The Death of Grass: A New Hope

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This mealybug: *Heliococcus summervillei*

Has caused dieback in

- Cooroy, Queensland 1926
- Atherton Qld 1938
- New Caledonia 1998-2003
- **Atherton 2016**
- Puerto Rico 2019
- Barbados 2020

Also found :

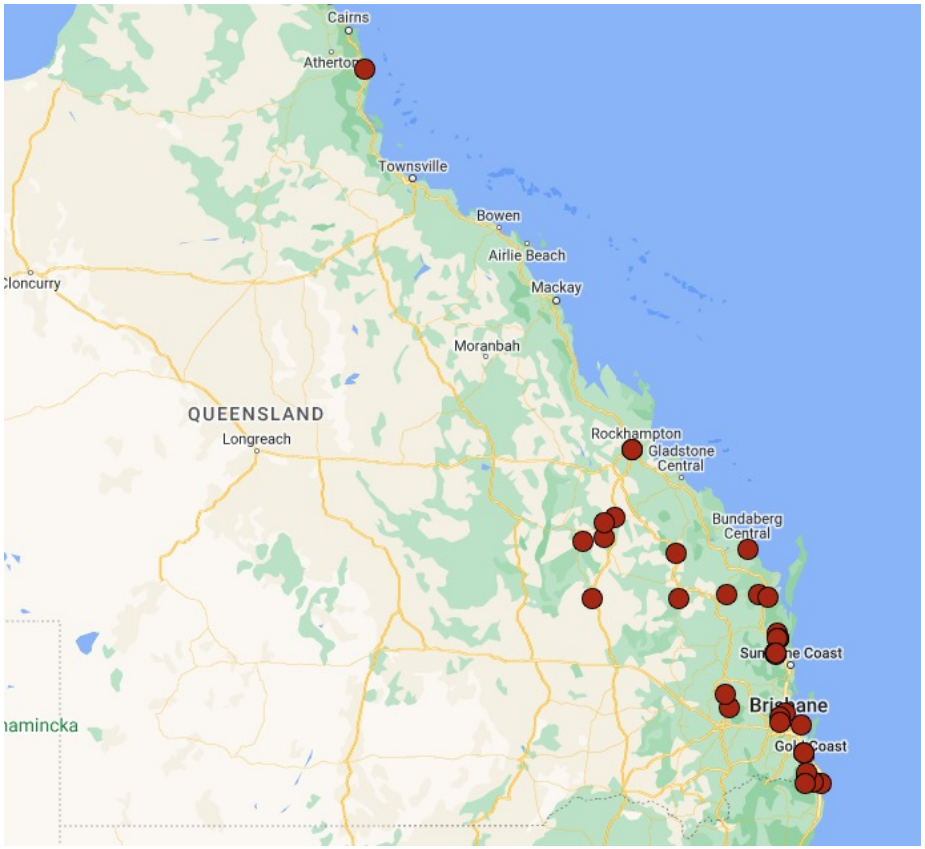
- on sugar-cane in Pakistan (1975)
- rice in West Bengal (1987)

How does ‘dieback’ happen?

Sucking pest: Feeds on sap

- Saliva injected
- **Suppression of plant defenses** (JA/SA crosstalk) within 24 hours.
- Genes JA biosynthesis downregulated
- Genes SA response upregulated
- Plant may live but: unproductive
- **Plants die from secondary infections** (*Fusarium*)

Field distribution and hosts



H. summervillei with pasture dieback

Schutze, M.K, D.J. Tree, C. Hauxwell, A.B. Dickson & P.J. Gullan 2019.
The Mealybugs Strike Back: the return of *Heliococcus summervillei* and Queensland pasture dieback.
Aus. Ent. Soc. Conference 2019, Abstracts p. 126.

- *Bothriochloa bladhii (Australian bluestem)*
- ***Bothriochloa insculpta* (Creeping blue-grass)**
- *Brachiaria decumbens* / *Urochloa decumbens* (Signal grass)
- ***Cenchrus ciliaris* (Buffel grass)**
- *Cenchrus clandestinus (*Kikuyu*)*
- *Chloris gayana* (Rhodes grass)
- Cyperus rotundus (nut grass)
- *Dichanthium sericeum* (Queensland bluegrass)
- *Digitaria didactyla* (Qld blue couch)
- *Digitaria eriantha* (Pangola)
- *Lolium rigidum* (Annual ryegrass)
- *Megathyrsus maximus* (Guinea grass)
- *Melinis minutiflora* (Molasses grass)
- *Melinis repens (*Red Natal grass)
- *Panicum maximum* green panic
- ***Panicum cv Gatton (Gatton Panic)***
- *Paspalum dilatatum* (Dallis grass)
- ***Paspalum mandiocanum* (Broad-leaved paspalum)**
- *Paspalum notatum*
- *Setaria splendida* (Setaria)
- *Stenotaphrum secundatum* (Buffalo turf grass)
- *Themeda triandra* (Kangaroo grass)
- *Urochloa oligotricha* (Signal grass) incl. 2 research varieties

