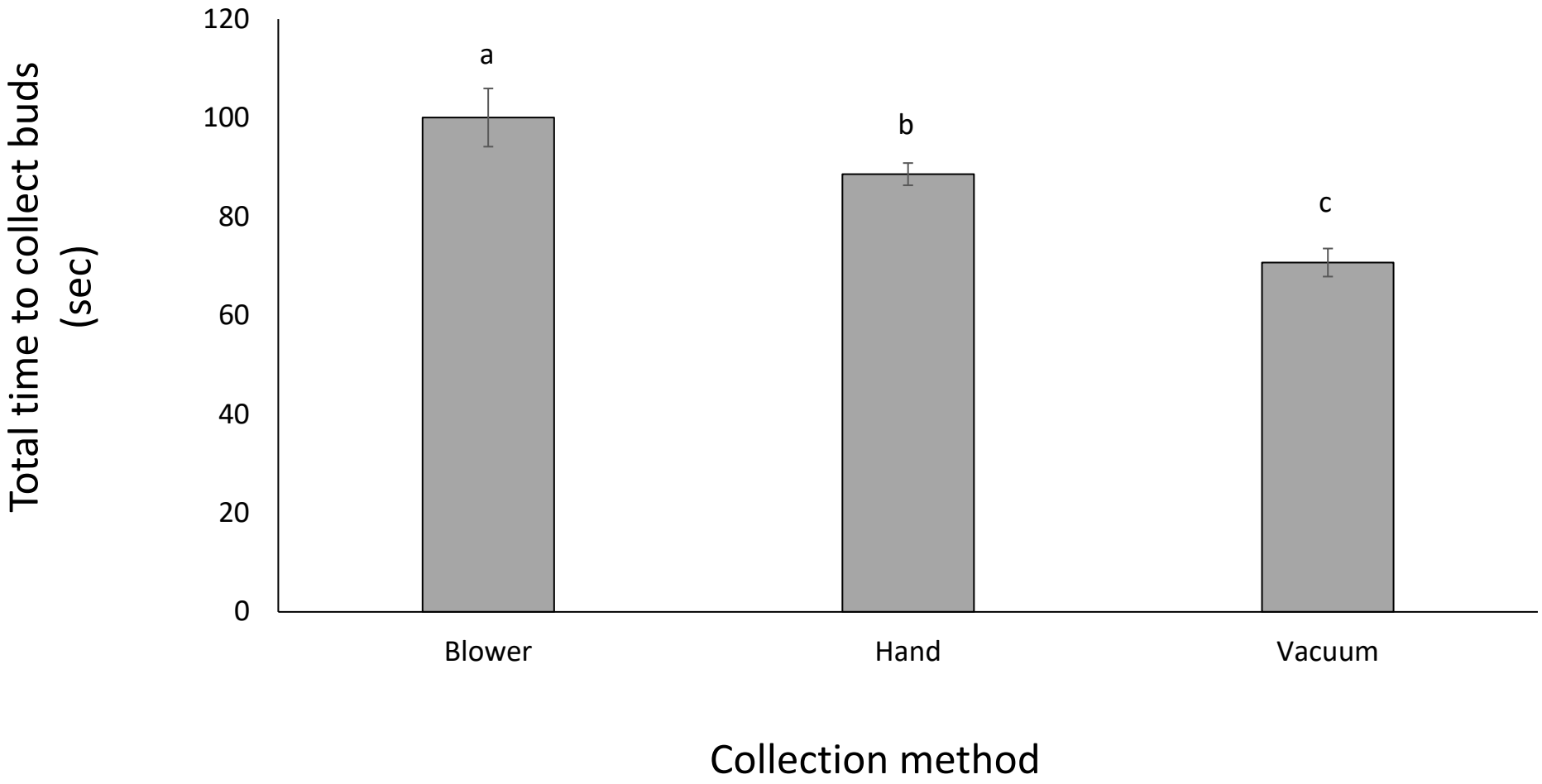
- Experimental area: 12 ft x 6 ft
- 25 different aged infested buds (fresh, 1 and 2 wks)
- 50 pots (3 gal) +75 buds
- N = 10 per collection method

Photo: A.D. Greene



Photos: A.D. Greene

Can We Optimize Sanitation?



Sanitation - Conclusions

- Sanitation experiments revealed:
  - a reduction in fallen buds
  - a reduction in HBW eggs and larvae on healthy buds
  - prevention of at least 1.5 HBW/plant from reinfesting hibiscus plants

- Vacuum is the fastest method to implement sanitation

Photo: Y. Velazquez Hernandez

Next Steps

- Continue research on biological control (parasitoids)
- Focus on chemical and behavioral ecology → develop a HBW lure
- Define variety preference

Thank you!

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