

NEW CHERRY FRUIT FLY CONTROLS IN TART CHERRY



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WESTERN CHERRY FRUIT FLY IN UTAH

RHAGOLETIS INDIFFERENS

- ✦ Native hosts don't play a role
- ✦ Tart & sweet cherry
- ✦ Unmanaged trees
 - ✦ Home yard trees
 - ✦ Neglected orchards
- ✦ Hostile environment & ecosystem outside of orchard & urban areas



Tart cherry orchard



Home yard sweet cherry tree

WCFF MANAGEMENT – TART CHERRY

- * Primary insect pest
- * Zero tolerance for larvae in fruit
- * Growers struggle with control timing
 - ✦ Low populations – difficult to set biofix
 - ✦ Large orchards (10+ acres)– if minimal outside influx, does entire interior need to be treated?
 - ✦ Excessive spraying
- * Growers use a low trap density (1-2 traps per 5-10 acres) & most are placed on borders



CFF-infested fruits

UTAH CFF RESEARCH

- * Field-based
- * Efficacy of new insecticides
 - Neonicotinoid (imidacloprid, Provado®)
 - Microbial (spinosad, GF-120®)
 - Adult & larval suppression
 - Non-target effects on mites
- * Monitoring (Pherocon AM® trap)
 - Additional attractants
 - Trap placement (border & interior)
 - Trap density
 - Insecticide influences on dispersal of males & females (immature & gravid)



Pherocon AM® trap + ammonium carbonate bait

1. EFFICACY OF NEW INSECTICIDES

- * 2004-07: 19 orchard trials
 - ✦ 15 trials on commercial farms
 - ✦ 4 trials on university research farm
- * Objectives:
 - ✦ Evaluate, demonstrate, & encourage adoption of non-OP insecticides for CFF management
 - ✦ Test & refine strategies, technologies, & timing for alternative products
 - ✦ Develop and validate predictions of fruit injury from trap catch



Infested cherry fruits

GF-120 APPLICATION



Photo courtesy of
Tim Smith, WSU Ext.

Electric pump sprayer mounted on 4-wheeler applies a strip of spray along the mid- and upper-line of each tree row

EFFICACY OF NEW INSECTICIDES

COMMERCIAL ORCHARD TRIALS

Year	Orch #	Treatment*	# CFF larvae^
2004	1	Guthion	0
		Provado	0
	2	Dimethoate	0
		Provado	0
	3	Guthion	0
		Imidan	0
		Provado	0
2005	4	Guthion	0 c
		Provado	2.4 a
		GF-120	0.8 b
	5	Guthion	0
		GF-120	0

Year	Orch #	Treatment*	# CFF larvae^
2005	6	Guthion	0
		GF-120	0
	7	Guthion	0
		GF-120	0
2006	8	Provado/Guthion	0
	9	Provado/Imidan	0
	10	Provado/GF-120	0
	11	Provado/GF-120	0
	12	GF-120	0
	13	Provado/Guthion	0.0002
	14	Provado/GF-120	0
	15	Provado/GF-120	0.0004

*Total of 2-6 applications per season, ^Cumulative # CFF larvae per 100 fruit (2,000-5,000 fruit sampled per orchard)

EFFICACY OF NEW INSECTICIDES

RESEARCH ORCHARD TRIALS

Year	Orch #	Treatment*	# CFF larvae [^]
2004	16	Untreated	44.7 a
		Guthion	1.1 b
		GF-120	0.3 c
2005	17	Untreated	9.3 a
		Guthion	1.3 b
		GF-120	0.1 c
2006	18	Untreated	10.0 a
		GF-120	4.0 b
		GF-120+AC	3.3 b
		GF-120+AA	0.3 c
		Success	2.3 bc
		Provado	1.8 bc

Year	Orch #	Treatment*	# CFF larvae [^]
2007	19	Untreated	9.1 a
		GF-120	1.9 b
		GF-120+AA	0.8 b
		GF-120+U	1.4 b
		GF-120+TY	0.5 b
		GF-120+CCJ	0.9 b

*Total of 2-6 applications per season;
 AC=ammonium carbonate,
 AA=ammonium acetate, U=urea,
 TY=torula yeast, & CCJ=concentrate
 cherry juice (10% w/v)

[^]Cumulative # CFF larvae per 100 fruit
 (2,000-5,000 fruit sampled per orchard)

IMIDACLOPRID (PROVADO®)

- * Prevented WCFE fruit injury in 13 of 15 commercial orchard trials
- * In Orchard 4 (2.4% fruit injury), crop load was small and external, home yard sources of fruit flies compromised Provado's performance
- * In Orchard 13 (0.0002% fruit injury), fruit maturity was advanced
 - ✦ 16% of fruit was rosy in color on June 12 (collection date of infested fruit)



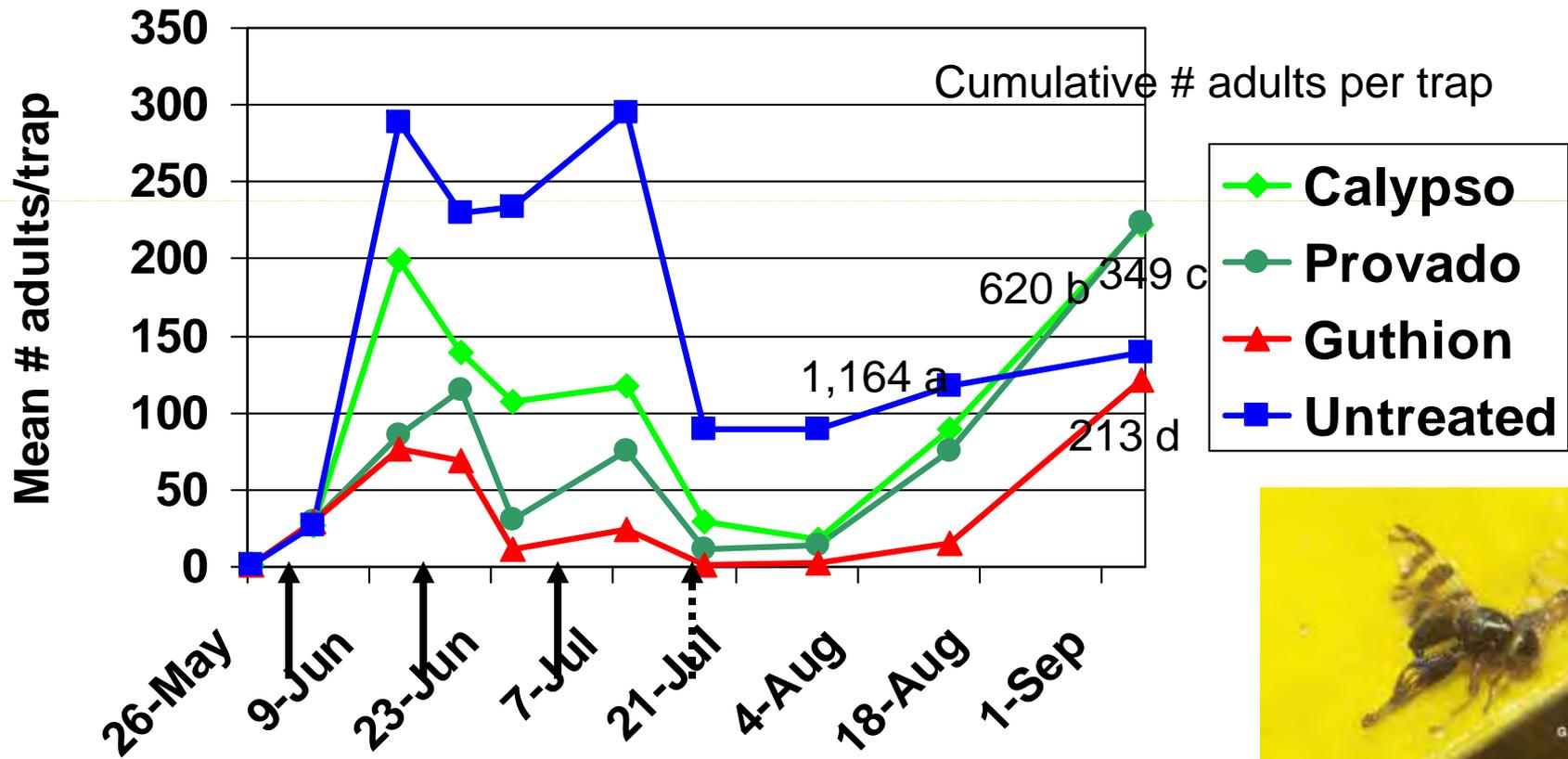
Home yard sweet cherry tree



SPINOSAD (GF-120 NF®)

