Annual Central Coast Strawberry Meeting
Watsonvillle, February 5, 2013

Drosophila and Mites in Strawberries, 2013?

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Drosophila spp. - aka 'Vinegar flies'

Usually considered a processing concern.

One of the few insects considered a contaminant in processed products by the Food and Drug Administration, depending on the crop and type of product.

Drosophila spp. - aka 'Vinegar flies'

Has been an export phytosanitary concern.

Quality assurance protocol developed for shipping frozen strawberries to Japan in 1997.

Drosophila spp. - *aka* 'Vinegar flies'

Vinegar flies are rarely ever a problem in fresh production fields where they are incidentally managed by incidental controls such as relatively frequent harvests, sanitation (keeping the field free of old, over ripe or rottin fruit), and insecticides applied for other insects

Drosophila spp. - *aka* 'Vinegar flies'

Guidelines for managing vinegar flies, developed as quality control standards following the 1997 incident with shipments to Japan included:

- Monitoring for presence of adult flies
- More frequent harvests
- Sanitation
- Insecticides

Drosophila spp. - *aka* 'Vinegar flies'

Camarillo, 2012

Drosophila spp. - *aka* 'Vinegar flies'

Sources

Drosophila spp. - *aka* 'Vinegar flies'

Sources

Some of the problem was due to insufficient labor that increased harvest intervals and precluded removal of old fruit.

Some of the problem was lack of monitoring for vinegar flies and application of treatments only after the problem had become severe.

Drosophila spp. - *aka* 'Vinegar flies'

Traps will capture many species and other flies, too

Traps contain either:

baker's yeast + sugar + water

or apple cider vinegar

Drosophila spp. - *aka* 'Vinegar flies'

Insecticides won’t control the maggots once fruit are infested, they can only knock down adult flies and protect uninfested fruit.

- Organophosphates
  - Malathion
- Pyrethroids*
  - Danitol, (Brigade, Bifenture)
- Spinosyns
  - Entrust, Success, Radiant

** Using pyrethroids can exacerbate Lygus resistance*

Spotted Wing Drosophila

Drosophila suzukii

New species in North America
Attacks sound fruit
Problem for fresh market

Drosophila melanogaster and other species

Always present
Attacks older fruit
Problem for processing

Spotted Wing Drosophila

Identification

Male

Female

Adults are 2-3 mm in size. Females and their larvae (maggots) are easily confused with other *Drosophila*

Spotted Wing Drosophila

Other *Drosophila*

Drosophila suzukii

Female *D. suzukii* have a specialized sharp ovipositor that is different from other common *Drosophila*.

Spotted Wing Drosophila

Management is same as for all *Drosophila*

- Sanitation, remove mature and overripe fruit
- Sanitation, eliminate alternate habitat (culled fruit and abandoned host fields) that sustains the infestation
- Monitoring and trapping to quickly detect infestations - get ahead of the damage
- Use insecticidal sprays or baits to suppress fly populations
  - organophosphates, pyrethroids, spinosyns

Spotted Wing Drosophila - research

- Seasonal trapping of *D. suzukii* in Watsonville raspberries with Mark Bolda and Monise Sheehan
  - Adult trap lure comparison (yeast vs. vinegar)
  - Vacuum sampling
  - Larval sampling

Spotted Wing Drosophila - research

New project with Mark Bolda, monitor D. suzukii and other *Drosophila* in strawberries:

- Monitor densities and fruit damage at different distances from infested host fields
- Effect of harvest interval on fruit infestation

Spotted Wing Drosophila - research

Collaborations on *D. suzukii* biology

Dr. Zain Syed

- *D. suzukii* scent/taste organs
- Electroantennagrams
- Host odor profiles

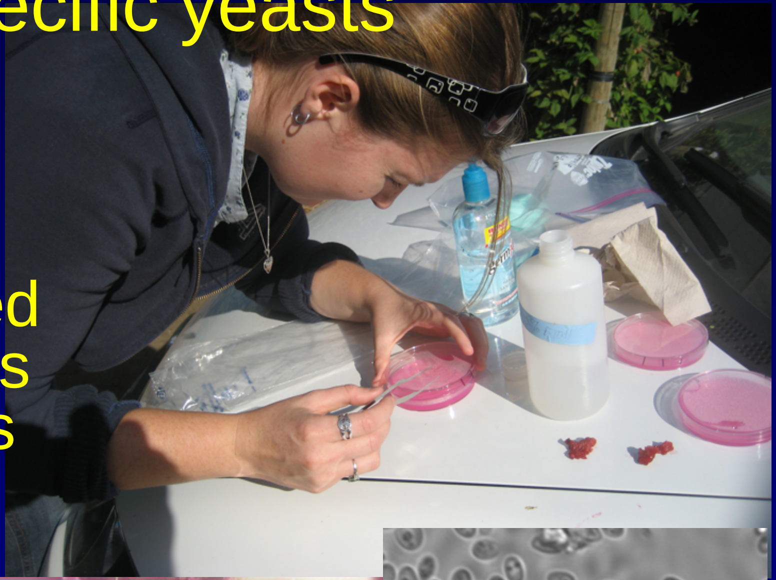
D. suzukii yeast associations

Yeasts are an important food source for *D. melanogaster*, and they have recently been found to cultivate or ‘farm’ specific yeasts

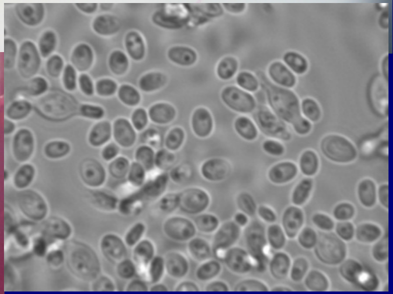
Are species-specific yeasts more attractive?; implications for better trapping and baits

