Huanglongbing: the pathogen, the disease, its transmission and horticultural effects on yield and quality

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THE PATHOGEN AND DISEASE

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HUANGLONGBING

Tree decline disease

- Characteristic yellow shoots
- Diagnostic leaf symptom 'blotchy mottle'
  - Asymmetrical chlorosis
- Sparse foliage – twig dieback
- Nutrient deficiencies often associated – Zn, Mn

Younger trees succumb more rapidly than older trees

- Disease severity reaches maximum in less than 2 years in young trees
- Older trees do not reach same severity until 8-10 years post infection (Belasque et al, 2008)

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HLB Fruit Effects

- **Fruit are small and misshaped**
  - Lopsided fruit
  - Center axis curved
  - Seeds often aborted
  - Abnormal color break – orange on peduncle end first

- **Affected fruit often fall from the tree before harvest**
  - Staining of vascular bundle below peduncle
- **Off-flavors in affected fruit**
  - Similar to less mature fruit

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3 Species of Gram Negative Bacteria Cause HLB

- ***Ca.* Liberibacter asiaticus (Las)**
  - only known species in Florida
- **Vectored by 2 psyllid species**
  - *Diaphorina citri* and *Trioza erytreae* (experimentally)

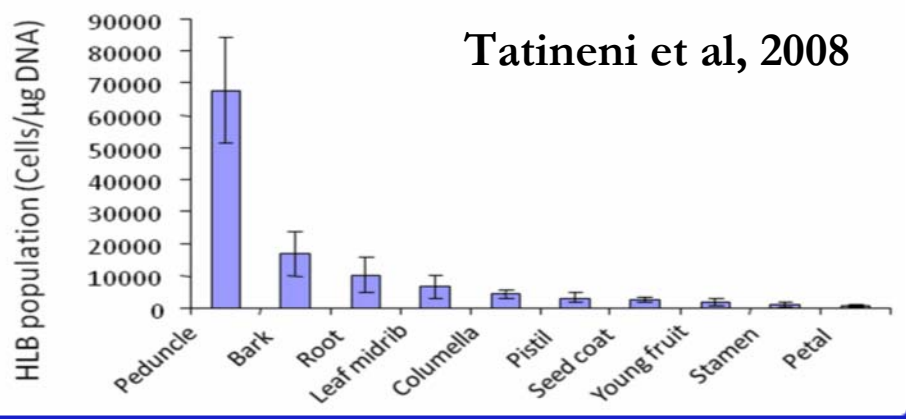
Garnier and Bové, 1983

- **Heat tolerant**
- **Found on the Indian Subcontinent, Southeast Asia, Arabian peninsula, Brazil, Louisiana and Florida**

Causal Agent Can Be Ephemeral

- **Historically not understood to be bacteria**
  - Originally thought to be caused by nutrient deficiencies, nematodes, viruses and mycoplasmas (phytoplasmas)
- **Las is unevenly distributed throughout tree**
  - As expected found in phloem dense tissues
  - In single tree, distribution patchy
    - Asymptomatic branches no bacteria were found
    - Symptomatic leaves up to 10^7 bacteria/gram of tissue

Teixeira et al., 2008



Ca. Liberibacter asiaticus genome sequenced

- **Original sequence from psyllid**
  - Confirmatory sequence from citrus phloem
    - Only organism with complete sequence found in phloem
    - As close to Koch's postulates without culture
    - Estimate of 1.7 cells / phloem cell in sample
- **Circular 1.23 Mb circular genome**
  - Confirmed part of α-proteobacteriaceae
  - Closest relatives in the Rhizobiaceae
  - Lacking Type III and Type IV secretion systems

Duan et al., 2009 and Tyler et al., 2009

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THE PATHOGEN – VECTOR RELATIONSHIP