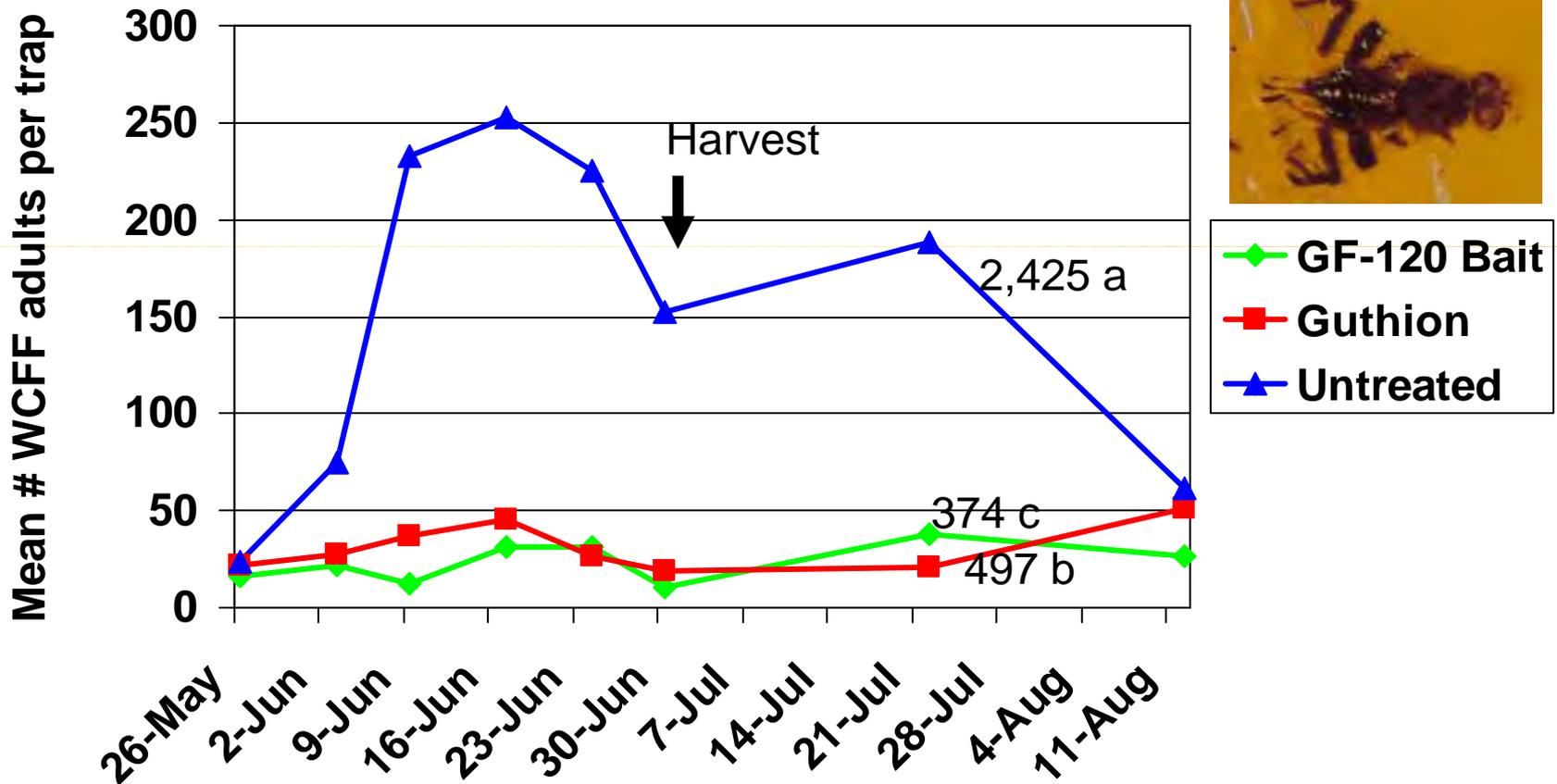
- * Similar to Provado, GF-120 prevented WCFF fruit injury in 13 of 15 commercial orchard trials
- * GF-120 did not completely protect fruit in any of the 4 research orchard trials
- * Fruit fly densities were 2-100× times higher in research orchards (21-1211 cumulative adults per trap) than in commercial orchards (0-12 cumulative adults per trap)
 - ✦ High CFF densities & close proximity of untreated plots were major reasons for the inability of GF-120 to prevent fruit injury in research trials
 - ✦ Despite high CFF densities & influx of gravid females, GF-120 kept fruit injury ≤ 4.0 larvae per 100 fruit
- * 10% AA (w/v) improved performance of GF-120 in 2006 trial, but no added attractants enhanced GF-120 in 2007 trial

Life Stage Suppression – Neonicotinoid insecticides are moderate adulticides



Solid arrows indicate insecticide spray timings; broken arrow indicates cherry harvest date

Life Stage Suppression – Spinosad is a good adulticide



- GF-120 Bait
- Guthion
- Untreated

GF-120 Bait and Guthion dramatically suppressed WCFE pops.
Guthion: 76% flies caught next to Untreated
GF-120 Bait & Guthion suppressed populations post-harvest

GF-120 MODE OF ACTION

- * Bait in GF-120 must be arresting adults reasonably well, but it doesn't appear to be attractive
- * Bait droplets encountered during routine adult foraging
- * Adult fruit flies that feed on GF-120 are killed quickly
- * 0.02% a.i. spinosad is highly toxic to adults when ingested
- * Need to keep enough GF-120 available for adult population size
- * Not rain-fast
- * Reapply every 5-7 d & after rain

PROVADO MODE OF ACTION

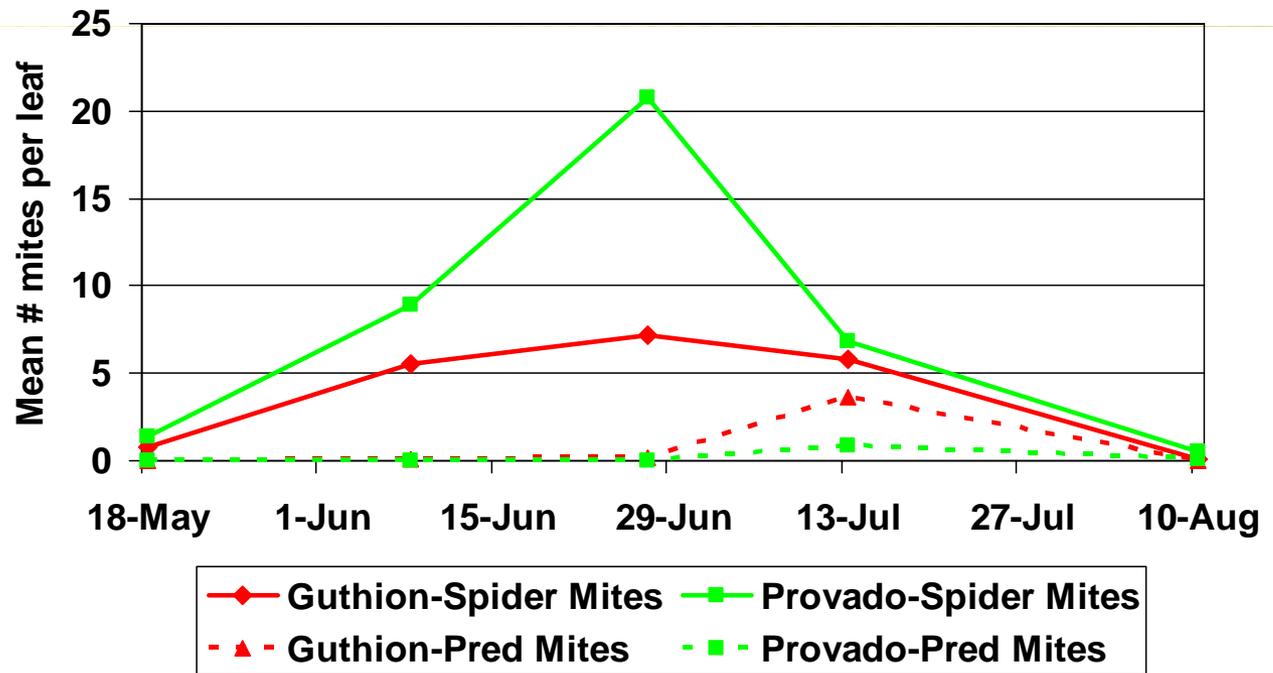
- * Contact – only moderate adulticide
- * Systemic – kills larvae (eggs) inside fruit
- * Under high populations in research orchard trials –
14 d of fruit protection

NON-TARGET EFFECTS ON MITES

EXAMPLE

- Stimulation of spider mites
- Follows 2-3 applications of Provado
- Predaceous mite densities lowered none or moderately
- Primary mechanism: Hormoligosis
- No non-target effects of spinosad detected

Genola, UT – Economic mite populations



Provado increased spider mite densities vs. Guthion
Pred mites increased in mid July – too late

COMPARISON OF INSECTICIDE LABELS

* GF-120

- ✦ 4 h REI
- ✦ 0 d PHI
- ✦ 10-20 fl oz/acre
- ✦ Coarse spray droplet size (4-6 mm)
- ✦ 1:4 or 1:5 dilution with water
- ✦ Strip application
- ✦ PPE:
 - ✦ Coveralls, gloves, shoes

* Provado

- ✦ 12 h REI
- ✦ 7 d PHI
- ✦ 6-8 fl oz/acre
- ✦ Minimum of 10 days between sprays
- ✦ Post-bloom only
- ✦ Toxic to bees
- ✦ Full cover spray
- ✦ PPE:
 - ✦ Coveralls, gloves, shoes

INSECTICIDE EFFICACY SUMMARY

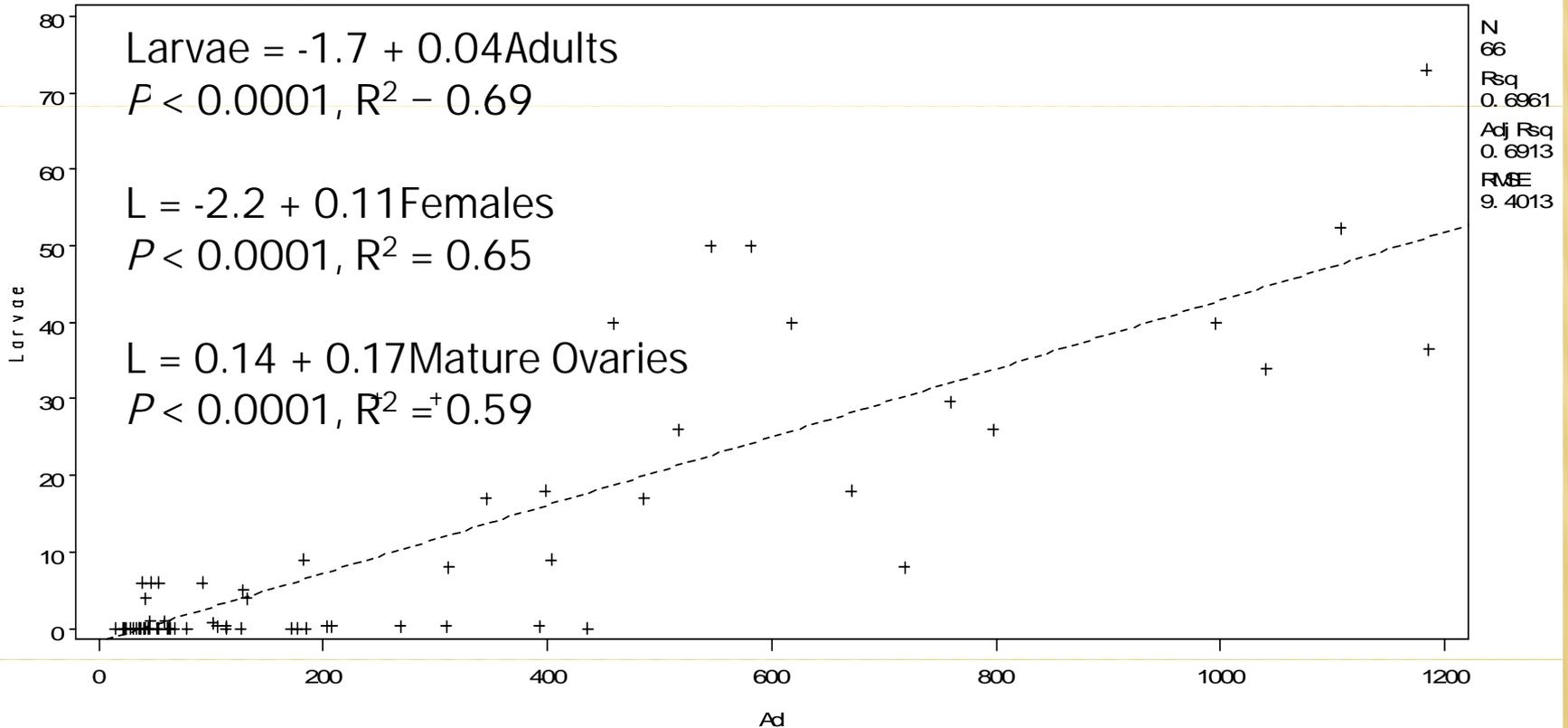
- * Spinosad (GF-120 and Success) and imidacloprid (Provado) offer greater flexibility in REIs and PHIs than organophosphate insecticides
- * GF-120 offers an alternative application method
- * The two products differ in pest target stage
 - ✦ Provado: larvicide (ovicide), moderate adulticide
 - ✦ Spinosad: adulticide
- * GF-120 cannot protect fruit against migrating females that contain mature eggs
 - ✦ Prevented fruit injury for orchards \leq ~ 20 cumulative CFF on traps
- * Important to rotate applications of neonicotinoid (Provado) with other insecticide classes
 - ✦ Stimulation of spider mites