Isolated yeast from juice of infested fruit, adult midguts, and larval frass from both cherries and raspberries

A few of the yeast species were found in most samples



A maggot ‘walk’ on a yeast plate

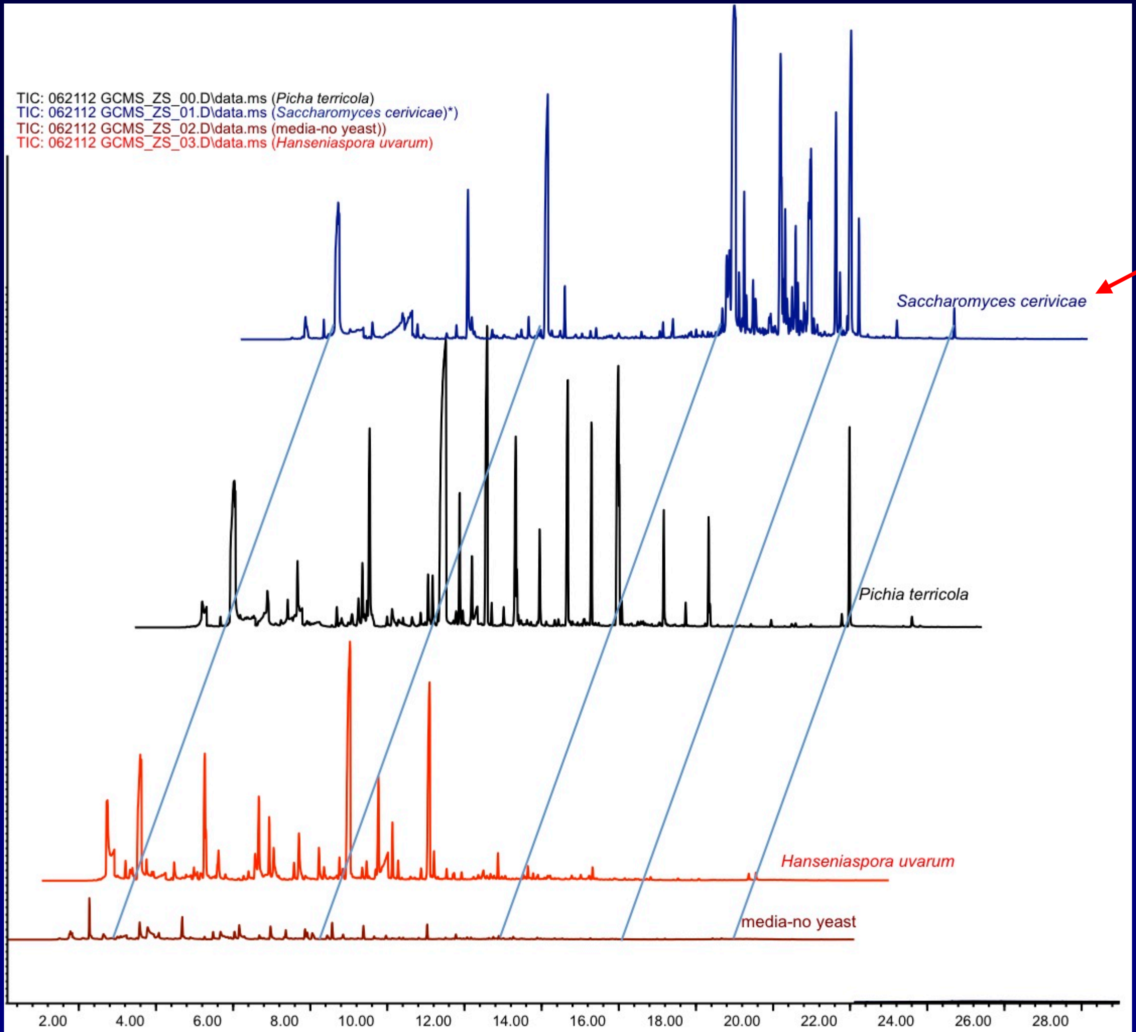


Hamby, K.A., Hernández, A., Boundy-Mills, K., and F.G. Zalom
Applied and Environmental Microbiology 2012, 78(14): 48-69.

TABLE S1 Summary of total yeasts (n = 126) isolated from all locations and fruit varieties. Fruit varieties(n): U, unknown; R, Rainier; R, Royal Ann;I, Isabel; M, Maravilla; P, Pacifica.

