Ambrosia beetles pests of Avocado

Daniel Carrillo & Marc Hughes

Ploetz, Crane (TREC) – Cave (IRREC) – Stelinski (CREC) – Kendra, (USDA-ARS) – Cooperband (USDA-APHIS)-

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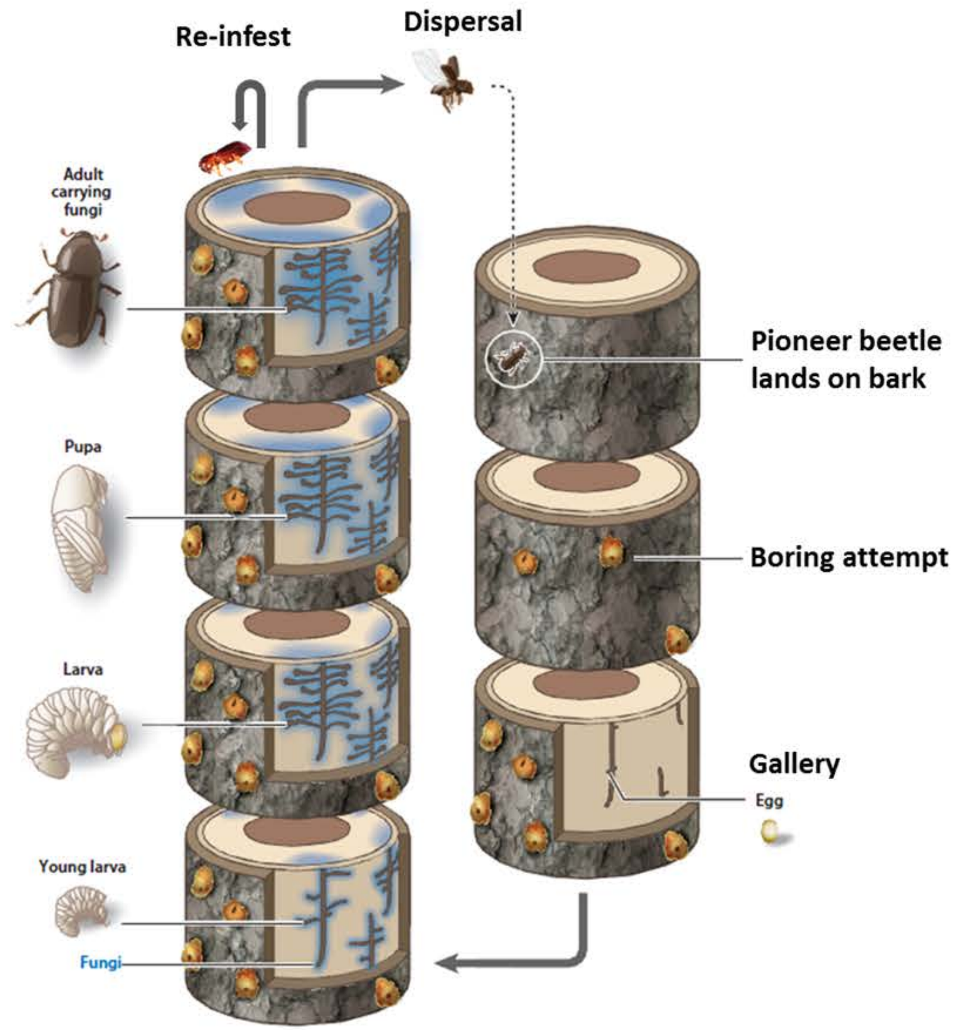
Ambrosia beetles are fungal farmers

- specialized saclike organ
- selectively maintain and transport fungi during dispersal



Modified form Six et al. 2011

Red Bay Ambrosia Beetle, *Xyleborus glabratus*, primary vector of the laurel wilt disease in natural forests

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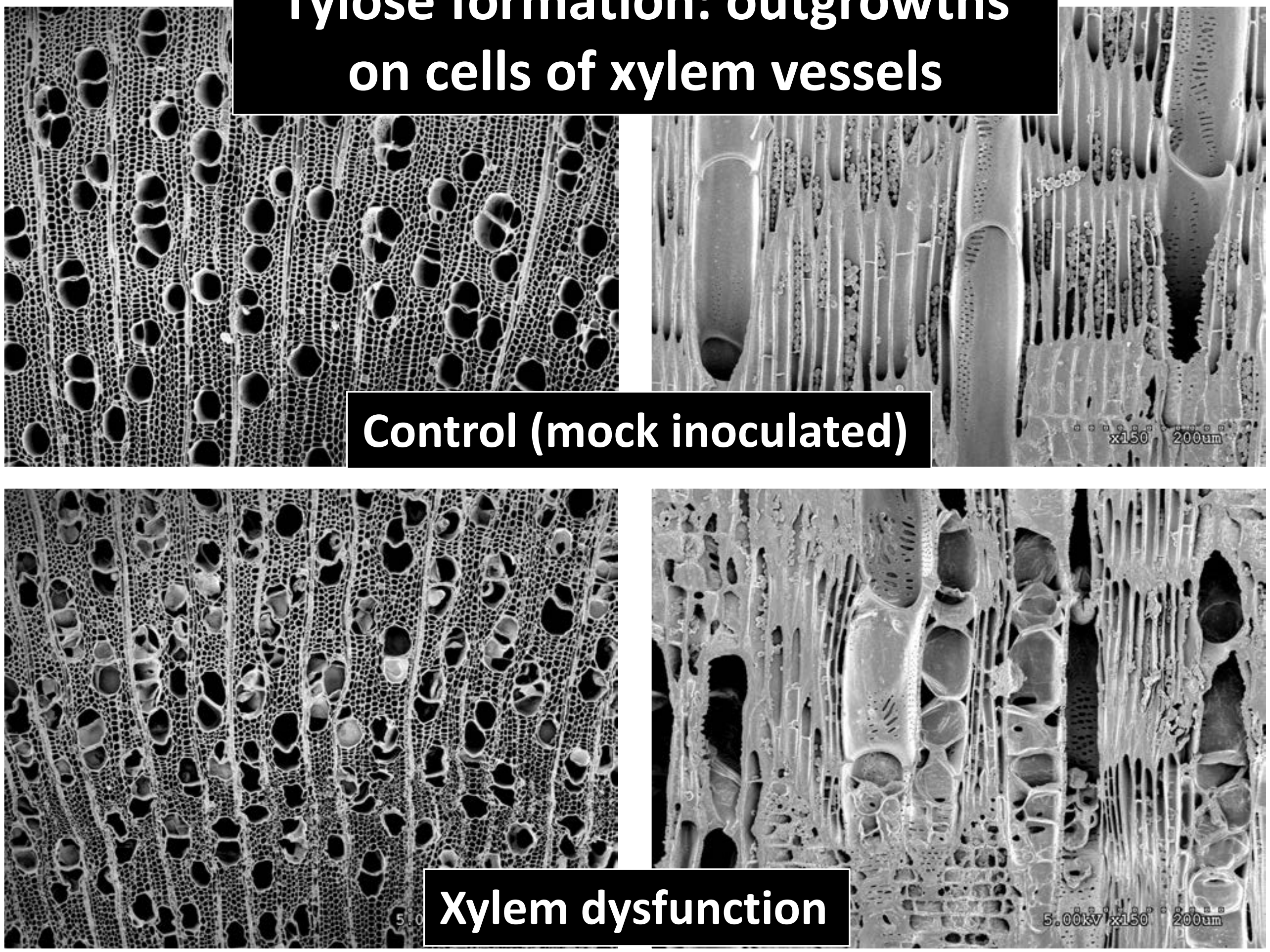
Causal agent : *Raffaelea lauricola*

