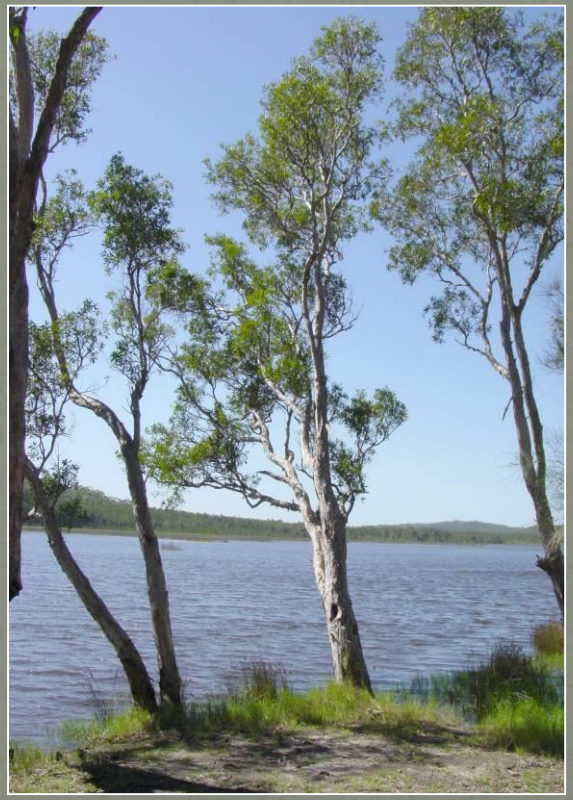
The role of gall formers as biological control agents of the broad-leaved paperbark tree *Melaleuca quinquenervia* in Florida USA

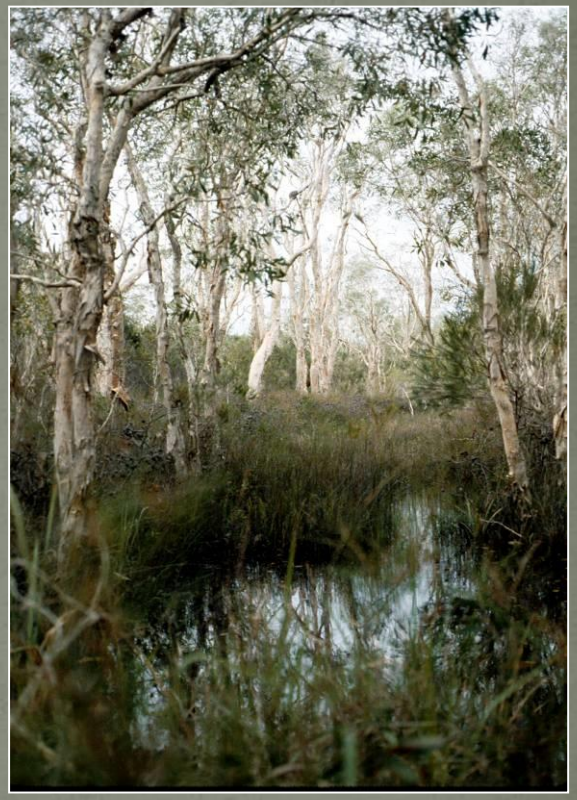
Matthew Purcell[1], Paul Pratt[2], Jeff Makinson[1], Bradley Brown[1], Kerrie Davies[3], Gary Taylor[4], Robin Giblin-Davis[5] and Sonja Scheffer[6]