RELATIONSHIP BETWEEN LARVAL INFESTATION AND ADULT DENSITIES

2004 and 2005

Regression of Larvae per 100 fruit on Adult Trap Catch
Cumulative # Adults

Larvae = -1.7132 + 0.0446 Ad



PREDICTION OF FRUIT INJURY FROM ADULT TRAP CATCH

- * For untreated & treated cherries combined
 - ✦ 100 adults \Rightarrow 4 larvae
 - ✦ 100 females \Rightarrow 11 larvae
 - ✦ 100 females with mature ovaries \Rightarrow 17 larvae
- * >0.14 gravid females corresponded to infested fruit
- * Need to analyze with larger data set & refine predictions

2. MONITORING CFF WITH TRAPS

A. ADDITIONAL ATTRACTANTS

- * Pherocon AM® yellow sticky trap – standard
 - ✦ Visual attractant – yellow color
 - ✦ Host/Food attractant – yeast
- * Objective:
 - ✦ Evaluate additional attractants to enhance “sphere of influence” of trap
 - ✦ Ammonia-containing compounds
 - ✦ Cherry fruit juice and extracts
 - ✦ Yeasts
 - ✦ Sugars



Pherocon AM® trap + ammonium carbonate bait

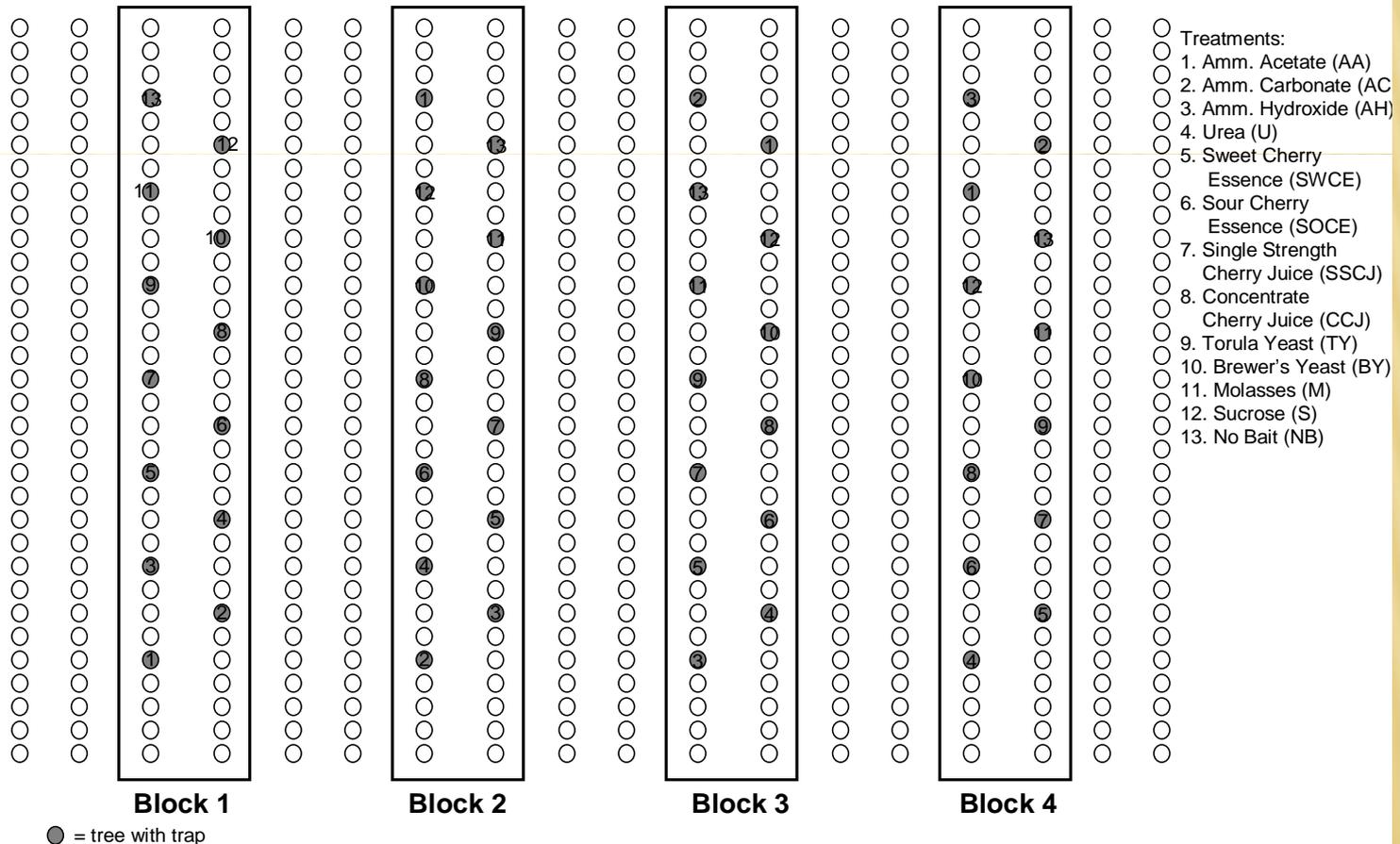
TRAP ATTRACTANT TRIAL

- * 2007
- * 5 'Montmorency' tart cherry orchards (4 commercial, 1 research)
 - ✦ 13 potential attractants:
 - + Ammonium acetate (AA) – volatile powder
 - + Ammonium carbonate (AC) – volatile powder
 - + Ammonium hydroxide (AH) – volatile liquid
 - + Urea (U) – volatile granular
 - + Sweet cherry essence (SWCE) – volatile liquid
 - + Sour cherry essence (SOCE) – volatile liquid
 - + Single strength cherry juice (20-25 brix) (SSCJ) – liquid
 - + Concentrate cherry juice (65 brix) (CCJ) – liquid
 - + Torula yeast (TY) – powder dissolved in water
 - + Brewer's yeast (BY) – powder dissolved in water
 - + Molasses (M) – 10 drops per trap
 - + Sucrose (S) – crystals dissolved in water, 10 drops per trap
 - + No bait

TRAP ATTRACTANT TRIAL DESIGN

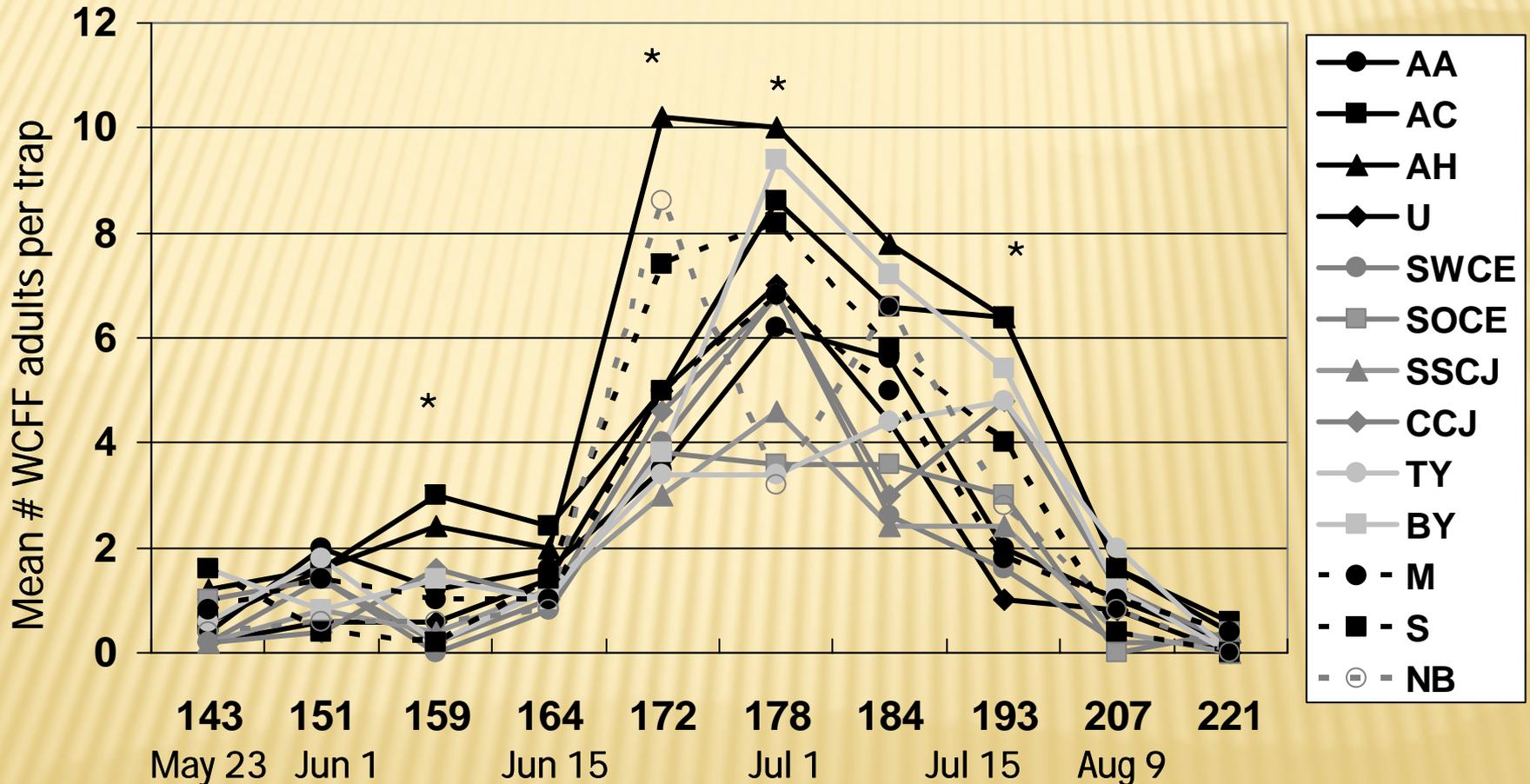
Map of Utah County Tart Cherry Orchards 2007 Western Cherry Fruit Fly Attraction to Traps