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Pathogen-vector interaction

- **Why continue to study basic psyllid / pathogen interaction given the large amount of literature?**
- **The published "FACTS WE KNOW" include:**
  - Psyllids quickly acquire and transmit HLB
  - Once a psyllid is infected it is always infected
  - No discernable effects of pathogen on psyllid
  - Etc…

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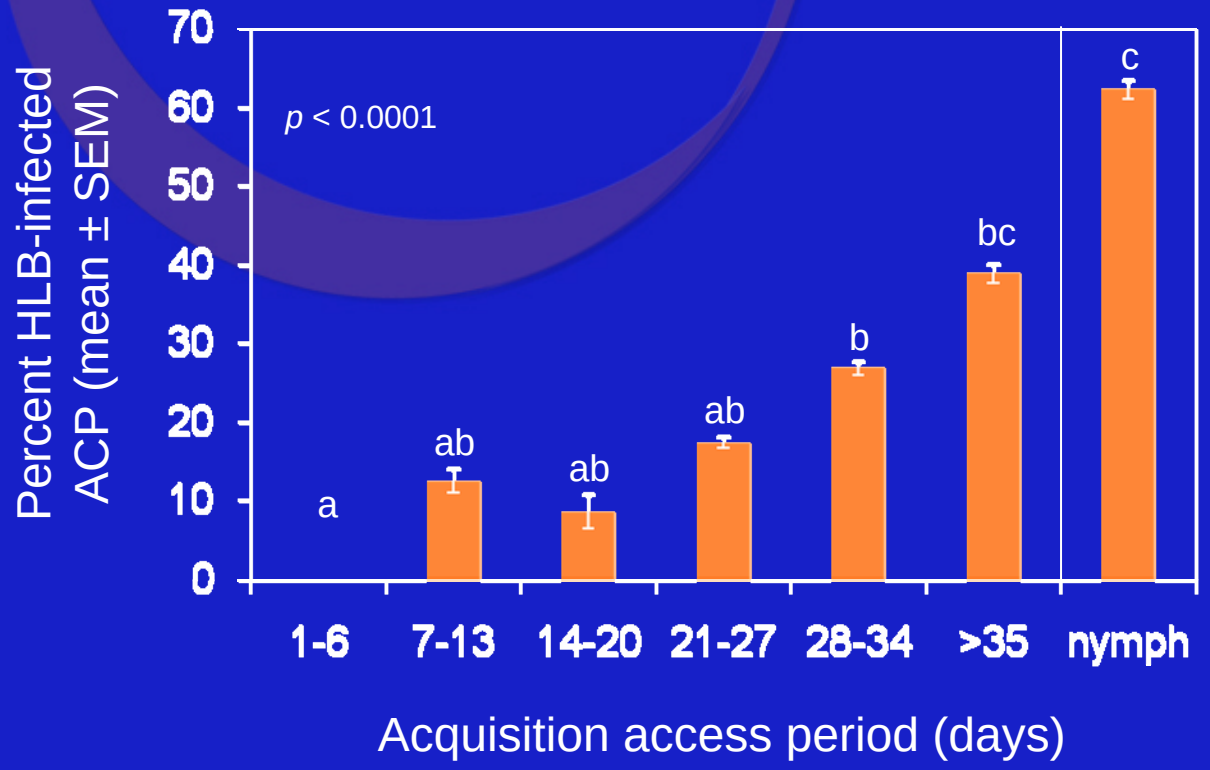
Pathogen-vector interaction

- Acquisition of Las by Asian citrus psyllid (ACP) greatest when reared on infected plant