Melaleuca quinquenervia in Australia

Swamps



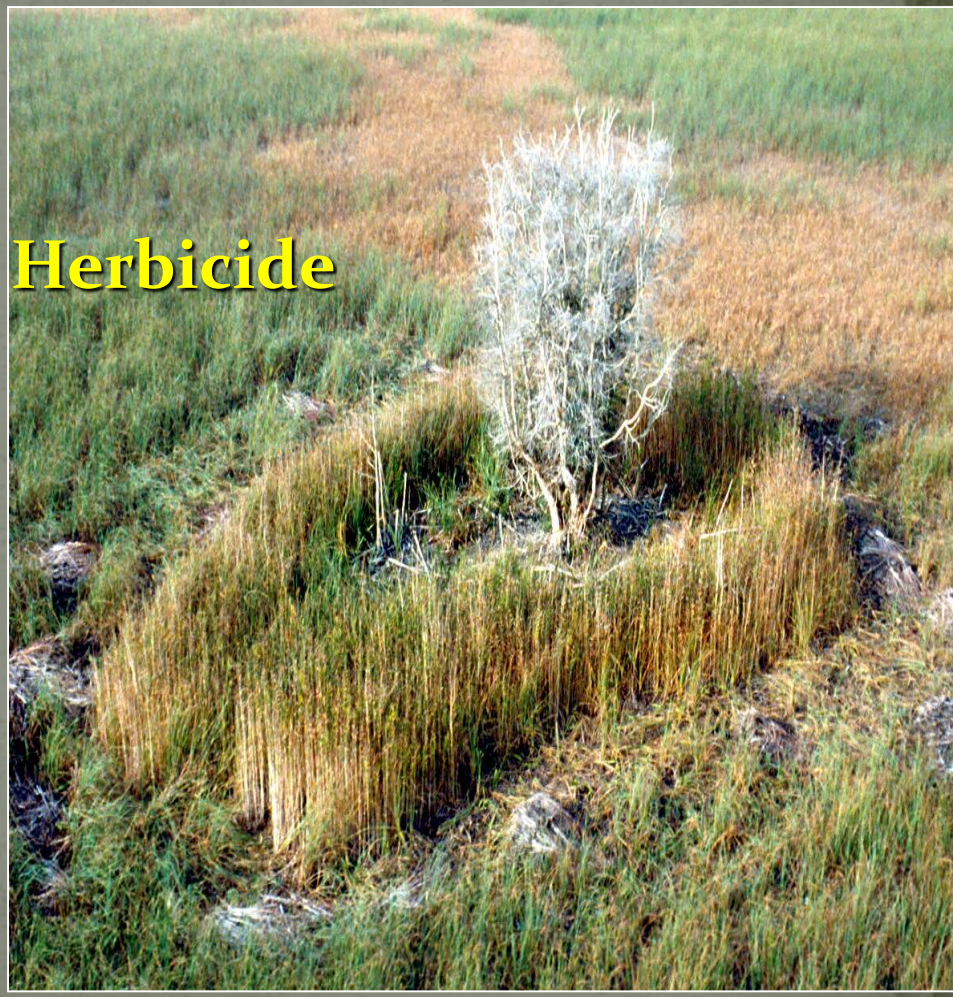
Lakes



River Systems

Melaleuca in the wetlands of Florida, USA

Regeneration after disturbance

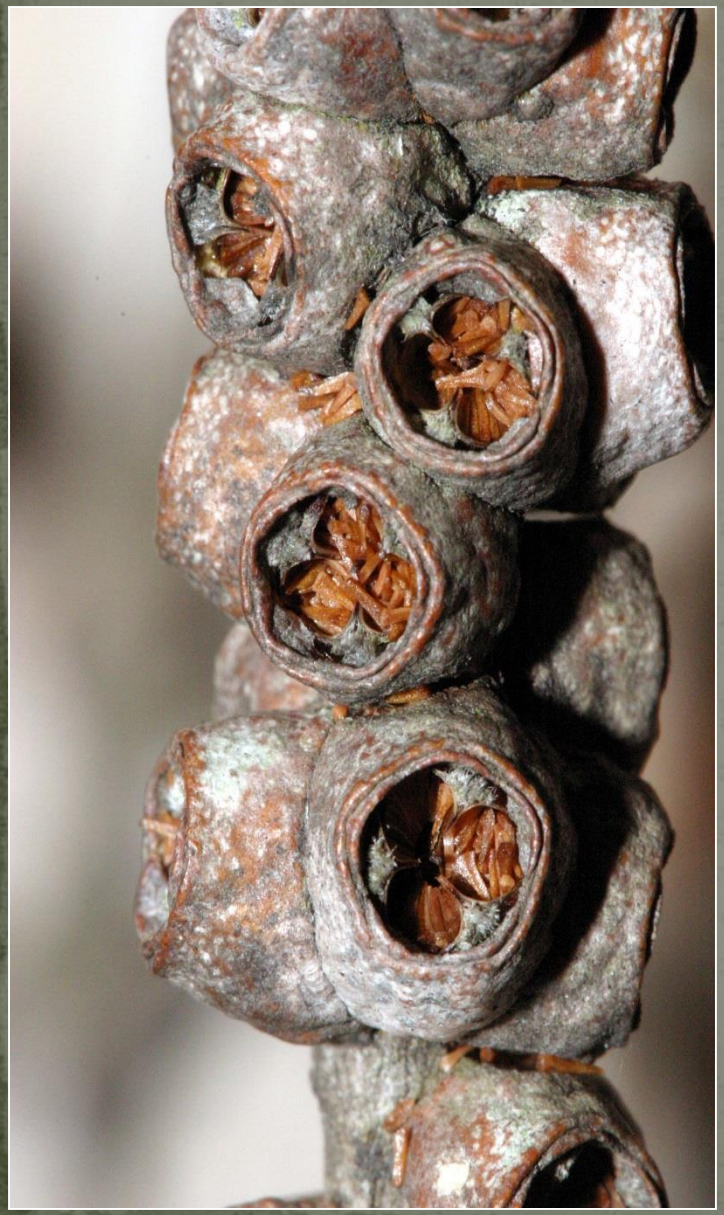


Reproductive potential (USA)

- Flowers multiple times per year
- Capsule clusters contain ±70 serotinous seed capsules
- Capsules contain ±450 seeds of which:
  - 15% are embryonic
  - 9% are viable
  - 7% germinate within 10 d

A large (21 m) tree, with a moderate crown, located inside a stand holds ca. 50 million seeds in its canopy which can produce up to 4.5 million seedlings.

Melaleuca quinquenervia



Melaleuca management plan

Strategy

Eliminate stands

Herbicidal Control
&
Mechanical Removal

Prevent regeneration

Biological
Control













Biological Control Agents

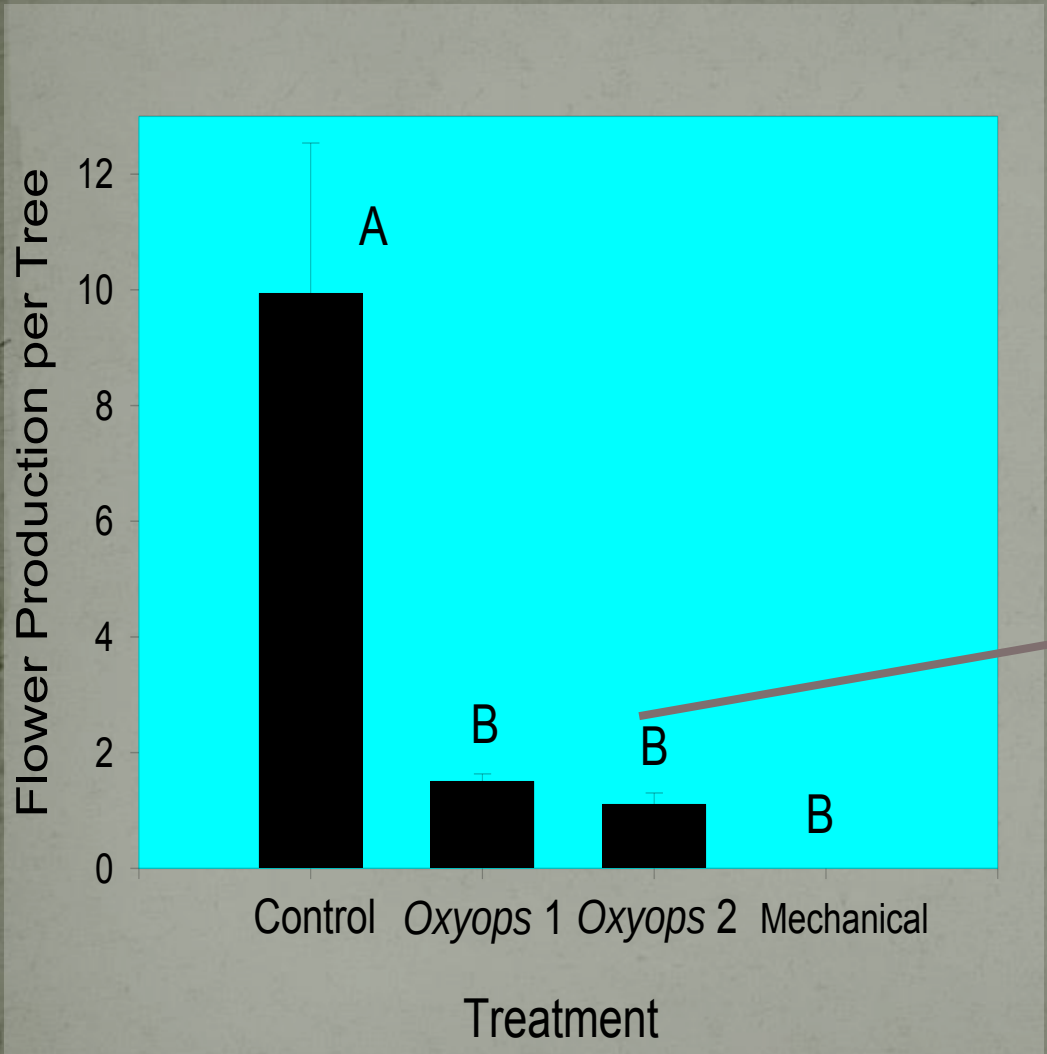
Oxyops vitiosa (1997)

- Established in most areas
- Adults feed on buds & leaves
- Larvae feed on flushing leaves

