CODLING MOTH MONITORING IN MATING DISRUPTED APPLE ORCHARDS

CHERRY FRUIT FLY ATTRACTION TO BAITS

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Utah State Horticultural Association
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UTAH PESTS

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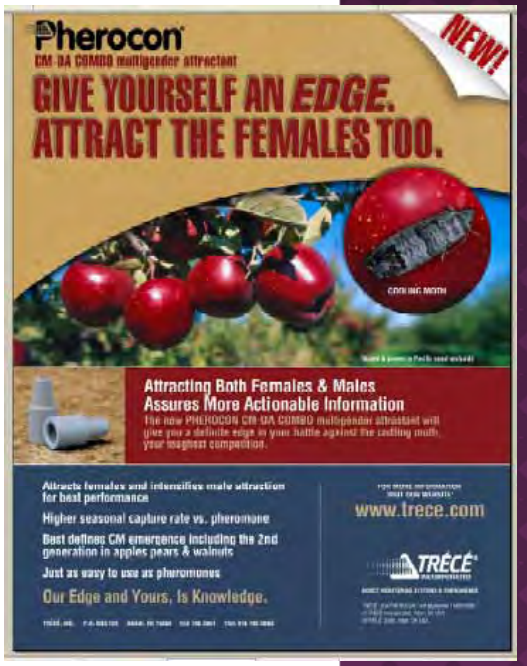
CODLING MOTH MONITORING IN MATING DISRUPTED APPLE ORCHARDS

WHY USE MATING DISRUPTION & WHY MONITOR?

- Mating disruption (MD) can effectively lower codling moth (CM) populations & allow integration of lower toxicity insecticides into pest management programs
- Monitoring CM is essential to evaluating success of MD & insecticide program
- More data is needed on performance of commercial CM lures
- Development of trap thresholds & predictive relationships for fruit injury will empower Utah apple producers to implement CM MD to their full advantage

CODLING MOTH LURES

- Codlemone (female sex pheromone) – captures only males
  - Standard 1X pheromone lure
    - designed for non-MD orchard
    - red septa, Biolure membranes (4 wk)
    - gray septa - Long-life lures (8 wk)
  - 10X pheromone lure (3 wk)
    - designed for MD environment
- Food & egg-laying host attractant (non-pheromone) – attractive to males & females
  - DA lure – pear ester (8 wk)
  - DA-Combo lure - pear ester + high load of pheromone (8 wk)



TRAP THRESHOLDS IN MD ORCHARDS

Using pear ester to monitor codling moth in sex pheromone treated orchards

EM 8904
February 2006
$4.50

A. Knight, R. Hilton, P. VanBuskirk, and D. Light

Advantages in using pear ester include:

- Tracking female flight patterns
- Improving prediction of first egg hatch
- Using action thresholds to optimize a spray program

Pear ester is a characteristic pear flavor attractive to codling moth (i.e., a kairomone). Traps baited with a pear ester lure can be used to monitor male and female adult codling moth activity.

Pear ester is a natural volatile produced by ripening pears. Male and female codling moths have specialized receptors on their antennae that can detect pear ester. Male moths respond to pear ester while searching for a host where female moths will be available for mating. Female codling moths also use the pear ester to locate the host, and mated females use the pear ester to locate specific sites to lay eggs (on or on fruit. Other host-produced chemicals can affect the behavior of codling moth, but no other compound tested so far has proven to be as attractive and chemically stable as pear ester.

Growers' use of sex pheromones to disrupt codling moth mating strongly impacts male moth behavior but does not affect moths' response to pear ester. Thus, pear ester can be an effective lure to use in orchards treated with sex pheromone. Many studies have been conducted to understand how to best use pear ester. This publication summarizes the current state of our knowledge regarding the use of pear ester as additional information is gathered, recommendations for use will be updated.

How to monitor

Careful monitoring of codling moth in orchards treated with sex pheromone mating disruption is critical due to the influence of moth density on effective disruption and the potential for undetected moth immigration into treated orchards. Thresholds have been established both to minimize the unnecessary use of insecticides and to avoid failing to detect a within-orchard population. Growers' monitoring programs need to be standardized, and recommendations in this report are based on the best available data. Any changes in this program will likely influence the interpretation of trap counts and may affect the efficacy of your management program.

The pear ester lure often will catch fewer moths than other pheromone lure, this is particularly true in orchards that are not treated with sex pheromone and where densities of codling moth are high. However, in sex pheromone treated orchards with low populations of codling moth, the pear ester lure generally will catch similar numbers of moths as a standard (i.e., high load) sex

Alan Knight, research entomologist, U.S. Department of Agriculture Agricultural Research Service, Wapato, WA; Richard Hilton, senior research assistant; and Philip VanBuskirk, Extension horticulturist, both of Southern Oregon Research and Extension Center, Oregon State University; and Douglas M. Light, research entomologist, U.S. Department of Agriculture Agricultural Research Service, Albany, CA

Oregon State University | Extension Service

Brunner and Gut

10X pheromone traps:

4-10 moths

Knight *et al.* (OSU fact sheet)

DA traps:

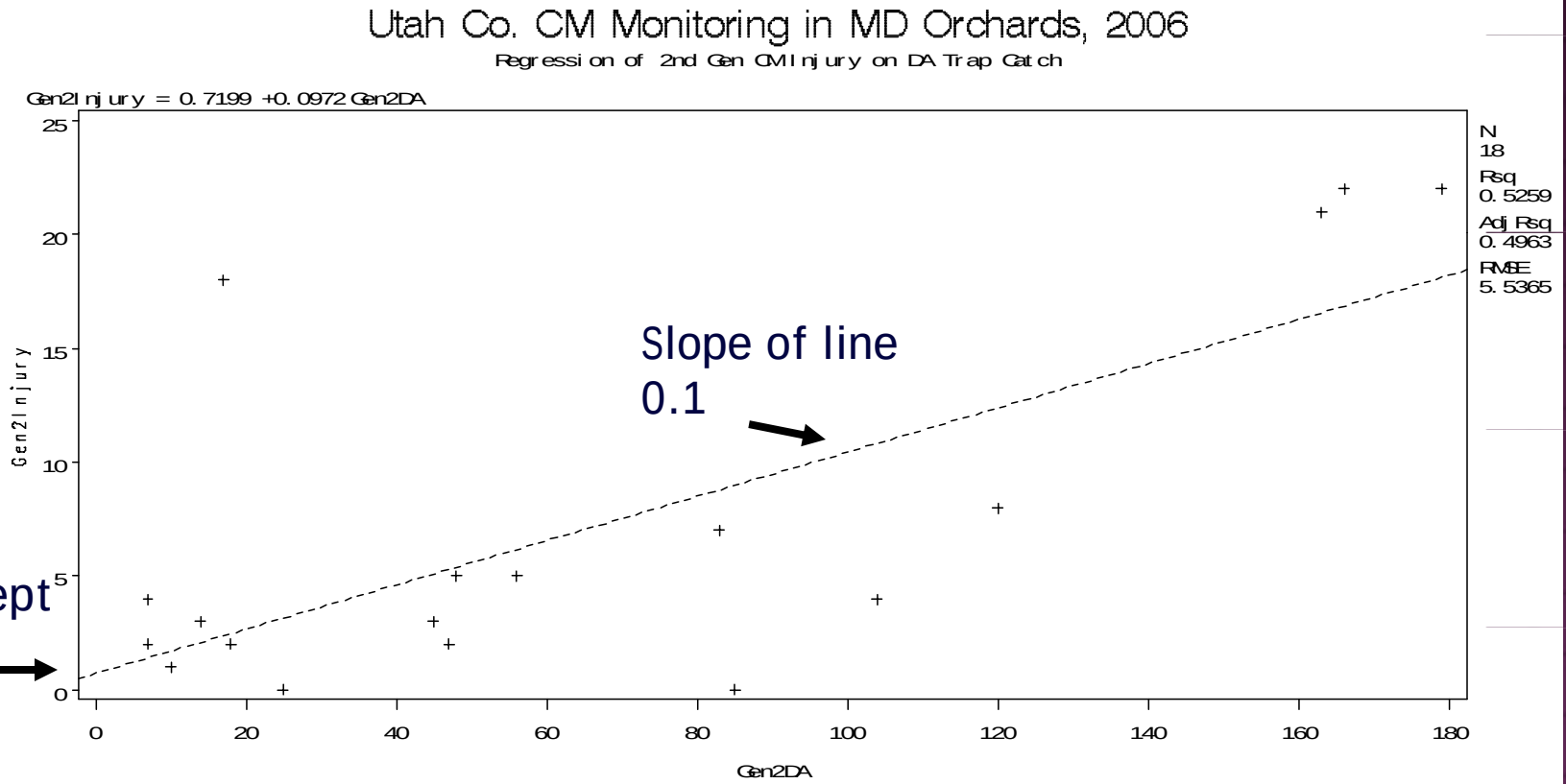
2 moths or 1 female moth

Trece' recommendation

DA-Combo traps:

5-10 moths

2006 STUDY: REGRESSION OF % FRUIT INJURY ON CUMULATIVE MOTH CATCH IN DA-COMBO TRAPS FOR 2ND GENERATION



Slope of line
0.1

X- axis intercept
0.7

0.7% fruit injury + 0.1% fruit injury (stings + entries) for every moth caught

5 moths → 0.5% injury, 10 moths → 1.0% injury

2007 OBJECTIVES

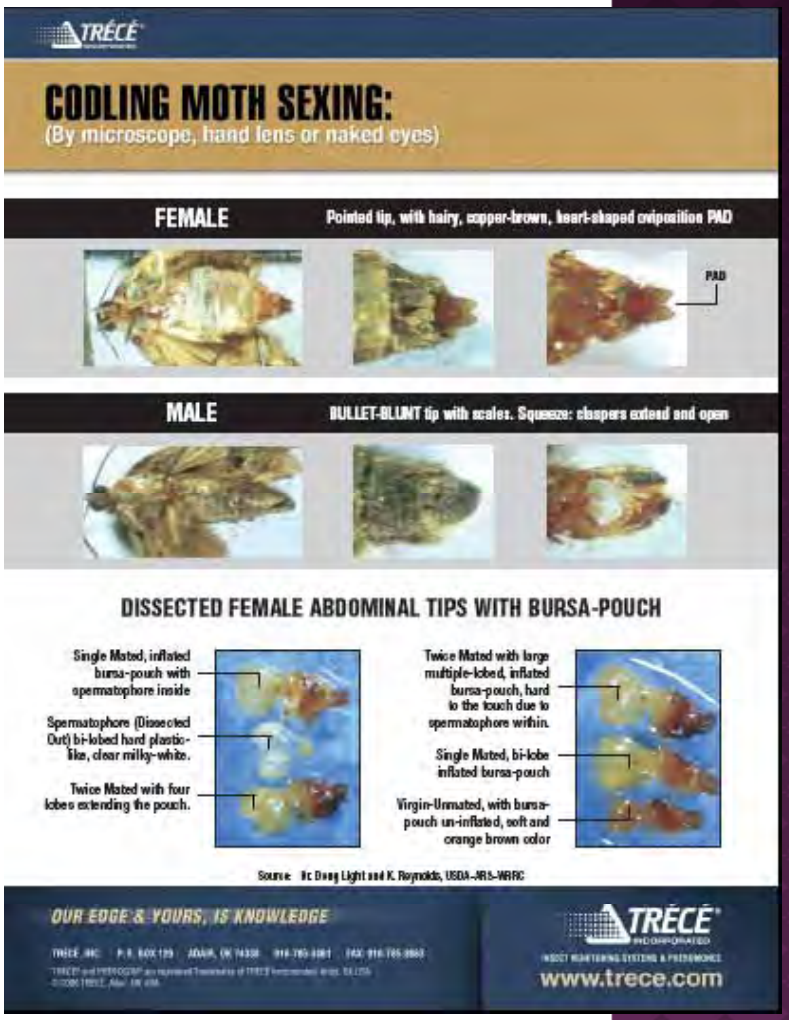
- Evaluate 4 types of commercial lures to compare trap catch for each CM generation & across season
- Develop economic-based trap threshold to signal when supplementary controls are needed
- Develop a predictive relationship between fruit injury & trap catch for effective lures