Moves systematically within the host (Lauraceae) and causes vascular wilt

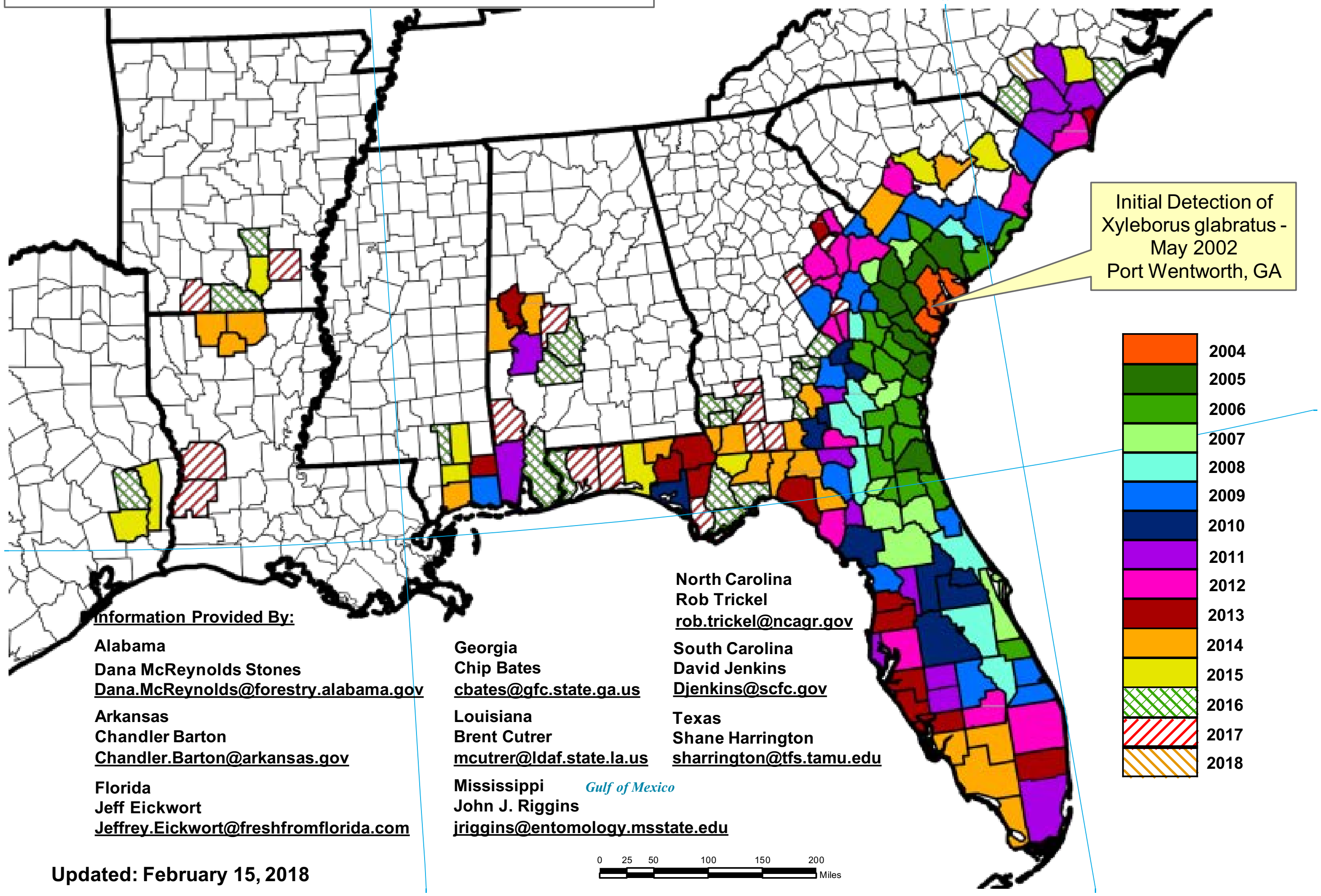
Tylose formation: outgrowths on cells of xylem vessels

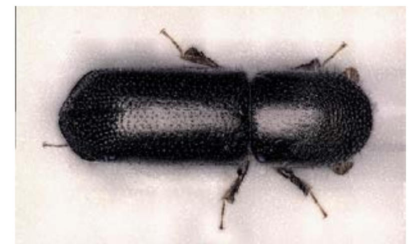


Inch, S.A.

Distribution of Counties with Laurel Wilt Disease* by year of Initial Detection

* Laurel Wilt Disease is a destructive disease of redbay (Persea borbonia), and other species within the laurel family (Lauraceae) caused by a vascular wilt fungus (Raffaelea lauricola) that is vectored by the redbay ambrosia beetle (Xyleborus glabratus).The pathogen has been confirmed through laboratory analysis of host samples collected in the counties highlighted.



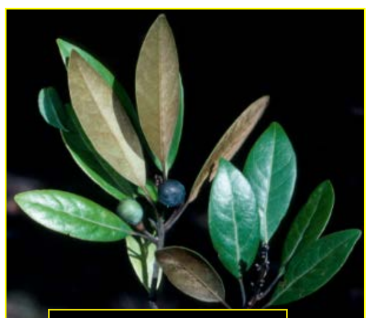


Native to Taiwan, Japan & South East Asia

Xyleborus glabratus, Redbay Ambrosia Beetle (RAB)

- **infected ~ 0.5 billion native lauraceous trees with *R. lauricola* in the southeastern U.S.**