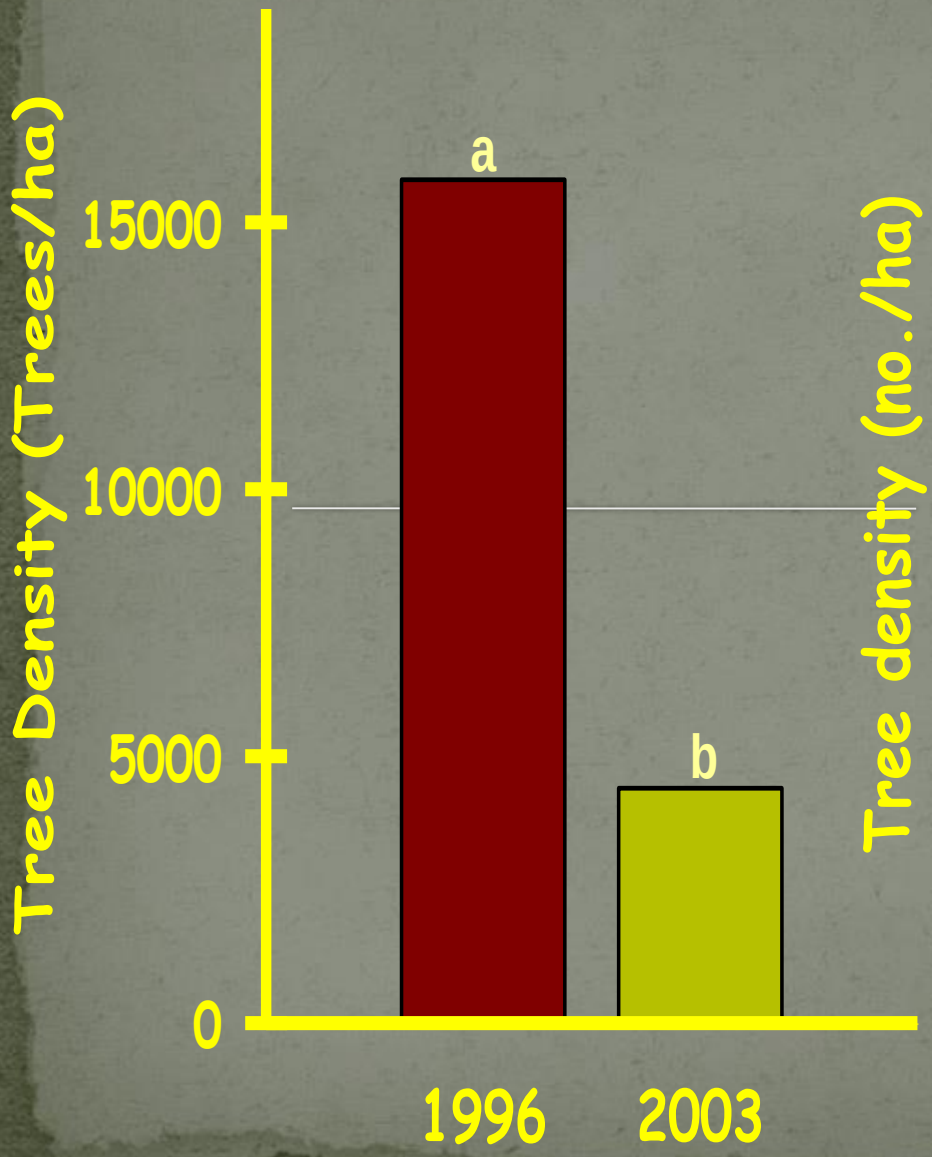
Boreioglycaspis melaleucae (2002)

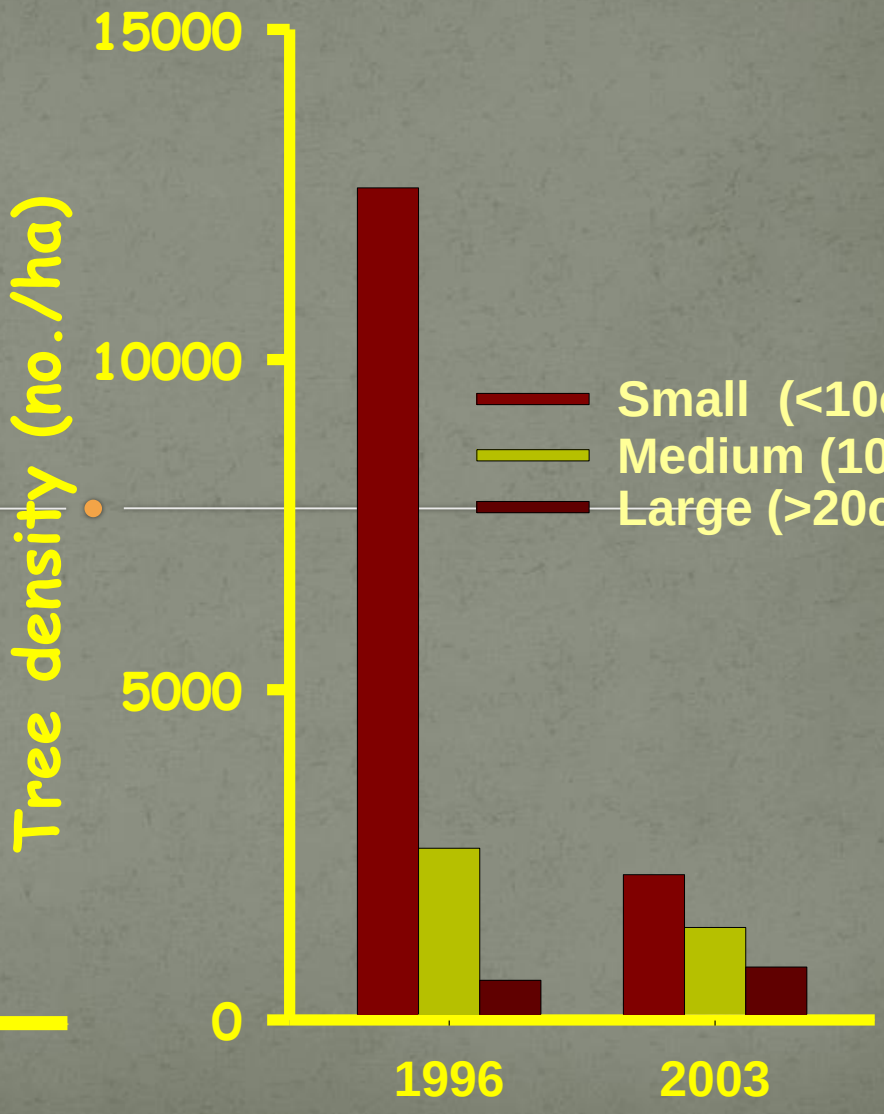
- Established in all areas
- Adults, nymphs phloem feeders.

