

# The Polyphagous Shot Hole Borer, *Euwallacea fornicatus*, a New Invasive Pest in Southern California

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# PSHB is an ambrosia beetle

- Weevils that are related to bark beetles
- Shot hole borers are a group of ambrosia beetle that make tiny entry holes in trees
- Ambrosia refers to a symbiotic fungus
- Fungus is carried along by female in special organs in the head of the beetle
- Fungus is used to infest the host plant and both adult beetles and larvae feed on fungus
- Why should we worry about this beetle/fungus complex?



# Beetle fungus complex can infest many host plants and causes branch die back and may kill host trees



Ambrosia beetle

+



Fungus (=ambrosia)

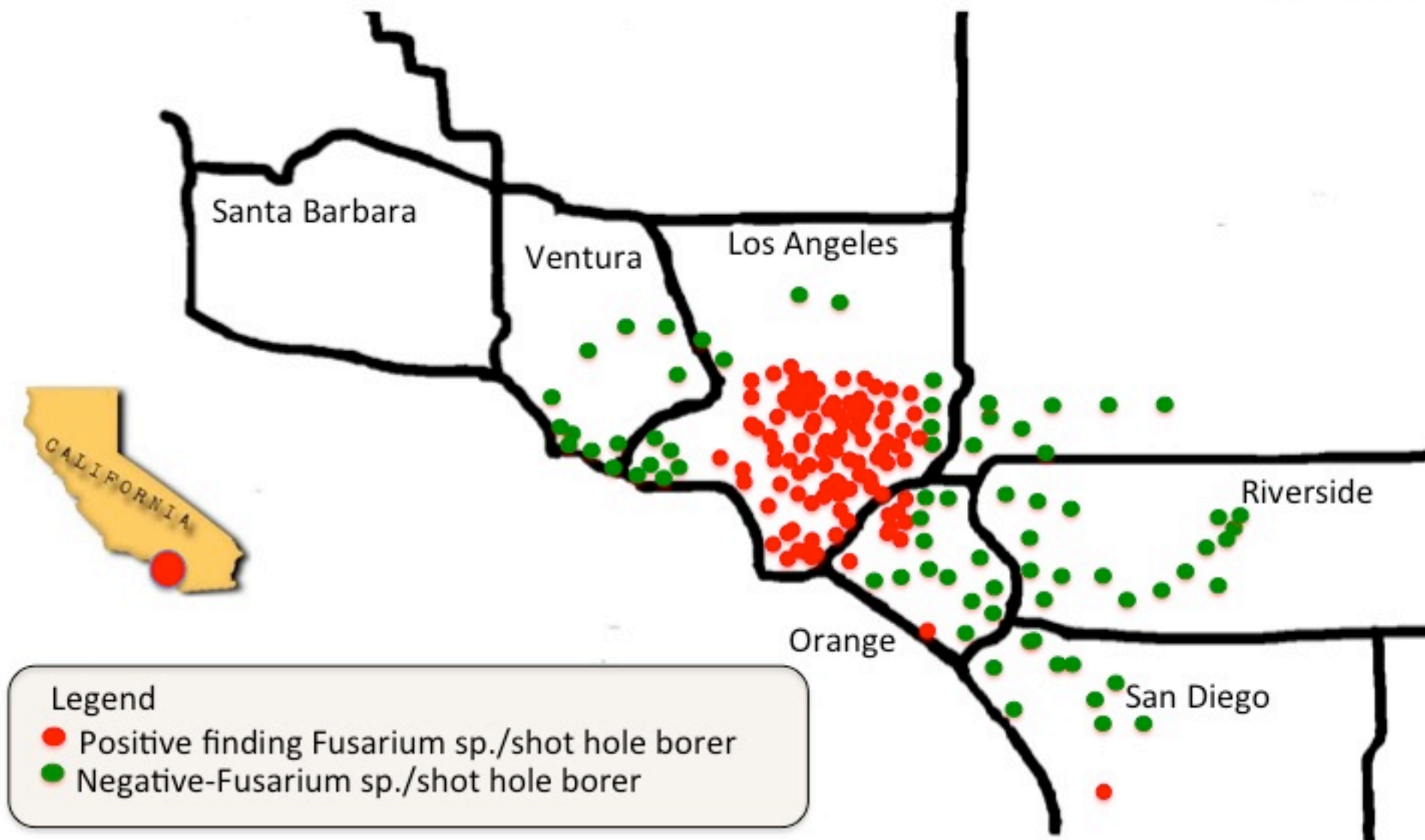


Dead Tree

# *Euwallacea fornicatus*

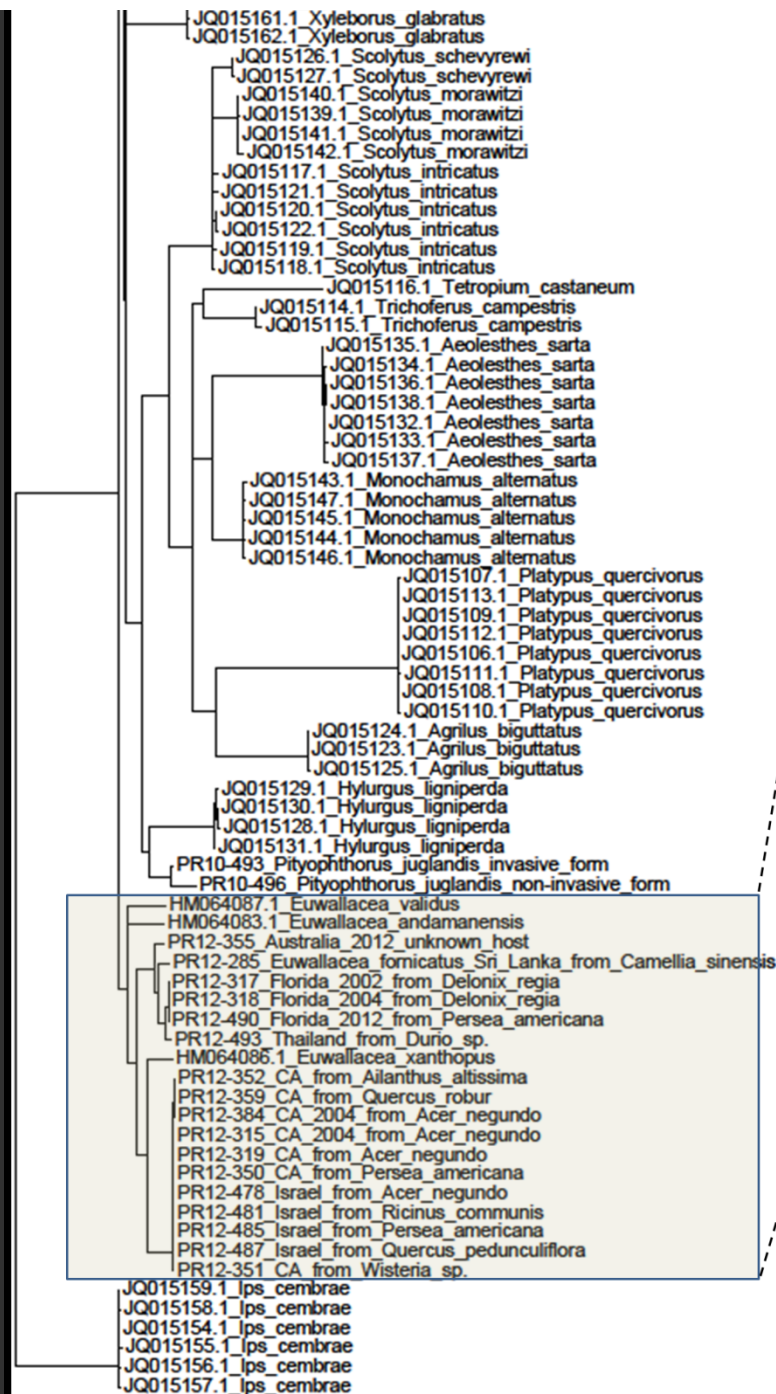
- First detected in CA in 2003 in Whittier Narrows
- Since then caught a couple of times in CDFA traps in LA County
- Caused death of large number of Box Elder street trees in Long Beach in 2010
- Problem not recognized until February 2012 when Akif Eskalen found it on a backyard avocado in South Gate
- Since then surveys have shown that
  - Widely spread in LA Co. and parts of Orange Co.
  - Attacks many host tree species





# *Euwallacea fornicatus*

- Where does the beetle come from?
  - Probably South East Asia, possibly Africa
  - Also an invasive species in Israel causing extensive damage to Avocado
- Beetle identity
  - Morphologically *E. fornicatus*
  - Based on DNA evidence it is another species
  - Suggested common name Polyphagous Shot Hole Borer



RELATIONSHIPS BETWEEN CALIFORNIAN SPECIMENS OF TSHB  
INFERRED FROM COI mtDNA SEQUENCES.