(Need at least 16-18 rows X ca. 30 trees; skip 1-2 edge rows and 2-4 end trees per row)



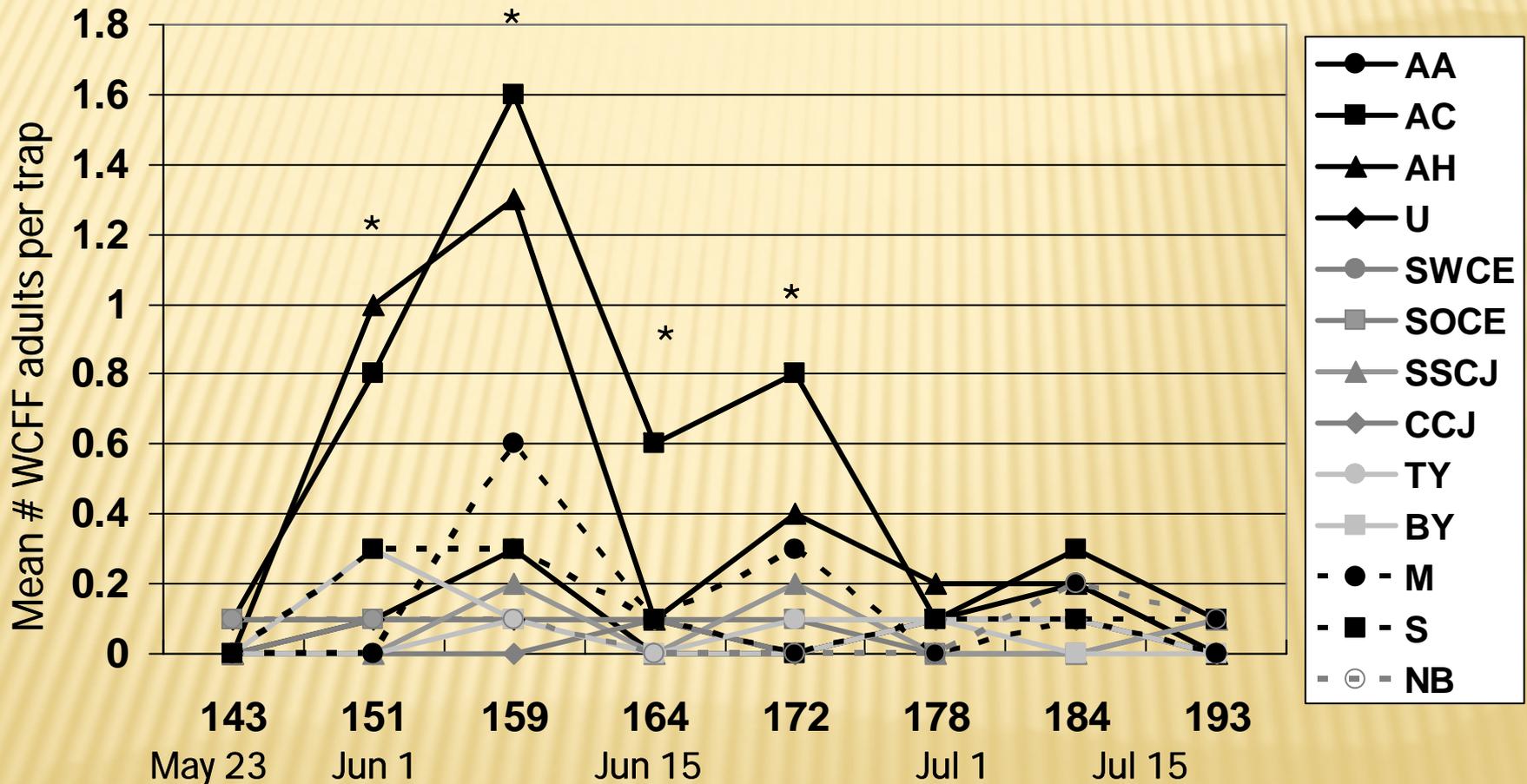
Position of treatments upon initial placement of traps indicated by numbers. Traps will be rotated weekly to the next position from front to back.

TRAP CATCH IN KAYSVILLE RESEARCH ORCHARD



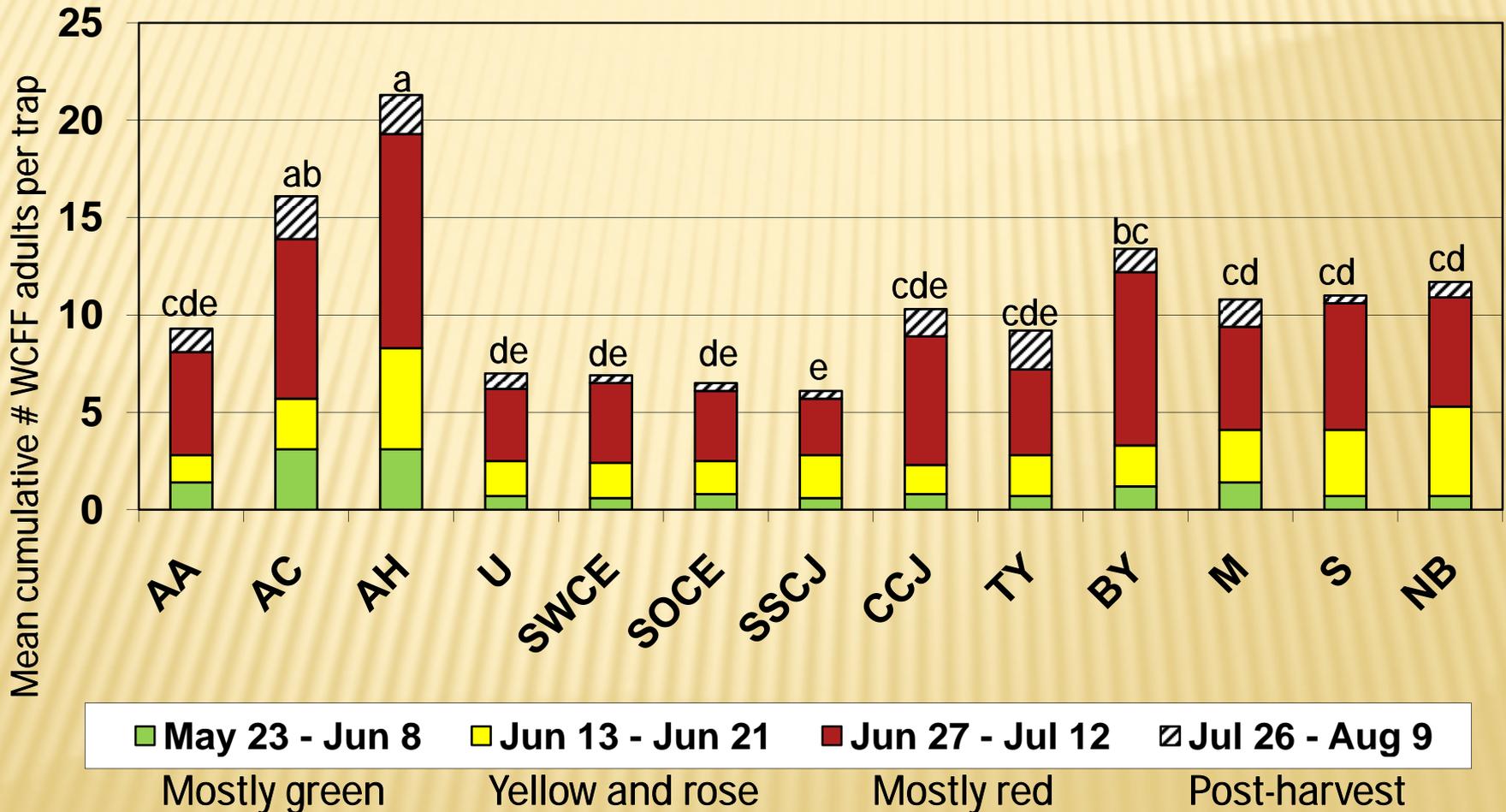
* indicates treatment means were significantly different (Tukey-Kramer test; $p \geq 0.05$) on indicated dates.

TRAP CATCH IN FOUR COMMERCIAL ORCHARDS



* indicates treatment means were significantly different (Tukey-Kramer test; $p \geq 0.05$) on indicated dates.

CUMULATIVE ADULTS FOR FOUR FRUIT MATURITY PERIODS – ALL 5 ORCHARDS



Means followed by the same letter are not significantly different (Tukey-Kramer test, $p \geq 0.05$)

TRAP ATTRACTANTS SUMMARY

- * AH & AC increased adult trap catch by 1.5-2× over NB traps
 - ✦ AH releases the most ammonia, AC also releases CO₂
- * BY enhanced catch over NB on dates when fruits were mature or nearly mature
- * Overall, more adults were caught when fruits were mostly red in color (June 27 – July 12), but more were caught in commercial orchards during June (fruits mostly yellow and rose in color)
- * More work needed on release rates & formulations, & enhancement of compound volatility

TRAP ATTRACTANT RECOMMENDATIONS

- ✦ Use of commercial AC bait recommended (~2× increase in trap catch over no bait)
- ✦ “Sphere of influence” of trap small
- ✦ Greater accuracy in CFF detection depends on higher trap densities
- ✦ Further work on CFF attractants is needed!!