2007 STUDY

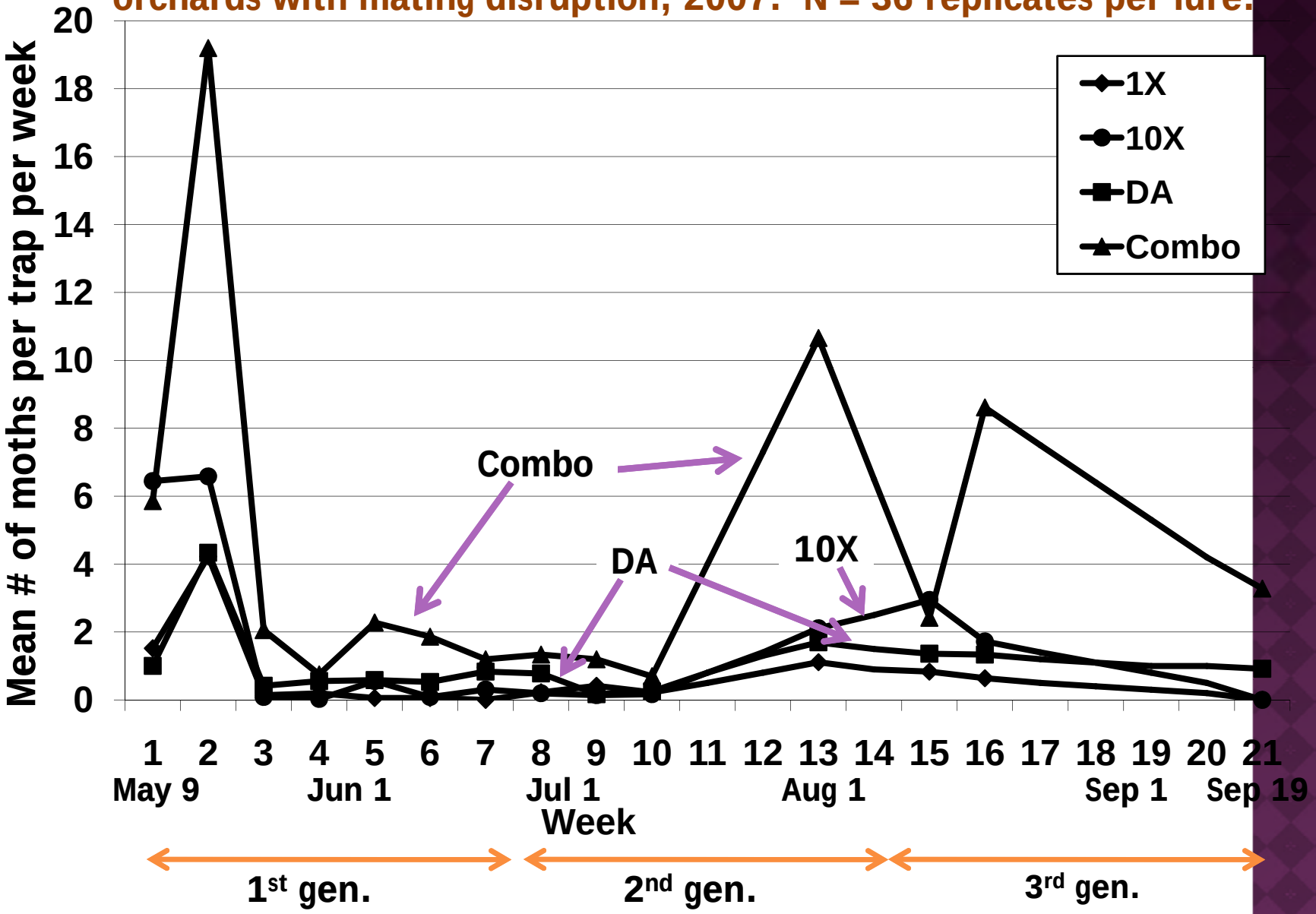
- 12 apple orchards
  - Payson, Santaquin, Genola, West Mtn.
  - CM biofix: April 26-29
- 1×, 10×, DA, DA-Combo (Combo)
  - 3 reps in each orchards, RCBD, trap positions rotated (36 reps. for each lure, 144 traps total)
  - Large-size Delta trap, placed May 1-9
  - CM counted weekly (bi-weekly after mid July)
  - Moths in DA & Combo traps were sexed & females dissected to determine mating status
  - Lures & sticky liners replaced
- Fruit injury assessments
  - July 11 & August 16 (400 fruit per orchard)