AND

- ***Saccharum officinarum* (sugarcane)**

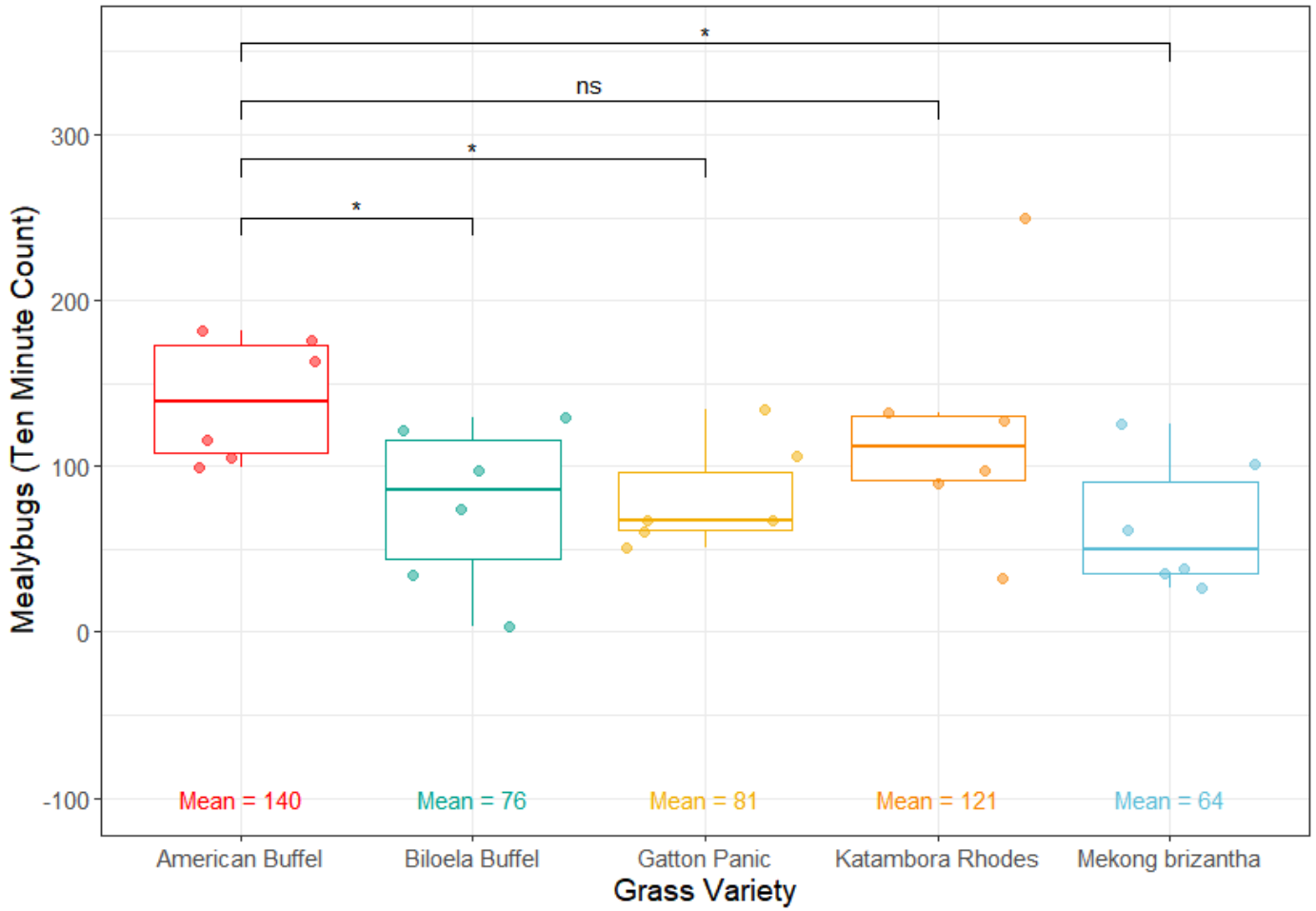
NOT LEGUMES OR BRASSICAS

Grass varieties and susceptibility…

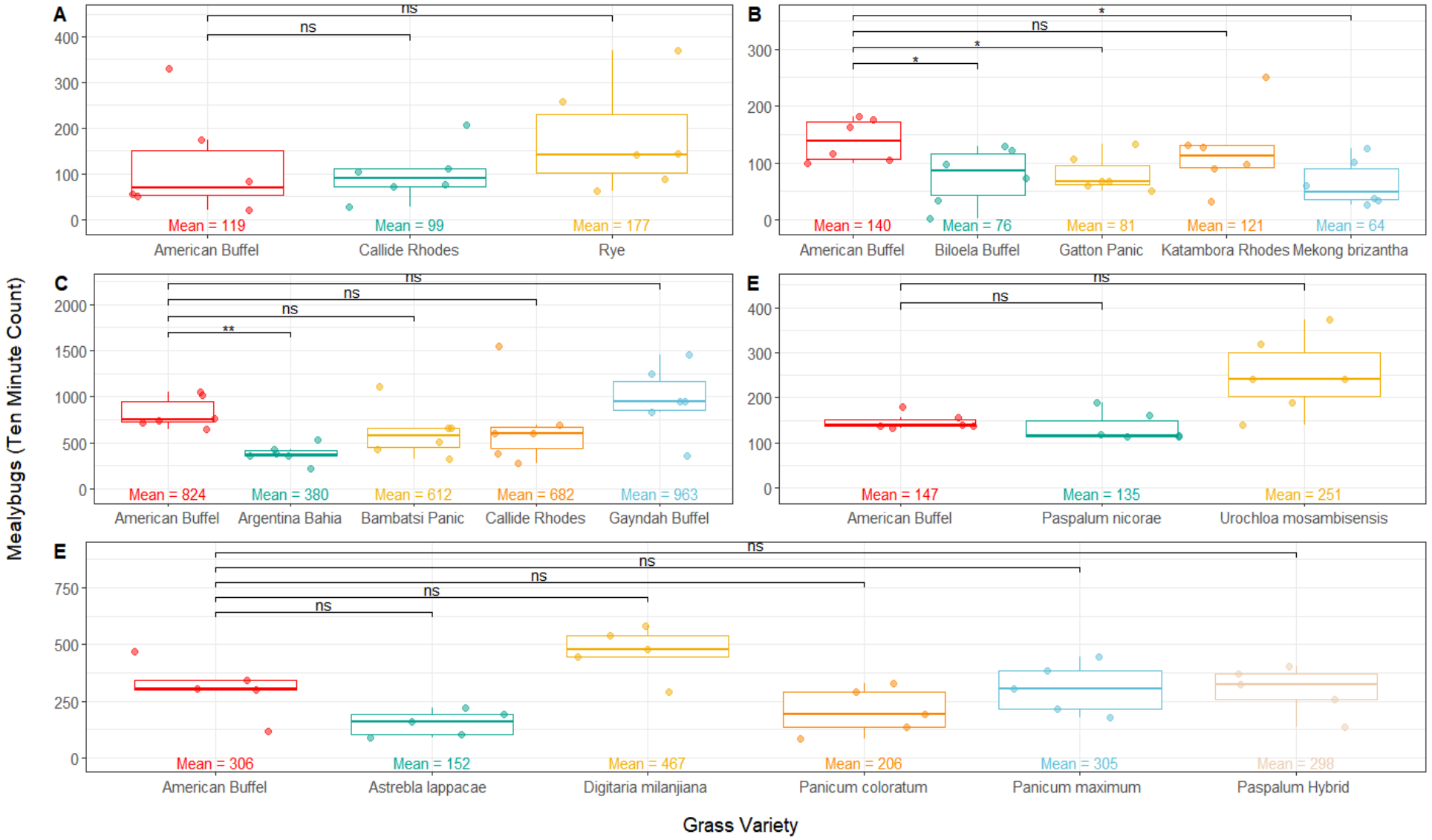
Buffel grass and Green panic
Photo: D. Patrick, QUT

- Buffel grass and broad leaf Paspalum highly susceptible
- Gatton Panic, Biloela buffel and Mekong Brizantha have greater tolerance
- **Legumes and brassica forage are not susceptible**
- Legumes: also improve pasture resilience

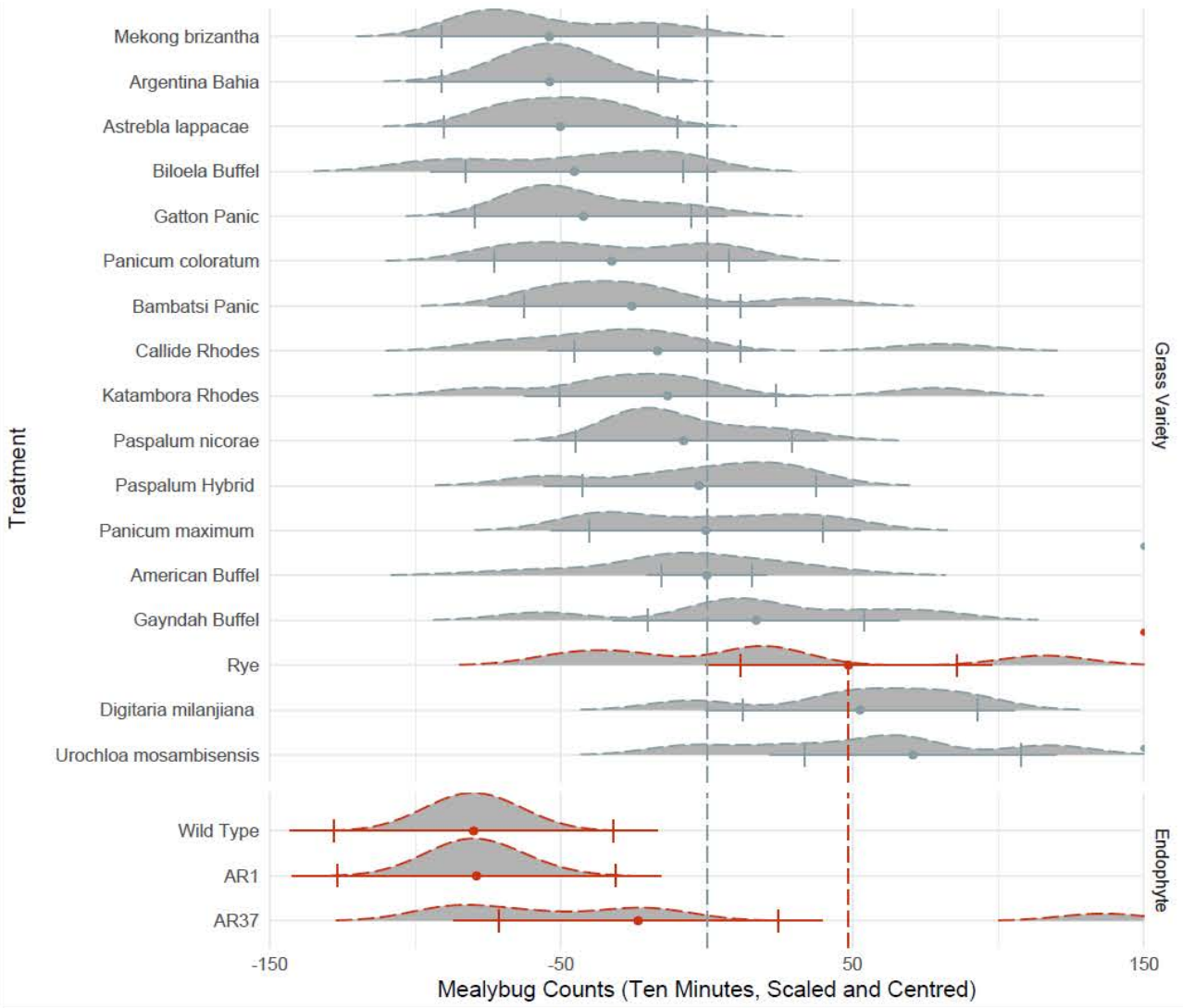
Biloela buffel, Gatton Panic and Mekong Brizantha all significantly fewer mealybugs that American buffel. Katambora Rhodes not sig. diff from A. Buffel.



