CODLING MOTH MONITORING IN MATING DISRUPTED APPLE ORCHARDS

CHERRY FRUIT FLY ATTRACTION TO BAITS

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Utah State Horticultural Association Annual Convention
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CODLING MOTH MONITORING IN MATING DISRUPTED APPLE ORCHARDS
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

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

Utah Co. CM Monitoring in MD Orchards, 2006

Regression of 2nd Gen CM Injury on DA Trap Catch

Gen2 injury = 0.7199 + 0.0972 Gen2DA

R² = 0.5259

Adj R² = 0.4963

RMSE = 5.5365

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.

Mean # of moths per trap per week

- 1X
- 10X
- DA
- Combo

1st gen. 2nd gen. 3rd gen.
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

<table>
<thead>
<tr>
<th>Variety</th>
<th>Cumulative mean # CM / trap</th>
<th>Mean % CM injury*</th>
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<tbody>
<tr>
<td></td>
<td>1×</td>
<td>10×</td>
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<tr>
<td>1. Fuj</td>
<td>1.3</td>
<td>5.3</td>
</tr>
<tr>
<td>2. Jon</td>
<td>9.6</td>
<td>20.3</td>
</tr>
<tr>
<td>3. Red</td>
<td>5.0</td>
<td>27.3</td>
</tr>
<tr>
<td>4. Fuj</td>
<td>0.3</td>
<td>2.0</td>
</tr>
<tr>
<td>5. Gal</td>
<td>2.0</td>
<td>5.3</td>
</tr>
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<td>6. Gal</td>
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<td>9.6</td>
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<tr>
<td>7. Gol</td>
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<td>2.6</td>
</tr>
<tr>
<td>8. Gol</td>
<td>39.4</td>
<td>44.6</td>
</tr>
<tr>
<td>9. Cam</td>
<td>0.9</td>
<td>4.1</td>
</tr>
<tr>
<td>10. Gal</td>
<td>36.6</td>
<td>84.7</td>
</tr>
<tr>
<td>11. Red</td>
<td>3.7</td>
<td>11.3</td>
</tr>
<tr>
<td>12. Red</td>
<td>8.3</td>
<td>19.7</td>
</tr>
</tbody>
</table>

*Season total (1\textsuperscript{st} & 2\textsuperscript{nd} generation injury combined)
Regression relationship between apple fruit injury and trap catch in Combo-baited traps for the first generation of codling moth ($p = 0.006$, $r^2 = 0.23$).

Utah Co. CM Monitoring in MD Orchards, 2007

1st Gen

Regression of 1st Gen CM Injury on Combo Trap Catch

Slope of line $0.1$

X-axis intercept $3.8$

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

5 moths $\rightarrow$ 0.5% injury or 10 moths $\rightarrow$ 1.0% injury
CM TRAP ACTION THRESHOLDS
DA: 2 MOTHS, COMBO & 10×: 5 MOTHS / ≤0.5% ENTRIES & ≤6.0% STINGS

Grower A.

Grower B.

Grower C.

Grower D.
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)
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
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
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
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
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)

<table>
<thead>
<tr>
<th>Block 1</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Block 4</th>
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<tr>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
</tr>
</tbody>
</table>

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

Mean cumulative # WCFF adults per trap

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<thead>
<tr>
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<tbody>
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</tr>
<tr>
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<tr>
<td>AH</td>
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<td></td>
</tr>
<tr>
<td>U</td>
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</tr>
<tr>
<td>SWCE</td>
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<tr>
<td>SOCE</td>
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</tr>
<tr>
<td>SSCJ</td>
<td></td>
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</tr>
<tr>
<td>CCJ</td>
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</tr>
<tr>
<td>TY</td>
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<td></td>
</tr>
<tr>
<td>BY</td>
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<td></td>
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<tr>
<td>M</td>
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<td></td>
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<tr>
<td>S</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>NB</td>
<td></td>
<td></td>
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Mostly green | Yellow and rose | Mostly red | Post-harvest

Means followed by the same letter are not significantly different (Tukey-Kramer test, $p > 0.05$)
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
EFFICACY OF NEW CHERRY FRUIT FLY 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
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

<table>
<thead>
<tr>
<th>Year</th>
<th>Orch#</th>
<th>Treatment*</th>
<th># CFF larvae</th>
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<tbody>
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<td>1</td>
<td>Guthion</td>
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</tr>
<tr>
<td></td>
<td></td>
<td>Provado</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>Dimethoate</td>
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</tr>
<tr>
<td></td>
<td>Provado</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Guthion</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Imidan</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Provado</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>4</td>
<td>Guthion</td>
<td>0 c</td>
</tr>
<tr>
<td></td>
<td>Provado</td>
<td>2.4 a</td>
<td></td>
</tr>
<tr>
<td></td>
<td>GF-120</td>
<td>0.8 b</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Guthion</td>
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<td></td>
</tr>
<tr>
<td></td>
<td>GF-120</td>
<td>0</td>
<td></td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>Orch#</th>
<th>Treatment*</th>
<th># CFF larvae</th>
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<td>2005</td>
<td>6</td>
<td>Guthion</td>
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<tr>
<td></td>
<td>GF-120</td>
<td>0</td>
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<tr>
<td>7</td>
<td>Guthion</td>
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<tr>
<td></td>
<td>GF-120</td>
<td>0</td>
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<tr>
<td>2006</td>
<td>8</td>
<td>Provado/Guthion</td>
<td>0</td>
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<tr>
<td>9</td>
<td>Provado/Imidan</td>
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<td>Provado/GF-120</td>
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*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

