Bagrada bug: biology, host range and effects on cole crops

Darcy Reed, PhD
Phone: 951-827-4518
Email: darcy.reed@ucr.edu
Research Collaborations

• **UCR personnel** – Tom Perring, Darcy Reed, Nilima Castle, Jocelyn Millar, Steve McElfresh, Satya Chinta

• **Univ of Arizona** – John Palumbo

• **USDA-ARS Biological Control** – Walker Jones

• **Oklahoma State Univ** – Monica Papes, Tom Royer

• **New Mexico State Univ** – Tessa Grasswitz, Scott Bundy

• **Funding:** USDA/NIFA – WR-IPM and Critical Issues
Research Areas

• Insect development – as affected by temperature, host plant
• Seasonal migration
• Monitoring, trapping, attractant pheromone
• Effects on plant development
• Pesticide testing and timing
• Biological Control
• Current / Projected Distribution
Historical Geographic Range:

- African origins (also India, Pakistan, SE Asia, parts of Italy)
- Outbreaks common, dependent on weather conditions and food availability
- Wide host plant range (mainly cruciflers, but also grasses and grains, potatoes, some legumes...
Geographical Range of Invasion in the US

Bagrada hilaris Distribution 2008-2012

- 2012 Confirmed
- 2011 Confirmed
- 2010 Confirmed
- 2009 Confirmed
- 2008 Confirmed
Bagrada Bug

• *Bagrada hilaris* Burmeister
  – Previously *B. cruciferarum* Kirkaldy

• Common names: Painted bug, Bagrada bug, Harlequin bug (Old World)
IDENTIFICATION/RECOGNITION

Harlequin Bug

Bagrada Bug

www.bugguide.net
Female and Male Adult
Bagrada hilaris
Oviposition

• ~3-4 days after adult emergence
• Females produce ~10 eggs/day
• Undersides of leaves, cracks & crevices, hairy stems of non-host plants
Oviposition

• ~3-4 days after emergence
• Females produce ~10 eggs/day
• Undersides of leaves, cracks & crevices, hairy stems
• Go from adult reproductive quiescence to young feeding nymphs in ~12-14 days.
• Eggs often laid on non-biological structures, e.g. row cover, shade cover
Eggs of Stink Bugs
Eggs on weed seedling 14d PID
Total Development Time of *Bagrada hilaris*

- Constant Rearing Temperature (°F)
  - 75.2: 45 days
  - 78.8: 25 days
  - 86: 20 days
  - 89.6: 22 days
  - 95: 20 days
Survivorship to Adulthood of *Bagrada hilaris*
Reared at Constant Temperatures

<table>
<thead>
<tr>
<th>Temperature (°F)</th>
<th>% Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>75.2</td>
<td>75.2</td>
</tr>
<tr>
<td>78.8</td>
<td>95</td>
</tr>
<tr>
<td>86</td>
<td>89.6</td>
</tr>
<tr>
<td>89.6</td>
<td>86</td>
</tr>
<tr>
<td>95</td>
<td>78.8</td>
</tr>
</tbody>
</table>
Seasonal Activities

What are these bugs doing and where are they doing it?
Aggregations

Early Fall
2011 Field Activity in Riverside, CA of *Bagrada hilaris*

- London rocket
- Shortpod mustard
- Telegraph weed
- Russian thistle
- London rocket
- Shepherd's purse

# Bugs Counted at All Sites

<table>
<thead>
<tr>
<th>Month</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>0</td>
</tr>
<tr>
<td>Feb</td>
<td>0</td>
</tr>
<tr>
<td>Mar</td>
<td>0</td>
</tr>
<tr>
<td>Apr</td>
<td>0</td>
</tr>
<tr>
<td>May</td>
<td>0</td>
</tr>
<tr>
<td>June</td>
<td>0</td>
</tr>
<tr>
<td>July</td>
<td>2507</td>
</tr>
<tr>
<td>Aug</td>
<td>110</td>
</tr>
<tr>
<td>Sept</td>
<td>170</td>
</tr>
<tr>
<td>Oct</td>
<td>110</td>
</tr>
<tr>
<td>Nov</td>
<td>50</td>
</tr>
<tr>
<td>Dec</td>
<td>110</td>
</tr>
</tbody>
</table>
### 2011 Field Activity in Coachella Valley, CA of *Bagrada hilaris*