	Cherry										Raspberry										
	Adult	Larva			Uninfested Fruit			Infested Fruit			Adult	Larva			Uninfested Fruit			Infested Fruit			
Yeast Isolated	U(3)	R(4)	RA(2)	U(7)	R(1)	RA(1)	U(2)	R(1)	RA(1)	U(1)	P(8)	I(6)	M(8)	P(7)	I(1)	M(2)	P(2)	I(1)	M(2)	P(2)	**Total**
Hanseniaspora uvarum	3	4	2	7	1	0	2	1	1	1	8	6	6	7	1	2	2	1	2	2	**59**
Pichia terricola	0	0	0	0	0	0	0	0	0	1	1	1	0	2	0	0	1	1	1	2	**10**
Pichia kluyveri	1	0	0	3	0	0	0	0	0	1	0	2	0	0	0	0	0	1	0	1	**9**
Aureobasidium pullulans	0	0	0	0	1	0	2	1	1	0	0	0	0	0	0	0	0	0	0	0	**5**
Metschnikowia pulcherrima	0	0	0	2	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	**5**
Cryptococcus magnus	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	0	**3**
Cryptococcus victoriae	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**3**
Hanseniaspora occidentalis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2	**3**
Metschnikowia gruessii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	1	0	0	1	**3**
Cryptococcus carnescens	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
Cryptococcus macerans	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
Debaryomyces hansenii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	1	**2**
Metschnikowia fructicola	0	0	0	0	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	**2**
Metschnikowia reukaufii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1	0	**2**
Sporobolomyces beijingensis	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	**2**
Udeniomyces pyricola	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	**2**
Candida asiatica	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**
Candida diversa	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	**1**
Candida quercitrusa	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Candida railenensis	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Candida xylopsoci	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	**1**
Cryptococcus festocosus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	**1**
Debaryomyces nepalensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**
Metschnikowia chyrsoperlae	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	**1**
Meyerozyma guilliermondii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	**1**
Moniliella megachiliensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	**1**
Sporobolomyces odoratus	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	**1**
Sporobolomyces ruberrimus	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**1**