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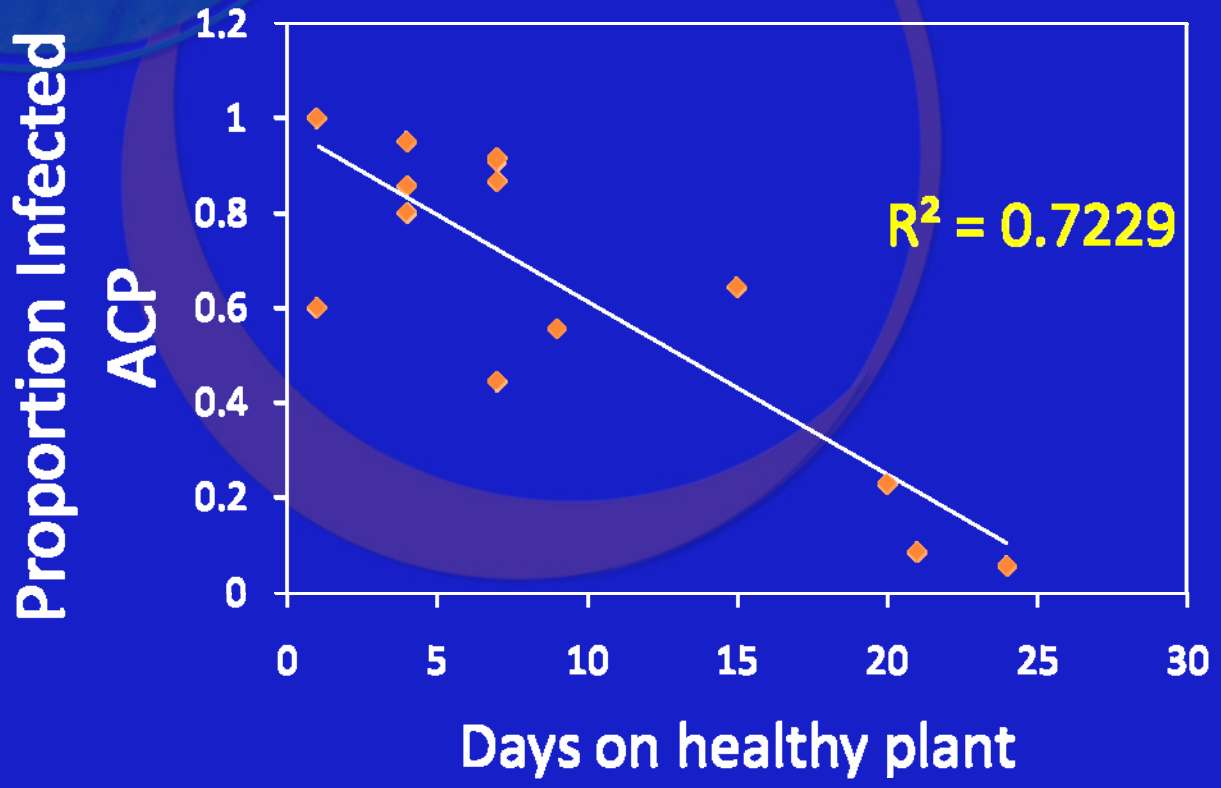
Psyllid retention of *Ca.* Liberibacter asiaticus



Retention of Las by ACP decreases over time

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Does the *Ca.* Liberibacter asiaticus affect fitness of psyllids?

Newly-emerged healthy and infected ACP placed on HLB- plants

Assessed:

- Egg production
- Adult survival
- Nymphal survival

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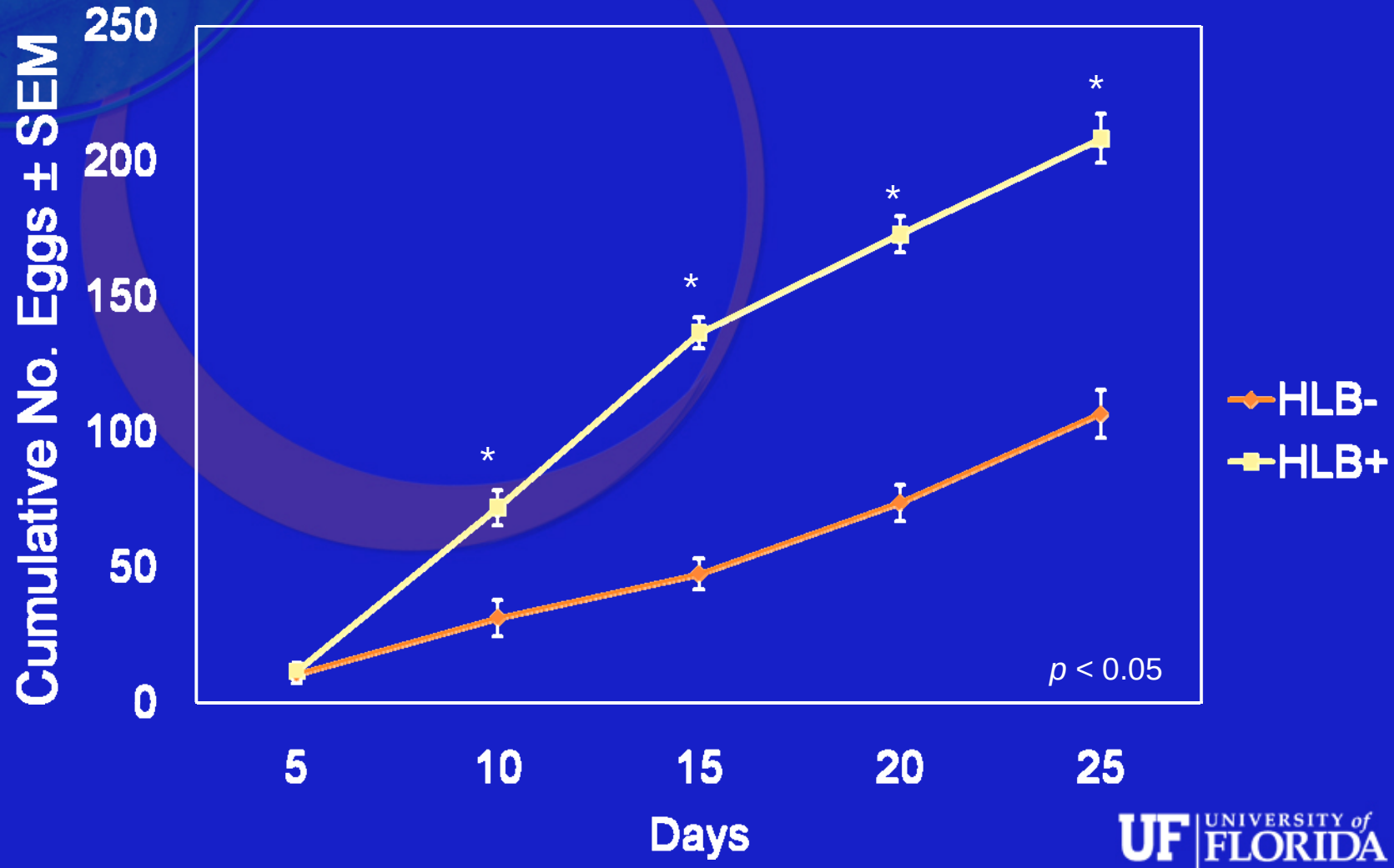
Cumulative Egg Production



