Offshore Biological Control Strategy Applied to Pink Hibiscus Mealybug

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Biological Control of Invasive Species in the Caribbean Region

Attack the pest problem abroad prior to invasion

- “Buys Time” to develop control technology
- Suppresses exploding pest populations
- Reduces rate of dispersal between islands and entering Continental U.S.
- Prolonged invasions reduces potential economic losses
Classical Biological Control

- Importing and releasing exotic natural enemies that become established and self-perpetuating
- Environmentally sound pest control
- Self-sustaining
- Relatively easy to implement
- Cost efficient
Biological Control of the Pink Hibiscus Mealybug - Caribbean

- Serves as a “Model” for control of an invasive pest species in the Caribbean
- Excellent Caribbean Regional Cooperative Effort
- Cost Sharing
- Biological control technology easily transferred
Pink Hibiscus Mealybug, *Maconellicoccus hirsutus* (Green)
World Distribution Prior to 1994
Economic Losses from Pink Hibiscus Mealybug

- **INDIA**: Pest Status - grapes 58-90% losses, rosell or sorrel (Hibiscus sabdariffa) losses up to 75%, heavy infestations on cotton and teak

- **EGYPT**: Cotton damage

- **GRENADA**: IICA est. of economic, social + environmental = US $3,471,900; Crop Losses 1995-97 was US$1.8 million/year Potential Annual Losses = $ 10 mil./year
Economic Losses (Contin.)

- **TRINIDAD AND TOBAGO**: Potential Losses of $125 million TT Dollars
- **ST. KITTS**: Significant loss of ornamentals, export losses on pumpkins, etc., no sorrel production.
- **U.S. VIRGIN ISLANDS**: Significant Losses to ornamentals (hibiscus) and soursop.
Risk Assessment of PHM

Host Range

- Risk Element: **HIGH**

- PHM is Polyphagous

- Feeds on more than 200 plant genera within 70 plant families
# Pink Hibiscus Mealybug Host Plants

<table>
<thead>
<tr>
<th><strong>Fruits</strong></th>
<th><strong>Ornamental</strong></th>
<th><strong>Vegetable</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Papaya</td>
<td>Hibiscus</td>
<td>Tomato</td>
</tr>
<tr>
<td>Sugar-apple</td>
<td>Croton</td>
<td>Pumpkin</td>
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<tr>
<td>Golden apple</td>
<td>Allamanda</td>
<td>Okra</td>
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<tr>
<td>Pigeon pea</td>
<td>Anthurium</td>
<td>Lettuce</td>
</tr>
<tr>
<td>Carambola</td>
<td>Heliconia</td>
<td>Beans</td>
</tr>
<tr>
<td>Soursop</td>
<td>Lantana</td>
<td>Cucumber</td>
</tr>
<tr>
<td>Cherry</td>
<td>Seagrape</td>
<td>Peppers</td>
</tr>
<tr>
<td>Passion fruit</td>
<td>Bougainvillea</td>
<td>Dasheen</td>
</tr>
<tr>
<td>Avocado</td>
<td>Oleander</td>
<td>Cabbage</td>
</tr>
<tr>
<td>Mango</td>
<td>Ginger lily</td>
<td>Squash</td>
</tr>
<tr>
<td>Plum</td>
<td>Schefflera</td>
<td></td>
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<tr>
<td>Grape</td>
<td>Ficus</td>
<td></td>
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<tr>
<td>Citrus</td>
<td></td>
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<tr>
<td>Breadfruit</td>
<td></td>
<td></td>
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<tr>
<td>Guava</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Banana</td>
<td></td>
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</tbody>
</table>
Risk Assessment of PHM

Dispersal Potential

- Risk Element: HIGH
- High reproductive potential
  - 10 generations/year
  - Female Egg Sac >600 eggs
- Highly mobile life stages by wind, animals, man, and machinery
Risk Assessment of PHM
Economic Impacts to US

- Risk Element: HIGH
- Reduce Commodity Yield
- Lower Commodity Value
- Result in Loss of Markets
- Potential Economic Losses $2 Billion/year
  (2003 Dollars)
Risk Assessment of PHM