Preliminary Results

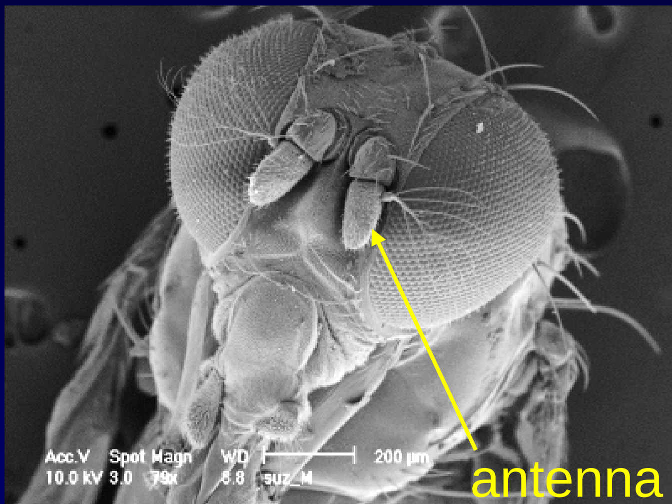


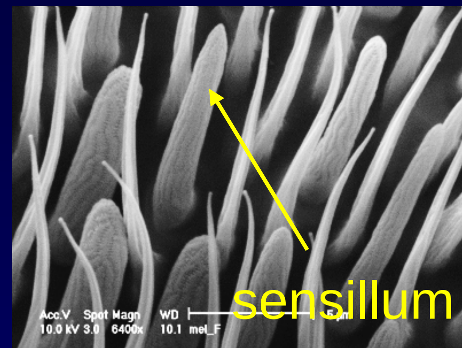
baker's yeast

Nicole Sheidle,
Grad student
University of Notre Dame

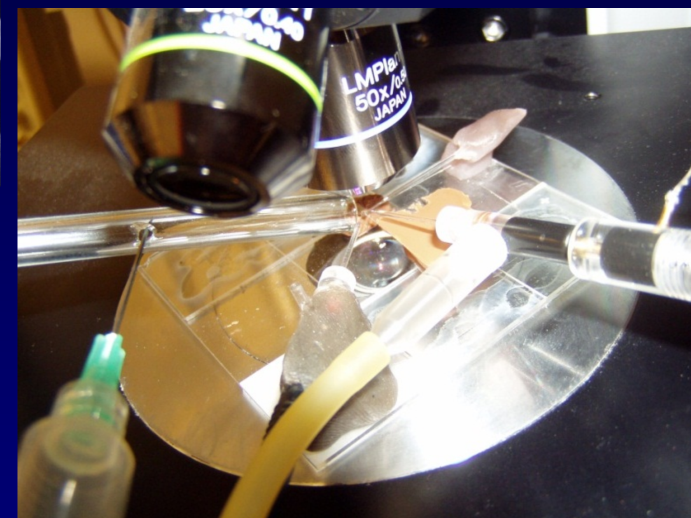
Yeast-associated volatile profiles

D. suzukii scent detection

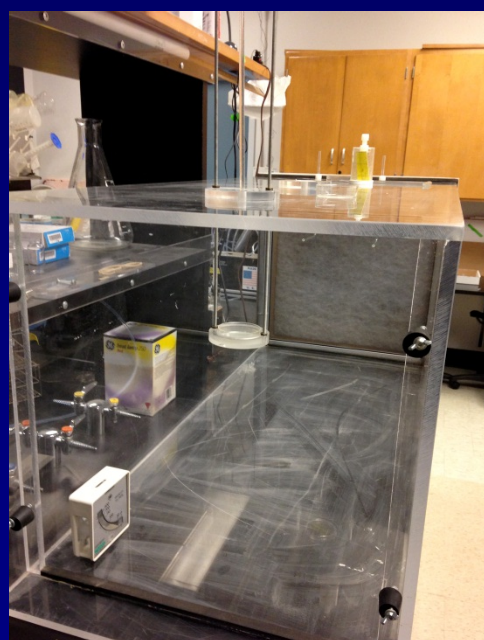


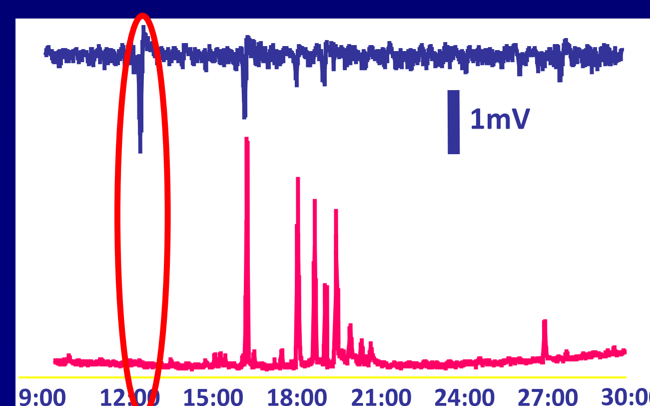


electroantennagram



flight chamber





Spotted Wing Drosophila - research

Collaborations on *D. suzukii* biology

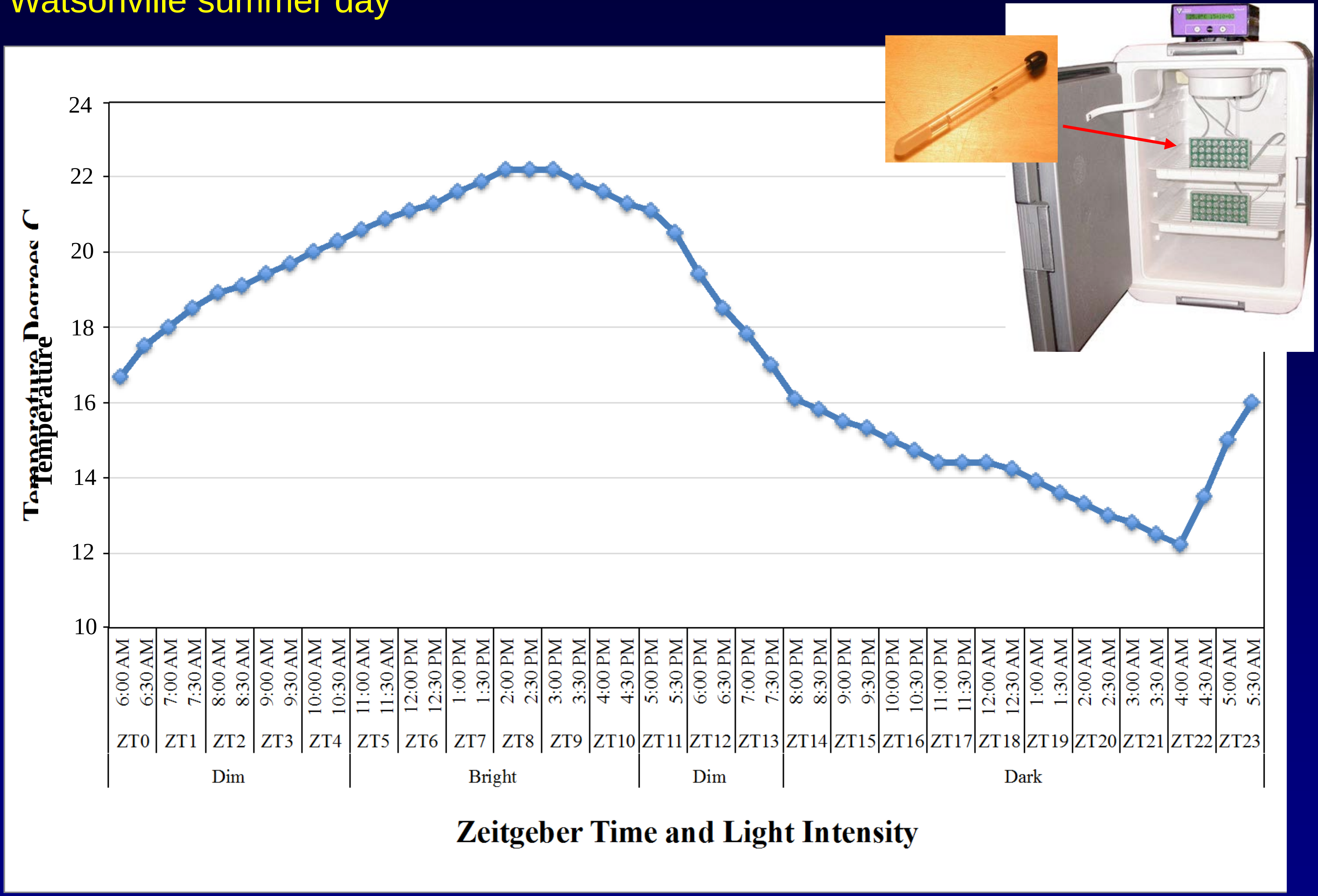
Dr. Joanna Chiu

Circadian rhythms

- Activity monitoring system
- Insecticide activity

Circadian rhythm - ('biological clock'); A daily cycle of biological activity based on a 24-hour period and influenced by regular variations in the environment, such as the alternation of night and day.

