

Exploration of biological control strategies for the polyphagous shot-hole borer





Research Career



1/25.

- **2020-2023** -> PhD, first post-doc at Stellenbosch University: Research into the ***taxonomy**, pest status, biological control and physiology of a South African weevil pest
- ***Taxonomy** part of a very successful collaboration with CIRAD, INRAE at CBGP
- Continuing with many more weevils to describe!





Research Career

2/25.

- In 2022, polyphagous shot-hole borer (**PSHB**) attacks **deciduous fruit** (pear) for first time worldwide in SA.
- **Pecan** nuts also attacked, with potential risk to **macadamia***
- **Oct 2023** -> I obtain funding from industry bodies (Hortgro Science, SAPPAA, SAMAC) for a three year postdoc at SU





Background

3/25.

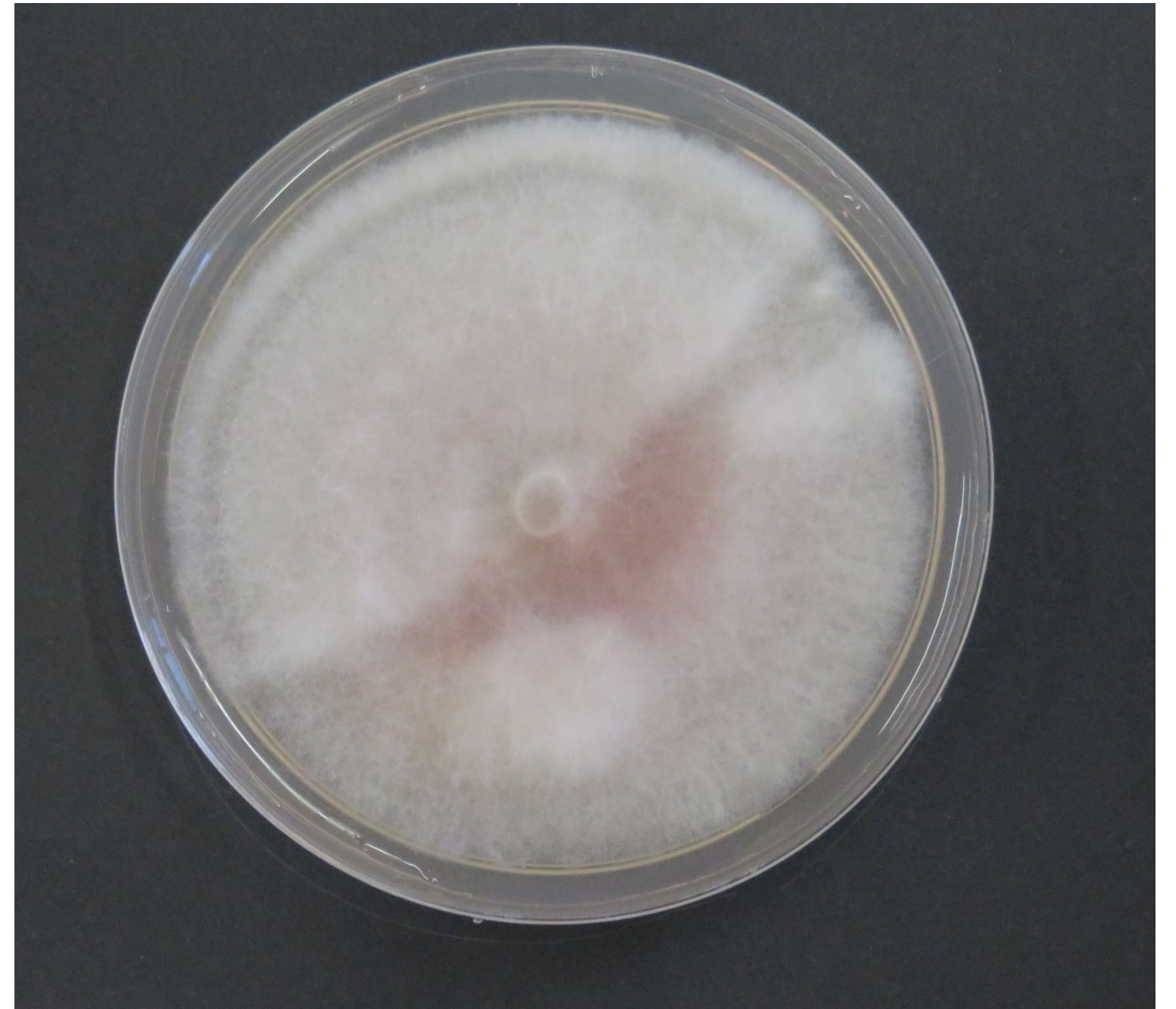
- *Euwallacea fornicatus* (PSHB) is a Scolytinae ambrosia beetle native to South-East Asia
 - Vectors **ambrosia fungi** into tree, upon which it and its progeny **feeds**
- In past 20 years, it starts invading California, Israel, South Africa (Paap *et al.*, 2018). Damage seen on avocado, urban and native trees
- Closely associated ambrosia fungus (*Fusarium euwallacaea*) described by Freeman *et al.* (2013)





Beetle & Fungus

4/25.



Damage and Symptoms



5/25. One of very few ambrosia beetles to attack living trees

- Causes Fusarium dieback (FD) in more than 100 species of host tree -> new susceptible hosts get added to list
- FD -> Mechanical damage by beetle (girdling), blocking xylem by *F. euwallaceae*
- Kills very susceptible hosts (e.g. *Acer negundo*) in a few months





PSHB and FD



6/25.