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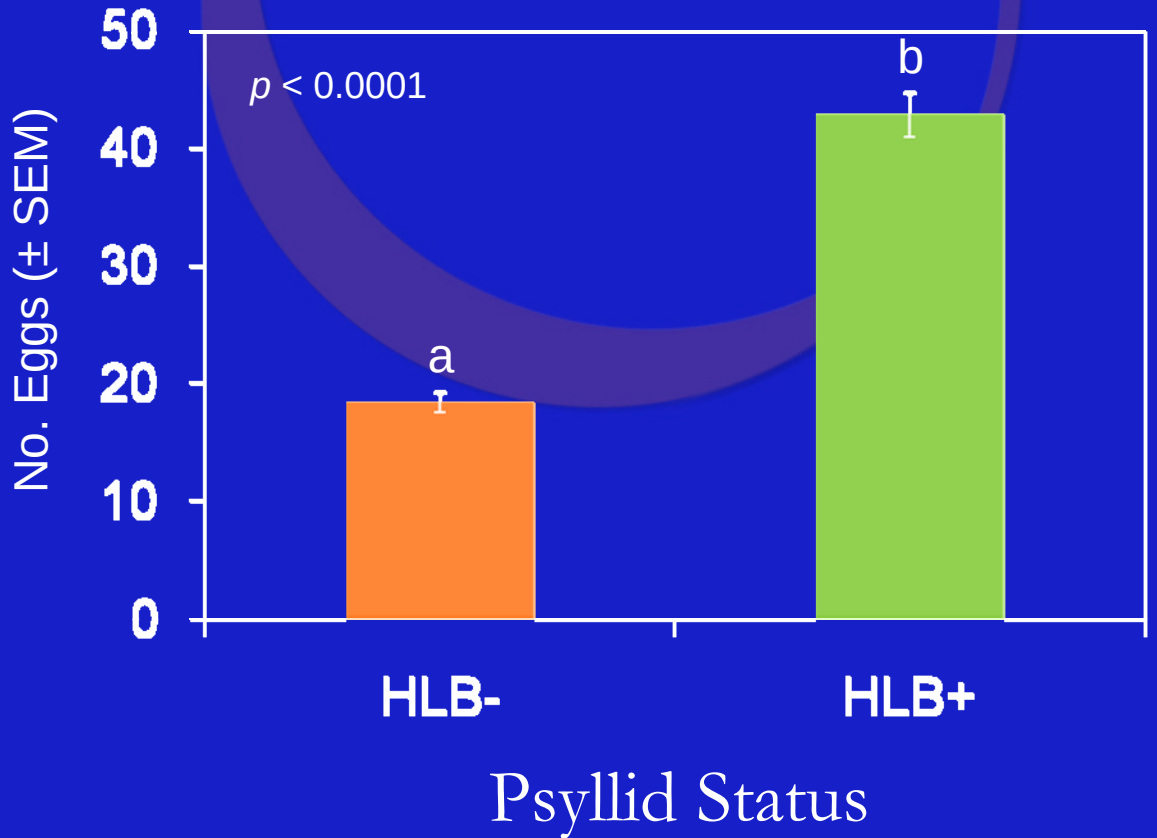
Eggs per female per 5 days