A single attack reduces floral intensity



Impacts (both agents): tree mortality





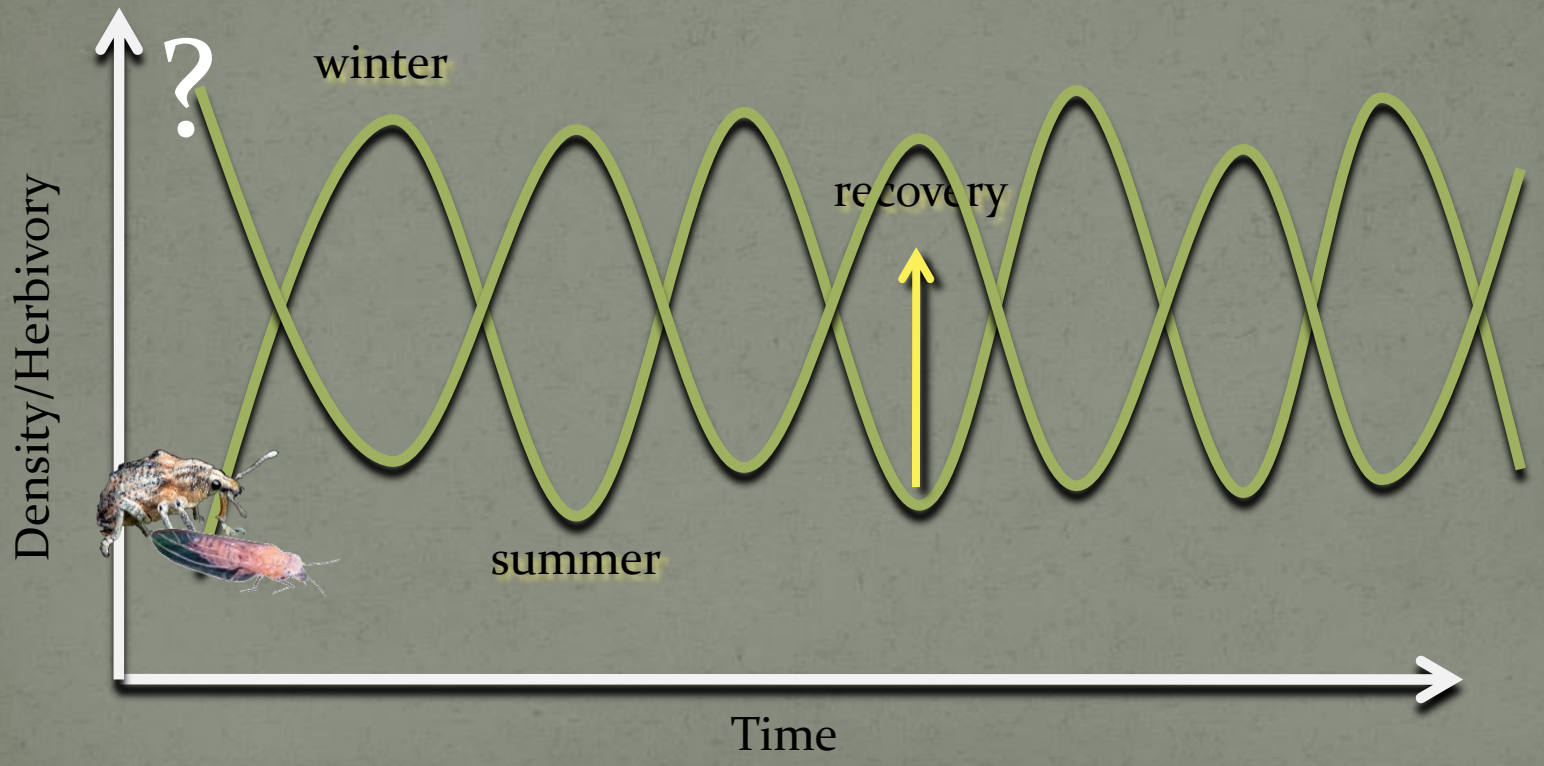

Insecticide
No Insecticide

Early Accomplishments

- Melaleuca stands removed from public lands
- Biological control implemented
  - Seed production reduced 98%
  - Stand densities reduced ≥85%
  - Sapling growth strongly curtailed
  - Coppicing reduced
  - Seedling survival reduced by ≥60%
  - Reduced canopy, increased light penetration
  - Increasing biodiversity
- Melaleuca was much less invasive

- Conclusion: All goals were achieved so the project was a "success" despite the continued existence of dense infestations.

Seasonal fluctuations in herbivore densities



Fly: *Fergusonina*

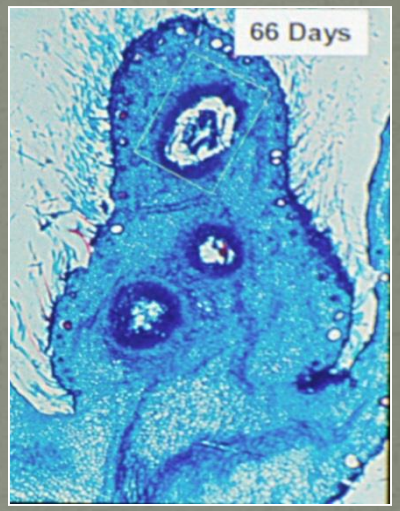
New species

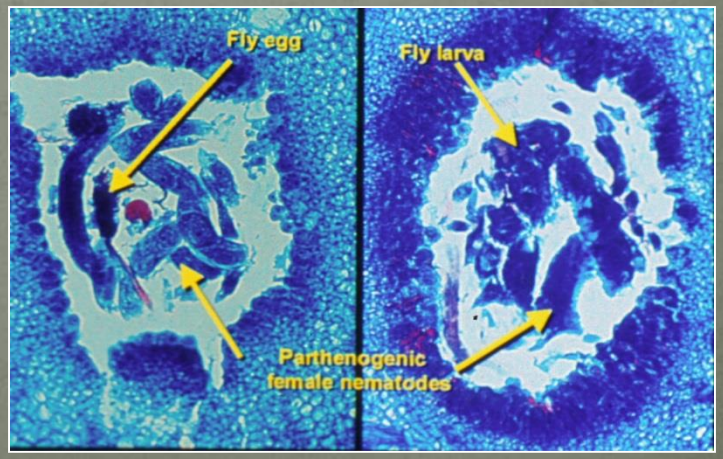
Genus

- Known from other myrtaceous species
- Geographically restricted to Australasia
- Mutualism
  - Associated with nematodes
  - *Fergusobia*

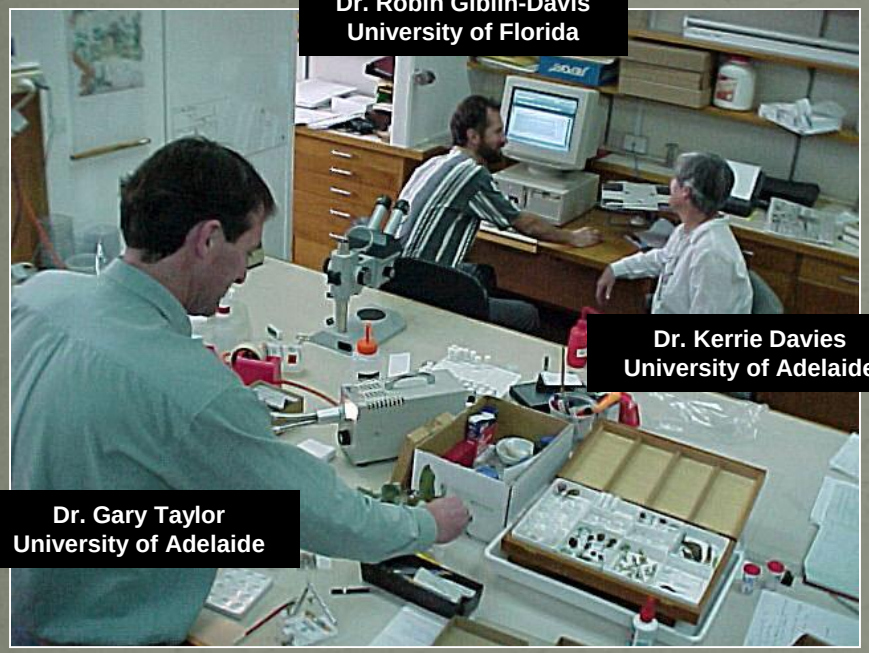
The Melaleuca Bud-Gall Fly

Fergusonina galls



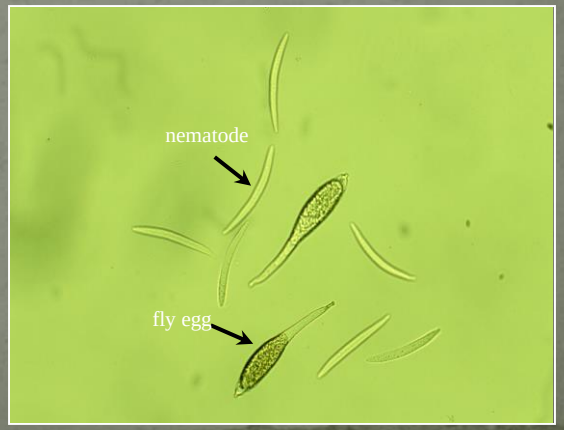


Life history research



Described the new species:

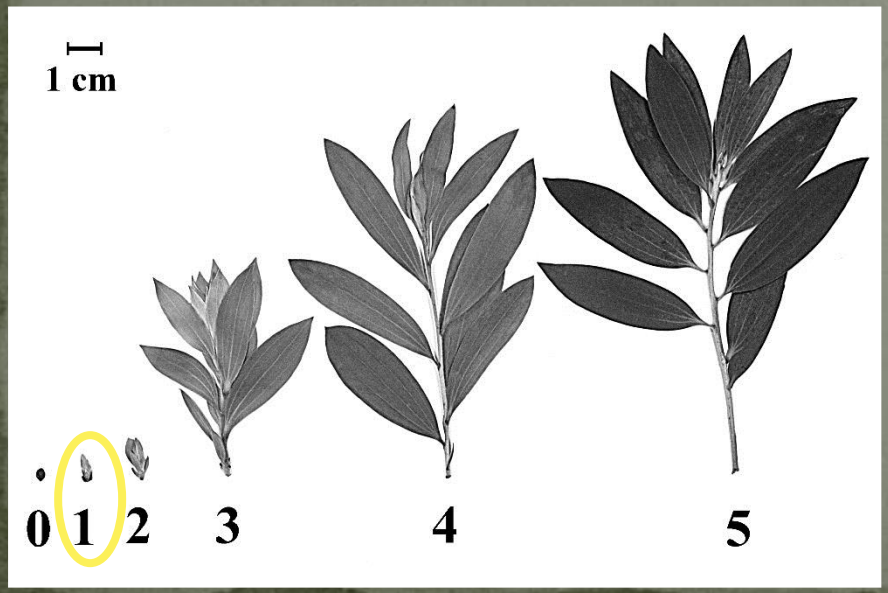
- *Fergusonina turneri*
- *Fergusobia melaleucae*



Life history research

Phenological synchronization

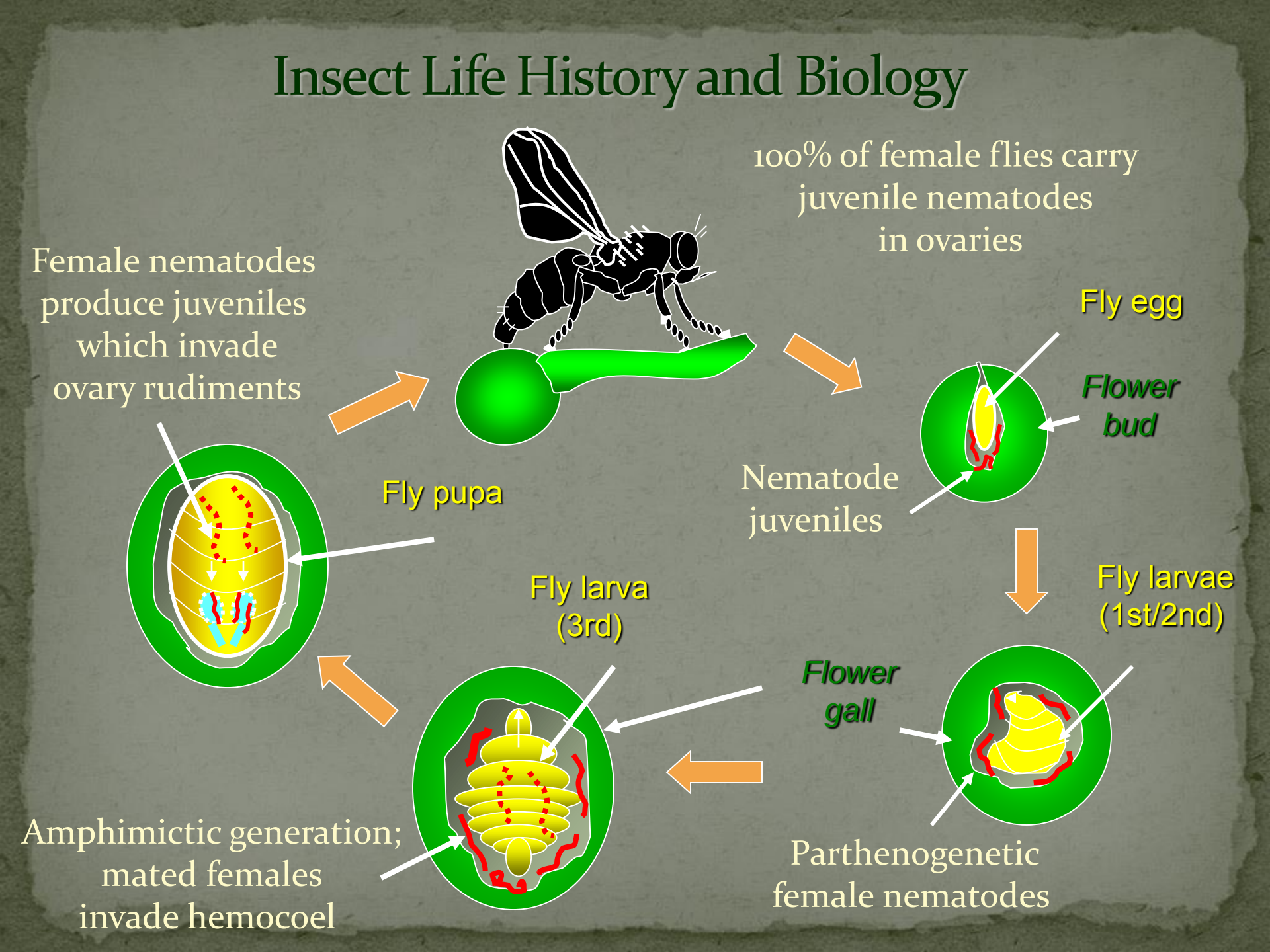
- Flies oviposit into bud stage 1.
- Oviposit in leaf and flower buds.



Obligate relationship

- Needle inoculations:
  - Mortality when inserted singly
- Nematode initiates gall development
- Fly disperses and sustains the nematode