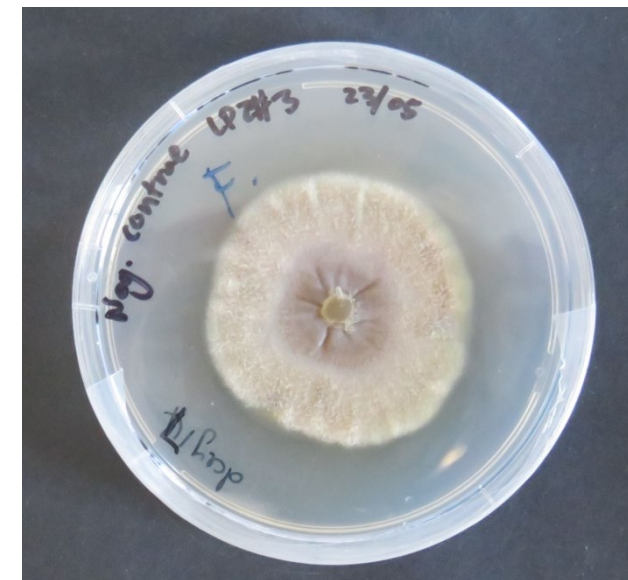




Other PP Fungi

7/25.

- Other plant pathogenic fungi (*Graphium euwallaceae*; *Paracremonium pembeum*, etc.) found in beetle mycangia and galleries (Lynch *et al.*, 2016)



- Various opportunistic wood-rot/canker causing pathogens -> on beetle integument and/or infect after damage is caused?. e.g. *Phaeacremonium minimum*



Economic Impact



8/25.

- Can cause extreme damage to native ecosystems, and urban trees
- Widespread tree death not reported for cultivated crops, but has the potential to cause serious economic harm
- Cost to SA estimated to be multi-billion USD (tree loss, removal, etc. De Witt *et al.*, 2022)
- Attacks avocado, pears, apples, plums, pecan nut, macadamia nut

Control Options



9/25.

- Monitoring
- Removal of excellent reproductive hosts (*A. negundo*, *Quercus robur*) where feasible
- Removal and sanitation of infested plant material
- Chemical injection -> Limited efficacy, potential for harm to tree





Control Options



10/25.

Beetle and fungus deep in gallery -> Difficult to reach

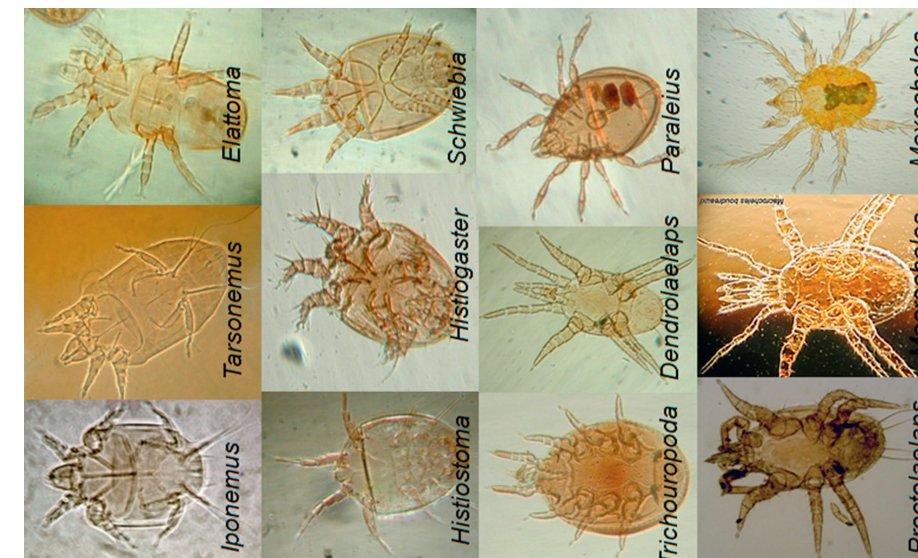




The Role of Mites...

11/25.

- Multiple mite species associated with bark-and-ambrosia beetles
- Ecological roles: detritivores, **fungivores**, predators, parasitoids
- Some live on bark, some inside galleries, many are **phoretic** (i.e. use beetles as transport)