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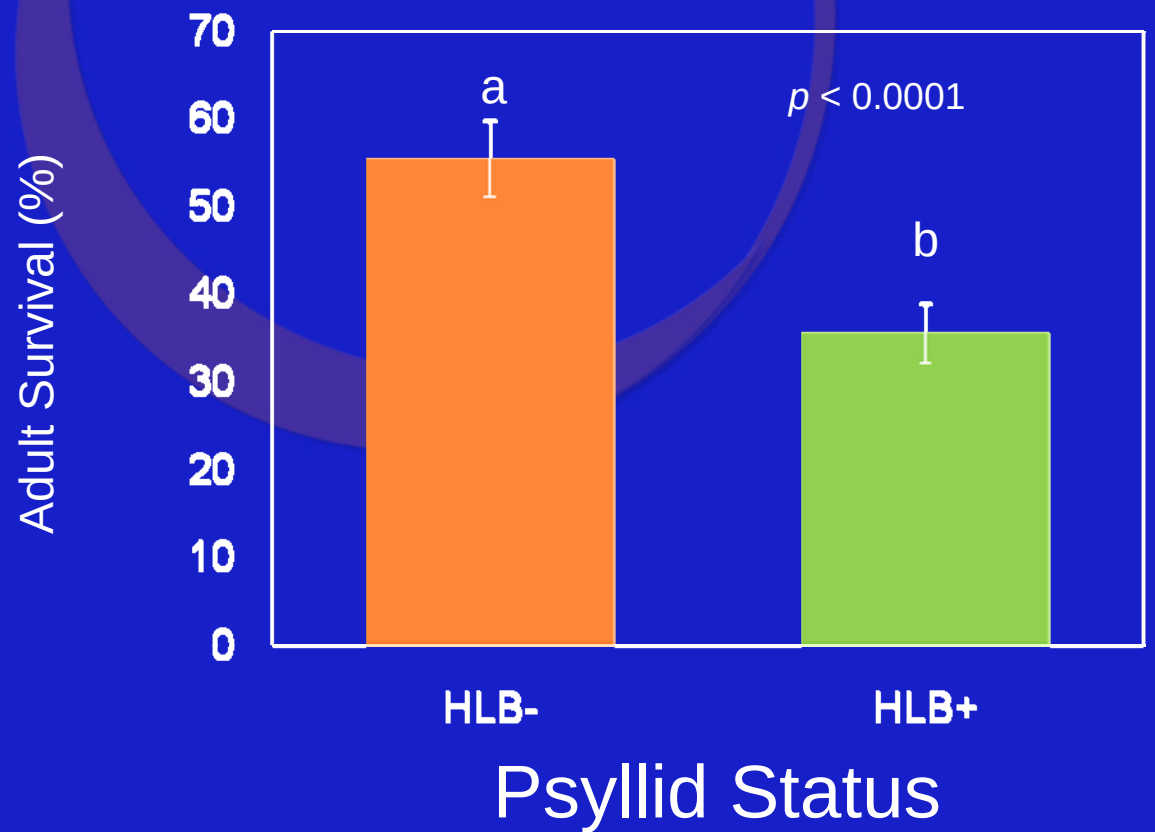
Adult Survival



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Nymphal survival

Preliminary results:

- No differences in the number of nymphs emerged from HLB+ and HLB- ACP
- Work ongoing

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Conclusions

- We didn't really know what we thought we knew!
- Acquisition greatest by nymphs
- The "fact" that adults retain pathogen their entire lives is not necessarily true
- Presence of HLB+ trees will increase the likelihood of HLB+ psyllids (continued feeding)
- *Ca.* Liberibacter asiaticus does affect fitness of adult psyllids: increased egg laying, shorter lifespan

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HORTICULTURAL EFFECTS OF HLB

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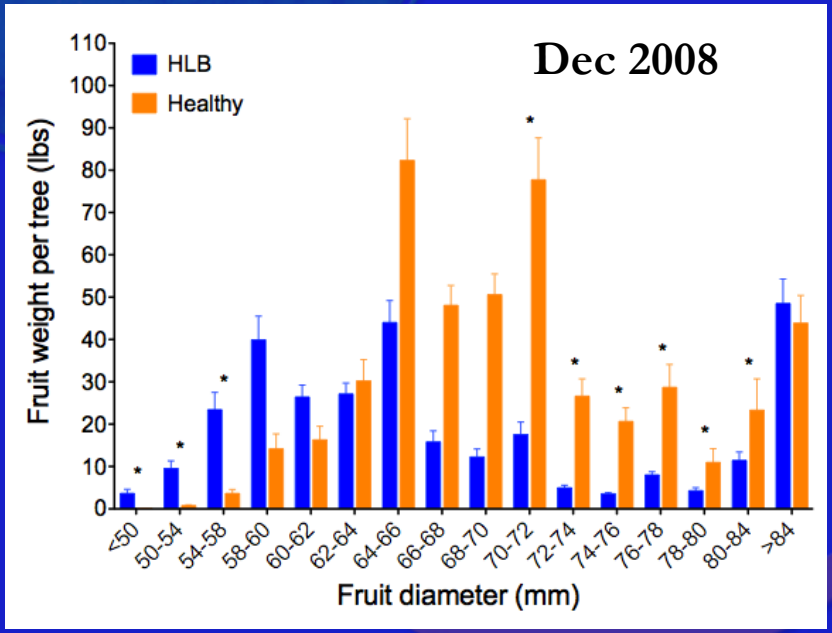
Introduction