All varieties



Susceptibility relative to American Buffel



Less susceptible **More susceptible**

Rapid lab screens for pasture grasses

Conducted over 10 days: FAST!

Can be repeated quickly

Statistically very robust

Differentiate varieties based on:

- Mortality: Brizantha > Panic > Buffel
- Development: Brizantha < Panic < Buffel

Next stage: the mechanisms…

Endophytes and resistant grasses

Hypocrealean fungus isolated from soil,
Samford Environmental Research Facility
Photo: Naimul Islam, QUT

Seed-born endophytes:

Epichloë

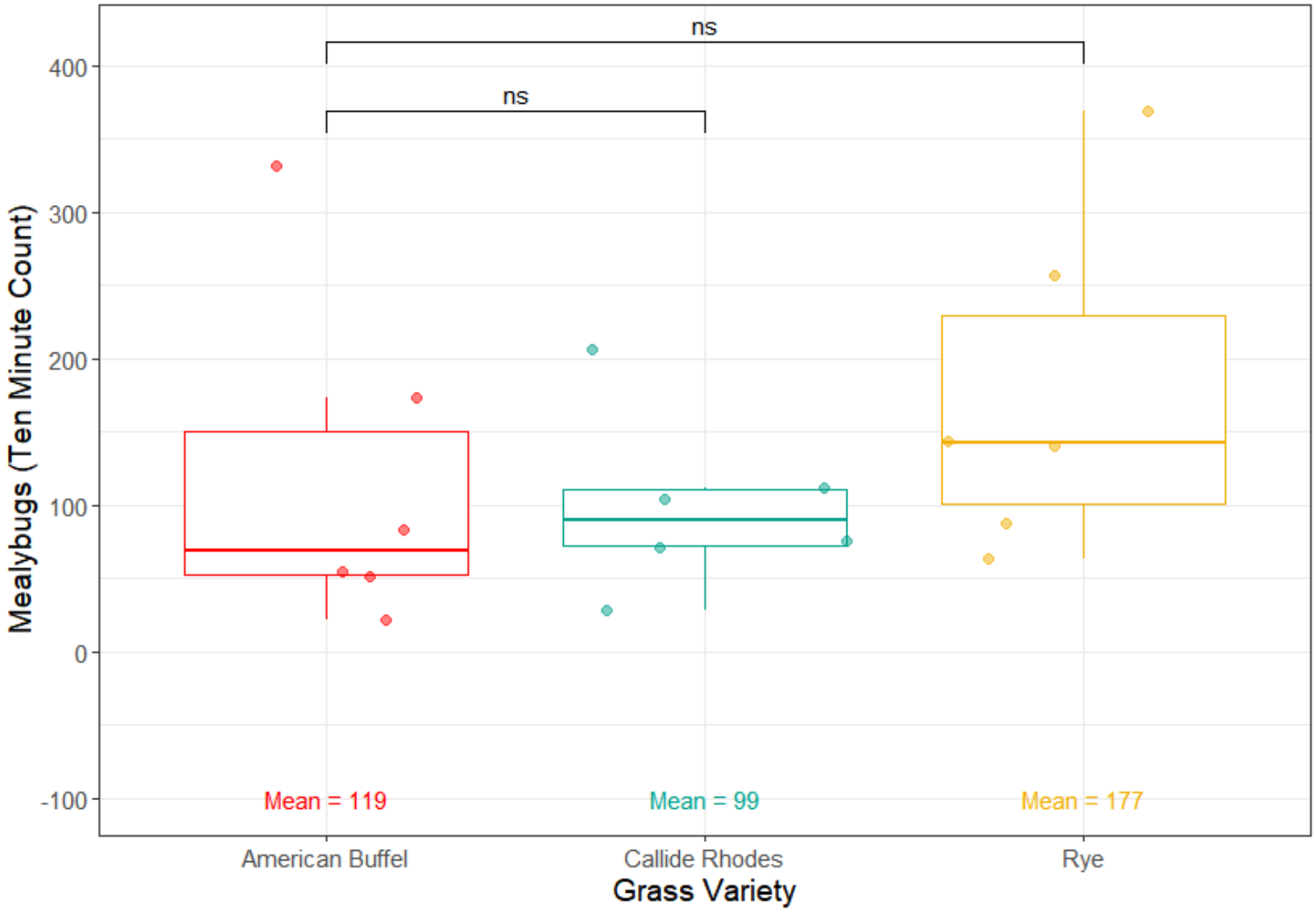
New Zealand perennial ryegrass

Rhizospheric endophytes:
Trichoderma

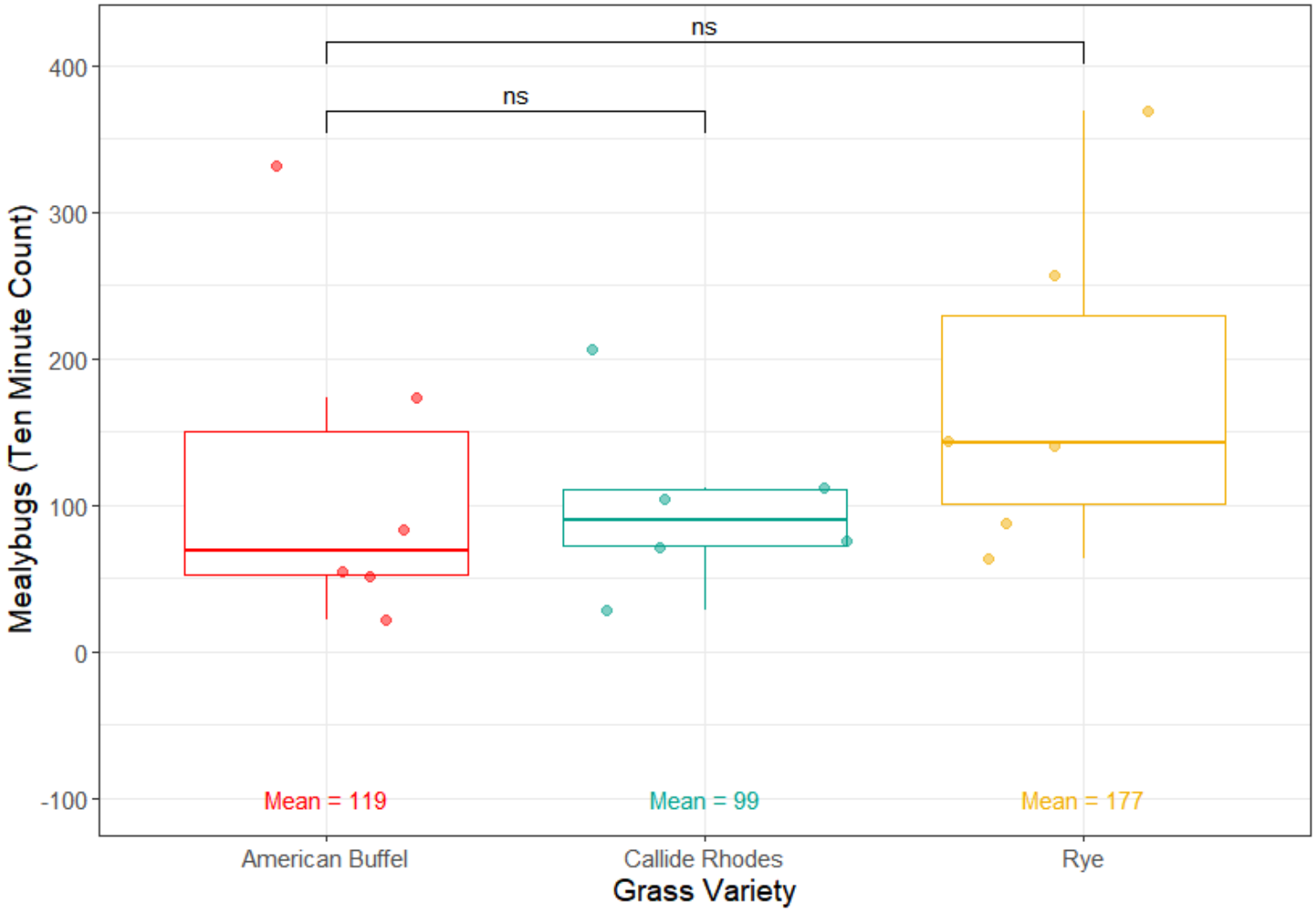
Long term: ‘Soil health’