Persea borbonia
Red bay



Persea humilis
Silk bay

Sassafras albidum

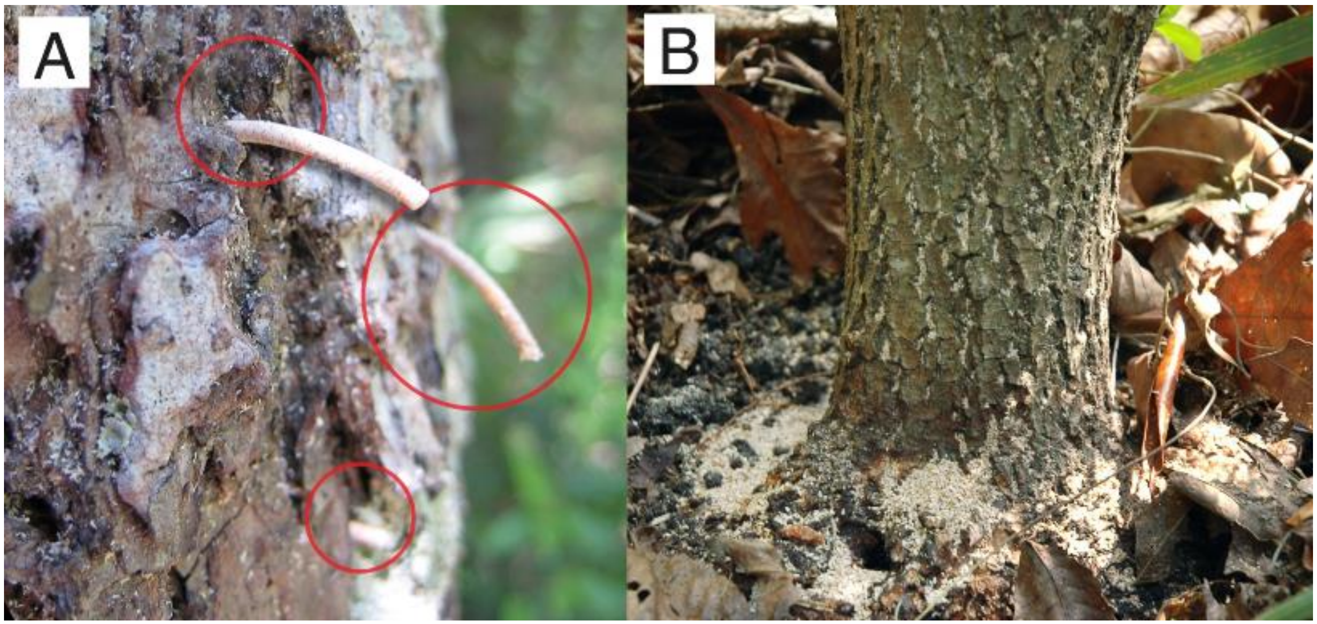
Persea palustris
Swamp bay

Redbay

A. wilt in upper crown B. Complete wilt of canopy

Photo: Hughes et al. 2015

Ambrosia Beetle Boring

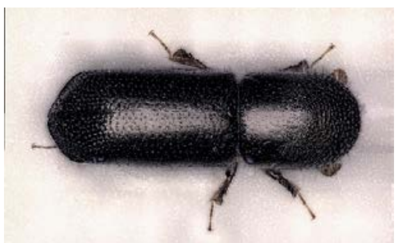


A. Frass “toothpicks” or “tubes”

B. Accumulated frass at tree base

Photo: Hughes et al. 2015

Avocado *(Persea americana)*

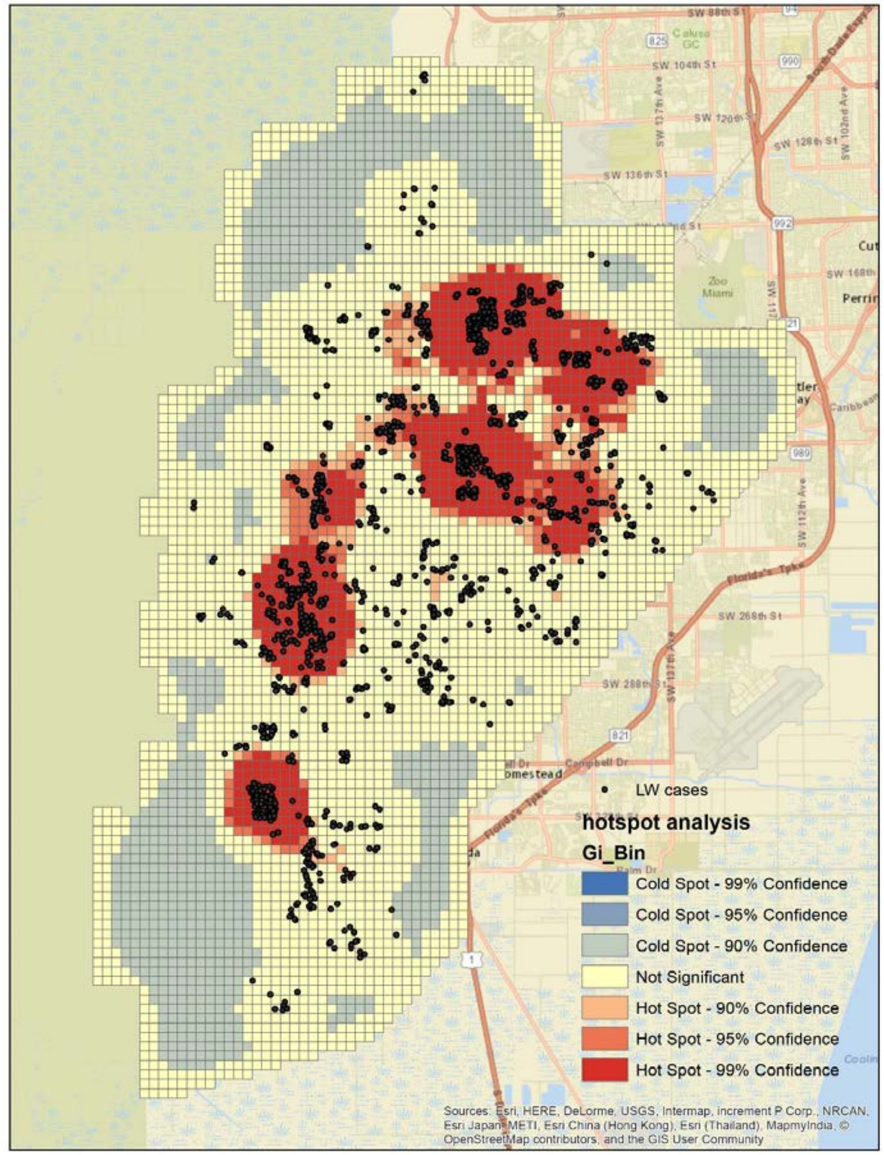


Avocado is not a good host for *Xyleborus glabratus*

~44,000 lost to LW

Pathogen spreading in the apparent absence of *X. glabratus*

Alternative vectors?



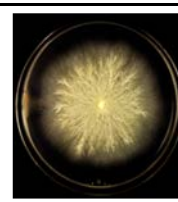
Several species of AB can carry *R. lauricola*

Plant Pathology (2014) **63**, 54–62 Doi: 10.1111/ppa.12073

Lateral transfer of a phytopathogenic symbiont among native and exotic ambrosia beetles