Insect Life History and Biology



Melaleuca cajuputi

M. dealbata

M. fluviatilis

M. leucadendra

M. nervosa

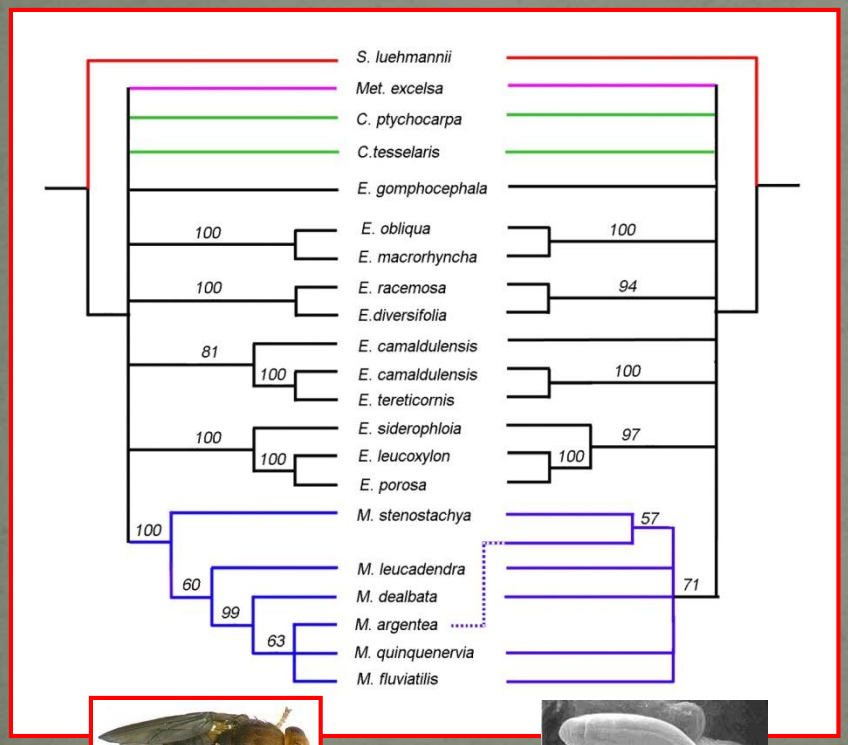
M. nervosa

M. quinquenervia

M. stenostachya

Speciation and host fidelity

- Sonja Scheffer et al. 2004



- 1 to 1 relationship
  - 1 to 2 for *F. turneri*
  - Host associations existed for 3 million years
- Host range testing:
  - Ovipositor probing on some *Melaleuca* species
  - No development on test plants
- Permitted for release in 2005

Rearing and release: 2005

- Rearing its ugly head…
  - Rearing only effective in sleeve cages
  - Difficult to synchronize plant buds with fly emergence
  - Short adult longevity
  - Heat spikes in glasshouse (>40 C)

Re 2005

Galled plants placed at two field sites (n= 489, 987)

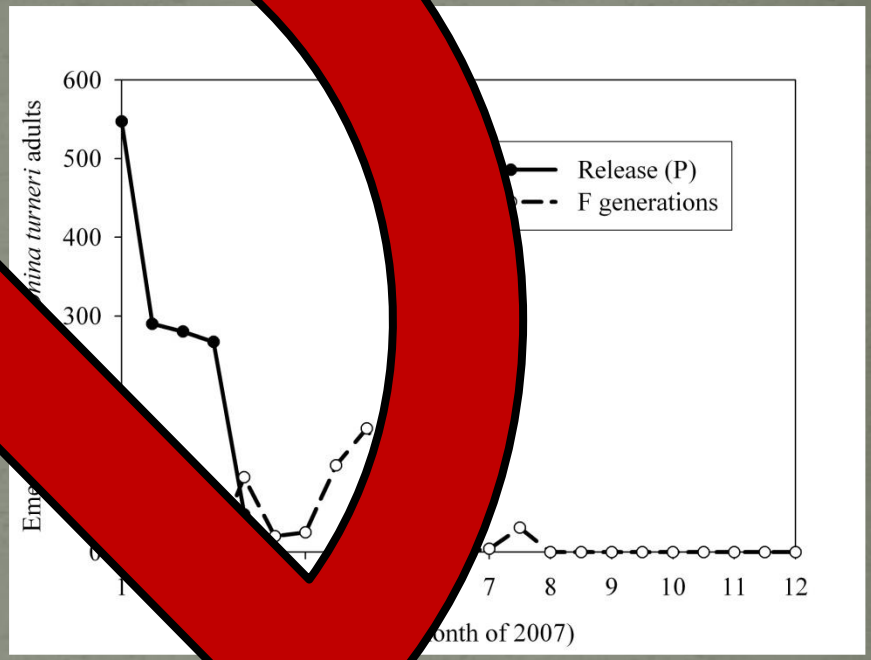
plants at three sites and then removed after galling (n= 75, 77, 79).

Adults a mated and then released at two release sites (n= 141, 148).

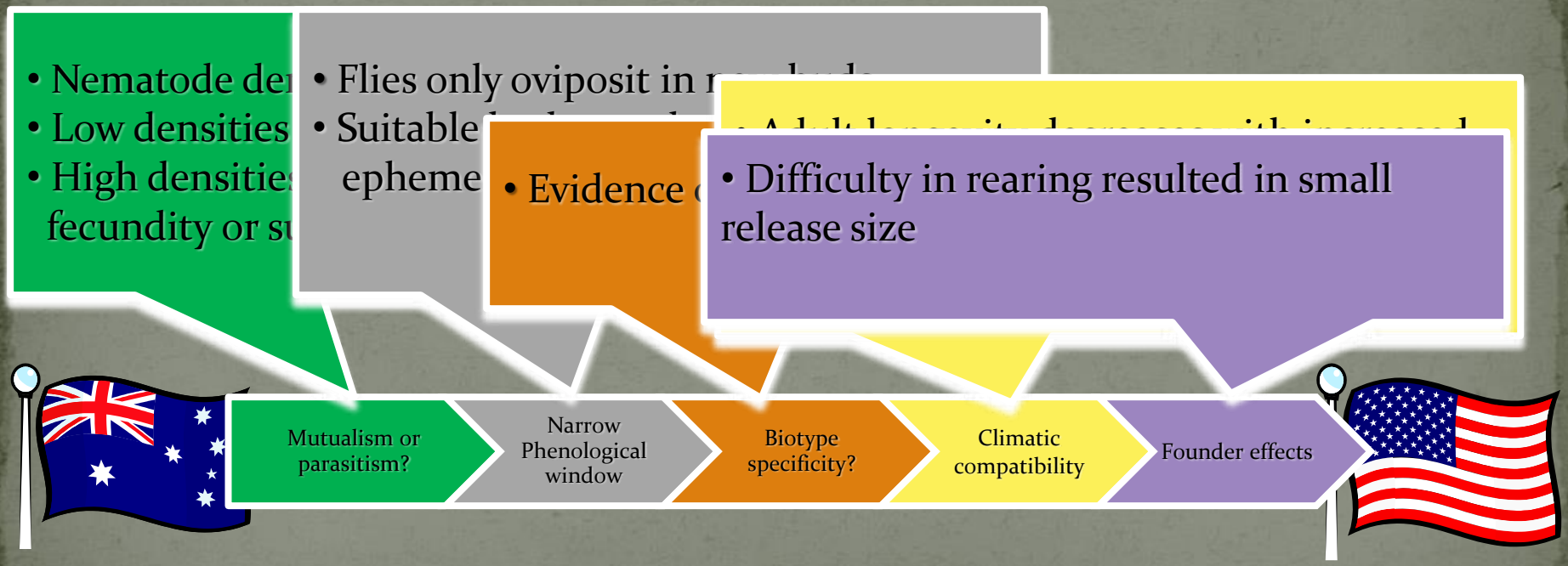
Grand total: 1996

S 006

- Same rel ds
- Increas undi popula size: 143
- Releas a single sit
- Better ological synchro tion
  - Flowe eaf buds
- Monitored 2 weeks.
  - Gall develo tes
  - Fly emergence
  - Local spread



Why so hard to establish?