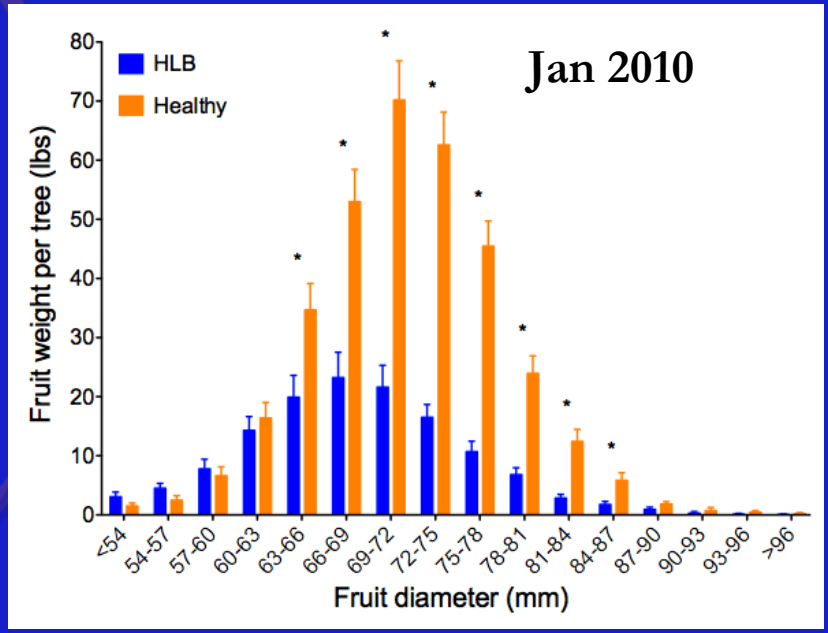
- HLB infection results in small, misshapen, lopsided fruit that drop prematurely
- Juice from fruit displaying these symptoms is similar in quality to juice from less mature fruit (Dagulo *et al.* 2010)
- Groves can become unproductive in as little as 2-4 years (Ke *et al.* 1988)
- Yield can be reduced by 10 to 80% depending on percent of canopy affected (Bassanezi *et al.* 2006)
- What happens to yield and quality over time

Methods

- 10 HLB infected and 10 healthy trees harvested
- Fruit sized, counted and weighed
- 1 sack of small fruit and 1 sack of "average size" fruit sampled from each tree
  - °Brix, acid, ratio and color
- Yield per tree – pieces of fruit and total weight

Hamlin Sweet Orange





Average total tree yield (kg) for Hamlin trees harvested in two successive seasons.

	Hamlin	
	Dec 2008	Jan 2010
Healthy	217.0	69.7
HLB	136.4	29.6

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Hamlin Juice Analysis

December 2008 Hamlin juice quality parameters

		°Brix	Acid	Ratio	Color	Juice Yield (ml/fruit)
HLB	Small	9.25 c	0.95 a	9.87 b	34.38 c	29.45 d
	Average	10.98 a	0.70 b	15.65 a	35.47 b	75.49 b
Healthy	Small	10.37 b	0.67 bc	15.73 a	36.11 a	47.05 c
	Average	9.58 c	0.64 c	14.97 a	36.32 a	92.75 a

January 2010 Hamlin juice quality parameters

		°Brix	Acid	Ratio	Color	Juice Yield (ml/kg)
HLB	Small	11.27	0.57 a	19.88 ab	35.44 ab	336.1 b
	Average	10.88	0.57 a	19.13 b	35.13 b	368.0 a
Healthy	Small	11.54	0.54 ab	21.60 a	35.63 a	382.6 a
	Average	11.27	0.52 b	21.65 a	35.55 ab	387.5 a

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Conclusions

- HLB infected trees have more small fruit
- Only small, symptomatic fruit show quality changes
  - Similar to immature fruit
- Due to normal year-to-year variation in fruit sizes and yield it is too early to know for sure the long term effects

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