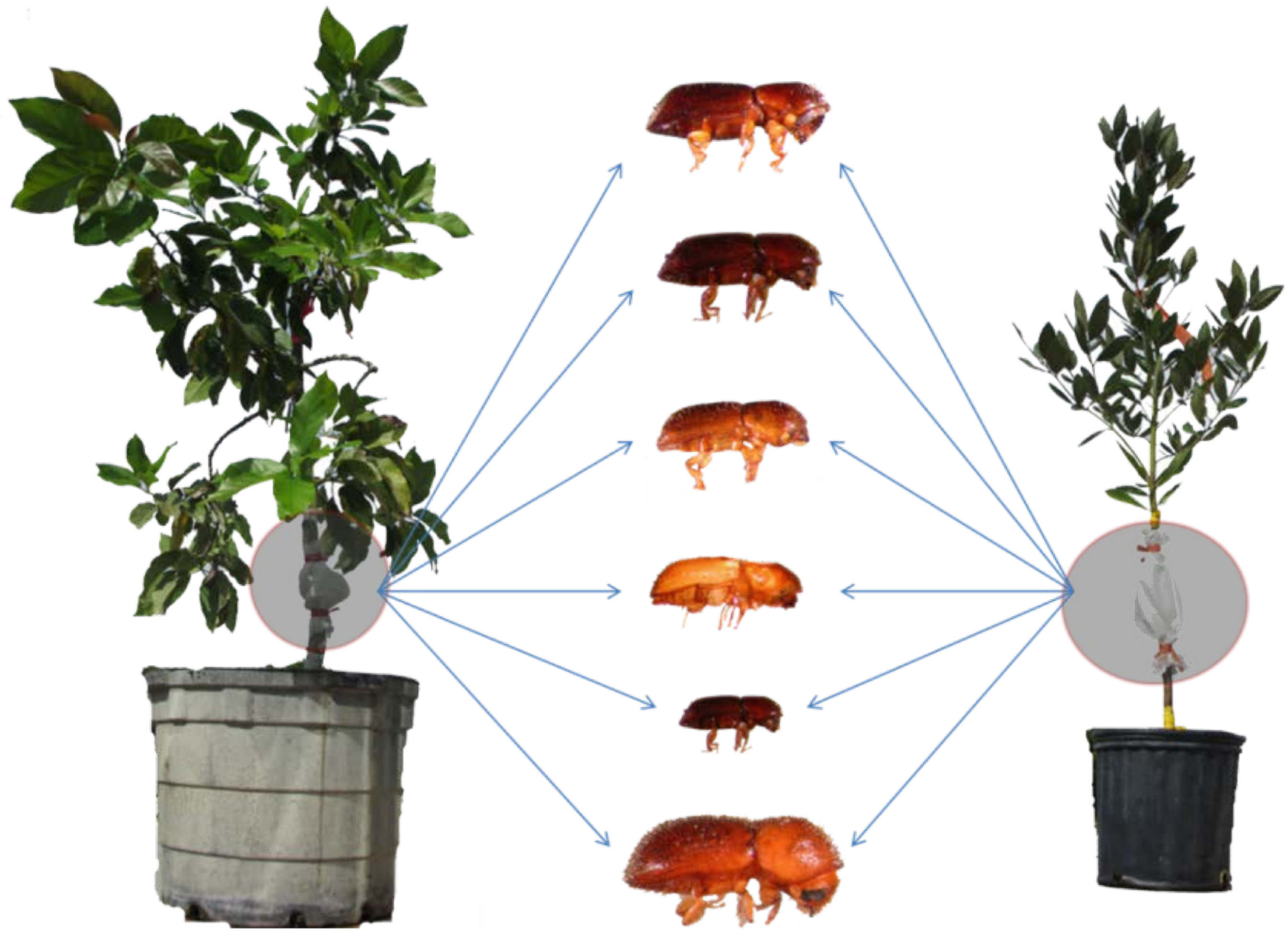
D. Carrillo*, R. E. Duncan, J. N. Ploetz, A. F. Campbell, R. C. Ploetz and J. E. Peña
Tropical Research & Education Center, University of Florida, 18905 SW 280 Street, Homestead, FL, 33031-3314, USA

species	n=	No. beetles carrying *R. lauricola*	probability of a beetle carrying *R. lauricola*	CFUs Mean ± SEM	CFU Range
Xyleborus glabratus	50	43	0.86 a	2783.3 ± 281.9 a	0 - 7800
Xyleborus affinis	41	5	0.12 c	1 ± 0.6 c	0 - 20
Xyleborus volvulus	39	20	0.51 b	28.4 ± 10.6 b	0 - 100
Xyleborus ferrugineus	118	70	0.59 b	33 ± 7.4 b	0 - 118
Xyleborinus gracilis	52	26	0.50 b	100.6 ± 34 b	0 - 1240
Xyleborinus saxeseni	68	2	0.03 c	1.5 ± 1 c	0 - 60
Xylosandrus crassiusculus	39	1	0.03 c	2.6 ± 2.6 c	0 - 100
Ambrosiodmus devexulus	25	0	-	-	-
Ambrosiodmus lecontei	41	0	-	-	-



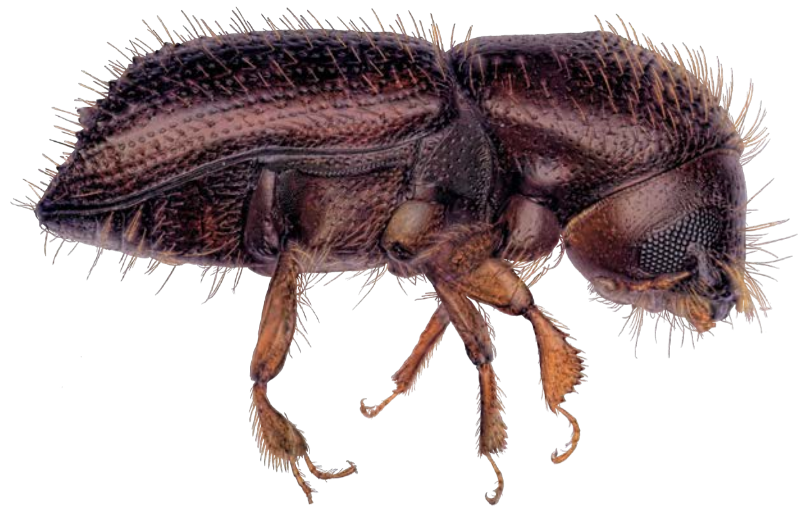
Raffaelea lauricola

Two can transmit *R. lauricola* to avocado



Xyleborus bispinatus (~X. ferrugineus)

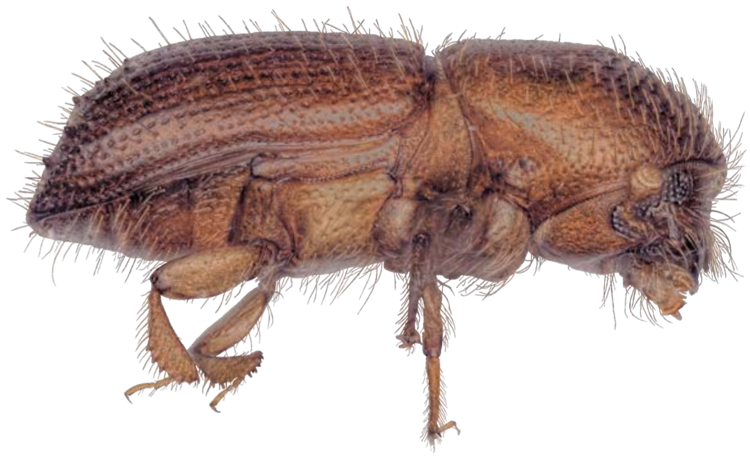
Can develop and reproduce feeding exclusively on *R. lauricola*