MAXIMUM-LIKELIHOOD TREE (BRANCH SUPPORT >50%)

PRODUCED USING PHYML VIA PHYLOGENY.FR

(<http://www.phylogeny.fr/version2.cgi/index.cgi>)



# *Euwallacea fornicatus*-like species

*E. fornicatus*



*E. andamanensis*



*E. xanthopus*



*E. velatus*

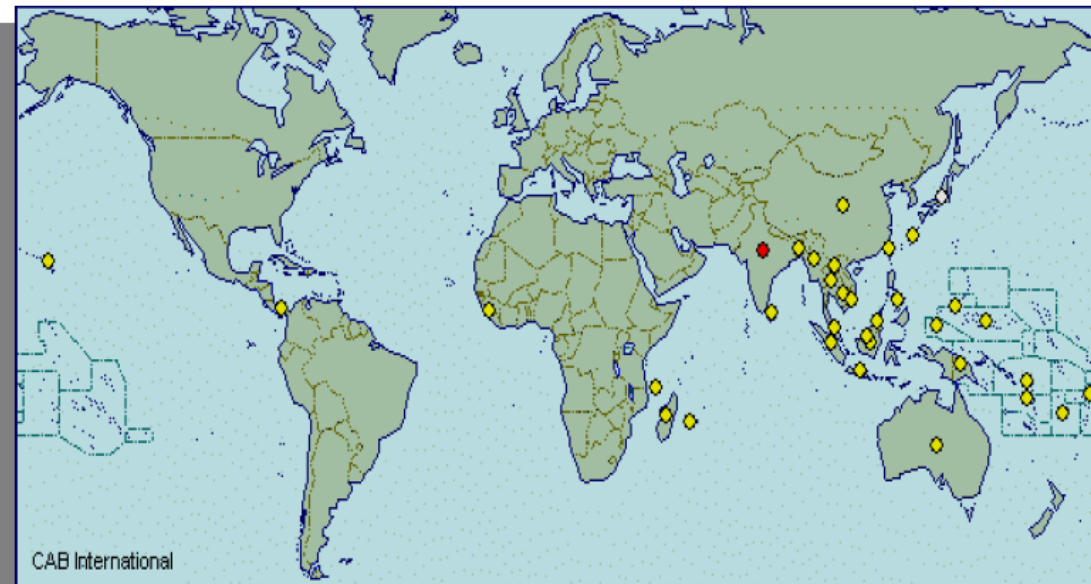


# *Euwallacea fornicatus*-like species

- ***Euwallacea xanthopus*. Synonyms:** *E. rudis*, *E. semirudis*, *E. fraternus*, *E. sereinuus*, *E. dubius*, *E. hybridus*, *E. kivuensis*, *E. interruptus*, *E. neohybridus*, *E. artehybridus*, *E. longehirtus*
- ***Euwallacea fornicatus*. Synonyms:** *E. fornicator*, *E. whitfordiodendrus*, *E. perbrevis*, *E. schultzei*, *E. tapatapaoensis*
- **California and Israeli form of beetle identical and different from the tea infesting form from Sri Lanka (original collection site of *E. fornicatus*).**
- **What do we call it? USDA needs a name.**