DETERMINING GENDER & MATING STATUS OF CODLING MOTHS

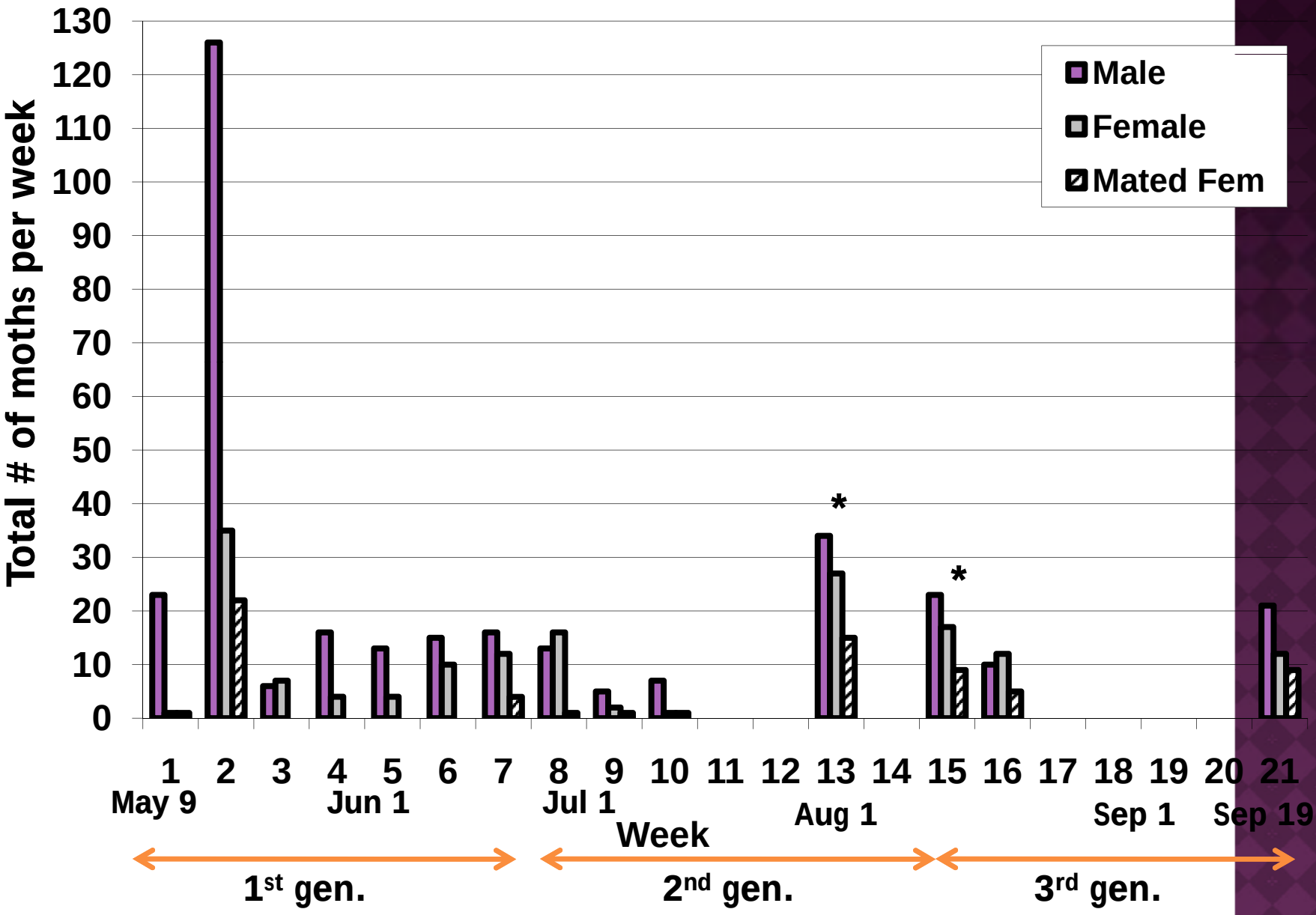
- On the reproduction-business end the moth
- Male: claspers
- Female: heart-shaped oviposition pad
  - Mating status: presence of spermatophore (sperm packet), can count the number



Influence of trap lure on CM adult catch in 12 Utah County apple orchards with mating disruption, 2007. N = 36 replicates per lure.