‘Proof of concept’ using endophytes in ryegrass

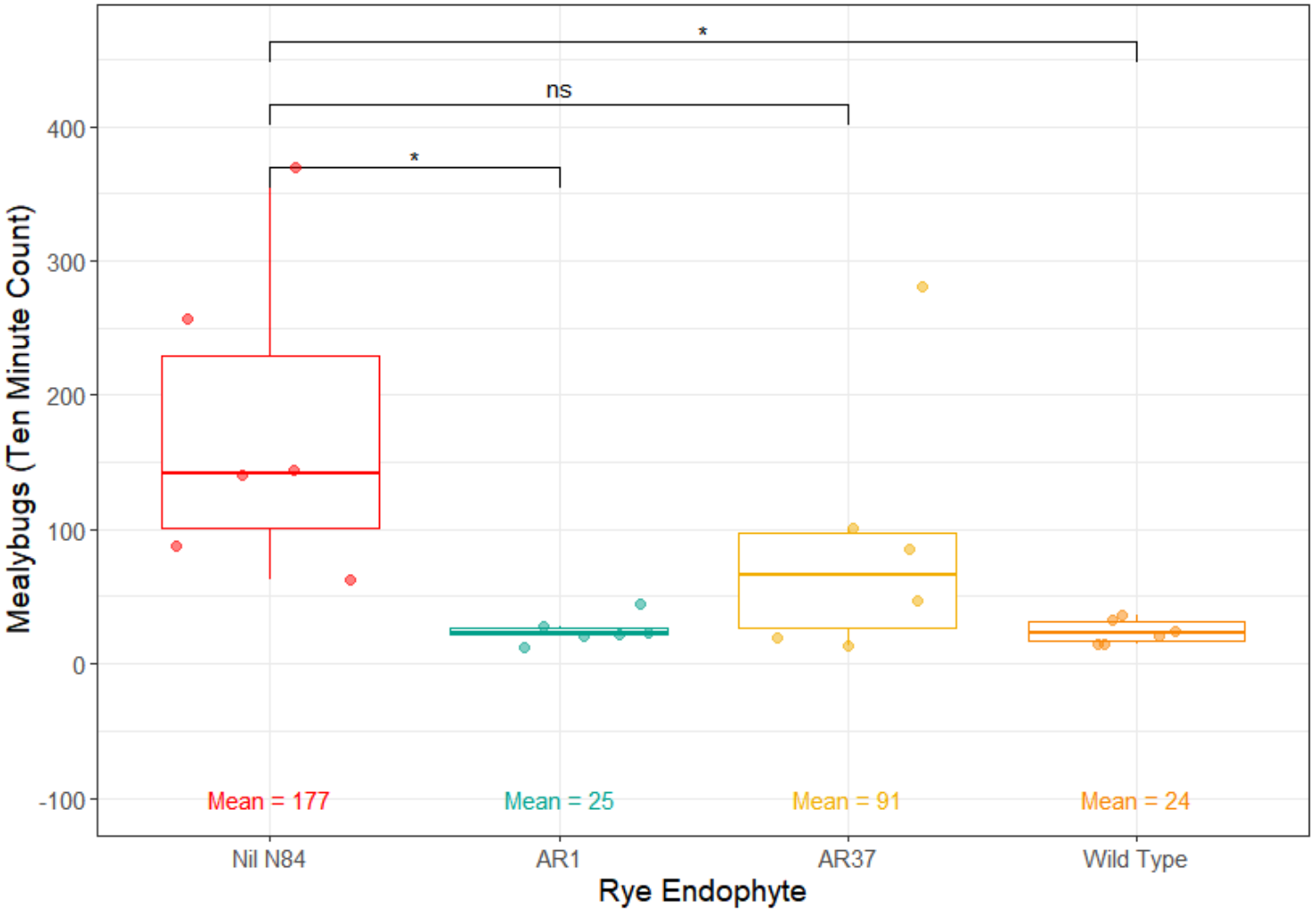
Callide Rhodes and perenial ryegrass both NSD from A. buffel



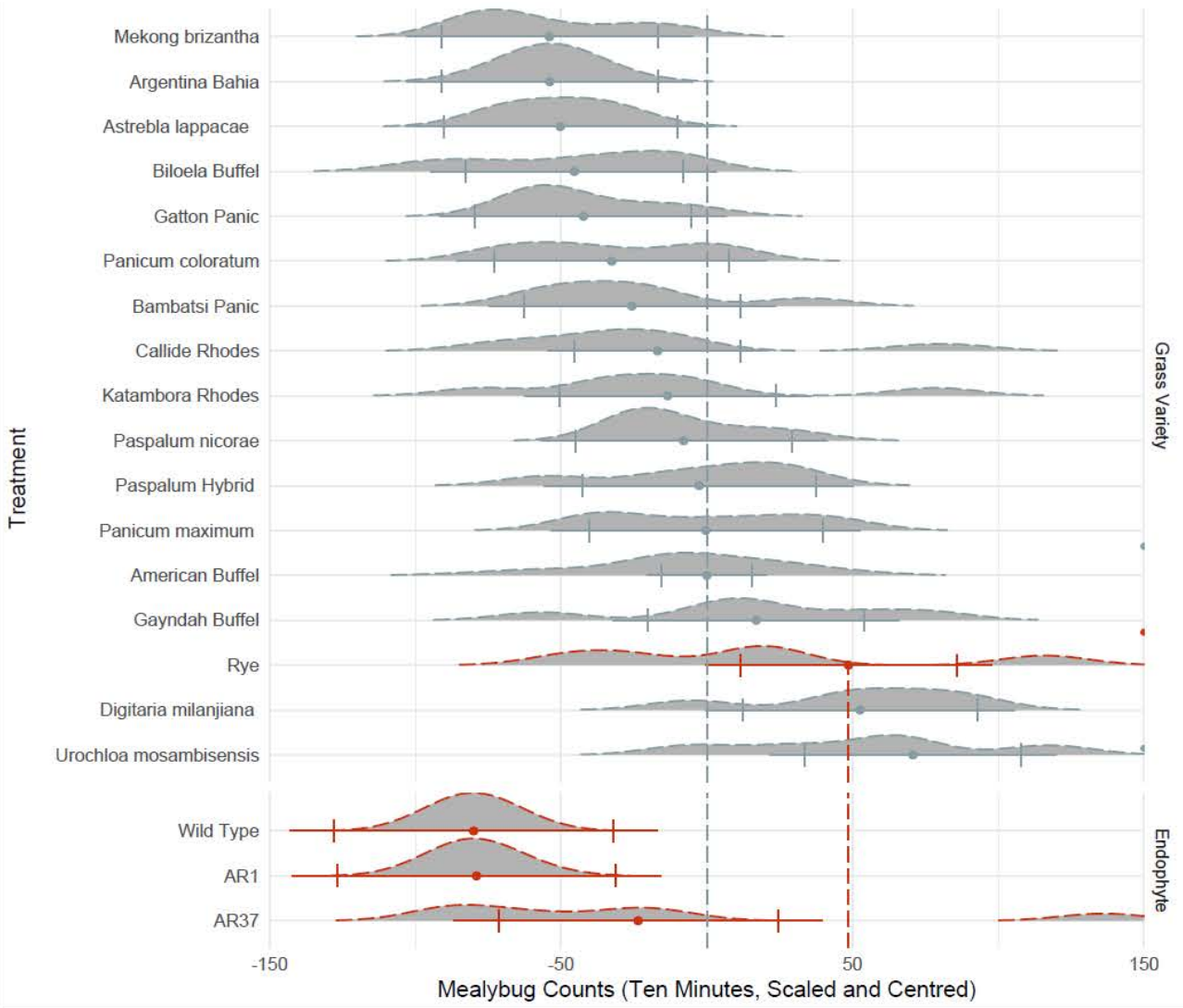
Ryegrass without endophytes as susceptible as A. buffel or Callide Rhodes



Endophytes and resistance…
Rye grass with AR1 and wild-type endophytes have significantly few mealybugs



