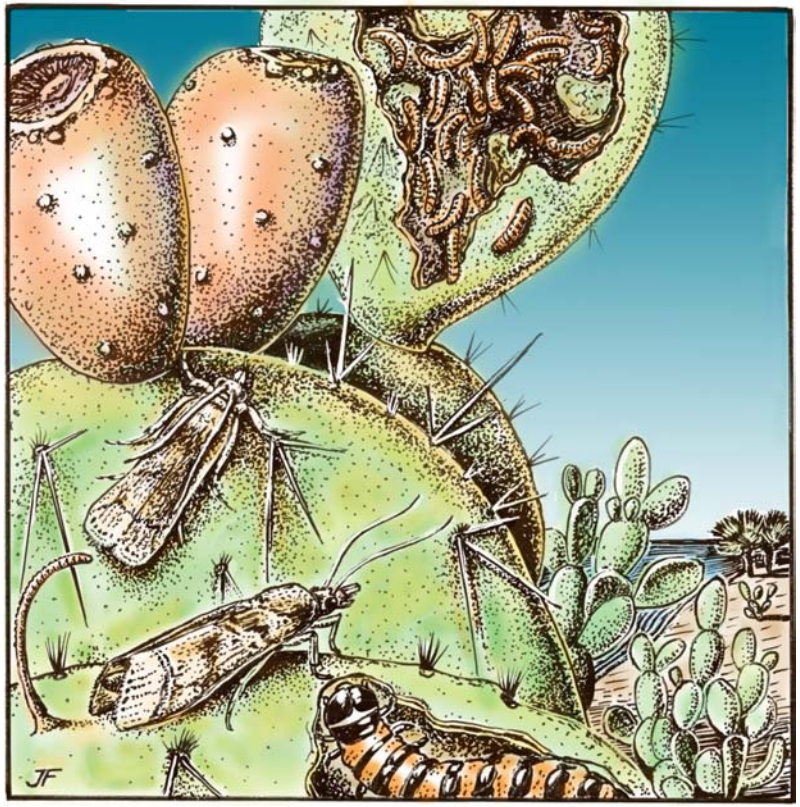

Illustration by Joel Floyd

Cactus Moth *(Cactoblastis cactorum)* Planning Meeting

Miami, Florida

December 9 - 10, 2003

USDA

Plant Protection and Quarantine
PPQ
United States Department of Agriculture
Animal and Plant Health Inspection Service

ARS

USGS
science for a changing world

Background and Synopsis
Cactus Moth (*Cactoblastis cactorum)* Planning Meeting
Miami, Florida, December 9 - 10, 2003

Hosted and Sponsored by USDA, APHIS, PPQ
Co-sponsors: US Geological Survey and USDA Agriculture Research Service
In cooperation with the Interagency Committee on Invasive Terrestrial Animals and Pathogens

The Cactus moth, *Cactoblastis cactorum*, received the attention of the research community in Florida some time after its detection in the Florida Keys in 1989. Since that time, a group of scientists has assembled a large body of knowledge about its spread in Florida and to other states, its behavior, ecology, hosts, and reproductive biology. A workshop organized by concerned scientists and sponsored in part by the APHIS National Biological Control Institute was held in Tampa, Florida September, 2000. The workshop documented their findings to that point and also included presentations on threatened resources in the US and Mexico. The papers from this workshop were assembled in the December 2001 issue of the *Florida Entomologist*, (vol. 84, no. 4) which can be accessed on the Internet at: http://www.fcla.edu/FlaEnt/fe844.htm

USDA APHIS Plant Protection and Quarantine (PPQ)'s New Pest Advisory Group (NPAG) took up the cactus moth in 2001 and recommended to the PPQ Executive Team that the PPQ Pest Detection and Management Programs staff manage and develop a long-term plan to address this pest. An APHIS position paper was drafted in December 2002 and in July of 2003, the NPAG recommendation was approved by the Deputy Administrator.

In December 2003, a planning meeting was sponsored by USDA-APHIS-PPQ in Miami to bring together experts and stakeholders to help define what is understood of the problem and issues, learn about the current state of research, and identify further research / information needs necessary to justify and develop a long-term strategy for mitigating the spread of the cactus moth. The meeting summary contained in this summary of presentations and discussions gives a snapshot of where scientists in the US are with research and what is known about potential impacts of the cactus moth on agriculture and natural resources in the US and Mexico. It also contains valuable information that will help in making informed decisions on priorities for funding research and programs based on potential impacts. The planning meeting summarized here produced collaborative opportunities with a variety of non-traditional stakeholders for APHIS, and there was general enthusiasm among participants to continue on this track.

While *Cactoblastis cactorum* proved to be a successful agent for the biological control of weedy *Opuntia* species in Australia in the 1920's and other places where these cacti are not endemic, its movement to the Caribbean in the 1950's and detection in the Florida Keys in 1989 has been cause for concern in many circles. Since arriving in Florida, the cactus moth has spread along both Florida

coasts reaching South Carolina and to the border with Alabama in the Florida panhandle. Recent observations show the cactus moth completes three generations per year in Florida as opposed to two in other areas of the world and is spreading at the rate of approximately 100 miles per year. At the current rate of natural spread, according to researchers, it is expected to reach Texas in four years.

Most species of *Opuntia* tested are susceptible as hosts to *Cactoblastis cactorum*. There are 31 species of *Opuntia* in the US and they occur in 47 states. The importance of *Opuntia* spp. in the western US are as major components of desert and rangeland ecosystems**,** providing habitat and forage for wildlife, and forage for cattle during drought years. Healthy cacti in desert landscapes are also considered conservation icons by the public, similar to oak or redwoods in other parts of the country. Other than for grazing in the southwest United States and limited fruit production in California, the agricultural importance of *Opuntia* in the US is mainly in its wide use as nursery plants for xeriscape, or low water-use, landscaping.

The Nature Conservancy has raised *Cactoblastis cactorum* to APHIS as an invasive species of major concern for their organization because of its potential impact on lands they manage. For the last several years, they have worked closely with a researcher at the University of South Florida in protecting an endangered *Opuntia* species being attacked by the Cactus moth on one of their reserves in the Florida Keys. The Cactus and Succulent Society of America has also been active in lobbying USDA for action and has provided some funding to the USDA Agricultural Research Service. Several agencies within the Department of Interior manage lands they believe are in danger of impacts by *Cactoblastis cactorum* and have shown a great deal of interest in cooperating with APHIS in assisting with detection activities.

To the people of Mexico, *Opuntia* cacti are of great importance ecologically, agriculturally, and culturally. There are 56 species of *Opuntia* in Mexico where they form major components of desert ecosystems and provide important forage for livestock. Several species in Mexico are cultivated for their fruit, leaves (or pads), and cochineal dye. Mexico's total industry related to *Opuntia* production and processing accounts for 2.5% of the value of their agricultural products and generates approximately $50 million in income per year. These cacti grow in areas of Mexico not productive for other crops and large segments of the population are dependent upon them. The *Opuntia* cactus is also culturally

important in Mexico's religion and history, appearing on their nation's flag and in other country symbols.

Mexico has surveyed for *Cactoblastis cactorum* and reported no detections. They have instituted a National Preventative Campaign at their borders, a public awareness initiative, and an action plan for early detection and eradication if feasible. SAGARPA is APHIS' equivalent in Mexico and they have raised *Cactoblastis cactorum* as a pest issue of concern in North American Plant Protection Organization (NAPPO) meetings, implied its importance in trade issues with the US, and have quarantined US *Opuntia* plant products.

The presentations contained in this meeting summary give highlights of the research that has been conducted on *Cactoblastis cactorum* by ARS, Florida universities, and the Plant Protection Research Institute of South Africa. For the last several years, ARS researchers in Florida and Georgia have undertaken investigations on *Cactoblastis cactorum* biology, behavior, pheromone characterization, biological control options, rearing and sterile insect techniques (SIT). This has taken place with no specific funding from ARS, but much progress has been made. The International Atomic Energy Agency and the Cactus and Succulent Society of America have also provided some funding.

The development of a sex pheromone is still not complete, but it appears to be a blend of four compounds, three of which have been identified. Trapping studies indicate that this fourth unknown compound may be what helps moths communicate short range mate-finding behavior. Investigators are still working to identify this molecular complex, testing the most attractive blend of compounds, and work toward synthesizing the blend for the eventual manufacture of a trapping lure. Until the pheromone is developed, virgin females are used in detection trapping studies.

Biological control options have been analyzed, however most candidate agents present problems because of lack of sufficient host specificity. Inundative release of hymenopteran egg parasitoids that do not become established shows some promise and *Nosema* bacterial applications may be an option, but more research is needed. Chemical controls have shown some efficacy in cultivated *Opuntia* in South Africa, but are not practical or advised for native cactus stands.

The sterile insect technique (SIT), and specifically inherited or F1 sterility, shows the most promise for control in a limited area or slowing an advancing infestation.

Rearing is currently most successful on cactus pads, however progress has been made in developing an artificial diet. Irradiation studies have shown that, similar to other lepidoptera, exposure of *Cactoblastis cactorum* males to approximately half the radiation dosage necessary to sterilize females results in partially fertile males that pass sterility genes to the next generation. This phenomenon significantly improves the effectiveness of sterile moth releases when compared to conventional SIT. This technique could be applied at the leading edge of the infestation to stop or slow the movement along the Gulf Coast as it progresses westward.

ARS researchers now believe they have developed rearing and F1 sterility to a point where they can demonstrate success in a limited area. They proposed a validation experiment in which they would produce sterile moths and release them on Santa Rosa Island on the Florida Gulf Coast, on the leading edge of the westward movement. The project proposal has an itemized budget and will require approximately $130,000 to conduct.

There is some urgency to funding this project due to the rapid migration of the Cactus moth toward the desert Southwest along the Gulf Coast. If SIT is to be successfully implemented, it will be much more feasible in the current narrow band of the moth's advancing front along the coast. *Opuntia stricta* is a common species concentrated along the coast that appears to provide a rapid pathway for the Cactus moth's westward dispersal. The cactus moth does not appear to disperse inland as quickly because of the reduced density of wild *Opuntia* populations further from the coast. However, once it reaches Texas in an estimated four years, opportunities for successful containment may not be impossible, or will be much more costly.

If the SIT technology proves successful on a limited scale, using it in a program to stop the spread of the Cactus moth along the coast will require regular funding. The costs of such a program need justification in order to get support from decision makers and/or legislators. The International Atomic Energy Agency (IAEA) is currently funding a "Cactus Moth Economic-Ecological Impact Analysis on the US and Mexico" that is being produced by the National Institute for Invasive Species Science at Colorado State University. As a result of this planning meeting in Miami, the Institute is collaborating with APHIS' Center for Plant Health Science and Technology (CPHST) and the US Geological Survey/NatureServe liaison to produce a draft report by late March.

Participants at the meeting were treated to a showing of two videos brought from South Africa by Helmuth Zimmermann. One was reproduced from 1930's Australian newsreel footage highlighting the invasive *Opuntia* weed problem and efforts to explore the world looking for an effective biological control agent. The video showed scientists and workers rearing the cactus moth and the success in controlling *Opuntia* there. The other video was a rough cut being prepared by Dr. Zimmermann for Mexico and produced by the IAEA. It will be in Spanish when complete and is to inform the public there about the problem and what to look for.

After the meeting, there was a tour of the ARS Subtropical Horticulture Research Station where participants were able to see the pheromone chemistry work, electro-antennogram and behavioral studies, and rearing operations. Thanks to Nancy Epsky for organizing this tour and to the lab director, Bob Heath for hosting the visit.

The primary action items from the meeting are:

1) A report by PPQ Pest Detection and Management Programs (PDMP) Planning and Preparedness staff on the options for controlling the spread of *Cactoblastis cactorum* in the US;

2) Agriculture economist at PPQ's Center for Plant Health Science and Technology (CPHST) will complete a white paper on the potential US economic impacts of *Cactoblastis cactorum* if allowed to spread**;**

3) PDMP will work with cooperators and CPHST to produce a risk map of the US showing where *Cactoblastis cactorum* may become established if not contained**;**

4) PDMP staff will explore funding options for SIT validation proposal**;**

5) A Cactus Moth Economic Environmental Impact Analysis for the US and Mexico produced by the National Institute of Invasive Species Science in conjunction with CPHST and NatureServe/US Geological Survey;

6) The development of taxonomic keys for the public and taxonomists on related cactus lepidoptera likely to be encountered in potential surveys by the ARS Systematic Entomology Laboratory in collaboration with APHIS;

7) PDMP will work with the National Survey Coordinator and the Cooperative Agriculture Pest Survey (CAPS) to develop survey methodology for a pilot project in Florida, Alabama, Georgia and Louisiana. The survey will include a pilot volunteer component involving the Nature Conservancy, the US Park Service,

and the National Wildlife Refuge System. The Georesources Institute at Mississippi State University will be used as a resource to document plant distributions**;**

8) Regulatory considerations will be explored further within APHIS, the National Plant Board and the nursery industry. Artificial spread in nursery stock is a primary concern.

The organizers would like to thank Ken Bloem for all his help in coordination of meeting planning in Florida**,** the ARS scientists for working with Ken in making agenda suggestions, Bill Gregg who provided valuable input into the agenda and funded for the field trip transportation, and to Stephanie Bloem for translating the presentations, questions and answers for the participants from Mexico**.**

The meeting was organized and summary produced by Joel Floyd, Jim Writer, and Susan Ellis, of:

Pest Detection and Management Programs

USDA, APHIS, PPQ

4700 River Road, Unit 137

Riverdale, MD 20737

Phone: 301-734-4396

Questions or inquiries can be directed to Joel Floyd, PDMP Planning and Preparedness, e-mail: joel.p.floyd@aphis.usda.gov

List of Presentations
Cactus Moth (*Cactoblastis cactorum)* Planning Meeting
Miami, Florida, December 9 - 10, 2003

Presentations

• *Overview of the Cactus Moth Problem*	Ken Bloem
• *Conservation Interest of Cactus Moth Problem*	Doria Gordon
• *Perspective on the Cactus Moth Problem from the Department of Interior*	Bill Gregg
• *Importance of the Cactus Moth Problem to Mexico*	Hector Sanchez Anguiano
• *Economic Risk Assessment for the Cactus Moth, Cactoblastis cactorum*	Lynn Garrett
• *Distribution and Conservation Status of Opuntia cactus in North America and the Caribbean: a Preliminary Report*	Rachel Muir
• *Information Gathering for a Cactus Moth Impact Assessment*	Sara Simonson
• *Interest in the Cactus Moth Problem by the International Atomic Energy Agency*	Dr. Walther Enkerlin
• *Detection Techniques for Cactoblastis cactorum*	Steve Hight Jim Carpenter
• *Pheromone Development for Cactoblastis cactorum*	Nancy Epsky

List of Presentations
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• *Identification Issues for Cactoblastis cactorum and other cactus feeding insects*	Alma Solis
• *The Feasibility of Conventional Control Methods Against Cactoblastis cactorum*	Helmuth Zimmermann
• *Biological Control Options for Cactoblastis cactorum*	Robert Pemberton
• *Sterile Insect Technique Options for Cactoblastis cactorum*	Jim Carpenter Stephanie Bloem
• Discussion Topics	

Other Documents

- Meeting Agenda
- Meeting Summary
- Meeting Participants
- Photograph of Meeting Participants
- Photographs of *Cactoblastis Cactorum:* Life stages and hosts

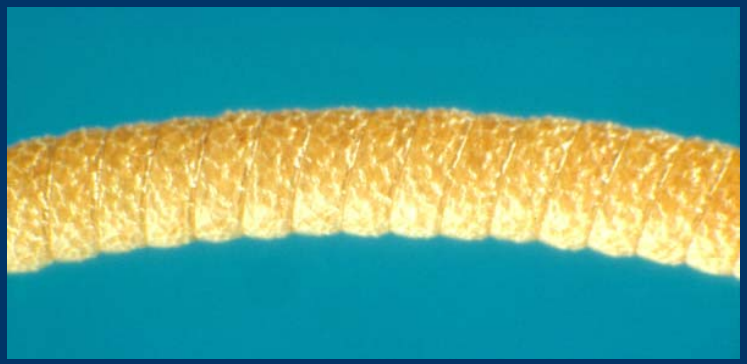
Overview of the Cactus Moth Problem

Ken Bloem
USDA-APHIS
Tallahassee, FL

Cactoblastis cactorum – Life cycle

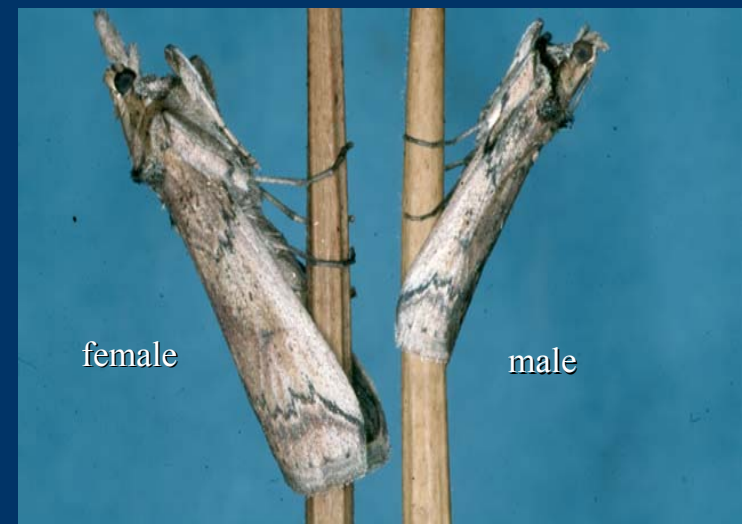
Female lays 2-4 egg sticks in her lifetime

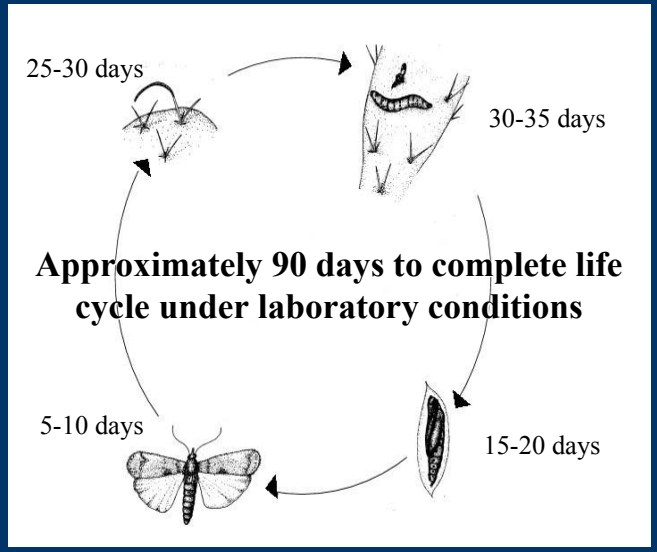
Egg stick has 70-90 eggs



MEETING NOTES

- Larvae are gregarious feeders
- Pupate in leaf litter, dried out sides of plant
- Long-lived
  - 30 days to eclosion
  - 30 days to larval
  - 15-25 pupae
  - Adults short-lived





- *Cactoblastis cactorum*
- Lepidoptera: Pyralidae, Phycitinae

- Pyralidae – 20 genera & 60 species associated with Cactaceae

- *Ozamia* in both hemispheres
- *Cactoblastis* in South America
- *Melitara* & *Olycella* in North America

Cactoblastis cactorum – History

MEETING NOTES

- Australia
  - Introduced Opuntia
    - Used for fencing
    - Raising cochineal insects for dye industry
- South Africa
  - Similar history to Australia's
    - Cactus proliferated
    - Searched for natural enemies

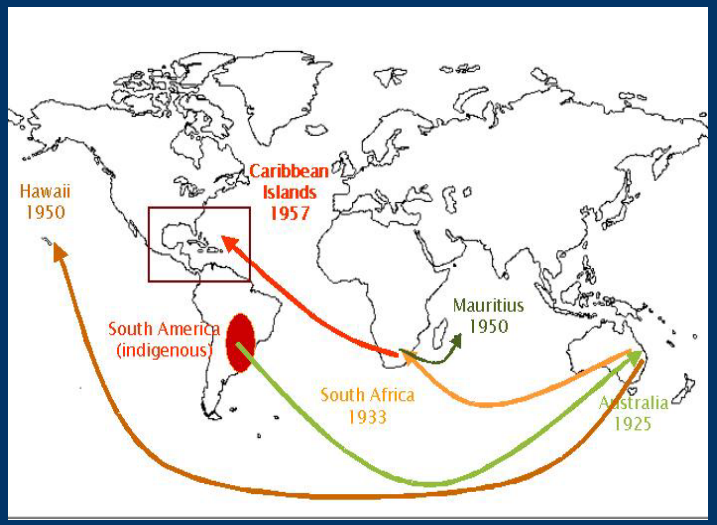
- Genus *Cactoblastis*
- 5 described species
- *C. cactorum*, *C. bucyrus*, *C. mundelli*, *C. doddi* & *C. ronnai*
- Parts of Peru & Bolivia, Paraguay, Uruguay, Argentina and southern Brazil
- Larvae of all species are orange with black bands
- Only *C. cactorum* is "oligophagous" (feeds on several species)

- Australia 1925 - ca. 40 egg sticks or 2,750 eggs of *C. cactorum*
- All subsequent movement of the species comes from this importation into Australia

MEETING NOTES

- Cactoblastis introduced into Australia as a biocontrol agent
  - Also used in:
    - Hawaii
    - South Africa
    - Mauritius
    - Caribbean (initial introduction in Nevis)
    - Island hopped its way to Florida Keys
- Rapid decline in cactus populations

Cactoblastis Memorial Hall in Queensland, Australia



Cactoblastis cactorum –
Impact on *Opuntia* spp.