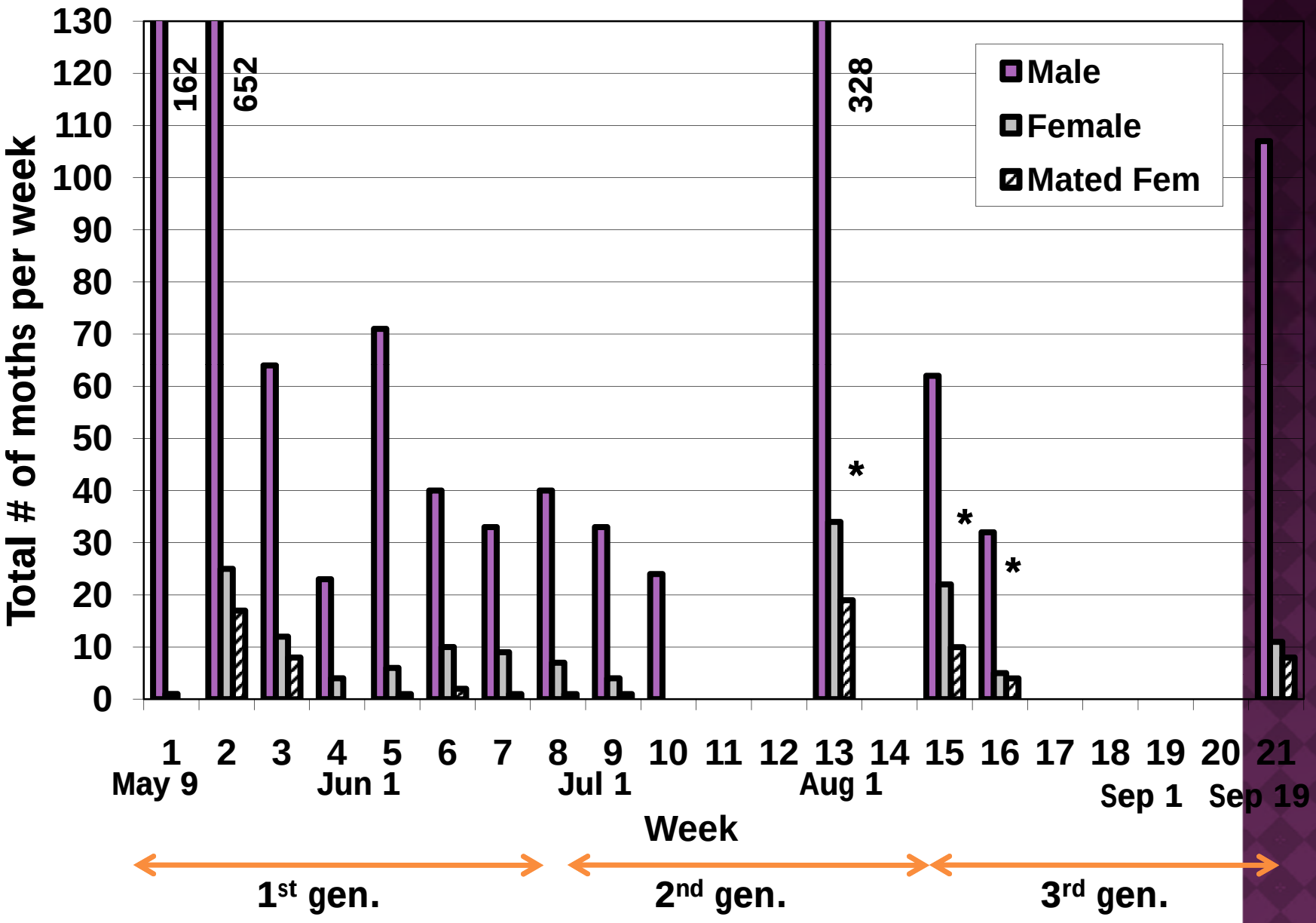


Gender and mating status of CM adults caught in DA-baited traps



*Dates with females that were mated more than once

Gender and mating status of CM adults caught in Combo-baited traps



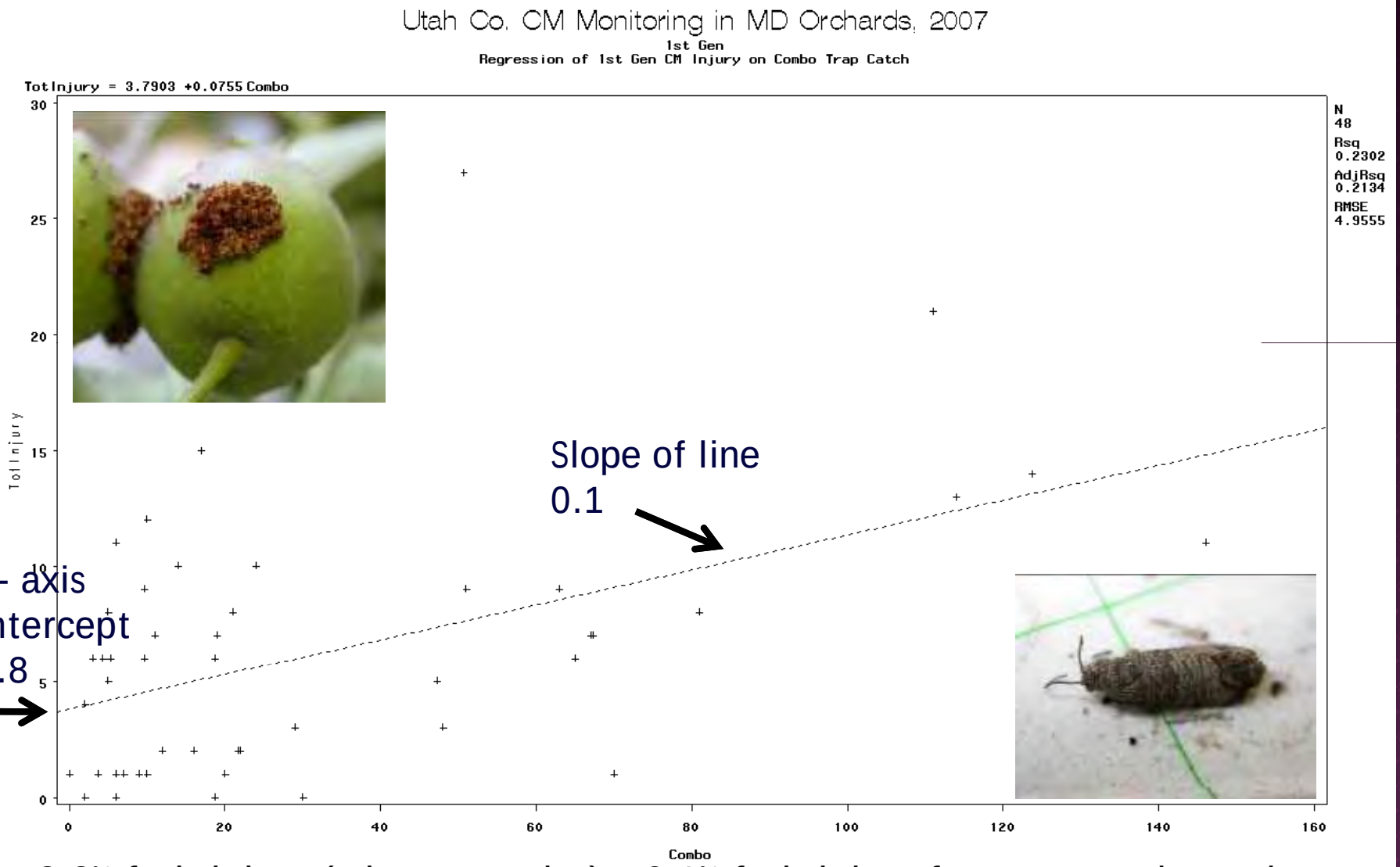
*Dates with females that were mated more than once

RELATION OF CM TRAP CATCH TO FRUIT INJURY IN 12 ORCHARDS, 2008

Orch /	Cumulative mean # CM / trap				Mean % CM injury*		
Variety	1×	10×	DA	Combo	Sting	Entries	Total
1. Fuj	1.3	5.3	4.7	22.3	9.5	0	9.5
2. Jon	9.6	20.3	2.9	28.2	8.8	0.3	9.1
3. Red	5.0	27.3	16.3	54.4	12.8	0.3	13.1
4. Fuj	0.3	2.0	4.0	9.9	10.5	0	10.5
5. Gal	2.0	5.3	1.6	19.7	6.3	0.3	6.6
6. Gal	1.3	9.6	2.3	20.1	2.5	0	2.5
7. Gol	2.3	2.6	6.3	6.7	6.8	0	6.8
8. Gol	39.4	44.6	24.1	85.9	8.8	0	8.8
9. Cam	0.9	4.1	1.3	14.0	4.8	0.5	5.3
10. Gal	36.6	84.7	55.0	263.3	17.3	1.0	18.3
11. Red	3.7	11.3	25.1	64.1	8.3	0.3	8.5
12. Red	8.3	19.7	30.4	128.7	5.0	0	5.0

*Season total (1st & 2nd generation injury combined)

Regression relationship between apple fruit injury and trap catch in Combo-baited traps for the first generation of codling moth (p = 0.006, r^2 = 0.23).