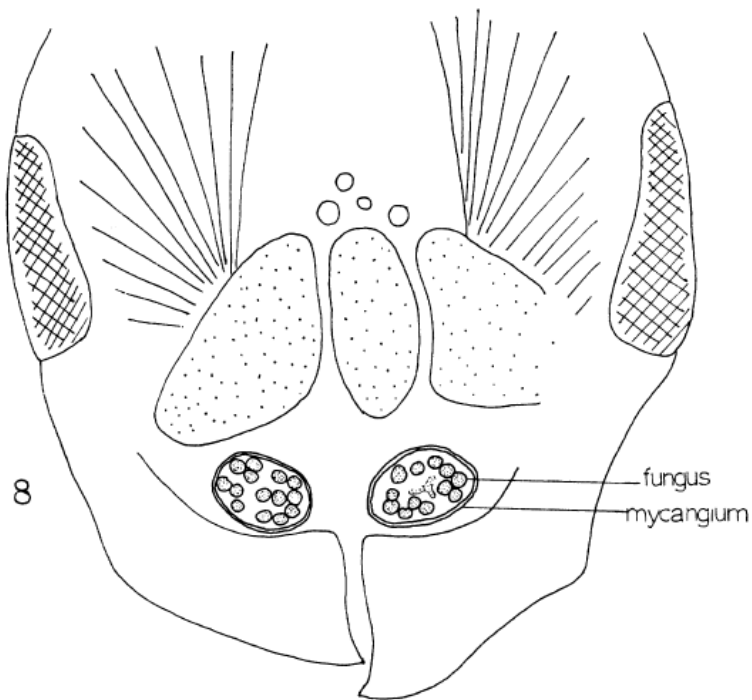
# Distribution of the TSHB



**Plate 2** Distribution of *Xyleborus fornicatus* Eichh. (Coleoptera: Scolytidae) in the world (source. CABI CPC 2004) (Yellow dot indicates at least one positive record from the country).

# Life cycle beetle

- Mated female bores into tree, creates galleries in tree, in the region that transports the water from the roots to the leaves
- Galleries are infected with symbiotic fungus (= ambrosia in this case a new *Fusarium* species) that beetle carries in mouth parts
- Fungus grows on gallery walls and spreads through the tree



# Gallery formation

- Boring the gallery takes several days
- Starts out with a straight entrance gallery
- Terminates in the wood near the cambium and then runs parallel to the outer surface of the stem
- Fungus transferred to the gallery walls
- Spores can be seen as a fine dust on the gallery wall
- No eggs found in galleries less than 8 days old
- Egg laying starts in the second week (pile at end of gallery)
- Eggs are laid on successive days
- Larvae feed on spores

# Beetle entrance



# Life cycle beetle

- Female lays eggs in galleries
- Eggs hatch and larvae feed on the fungus
- New adults after about one month



Plate 5c Isolated eggs of the beetle



Plate 5d Isolated pupae of the beetle

From Thesis Walgama 2007



# Life cycle beetle

- Sex ratio offspring very female biased, brothers mate with sisters in galleries and mated females leave the galleries to create their own galleries for offspring production
- Lifestyle leaves very few ways to combat the beetle. Single mated female can initiate new population

# Gallery formation

- Galleries in Pomegranate and Castor are found in the lower part of the trunk

**Table 2.** Total number of holes on tree trunk of castor plant.

Castor (year plant)	No. of holes/30 cm from ground level						
	30	60	90	120	150	180	210
One	18	3	—	—	—	—	—
Two	67	33	15	3	3	—	—
Two	75	12	5	—	—	—	—

From: Mote and Tambe 1989, J. Maharashtra Agric Univ 16: 439-440

# Development time

## Gadd 1941

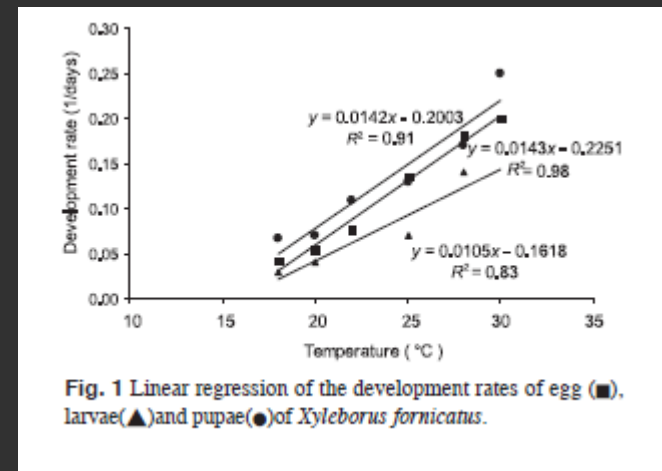
- Entrance of female to laying of first egg 8.4 days
- Egg stage 6.9 days
- Larval stages (3) 15.2 days
- Pupal stage 7 days
- Adult before emergence 2-3 days
- Total 40 days