In Florida we have 6 species
of *Opuntia* and all are attacked
by *Cactoblastis cactorum* …


Opuntia humifusa


Opuntia pusilla
OLYMPUS


Opuntia stricta


Opuntia ficus-indica

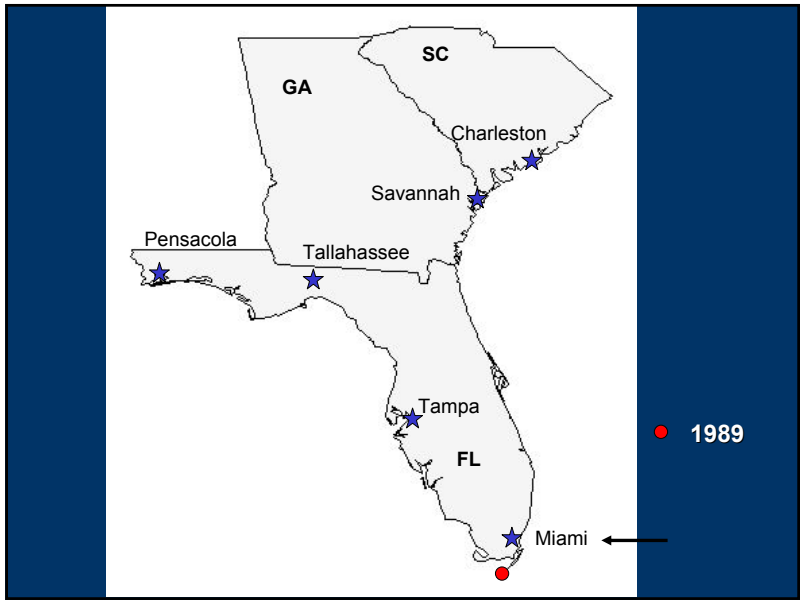
Opuntia cochenillifera

Help !!

Opuntia corallicola

Known *Cactoblastis Opuntia* host species		Country of origin	Country of Observation
Large tree-like species			
1	*O. (Nopalea) cochenillifera*	Mexico	USA
2	*O. ficus-indica (= megacantha)*	Mexico	South Africa, USA
3	*O. robusta* (all Burbank varieties)	Mexico, USA	South Africa.
4	*O. streptacantha*	Mexico	Australia
5	*O. tomentosa*	Mexico	Australia, South Africa
Shrub-like species			
6	*O. antillana*	Caribbean Islands	Caribbean
7	*O. cardiosperma (= paraguayensis)*	Argentina, Paraguay, Uruguay,	Australia
8	*O. corallicola*	USA	USA
9	*O. cubensis.*	USA	USA
10	*O. dillenii*	Caribbean	Caribbean
11	*O. elatior*	Caribbean, Central America, Venezuela	Australia
12	*O. engelmannii (= lindheimeri ?)*	USA	South Africa
13	*O. humifusa*	USA	USA, South Africa
14	*O. leucotricha*	Mexico	USA
15	*O. lindheimeri* (?) (= *engelmannii*?)	Caribbean	Antigua, Nevis
16	*O. monacantha*	South America	Australia, South Africa, USA
17	*O. moniliformis*	Desecho, Haiti, Domin. Rep.	Desecho Is.
18	*O. pusilla*	USA	USA
19	*O. rubescens*	Puerto Rico	Puerto Rico
20	*O. stricta* vars. *stricta & dillenii*	Caribbean, Mexico, USA,	Australia, Caribbean, S. Africa, USA
21	*O. tardospina (= engelmannii?)*	USA	South Africa
22	*O. triacantha*	Caribbean, USA	Caribbean, Mauritius, USA
23	*O. tuna*	Caribbean	Mauritius
24	*Opuntia* sp.	Unknown	Asuncion
25	*Opuntia* sp.	Unknown	St Helena
Small low-growing species			
26	*O. aurantiaca*	Argentina, Uruguay	South Africa, Australia
27	*O. curassavica* (?)	Antigua, Nevis	Antigua, Nevis
28	*O. repens*	Puerto Rico	Puerto Rico
29	*O. salmiana*	Argentina	South Africa
30	*O. taylori*	Haiti, Santo Domingo	Haiti, Santo Domingo

Cactoblastis cactorum –
Dispersal and Geographical Range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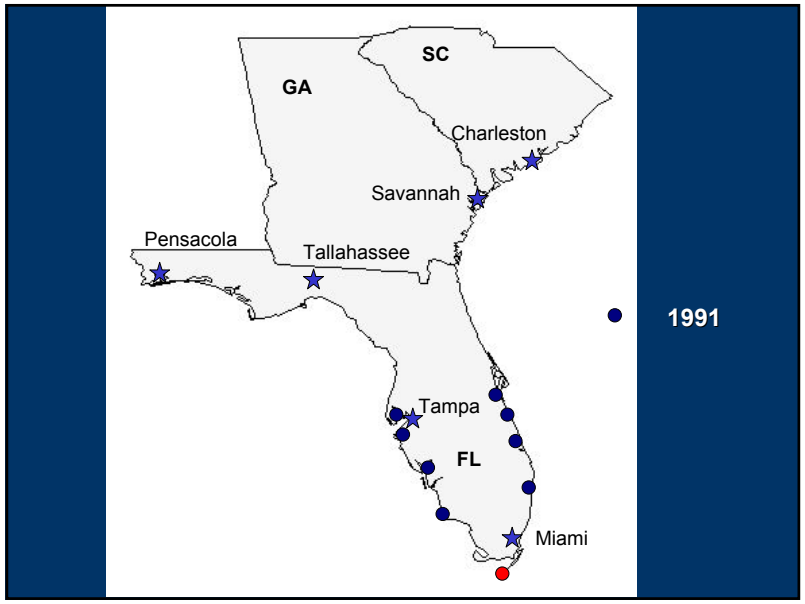
Savannah
Pensacola
Tallahassee
Tampa
FL
Miami
1989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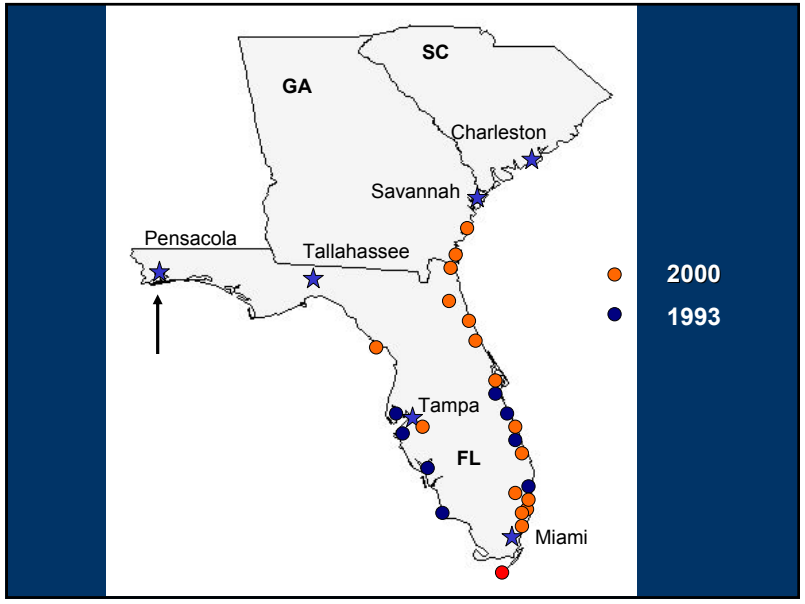
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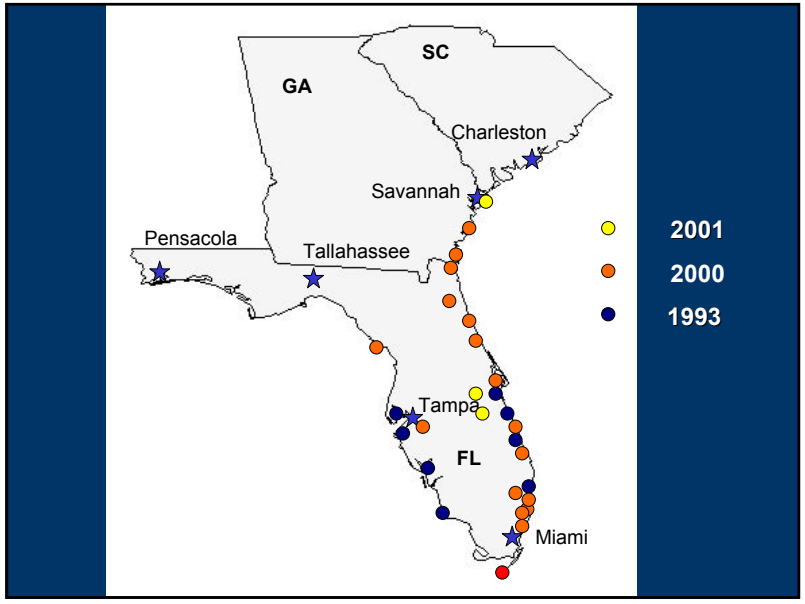
FL
Miami
2000
1993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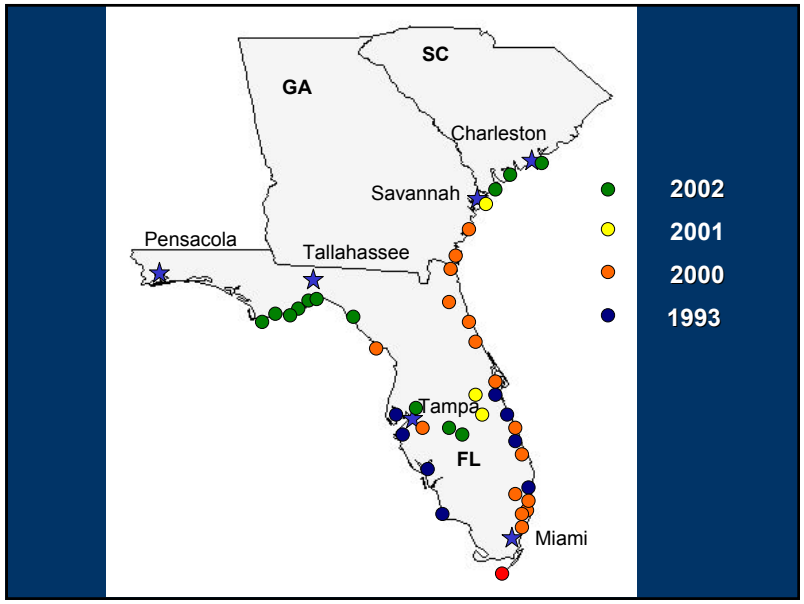
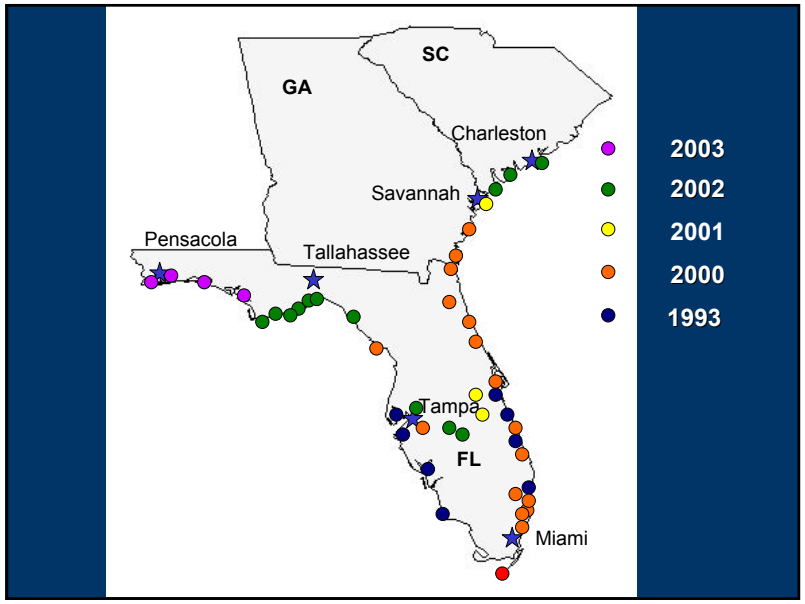
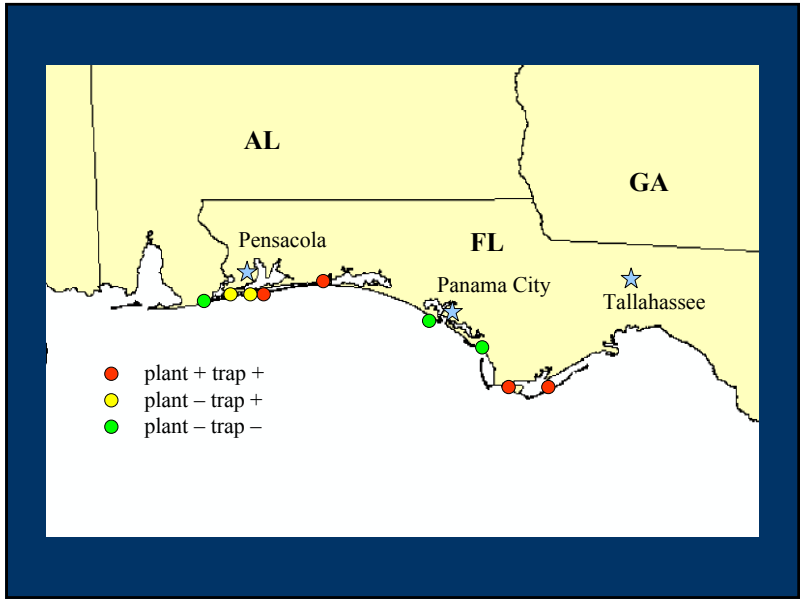
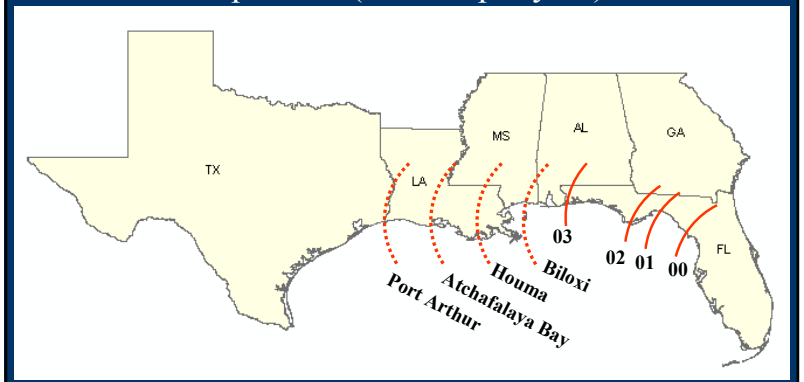






Solid lines true expansion; dotted lines projected expansion (160 km per year)



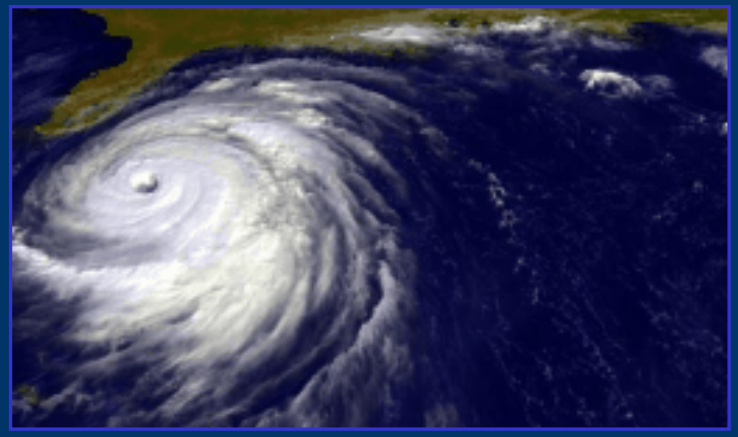
MEETING NOTES

- Virgin Female baited traps used for dispersal surveys
- 150 Km annual spread projected based on historical spread
- Seems to be hugging the coast / barrier islands
- Little inland spread reported

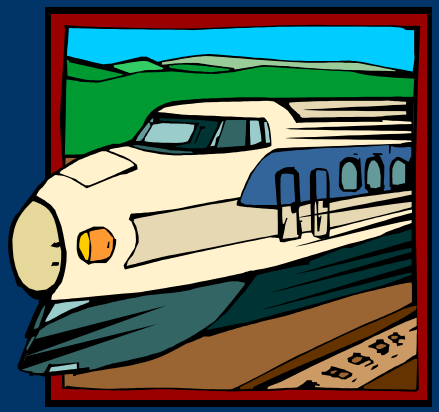
- Dodd (1940) – females can fly up to 24 km
- In Australia 16-24 km in 2.5 years
- In South Africa 3-6 km in 2.5 years
- In Florida 50-75 km per year (average of 1989-1999)
- Between 2000-2003 the front has moved 476 km (158 km/year)

- ***Why the big difference in dispersal ability ?***

Climactic events aiding dispersal ?



Wind-aided dispersal ??



Dispersal by trains ??

Dispersal aided by cars ??

Dispersal aided by movement of infested plants ?

2000 Tampa Meeting Recommendations

1. Conduct bioclimatic modeling in the USA to determine areas most likely to be colonized
2. Document localized endemic &/or threatened species of *Opuntia* in the USA & Mexico
3. Determine importance of ecological roles of prickly pears in natural environments
4. Conduct host range testing on important agricultural & horticultural species, dominant species in natural ecosystems & localized endemic species
5. Conduct insecticide trials (USA & Mexico) to prove efficacy & gain registration for use on cactus
6. Further explore biological control options
7. Develop an effective monitoring tool for cactus moth
8. Accelerate research on SIT/F_1 sterility to provide barrier, control & eradication options

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The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

Conservation Interest of the Cactus Moth Problem

Doria Gordon
Senior Ecologist, Florida

The Nature Conservancy

Mission: To preserve the plants, animals, and natural communities that represent the diversity of life on Earth by protecting the lands and waters they need to survive.

Outline:

- History of *Cactoblastis* in Florida
- Impacts to Opuntia in Florida
- Potential impacts to biodiversity

Peter Stiling

Timeline of *Cactoblastis* in Florida

1988 FL botanists alerted that *Cactoblastis* was found in Cuba

1989 *Cactoblastis* found on *O. stricta* on Big Pine Key

1990 *Cactoblastis* kills 1 of 14 remaining *O. corallicola*

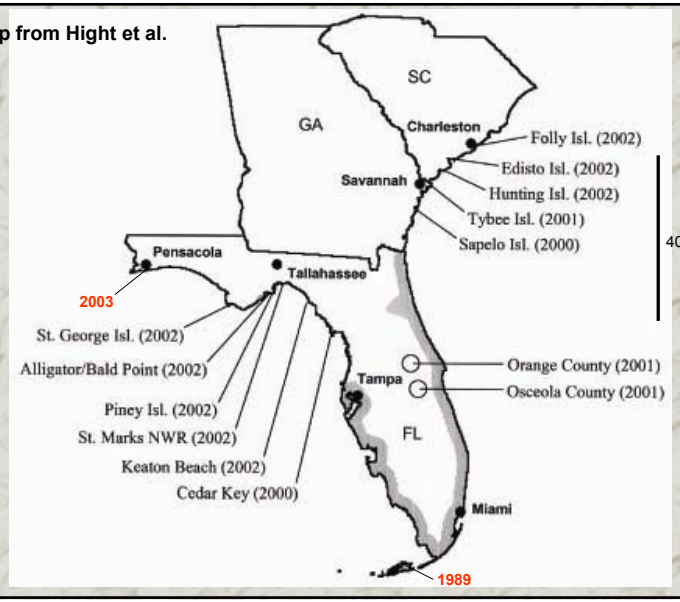
1990 *Cactoblastis* found 200 km N of Big Pine Key

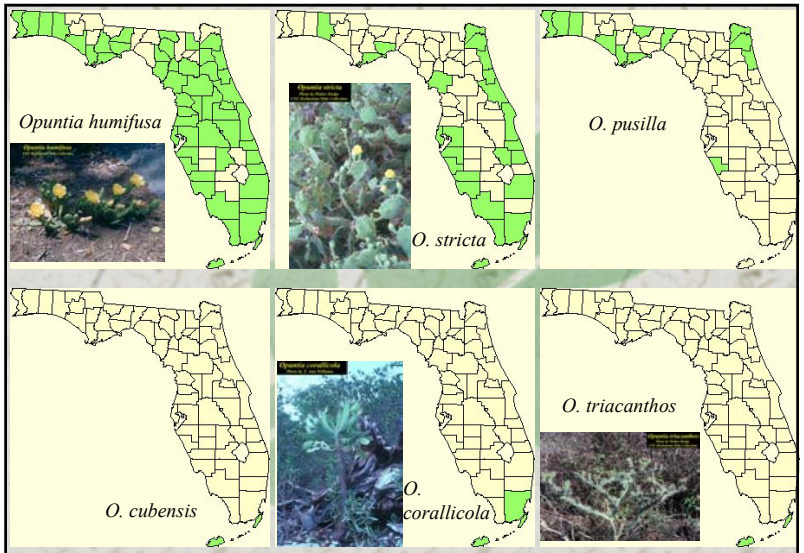
1993-2002 *Cactoblastis* moving northward at 50+ km/yr

2000 *Cactoblastis* found in nursery stock in Pensacola

2003 Distribution apparently continuous to Pensacola

Map from Hight et al.





Opuntia native to Florida

MEETING NOTES

- 5 non-native Opuntia species used in the ornamental industry in Florida
- 60% of native cactus lost to Cactoblastis in first 3 years of infestation
- Host preference: O. corallicola
  - Moths seem to perfer this species but do not have the highest survival rates on it.

Percentage of *O. stricta* with damaged pads

0-10 pads: 31% (n=64)

>10 pads: 90% (n=240)

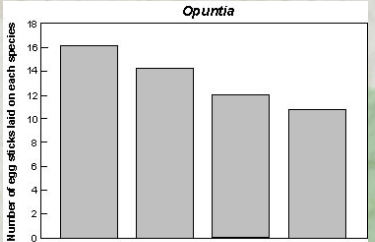
Johnson and Stiling 1998

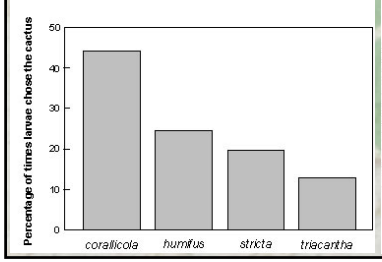
Mortality of *Opuntia stricta*:

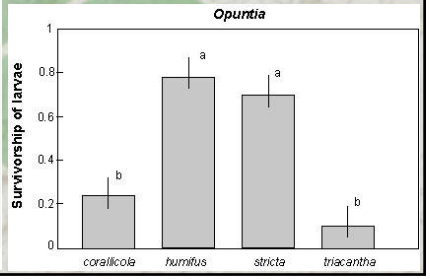
15% of 20 marked plants died: the 3 smallest plants

Johnson and Stiling 1998

Host preference:







***Cactoblastis* larvae and adults prefer *O. corallicola* over other opuntia despite lower survival.**

Johnson and Stiling 1996

5-20 m from *O. stricta* with *Cactoblastis*

vs.