<table>
<thead>
<tr>
<th>Month</th>
<th>Artichoke</th>
<th>Broccoli</th>
<th>Carrot</th>
<th>Beans</th>
<th>Carrots</th>
<th>Corn</th>
<th>Chenopods</th>
<th>Grasses</th>
<th>Cauliflower</th>
<th>Celery</th>
<th>Lettuce</th>
<th>Spinach</th>
<th>Sunflower</th>
<th>London Rocket</th>
<th>Rapini</th>
<th>Sudan Grass</th>
<th>Tomatoes</th>
<th>London Rocket</th>
<th>Temp. &lt;75F</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>November</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# Bugs Counted at All Sites

<table>
<thead>
<tr>
<th># Bugs Counted at All Sites</th>
</tr>
</thead>
</table>
2011 Field Activity in Yuma, AZ
of *Bagrada hilaris*

<table>
<thead>
<tr>
<th>Month</th>
<th>Broccoli</th>
<th>Cabbage</th>
<th>Canola</th>
<th>Canola</th>
<th>Cauliflower</th>
<th>Cauliflower</th>
<th>Celery</th>
<th>Celery</th>
<th>Lettuce</th>
<th>Date Palms</th>
<th>Spinach</th>
<th>Lettuce</th>
<th>Weeds</th>
<th>Spinach</th>
<th>Wheat</th>
<th>Weeds</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>February</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>March</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>April</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>May</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>June</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>July</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>August</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>September</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>October</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>November</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>December</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

# Bugs Counted at All Sites
Seasonal Movement

Population Dynamics
April – August: Shortpod Mustard
Crop Hosts Tested

Arugula, Bell pepper, Broccoli, Cabbage, Cantaloupe, Cauliflower, Cilantro, Collards, Corn, Cowpea, Cucumber, Delta Pine cotton, Fungicide-treated cotton, Fava bean, India mustard, Italian squash, Kale, Lettuce, Smooth leaf cotton, Snap bean, Lima bean, Soybean, Sudan grass, Spinach, Sunflower, Tomato
Weed Hosts Tested

Birdsfoot trefoil, Shortpod mustard, Black nightshade, Goosefoot, Groundsel, London rocket, Shepherd’s purse, Sowthistle, Sweet alyssum, Tree tobacco, Vetch, Wild gourd

<p>| Not a host | Marginal host | Preferred host |</p>
<table>
<thead>
<tr>
<th>Plant tested</th>
<th>Plant Family</th>
<th>Date Started</th>
<th>Generation</th>
<th>Stage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Altor*</td>
<td>Brassicaceae</td>
<td>Aug 2012</td>
<td>F1</td>
<td>Nymph</td>
</tr>
<tr>
<td>Artichoke</td>
<td>Asteraceae</td>
<td>June 2012</td>
<td>F1</td>
<td>Nymph</td>
</tr>
<tr>
<td>Bermuda grass*</td>
<td>Poaceae</td>
<td>Nov 2011</td>
<td>F3</td>
<td>Nymph</td>
</tr>
<tr>
<td>Bluegrass</td>
<td>Poaceae</td>
<td>Sept 2011</td>
<td>F2</td>
<td>Nymph</td>
</tr>
<tr>
<td>Broccoli*</td>
<td>Brassicaceae</td>
<td>Feb 2011</td>
<td>F14</td>
<td>Nymph</td>
</tr>
<tr>
<td>Cauliflower</td>
<td>Brassicaceae</td>
<td>Feb 2011</td>
<td>F9</td>
<td>Adult</td>
</tr>
<tr>
<td>Corn, Bantam</td>
<td>Poaceae</td>
<td>Apr 2011</td>
<td>F1</td>
<td>Nymph</td>
</tr>
<tr>
<td>Corn, Brighton</td>
<td>Poaceae</td>
<td>Feb 2011</td>
<td>F1</td>
<td>Nymph</td>
</tr>
<tr>
<td>Cowpea</td>
<td>Fabaceae</td>
<td>May 2011</td>
<td>F1</td>
<td>Nymph</td>
</tr>
<tr>
<td>Sudan grass*</td>
<td>Poaceae</td>
<td>Mar 2011</td>
<td>F9</td>
<td>Adult</td>
</tr>
<tr>
<td>Sunflower hybrid</td>
<td>Asteraceae</td>
<td>Oct 2011</td>
<td>F1</td>
<td>Nymph</td>
</tr>
<tr>
<td>Sunflower, wild</td>
<td>Asteraceae</td>
<td>May 2012</td>
<td>F1</td>
<td>Nymph</td>
</tr>
<tr>
<td>Sunflower, ornamental</td>
<td>Asteraceae</td>
<td>July 2011</td>
<td>F2</td>
<td>Nymph</td>
</tr>
<tr>
<td>Vetch</td>
<td>Fabaceae</td>
<td>Feb 2011</td>
<td>F2</td>
<td>Adult</td>
</tr>
</tbody>
</table>