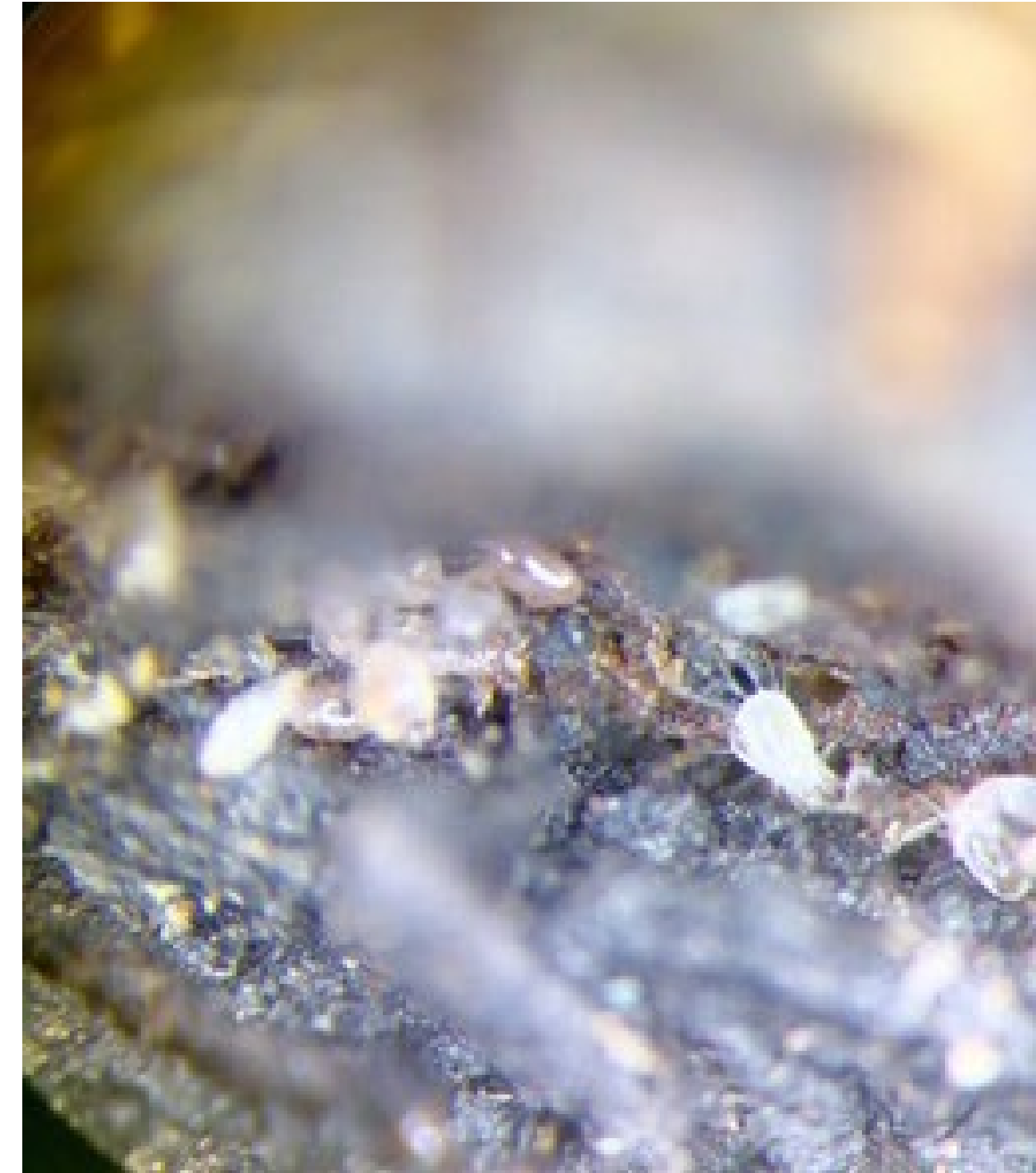
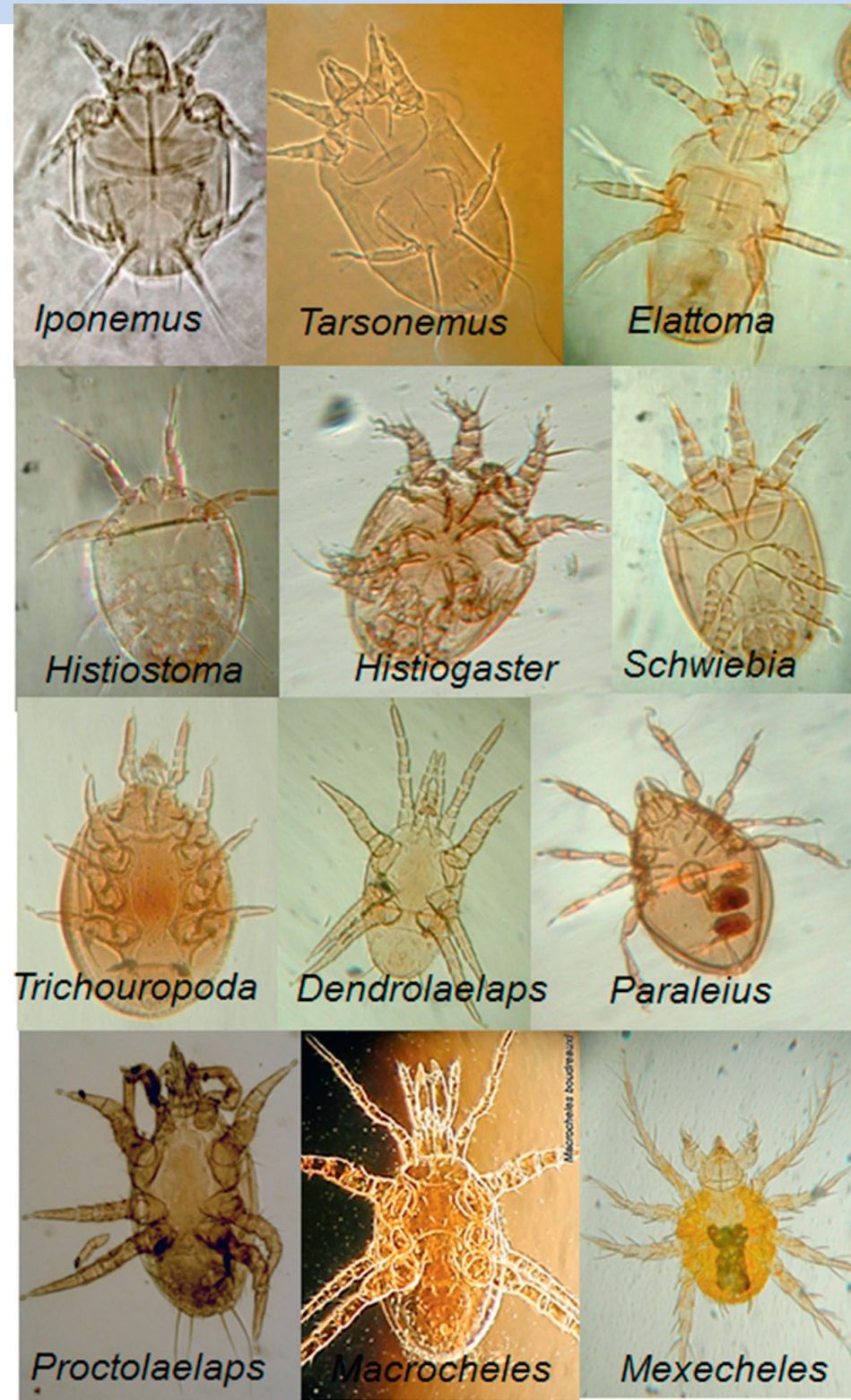