P = 0.01

5-20 m from *O. stricta* without *Cactoblastis*

or

Far from any opuntia

Stiling, Moon, and Gordon 2003

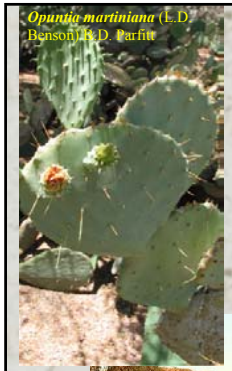
MEETING NOTES

- "Contagion Effect"
  - Less infestation further from infested plants
    - Makes case for "out plantings"
- Florida Keys
  - Threat to rare endemic Optunia
  - Ornamental plants are threat because they draw Cactoblastis / serve as reservoirs

Potential impacts to diversity*

- Platyopuntia
  - U.S. has 31 species, 9 endemic
  - Mexico has 56 species, 38 endemic
  - Caribbean has 22 species
  - Central America has 17 species
- May also attack *Consolea*
  - 9 endemic to Caribbean

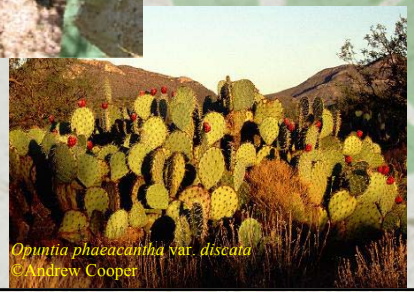
*approximate numbers



Opuntia martiniana (L.D. Benson) D. Parfitt

Opuntia echios, Galapagos
Letzte Änderung: 2002

Opuntia tomentosa Salm-Dyck



Opuntia phaeacantha var. *discata*
©Andrew Cooper

Sonoran Desert National Park, Arizona, USA

David Olson photo

Potential impacts of Opuntia loss

Altered soil water / nutrients
Altered soil erosion
Altered microbial communities

↓

Altered germination conditions

↓

Altered plant community composition

↓

Altered food / habitat conditions

↓

Altered vertebrate and invertebrate communities

Food for:

- **javelinas** (90% of winter diet)
- **wood rats** (90%)
- **white-tailed deer** (≤ 55%)
- **desert mule deer**
- **13-lined ground squirrels**
- **> 10 bird species**
- **coyotes**
- **lagomorphs**
- **tortoises**
- **insects (109 in Mexico)**

Nesting habitat for:

- **cactus wren**
- **curve-billed thrasher**
- **other birds**
- **wood rats**
- **other rodents**

Hellgren 1997
Chavez-Ramirez et al. 1997

TNC response to *Cactoblastis* threat

1990 Erected screen cages around most cacti

1999
Removed cages because of storm damage

Detection protocol:

Carefully examine all cacti weekly.

If an eggstick is found on a pad and there are no signs of hatched larvae - remove, and destroy the eggs.

If we have missed the eggstick stage and a larvae-infested pad is found, verify the identification and destroy the pad and larvae.

Gabriela Ocampo photo

MEETING NOTES

- Visual inspections for eggs not feasible in desert ecosystems
- The Nature Conservancy is publicizing the issue
- Discussing possible use of volunteer staff with APHIS
- Conservation *in situ* is always more successful than reintroduction
- Before/After Opuntia population counts is missing for Caribbean islands

Cactoblastis cactorum
Looming Threat to Conservation on Public Lands?

A Perspective from the Department of the Interior

William Gregg
Invasive Species Program Coordinator
U.S. Geological Survey

Cactus Moth Planning Meeting
December 9-10, 2003
Miami, Florida

USGS

CONCERNS

- Global history of impacts on Platyoptunia
- Rapid spread of initial infestations
- Uncertain susceptibility of native species
- Potential for cascading and interacting impacts
- Conservation significance of target ecosystems and native species
- DOI management units throughout potential range
- Low public awareness
- Need for North American Response Strategy

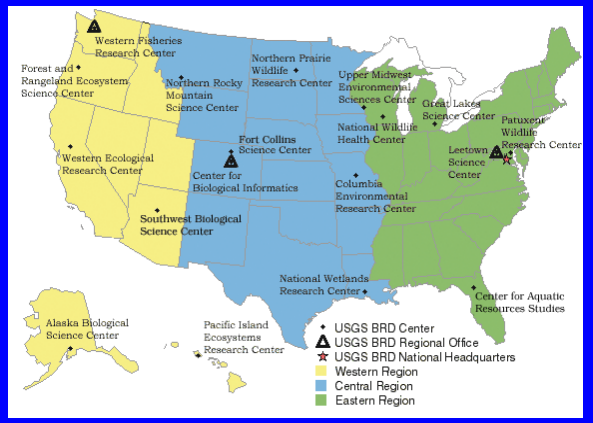
USGS

DOI MANAGEMENT BUREAS - POTENTIAL CONTRIBUTIONS

- Public education
- Targeted surveys:
  - (Data collection/vouchering/reporting/ volunteer programs)
- Rapid response teams
- Demonstration/testing of control treatments
- Monitoring of treatment effectiveness

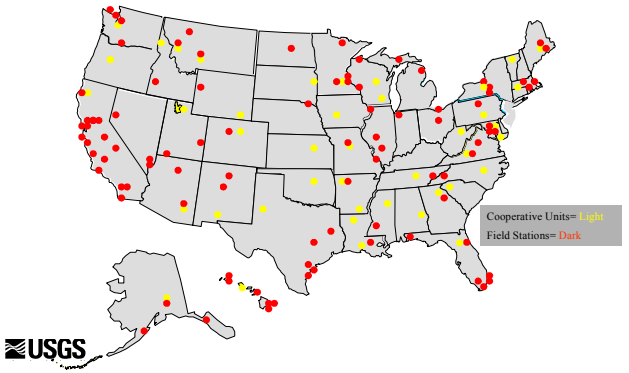
USGS

USGS Biological Science Centers

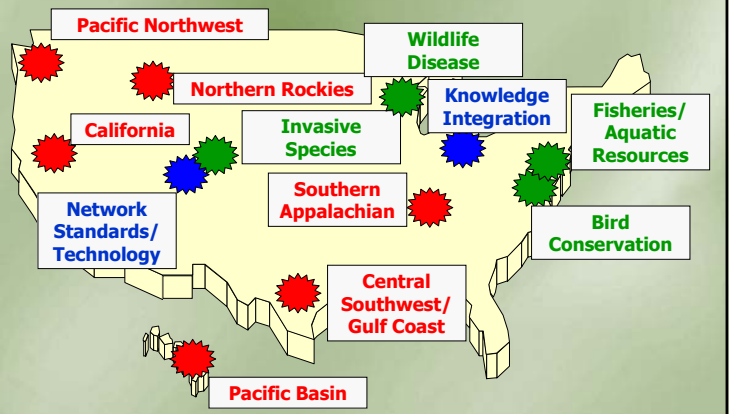


USGS

USGS Cooperative Research Units and Field Stations for Biology



National Biological Information Infrastructure - Network of Nodes



USGS Invasive Species Information Node

Support for National Information System for Early Detection & Rapid Response ($1M in 04)

- Taxonomic databases
- Identification aids
- Mapping and reporting system for occurrences
- Search interface for integrating data from many sources
- Platform to promote data collection standards and interoperability
- Support for specimen & species-based databases
- Support for regional pilot projects

USGS

NATIONAL INSTITUTE OF INVASIVE SPECIES SCIENCE

- Virtual framework for integrated science involving USGS & partner consortia
- Design of multi-scale "smart" monitoring
- Research – species invasiveness and effects, habitat vulnerability, invasion patterns and processes
- Spatial and temporal modeling & mapping
- High performance computing (with NASA)

USGS

NATIONAL INSTITUTE OF INVASIVE SPECIES SCIENCE (cont'd)

- Assessments of incipient & established invaders
- Control and restoration methods
- Decision support systems
- Technical assistance
- Facilitates NBII Invasive Species Info. Node
- Administrative support through USGS Fort Collins Science Center

USGS

OPPORTUNITIES

- Standard bearer for multi-sector cooperation
  - –Gulf States Early Detection/Rapid Response Initiative
  - –National Public Awareness Initiative
- Accelerated research on host specificity & biological, genetic, chemical and integrated methods for effective control
- Integrated assessment (in progress)
- Strong candidate for National Invasive Species Council priority initiative (2006)
- U.S. coordination through Interagency Committee for Terrestrial Animals and Pathogens
- International Coordination

USGS

IMPORTANCIA DE LA PALOMILLA DEL NOPAL
***Cactoblastis cactorum* Berg. PARA MÉXICO**

DIRECCIÓN GENERAL DE SANIDAD VEGETAL

Diciembre de 2003

PRINCIPALES PAISES PRODUCTORES DE TUNA

- **90% MÉXICO**
- **4.5% ITALIA**
- **2.7% SUDÁFRICA**
- **3.8% CHILE, ISRAEL, ARGENTINA Y EE.UU.**

MEETING NOTES

- High interest in controls measure
- Opuntia are very important to Mexico
- Mexico has 90% of world Opuntia production
  - 150,000 Ha for forage
  - 60,000 Ha for tuna fruit production
  - 10,500 Ha for nopales
  - 100 Ha for cochineal insects for dyes

IMPORTANCIA DEL NOPAL EN MÉXICO

- **150,000 Ha. para forraje**
- **60,000 Ha. para producción de tuna**
- **10,500 Ha. nopal verdura**
- **100 Ha. para grana cochinilla**

MEETING NOTES

- Crop value is 150 million US Dollars
- 20,000 families depend on it
- 100,000 individuals involved in cultivation
- Natural Heritage: 3 million Ha of wild Opuntia
- High Ecological Concern
- Many ecosystems supported

MEETING NOTES

- Diversity, 107 species described
  - 51 cylindropuntia
  - 56 platyopuntia
- Research suggests:
  - 2 spp. cyclindropuntia are Cactoblastis hosts
  - 20 spp. platyopuntia are Cactoblastis hosts
- Arrival of Cactoblastis in Mexico would be devastating to agriculture and ecology

ANTECEDENTES

Reunión de expertos en Viena, Austria. Sede: Oficinas del Organismo Internacional de Energía Atómica. Julio de 2002.

Asisten siete expertos de países como: Cuba, Estados Unidos, Sudáfrica, Italia (FAO) y México.

Conclusiones del grupo: *Mitigating the threat of Cactoblastis cactorum to International Agriculture and Ecological Systems and Biodiversity*.

PROYECTO DE MÉXICO AL OIEA **CAMPAÑA DE PREVENCIÓN**

MEETING NOTES

- International Atomic Energy Agency funding national prevention campaign
  - Detect and eradicate
- Education
  - Radio spots / TV interviews / pamphlets / web page / government publications
- Risk Analysis
  - Environmental / ecological / social

CAMPAÑA PREVENTIVA CONTRA *Cactoblastis cactorum* EN MÉXICO

OBJETIVO

Prevenir, detectar y en su caso erradicar a *C. cactorum*

MEETING NOTES

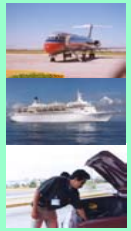
- International Atomic Energy Agency (con't)
- Education of technical personnel
  - Life cycle / taxonomy / damage / SIT / other technologies (GPS/GIS)
  - Conducted by IAEA, University of Florida / USDA / South Africa
- 105 port inspection centers in Mexico looking for Cactoblastis

MEETING NOTES

- International Atomic Energy Agency (con't)
- Funding coordination with South Africa
  - Production of manual and video
- Technical personnel have visited
  - South Africa / Florida and research sites
  - Interregional consortium planned on how to protect Mexico from Cactoblastis

ACCIONES

- **Divulgación y alerta**
- **Análisis de Riesgo**
- **Capacitación**
- **Establecimiento de un grupo de expertos**
- **Vigilancia en puntos de ingreso y dispersión**
- **Monitoreo**
- **Servicio de identificación**



APORTACIONES DEL OIEA A MÉXICO

- **Visita de experto de Sudáfrica a México (video y manual)**
- **Visita a Sudáfrica**
- **Visita a Florida**
- **Taller inter-regional (agricultura y ambiente)**

CONCLUSIONES:

Proyecto de colaboración interinstitucional

Compromiso internacional ➡ **Proteger a México de *Cactoblastis cactorum***

CAPACITACIÓN EN SUDAFRICA

CAPACITACIÓN EN FLORIDA

CAPACITACIÓN A PERSONAL OFICIAL

DIVULGACIÓN A TODO EL PÚBLICO

ACCIONES DE ERRADICACIÓN SI SE LLEGA A PRESENTAR *C. cactorum* EN MÉXICO

Dispositivo Nacional de Emergencia

Acciones de erradicación, mediante técnicas de control:

- **Intensificación de medidas cuarentenarias (nacionales e internacionales)**
- **Insecto estéril (autocida)**
- **Biológico**
- **Químico**
- **Cultural**
- **Otras que sugieran los expertos**

MEETING NOTES

- What would Mexico do if Cactoblastis appeared
  - Has federally-mandated action plan:
    - Increased quarantine measures
    - Increased measures at ports of entry
    - Looking at several control technologies
      - Autocidal (SIT)
      - Biocontrol agents
      - Chemical
      - Cultural

RESULTADOS DE LAS ACCIONES 2003, CON LA FINALIDAD DE PREVENIR EL INGRESO DE *C. cactorum* A MÉXICO

- **NOM-EM-040-FITO-2003, Por la que se implementa el sistema para prevenir la introducción, diseminación y establecimiento de la Palomilla del Nopal (*Cactoblastis cactorum* Berg.) en el Territorio Nacional. Mayo 2002.**
- **Delimitación de las áreas de riesgo del impacto potencial de *C. cactorum* sobre la ecología, economía y sociedad**
- **Capacitación en Sudáfrica y Florida en los aspectos más relevantes de *C. cactorum***
- **Establecimiento de un grupo consultivo de expertos nacionales**
- **Capacitación a técnicos para su detección e identificación en campo**

MEETING NOTES

- By law Mexico has a established a program
  - Preventive campaign to keep Cactoblastis out
  - Delimitation of risk (commercial and social)
  - Training with South Africa and Florida
  - Consultant group established

- **Capacitación al personal de aduanas, puntos de control, fronteras y productores**
- **Campaña de información al público**
- **Vigilancia de las rutas de invasión: puertos y aeropuertos**
- **Elaboración de fichas técnicas, posters y carteles**
- **Entrevistas en radio difundiendo la problemática de *C. cactorum***
- **Reportaje de televisión**

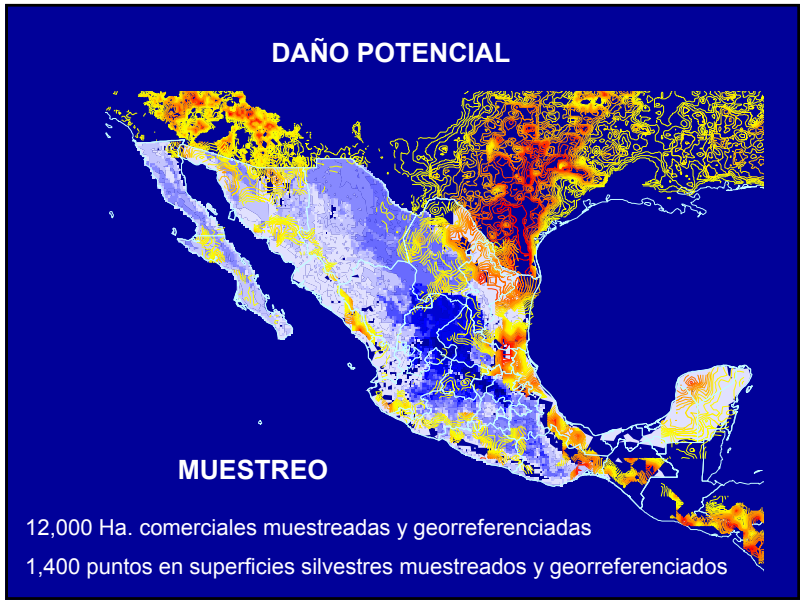
MEETING NOTES

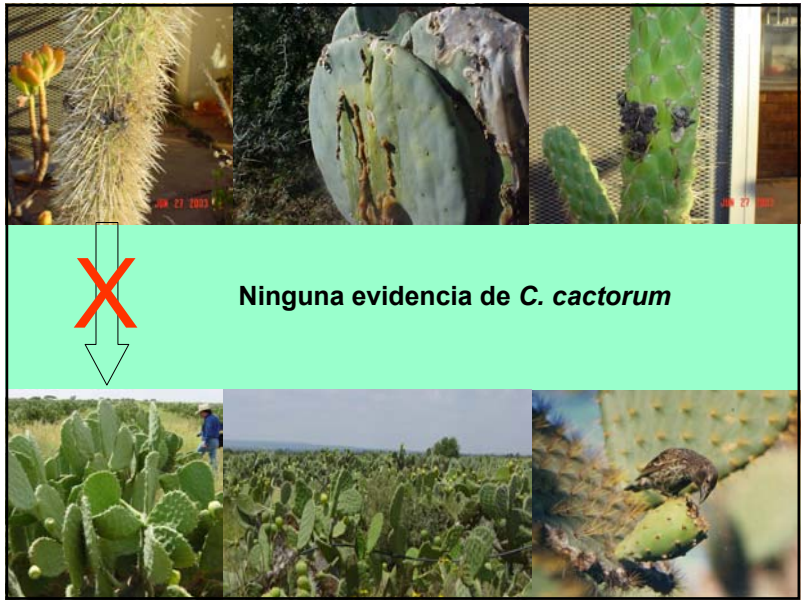
- Training to increase awareness:
  - Customs and agricultural personnel
  - Information to public
  - Surveillance of pathways
  - Production of technical brochures / materials
  - Radio and TV spots and interviews

- **Presentación del problema en la reunión anual de la mesa de Agricultura, XXI Conferencia de Gobernadores Fronterizos, Agosto 2003 en Chihuahua**
- **Desplegados en periódicos**
- **Presentación del cartel "Campaña Nacional Preventiva contra la Palomilla del Nopal *C. cactorum* en México", en la reunión anual de NAPPO, en Nueva Orleans**
- **Elaboración de un video que esta dirigido a productores: apoyado por OIEA**
- **Elaboración de un libro: apoyado por OIEA**

MEETING NOTES

- Training to increase awareness: (con't)
  - Discussions / communications with
    - Governing bodies in Mexico
    - NAPPO
    - IAEA
    - Commercial growers





MEETING NOTES

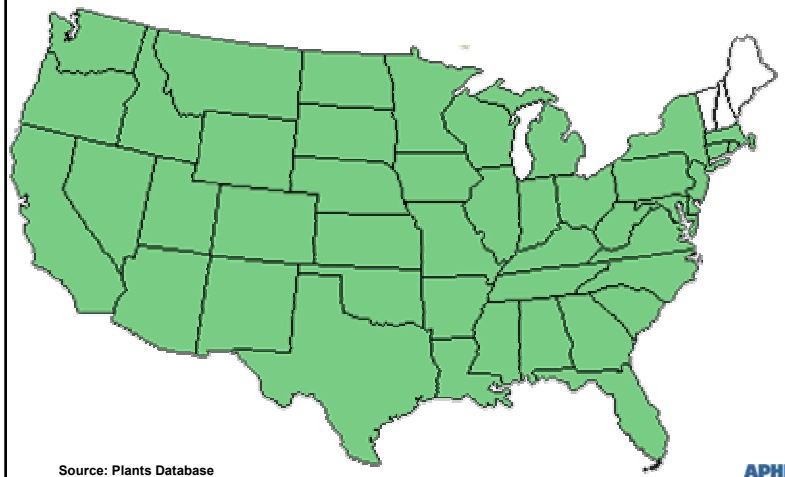
- Areas of greatest risk:
  - South Central Mexico
  - Baja could also be at risk
  - No evidence of Cactoblastis in Mexico to date
    - 12,000 commercial Ha sampled/surveyed
    - 1,400 wild Ha sampled/surveyed
- Question:
  - Other pests attack Opuntia and pesticides are used to control them. But use is minimal

Economic Risk Assessment For the Cactus Moth, *Cactoblastis cactorum*

Lynn J. Garrett
Agricultural Economist
USDA, APHIS, PPQ,CPHST
Raleigh, NC
lynn.j.garrett@aphis.usda.gov

U.S. Postage stamp issued December 11, 1981

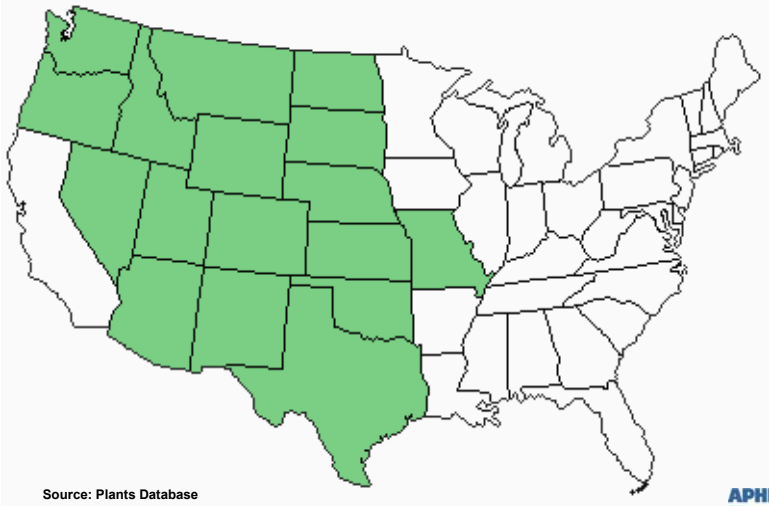
U.S. Distribution Area of Prickly-Pear



Source: Plants Database

Plains Prickly-Pear – *Opuntia polyacantha*

U.S. Distribution Area of Plains Prickly-Pear



Source: Plants Database

APHIS

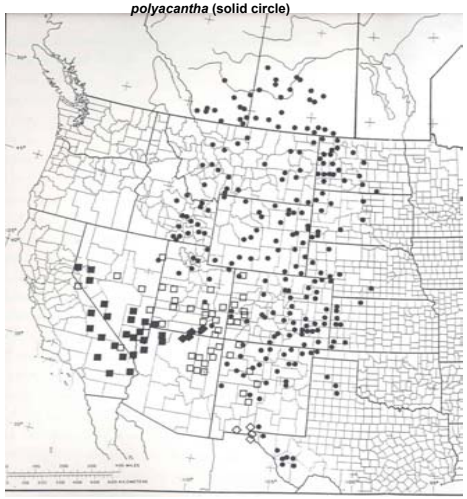
Englemann Prickly-Pear Cactus

(*Opuntia engelmannia*)- is one of the most widely distributed cactus species. Its range extends from the Gulf Coast to the Pacific and from southern Mexico to central Oklahoma. It is extremely common in the Rio Grande Plains and Trans Pecos Texas and throughout much of Mexico.