Susceptibility relative to American Buffel



Less susceptible **More susceptible**

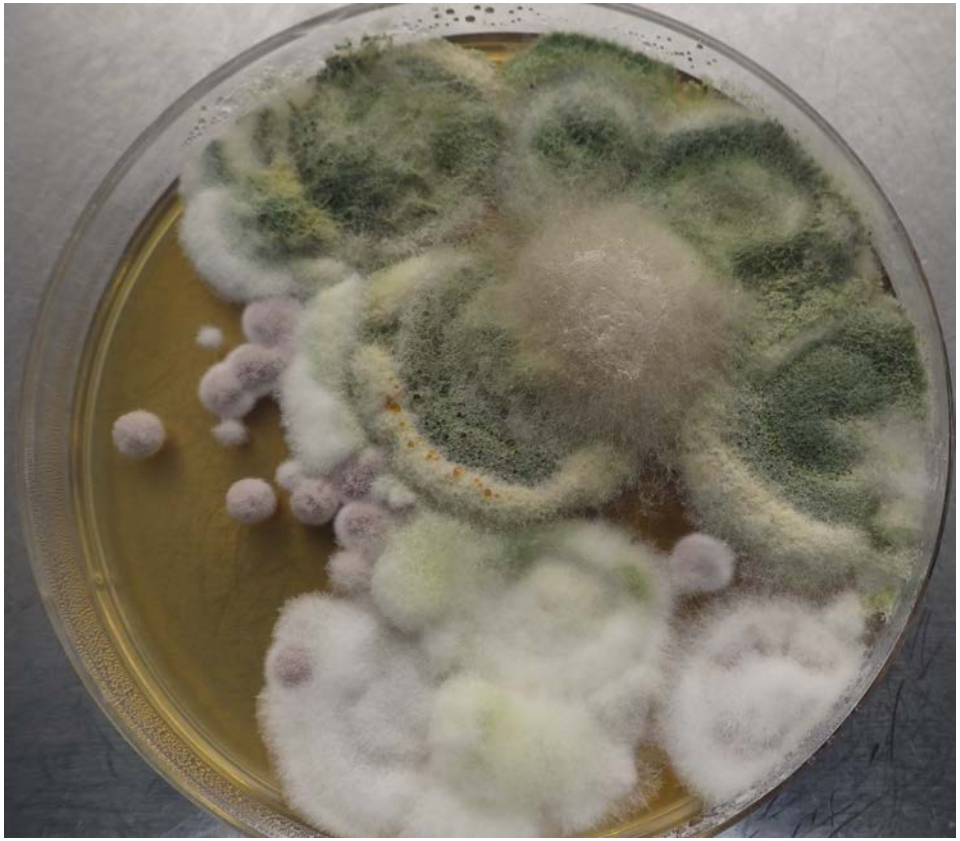
Endophytes and resistant grasses

Hypocrealean fungus isolated from soil,
Samford Environmental Research Facility
Photo: Naimul Islam, QUT

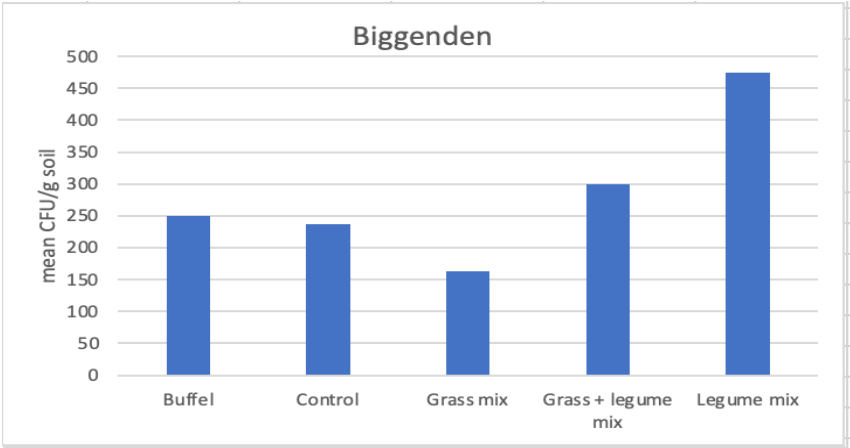
Fungal endophytes and biocontrol:

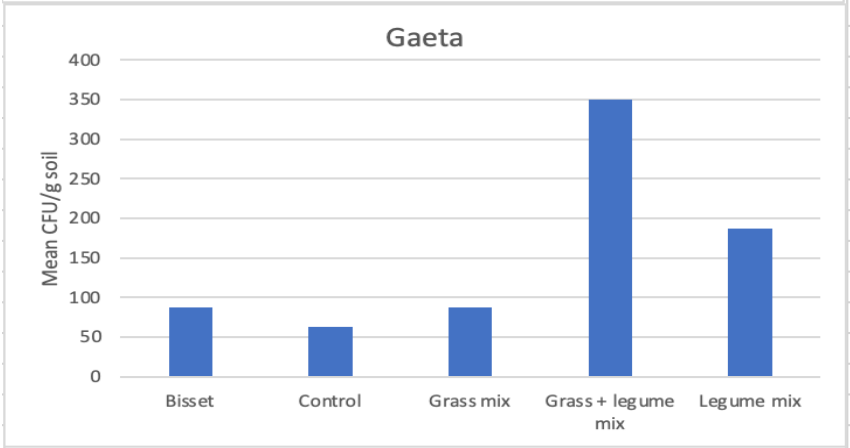
- Mycoparasitism
- Antibiosis
- Competition root niches
- Inducing resistance mechanisms

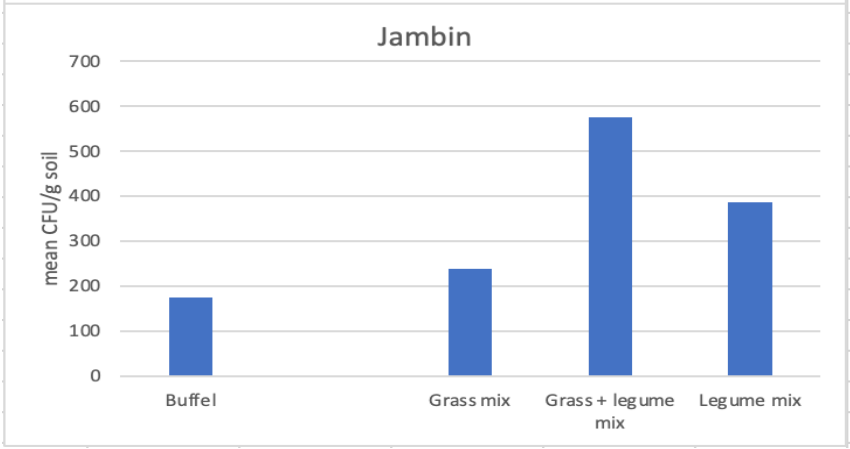
Resilience, recovery: rhizospheric endophytes



- Soils with greater resilience have more abundant and diverse beneficial fungi.
- Soils with chronic and recurrent dieback have greater abundance of multiple species of *Fusarium.*
- Patches of recovered grasses associated with beneficial fungi (*Trichoderma*, *Purpureocillium*, *Penicillium*, *Clonostachys*)
- Burning is associated with reduced beneficial fungi, increased *Fusarium*
- Legumes and other forbs are associated with resilience



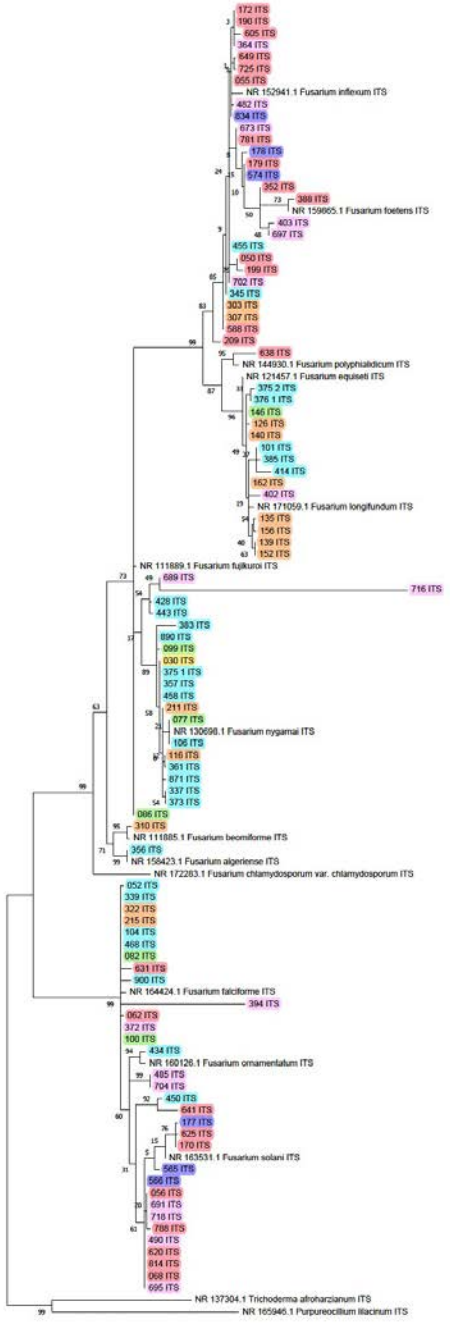




The AHR management trials

- Legumes and other forbs are not hosts for *H. summervillei*
- Legumes are associated with resilience, rhizospheric endophytes