The Role of Mites...



12/25.

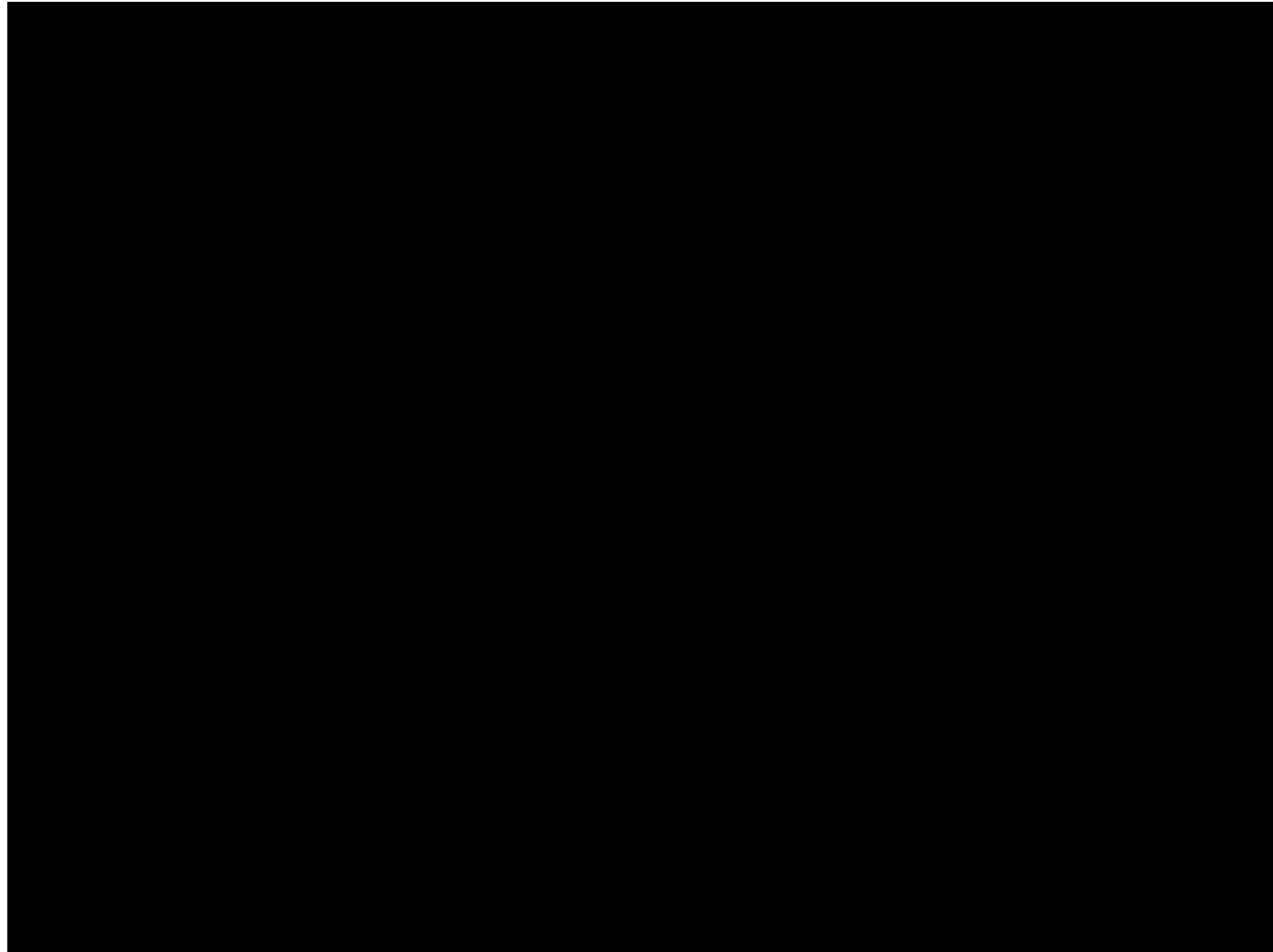




The Role of Mites...