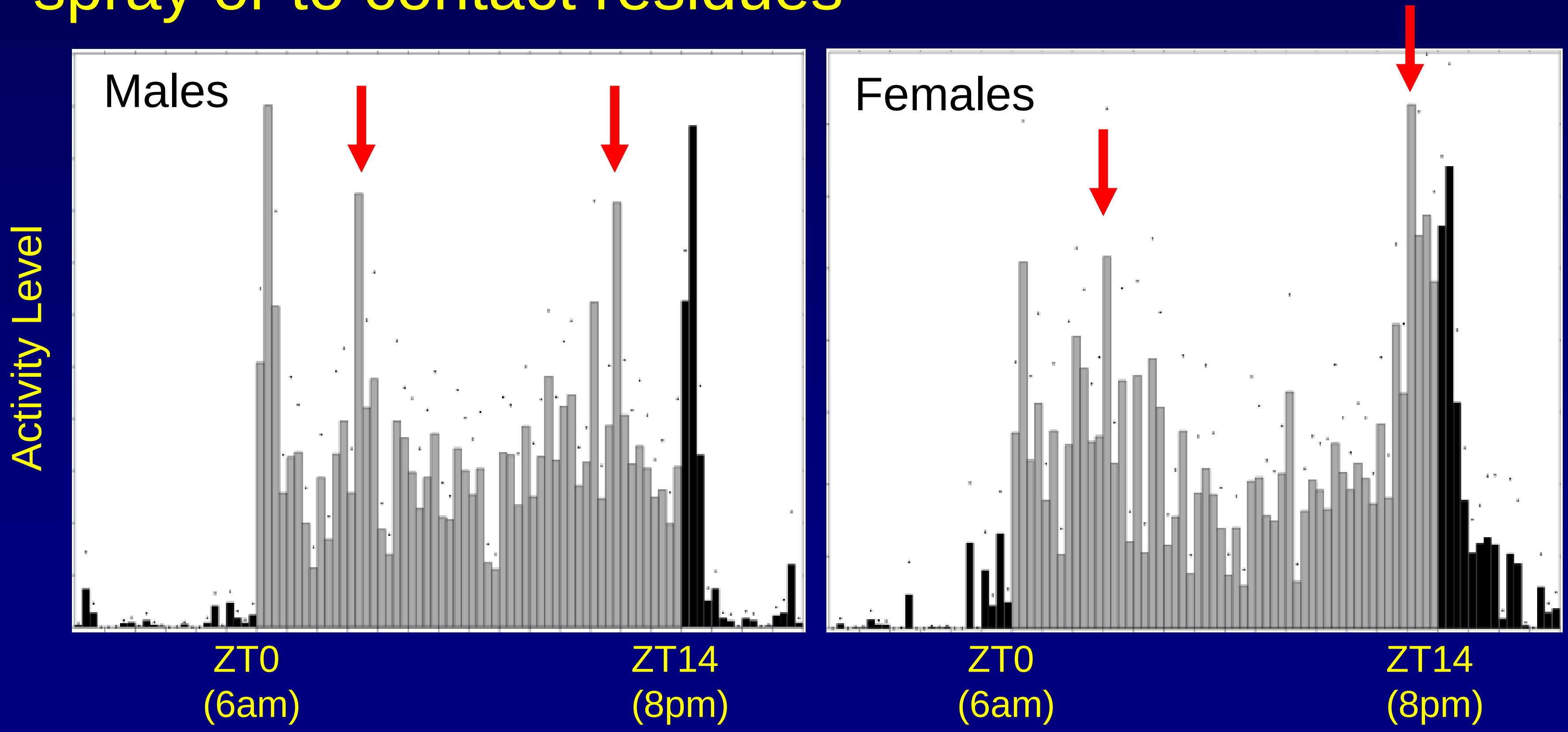
Studies are performed in a growth chamber programed to be similar to a Watsonville summer day



Circadian rhythms and pesticide efficacy

If flies more active, they are more likely to be more easily vacuumed or captured in traps

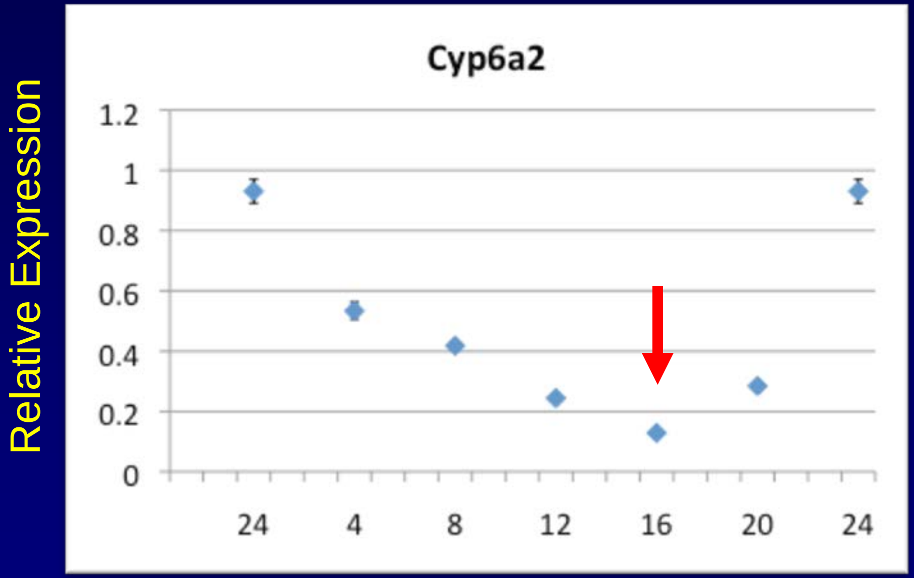
If flies are more active and more likely to be hit by spray or to contact residues



Circadian rhythms and pesticide efficacy

In *Drosophila melanogaster*, the amount of detoxification enzyme present changes with time of day