**Generational Study**

*Continuing*

- 5 female/5 males to begin
Host Plant Suitability

Mean Adult Longevity (days)

Chenopod  Carrot  Sunflower  Cantaloupe  Watermelon  Alfalfa  Alfalfa  Cowpea  Vetch  Basil  Cheeseweed  DeltaPine Cotton  Hairy Cotton  Smooth Cotton  Paymaster Cotton  Corn  Sudangrass  Bell Pepper  Bell Pepper  Eggplant  Broccoli Control
### Host-Switch Experiment

<table>
<thead>
<tr>
<th>Plants tested:</th>
<th>Family</th>
<th>How many Bagrada survived:</th>
<th>Adult Survival % From original 100 adults</th>
<th>Same Host Plant No. Nymphs</th>
<th>Switch to Broccoli No. Nymphs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflower, wild</td>
<td>Asteraceae</td>
<td>2♀ 2♂</td>
<td>4</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Artichoke</td>
<td>Asteraceae</td>
<td>17♀ 0♂</td>
<td>17</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>Groundsel</td>
<td>Asteraceae</td>
<td>6♀ 4♂</td>
<td>10</td>
<td>0,0</td>
<td>13,10</td>
</tr>
<tr>
<td>Sowthistle</td>
<td>Asteraceae</td>
<td>2♀ 6♂</td>
<td>8</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Watermelon</td>
<td>Cucurbitaceae</td>
<td>20♀ 14♂</td>
<td>34</td>
<td>pending</td>
<td>pending</td>
</tr>
<tr>
<td>Cowpea</td>
<td>Fabaceae</td>
<td>33♀ 33♂</td>
<td>66</td>
<td>2,9</td>
<td>7,16</td>
</tr>
<tr>
<td>Cheeseweed</td>
<td>Malvaceae</td>
<td>22♀ 24♂</td>
<td>46</td>
<td>1,0</td>
<td>24,25</td>
</tr>
<tr>
<td>Cotton, Hairy Leaf</td>
<td>Malvaceae</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Corn, Bantam</td>
<td>Poaceae</td>
<td>14♀ 12♂</td>
<td>26</td>
<td>6,6</td>
<td>7,13</td>
</tr>
<tr>
<td>Bermuda grass</td>
<td>Poaceae</td>
<td>17♀ 6♂</td>
<td>23</td>
<td>0,0</td>
<td>15,0</td>
</tr>
<tr>
<td>Sudan grass</td>
<td>Poaceae</td>
<td>43♀ 15♂</td>
<td>58</td>
<td>8,3</td>
<td>25,10</td>
</tr>
</tbody>
</table>
Lacerate /Flush Feeding
Effects of Feeding Damage

• Wilting
• Scorching
Recognition: Feeding Damage
Effects of Feeding Damage

• Wilting – esp. leafy mustards
• Scorching – old feeding lesions
• Blind plants- death of apical meristem
  – “Macho” plant
“Macho” plant
“Blind” cauliflower plant
Effects of Feeding Damage

- Wilting
- Scorching
- Blind plants- death of apical meristem
- Adventitious stems/ multiple heads
Undamaged cabbage plant  Multi-headed cabbage plant
Undamaged broccoli plant