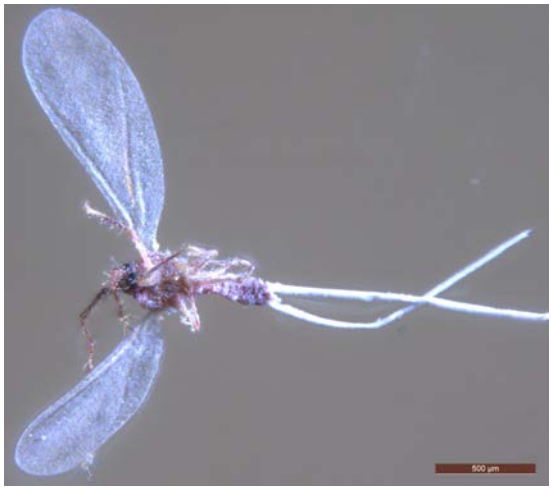
- Soils from plots with legumes have more abundant and diverse beneficial fungi:
- *Trichoderma*
- *Purpureocillium*
- *Penicillium*
- *Clonostachys*



Fusarium spp.

- Multiple species / races of Fusarium…
- …many at same location
- Abundant in heavily burnt and chronic dieback sites
- Less abundant in resilient sites

Targeted management



H. summervillei male. A. Dickson QUT

Male with female. L. Oliver QUT

Adult females (arrow)
Photo: R. Morgan, C. Hauxwell (QUT)

H. summervillei "egg mass" in soil.
C.Hauxwell, QUT

- Adult males: winged, spring/early summer, **do not feed**.
- Reproductive females are pink, disperse, **do not feed**, persist in soil
- **Early instars feed and cause damage** (both sexes)

2 insecticides under permit

	Description	Date Issued	Expiry Date	Comments
PER87423	Confidor 200 SC Insecticide (imidacloprid) Grass pastures Pasture mealybug (*H. summervillei*)	Feb-21	Feb-24	New minor-use permit. Issued for NSW and Qld only. APVMA requires residue data for the renewal of the permit.
PER88482	Movento 240 SC Insecticide (spirotetramat) Various pastures Pasture mealybug (*H. summervillei*)	Sep-19	Sep-22	New emergency permit. Issued for NSW and Qld only. APVMA requires additional residue data for the renewal of the permit.

Systemic insecticides target leaf and roots

- Movento (Spirotetramat)

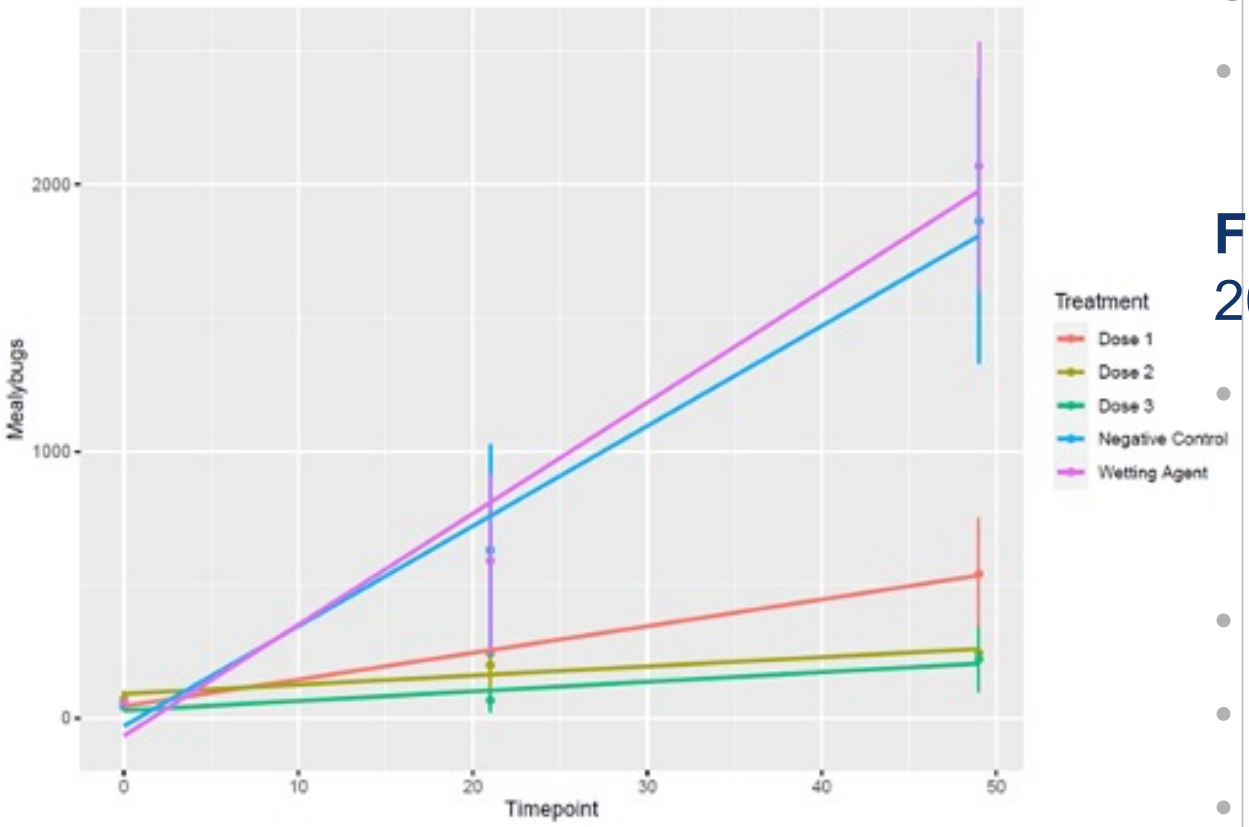
Minor use permit in train

- Imidacloprid: 6 month exclusion period

Only for incursion management

Not for large areas

Insecticides are effective



Screenhouse tests 2020, 2021

- Spirotetramat rates (Rhodes, Buffel)

Field trials: 2019/20, 2021, 2022

- Spirotetramat (rates), with residue data towards minor use.
- Imidacloprid
- New products (Sivanto)
- Microbial products

2 applications 2-3 weeks apart

Minor use permit: Movento

Dieback patches, SERF
Photo: QUT

Best use:

For incursion management

Emerging spring populations

Small areas

Early instars feeding on leaf

Not: adult females, dry grass, soil (winter, drought)

Not viable for large areas

Useful for small, emerging patches in spring and summer – so monitor!

Management: Nowhere to hide

- Reduce thatch in breeding season
- Open plant canopy reduces refuges for reproduction
- Crash graze or slash

Slashing and resilience
Josh Connolly, NLA Contracting

Crash grazing: use it or lose it

- "Coonabar" Station, Rolleston
- Rotational grazing
- Noticed dieback in early summer
- Crash grazed with high stocking
- Pasture recovered

Banana Station: invest in the best

- Soil test, add phosphate
- Forage crop: sorghum, lucerne
- Resow with Gatton Panic
- Rotation grazing
- Slash stalk to reduce aerial tillering and reduce run-off

"Aerodrome" Panic gross margins

	AERODROME	125	Ha		
	Problem - Pasture dieback				
	GPS 132Ha whole pdk				
DATE		Units		$	$Total
ov-19/10-Jan	Spray Contractor x5 sprays	625	Ha	15	$9,375
ov-19/10-Jan	Chemical X5	625	Ha	13.5	$8,438
16-Oct-19	Planting costs	125	Ha	$45	$5,625
16-Oct-19	Gatton Panic seed	11	Kg	$13	$17,875
16-Oct-19	Fertiliser Granulock Z	150	Kg	$785/t	$14,719
	COSTS	125	Ha	$448.24	$56,031
11-Mar_20	**Heifiers**				
Actual	Panic Grazing				
	Stocking Rate	9.58	hd/Ha		
	Days Grazing	34	Days		
	Weight gain	1.1	kg/day		
	$/kg Cattle liveweight value	3	$/kg		
	PRODUCTION	125	Ha	$1,075	$134,416
24-Dec-20	**Heifiers & Steers**				
Actual	Panic Grazing				
	Stocking Rate	7.75	hd/Ha		
	Days Grazing	43	Days		
	Weight gain	1.1	kg/day		
	$/kg Cattle liveweight value	3	$/kg		
	PRODUCTION	125	Ha	$1,100	$137,501
Comparison	Dieback affected grazing				
	Stocking Rate (reduced by 50% - 1:6 Ha)	0.167	hd/Ha		
	Days Grazing	365	days		
	Weight gain	0.5	kg/day		
	$/kg cattle liveweight value	3	$/kg		
	PRODUCTION	125	Ha	$91.43	$11,429