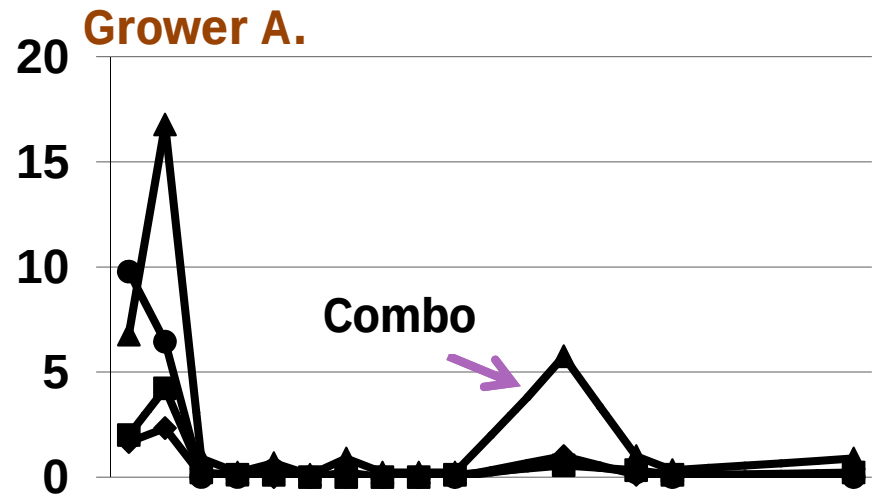


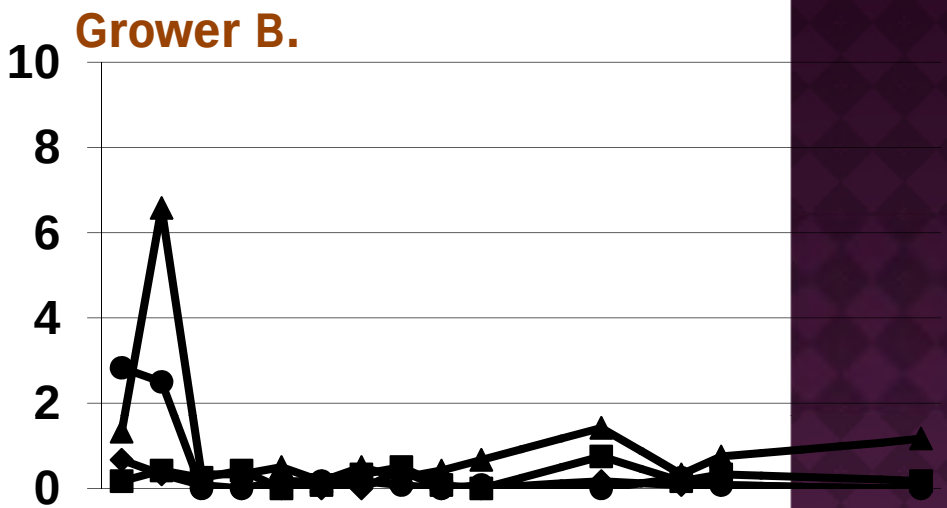
3.8% fruit injury (stings + entries) + 0.1% fruit injury for every moth caught

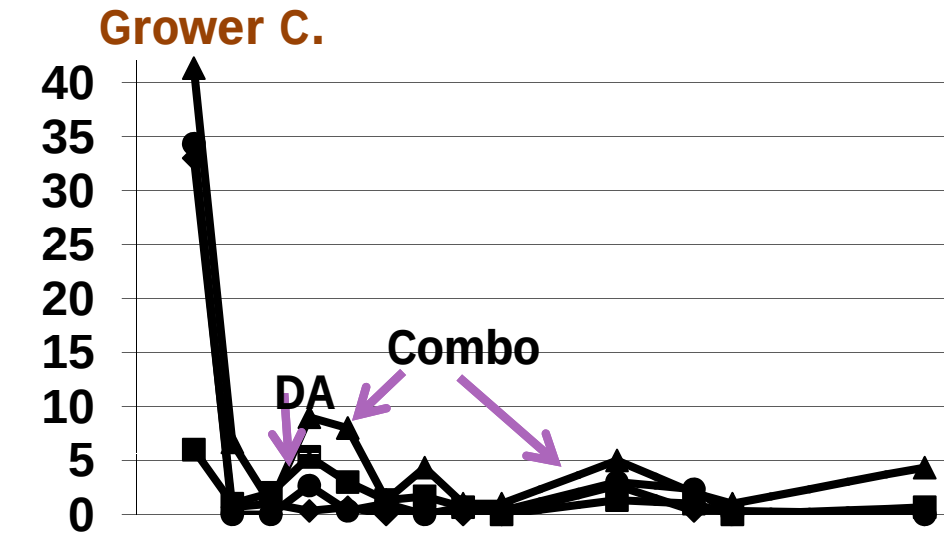
5 moths → 0.5% injury or 10 moths → 1.0% injury

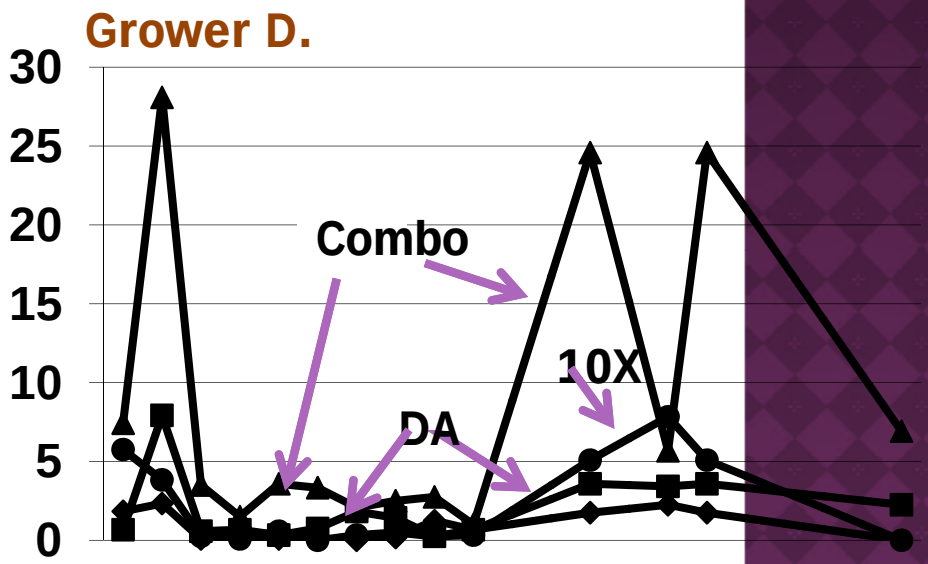
CM TRAP ACTION THRESHOLDS

DA: 2 MOTHS, COMBO & 10×: 5 MOTHS / ≤ 0.5% ENTRIES & ≤ 6.0% STINGS









CM TRAP LURES - CONCLUSIONS

- DA & Combo-baited traps most predictive of fruit injury (10× in some orchards & years)
  - ~0.1% fruit injury per moth
- DA & Combo lures attract females
  - To use this information, moths must be sexed (10-20× hand lens)
  - To determine female mating status, female moths must be dissected (microscope)
- Trap thresholds
  - DA: 2 moths
  - Combo & 10×: 5 moths
- Economics
  - 10× (3 wk): $1.23 ea; DA (8 wk): $3.81; Combo (8wk): $4.08
  - DA & Combo lures last 2.7× longer
  - Cost-savings of 10× is only $0.49 to $0.76 per lure (less than $1 per trap for an 8-wk period)