	N	# with *R. lauricola*	% of beetles with *R. lauricola*	CFU mean	CFU range
Swampbay	118	70	**59**	60	0-118
Avocado logs	5	5	**100**	40	0-80
Avocado logs R.	20	18	**90**	53	0-320
Traps	35	6	**17.1**	4.7	0-60

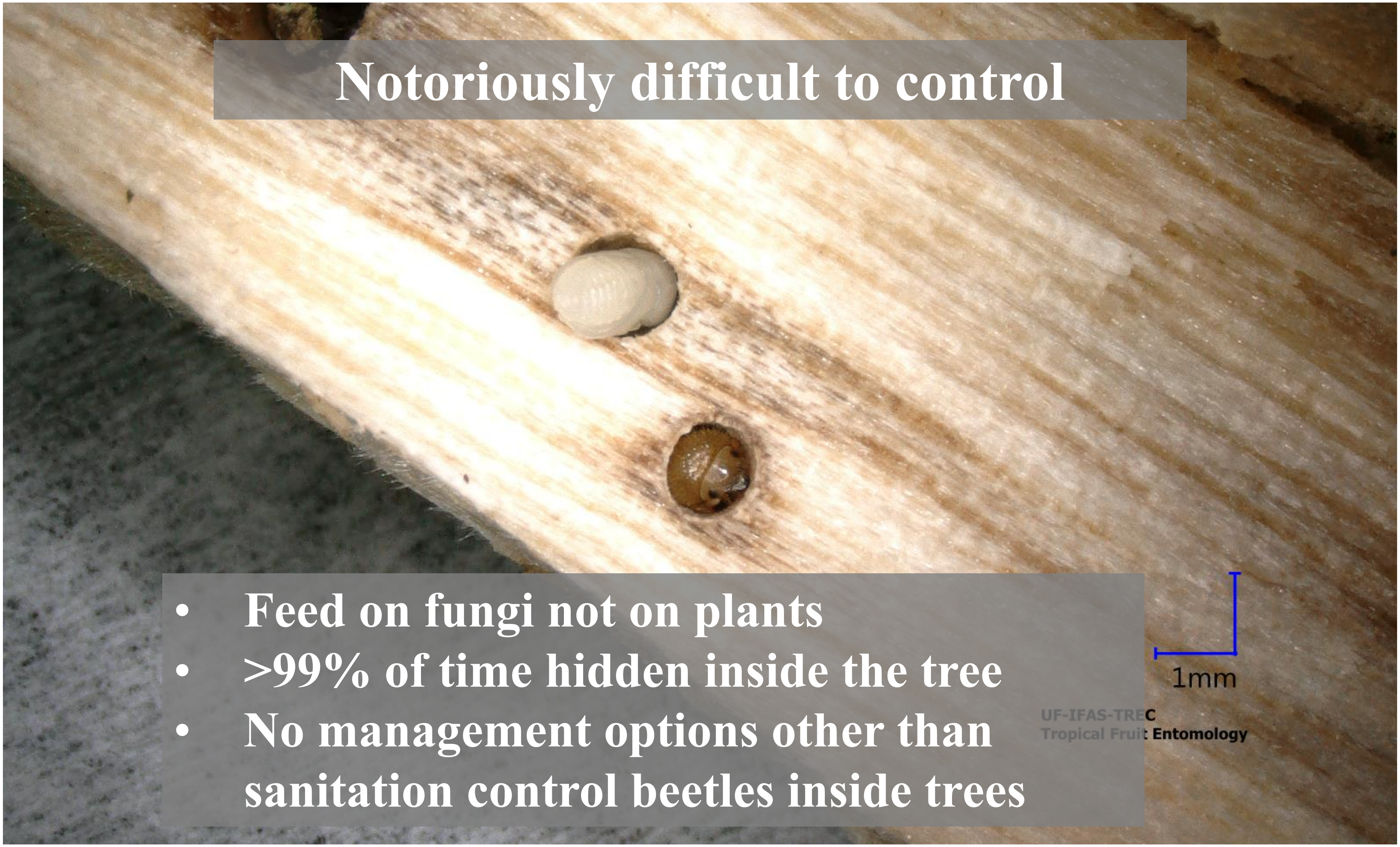
Xyleborus volvulus

Carries *R. lauricola* passively



	N	# with *R. lauricola*	% of beetles with *R. lauricola*	CFU mean	CFU range
Swampbay	39	20	**51**	28	0-100
Avocado logs	53	10	**19**	30	0-1140
Avocado logs R. Saucedo	20	2	**3**	12	0-20
Traps	117	3	**2.6**	0.4	0-20

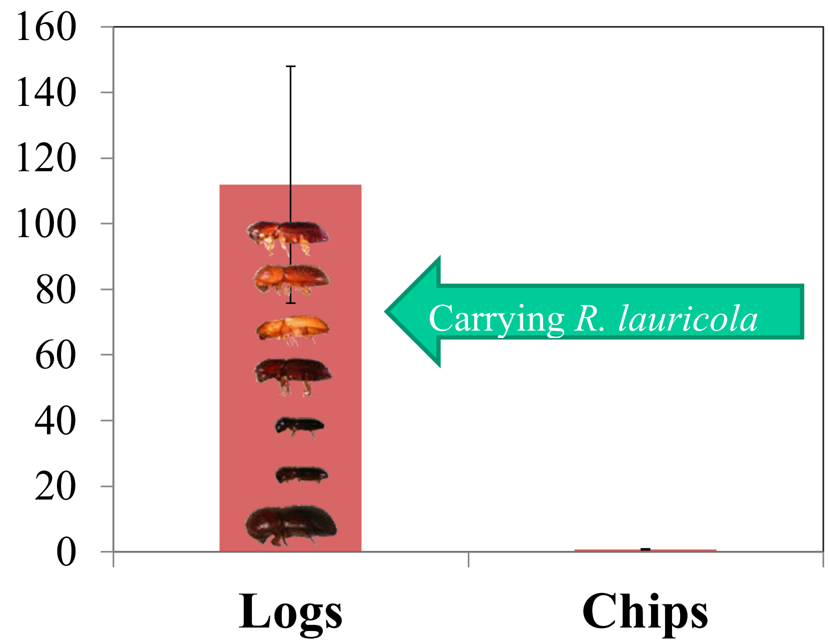
Notoriously difficult to control



- Feed on fungi not on plants
- >99% of time hidden inside the tree
- No management options other than sanitation control beetles inside trees

Monitoring- Scouting

Early detection and rapid removal



Chipping wood is an effective way of killing beetles inside the trees

Chemical Ecology of RAB

Attractants

- **Fungal volatiles (Kuhns et al. 2013)**
- **Sesquiterpenes (Kairomones)**

  α-Copaene, Cubeb, and Eucalyptol

  (Kendra et al; Kuhns et al.)

“GC-MS analysis revealed an increase in methyl salicylate (MeSA) 3 DAI, whereas an increase of sesquiterpenes and leaf aldehydes was observed 10 and 20 DAI in leaf volatiles.” Martini et al. 2017

- **Repellents: methyl salicylate (MeSA) & verbenone (Hughes et al.2017)**

Insecticides have very limited use:

- Do not kill ambrosia beetles that are inside the tree.
- Broadcast sprays do not suppress ambrosia beetle populations.
- Low persistence - estimated efficacy 2-3 weeks when applied with a sticker.