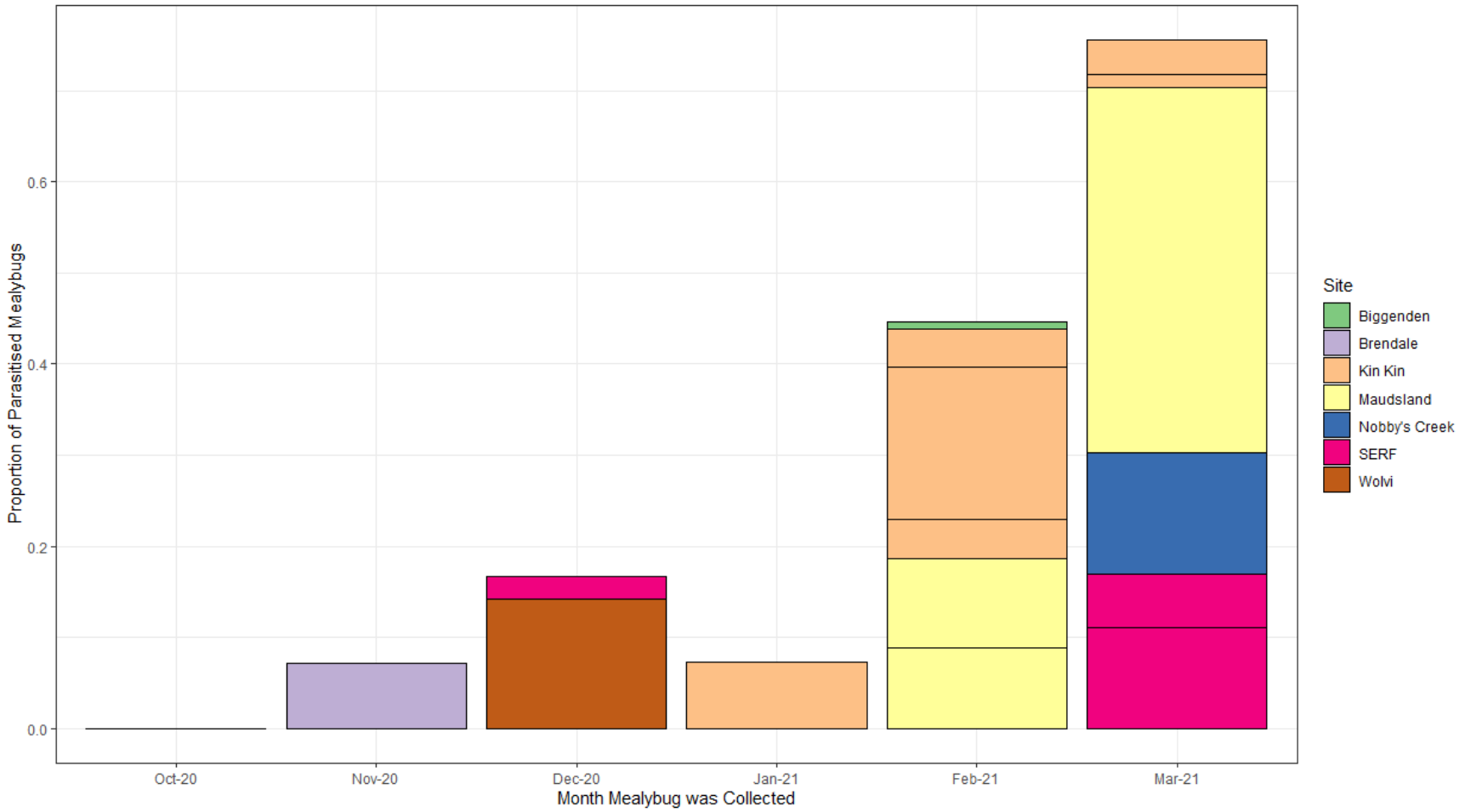
- 125 Ha
  Granulock Z fertilizer
  5 sprays +contractor
  Gatton panic seed
- Cost: $448.24 / Ha $56,031 total
- Grazed twice: March & December 2020
- Return: $2,177/Ha $272,125 total
- Gross margin, 16 months:
  $1,729/Ha **$216,094 total**
- Expected return without investment, with dieback:
  $91.43/ha $11,479

Resilience, recovery: natural enemies

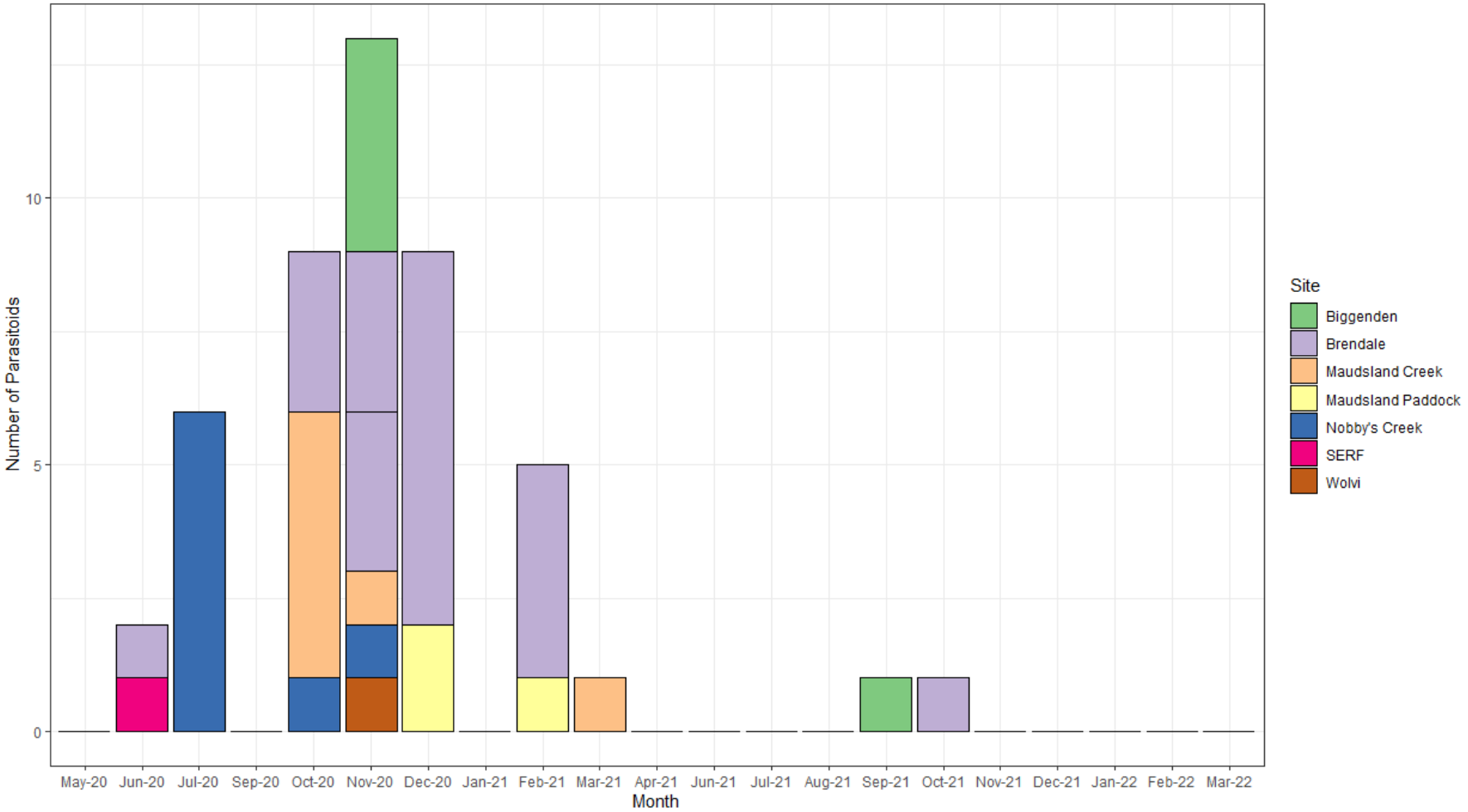
TL: *Parectromoidella* sp. *Photo: E. Bryans, QUT*
LL: *Yasumatsuiola orientalis. Photo: E. Bryans, QUT*
TR: *Callipteroma* sp.? *Photo: DAF Qld*

- 2348 live mealybugs collected & reared
- 3 species parasitoid wasp (2 new records)
- New species in genus *Parectromoidella*
- 1 new Australian record: *Yasumatsuiola orientalis*
- 1 to 1.5% parasitism
- Predatory beetles: *Cryptolaemus*

Seasonal abundance *Parectromoidella* in mealybugs: repeat sampling at 8 sites, abundance high Feb/March, then crashes



Seasonal abundance *Parectromoidella*: sweep nets
Abundance highest Oct- Dec
Alternate host?