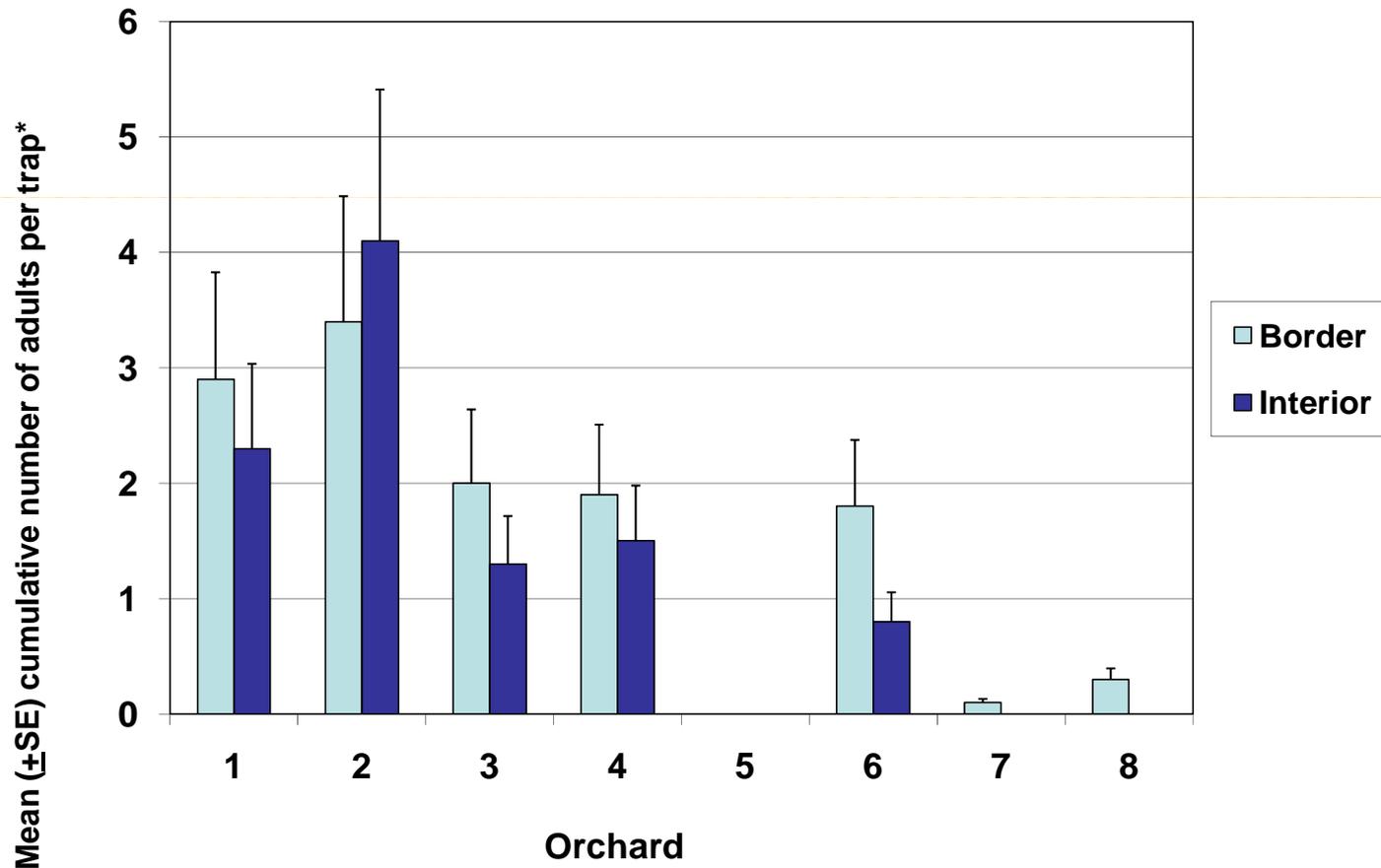
Pherocon AM® trap + ammonium carbonate bait

2. MONITORING CFF WITH TRAPS

B. TRAP PLACEMENT

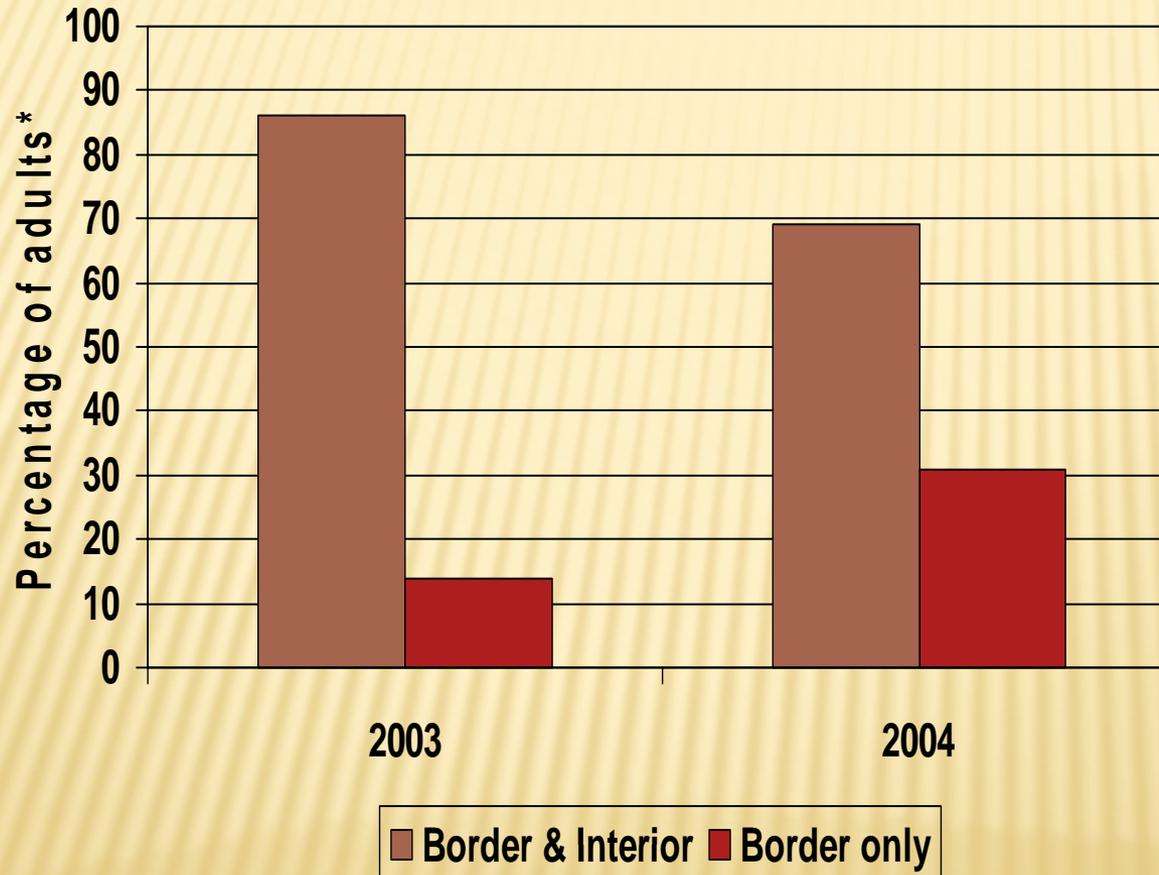
- * Most Utah tart cherry growers place 1-2 traps per orchard (10+ acres), on border trees
- * Growers most concerned about detection of external sources of flies
- * Objective:
 - ✦ To compare adult catch on borders vs. interiors of orchards
 - ✦ 2005 & 06: 11 orchards (compared border (B) vs. interior (I) trap catch within orchards)
 - ✦ 2003 & 04: 32 orchards (compared orchards with B & I traps vs. B only)