# Degree day model

## Walgama and Zalucki 2007

- Detailed studies on development as a function of temperature on tea shoots
- Degree day model made
- Once we figure out the relationship between stem temperature and ambient temperature we should be able to determine the number of generations we can expect (if it our beetle is TSHB)
- 9 generations per year in Sri Lanka
- Using this model from 2-4 generations per year in So Cal

## Temperature dependent development rate



# Emergence from stems

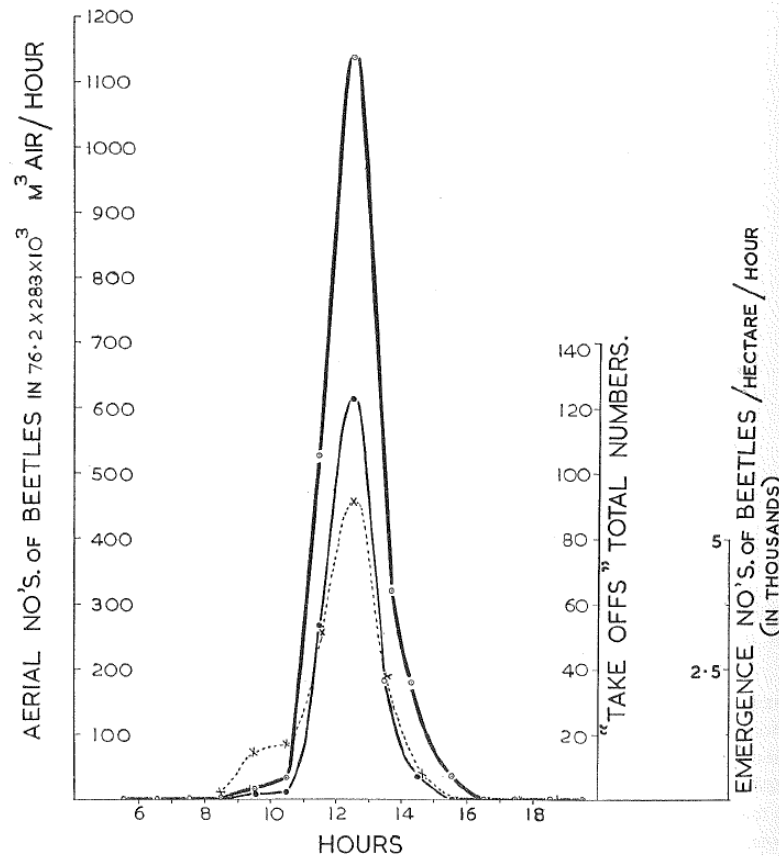


Fig. 4 'The numbers of beetles "emerging" from galleries in crop (x---x), the numbers "taking off" (—), and the integrated total aerial numbers up to 76.2 m (o—o).