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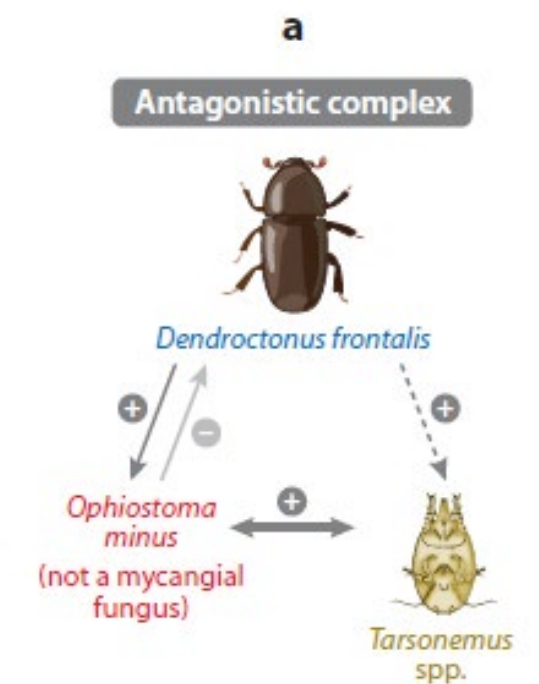




The Role of Mites...

14/25.

- Can we use fungus feeding mites to vector **Microbial Biocontrol Agents** to the galleries? (**Berto *et al.*, 2022**).



- Mites can act as **dispersers** of **fungus** propagules

Hoftstetter & Moser, 2014

- Specialized relationships with mutualists (e.g. *Tarsonemus* spp. in *Dendroctonus frontalis* (Curculionidae: Scolytinae) galleries
- Less specialized, on cuticle or through ingestion/excretion (Astigmata)

Collection

15/25.

- We collected mites from:
 - Trapping beetles in field (quicevorol baited dry funnel traps)
 - Collecting infested material -> Emergence bucket in lab
 - > 1) Collect from emerging beetles, 2) surface of logs near galleries, 3) splitting open logs
- Cultivated (pecan) and ornamental material from **SA**, also collection from **Vietnamense** samples (FABI quarantine facility)





Identification

16/25.

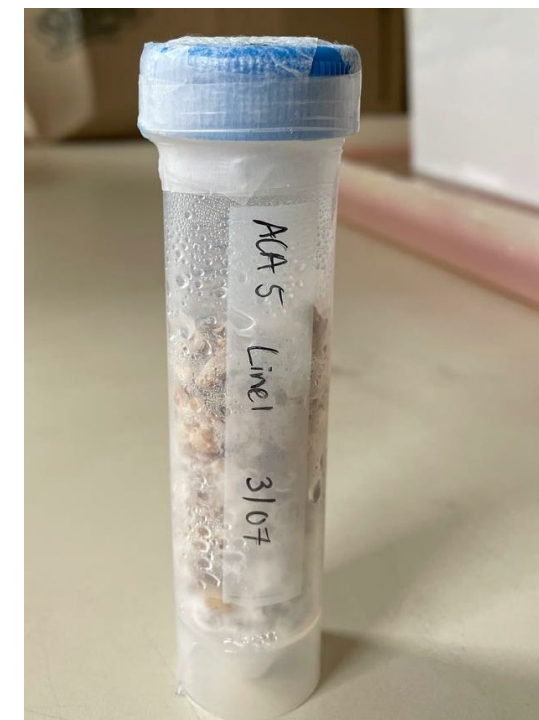
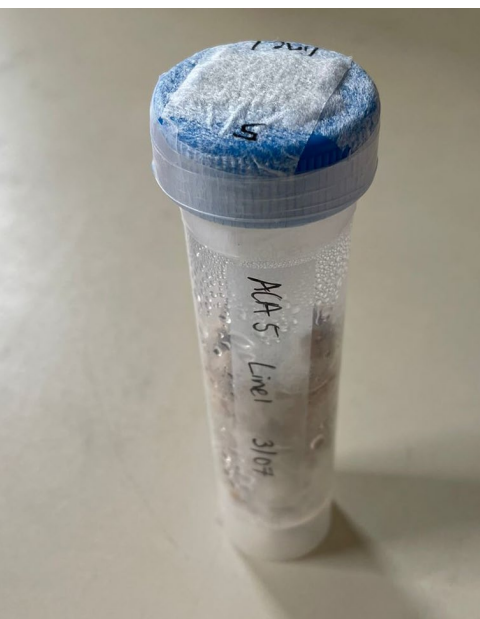
- We've collected 15+ species of mites associated with PSHB (and some other bark beetles) from SA (invasive) and 5 + species from Vietnam samples -> ID
 - Morphological (relevant experts)
 - Molecular (?) Spider mite direct PCR protocol? (Sakamotoh & Gotoh, 2017)
- Mainly Mesostigmata, Astigmata, some Tarsonemidae



Culture

17/25.

- 5 species from SA currently in culture
 - Feed and reproduce on **autoclaved barley** inoculated with *F. euwallaceae* in sterile 50 ml centrifuge tubes
 - **Three Astigmatan species** (potentially Acaridae), two of which form **hypopi** that are phoretic on beetles
 - Two **Uropodine mesostigmata** (Uropodina?), one established phoretic on *E. fornicatus*, one collected in galleries of a *Platypus* spp.





Going Forward...

18/25.

- Test ability of these mites to feed and reproduce on biocontrol fungi (such as *Beauveria*, *Trichoderma*)
- Grow fungi on cellophane on growth media, remove cellophane and add 5 mites -> Assess for survival, feeding and reproduction
- Assess whether mites can vector viable fungal propagules on cuticle, and intestine (surface sterilization) on sterile growth media



Going Forward...

19/25.

- Assess whether mites can vector biocontrol fungi into active *E. fornicatus* galleries, and assess for control efficacy, in laboratory colonies.
- Start thinking about an in-field delivery mechanism....