INFLUENCE OF TRAP PLACEMENT ON WCFE CATCH - 2006



*Cumulative catch from early June to early August

INFLUENCE OF TRAP PLACEMENT ON WCFE CATCH – 2003 & 04

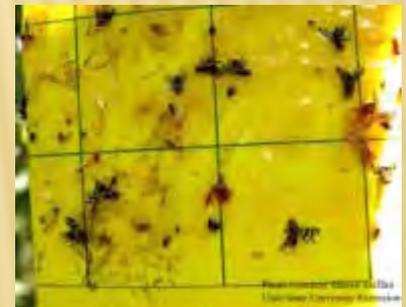
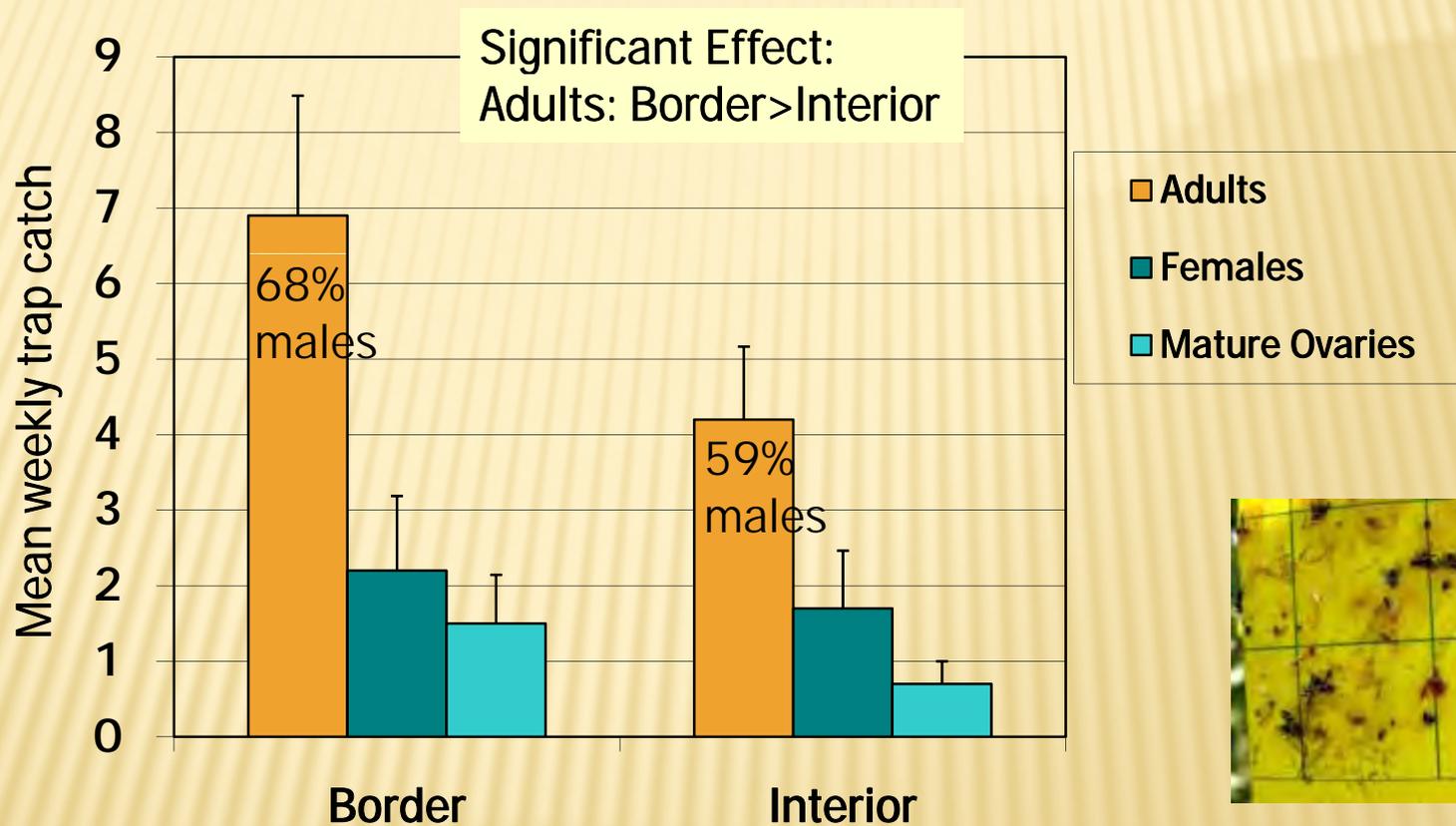


- First adult catch was an average of 2.4 days earlier in orchards with both border and interior traps vs. border traps only
- 2003 & 2004:
B & I > B ($p < 0.05$)

*Caught on traps from biofix to Jul 31

INFLUENCE OF TRAP PLACEMENT ON TRAP CATCH

CATCH – 2004 & 05



*For 8 border & 8 interior traps in each treatment of 6 cherry orchards from late May to Mid Aug, 2004 & 2005

2. MONITORING CFF WITH TRAPS

C. TRAP DENSITY



2003:

6 Treatments

Factorial design

Reps.: 3X (18 orchards)

Orchard size: 10-14 acres

2004:

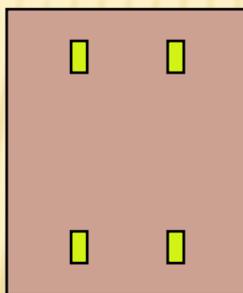
2 Treatments

1 trap/acre

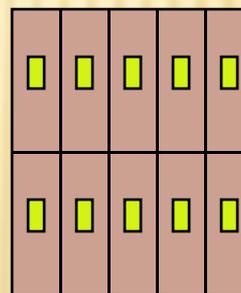
7X (14 orchards)

10-14 acres

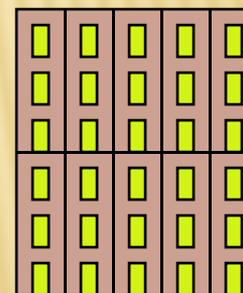
4 traps/orch.



1 trap/acre

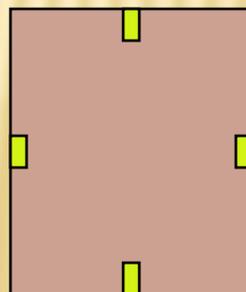


3 traps/acre

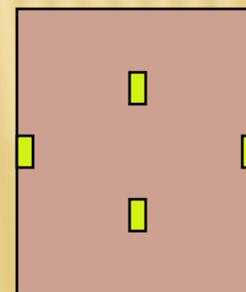


Trece® Pherocon AM +
Ammonium carbonate

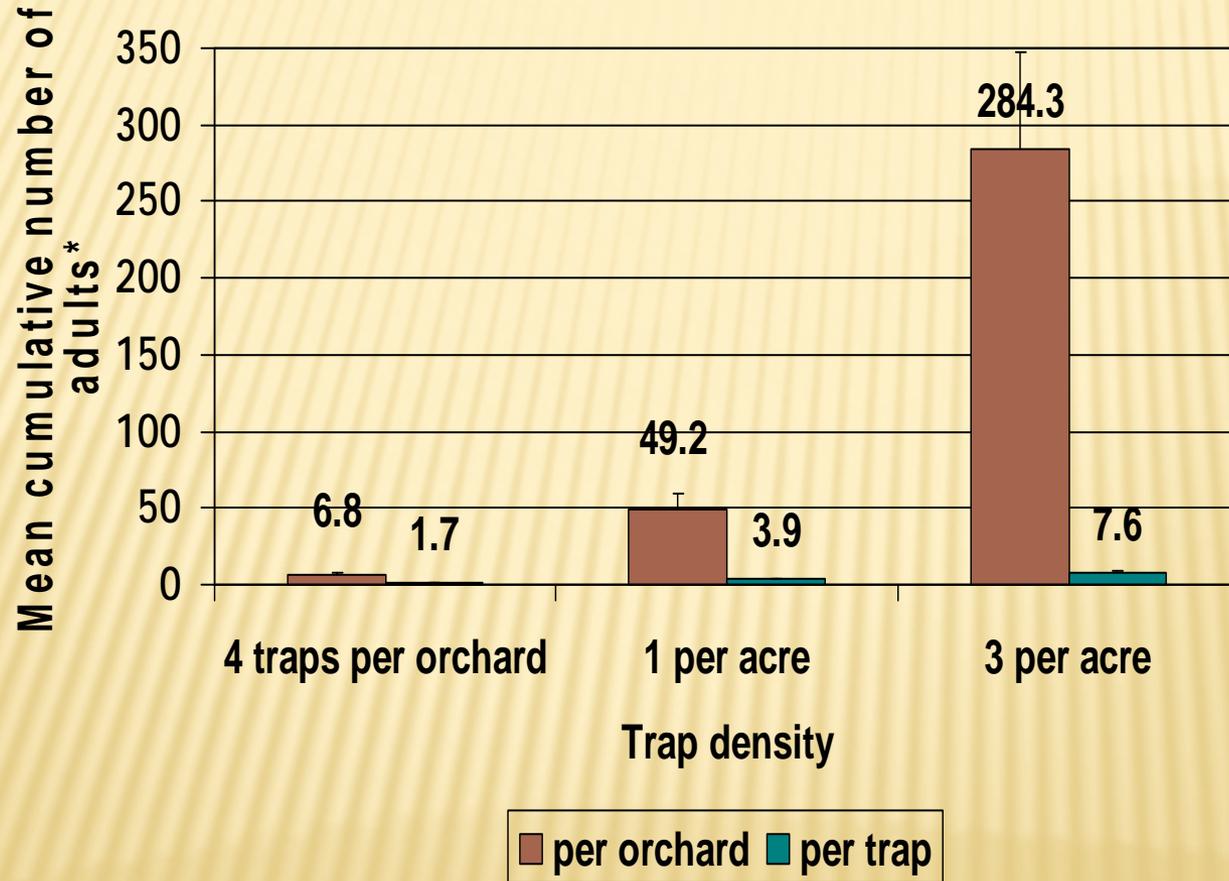
Borders only



Borders & Interior



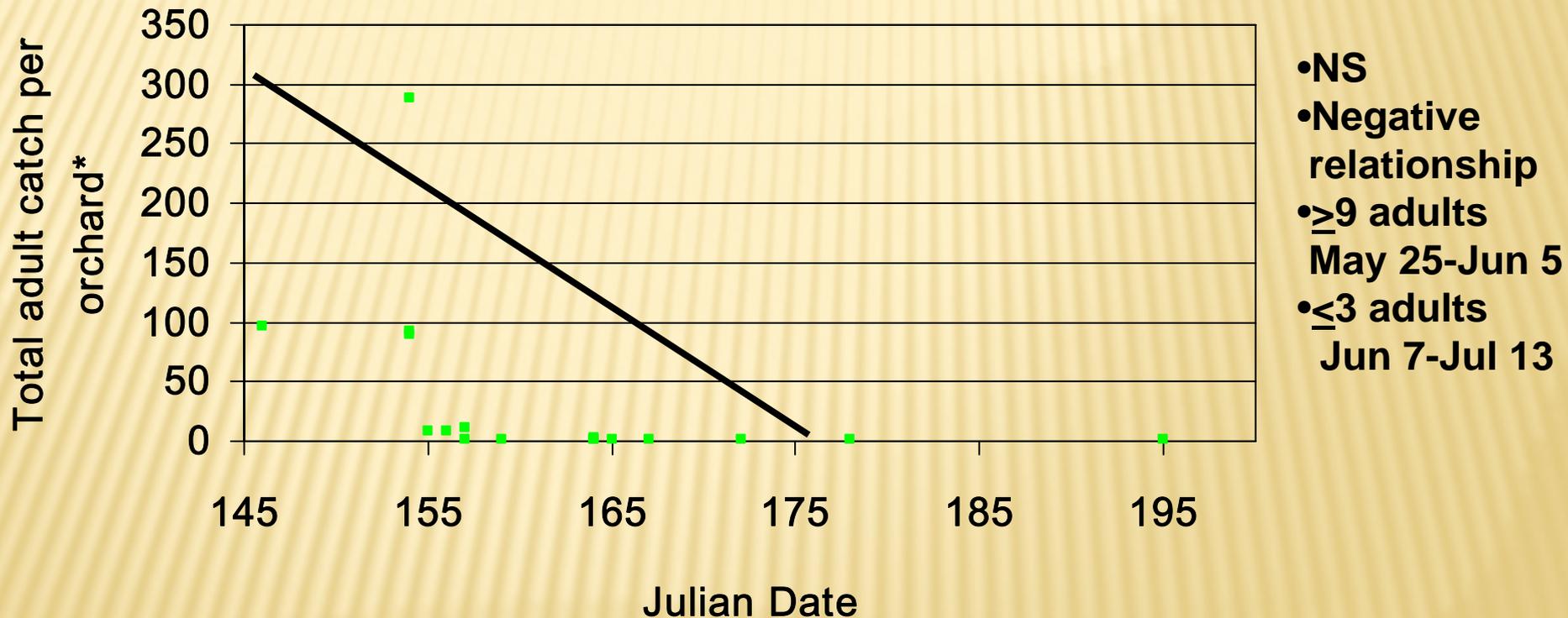
INFLUENCE OF TRAP DENSITY ON WCFE CATCH



- Adults were caught in 19/32 orchards (59%)
- Mean number per orchard:
 - 3 per acre >
 - 1 per acre >
 - 4 traps per orch.($p < 0.05$)