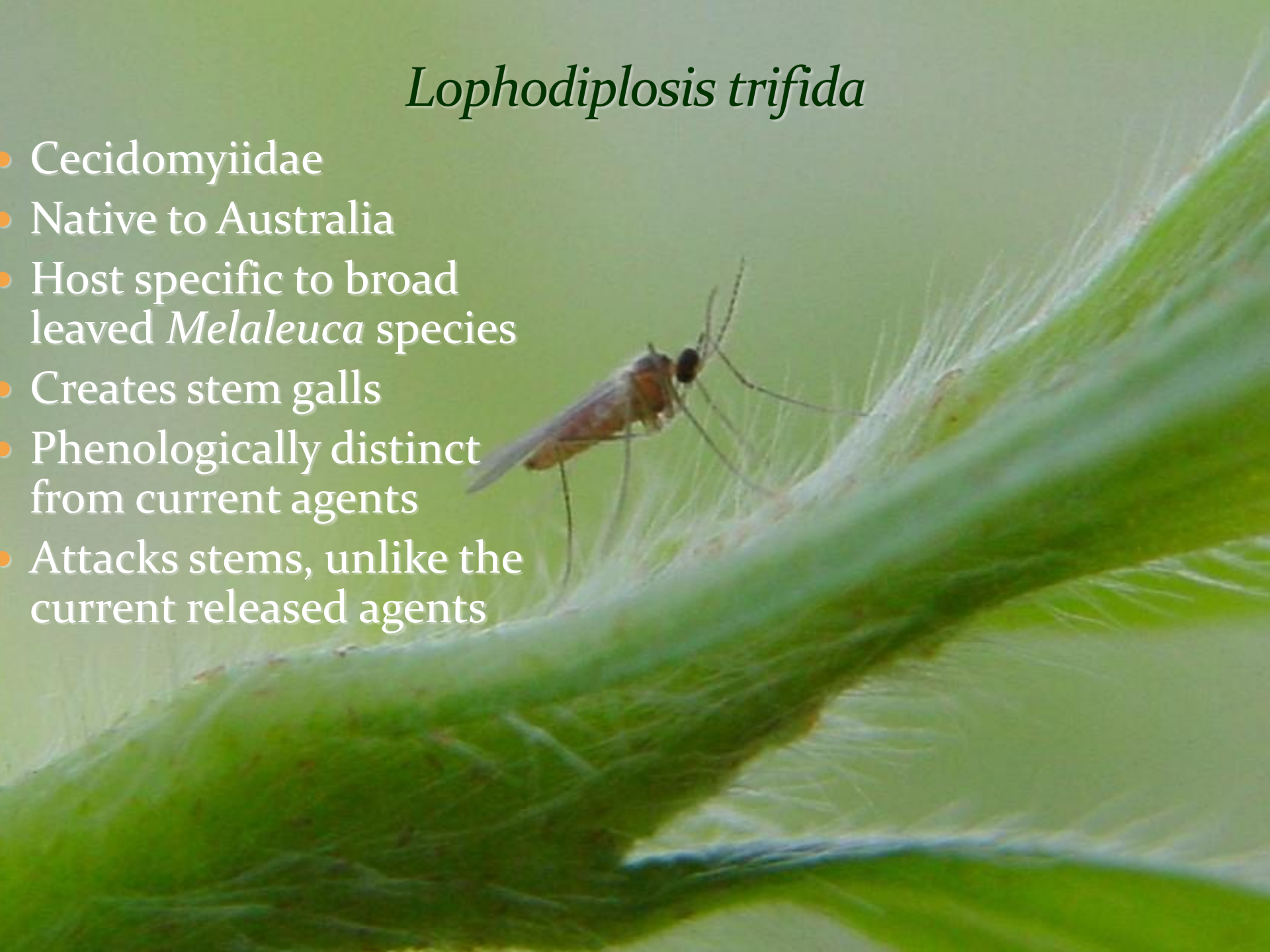


Fergusonina turneri conclusions

- No establishment in Florida
- Non-traditional biocontrol agent(s)
  - First mutualism introduced
  - Only example of an insect-nematode mutualism
- Collaboration among 7 labs
- 20+ publications

Lophodiplosis trifida

- Cecidomyiidae
- Native to Australia
- Host specific to broad leaved *Melaleuca* species
- Creates stem galls
- Phenologically distinct from current agents
- Attacks stems, unlike the current released agents



Gall Fly - *Lophodiplosis trifida*

- Prefers wet habitats
- Attacks seedlings
- Kills saplings

Lophodiplosis trifida

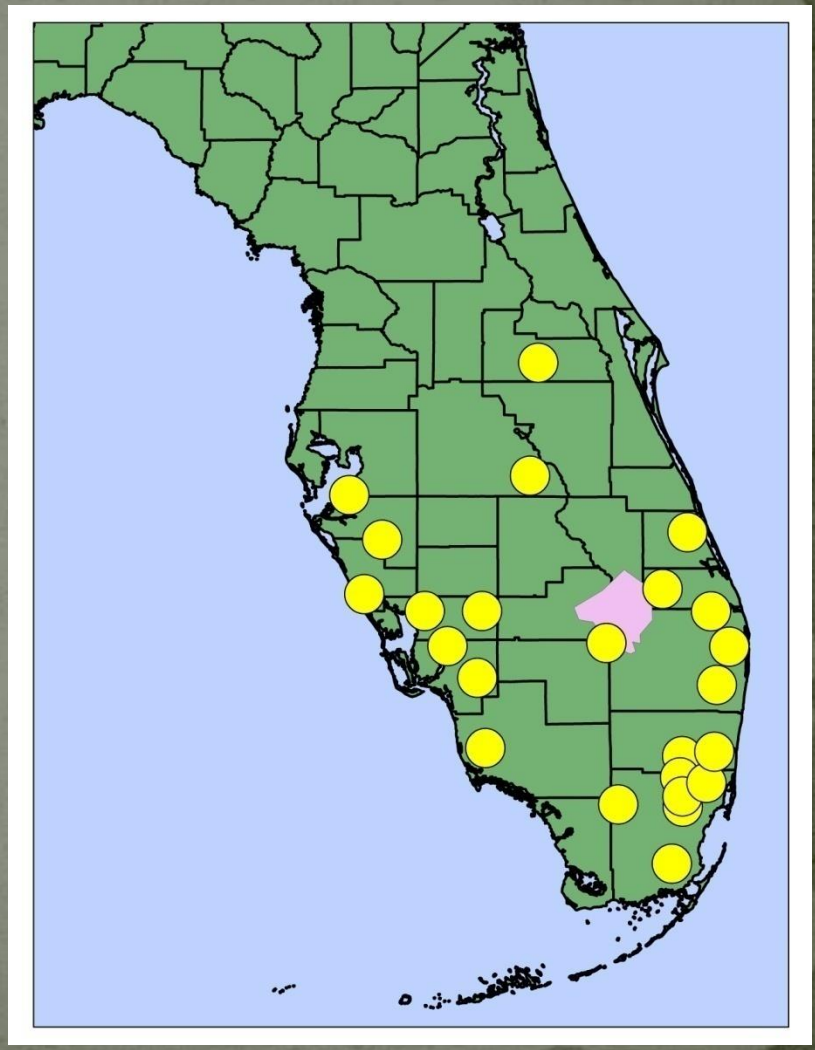
Because *L. indentata* was:

- Host specific to broad leaved Melaleuca species
- Phenologically distinct from the released agents attacking stems year round