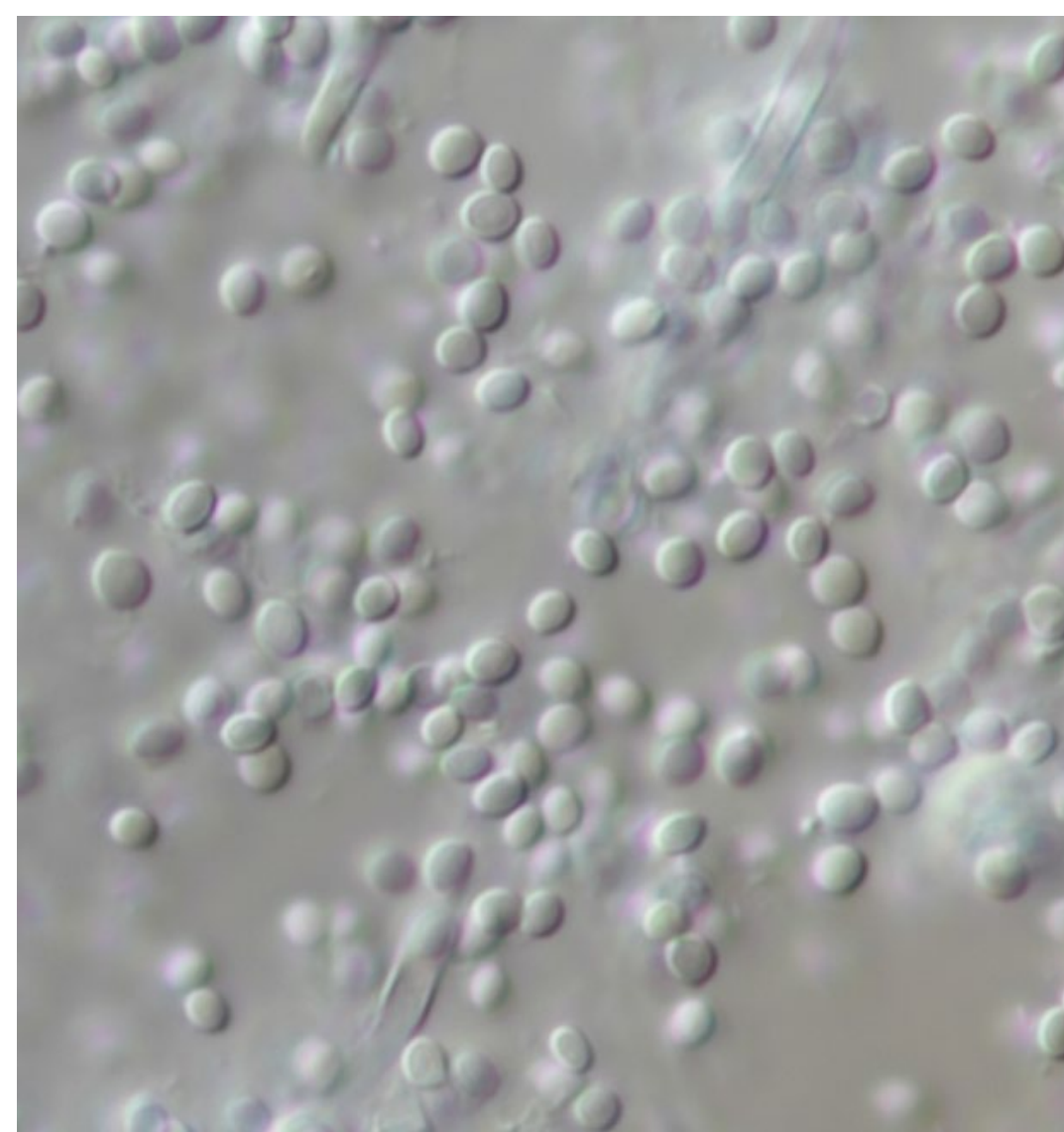
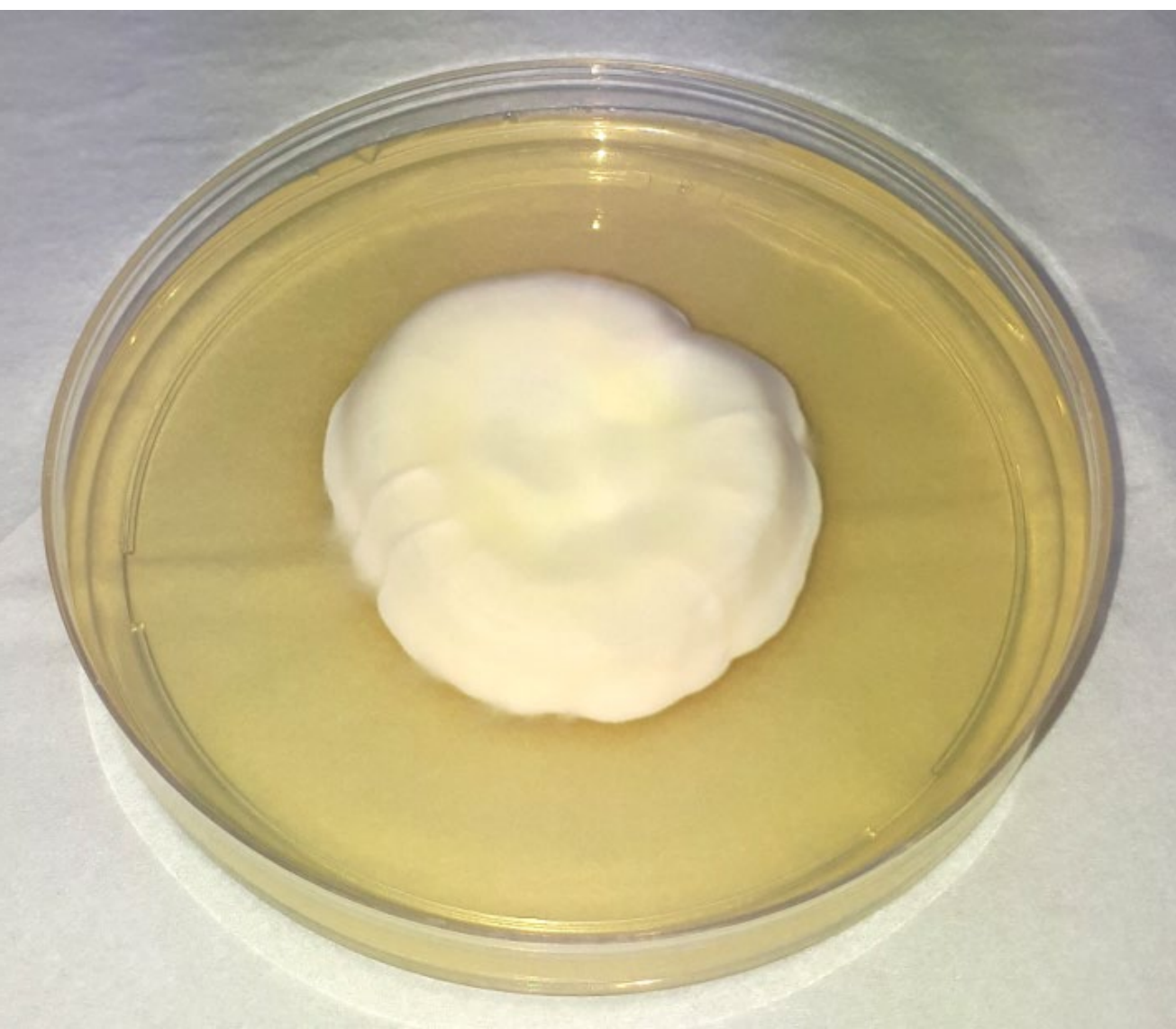