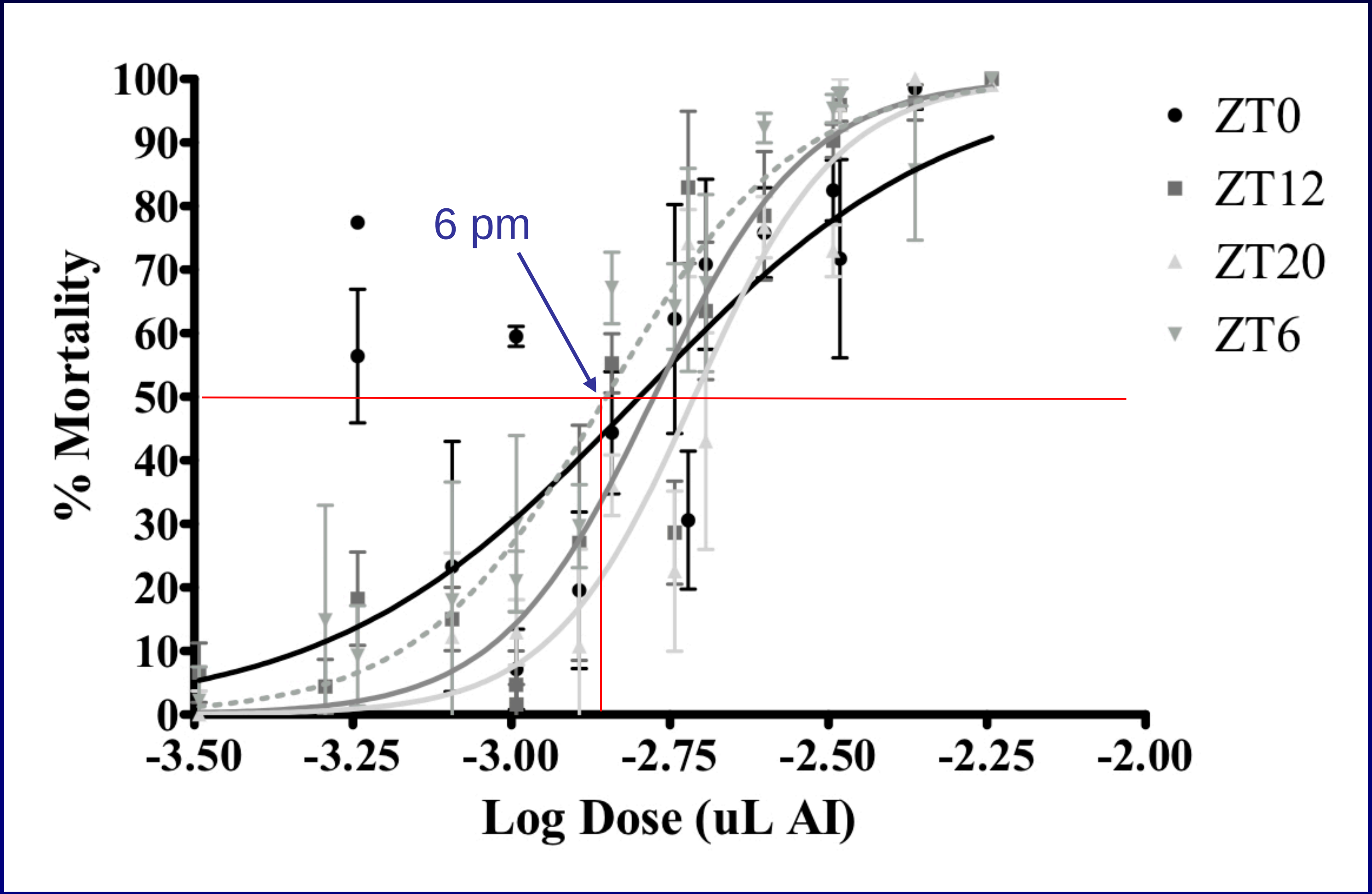
Using molecular techniques to measure the relative expression of the detoxification enzyme for organophosphates in *D. suzukii*…



Quantitative PCR measuring expression of *cyp6a2* encoding cytochrome P450 in *Drosophila suzukii* over a circadian day (n=3).