Source: Tarleton State University

Distribution of *Opuntia polyacantha* varieties (Plains Prickly-Pear Cactus)

O. arenaria **(open diamond),** ***O. erinacea*** **(solid square),** ***O. hystricina*** **(open square),** ***O. nicholii*** **(solid diamond),** ***O. polyacantha*** **(solid circle)**

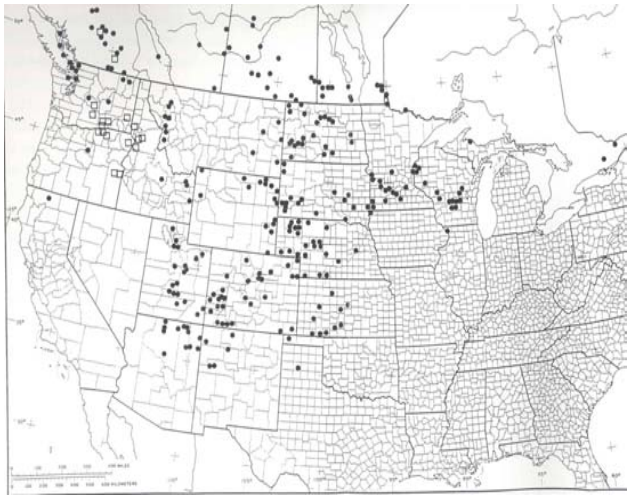


Source: Parfitt, Bruce D. 1991. Biosystematics of the *Opuntia Polyacantha* Complex (Cactaceae) of Western North America. Ph.D. dissertation, Arizona State University

APHIS

Opuntia xcolumbiana **Griffiths Columbia Prickly-Pear (open squares)**

Opuntia fragilis **(Nutt.) Haw. Brittle Prickly-Pear (solid circles)**

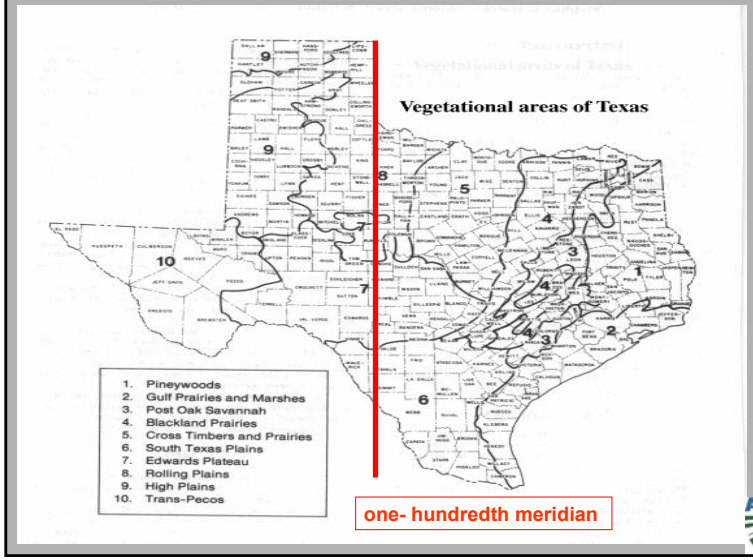


Source: Parfitt, Bruce D. 1991. Biosystematics of the *Opuntia Polyacantha* Complex (Cactaceae) of Western North America. Ph.D. dissertation, Arizona State University

APHIS

American Deserts

Source: "Deserts" K. Bruce Jones, Inventory and Monitoring of Wildlife Habitat, U.S. Department of Interior, 1986



MEETING NOTES

- Opuntia can have high "icon value"
- Chihuahuan desert has 25% of described cactus species
- Primary food cactus is *O. ficus Indica*

Eastern Prickly-Pear – *Opuntia humifusa*

Eastern Prickly-Pear – *Opuntia humifusa*

Source: Plants Database

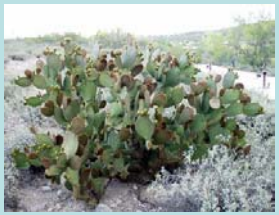
APHIS

Prickly-Pear Cactus (*Opuntia ficus indica)* Indian Fig Cactus
Commercially harvested species for food

APHIS

Western Landscape Varieties

Cow's Tongue Prickly-Pear Cactus
Opuntia lindheimeri var. linguiformis



Bunny Ears Prickly-Pear Cactus
Opuntia microdasys

Engelmann's Prickly-Pear
Opuntia engelmannii

Santa Rita Prickly-Pear
Opuntia violaceae santa rita

Source: Compiled by the Master Gardeners of the University of Arizona Pima County Cooperative Extension

APHIS

Florida's Indian River Lagoon Area "estuary of national significance"

Home to one of the most common Prickly-Pear Cactus species

Prickly-Pear, *Opuntia stricta*, growing on a dune near Sebastian Inlet, Florida. Photo courtesy of K. Hill, Smithsonian Marine Station.

Prickly-Pear, *Opuntia stricta*. Photo courtesy of K. Hill, Smithsonian Marine Station.

Source: Smithsonian Marine Station at Fort Pierce

APHIS

Recreational activities such as boating, fishing, water sports, hunting and ecotourism generate approximately $465 million dollars annually.

Known Distribution of *Cactoblastis cactorum* in North America

County Distribution of *Opuntia* (in green)
Source: Plants Database

County Distribution of *Opuntia* (in green)
Source: Plants Database

Note: Areas gray shaded represent the known distribution to 1999.

Source: Hight, S.D., Carpenter, J.E., Bloem, K.A., Bloem, S., Pemberton, R.W., and Stiling, P. (2002), "Expanding Geographical Range of *Cactoblastis cactorum* (Lepidopthera: Pyralidae) in North America", *Florida Entomologist, Vol. 85, No. 3, pp. 527-529.*

Prickly-Pear Cactus as a Food in the U.S.

- Cactus Leaves/Nopales available year-round but most plentiful in the Spring

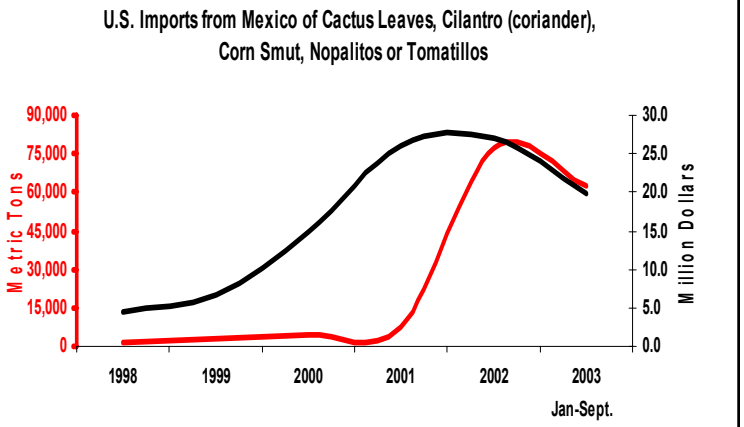
Prickly-Pear Cactus as a Food in the U.S.

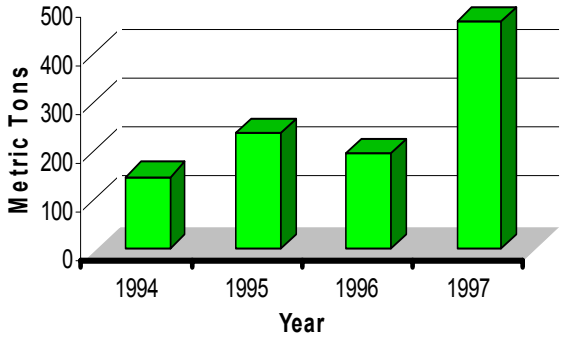
- Prickly/Cactus Pears harvested "Tuna" (sweet succulent fruit, actually berries with crunchy seeds) – U.S. annual imports from Mexico have been estimated at 1.5 million pounds. Total U.S. imports from Mexico and South America has reportedly been as high as 2.7 million pounds.

- Texas A&M – Kingsville research identifies cactus fruit as a potential cash crop in the Rio Grande Valley – with some significant complimentary advantages with citrus

Prickly Pear Cactus as a Food in the U.S.

- Minor crop in the U.S. – California produces approximately 70-80%.
- California Acreage is approximately 600 acres (number of plants ranging from 72,000 to 132,000).
- Top Producing County in California is Monterey County with 400-450 acres having a crop value of $2 million in 1998.





Source: Monterey County Overall Economic Development Program 1998 Report

Nursery Stock

- Market of *Opuntia* plant and seeds – abundant marketing over the internet
- Nurseries located mostly in California, Arizona, New Mexico, or Texas
- 1998 Census of Agriculture listed Cacti and succulents foliage plants sold for the United States (2002 Census available Dec '05):

  Number of Operations = 341 (CA 17%, FL14%, AZ 5%)
  Total Number of Pots Sold all sizes = 11,216,000
  Total Sales = $23,907,000

Landscape Industry

- Prickly-Pear Cacti are commonly used xeriscape landscaping plants in the Southwest U.S.
- Sources of plants include commercial extraction of wild native cacti destabilizing wild populations of some species.
- Irish, M. F., 2001. The Ornamental Prickly-Pear Industry in the Southwest United States – in Arizona 550,000 plants with wholesale and retail values of $4.5 million and $9.5 million (currently Irish estimates as much as 10 % growth since study was done).

Range and Pasture Lands

- *Opuntia* – critical reserve forage for animals in severe drought 70% dry matter digestibility, 6% protein.
- Has highest conversion efficiency of water to dry matter than any other class of plants and because cactus can survive during dry periods when other forms of forage become absent. Spine and spineless varieties are used. Spineless varieties less cold hardy as compared to spiny varieties.
- Value of *Opunita* to a small breeding herd of 50 head of cattle during the summer months when forage is limited could replace hay forage valued at up to $700.

Range and Pasture Lands

- Potential value in the 14 county *Opuntia* rich Trans-Pecos region of West Texas $4 million during a summer drought season.
- Greatest value for *Opuntia* in South Texas region as a wildlife feed for game animals – white-tail deer leases $6 per acre, quail lease $4 per acre compare to a lower lease price for cattle at $3 per acre (Rakowitz, 1997).
- King Ranch, in Kingsville, TX – 860,000 acres (principally cattle and oil) has a hunting lease rate ranging from $6-$8 per acre.
- A Texas Agricultural Statistic Service 1996 study compiled a list of more than 1,233 highly managed, high-fenced hunting operations in 194 of 254 counties in Texas (Baen, 1997).

Wildlife Habitat

- *Opuntia* is important to wildlife habitat– some estimates place a 50% to 70% reduction in *Opuntia* population to have a "negative influence on most wildlife habitat in Texas". (Rakowitz, 1997)
- The host status of all of the Cactaceae is not known. There is a potential for other cactus genre to also be attacked.
- The wildlife species to decreases in most vulnerable *Opuntia* include: javelina – *Opuntia* comprises as much as 85% of its diet – some populations, however, exist in areas where there are no prickly-pear cactus; experiments on captive javelina reveal that they can survive solely on a diet of prickly-pear cactus for as long as 3 months.

Wildlife Habitat

Habitat of the Javelina
in Arizona
34 % of the area of the state
60,000 animals

Source: Arizona Game and Fish Commission

Wildlife Habitat

- *Opuntia* is important to wildlife habitat– some estimates predict that a 50% to 70% reduction in *Opuntia* population would have a "negative influence on most wildlife habitat in Texas" (Rakowitz, 1997).
- The most vulnerable wildlife species to decreases in *Opuntia* include:
  javelina – *Opuntia* comprises 85% of its diet
  white-tailed deer - 21% to 33% of its diet is *Opuntia*
  Other wildlife that use *Opuntia* for food and or cover in Texas include: Texas tortoise (protected species), Lesser Long-Nosed Bat (USFWS endangered species August 30, 1988 quail, roadrunners, jack rabbits, honey bees (Rakowitz, 1997).

Wildlife Habitat

- Hunting lease income to rural land owners can enhance value to the point that recreation becomes the highest and best use of rural land for both the market and income and approaches to valuation (Baen, John S., 1997).

Other Potential Economic Impacts

- Outdoor Recreational Activities
  Sightseeing
  Hiking / Walking
  Picnicking
  Camping
- Off-Highway Vehicle Recreation
  Major associated activities – sightseeing, hiking / walking

Other Potential Economic Impacts
Off – Highway Vehicle Recreation

Arizona Study – Economic Importance of Off-Highway Vehicle Recreation (Silberman, 2003 Arizona State University West)

- Expenditure $3 Billion in Off-highway Vehicle recreation during 2002
- Statewide economic impact of $4.25 billion
- Supported 36,951 jobs in Arizona
- Created household income (salaries and wages) for Arizona residence totaling $1.1 billion
- Added $187 million to annual state tax revenues.

Endangered And Other Status Species of *Opuntia*

Endangered Status

Opuntia treleasei – Bakersfield cactus
Range: California
Status: Endangered for entire range as of July 19, 1990 by USFWS

Other Designated Status

Consolea Opuntia corallicola – Florida semaphore cactus
Range: Florida
Status: Candidate Notice of Review for Endangered Status by USFWS June 13, 2002

Opuntia basilaris – Beavertail Prickly-Pear
Range: California, Nevada, Utah, Arizona
Status: Convention on International Trade in Endangered Species Protection Status (CITES) Appendix II

Opuntia aureispina,- Golden-Spined Prickly-Pear (Texas)
Opuntia aurea, - (Arizona, Utah)
Opuntia bigelovii, - Teddy-Bear Cactus (Arizona, California, Nevada)
Opuntia arenaria, - Sand Prickly-Pear (New Mexico, Texas)
Opuntia triacantha, - Keys Joe-jumper (Florida – Endangered List)

Other Ongoing Threats to *Opuntia*

- Uncontrolled harvesting of Chihuahuan Desert *Opuntia*
- Growing domestic demand from population growth areas in Arizona
- During the period 1998-2001, Arizona trade statistics indicate a total of 609 *Opuntia* plants were brought into the state from Texas
- Habitat destruction due to urbanization

Summary of Economic Values of *Cactoblastis cactorum Host*

- Minor Agricultural Significance:
  Crop Value for Food Use = $2 million (limited to one county in California)

  Forage Value (highly variable) = $4 million (Trans-Pecos Region of Texas)

  Nursery Industry (unknown) = $23.9 million (portion of value 1998 Census)

  Landscape Industry (unknown) = $15 million (2001 Irish Survey in Arizona)

- Trade:
  U.S. Imports from Mexico: estimated to be a major portion of $25 million edible vegetable aggregate includes with *Opuntia* (corn smut, and cilantro (coriander) and tomatillos)

Summary of Economic Values of *Cactoblastis cactorum Host*

- Ecological Potential Significant Impact:
  Habitat Impacted – wildlife (javelina, whitetail deer, quail, others)
  Endangered *Opuntia* species – California's Bakersfield Cactus
  Conservation Value- natural areas soil conservation value
  Biodiversity in marginal areas in southwest

- Other Impacts:
  Rural Landholders – hunting leases where *Opuntia* serves as a major wildlife food source (Texas, New Mexico, Arizona)

  Recreational Activities – Off-Highway Vehicle Recreation

  Other: Manufacturers of medicinal products, cosmetics, dye production

Political Considerations of Future Actions on *Cactoblastis cactorum*

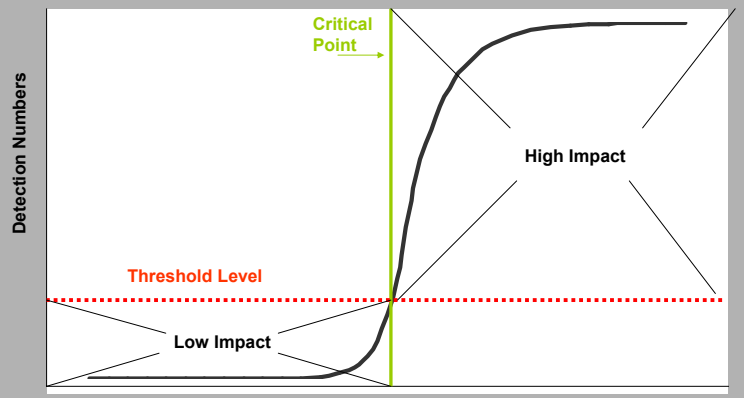
- Importance to Mexico
  - National Symbol (appears on National Flag)
  - Economic Significance
- Individual State Concerns
  - Texas state symbol
    House Concurrent Resolution No. 44, 74th Legislature, Regular Session (1995) – making Prickly-Pear Cactus the state plant
- View of species of Prickly-Pear as a brush/noxious plant
  - *Opuntia aurantiaca* (jointed prickly pear) on Federal Noxious Weed List
- Tribal Lands (food use, hunting leases where *Opuntia* is significant food source of wildlife)

Classification of economic damages caused by *Cactoblastis cactorum* on Opuntia

Total economic value	Example of damages	Most suitable valuation technique
Direct use value	Loss agricultural crop commercial value: processed and fresh food, livestock forage grazing value, horticultural specialty foliage nursery plant and landscape plant.	Market price valuation technique
	Wildlife feed value (tourism and recreational benefits, e.g. hunting, wildlife viewing)	Travel cost method, contingent valuation
	Other value: (pharmaceutical industry use)	Market price valuation technique
Indirect use value	Effects on arid ecosystem health, loss of desert living resource diversity.	contingent valuation
	Loss of "critically imperiled native plant" and endangered species (Bakersfield cactus - *Opuntia treleasei)*	contingent valuation
Bequest value	Risk of loss of legacy benefits, e.g. no legacy of *Opuntia* species for future generations	contingent valuation
Existence value	Cultural, icon of arid environment, political in Southwest U.S, political cost with spread into Mexico	contingent valuation

Note: The overall consequences related to the potential damages that Cactoblastis cactorum on Opuntia may cause are identified above. Most of the potential damages have a non-market nature with no market price that is able to caputre the overall cost that may be caused by the Cactoblastis cactorum on species of Opuntia. In the absence of market prices, specific monetary valuation techniques can measure the total economic value of the potential damages of Cactoblastis cactorum.

National Importance of Early Detection



High Impact for *Cactoblastis cactorum*

- Agricultural – food, forage, soil conservation
- Landscape
- Nursery
- Biodiversity
- Recreation
- Other – Rural Landowner (leasing for hunting)
  Trade
- Political

Now What ?

What are the recommendations ?

What comes next for the economic analysis ?

Phil Coale, Associated Press

Good Morning

Distribution and Conservation Status of *Opuntia* Cactus

Rachel Claire Muir, USGS
Stephanie Lu, NatureServe
Meghan Fellows, NatureServe
December, 2003

Proposal – A Partnership of Research and Monitoring

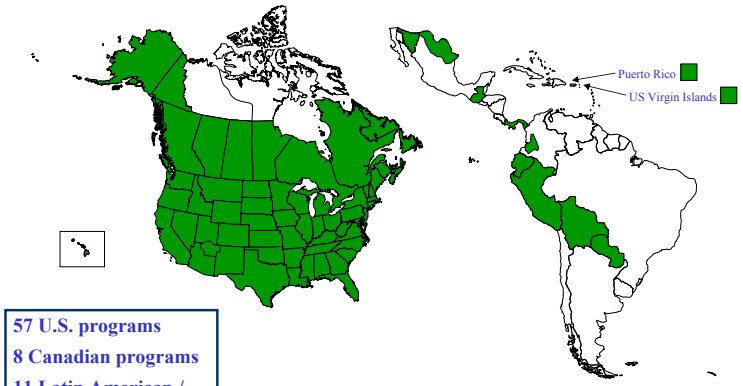
- USGS and NatureServe Cooperation on Invasive Species
- MOU signed in 2003 designed to combine –
  - -- USGS nationwide research capabilities
  - -- NatureServe Western Hemisphere distribution and occurrence data and information network
- ***Cactoblastis cactorum*** – a threat to both economic and ecological communities and a priority for both

NatureServe Network

- 76 independent centers that collect and manage data about plants, animals, and ecological communities.
- Natural heritage programs in all 50 U.S. states, 11 Canadian provinces and territories, 10 countries and territories of Latin America and the Caribbean ("conservation data centers")
- Focus on at-risk species and ecosystems
- Most programs are state or provincial agencies; some affiliated with universities; just a few are still TNC-operated.