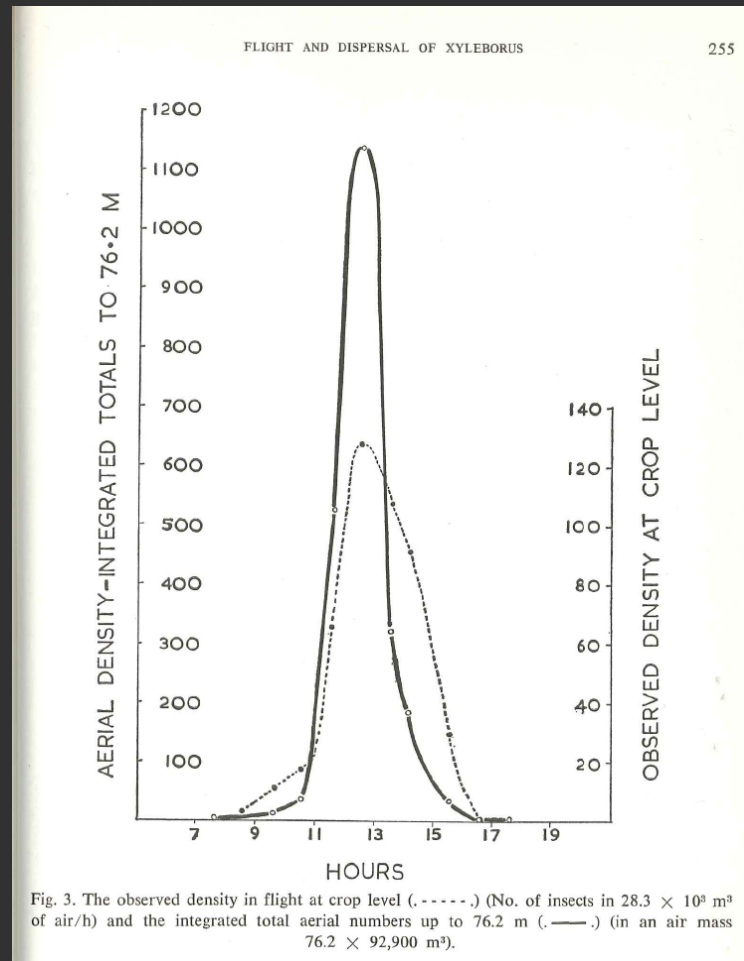
- Most beetles emerge between 11am and 2 pm
- About half of them take off
- What happens to the non-dispersers?



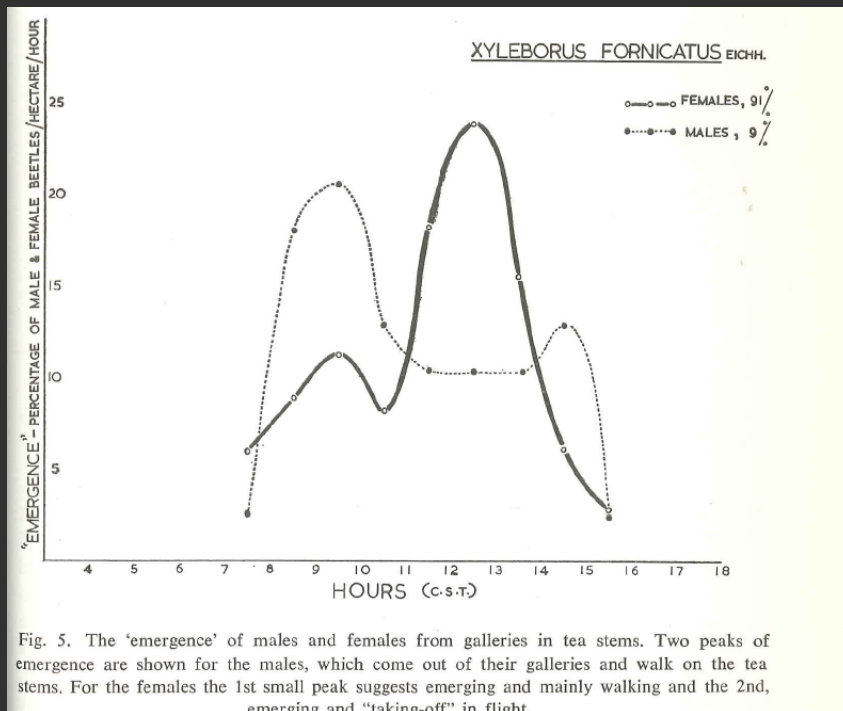
# Flight activity in Tea in Sri Lanka

## Fight activity

- Trapped with suction traps
- Only females fly
- Generally fly vertically up 6-9 m, in spiraling pattern
- Velocity w/o wind 0.3-0.6m/sec
- Longest flight in room was 24 min.
- Estimated that they could fly 430-860m without wind
- Estimated flight duration in field <1hr



# Emergence pattern of males and females



- Only females fly
- Assumed only inseminated females fly
- There is a time period after emerging from the pupae, before the beetles can fly