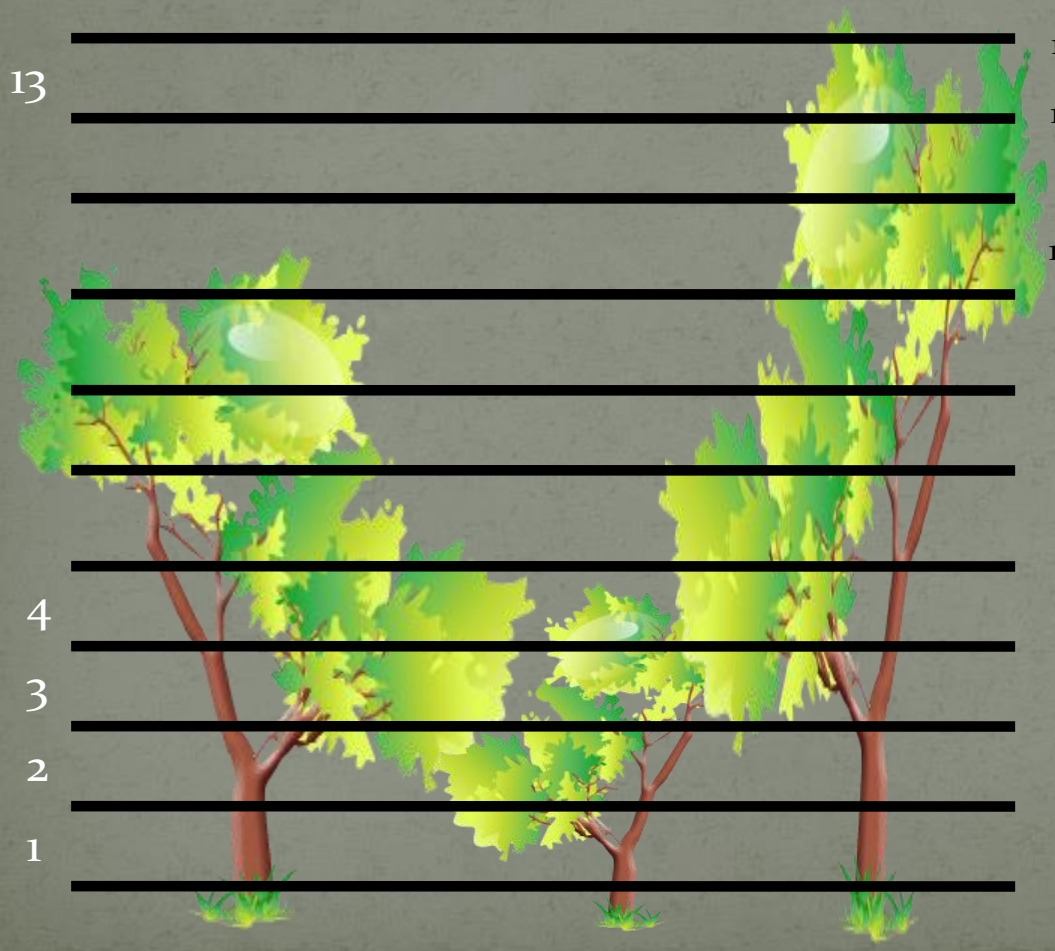
APHIS release permit for the US was granted in July 2008

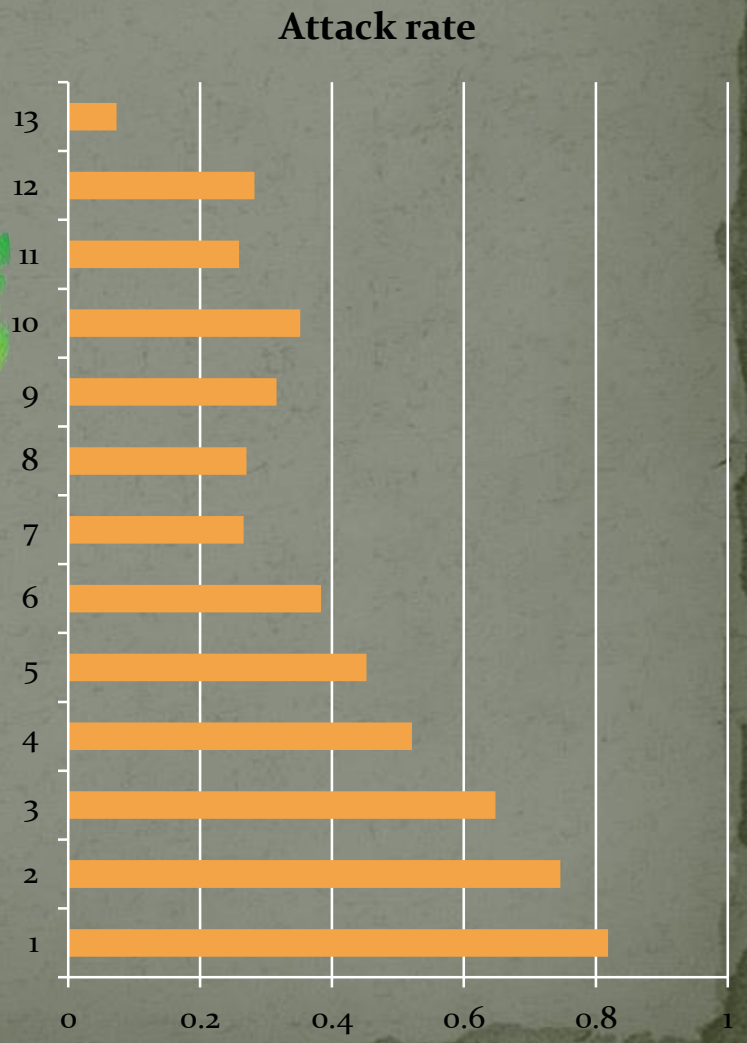
Lophodiplosis trifida

- Released at 24 sites
  - Variable founding pop. size
    - 100, 2000, 6000 individuals
  - Variable patch size
    - From 5 trees to stands > 40 ha
- Uniform establishment
- Dispersing at 6 km/yr



Lophodiplosis trifida





Lophodiplosis trifida

- Common garden
  - Natives
  - Exotic ornamentals
  - Melaleuca species
  - *Melaleuca quinquenervia*
- No instances of galls on any non-target species
- No instances of galls on *Melaleuca* species, except the intended host.

Lophodiplosis trifida conclusions

- Melaleuca midge widely established in Florida
- Populations continue to increase
- Distributed in lower portions of canopy, seedlings and saplings
- No non-target feeding
- Influence of herbivory on plant performance and population growth.


Regeneration of Natives

Brown is beautiful

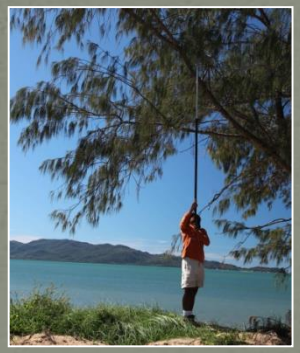
Funding Agencies

USDA

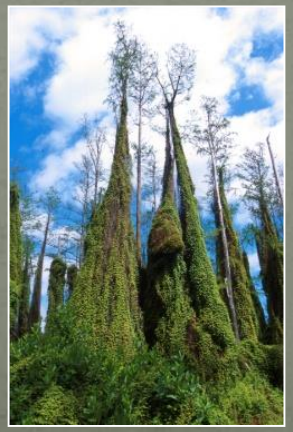
South Florida Water Management District
Protection of the Everglades Since 1949
sfwmd.gov

Florida Fish and Wildlife Conservation Commission





CSIRO

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