*From biofix to Jul 31

INFLUENCE OF CFF DENSITY ON DATE OF FIRST TRAP CATCH – 2003 & 04



*Biofix to Jul 31; missing data point: JD 151, 1600 adults

SUMMARY OF TRAP DENSITY AND PLACEMENT

- * Adult trap catch was markedly increased by increasing trap density
 - † 3 traps per acre > 1 trap per acre > 4 traps per orchard
- * Adult catch on border vs. interior traps varied between years
 - † More adults caught on border than interior traps in some years and orchards
 - † Varied with primary source of fruit fly population
 - † In one study, greater proportion on border traps were males
 - † Males may disperse differently than females
- * Percentage of adults caught was greater in orchards with traps on both borders and within interiors
 - † First catch was an average of 2.4 days earlier
- * Although NS relationship, adults were caught earlier in orchards with higher fruit fly densities



Female WCFF with ovipositor



2. MONITORING CFF WITH TRAPS

D. UNDERSTANDING MALE & FEMALE DISPERSAL

✦ Objective:

- ✦ To assess the influence of different insecticides on dispersal of male & female flies in orchards

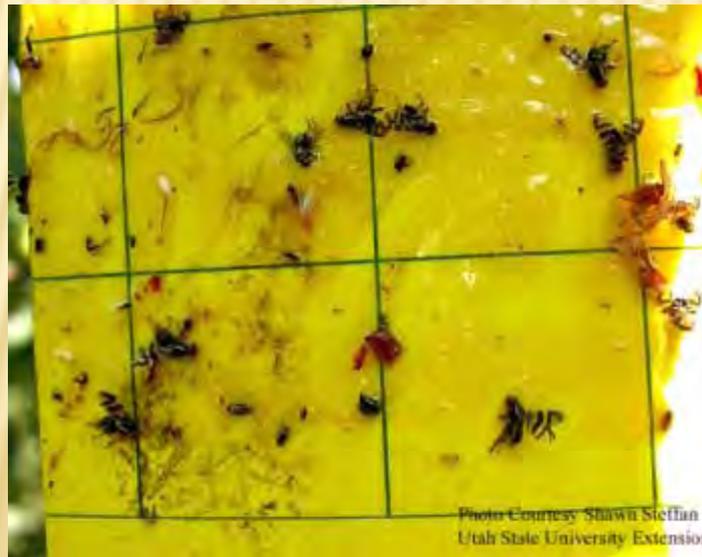
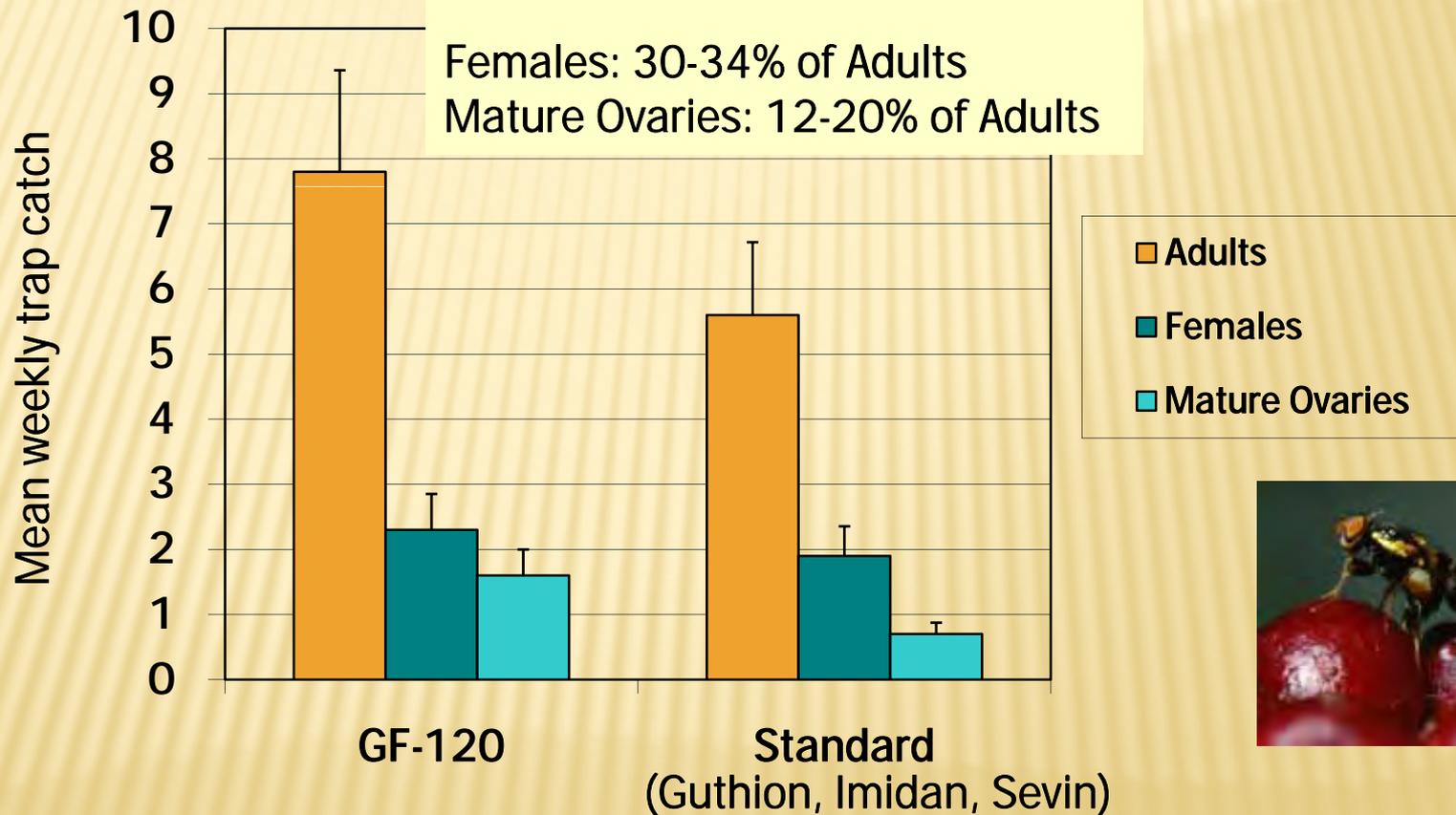


Photo Courtesy: Shawn Stellan
Utah State University Extension

WCFF adults on sticky trap

INSECTICIDE EFFECTS ON TRAP CATCH

Significant Effect:
Mature Ovaries: GF-120 > Standard



*For 16 traps in each treatment of 6 cherry orchards from late May to mid Aug, 2004 & 2005

GF-120 EFFECTS ON TRAP CATCH

- * GF-120 plots retained more females with mature ovaries
 - ✦ Ammonium acetate bait in GF-120 influenced gravid and non-gravid adults differently
- * Evaluation of how attract-and-kill products and insecticides influence adult activity / movement should sort out effects on gravid females

EXTENSION / OUTREACH PRODUCTS



Prionus Root Borer (*Prionus californicus*)

Shawn Jeffers and Diane Alton

Did You Know?

- This long-banded beetle is native to the West and lives 3-4 years underground, feeding on tree roots.
- Infestations can cause the direct or indirect death of mature cherry trees.
- Insecticide applications do little to suppress prionus beetle populations.

Description and Host Injury

Prionus root borers belong to a family of beetles commonly known as long-banded beetles (Cerambycidae). The larvae are often referred to as round-headed borers because their body shape is somewhat cylindrical.

Several species in the *Prionus* genus are large, root boring beetles, and they are widely distributed across the U.S. One species, the California prionus (*Prionus californicus*), appears to have a particular affinity for stone fruit trees in Utah (Fig. 1).

The adult California prionus is a very large beetle, ranging in size from 45-60 mm long (1 7/8 - 2 1/4 inches). Adults are reddish-brown in color, relatively smooth and shiny, with long, deeply notched antennae (Fig. 2). The larvae can be as long as 100 mm (4 3/4 inches) with a diameter of approximately 18 mm (3/4 inch) at the widest point of the larva's body (Fig. 3).

Adults emerge from pupae in the soil in July in northern Utah. The beetles fly at night in



Fig. 1. Typical larva (1-inch wide) made by a prionus larva.



Fig. 2. Adult prionus root borer, 1 7/8 - 2 1/4 inch length.



Greater Peachtree Borer (*Synanthedon exitiosa*)

Diane Alton, Extension Entomology Specialist • Marton Murray, IPM Project Leader

Do You Know?

- Greater peachtree borer is an important pest of peach, nectarine, apricot, cherry, and plum.
- Adults are cleaving moths and larvae are caterpillars that burrow and feed in the cambium beneath the bark near or just below the soil line.
- Severe larval feeding can girdle and kill trees.
- Mating disruption is an effective control and has been proven in Utah peach orchards as small as one acre in size.
- Treatment of lower tree trunks before egg hatch is also effective in preventing injury.

The greater peachtree borer (*Synanthedon exitiosa*) is native to the United States and Canada where wild cherries and plums are its native hosts. It is a sporadic pest in Utah stone fruit orchards, but if left unmanaged it can be severe enough to cause major tree loss. Infestations are more common in home orchards. The adults are cleaving moths (Fig. 1). The larvae are pinkish-white caterpillars that bore into the trunks where they feed just under the bark in the cambial tissue (Fig. 2). There is one generation per year, but some larvae may require two years to complete development (Fig. 3).