Microbial Biological Control



20/25.

What will the mites potentially vector??



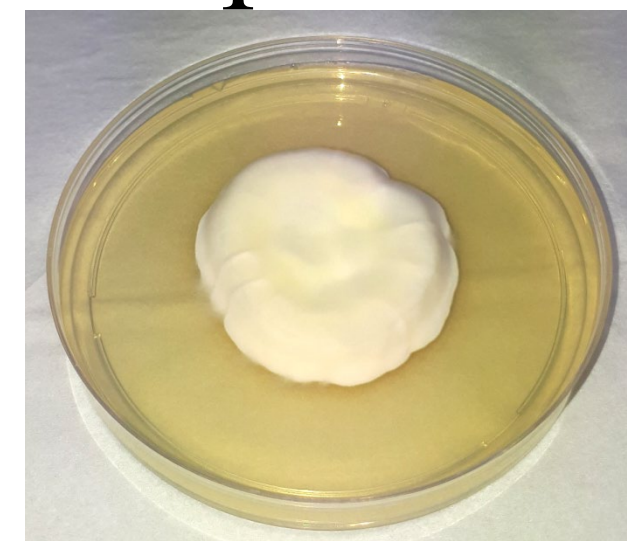


Microbial Biological Control



21/25.

- **Entomopathogenic fungi**, e.g. *Beauveria* -> Attack beetles
- **Antagonistic fungi**, e.g. *Trichoderma* -> Attack or outcompete plant pathogenic fungi
- Lots of local isolates, as well as commercial products for general biological control.

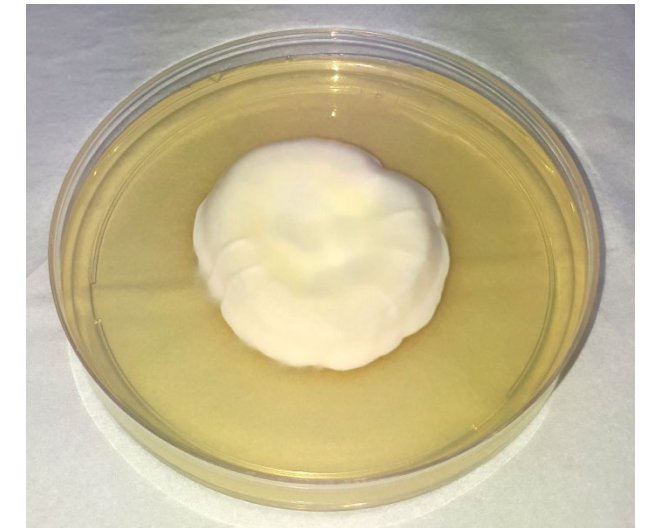


Entomopathogenic Fungi



22/25.