Multi-crowned broccoli plant
Effects of Feeding Damage

- Wilting
- Scorching
- Blind plants - death of apical meristem
- Adventitious stems / multiple heads
- Stunted plants
- Death
At what plant stage is a direct-seeded broccoli crop no longer in danger from *Bagrada* bug feeding?
Impact of Bagrada on Broccoli 14-d after infestation

- 1 adult / 8 plants
- 14-d infestation period

% Plant Injury (Dead, Blind or Multiple terminals)
Impact of Bagrada on Broccoli Plant Growth, Pre- and Post-thinning

% Plant Injury (Blind or Multiple terminals)

Dry Wt (g/plant) of thinned plants

Coty. 1 leaf 2 leaf 4 leaf 6 leaf Not infested
Impact of Bagrada on Broccoli Yield

Cumulative Avg. Marketable Crowns / 20 row ft

- 6 - leaf
- 4 - leaf
- 2 - leaf
- 1 - leaf
- Uninfested
- Cotyledon

Harvest

Nov 28
Dec 7
Dec 14
Impact of Bagrada on Plant Growth / Yield - Cauliflower

% Plants with Fresh Feeding Signs and Terminal Damage

- Fresh Feeding Signs
- Plant Injury (Blind or Multiple Terminals)

- 7-DATP
- 17-DATP
- 28-DATP
- Not Infested
Impact of Bagrada on Plant Growth / Yield - Cauliflower
Control Measures

• Cultural Control
  – Reduce weedy mustards, remove post-harvest vegetation
  – Monitoring, proximity crops
Control Measures

• Cultural Control
  – Reduce weedy mustards, remove post-harvest vegetation
  – Monitoring, proximity crops
  – Row covers?
Row cover efficacy?
Control Measures

• Cultural Control
  – Reduce weedy mustards, remove post-harvest vegetation
  – Monitoring, proximity crops
  – Row covers?
  – Trap crops and borders?

• Biological Control
  – Predators
  – Parasitoids
Biological Control

- Diptera: Sarcophagidae, Tachinidae
- Hymenoptera: Scelionidae (*Trissolcus*, *Telenomus*), *Telenomus podisi*
- *Ooencyrtus* sp.
Trissolcus eushisi on Piezodorus guildinii
Ooencyrtus sp. on Camptototus literalis

Courtesy Walker Jones, USDA-ARS, Stoneville, MS
Control Measures

• Cultural Control
  – Reduce weedy mustards, remove post-harvest vegetation
  – Monitoring, proximity crops
  – Row covers?
  – Trap crops and borders?

• Biological Control
  – Predators
  – Parasitoids

• Chemical Control
  – Early pyrethroids
  – Later neonicotinoids
Insecticides

• Foliar:
  – Chlorpyrifos (Lorsban)
  – Bifenthrin (Capture)
  – Fenpropathrin (Danitol)
  – Methomyl (Lannate)
  – Dinotefuran (Venom)
  – Spirotetramat (Movento)
  – Cyazypyr
  – Novaluron
  – Pyrifluquinazone

• Systemic:
  – Imidaclorpid (Admire)
  – Thiamethoxam (Platinum)
Highlights of Results

- Bifenthrin (pyrethroid) most potent against Bagrada
- Chlorpyrifos (organophosphate) is also toxic to Bagrada
- Neonicotinoids similarly active
- Movento not very active against immatures
- Cyazypyr less active
- Pyrifluquinazon has some activity
Behavior

• Patterns of Activity
  – Late Risers
  – Warm-temperature insect on cold-temperature plants
  – Often coupled as adults
  – Fly readily during hottest part of the day
  – Drop when disturbed
  – Extremely localized activity
Bagrada Bug Management Tips for the Low Desert

Fields near these areas may be at high risk:
- grassy areas (including sudangrass)
- weedy drains, river bottoms
- residential areas
- lush desert habitat

Monitoring and Scouting:
- Sampling before 9:00 am may be misleading
- Look for damage on cotyledons and young leaves
- Look for adults on undersides of cotyledons and leaves
- Keep your eyes on the soil underneath plants

Control:
- In high risk areas, chemigate at emergence (~4 d)
- Once pipe is pulled consider using the following products:
  1. Pyrethroids (Brigade, Mustang, Warrior)
  2. Lannate / Lorsban
  3. Venom / Scorpion / Belay
Bagrada bug Research Team