Fungicides

- Alamo and Tilt
  (propiconazole)

- Macro-infusion process

- Requires professional help

Biological Control

Predators and parasitoids associated with Scolytinae in *Persea* species (Laurales: Lauraceae) and other Lauraceae in Florida and Taiwan

Jorge E. Peña[1,], Scott W. Weihman[2], Stephen McLean[3], Ronald D. Cave[4], Daniel Carrillo[1], Rita E. Duncan[1], Gregory Evans[5], Stephen Krauth[6], M. C. Thomas[7], S. S. Lu[8], Paul E. Kendra[9], and Amy L. Roda[2]*

- Multiple potential parasitoids and predators associated with infested logs but could not determine if they were AB parasites.

Biological Control

Entomopathogenic Fungi

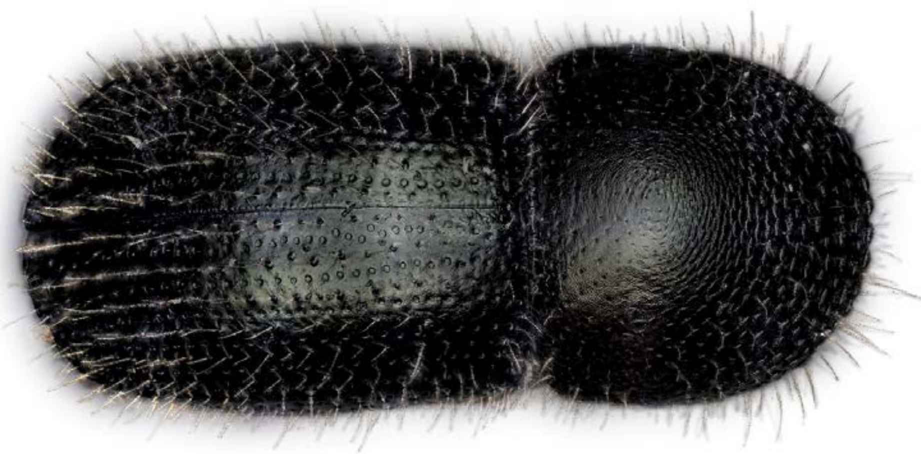
Augment beetle pathogens
and increase beetle mortality

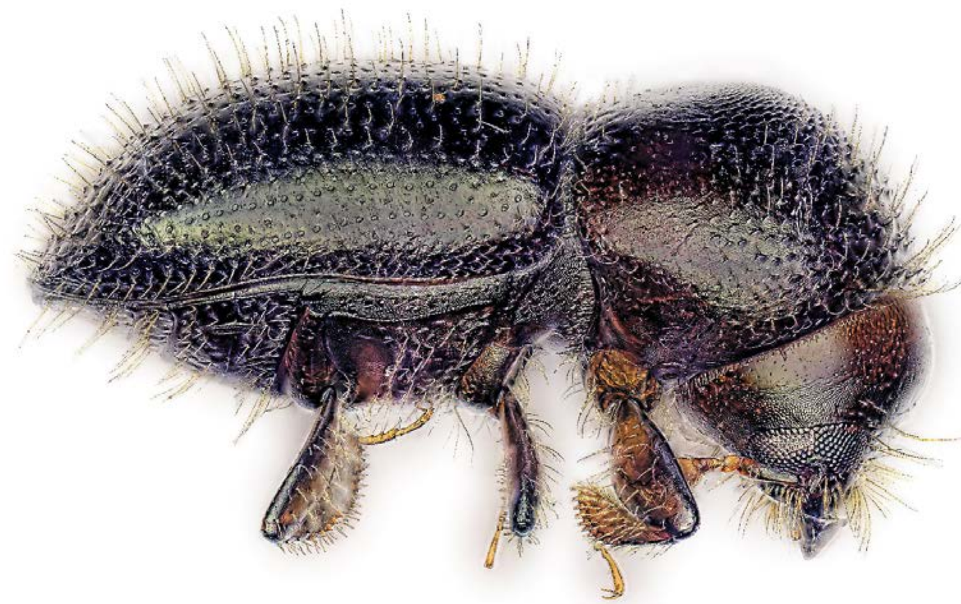
Host Resistance

- Propagation of redbay survivors from severely affected sites
- Screen for resistance to LW pathogen
- Tolerance redbays in development

Hughes and Smith 2014, Native Plants Journal

Euwallacea fornicatus species complex





- Originally thought to be one species: Tea Shot Hole Borer
- Several cryptic species, three of which are found in the US:
  - Polyphagous SHB (California)
  - Kuroshio SHB (California)
  - Tea SHB (Florida, Hawaii)

Primary nutritional symbionts- Fusarium fungi (AFC)

Fusarium dieback

- Polyphagous SHB (California) - AF 2 *Fusarium euwallaceae*
- Kuroshio SHB (California) – AF 12 *Fusarium* sp.
- Tea SHB (Florida) – AF 6, AF 8, AF 9 *Fusarium* sp.

O'Donnell K, Sink S, Libeskind-Hadas R, Hulcr J, Kasson MT, Ploetz RC, Konkol JL, Ploetz JN, Carrillo D, Campbell A, Duncan RE, Liyanage PNH, Eskalen A, Na F, Geiser DM, Bateman C, Freeman S, Mendel Z, Sharon M, Aoki T, Cossé AA, and Rooney AP. 2015. Discordant phylogenies suggest repeated host shifts in the *Fusarium - Euwallacea* ambrosia beetle mutualism. *Fungal Genetics and Biology* **82**:277-290.