- Some commercial isolates tested (Nel *et al.*, 2023)
 - Works well in petri-dish, but not in infested plant material
- Colonies of *E. fornicatus* in emergence cages often killed by *Beauveria* (e.g. *Beauveria bassiana*)
- Two native, one commercial isolate of *B. bassiana* to be screened on *E. fornicatus* females allowed to establish colonies in growth media in tubes



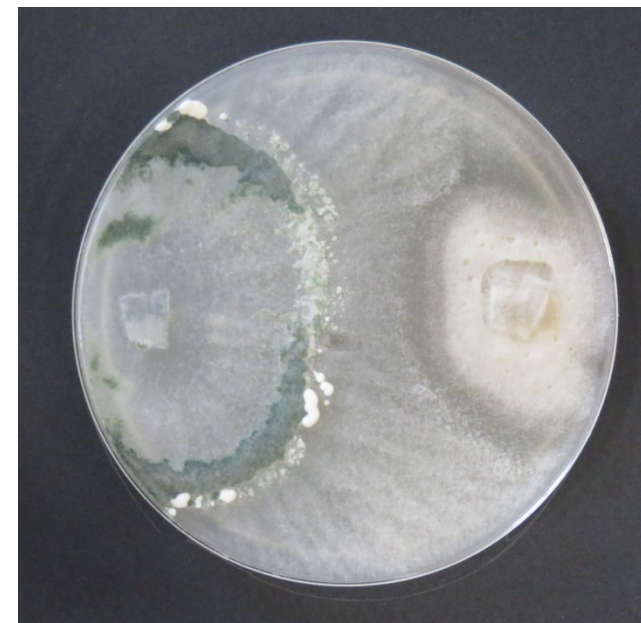


Antagonistic Fungi



23/25.

- *Trichoderma atroviridae* : Fast growing fungus that shows antagonistic effects against other fungi
 - Some isolates used for **bio-control of wood pathogens**, applied on pruning wounds
- Three isolates tested **easily outcompetes** *F. euwallaceae*, other mycangial fungi and wood-rot pathogens *in vitro* (preliminary results).
- How does *T. atroviridae* and *Beauveria* spp. interact?

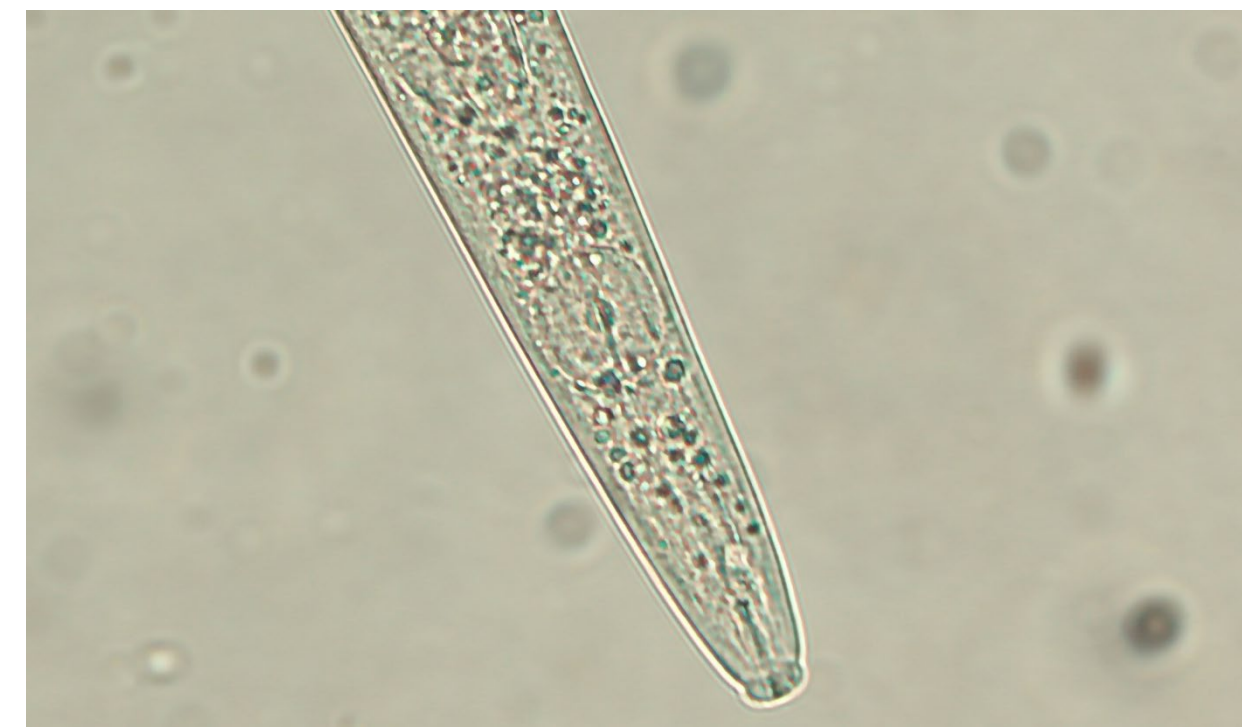




Future Work

24/25.

- What role do **phoretic nematodes** associated with PSHB play?
- Commonly found in galleries
- Two bacterial feeders, one fungal feeding species -> pending identification
 - Can we potentially exploit these as well?





Team



25/25.

- Dr. Steffan Hansen (Postdoctoral Fellow, SU)
- Prof Francois Roets (Host, SU)
- Dr. Davina Saccaggi (Collaborator, CRI, SU)
- Prof Edward Ueckermann (Collaborator, NWU)
- Prof Lizel Mostert (Collaborator, Plant Pathology, SU)
- Ms. Annelie Smit (Research Assistant, SU)
- Hortgro Science, SAPPA, SAMAC, BlueBug ID service industry partners




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- FABI quarantine facility (B. Hurley, A. Collop)
- P. Barker (arborist, Capetown)
- SU nematology (A. Malan, C. Kapp)




SAMAC
Macadamias South Africa NPC





Comments/Questions?



- Thank you for your attention!
- For any questions or comments on this work, please feel free to contact me on shansen.rsa@gmail.com