Female abdomen with heart-shaped oviposition pad

NEW CM PRODUCTS

- **Insecticides (broad spectrum)**
  - **Battalion** (deltamethrin) – 5th gen. synthetic pyrethroid, less mite flare, Arysta LifeScience Corp.
  - **Altocor** (rynaxypyr) – new class, "anthranilic diamide", interferes with calcium gates in muscles, affects movement, DuPont Crop Protection
  - **Delegate** (spinetoram) – new spinosyn insecticide, Dow AgroSciences
  - **Belt** (flubendiamide) – new class, "phthalic acid diamides", disruption of cellular calcium balance, Bayer CropScience

NEW CM PRODUCTS

- **Pheromone MD products**
  - **CideTrak DA-Combo dispenser** – pear ester + pheromone in dispenser, Trece
  - **CideTrak DA MEC** – micro-encapsulated, sprayable pear ester MD product, Trece
  - **SPLAT** – flowable pheromone dispenser, MD and attract-&-kill if insecticide added, ISCA Technologies
  - Pheromone flakes & fibers – applied in sticky glue, not commercially available

UPDATE ON GUTHION REGISTRATION

- **Apple, Pear, Sweet & Tart Cherry**
  - Registration will end in 2012
  - Phase-down of allowed pounds per acre for the season
  - 60 ft buffer from treated orchards to bodies of water
  - 60 ft buffer from orchards to human occupied buildings
  - Lengthy PHI for U-pick orchards

CHERRY FRUIT FLY ATTRACTION TO BAITS

MONITORING CFF WITH TRAPS
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

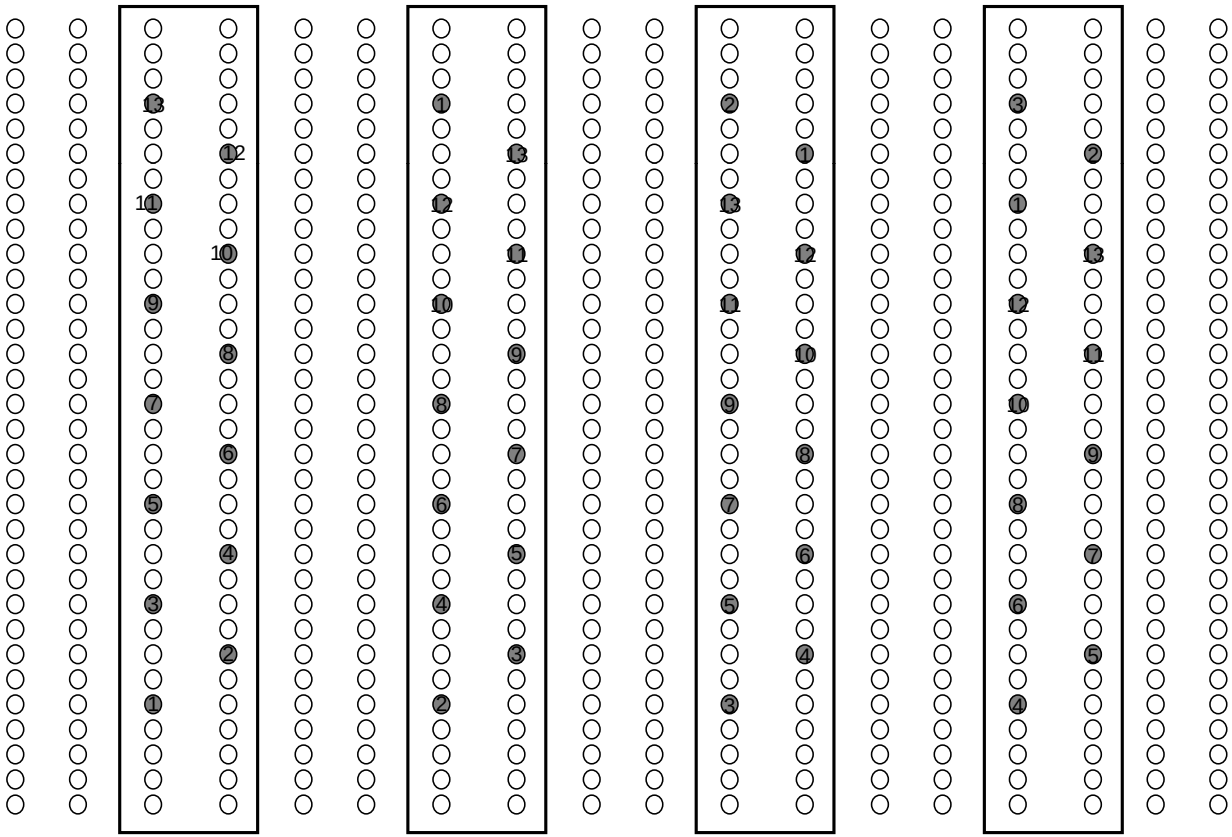
Pherocon AM® trap + ammonium carbonate bait

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)