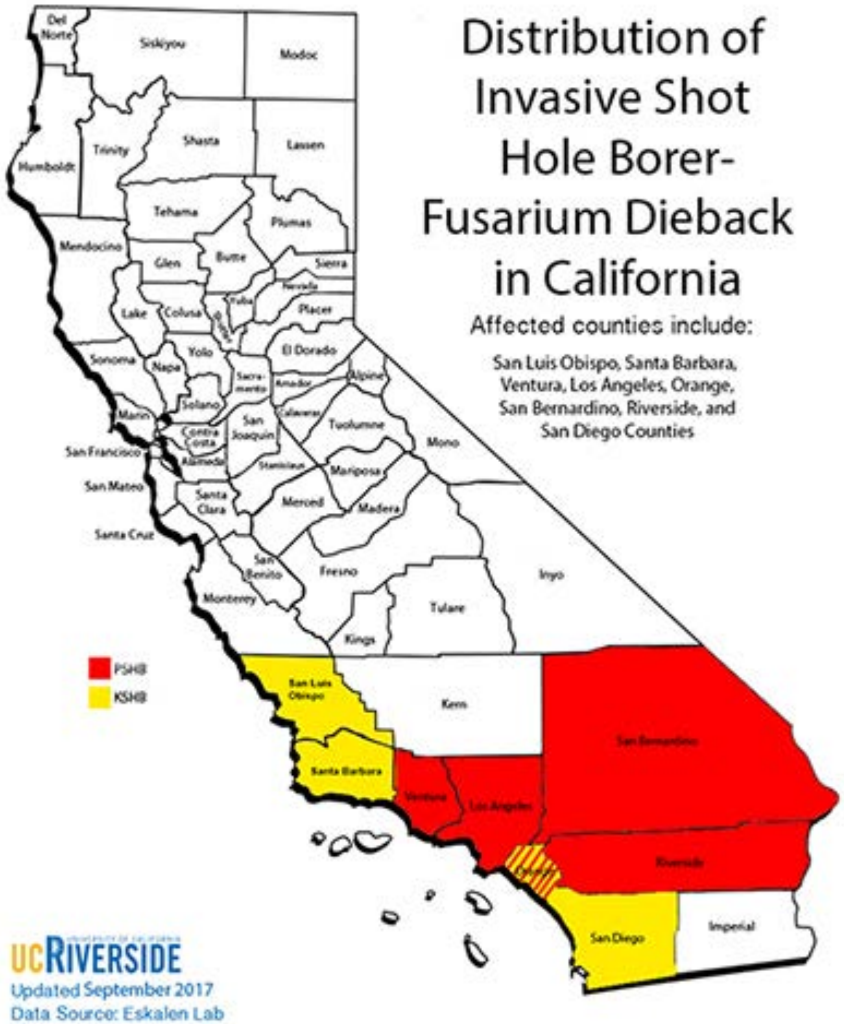
Early signs:
Sugar volcanoes

Late signs:
Frass - sawdust

Damage




- attack and kill medium and small branches
- Interior-shaded braches first, later outer branches
- base of the branch first, later all the branch
- can lead to the death of individual branches or, in severe cases, the entire tree



Impact

- Urban Forests
  - ~30% of street trees in So. CA are susceptible spp.
  - Tree removal costs about $1000 per tree
  - Danger of falling branches
- National Forests, State Forests
  - Many native, threatened, or endangered species are highly susceptible (California sycamore, red willow, white alder, coast live oak, etc.)
  - Riparian dominant spp. at risk

http://eskalenlab.ucr.edu/distribution.html

64 Hosts Support Beetle Reproduction in California

1.Box Elder (*Acer negundo*)*
2.Big Leaf Maple (*Acer macrophyllum*)*
3. Evergreen Maple (*Acer paxii*)
4. Trident Maple (*Acer buergerianum*)
5. Japanese Maple *(Acer palmatum)*
6. Castorbean (*Ricinus communis*)
7. California Sycamore (*Platanus racemosa*)*
8. Mexican Sycamore *(Platanus mexicana)*
9. Red Willow (*Salix laevigata*)*
10. Arroyo Willow *(Salix lasolepis)**
11. Avocado (*Persea americana*)
12. Mimosa (*Albizia julibrissin*)
13. English Oak (*Quercus robur*)
14. Coast Live Oak (*Quercus agrifolia*)*
15. London Plane (*Platanus x acerifolia*)
16. Cottonwood (*Populus fremontii*)*
17. Black Cottonwood (*Populus trichocarpa*)*
18. White Alder (*Alnus rhombifolia*)*
19. Titoki (*Alectryon excelsus*)
20. Engelmann Oak (*Quercus engelmannii*)*
21. Cork Oak (*Quercus suber*)
22. Valley Oak (*Quercus lobata*)*
23. Coral Tree (*Erythrina coralloides*)
24. Blue Palo Verde (*Cercidium floridum*)*
25. Palo Verde (*Parkinsonia aculeata*)*
26.Moreton Bay Chestnut (*Castanospermum australe*)
27. Brea (*Cercidium sonorae*)
28. Mesquite (*Prosopis articulata*)*
29. Weeping Willow (*Salix babylonica*)
30. Chinese Holly *(Ilex cornuta*)
31. Camelia (*Camellia semiserrata*)
32. Acacia (*Acacia* spp.)
33. Japanese Wisteria (*Wisteria floribunda*)
34. Black Willow (*Salix gooddingii*)*
35. Tree of Heaven (*Ailanthus altissima*)
36. Kurrajong (*Brachychiton populneus*)
37. Black Mission fig (*Ficus carica*)**
38. Japanese Beech (*Fagus crenata*)
39. Dense Logwood (*Xylosma avilae*)
40. Mule Fat (*Baccharis salicina*)*
41. Black Poplar (Populus nigra)
42. Carrotwood (*Cupaniopsis anacardioides*)
43. California Buckeye (*Aesculus californica*)*
44. Canyon Live Oak (*Quercus chrysolepis*)*
45. Kentia Palm (*Howea forsteriana*)
46. King Palm (*Archontophoenix cunninghamiana*)
47. Tamarix (*Tamarix ramosissima*
48- Red Flowering Gum (*Eucalyptus ficifolia*)** 49- American Sweetgum (*Liquidambar styraciflua*) 50- Honey Locust (*Gleditsia triacanthos*)
51. Brazilian Coral Tree (*Erythrina falcata*)
52. Purple Orchid Tree (*Bauhinia variegata*)**
53. Council Tree (*Ficus* altissima)**
54. Tulip Wood (*Harpullia pendula*)
55. Chinese Flame Tree (*Koelreuteria bipinnata*)**
56. Laurel-leaf Snailseed tree (*Cocculus* laurifolius)**
57. Southern Magnolia (*Magnolia grandiflora*)**
58. Jacaranda *(Jacaranca mimosifolia)***
*59. Coast coral tree (Erythrina caffra)***
60. Australian blackwood (*Acacia melanoxylon*)
61. Sweet Bay *(Magnolia virginiana)***
62. African Tulip Tree *(Spathodea campanulata)***
63. Strawberry snowball tree *(Dombeye cacuminum)***
64. Chinese Wingnut *(Pterocarya stenoptera)***

19 CA Native (*)
Canker associated (**)

Eskalen and Lynch, 2017.
Unpublished data

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http://eskalenlab.ucr.edu/distribution.html

Surveyed Distribution

TSHB in the avocado growing region of Florida

Persea americana Mill., (Lauraceae)
Lysiloma latisiliquum (L.) Bentham (Fabaceae)
Annona muricata L. (Annonaceae)
Albizia lebbeck (L.) Bentham (Fabaceae)
Manguifera indica (L.) Anacardiaceae
Delonix regia Sarg. (Fabaceae)
Persea palustris (Lauraceae)

insects MDPI

Article

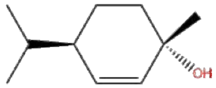
Distribution, Pest Status and Fungal Associates of *Euwallacea* nr. *fornicatus* in Florida Avocado Groves

Daniel Carrillo [1,*], Luisa F Cruz [1], Paul E. Kendra [2], Teresa I. Narvaez [1], Wayne S. Montgomery [2], Armando Monterroso [3], Charlotte De Grave [1,4] and Miriam F. Cooperband [5]

Chemical Ecology
Quercivorol

“Pheromone" of the ambrosia beetle
Platypus quercivorus (Kashigawi et al 2006)