<table>
<thead>
<tr>
<th>Year</th>
<th>Orch #</th>
<th>Treatment*</th>
<th># CFF larvae^</th>
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<tbody>
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<td>GF-120</td>
<td>0.3 c</td>
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<tr>
<td>2005</td>
<td>17</td>
<td>Untreated</td>
<td>9.3 a</td>
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<td>Guthion</td>
<td>1.3 b</td>
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<td>0.1 c</td>
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<td>Provado</td>
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<td>GF-120</td>
<td>1.9 b</td>
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<td>GF-120+AA</td>
<td>0.8 b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GF-120+U</td>
<td>1.4 b</td>
</tr>
<tr>
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<td>GF-120+TY</td>
<td>0.5 b</td>
</tr>
<tr>
<td></td>
<td></td>
<td>GF-120+CCJ</td>
<td>0.9 b</td>
</tr>
</tbody>
</table>

*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
Spinosead (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
- Spinosead: adulticide

GF-120 cannot protect fruit against migrating females that contain mature eggs:
- Prevented fruit injury for orchards ≤ 20 cumulative CFF on traps

Important to rotate applications of neonicotinoid (Provado) with other insecticide classes:
- Stimulation of spider mites
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 website links below to get started!

**integrated pest management**
Choose this site for the plant pest addresses, the IPM Mini-Grant program, weather data, and much more.

**plant diseases**
Choose this site for a multitude of fact sheets on diseases and disorders of field crops, fruits, ornamentals, turf and vegetables.

**insects and their relatives**
This site will help to shed some light on the insects with fact sheets, images, slide shows, and more.

**utah plant pest diagnostic lab**
The UPDOL, the only lab of its kind in Utah, is here to identify and provide management recommendations for your pest problems.
EXTENSION / OUTREACH PRODUCTS

Prijoues Root Borer (Prijoues californicus)

Shawn Sefton and Diane Aison

The Prijoues root borer belongs to a family of beetles commonly known as longhorned beetles (Cerambycidae). The larvae are often referred to as round-headed borers because their head is large compared to their body.

Several species of longhorned beetles are native to the United States, including the California prijoues (P. californicus) and the Prijoues root borer (P. californicus). These beetles are distributed across the U.S. and Canada. The California prijoues is a pest of citrus groves in southern California, while the Prijoues root borer is a pest of several other crops, including citrus, avocado, and coffee.

The Prijoues root borer is a serious pest for avocado orchards in the southwestern U.S. The larvae feed on the roots of avocado trees, causing root damage and reducing the tree's ability to absorb water and nutrients. This can lead to stunted growth, reduced fruit production, and even tree death.

To control the Prijoues root borer, growers can use chemical insecticides, cultural practices, and biological control methods. Cultural practices include maintaining a healthy, well-managed orchard, rotating crops, and monitoring for the presence of the pest. Biological control methods include introducing natural predators and parasitoids to control the pest population.

Western Cherry Fruit Fly (Rhagoletis indifferens)

Diane Aison, Extension Entomology Specialist - Hoston Maryon, Phil Project Leader - Michael Redig - Federalist

The Western Cherry Fruit Fly is a pest of cherry and plum crops. Adult flies lay eggs in the fruit, which hatch into maggots that feed inside the fruit. This damage can reduce the fruit's quality and yield, leading to economic losses for farmers.

To control the Western Cherry Fruit Fly, growers can use cultural practices, such as planting resistant cultivars, and chemical insecticides, such as organophosphates and pyrethroids. Biological control methods, such as the use of parasitoids and predators, can also be effective in reducing pest populations.

Life History

**Adult - Monitoring**
- Color and Appearance: Pink or red with a metallic sheen and a 1/4-inch head-to-body length.
- Behavior: Adult flies are active from May to August, feeding on nectar and pollinating cherry and plum trees.

**Life Cycle**
- Egg: Laid in the fruit, hatching in 4-6 days.
- Larva: Feeds inside the fruit, pupating in the same fruit.
- Pupa: Overwinters in the soil, emerging the following spring.

**Hosts**
- Cherry, Plum, Apricot

**Management**
- Cultural practices: Planting resistant cultivars, such as Sweet Cherry, and managing for adequate pollination.
- Chemical controls: Use organophosphates and pyrethroids for outbreak control.
- Biological controls: Use parasitoids and predators, such as the California cherry leafroller and the black cherry leafminer.

**Preventative Measures**
- Clean trees and orchards to remove overwintering sites.
- Monitor for adult flies using pheromone traps.

**Pest Control**
- Cultural practices: Remove dead branches and debris from the orchard floor.
- Chemical controls: Use organophosphates and pyrethroids as a last resort.
- Biological controls: Use parasitoids and predators to control the pest population.
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