Environmental Impact

- Risk Element: HIGH
- Damage to agriculture, forestry and horticulture
Spread of Pink Hibiscus Mealybug in Caribbean

No. Countries/Islands

Year

Spread of Pink Hibiscus Mealybug Throughout Western Hemisphere

- **1984** - Hawaii
- **1994** - Grenada, Carriacou
- **1995** - Trinidad, St. Kitts and Nevis
- **1996** - Tobago, Aruba, St. Maarten, St. Lucia
- **1997** - St. Eustatius, Curacao, Anguilla, Guyana, British Virgin Islands, St. Vincent, Grenadines, St. Thomas, St. Croix, St. John, Culebra, Vieques
- **1998** - Montserrat, Guadeloupe, Puerto Rico
- **1999** - Martinique, USA (California), Belize, Mexico, Venezuela?
- **2000** - Barbados, Bahamas
- **2001** - Antigua, Dominica, Suriname
- **2002** - Florida (USA), Haiti, Dominican Republic
Western Hemisphere Countries Infested with Pink Hibiscus Mealybug as of July 2004

- **PHMB present**
- **PHMB free**
Risk Assessment of PHM
US Entry Potential Consideration

- Risk Element: HIGH

- PHM Intercepted 813 times (PIN 2003)
Maconellicoccus hirsutus Interceptions at Ports of Entry Into United States From Caribbean

Note: Baggage = 211, Cargo = 8, Ship Store = 4
Risk Assessment of PHM
Habitat Suitability In US

- Risk Element: HIGH

- Attacks and survives on hosts in 4 or more plant hardiness zones
Climate Exclusion Map for PHM (75 days/yr with minimum daily Temperature lower than 0 degrees C)
Figure 2. Climex simulation showing PHM potential ecological range

Denotes areas with greater than 75% climatological similarity to areas where PHM is endemic
Damage

-Pink Hibiscus Mealybug-

- Toxic saliva
- Results in malformation of leaves, fruit and shoot growth
- Stunting of plant growth
- Occasional death of plant
- Shortened internodes = “Bunchy Top”
- Black Sooty Mold
PHM
Defoliated Hibiscus
Healthy Sammon Tree
Dead Sammon Tree - Grenada
With PHM Egg Mass
Healthy Soursop Fruit
Hawaii Infestation - Pink Hibiscus Mealybug -

- Since 1983
- **Not** an economically important pest
- Attacked by two primary, internal hymenopterous parasites
- Parasites:
  - 1) *Anagyrus kamali* Moursi
  - 2) *Anagyrus* sp.
Exotic Parasitoids Introduced

- Quarantine Facility – USDA, ARS, Newark, Delaware
- *Anagyrus kamali*
  - China
  - Hawaii
  - Taiwan
- *Gyranusoidea indica*
  - Egypt
  - Pakistan
  - Australia
- *Allotropa mecrida*
  - Egypt
  - Puerto Rico
Economic Benefits of Biocontrol Program

- 750 Million Dollars/Year Loss (1997)
- Estimated cost of Biological Control Technology Development and Transfer = $500,000/year for 3 to 5 years
- Expected Economic Benefits to Costs Ratio for a Single Year Exceeds 1500:1
- Based on 1997 Dollars and value of: Avocado, Citrus, Cotton, Grape, Mango, Ornamentals and Vegetables
Anagyrus Kamali
Technology Transfer of PHM
Biological Control Program To:

- St. Kits, W.I. - 1996
- US Virgin Islands - 1998
  - St. Thomas
  - St. Croix
  - St. John
- Puerto Rico - 1999
  - Vieques
  - Culebra
- Belize - 1999
- California - 1999
- Bahamas - 2000
- St. Eustatius - 2001
- Haiti - 2002
- Dominican Republic - 2002
- Florida - 2002
Impact of Parasites on Pink Hibiscus Mealybug – St. Kitts, W.I.