Fungal Kairomone



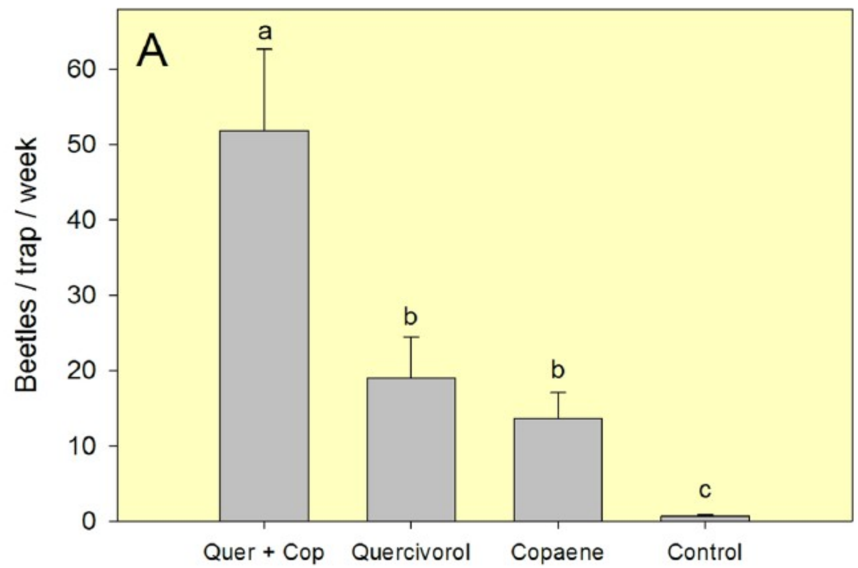
(1S,4R)-*p*-Menth-2-en-1-ol
(Quercivorol)

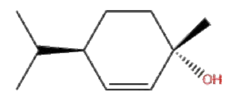
Carrillo et al. 2015. Attraction of *Euwallacea* nr. *fornicatus* to lures containing quercivorol. *Florida Entomologist* **98**:780-782. http://dx.doi.org/10.1653/024.098.0258

Dodge et al. 2017. Quercivorol as a lure for the polyphagous and Kuroshio shot hole borers, *Euwallacea* spp. nr. *fornicatus* (Coleoptera: Scolytinae), vectors of Fusarium dieback. *PeerJ* **5:e3656**. DOI 10.7717/peerj.3656

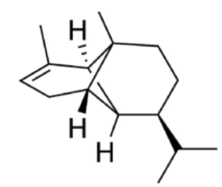
Chemical Ecology

Tea Shot Hole Borer (Florida) Quercivorol & α-Copaene





Quercivorol



α-Copaene

PLOS ONE

RESEARCH ARTICLE

α-Copaene is an attractant, synergistic with quercivorol, for improved detection of *Euwallacea* nr. *fornicatus* (Coleoptera: Curculionidae: Scolytinae)

Paul E. Kendra[1] *, David Owens[1], Wayne S. Montgomery[1], Teresa I. Narvaez[1], Gary R. Bauchan[2], Elena Q. Schnell[1], Nurhayat Tabanca[1], Daniel Carrillo[3]

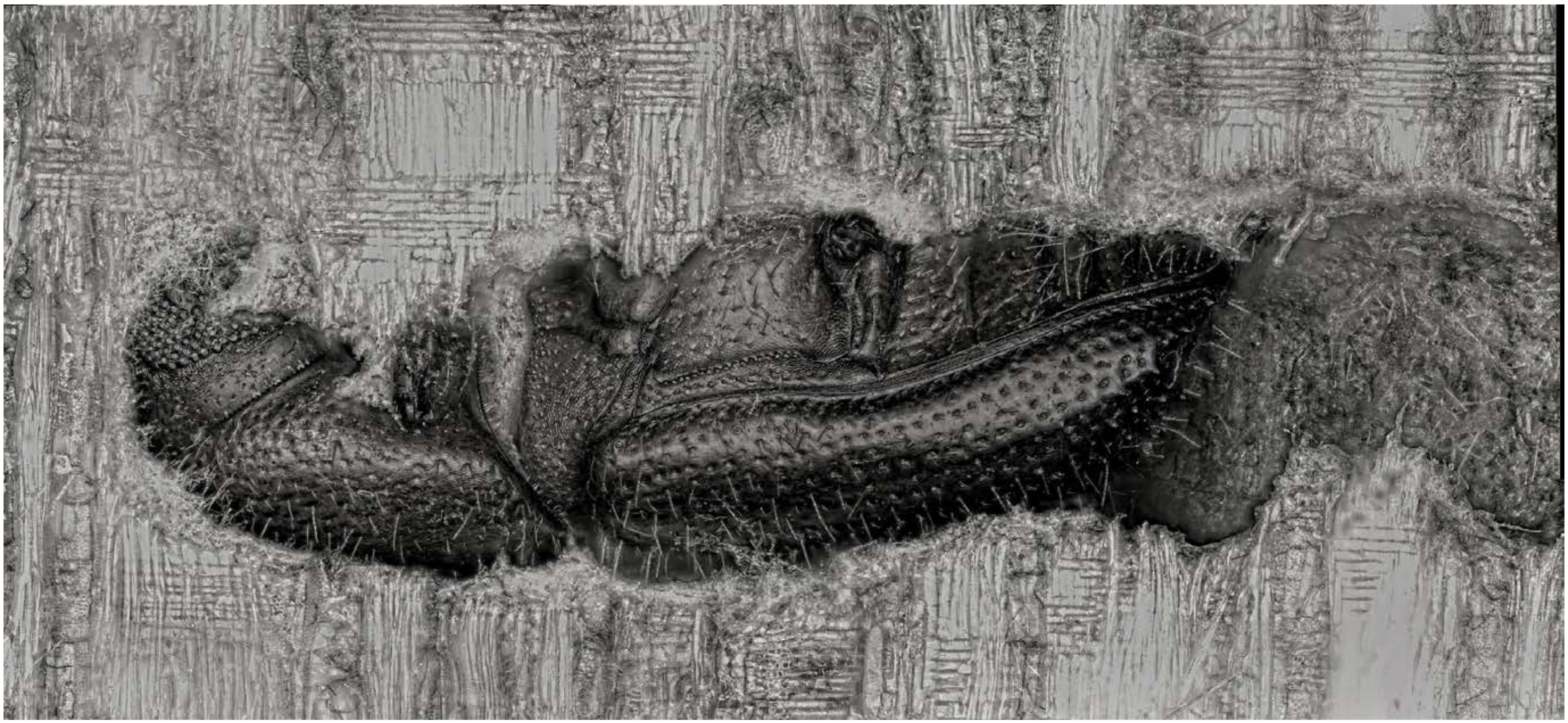
2017

Management?

- Sanitation
- Insecticide - injections (California)

  Emamenctin Benzoate, Imidacloprid
- Repellents?
- Biological control, parasitoids?

Thank you! Questions?



USDA

FLORIDA AVOCADO ADMINISTRATIVE COMMITTEE

Florida Department of Agriculture and Consumer Services
Adam H. Putnam, Commissioner

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