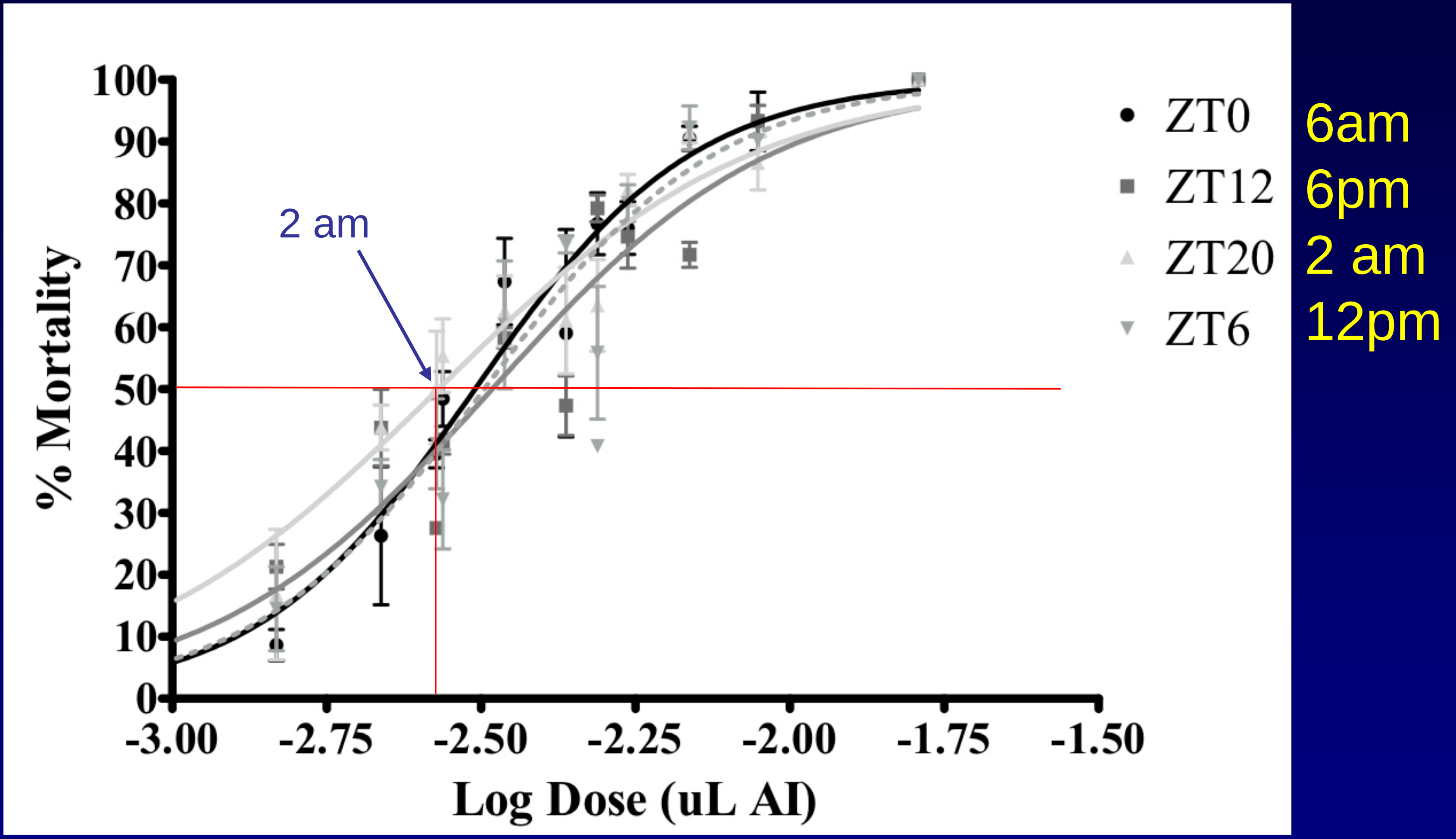
Preliminary results

Malathion circadian rhythm bioassays



6am
6pm
2 am
12pm

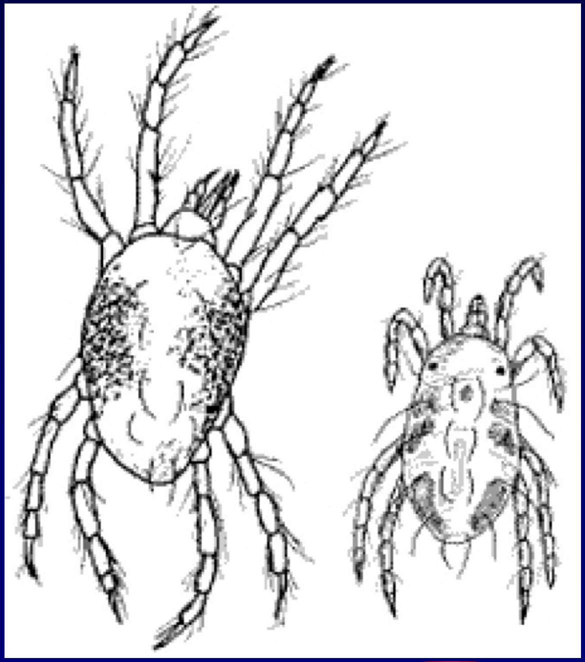
Danitol circadian rhythm bioassays



Spider mites

Tetranychus urticae

Eotetranychus lewisi

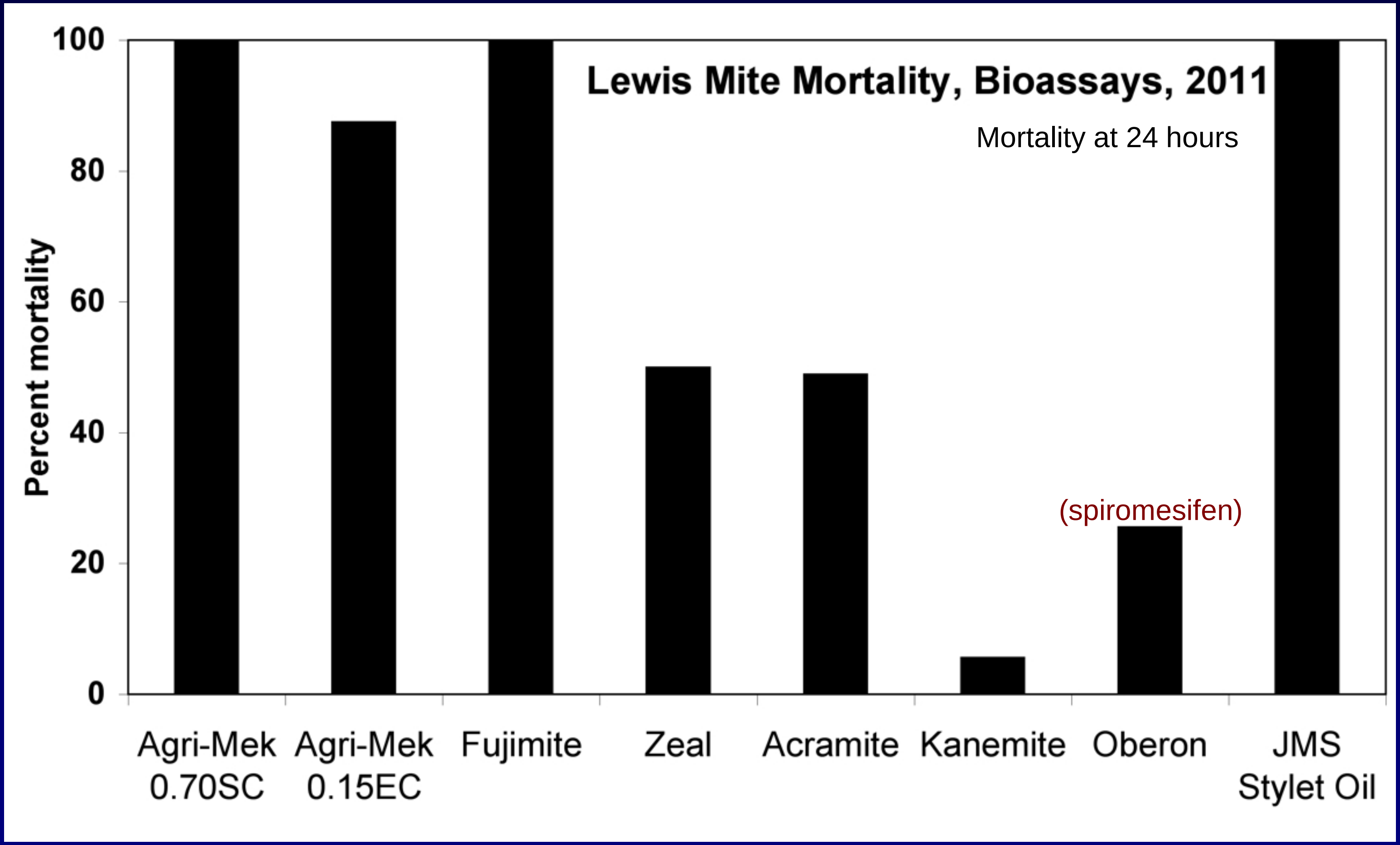


Twospotted spider mite

Lewis mite

Emerged as a problem in some Oxnard area fields in 2011

Lewis Mite - Bioassays



Also determined percent egg hatch for mite growth regulators:

No eggs hatched for either Savey or Zeal

Spider mite resistance?

- Dip strawberry leaves in different concentrations
- Let leaves air dry
- Transfer 10 to 15 adult female mites to the leaves
- Evaluate for mortality after 72 hours

Spider mite resistance?

Source of adult females are collections from strawberry fields. Population colonies are established on strawberry plants until sufficient adult females are available to conduct miticide bioassays

Initial locations:

- Zalom susceptible colony (>25 years without treatment)
- Irvine
- Santa Maria (West Stowell Rd.)
- Nipomo (Oso Flaco Lake Rd.)

Spider mite resistance?

Agrimek

Sampling site	Collection date	n	Slope ± SE	LC50 ppm	LC90 ppm
Zalom Lab Susceptible		329	5.528 (±0.899)	0.016	0.026
Santa Maria (Stowell Rd.)	6/18 & 6/28/12	658	1.259 (±0.117)	12.7	132.4
Nipomo (Oso Flaco Rd.)	8/8/12	291	1.604 (±0.189)	2.0	12.7
Irvine	7/2/12	205	1.212 (±0.188)	2.4	27.7
Lewis Mite, Ventura Co.	3/15/12	167		<0.0055	<0.0055

Field rate -

16 oz./acre in 200 gal. = 11.25 ppm

Spider mite resistance?

Acramite