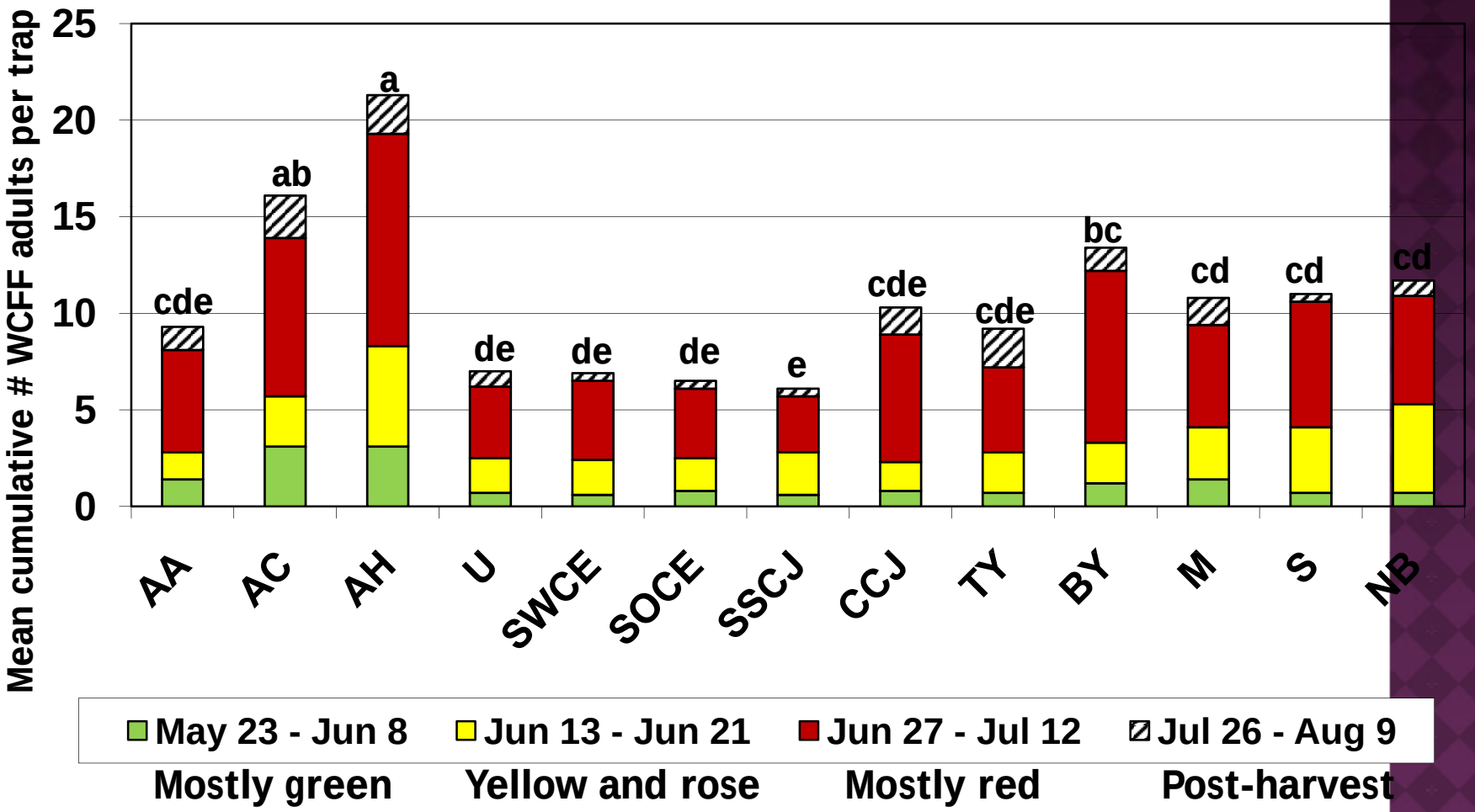


Treatments:
1. Amm. Acetate (AA)
2. Amm. Carbonate (AC
3. Amm. Hydroxide (AH)
4. Urea (U)
5. Sweet Cherry Essence (SWCE)
6. Sour Cherry Essence (SOCE)
7. Single Strength Cherry Juice (SSCJ)
8. Concentrate Cherry Juice (CCJ)
9. Torula Yeast (TY)
10. Brewer's Yeast (BY)
11. Molasses (M)
12. Sucrose (S)
13. No Bait (NB)

= tree with trap

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

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 CO_2
- 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

EFFICACY OF NEW CHERRY FRUIT FLY INSECTICIDES

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

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 plot)

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 plot)

GF-120 MODE OF ACTION

- Bait in GF-120 must be arresting adults reasonably well, but it doesn't appear to be attractive in lab trials
- 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

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

UTAH PESTS WEB PAGE

EXTENSION / OUTREACH PRODUCTS

Horticulture

EXTENSION

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July 2005 Orchard IPM Series HG/Orchan

Prionus Root Borer (*Prionus californicu*

Shawn Steffan and Diane Alston

Did You Know?

- This long-horned beetle is native to the West and lives 3–6 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-horned 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 ¾ -2 ¼ 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 108 mm (4 ¼ inches) with a diameter of approximately 18 mm (¾ inch) at the widest point of the larve'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 furrow (1-inch wide) made by a prionus larva.

Fig. 2.

UTAH PESTS fact sheet

UtahState UNIVERSITY

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Greater Peachtree Borer (*Synanthedon exitiosa*)

Diane Alston, Extension Entomology Specialist • Marion Murray, IPM Project Leader

Do You Know?

- Greater peachtree borer is an important pest of peach, nectarine, apricot, cherry, and plum
- Adults are clearwing 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

Fig. 1. Adult male (l) and female (r) pea

Fig. 2. Peachtree borer larva[2]

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 clearwing 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.

HOSTS

apricot, cherry, chokecherry, peach, plum, prune

LIFE HISTORY

Adult – Monitoring Stage

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

UTAH PESTS fact sheet

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Western Cherry Fruit Fly (*Rhagoletis indifferens*)

Diane Alston, Extension Entomology Specialist • Marion Murray, IPM Project Leader • Michael Reding • Carin 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 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, fabrics) can reduce pupation and fly emergence
- Post-harvest sanitation can reduce populations

Figure 1. Adult fly caught on trap.[1]

Figure 2. Larvae feeding inside a cherry fruit.[2]

Figure 3. Damaged cherries with larval exit holes.[2]

Figure 4. Cherry fruits are not susceptible to attack until they have a blush of salmon color.[2]

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 fruits (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 ripen to a salmon-blush color (Fig. 4) until they become too soft or fall from the tree.

HOSTS

Sweet, tart, and wild species of cherries

LIFE HISTORY

Pupa – Overwintering Stage

- Size: about 5/16 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 ⅕ 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 6)
- When: 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

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