Inventory at La Butte Creek Wildland Provincial Park, Alberta

NatureServe's Member Programs: the Network in 2003

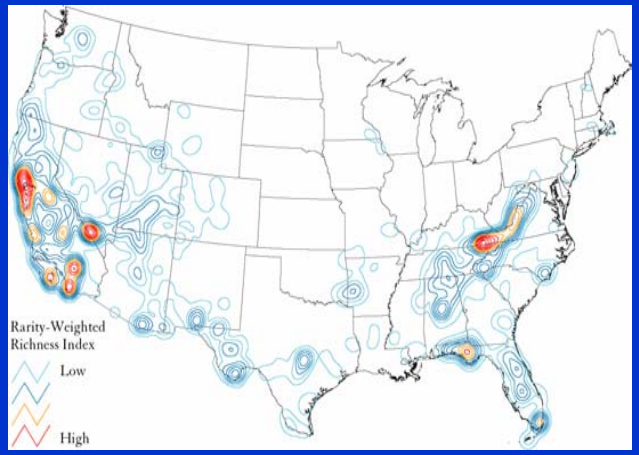


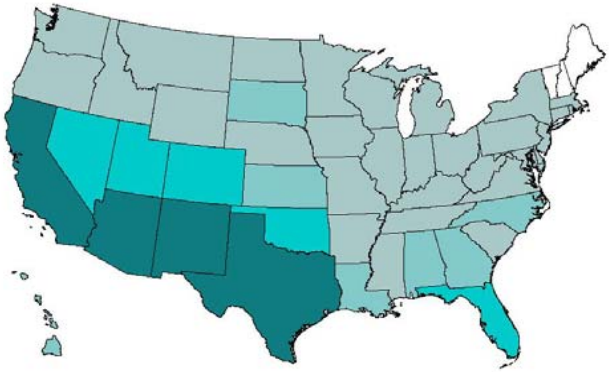
57 U.S. programs
8 Canadian programs
11 Latin American / Caribbean programs

IUCN – Heritage 'Equivalent' Statuses

IUCN Status	Heritage Status
Extinct	GX and GH
Critically Endangered	G1
Endangered	G1
Vulnerable	G2
Near Threatened	G3
Least Concern	G4 and G5
Data Deficient	Various or 'range rank'

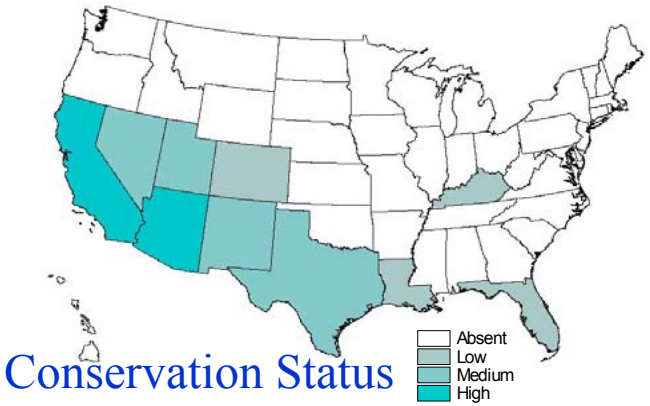
Hot Spots of Rarity and Richness





Opuntia Species Number

Absent
Low
Medium
High
Very High



Conservation Status

DATA GAPS

- Geographic – Mexico and Caribbean
- Distribution Data of Common Species
- *Opuntia* Species Vulnerability to *C. Cactorum*
- Distribution data for C. cactorum in Heritage Network

NEXT STEPS

Solicit comments and input from Cactus Moth Working Group

With Working Group approval, begin to fill data gaps

Refine design of threat assessment

Outreach – to governments, researchers, Heritage Programs and public

National Institute of Invasive Species Science

Colorado State University
Knowledge to Go Places

Assessing the threat of *Cactoblastis cactorum* to native *Opuntia* species in the U.S. and Mexico

Social, Environmental and Economic Costs

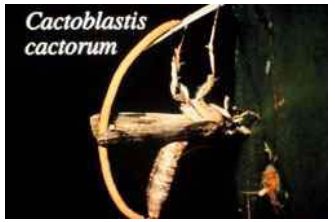
Natural Resource Ecology Laboratory

USGS
science for a changing world

Lepidoptera: Pyralidae
Cactoblastis cactorum Berg

Gregarious larvae feed inside cactus pads, leaving only "goo" and epidermis behind

Egg sticks could be one key to early detection



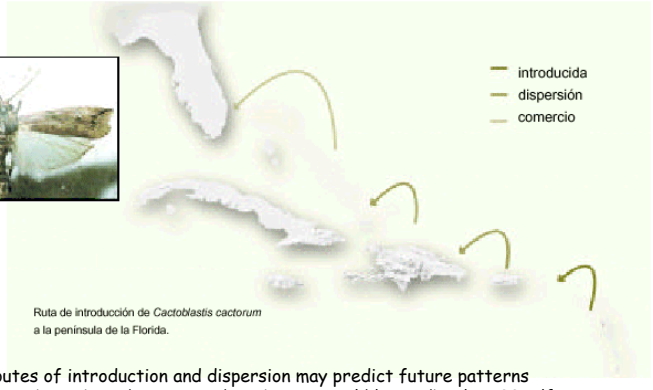
Identification of adults is difficult, but may be present long before larvae are detected

Dispersal:
110 km over water from Oahu to Kaui

Pheromone trapping for early detection

Assisted introductions, dispersion and accidental introductions have resulted in the moth's arrival to Florida, Georgia and South Carolina in the U.S., as well as Cuba, Dominican Republic and more.

Cactoblastis cactorum adulto



Ruta de introducción de *Cactoblastis cactorum* a la península de la Florida.

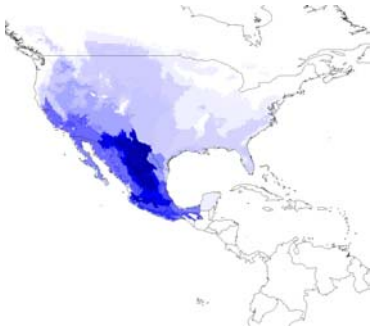
Historical routes of introduction and dispersion may predict future patterns
http://www.conabio.gob.mx/institucion/conabio_espanol/doctos/biodiver33.pdf

Opuntia P. Mill.

79 species in Mexico, 80 taxa in Natureserve

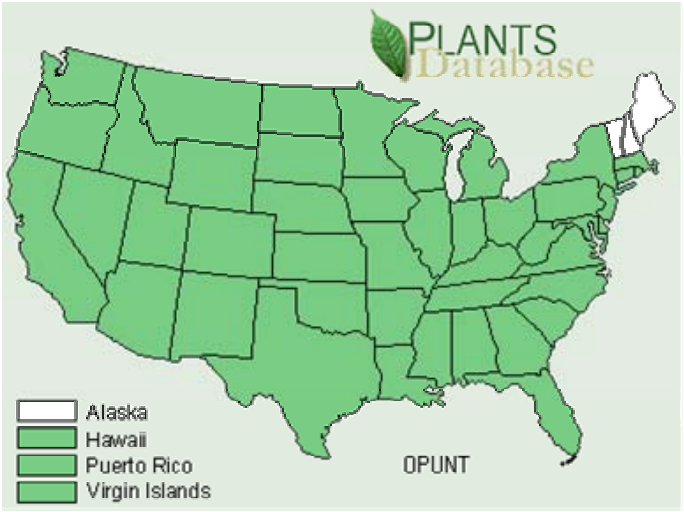
Threat severity and potential costs varies across locations

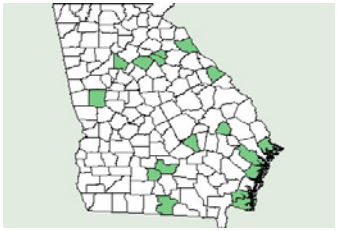
In Blue: Dr. Soberon and others compiled this map based on distribution of about 86 *Opuntia* species from collections (Smithsonian, Missouri Botanical Garden, San Diego Natural History Museum, the Mexican National Herbarium, the Mexican Scholl of Biological Sciences Herbarium, and a few others. Map represents niche modeling of the ~5000 occurrence points, analysis by the Mexican National Commission on Biodiversity (Conabio)



Opuntia distribution and hotspots

Not just Mexico and the Southwest U.S.!

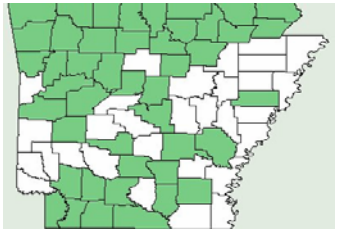




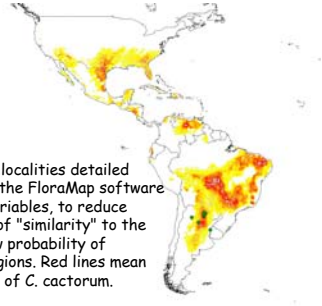
The distribution *Opuntia* species is not completely continuous in the states where *Cactoblastis* is currently found FL, GA (above), and NC.

However, dispersal ability of the adults could be great depending on weather patterns and accidental introductions through horticultural trade (Walmart interception!).

There are few obvious barriers to dispersal through Alabama (new datasets), Mississippi, and Arkansas (below), to Texas, which is predicted to be the likely invasion route to Mexico.



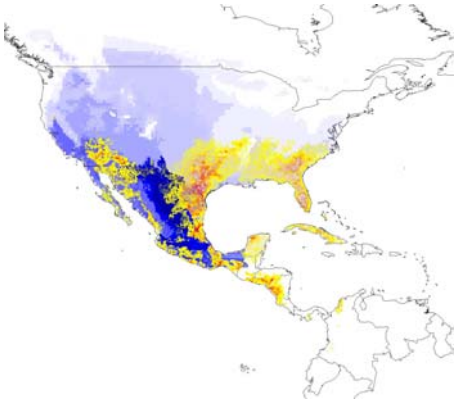
Potential distribution in Americas predicted through *Opuntia* museum records and climate tolerances (tolerance data from native Argentina)



The Smithsonian had many specimens but only 7 localities detailed enough to georeference. These were inputed to the FloraMap software that uses Principal Components on 36 climatic variables, to reduce dimensionality and fit a multinormal probability of "similarity" to the original localities. So, the yellow areas means low probability of climatic similarity to the original *C. cactorum* regions. Red lines mean high similarity. So this is a map of climatic niche of *C. cactorum*.

Mexico and U.S. Agencies need a plan to detect and prevent spread

The overlay of *Opuntia* distribution and predicted climatic tolerance of the moth shows many areas with suitable habitat and abundant food resources



MEETING NOTES

- Mexican and US agencies need a detection plan
- Climatic tolerances are only part of story
- Not only of economic importance in Mexico, US also has interest

Climatic tolerances tell only part of the story

Opuntia sangiunocula (Photo by Rick Shory, NIISS)

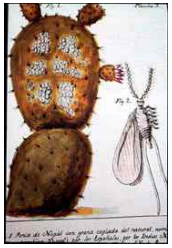
Economic, Social and Cultural

Employment ($50 million)
Sustainability
Food Security
Emergency fodder
Arts and even music!
3 million hectares

Countless diverse economic, social and environmental values

'nopales'

Tintes



Diversity of native cacti and at least 22 species of native cactus-feeding moths.
Opuntia are under threat but there could be many more hosts of *Cactoblastis*.
Ex. This Senita cactus moth pollinates and feeds on native cacti in Arizona.

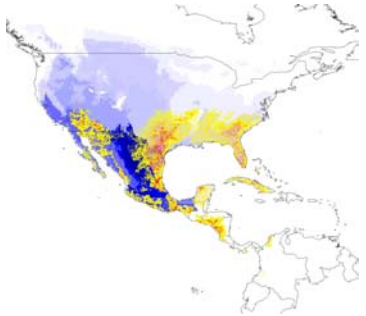
Market Values - $50 million
Non-Market Resources - $Billions
Native Landscapes and Species Diversity - Priceless!

There are some things you just cant buy…

A Call to Action! Agencies in Mexico and the U.S. must prevent spread

The renowned cactus moth, *Cactoblastis cactorum* Berg threatens native *Opuntia* species (prickly pear and other cacti) in the Southwest U.S. and Mexico.

Opuntia species are important social, economic and environmental resources.



The best available data is critical for improved prediction and early detection:
Modeled Opuntia species distribution in blue,
Potential range of the invasive moth in yellow.

International Atomic Energy Agency (IAEA) Headquarters in Vienna, Austria

Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
Insect Pest Control Section

The mission of the International Atomic Energy Agency (IAEA)

TO ACCELERATE AND ENLARGE THE CONTRIBUTION OF ATOMIC ENERGY TO PEACE, HEALTH AND PROSPERITY THROUGHOUT THE WORLD

MEETING NOTES

- 134 member states
- 3000 employees

HISTORICAL PROFILE

- 1940's

After the Second WW International attention focuses on controlling the atom. The **United Nations Atomic Energy Commission is Formed**.

- 1950's

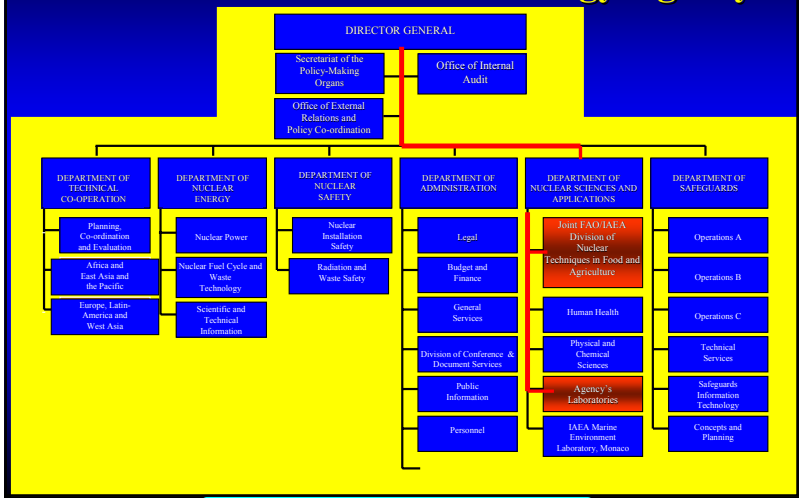
US **President Eisenhower's Atoms for Peace Speech** to the UN general Assembly paves the way for the creation of the International Atomic Energy Agency (IAEA).

- 1960's

The IAEA **first safeguard inspections** are conducted. Interest grows in using nuclear reactors for electricity generation.

The FAO and IAEA decide to create the **Joint FAO/IAEA Division** of Nuclear Techniques and Food and Agriculture.

Organisational Chart
The International Atomic Energy Agency



SIT : most environment-friendly method

- extremely target specific: intra-specific
- no introduction of exotic insects
- no establishment in time and space
- sustainable because of reduced insecticide use

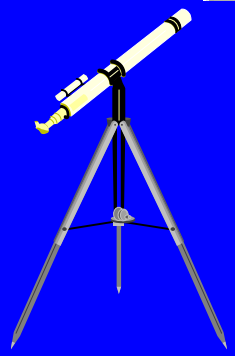
STERILE INSECT TECHNIQUE

Focus only on Major Key Pests:

- major targets of continuous insecticide use
- constraint to international trade in agricultural commodities
- key constraint for food security
- trans-boundary pest problems
- exotic alien invasive pests

Balanced Approach on "Three Legs":

1. Normative
2. Research and Methods Development
3. Technology Transfer and Field Programmes



1. Normative activities

Insect Pest Control Section
Entomology Unit IAEA Lab.

2. Major R&D Achievements (examples)

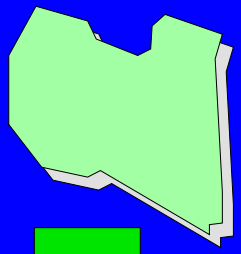
MEDFLY

- **Development of genetic sexing strains (GSS) and transfer to SIT operational programmes**
- **Analysis of mating behavior and compatibility of world-wide medfly populations**
- **Improved female attractants and traps for SIT programmes**

Joint FAO/IAEA Division of Nuclear Techniques in Food and Agriculture
Insect Pest Control Section

Eradication of NWS from North Africa:

Libya
1990-1992



SUPPORT OF IAEA TO THE CACTUS MOTH PROBLEM

Consultants Meeting in Vienna Austria July 2002

- Mexico's Plant Protection General Directorate (DGSV)
- Cuba's Plant Protection Research Institute
- FAO
- USDA/ARS
- Nature Conservancy

CONCLUSIONS & RECOMENDATIONS

SUPPORT OF IAEA TO CACTUS MOTH PROBLEM

PRESENT:

Research and Development (R&D)

- Research contracts with US and South Africa institutions to develop artificial mass rearing, sterilization procedures and survey mechanisms

Technical Co-operation Projects (TCP)

- TCP with Mexico on "**Prevention Against Cactus Moth in Mexico**"

  + PR material to raise awareness (book and video)
  + Training of plant protection staff through scientific visits to South Africa and a course in Florida
  + Impact assessment in progress

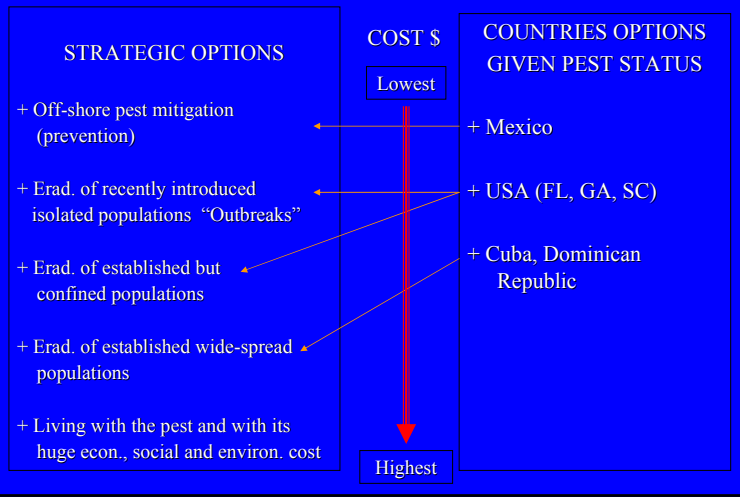
Note.- These activities have been commissioned by the IAEA to various organizations for execution.

SUPPORT OF IAEA TO THE CACTUS MOTH PROBLEM

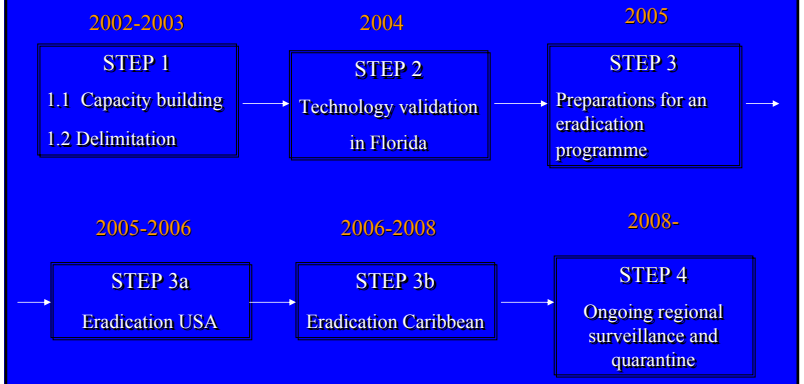
FUTURE:

- Through research contracts, continue supporting the development of survey techniques and the SIT for effective suppression/eradication of cactus moth.
- Upon request from the Mexican Government continue supporting activities aimed at preventing the introduction and establishment of cactus moth through a National Technical Cooperation Project.
- Upon request from countries affected or at risk from cactus moth support a regional initiative against this pest.

OPPORTUNITIES



ELIMINATING CACTUS MOTH FROM THE REGION

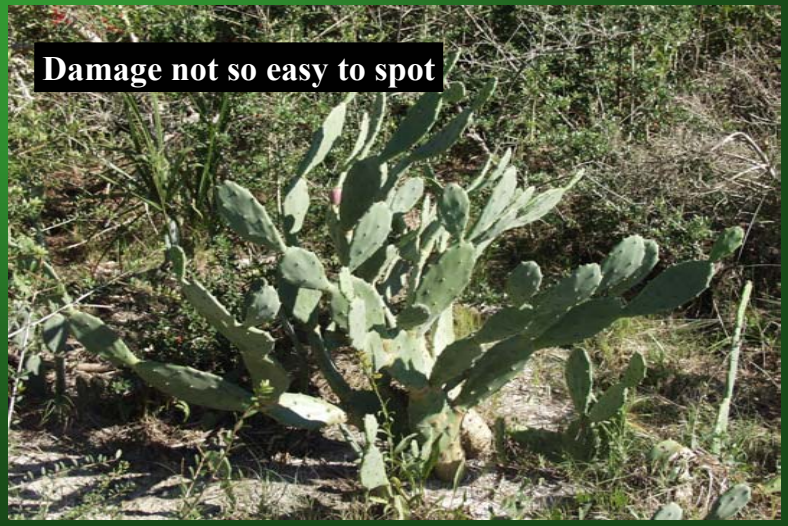


MEETING NOTES

- Still in a situation where there is time and not too wide a distribution to prevent Cactoblastis from becoming an unmanageable problem.