Calnaido, D (1965) Ent. Exp. Appl 8:249-262

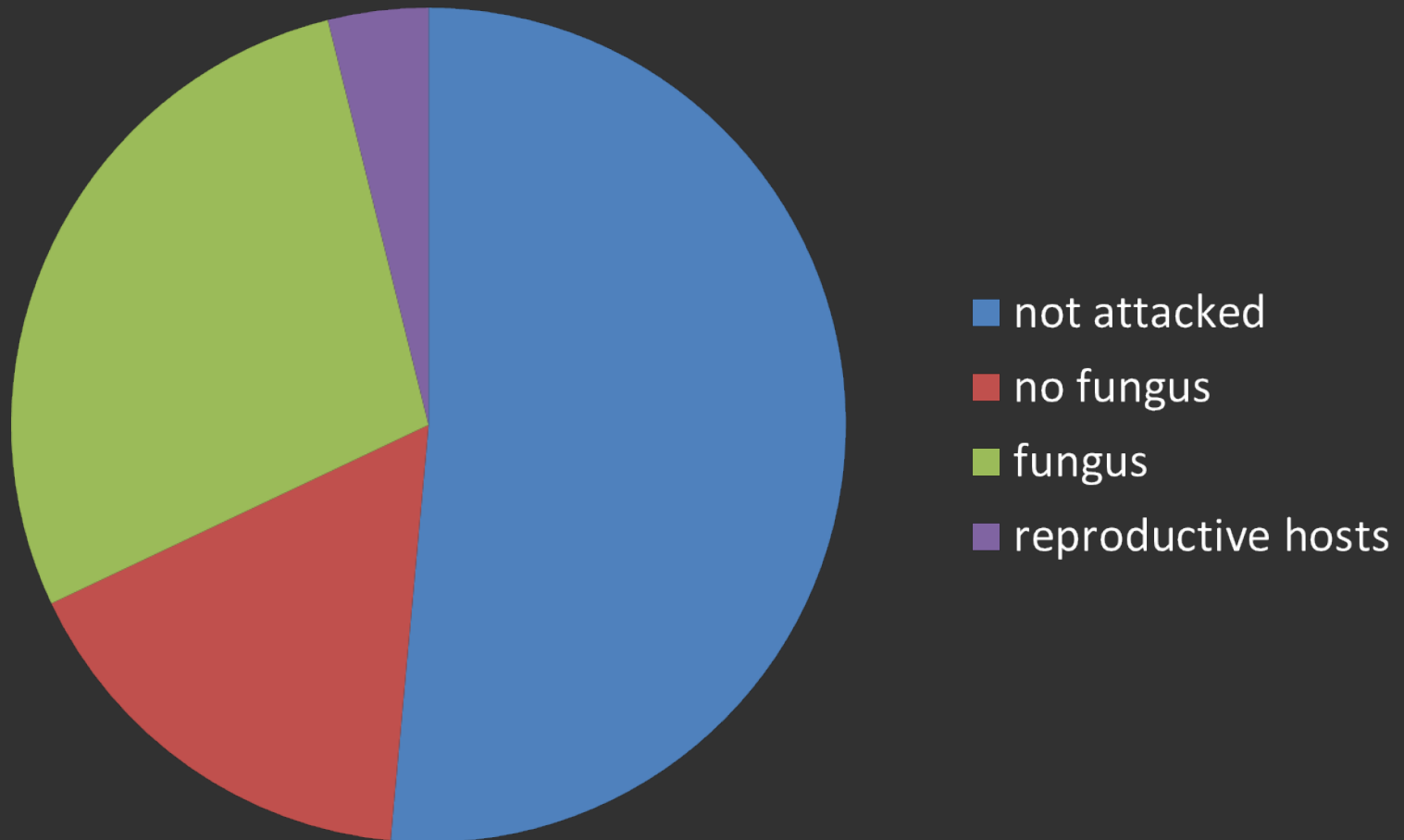
# How many species are vulnerable to beetle attack?