92% Reduction
Impact of Parasites on Pink Hibiscus Mealybug
St. Thomas, U.S.V.I. (Hibiscus)

Ave. No. 2nd-Adult MB/Terminal

<table>
<thead>
<tr>
<th>Month</th>
<th>1997-1999</th>
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<tbody>
<tr>
<td>July</td>
<td>450</td>
</tr>
<tr>
<td>Aug.</td>
<td>500</td>
</tr>
<tr>
<td>Nov.</td>
<td>100</td>
</tr>
<tr>
<td>Jan.</td>
<td>200</td>
</tr>
<tr>
<td>Feb.</td>
<td>300</td>
</tr>
<tr>
<td>March</td>
<td>400</td>
</tr>
<tr>
<td>April</td>
<td>250</td>
</tr>
<tr>
<td>May</td>
<td>300</td>
</tr>
<tr>
<td>Aug.</td>
<td>500</td>
</tr>
<tr>
<td>Oct.</td>
<td>100</td>
</tr>
<tr>
<td>Jan.</td>
<td>150</td>
</tr>
<tr>
<td>Feb.</td>
<td>0</td>
</tr>
</tbody>
</table>

% Parasitization

- 91.2% Reduction

Reducing the population by 91.2% seems to be effective, but it is necessary to maintain a consistent management strategy to ensure long-term control.

Mealybug: 
Parasite:
Impact of Parasites on Pink Hibiscus Mealybug
St. Coix, U.S.V.I. (Hibiscus)

Ave. No. 2nd-Adult MB/Terminal

% Parasitization

97.1% Reduction

1997-1999

Mealybug
Parasite
Impact of Parasites on Pink Hibiscus Mealybug Puerto Rico (Hibiscus)

92% Reduction

1998 - 2000
Impact of Parasites on Pink Hibiscus Mealybug Vieques (Hibiscus)

Ave. No. 2nd-Adult MB/Terminal

Ave. % Parasitization


97.8% Reduction

1998 - 1999
Impact of Parasites on Pink Hibiscus Mealybug
Belize - Hibiscus

Ave. No. 2nd-Adult MB/Terminal

% Parasitization

96.6% Reduction

Mealybug Parasites

0 10 20 30 40 50 60 70 80


1999 2000
Pink Hibiscus Mealybug in Imperial County, California (Mulberry)

Ave. No. 2nd to Adult MB/Terminal

- Mealybug
- Parasite

96% Reduction

1999-2001
Impact of Parasites on Pink Hibiscus Mealybug - Florida (Hibiscus)

98.7% Reduction
Impact of Parasites on Pink Hibiscus Mealybug - Nassau, New Providence, Bahamas (Hibiscus)

82% Reduction

Ave. No. 2nd-Adult MB/Terminal

2001-2002
Impact of Parasites on Pink Hibiscus Mealybug - Haiti (Hibiscus)

97.2% Reduction

2002 - 2003
Impact of Parasites on Pink Hibiscus Mealybug - Dominican Republic (Hibiscus)

96.6% Reduction
Level of PHM Population Density Reduction by Parasitoids

**Hibiscus**
- St. Kitts = 91.6%
- US Virgin Islands
  - St. Thomas = 91.2%
  - St. Croix = 97.1%
- Puerto Rico = 92%
- Culebra = 96.5%
- Vieques = 97.8%
- Belize = 96.6%

**California**
- Mulberry = 96%
- Carob = 93%

**Bahamas** = 82%
  (1 year)

**Florida** = 98.7%

**Haiti** = 97.2%

**Dominican Republic** = 96.6%
Potential Spread of PHM in United States in 2005

- Florida Nursery Shipped 900,000 potted hibiscus plants to 36 States from January to July 2005
- 11 of 17 States Climatically suitable for PHM
- Shipments were found to be partly infested with PHM in Late July 2005
Potential Spread of PHM in United States in 2005

- Shipments made to Garden Centers of Major Establishments

- PHM recovered from Garden Centers in Louisiana, North Carolina and Kansas.
Homestead, Florida Shipments from January through July 2004

Potted Hibiscus Plants Potentially Infested with Pink Hibiscus Mealybug