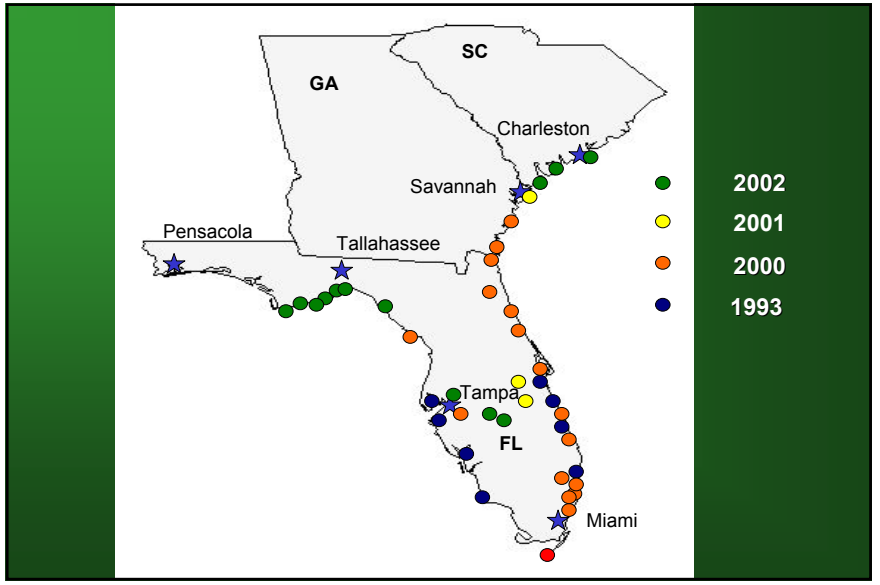
Detection Techniques for *Cactoblastis cactorum*

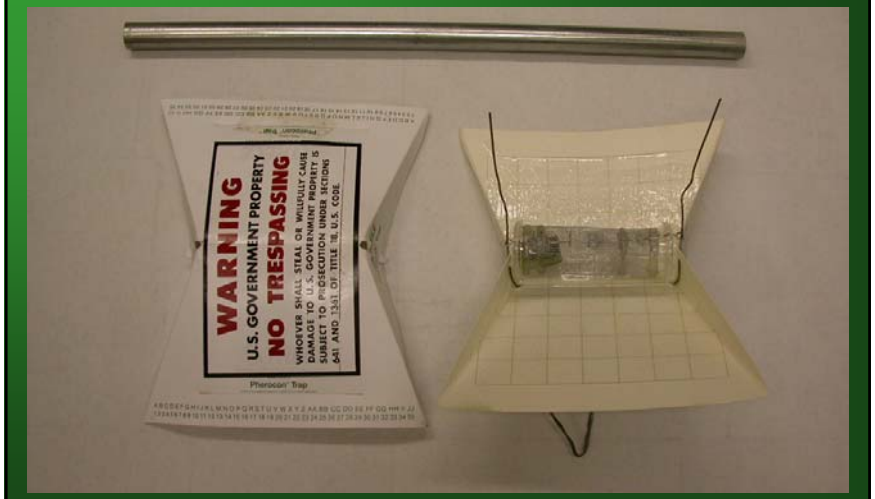
Initial detection efforts for *Cactoblastis cactorum* by examination of host plants …



MEETING NOTES

- Visual inspection: in some areas underbrush may conceal the cactus
- In 2002 the trapping system was a modified Phercon 1C sticky trap



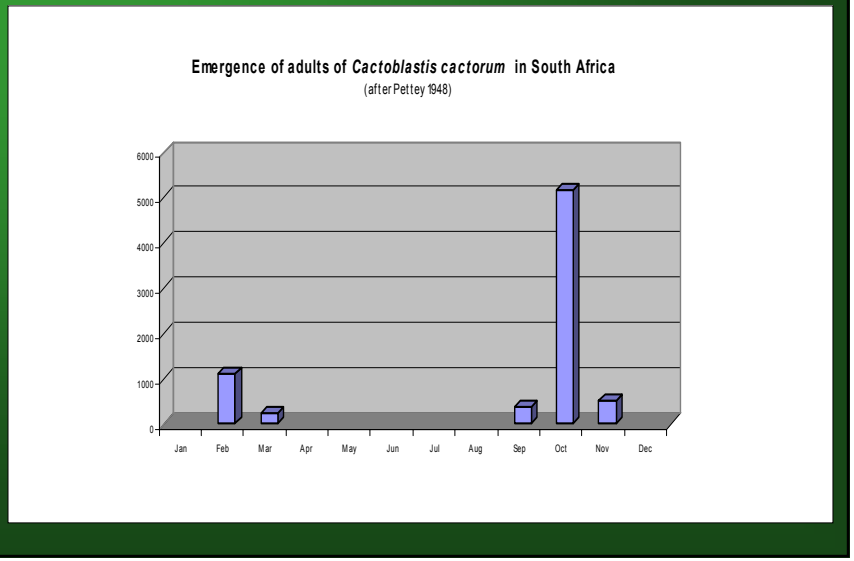


Virgin female-baited sticky traps detect the presence of *C. cactorum* in areas where plant damage is NOT evident

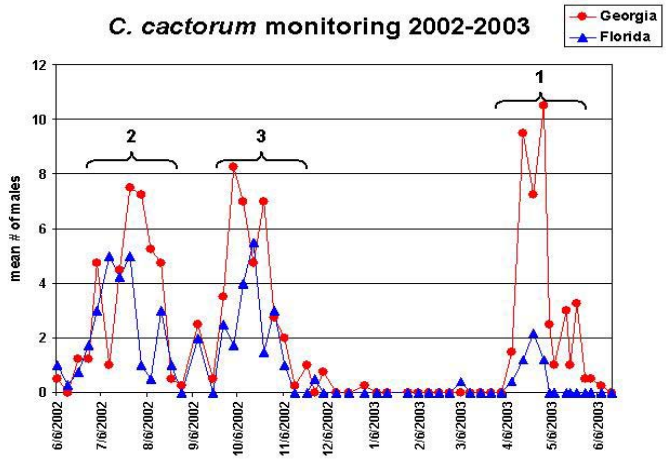
- Dodd (1940) – females can fly up to 24 km
- In Australia 16-24 km in 2.5 years
- In South Africa 3-6 km in 2.5 years
- **In Florida 50-75 km per year**

What is the seasonal phenology of *Cactoblastis cactorum* in the Southeastern USA ?

- In South Africa *C. cactorum* has 2 generations/year (Pettey 1948)
- Spring generation September-November
- Summer generation February-March



- 4-6 female baited sticky traps
- Jekyll Island, GA
- St. Marks Wildlife Refuge & Alligator Point, FL
- Weekly trap servicing



- In the southeastern USA *C. cactorum* has 3 generations/year
- Spring generation April-May
- Summer generation July-August
- Winter generation October-November

What is the best trap for monitoring *Cactoblastis cactorum* ?

Different trap types

- Wing > Delta > Bucket
- Wing traps captured 18% more males than Delta traps and 75% more males than Bucket traps

Traps placed at different heights

- 2 meter > 1 meter > 0.5 meter
- Traps placed at a height of 2 meters captured 13% more males than traps placed at 1 m and 38% more males than traps placed at 0.5 m

Traps baited with 1 or 4 females

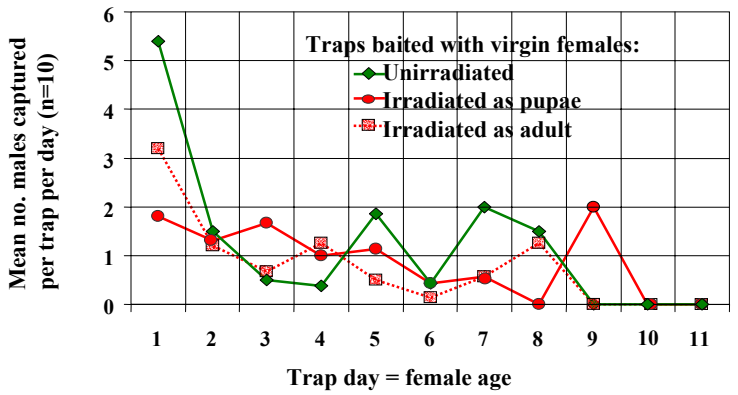
- 4 females > 1 female
- Traps baited with 4 females captured 3 times more males than traps baited with only 1 female

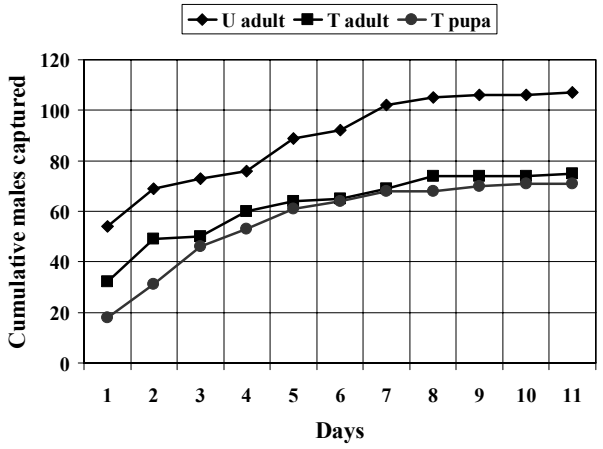
Traps baited with “young” (24 h-old) or “old” (96 h-old) females

- Young females > old females
- Traps with young females captured 85% more males than old females

Traps baited with fertile or sterile females (200 Gy of gamma radiation)

Nordion Gammacell 220





- **Fertile females = sterile females**
- **No statistical difference in trap captures in traps baited with fertile or sterile females**
- **All females had a mean longevity of about 1 week**
- **Sterile female-baited traps can be deployed in areas beyond the leading edge of the infestation**

- **What do trap captures really mean ?**
- **What is the trap efficiency ?**

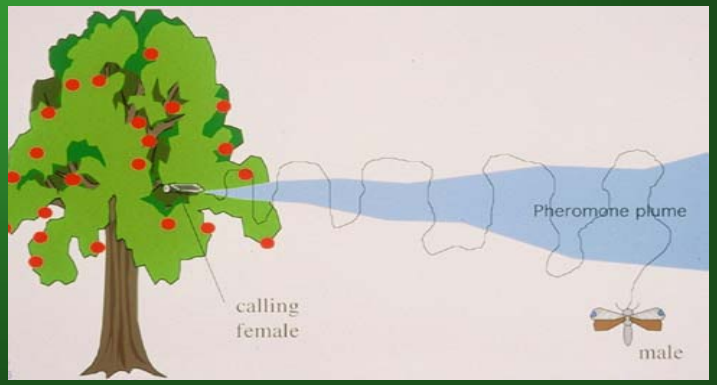
Limited release-recapture experiments in the USA

- Virgin female-baited traps recapture about 7.30% of the released males
- About 90 wild males were also captured in the same traps
- Wild population size about 1,233 males
- Sex ratio 1 male:1 female
- Wild population about 2,466 moths
- Wild population … IT'S BIG

Additional trapping studies that are planned

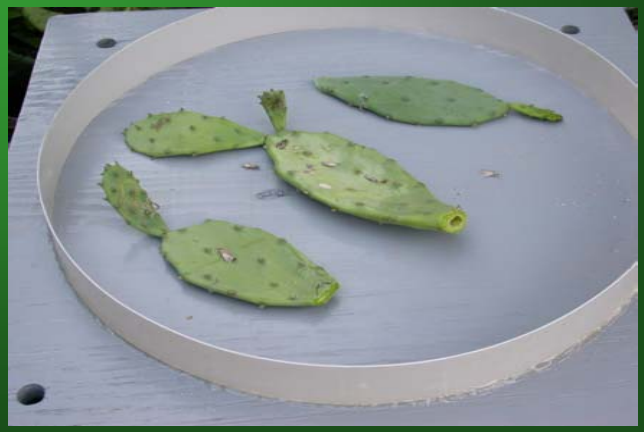
- Additional release-recapture studies (South Africa) to confirm the trap efficiency of the Pherocon 1-C sticky trap baited with virgin cactus moth females deployed at a certain density
- Effect of trap color

Sexual Communication & Mating Behavior in *C. cactorum*



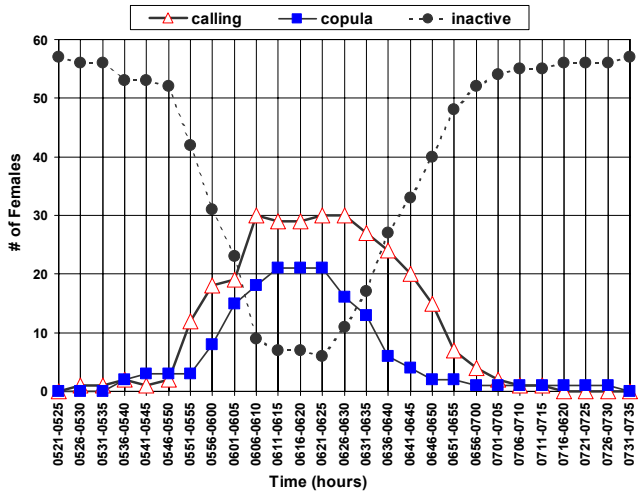
C. cactorum …

- Do they produce pheromone ?
- If so, when ?
- When does mating occur ?
- What type of mating behavior ?
- How long do they stay in copula ?
- Do females have a refractory period ?



MEETING NOTES

- Mating tables were checked every hour
- From 5:21am to 7:30am all mating and mating behavior is observed
- Sunrise was at 6:45am
  - ~6:00am females begins calling
    - Males respond within 5 minutes
    - Copula lasts about 30 minutes
  - ~6:44am female calling stops



TEMPORAL DESCRIPTION OF COURTSHIP AND MATING BEHAVIORS OF *C. CACTORUM*, AT ALLIGATOR POINT, FL, 15-18 JULY 2003.

Behaviors	**n**	**Mean (±SD)**
Initiation of ♀ calling posture	54	06:02(9 min)
Termination of ♀ calling posture	31	06:44(12 min)
Response of first ♂ to calling ♀	35	06:03(10 min)
Response of last ♂ to calling ♀	20	06:18(9 min)
Duration of calling for ♀ that did not mate	31	40.5(13.0)
Duration of calling for ♀ that mated	23	5.2(4.2)
Duration of copula	23	31.8(18.4)

C. cactorum …

- **Do they produce pheromone ? yes**
- **If so, when ? ≈1 h before sunrise**
- **When does mating occur ? ASA calling begins**
- **What type of mating behavior ? simple**
- **How long do they stay in copula ? ≈30 min**
- **Do females have a refractory period ? yes**

MEETING NOTES

- Other moths appear in the traps but none are similar to *Cactoblastis cactorum*
- SIT males do not have inferior sperm, at least to the extent that females have adjusted their mating refractory time (yet)

Pheromone Development for *Cactoblastis cactorum*

Nancy Epsky, Robert Heath, Thomas Weissling
USDA/ARS, Subtropical Horticulture Research Station
Miami, Florida

Peter Teal and Barbara Dueben
USDA/ARS, Center for Med., Agric. And Vet. Entomology
Gainesville, Florida

Collaborators and Support

Tifton, Georgia - Jim Carpenter, USDA/ARS

Tallahassee, Florida – Stephen Hight, USDA/ARS
Ken Bloem, USDA/APHIS
Stephanie Bloem, FAMU

Vienna, Austria – Walther Enkerlin, FAO/IAEA

Chemical Ecology, Identification of Semiochemicals:

- Naturally occurring, message-bearing chemicals
- Used by insects for communication and perception of their environment
- These chemicals may have behavioral or physiological effects on insects

Sex Pheromones:
produced by one sex to attract the opposite sex

Approaches to Pheromone Identification

Direct Approach (preferred)

Volatile chemical collections from live insect

Indirect Approach (ancillary)

Extracts from dissected abdominal glands
Electro-antennograph (EAG) analysis

Direct Approach to Pheromone Identification

- Document calling and mating behavior
- Develop laboratory bioassays
- Collect and identify volatile chemicals from calling moths (putative pheromone)
- Formulate and test to verify pheromone

Direct Approach to Pheromone Identification

- Document calling and mating behavior
- Develop laboratory bioassays
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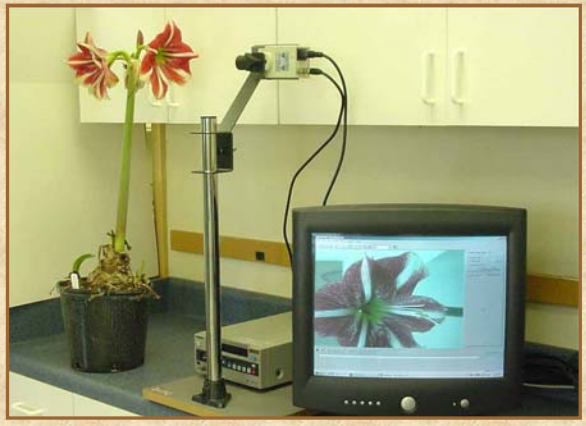
- Formulate and test to verify pheromone

Video analysis is used to document calling and mating behavior



Single male | Mating pair | Single female

Single male | Mating pair | Single female

Start of calling posture

Single male | Mating pair | Single female

Single male | Mating pair | Single female

Complete calling posture

Direct Approach to Pheromone Identification

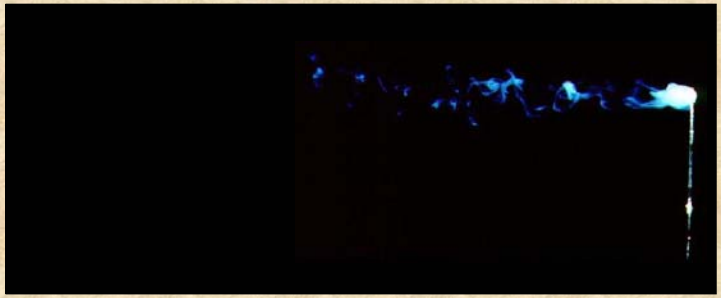
- Document calling and mating behavior
- **Develop laboratory bioassays**
- Collect and identify volatile chemicals from calling moths (putative pheromone)
- Formulate and test to verify pheromone

Laboratory bioassays used to test male response: Y –tube olfactometers

Laboratory bioassays used to test male response: Flight tunnels

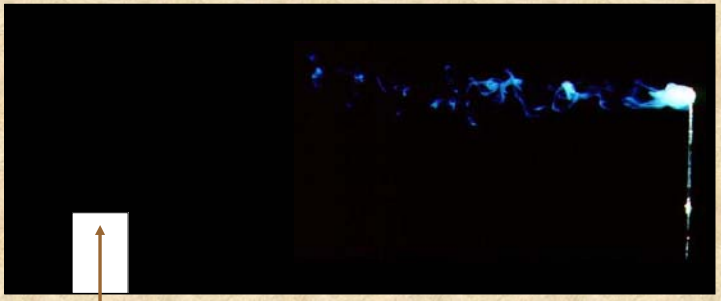
Odor Plume in Flight Tunnel

direction of air flow



Odor Plume in Flight Tunnel

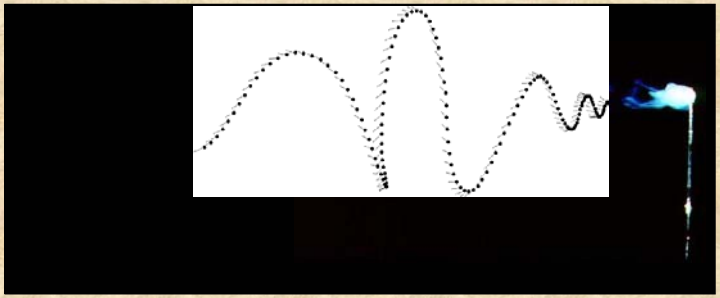
direction of air flow



Insects released into flight tunnel

Odor Plume in Flight Tunnel

Upwind flight in response to odor



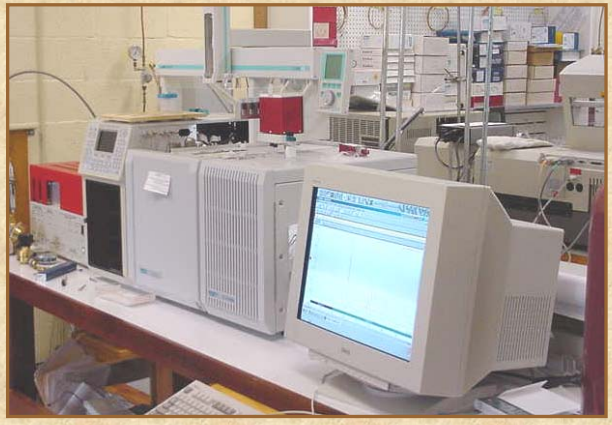
C-trap baited with live females was used in flight tunnel tests with 20 males

Direct Approach to Pheromone Identification

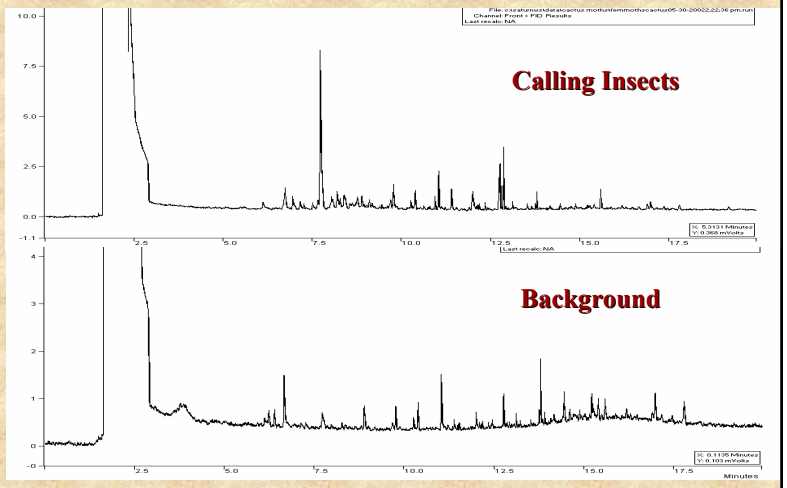
- Document calling and mating behavior
- Develop laboratory bioassays
- **Collect and identify volatile chemicals from calling moths (putative pheromone)**
- Formulate and test to verify pheromone

Headspace volatile collections are made from virgin females during calling period

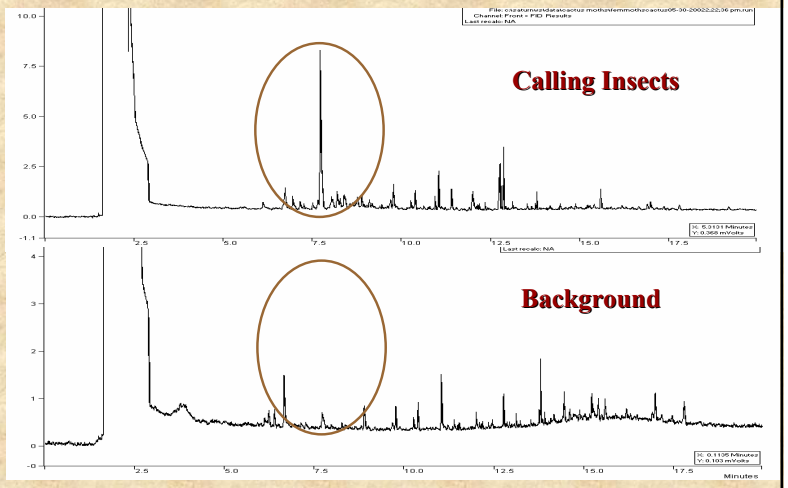
Gas chromotography (GC) with mass spec (MS) is used for chemical analysis and identification



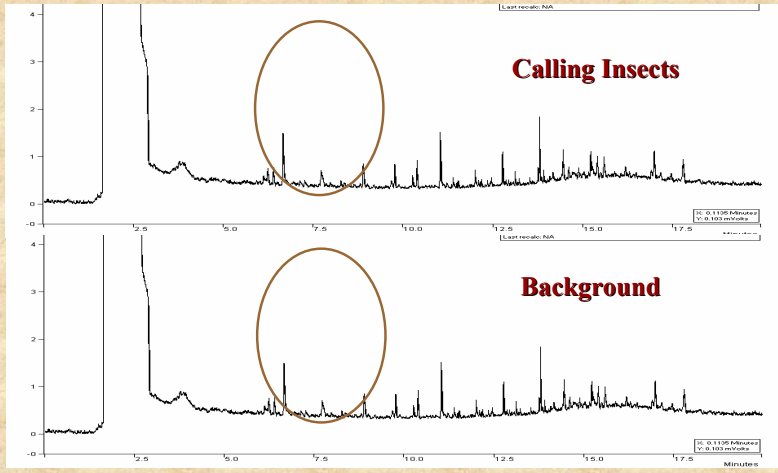
Ideal results from chemical collections:



Ideal results from chemical collections:



Actual results from volatile chemical collections



Indirect Approaches to Pheromone Identification

- Extracts from dissected abdominal glands
- Electro-antennograph (EAG) analysis
- Whole body wash/extract
- Extracts from filter paper
- Extracts from frass

Indirect Approaches to Pheromone Identification

- Extracts from dissected abdominal glands
- Electro-antennograph (EAG) analysis
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- Extracts from frass

Chemicals are extracted from excised glands of virgin females

- Pheromone is biosynthesized and released from abdominal gland, which is everted by female during calling
- Glands are dissected during calling period and placed in solvent for chemical extraction
- GC-MS is used for identification of chemicals

Enhanced collection from glands - PBAN application (P. Teal & B. Dueben)

- Pheromone Biosynthesis Activating Neuropeptide (PBAN) regulates pheromone biosynthesis
- Application of synthetic PBAN analogs stimulates pheromone biosynthesis
- Glands are excised after PBAN application and extracted for chemical analysis

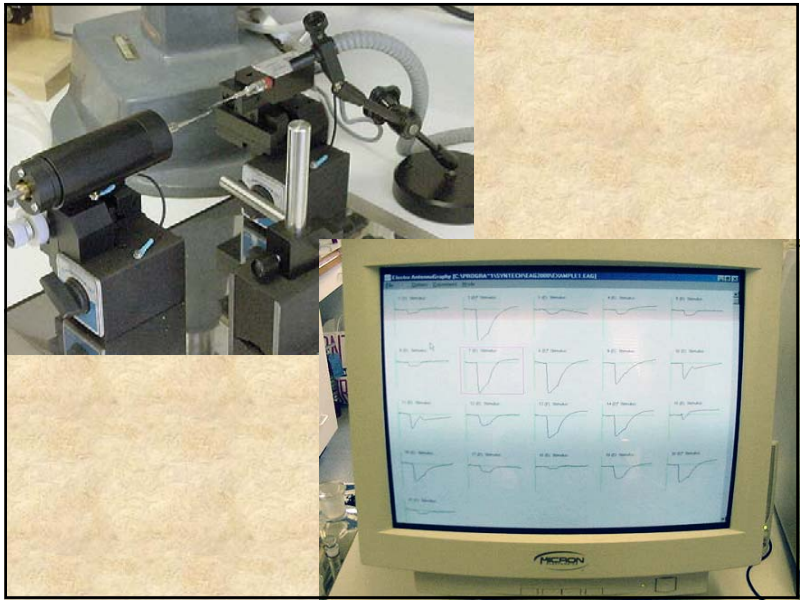
Result of chemical identification following PBAN application

- Four chemicals were identified from excised glands of PBAN-treated females
- However, it is not know if all are released from the glands during calling, or if some are biosynthetic precursors to the actual chemicals released
- Also, the total amount (rate) of pheromone released and the ratio of the individual components in the blend can not be determined from analysis of gland extracts

Indirect Approaches to Pheromone Identification

- Extracts from dissected abdominal glands
- Electro-antennograph (EAG) analysis
- Whole body wash/extract
- Extracts from filter paper
- Extracts from frass

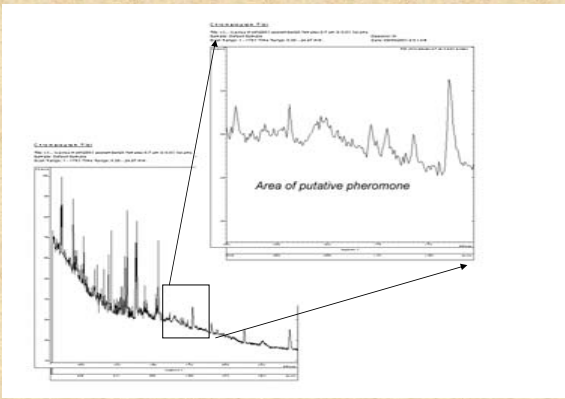
Electroantennagram-GC analysis is used to evaluate neural response of insect to chemicals



Indirect Approach to Pheromone Identification

- Document calling and mating behavior
- Develop laboratory bioassays
- **Identify chemicals from excised glands from PBAN-treated female (putative pheromone)**
- Formulate and test to verify pheromone

Some of the chemicals identified from excised glands were found by GC-MS of volatile collections, but in very small amounts



Indirect Approach to Pheromone Identification

- Document calling and mating behavior
- Develop laboratory bioassays
- Identify chemicals from excised glands from PBAN-treated females (putative pheromone)
- **Formulate and test to verify pheromone**

All four chemicals were available from ARS, Gainesville and were formulated on rubber septa for subsequent tests

Chemical components used were based on results of preliminary analysis; rates used were based on lures used for other pyralid moths

Number of chemicals	Amount loaded per septum					
	10 ng	100 ng	1 µg	10 µg	100 µg	1 mg
1	*	*	*	*		
2	*	*	*	*		
3		*	*	*	*	
4			*	*	*	*

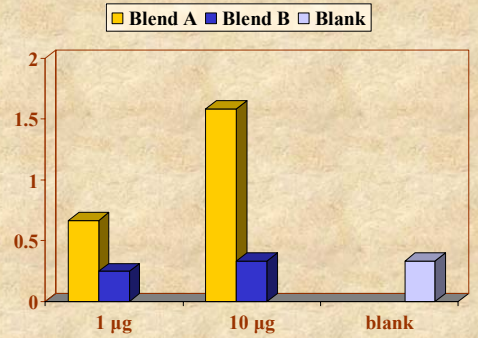
A three component chemical blend gave the best results in Y-tube olfactometer bioassays

Number of chemicals	Amount loaded per septum					
	10 ng	100 ng	1 µg	10 µg	100 µg	1 mg
1	*	*	*	*		
2	*	*	*	*		
3		*	*	*	*	
4			*	*	*	*

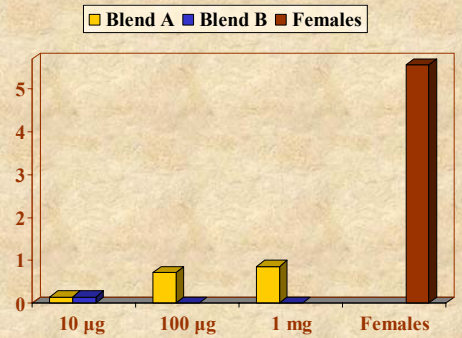
Two ratios of the three component chemical blend were formulated for further testing

3 cmpt blend	Laboratory tests			Field tests		
	1 µg	10 µg		10 µg	100 µg	1 mg
A	*	*		*	*	*
B	*	*		*	*	*

Number of males per trap per day in flight tunnel tests of synthetic lure-baited traps (n=3)



Number of males per trap per week in field tests of synthetic lures (S. Hight)



?

Summary of Results

- Three of the four chemicals identified from excised glands of PBAN-treated females are biologically active
- Confirmation of putative chemicals awaits structural validation
- Additional chemicals may be missing from the blend
- An additional peak, which is not yet identified, has been obtained from some volatile collections from calling females

Approaches to Pheromone Identification

Direct Approach (preferred)

Volatile chemical collections from live insect

Indirect Approach (ancillary)

Extracts from dissected abdominal glands
Electro-antennograph (EAG) analysis

Future Plans

Optimize volatile collection system to improve collection of released pheromone and provide material for structural elucidation of chemicals

• Additional tests with application of PBAN analogs will be made to replicate earlier results and to look for additional unidentified chemicals

• EAG-GC analysis will be used to determine biologically activity of additional unidentified chemicals

Needs

• Obtain sufficient amounts of pheromone for accurate identification and quantification

• Expand operation to a major commitment (increase priority/personnel)

• Obtain additional information on pheromone/mating system used by the cactus moth (e.g., temporal, environmental factors)

• Increase/maintain a steady supply of insects needed for pheromone collection and bioassay (e.g., artificial diet development)

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Elena Schnell
Daniel Mateo
Helena Puche

Collaborators and staff

FAO/IAEA

Identification issues for *Cactoblastis cactorum* and other cactus feeding insects

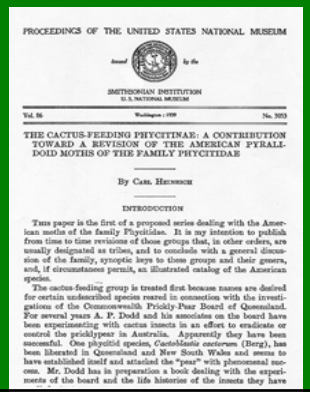
Dr. M. Alma Solis
Systematic Entomology Laboratory, USDA,
Smithsonian Institution, P.O. Box 37012
National Museum Natural History, E-517, MRC 168
Washington, DC 20013-7012
asolis@sel.barc.usda.gov
http://www.sel.barc.usda.gov

Objective: create up-dated key to immature phycitines feeding on U.S. cacti

1. Collect live specimens
2. Photograph live specimens
3. Preserve and study specimens
4. Create key and place on web site

Heinrich 1939 - genitalia, wing venation and line drawings to the species were illustrated for the first time, keys to adults of known species of each genus

Heinrich 1956 - reviewed again with few changes, genitalia and wing venation illustrated, host information, no keys



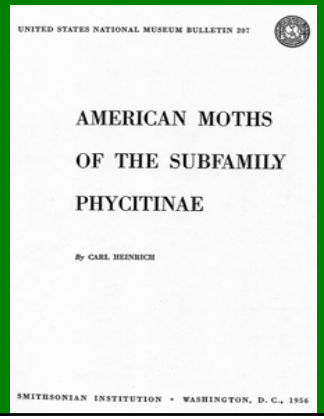
PROCEEDINGS OF THE UNITED STATES NATIONAL MUSEUM

SMITHSONIAN INSTITUTION

THE CACTUS-FEEDING PHYCITINAE: A CONTRIBUTION TOWARD A REVISION OF THE AMERICAN PYRALIDOID MOTHS OF THE FAMILY PHYCITIDAE

By Carl Heinrich

INTRODUCTION



UNITED STATES NATIONAL MUSEUM BULLETIN 207

AMERICAN MOTHS OF THE SUBFAMILY PHYCITINAE

By CARL HEINRICH

SMITHSONIAN INSTITUTION · WASHINGTON, D. C., 1956

Shaffer 1995 - Checklist of the Neotropical Phyctinae; closely related Phycitinae to cactus-feeding genera in the Western Hemisphere (33 genera; 160 species)

Laetilia 12
Rostrolaetila 10
Welderella 1
Baphala 7
Rhagea 2
Anderida 2
Cassiana 1
Mescinia 11
Barberia 1
Bema 1
Zophodia 1
Melitara 5
Olyca 1
Alberada 3
Nanaia 1
Cactoblastis 5
Cahela 1
Rumatha 3
Yosemitia 4
Tucumania 2
Eremberga 3
Salambona 1
Parolyca 1
Sigelgaita 3
Amalafrida 1
Ozamia 7
Cactobrosis 4
Echinocereta 1
Homoesoma 35
Patagonia 2
Unadilla 4
Phycitodes 5
Rinaphena 1

3 predaceous genera excluded

Rostrolaetila 10
Welderella 1

Rhagea 2
Anderida 2
Cassiana 1
Mescinia 11
Barberia 1
Bema 1
Zophodia 1
Melitara 5
Olyca 1
Alberada 3
Nanaia 1
Cactoblastis 5

Cahela 1
Rumatha 3
Yosemitia 4
Tucumania 2
Eremberga 3

Parolyca 1
Sigelgaita 3
Amalafrida 1
Ozamia 7
Cactobrosis 4
Echinocereta 1
Homoeosoma 35
Patagonia 2
Unadilla 4
Phycitodes 5
Rinaphena 1

7 Plant (non-cactus) feeding genera removed

Rostrolaetila 10
Welderella 1

Rhagea 2
Anderida 2
Cassiana 1

Barberia 1

Melitara 5
Olyca 1
Alberada 3
Nanaia 1
Cactoblastis 5

Cahela 1
Rumatha 3
Yosemitia 4
Tucumania 2
Eremberga 3

Parolyca 1
Sigelgaita 3
Amalafrida 1
Ozamia 7
Cactobrosis 4
Echinocereta 1
Rinaphena 1

16 cactus- feeding phycitine genera

Melitara 5
Olyca 1
Alberada 3
Nanaia 1
Cactoblastis 5
Cahela 1
Rumatha 3
Yosemitia 4
Tucumania 2
Eremberga 3
Sigelgaita 3
Amalafrida 1
Ozamia 7
Cactobrosis 4
Echinocereta 1
Rinaphena 1

MEETING NOTES

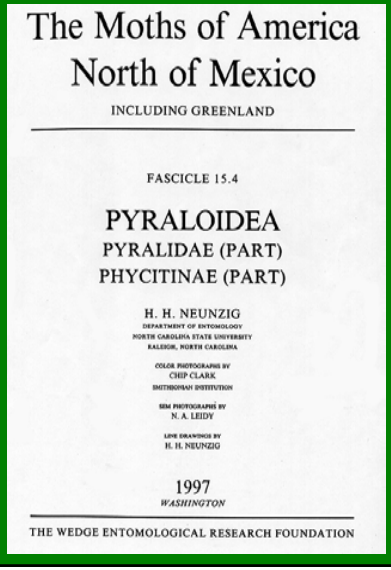
- Need 4 samples of each species
  - Sexual dimorphism and geographic variations
- Problems with key
  - Need to know the host palnt
  - Suggestion from audience that a host plant key be developed
- Lost of species in the US West

Genera and species not known to occur in the U.S.

Genus	species	Type locality
Olyca	nephelepasa	Mexico
	phryganoides	Dominican Republic
Nanaia	substituta	Peru
Cactoblastis	ronnai	Brazil
	doddi	Argentina
	mundelli	Peru
	bucyrus	Argentina
Yosemitia	didactica	Mexico
Rinaphena	discocellularis	Argentina
Tucumania	tapiacola	Argentina
	porrecta	Uruguay
Eremberga	insignis	Mexico
Salambona	analamprella	Argentina
Sigelgaita	chilensis	Chile
	huanucensis	Peru
	transilis	Peru
Amalafrida	leithella	Curacao
Ozamia	immorella	Mexico
	stigmaferella	Argentina
	hemilutella	Argentina
	punicans	Argentina
Cactobrosis	longipenella	Mexico
	insignatella	Mexico

Neunzig 1997 -

revision of U.S. species with photos of adults, line drawings of genitalia, wing venation, some larvae, and a key to cactus-feeding genera, host information


The Moths of America North of Mexico

INCLUDING GREENLAND

FASCICLE 15.4

PYRALOIDEA

PYRALIDAE (PART)

PHYCITINAE (PART)

H. H. NEUNZIG

DEPARTMENT OF ENTOMOLOGY
NORTH CAROLINA STATE UNIVERSITY
RALEIGH, NORTH CAROLINA

COLOR PHOTOGRAPHS BY
CHIP CLARK
SMITHSONIAN INSTITUTION

SEM PHOTOGRAPHS BY
N. A. LEIDY

LINE DRAWINGS BY
H. H. NEUNZIG

1997
WASHINGTON

THE WEDGE ENTOMOLOGICAL RESEARCH FOUNDATION

Cactobrosis

Eremberga, Echinocereta, Melitara

Melitara

Melitara

Melitara

Alberada

Alberada

Alberada, Rumatha

Cactoblastis, Melitara, Cahela

[From Neunzig, 1997]

KEY TO GENERA OF CACTUS-FEEDING PHYCITINAE (LAST STAGE LARVAE) Neunzig, 1997

1. Larva white to dark gray……..……2
- Larva blue, green, orange, pink, red, reddish,purple, or purplish black with our without transverse bands or distinct pinacula or white broad purple or black transverse bands……..5
2. Host cholla cactus (*Opuntia*(*Cylindropuntia*)) ……..……....3
- Host hedgehog cactus (*Echinocereus*) or cereus cactus (*Cereus*) ……4
3. Host desert Christmas cactus (*Opuntia leptocaulis*) ……...***Rumatha***
- Host cholla cactus (*Opuntia*(*Cylindropuntia*)), other than desert Christmas cactus…...……...***Cahela***
4. Host hedgehog cactus (*Echinocereus*) …..……..……***Eremberga***
- Host cereus cactus (*Cereus*) ……***Ozamia***, in part (*lucidalis*)
5. Larva feeding in fruit……..……***Ozamia***, in part
- Larva feeding in stems……..……6

KEY TO GENERA OF CACTUS-FEEDING PHYCITINAE (LAST STAGE LARVAE) Neunzig, 1997 [continued]

6. Hosts prickly-pear cactus (*Opuntia*(*Opuntia*)) and cholla cactus (*Opuntia*(*Cylindropuntia*))…….. 7

\- Hosts barrel cactus (*Ferrocactus*), fishhook cactus (*Mammillaria*), horse crippler or devel's head (*Echinocactus*), hedgehog cactus (*Echinocereus*) (and possibly saguaro) (*Carnegiea*) ……..……..***Cactobrosis, Echinocereta, Yosemetia***

7. Larva blue, without transverse bands of enlarge dark pinacula, or white with purple or black transverse bands on caudal margins of segments; 3 SV setae on abdominal segments seven and eight..……..……..8

\- Larva orange or red, with transverse bands of enlarged dark pinacula; 2 SV setae on abdominal segments seven and eight…..……...***Cactoblastis***

8. Host prickly-pear cactus (*Opuntia* (*Opuntia*)) ……..……....***Melitara***

\- Host (*Opuntia*(*Cylindropuntia*)) ……..…….... ***Alberada***

10 U.S. Phycitinae cactus-feeding genera and species numbers

Genus name	No. of Western Hemisphere Species	No. of U.S. species	Species with known larvae
Alberada	5	5	1
Cactoblastis[1]	5	1	1
Cactobrosis	4	1	1
Cahela	1	1	1
Echinocereta	1	1	1
Eremberga	3	3	1
Melitara	7	7	4
Ozamia[2]	6	4	3
Rumatha	4	4	1
Yosemitia	4	2	1

[1]*C. cactorum* reported in southern Florida (Habeck & Bennet, 1990)
[2]*O. lucidalis* reported in southern Florida (Habeck & Bennet, 1990)
from Heinrich, 1956; Neunzig 1997

U.S. Phycitinae cactus-feeding genera and hostplants

Genus name	Reported host plants
Alberada	Opuntia
Cactoblastis[1]	Opuntia
	Cleistocactus
	Trichocereus
	Echinopsis
	Denmoza
Cactobrosis	Ferrocactus
Cahela	Opuntia
Echinocereta	Echinocereus
Eremberga	Echinocereus
Melitara	Opuntia
Ozamia[2]	Opuntia
	Cereus
Rumatha	Opuntia
Yosemitia	Echinocactus
	Echinocereus
	Ferrocactus
	Mammillaria

	AR	AZ	CA	CO	KS	FL	GA	MI	MO	NE	NV	NJ	NM	NY	NC	ND	OK	PA	TX	UT	WY
M	X				X	X	X	X	X			X		X	X		X	X	X		
		X	X	X	X				X				X			X			X	X	X
																			X		
		X											X						X		
		X	X	X						X	X		X						X	X	X
A		X	X	X									X						X		
			X																		
		X																			
																			X	X	
																			X	X	
Ec		X	X																X		
Ch		X	X								X								X	X	
Ru						X													X	X	
		X	X								X		X						X		
			X																		
		X																	X		
Yo		X	X	X							X		X						X		
		X	X																		
Er		X																			
			X																		
																			X		
Oz																			X		
			X																		
			X																		
						X															
																			X		
Ca						X															
Cs		X	X																X		

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from Heinrich, 1956; Neunzig 1997

Habeck & Bennet 1990 - description and immature (larva, cocoon, egg stick) and adult photos of *C. cactorum* and photos of 2 other species, including key to species in Florida

Cactoblastis cactorum

Melitara prodenialis

Rumatha glaucatella

Key to Florida phycitine larvae associated with *Opuntia* spp.:

1. Larvae orangish-red with conspicuous dark spots forming transverse bands ……...……***Cactoblastis cactorum***
1.' Larvae dirty-white to bluish-purple not forming transverse bands……..……..……..…….2
2. Larvae with smaller dark spots ……...***Melitara prodenialis***
2.' Larvae without spots……..…3
3. Larvae dirty white; larvae gregarious…....***Rumatha glaucatella***
3.' Larvae white to dark gray color; larvae solitary……..
……...……..***Ozamia lucidalis***

Cactoblastis cactorum

Melitara prodenialis

Rumatha glaucatella

Shaffer 1995

MELITARA
prodenialis
dentata
doddalis
apicigrammella

OLYCELLA
junctolineella
nephelepasa
subumbrella

OLYCA
phryganoides□□□

Neunzig 1997

MELITARA
OLYCELLA
prodenialis
dentata
doddalis
texana
apicigrammella
junctolineella
subumbrella

nephelepasa???

O. nephelepasa
(research & plate by M. Sanchez Borja)

MEETING NOTES

- Concerned about non-specific attacks in moths in general
  - Arizona web site advocating destroying all egg sticks without regard to species
- Thinking about and electronic key
- Guidance on imagining caterpillars:
  - Need high magnification / use copy stand / slow caterpillars down by putting in refrigerator

The Feasibility of Conventional Control Methods against Cactoblastis

Helmuth Zimmermann
Plant Protection Research Institute
Agricultural Research Council
Pretoria, South Africa

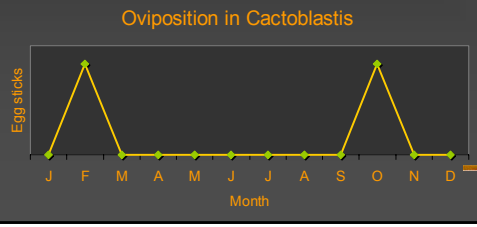
Summary

- Effect of Cactoblastis behaviour on chemical control
- Conventional control methods
  - Chemical control
  - Scouting and sanitation
  - Integrated control
- Conclusions

Behaviour of Cactoblastis and its effect on chemical control

Assisting control

- Aggregation of eggs in egg-sticks
- Gregarious larvae
- Two well synchronized generations



Behaviour of Cactoblastis and its effect on chemical control

Inhibiting control

- Internal feeding of entire larval stage
- Small window period available for control

Conventional Control Methods

1. Chemical Control
2. Scouting and sanitation control
3. Integrated control

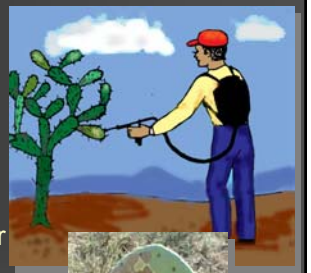
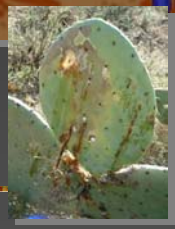
Their feasibility of application

1. Chemical Control:
Two Control Operations

1. Conventional insecticide cover spray with long residual action during peak egg-laying period and shortly before eggs hatch


1. Chemical Control:
Two Control Operations

- 2. Injecting insecticide into cavities harbouring cactoblastis colonies
  - Zero residual tolerance: full cover sprays discouraged. Contact insecticide injected into cavities using sheep-dose applicators

Insecticides Registered for the Chemical Control of Cactoblastis

- SOUTH AFRICA
  1) Carbaryl WP.
  2) Deltametrin EC.
  3) Methidathion WP.
  4) Tralemetrin EC.
- All full cover sprays
- Also effective against *Dactylopius opuntiae,* the primary pest of cactus pear in South Africa.