- Botanical gardens
- Total 341 species
- Attacked by beetle 203 sp
  - 113 the fungus grew in
  - ~15 species the beetle also reproduces on
    - Coast live oak
    - Avocado
    - Sycamore
    - Coral tree
    - Castor bean

# What happens when beetle attacks a tree?

- Appears to try out many different tree species, about 50 % of the **103 common street tree** species (50 species) in S. Cal.
- Outcome of attack:
  - Beetle is repelled, no fungus infection (17 species)
  - Beetle drills into the tree, transmits fungus to the tree but does not produce offspring on the tree (29 species)
  - Beetle is not repelled, fungus infects tree, beetle reproduces in tree (true host) at least 4 species

# 103 species of common street trees





# Beetle drills into the tree, transmits fungus to the tree but does not produce offspring on the tree

- We do not know the final outcome of this interaction
  - Often leakage of xylem fluid noticed on trunk and branches: can the tree leak to death?
  - Could still mean that the tree will suffer if the xylem vessels are clogged up and this will cause dieback of branches
  - Maybe nothing bad will happen to tree



# Beetle is not repelled, fungus infects tree, beetle reproduces in tree (true host)

- These trees suffer
- Mild symptoms will be branch dieback, severe symptoms tree death.
- Known hosts:
  - Castor bean
  - Box elder
  - Coast live oak
  - Avocado





# HostSpecies: Castor Bean

**External symptoms**



**Galleries inside trunk**



Photos  
Akif Eskalan

# Host species



Coast live oak (*Quercus agrifolia*)



# Host species Box Elder



Box Elder (*Acer negundo*)



# Host Species Avocado

- Sugar volcanoes





# Host species avocado (cv. Hass)



# In Israel PSHB has invaded commercial avocado

- First detected in 2005
- Now a serious problem in their avocado production area
- In Israel it also infects Castor and it is the same genetic form as we have here in CA
- Spreads at a rate of about 12 miles per year



Fig. 3 Galleries constructed by adult female beetles at a typical breaking point of an avocado branch

From Mendel et al 2012. An Asian ambrosia beetle *Euwallacea fornicatus* and its novel symbiotic fungus *Fusarium* sp. pose a serious threat to the Israeli avocado industry. *Phytoparasitica* :DOI 10.1007/s12600-012-0223-7



# Ambrosia Beetles are difficult to control

- Generally only short time outside the tree
- Attract
  - Sex pheromones- No
  - Aggregation pheromone No
- Repel
  - Anti aggregation pheromone- Maybe
- Influence reproduction
  - Potassium acetate added to fertilizer
  - Substantial reduction in # of eggs and # pupae
  - Not in the number of galleries
  - No evidence that this is used

# Bark Beetles are difficult to control

- Biocontrol
  - Unlikely (generalist predators)
  - One of our contacts in India has seen parasitoids
- Pesticides
  - Old literature in tea, many nasty chemicals DDT etc.
  - Fenthion is used in tea twice a year
  - Not allowed any longer in the US
  - Other bark beetles can be killed by putting pyrethroids (Bifentrin) on the bark
  - Systemic pesticides (fungicide) may be the most promising?
  - So far no good insecticidal strategy found in Israel where they have worked on it for several years

# What to do if you think you have an infestation?

- Go website of the Eskalen lab at UCR
- A submission form can be downloaded to submit a wood sample containing the fungus for identification
- Fungus will be identified to determine if it is the *Fusarium* species associated with the beetle
- If it appears that you have the beetle/fungus complex, we do not have as yet recommendations for you, but Dr. Tim Paine is working on coming up with solutions

# Conclusion

- New invasive ambrosia beetle
- Tries out many different trees (~50% of all tree species)
- Infects some of these trees with fungus (~60% of attacked tree species)
- Beetle reproduces in ~ 8% of attacked tree species
- Avocado, Coastal live oak, Box elder, Liquidambar, Sycamore
- Fungus infection and beetle reproduction can cause dieback of tree branches and death of trees
- We know little about the outcome of only fungus infection
- No known methods to control the beetle or fungus infection once it is in tree
- Looks to be a major problem in urban forest, commercial avocado and forests once it gets there.

# Funding and Collaborators

Funding: California Avocado Commission

Collaborators:

Paul Rugman-Jones, Entomology, UC Riverside

Akif Eskalen, Plant Pathology, UC Riverside

Reuben Hofshi, Hosfhi Foundation

Mary Lu Arpaia, UC Riverside

Tim Thibault, Huntington Botanical Garden

Frank McDonough, LA Arboretum

Gevork Arakelian, County Ag. Commissioner in LA

Tom Coleman, Forest Service, Southern California