Sampling site	Collection date	n	Slope ± SE	LC50 ppm	LC90 ppm
Zalom Lab Susceptible		240	3.072 (±0.418)	12.6	32.8
Santa Maria (Stowell Rd.)	6/18 & 6/28/12	770	2.112 (±0.165)	193.2	781.4
Nipomo (Oso Flaco Rd.)	8/8/12	372	1.861 (±0.187)	219.1	1070.1
Irvine	7/2/12	428	1.474 (±0.153)	22.6	167.6
Lewis Mite, Ventura Co.	3/15/12	378	1.784 (±0.189)	29.2	152.9

Field rate -

1 lb./acre in 200 gal. = 300 ppm

Lewis mite vs. Twospotted spider mite development - different hosts

- Ten female *E. lewisi* and *T. urticae* transferred to whole castor bean and strawberry leaves placed into Petri dishes
- Leaves and dishes transferred to growth chambers and held at 3 temperatures
- Females removed after 72 hours
- Total eggs laid and total number of mites surviving to the adult stage were determined

Lewis mite vs. Twospotted spider mite development - different hosts

	Mean number of mites at temperatures (¡C)								
		15 ¡C			20 ¡C			25 ¡C	
	Females	Males	Total	Females	Males	Total	Females	Males	Total
Castor bean									
T. urticae	0.33±0.57	0.0±0.0	0.33±0.57	7.33±4.61	2.66±2.08	10.00±6.24	13.00±4.35	4.33±2.51	17.33±6.65
E. lewisi	13.33±4.93	2.33±2.30	15.66±4.50	30.66±14.64	13.00±9.16	43.66±23.79	34.66±4.04	15.66±4.72	50.33±8.32
P =		0.0043			0.0768			0.0056	
Strawberry									
T. urticae				72.33±8.50	16.66±4.72	89.00±10.44	80.66±5.50	20.33±5.86	101.00±8.88
E. lewisi				11.33±3.21	3.33±1.15	14.66±4.72	17.33±4.72	2.33±0.57	19.66±4.93
P =		ongoing			0.0003			0.0002	

E. lewisi is not as successful on strawberries as is *T. urticae*

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