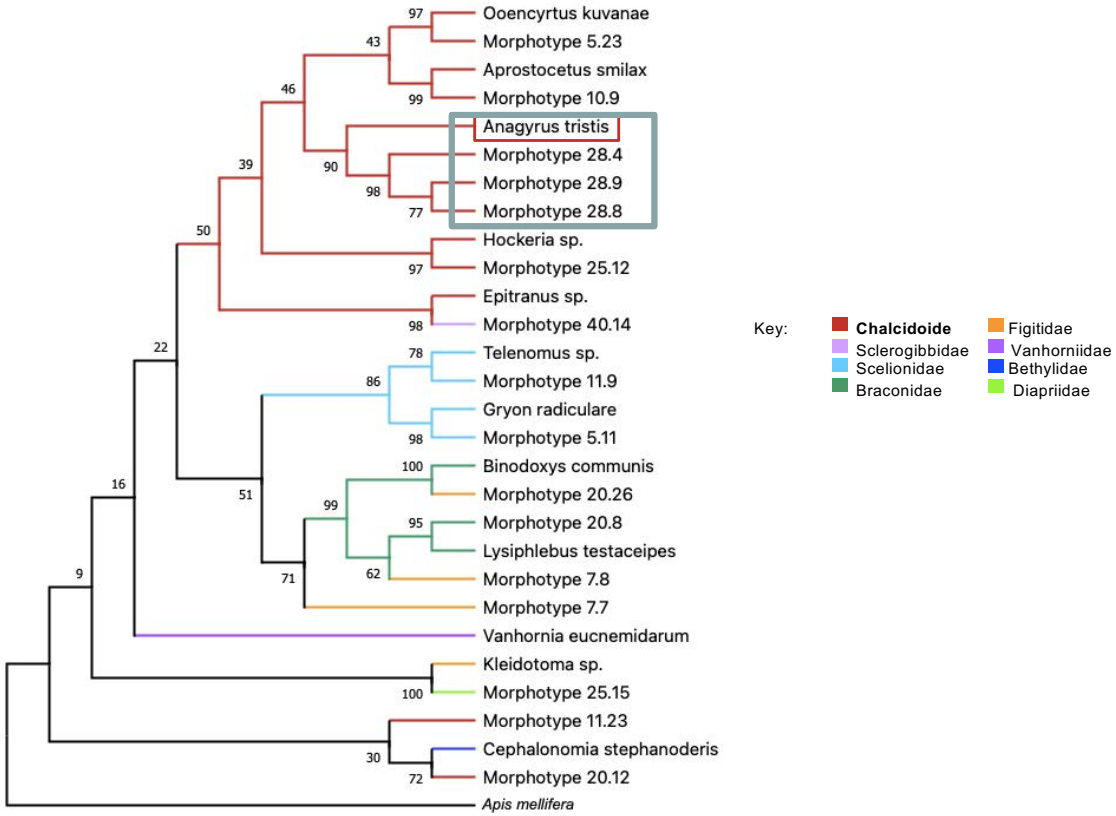
The mealybug assemblages

Mealybug species	Host plant
Saccharicoccus sacchari	Sugar Cane
Vryburgia brevicruris	Bluegrass
Antonina graminis	Rhodes grass, Setaria
Trionymus ascripticius	Balloon bush
Phenacoccus solenopsis	Parthenium
Monophlebulus sp	Brigalow
Coccus longulus	Leucaena
Hypogeococcus festerianus	Harrisia cactus
Icerya aegyptiaca	*Urochloa*

Identified by Mark Schutze, Biosecurity Qld.

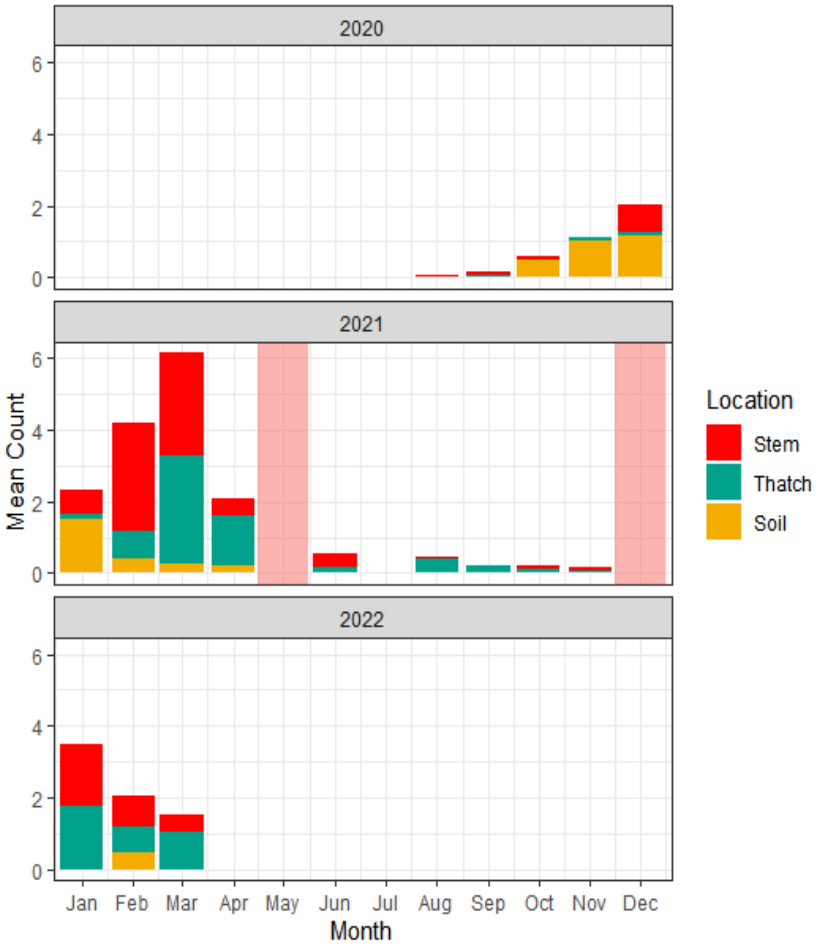
Ferrisia virgata? Host of Y. orientalis.

Augmenting control: the wasp assemblages



'Brendale' sweep net assemblage.
Wasp morphotype 28 is *Parectromoidella*, closely related to *Anagyrus tristis.*
(Hayley Bandera, QUT)

Seasonal biology: the key to management



September - December

- Females hide in upper soil/thatch and reproduce!
- Emerge onto leaf with rain and warmth

December to April:

- Large breeding population in thatch
- **Lots of small instars on leaf** – this is what does the damage
- Summer rain : pasture death

April – September:

- Mature females disperse into refugia: soil, logs, cowpats, dense thatch.

A quick summary of QUT findings:

- Proof of critical role of *H. summervillei* in 'death of grass' (including mechanism from transcriptome)
- Insecticide permits, efficacy data, and residues
- Quantitative sampling, seasonal biology, and links to strategies for management
- Screened 20 pasture varieties, identified resistant strains, and developed rapid screening assays
- Proof of concept for efficacy of fungal endophytes in resistance, and links to pasture diversity and resilience
- Identified parasitoids and evidence of multiple hosts
- Training videos, sampling 'kits', farm days, and media

The 4 ‘questions’ – where next for QUT research

- The mealybug: susceptibility and resistance mechanisms in pasture grasses (including transcriptome analysis)
- Timing and efficacy of management, seasonal biology
- Impacts of pasture mixtures on resilience, recovery and soil microbiota
- Ecology, host range and augmentation of parasitoids

This is a pest – we can beat it!

Monitor

- Know the early symptoms
- Learn to find mealybugs
- Be proactive and seasonal

Manage

- Graze / slash: reduce thatch
- Spray emerging patches?
- Improve with legumes & brassicas
- Tolerant grasses
- Break and forage crops
- Improve recovery: soil nutrition (P)

"When you have eliminated all which is impossible, then whatever remains, however improbable, must be the truth."