Extensive larval feeding can girdle and kill trees. The larvae primarily attack tree trunks just at or below the soil line (Fig. 4), but may enter trunks up to 12 inches above the ground. Other tree problems that are frequently confused with peachtree borer injury include winter freeze and mechanical injury, and infection by canker-causing fungi such as *Cytospora*. All of these problems can cause copious sap or gum to exude from holes or cracks in the bark. Key symptoms of peachtree borer infestation are the presence of sawdust and frass mixed with the gummy exudate near the base of the trunk (Fig. 5).

Prevention is the most effective approach to management. Pheromone-based mating disruption and trunk sprays with synthetic insecticides are the primary management tactics. Adult peachtree borers become active in mid to late June in northern Utah (Fig. 3) and trunks should be protected from tunneling larvae beginning the first week of July (3-4 weeks earlier in southern Utah) through late August to early September.



Fig. 1. Adult male (l) and female (r) peachtree borer.



Fig. 2. Peachtree borer larva.

HOSTS

apricot, cherry, chokecherry, peach, plum, prune

LIFE HISTORY

Adult - Monitoring Stage

- **Color and Appearance:** Similar to pop wags with a metallic-blue body and, however, the female's forewings are blue scales (Fig. 1). The female has a band on the abdomen (Fig. 1); the four narrow, yellow-white abdominal and 7.



Western Cherry Fruit Fly (*Rhagoletis indifferens*)

Diane Alton, Extension Entomology Specialist • Marton Murray, IPM Project Leader • Michael Reding • Cath Miller

Do You Know?

- Western cherry fruit fly is the primary insect pest of sweet and tart cherries in Utah.
- Damage occurs from the larva developing inside the fruit.
- Females lay eggs under the skin of fruit, so target adult flies for control.
- Insecticides are currently the most effective control method.
- A new insecticide technology—attract-and-kill (bait plus insecticide)—can be effective for control in commercial and home cherry trees.
- Use of ground barriers (mulch, fabric) can reduce pupation and fly emergence.
- Post-harvest sanitation can reduce populations.



Figure 1. Adult fly caught on trap.



Figure 2. Larvae feeding inside a cherry fruit.



Figure 3. Damaged cherries with larval exit holes.



Figure 4. Cherry fruits are not susceptible to attack until they have a blush of salmon color.

HOSTS

Sweet, tart, and wild species of cherries

LIFE HISTORY

Pupa - Overwintering Stage

- **Size:** about 1/8 inch (5 mm) long
- **Color:** light to dark brown and shaped like a large grain of wheat
- **Where:** overwinters in the soil of the orchard floor, 1 - 4 inches (2.5 - 10 cm) deep
- **Rate of pupal development and adult emergence** affected by soil temperature and moisture

Adult - Monitoring Stage

- **Size:** about 1/8 inch (5 mm) long
- **Color:** black body with white bands on abdomen (posterior body region); wings are transparent with a distinctive pattern of dark bands (Figs. 1 and 4)
- **Where:** adults begin emerging from soil in late May to early June (Table 1 and Fig. 5) depending on soil temperature and moisture and continue to emerge

The western cherry fruit fly (*Rhagoletis indifferens*) is the most important pest of tart and sweet cherries in Utah. Once the skin of fruits becomes soft enough to penetrate, adult females (Fig. 1) insert eggs with their ovipositor, and larvae develop inside the fruit (Fig. 2). The result is "wormy" fruit that is unmarketable. It is difficult to determine whether a fruit is infested until the larva exits through a hole that it chews (Fig. 3) or the fruit is cut open to reveal the larva inside. For processed cherries, detection of one larva by the processor can result in rejection of the entire crop from that orchard and/or farm. Therefore, the best management strategy is to prevent fruit infestation.

Adult flies will migrate only short distances (< 40 m) if host fruit is available. This causes infestations to be spotty in a region; however, once established in an orchard, the western cherry fruit fly can spread rapidly and require annual control. Protective insecticide sprays are currently the major tactic for preventing infestation. A new insecticide technology called "attract-and-kill," where adults are enticed to feed on a sticky bait droplet containing an ultra low concentration of insecticide, has proven effective in experiments in Utah orchards.

There is one generation per year; however, adults can emerge from the soil over a period of 12 weeks or more. Cherry fruits are susceptible to infestation from when they first open to a salmon-bush color (Fig. 4) until they become too soft or fall from the tree.

UTAH PESTS WEB PAGE

The screenshot shows a web browser window with the address bar displaying <http://utahpests.usu.edu/>. The browser's address bar includes a search engine (Google), a dropdown menu for "entomopathogenic nem", and a "Go" button. The browser's toolbar shows "Bookmarks", "0 blocked", "Check", and "AutoLink". The page title is "Utah Pests - utahpests.usu.edu".

The website content includes a navigation menu with links for "ext home", "site map", and "ext directory". A search bar is located in the top right corner, with a "GO" button and a dropdown menu for "Extension Sites A-Z". The main header features the "UtahState UNIVERSITY extension" logo and a large image of several apples. Below the image is the "UTAH PESTS" logo.

The main content area is titled "UTAH PESTS" and contains the following text:

Utah's diverse landscape supports thousands of insects and plant pathogens. UTAH PESTS is your portal for learning more about pests and their beneficial counterparts around the state, and how Utah Extension personnel are working to provide a greater understanding of these organisms in our world.

Click on one of the web site links below to get started!

The page lists several links for further information:

- [integrated pest management](#)
- [plant diseases](#)
- [insects and their relatives](#)
- [utah plant pest diagnostic lab](#)

A sidebar on the left contains a list of links: "home", "utah pests news", "quarterly newsletter", "fact sheets", "frequently asked questions", "photo gallery", "slideshows", and "contact us". Below this list is a "WEBSITES" section with links to "utah pests homepage", "integrated pest management", "plant diseases", "insects and their relatives", and "utah plant pest diagnostic lab".

The footer of the page includes the text: "webmaster XHTML, CSS text only en espanol".

RESEARCH PUBLICATION

HORTICULTURAL ENTOMOLOGICAL

Effects of Spinosad, Spinosad Bait, and Chloronicotinyl Insecticides on Mortality and Control of Adult and Larval Western Cherry Fruit Fly (Diptera: Tephritidae)

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ABSTRACT. Effects of spinosad, spinosad bait, and the chloronicotinyl insecticides imidacloprid and thiacloprid on mortality of the adults and larvae of western cherry fruit fly, *Rhagoletis indifferens* Curran (Diptera: Tephritidae), were determined in the laboratory and the field. Spinosad and spinosad bait caused higher adult mortality than imidacloprid, which caused higher mortality than thiacloprid. Only spinosad bait prevented oviposition. All materials were more toxic to adults when ingested than when topically applied. Spinosad bait had the greatest residual toxicity on leaves, killing 100% of adults when aged for 14 d in the field. When materials were sprayed on infested cherries, numbers of live larvae in fruit after 8 d were lower in imidacloprid and thiacloprid than in spinosad and spinosad bait treatments, which did not differ from the control, but all materials reduced larval emergence over 30 d. In the field, spinosad and spinosad bait were as effective in suppressing larval infestations as acrintho-methyl and carbaryl, whereas imidacloprid was effective in most cases and thiacloprid was generally less effective than acrintho-methyl and carbaryl. Overall, results in the laboratory and field show that spinosad and chloronicotinyl insecticides differed significantly in their effectiveness against adults and larvae of *R. indifferens* but that spinosad, spinosad bait, and imidacloprid seem to be acceptable substitutes for organophosphate and carbamate insecticides for controlling this fruit fly.

KEY WORDS. *Rhagoletis indifferens*, spinosad, imidacloprid, thiacloprid, control

Insecticides continue to be vital in efforts to control the western cherry fruit fly, *Rhagoletis indifferens* Curran (Diptera: Tephritidae), the most serious insect pest of commercial sweet and sour cherries, *Prunus avium* (L.) L. and *Prunus cerasus* L., respectively, in the western United States. Organophosphate and carbamate insecticides have been used for many years to successfully control this fly in Washington (Eide et al. 1949, Johansen et al. 1954, Frick et al. 1954, Frick 1957), Oregon (Zwick et al. 1970, 1975), Utah and other western states, and in British Columbia (Raine and Androna 1968). The zero tolerance for fly larvae in cherries (Anonymous 1998) has necessitated the use of these highly toxic insecticides in commercial orchards. Isolated homeowner or abandoned trees can be heavily infested and also need to be treated with these insecticides to reduce chances of flies dispersing to commercial orchards. However, because of their impending loss or restricted use in the future due to the Food Quality and Protection Act (1996), newer insecticides are increasingly important in efforts to control the fly. These insecticides include various formulations of macrocyclic lactone, spinosad, which is

derived from the soil bacterium *Sarriusraapetopyre* sp. nov. Metz and Yac and two chloronicotinyl insecticides, imidacloprid and thiacloprid (Hu et al. 1998, 2000; Lihard et al. 2003; Reising 2003; Barry and Polavarapu 2005). Spinosad is also used as the toxin in bait sprays (Reising 2003, Yee and Chapman 2006). These insecticides have been tested against adult apple maggot, *Rhagoletis pomonella* (Walsh) (Reising 2003), and adult blueberry maggot, *R. mendax* Curran (Lihard et al. 2003, Barry and Polavarapu 2005, Barry et al. 2005). In *R. pomonella*, spinosad was effective in the laboratory, although it performed inconsistently in the field, whereas spinosad bait was ineffective in the field. Imidacloprid was effective in the laboratory and not effective in the field. Thiacloprid was ineffective in the laboratory, but it was effective in the field (Reising 2003). In *R. mendax*, spinosad, imidacloprid, or thiacloprid were equally effective (Lihard et al. 2003, Barry and Polavarapu 2005, Barry et al. 2005). In the walnut husk fly, *R. completa* (Gresson), spinosad bait was also effective, but it did not eliminate infestations (Van Steenwyk et al. 2003), which was also true in *R. indifferens* (Yee and Chapman 2005).

In addition to killing the adult fly and therefore reducing oviposition, imidacloprid and thiacloprid may kill larvae inside fruit to some extent because both materials are absorbed by plant tissue (Elbert et al. 1991, 2001). Controlling eggs and larvae is important

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