Systemic insecticides?

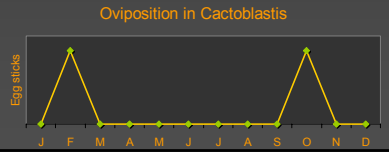
- No success so far: high dilution factor caused by the succulent tissue of cactus pear.
- However, new generation systemic and other insecticides could be more effective and more environmentally acceptable.

New generation insecticides
showing potential for cactoblastis control

- Abamectin
- Emamectin benzoate
- Imidacloprid
- Spinosad
- Indoxacarb
- Chlorfenapyr

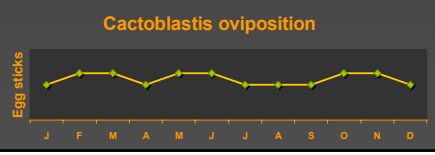
Chemical Control Feasible:

- Well-demarcated, small Opuntia populations of high value
- High-income, cultivated cactus pear plantations
- Temperate climates (synchronized populations)



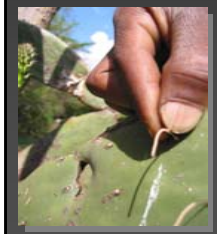
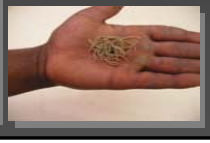
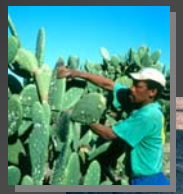
Chemical Control Not Feasible:

- Wild Opuntia populations in Central and North America
- Low-value cactus pear plantations
- Tropical climates (overlapping generations)



2. Control by Scouting and Sanitation

- Scouting, remove egg-sticks during 2 peak egg-laying periods
- Continuous scouting, remove infested cladodes.


3. Integrated Control

A combination of any of the following:

- Contact insecticide for control of hatching larvae
- Injecting cavities for larval control
- Scouting for egg-sticks and infested cladodes
- Collecting pupae under plants in debris
- Inundative release of selected biocontrol agents e.g. *Bracon hebetor* or *Trichogramma minutum*

Conclusions

- Control in plantations feasible but unaffordable for peasant farmers - have to control several other pests.
- Concern: wild populations in the remote, inaccessible areas of North America: chemical control not practical.
- Unconventional methods, e.g. SIT: chance of eradication or containment – to be pursued while still feasible.
- Biological control: suppression, NOT eradication or containment
- Eradication and/or containment should be the first line of attack.

I thank USDA-APHIS for the opportunity to participate in the search for a solution to the cactoblastis threat.

Potential and risk of biological control for *Cactoblastis cactorum* in North America

Robert W. Pemberton
Invasive Plant Research Lab
USDA-ARS Ft. Lauderdale, FL

Recorded parasitoids of *Cactoblastis* spp. in their native ranges

	Other hosts
• Braconidae	
– *Apanteles alexanderi*	*Tucumania*, *Salmbona*- Pyralid; *Plutella*- Plutellid.; *Eulia*- Tortricidae
• Chalcididae	
– *Brachymeria cactobalstidis*	hyperparasitoid?
• Tachinidae	
– *Epicoronimyia mundelli*	*Tucumania*; others ?

Recorded parasitoids of *Cactoblastis* spp. in the native range

	(attack rate)	other hosts
• Ichneumonidae		
– *Phyticiplex doddi*	(rare)	?
– *Phyticiplex eremnus*		?
– *Podogaster cactorum*	(rare)	?
– *Temelucha* sp.	(5-30%)	*Salambona*, *Tucuamia*

Recorded diseases of *Cactoblastis*

• Fungi	
– *Beauveria* sp.	Australia
– *Beauveria* prob. *bassiana*	S. Africa
• Microsporidia	
– *Nosema cactoblastis*	S. Africa
– *Nosema cactorum*	S. Africa
– *Nosema* sp.	Argentina

Parasitoids known to attack *Cactoblastis cactorum* in Florida

	(attack rate)	other hosts
• Chalcididae		
– *Brachymeria ovata*	(to 55%)	diverse Lepidop.
– *B. pedalis*	(rare)	cactus moths
• Trichogrammatidae		
– *Trichogramma* sp.	(rare)	many insects

Cosmopolitan generalist parasitoids known to attack *Cactoblastis cactorum* and which occur in North America

• Braconidae	
– *Bracon hebetor*	larval - to 25% (in S. Africa)
• Trichogrammatidae	
– *Trichogramma minutum*	egg - to 32% (in Australia)

Parasitoids of related N. A. cactus moths (Pyralidae: Phyticinae)

• Ichneumonidae	Hosts
– *Temelucha sinuatus*	*Melitara, Cactobrosis, Rumatha*
– *T. facilis*	*Melitara, Hellula, Pyrausta* (Pyral.), *Isophrictis*-Gelechid. - *Cahela*
Temelucha sp.	
– *Trichoma* sp.	*Melitara*, *Etiella* -Pyralid.
– *Chelonus electus*	*Melitara*, *Ozamia*, *Alberada*, *Laphygma*, *Prodenia*, *Ephestia* -Pyralid.; *Heliothis* -Noctuid.
– *Mesostemus gracilis*	*Ozamia*, other Pyralid-Pytic.

Parasitoids of related N. A. cactus moths (Pyralidae: Phyticinae)

• Braconidae	Hosts
– *Apanteles etiellae*	*Melitara*, *Cahela* & other Pyralid.
– *A. megathymi*	*Olycella*, *Megastes*-Pralid; *Megathymus*-Hesperiid.
– *A. mimoristae*	*Olycella*, *Miorista*, *Hymenia*-Pyralid
– *Bracon hebetor*	*Melitara*, *Ozamia*, *Galleria*, *Plodia*, *Vitula* -Pyralid.; *Sitotroga* (Gelechid)
– *Heterospilus melanocephalus*	*Olycella*, *Noctuellia*- Pyralid.

Parasitoids of related N. A. cactus moths (Pyralidae: Phyticinae)

	Hosts
• Chalcididae	
– *B. pedalis*	*Melitara, Olycella, Alberada*
• Tachinidae	
– *Phorocera texana*	*Melitara, Olycella*; diverse Lepidop.;sawflies
– *P. comstocki*	*Melitara, Ostrina*; Cossids; Megathymids; sawflies
Lespesia aletiae	*Olycela*; diverse Lepidop.; Epilachna- Coccinel.
– *Lespesia* sp.	*Melitara*; diverse Lepidop.

Potential non-target cactus moths of *Platyopuntia* pads in North America (US, Mexico, West Indies)

• *Melitara dentata*	western US
• *M. prodenialis*	Texas to Florida
• *Olyca phyganoides*	Hispaniola
• *Olycella junctolineella*	western US
• *O. subumbrella*	western US
• *O. nephelepasa*	western US-Mexico

Potential non-target cactus moths of *Platyopuntia* fruits in North America

• *Ozamia odiosella*	Western US-Mexico
• *O. lucidalis*	Florida-W. Indies, S.A.
• *O. thalasophila*	California

Potential non-target cactus moths of *Cylindropuntia* in North America

• *Alberada bidentella*	western US
• *A. holochlora*	Texas
• *A. parabates*	western US, Mexico
• *Cahela ponderosella*	western US, Mexico
• *Rumatha bihinda*	western US, Mexico
• *R. glaucatella*	Texas

Potential non-target cactus moths of other cactus genera in North America

- *Cactobrosis* 5 spp. *Echinocereus*, *Ferocactus*, *Peniocereus*
- *Eremberga* 3 spp. *Echinocerus*
- *Yosemitia* 4 spp. *Coryphantha, Echinocereus, Homalocephala, prob. Neomamillaria, Echinocactus*

Total number of cactus moths in North America

27 species in 10 cactus genera

15 species in 7 genera on *Opuntia*

12 species in 3 genera on 7 other genera of cacti

Criteria to consider and rank the risk of various *C. cactorum* biological control approaches

- Degree of host specificity of agent
- Whether new hosts will be exposed
- Relative number of new hosts
- Whether the agent's geographical range will increase
- Likely persistence of non-target use
- Whether rare species will be exposed
- Size of the treatment area

Biological control approaches for *C. cactorum* ranked by relative risk to non-target species (ranked from least to most risk)

Classical introduction from South America of parasitoids specific to the genus *Cactoblastis*

Innundative release of cactus moth parasitoids from Florida in Florida

Innundative release of parasitoids that attack *C. cactorum* in Florida

Innundative release of generalist parasitoids known to attack *C. cactorum,* and which occur in Florida

Classical introduction of Western N.A. cactus moth parasitoids that attack gregarious larvae

Classical introduction of other Western cactus moth parasitoids

Classical introduction of stenophagous *Cactoblastis* parasitoids from South America

Similarity attributes of N.A. cactus moths and *C. cactorum* that may influence their use as non-targets

- ***Platyopuntia* hosts**
- **Pad feeding**
- **Gregarious larvae**
- **Sympatric distribution**
- **Occurrence in warm areas**

Other attributes of N.A. cactus moths that may influence their use as non-target hosts

- Taxonomic diversity of host plants
- Number of host plant species
- Size of geographic range
- Occurrence in warm and/or cold areas

Conclusions

Relative capabilities of biological control approaches for *C. cactorum*

- Classical - regulation of existing populations
- Innundative - temporary depression of local populations

Conclusions

Biological control probably can't stop the spread of *C. cactorum*

Sterility and Sex Phermone-Bait techniques may be better tools to try to limit spead of the moth

In addition, these techniques should produce fewer non target effects than biological control

Cactoblastis in Nevis
Opuntia stricta

MEETING NOTES

- *Opuntia stricta*
  - Easy to find, on wet and dry sides of Nevis
  - Goats removed almost all other vegetation except poisonous plants
  - Other Species
    - *O. triacantha* – occurs along coast
    - *O. rubescens*

MEETING NOTES

- 8 *O. triacnatha* populations
  - 6 attacked
    - 20% of plants attacked
- *O. stricta* populations
  - 20% of plants attacked
    - 60% of stems attacked
- *O. rubescens:* not attacked
- *O. cochinynifers:* not attacked (from Jamaica)

MEETING NOTES

- *O. triacnatha*
  - Impact on sexual reproduction
  - Little flowering
- *O. stricta* populations
  - Plants looked pretty good
- Pre-Cactoblastis population unknown
- Not sure if experience on Nevis could be generalized elsewhere.

Cactoblastis in Nevis
Opuntia stricta

Cactoblastis in Nevis
Opuntia stricta


Goats and *Opuntia stricta*

Cactoblastis in Nevis
Opuntia triacantha


Opuntia rubescens

Sterile Insect Technique/Inherited Sterility Options for *Cactoblastis cactorum*

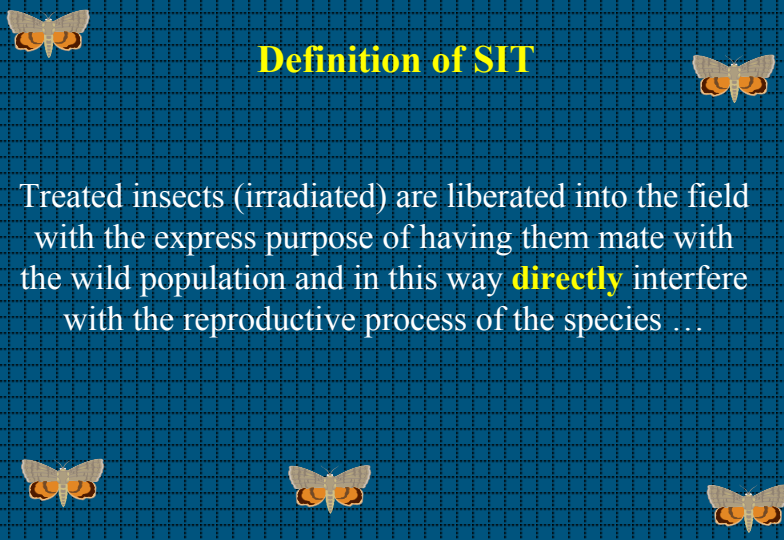
Jim Carpenter
USDA-ARS-CPMRU
Tifton, GA

Why Sterile Insect Technique for cactus moth?

Environmentally friendly
Species specific (no non-target effects)
Can lead to eradication
Can be used to set-up a barrier

Definition of SIT

Treated insects (irradiated) are liberated into the field with the express purpose of having them mate with the wild population and in this way **directly** interfere with the reproductive process of the species …



Sterile
male

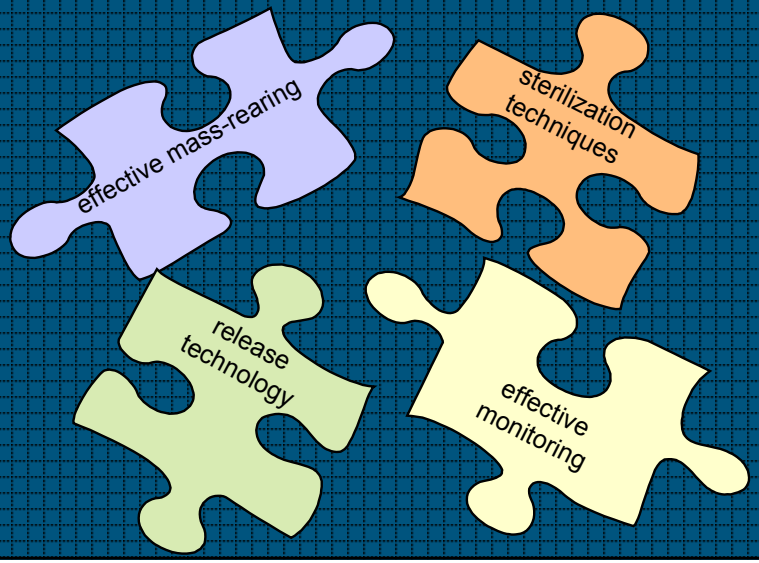
Fertile
female

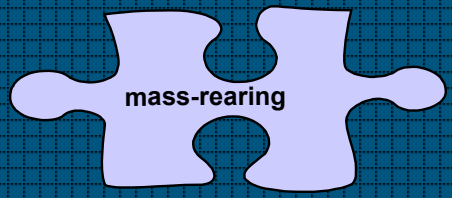
Parent (P)

X

NO Offspring (F_1)

SIT for any species of insect requires some basic components ….



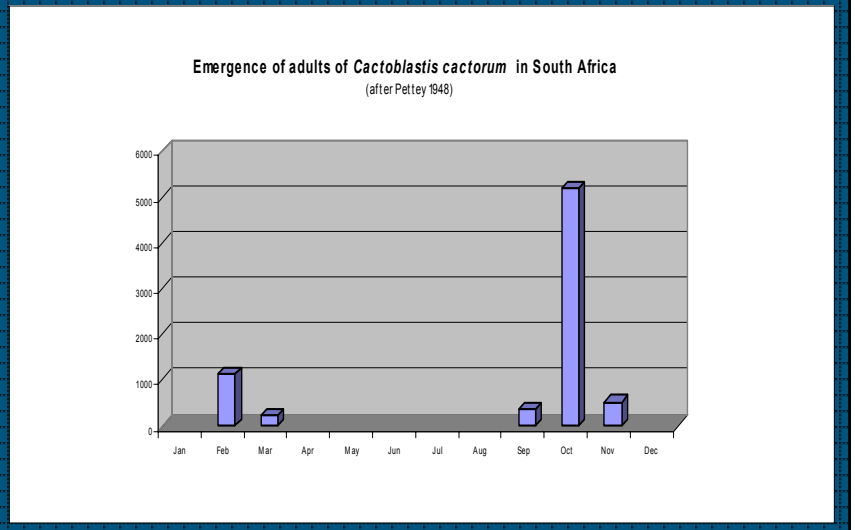


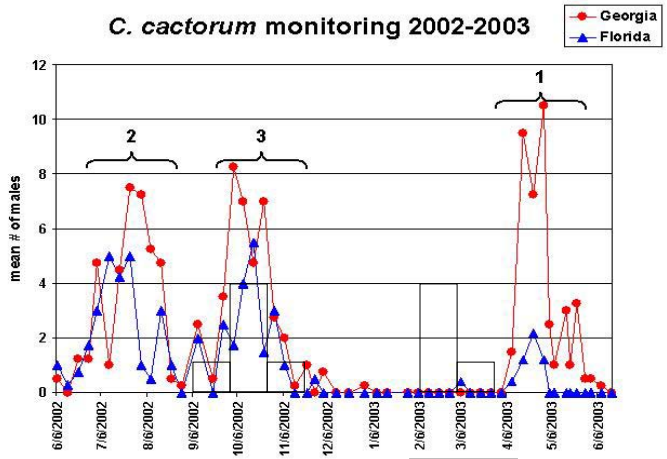
Where are we with *Cactoblastis cactorum* ?
rearing on host plant

Uitenhage, South Africa

Rearing in outdoor cages using cactus cladodes as food

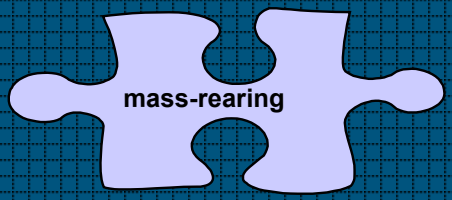
- Cage dimensions 1 x 1 x 2 meters
- Each cage is started with 40 cladodes & 4,000 eggs
- Each cage yields on average 1,700 pupae
- 13,600 pupae in 8 cages
- 2 generations per year at **Uitenhage -** Sept.-Nov. & Feb.-March
- Will importation of *C. cactorum* from South Africa meet our needs for a "barrier" using SIT/IS in the USA ?
- **USA** – 3 generations/year - April-May, July-Aug., Oct.-Nov.





Laboratory colony using cladodes as food

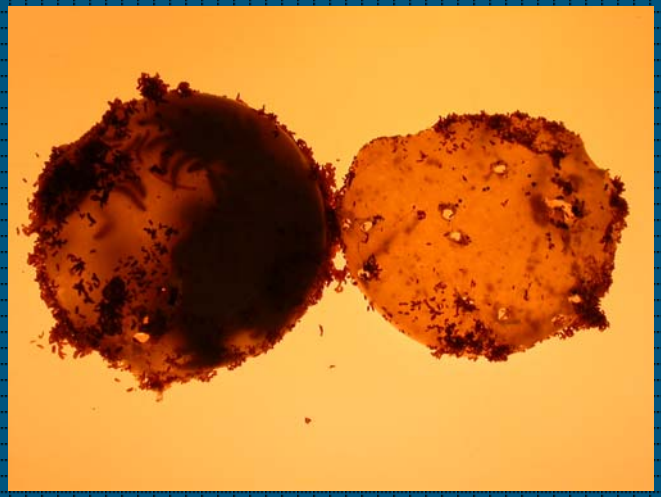
- Current production at the lab. in Tifton, GA – 20,000 larvae/pupae of *C. cactorum*
- If available space was used at peak capacity (20 m^2) – 75,000 larvae/pupae
- If additional space is added (40 m^2) – 150,000 larvae/pupae
- Keeping in mind developmental time (50 days as larvae/pupae) – 21,000-28,000 adults per week
- YEAR ROUND IF NEEDED



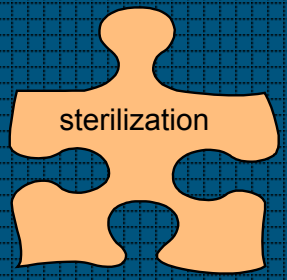
Where are we with *Cactoblastis cactorum* ?
rearing on artificial diet

- Diet contains ascorbic acid, cholesterol, distilled water, bean meal, methyl-4-hydroxy-benzoate, sorbic acid, sugar, yeast, freeze-dried cladode powder
- Insect development is longer
- Insects smaller
- Females less fecund (lower # of eggs)

- Using same artificial diet
- Diet presentation modified
- Encasement of diet sections on paraffin to simulate a cladode
- Additional diet ingredients added to increase fecundity and decrease developmental time

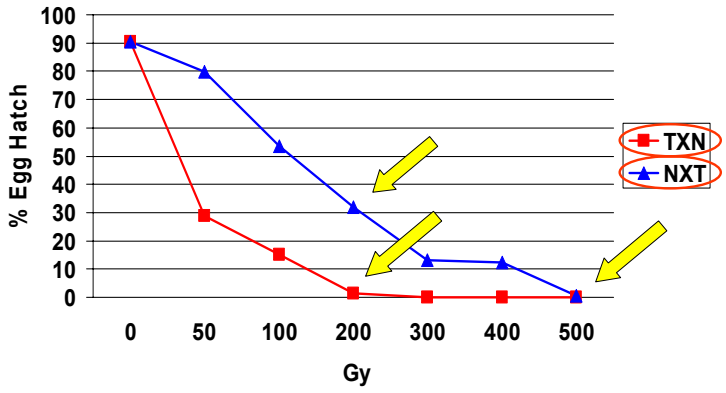


Where are we with *Cactoblastis cactorum* ?

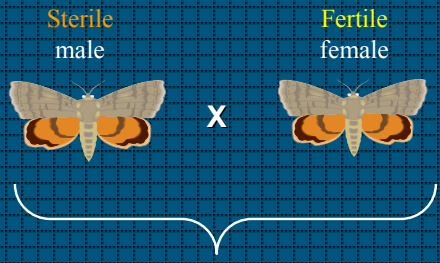


Nordion Gammacell 220

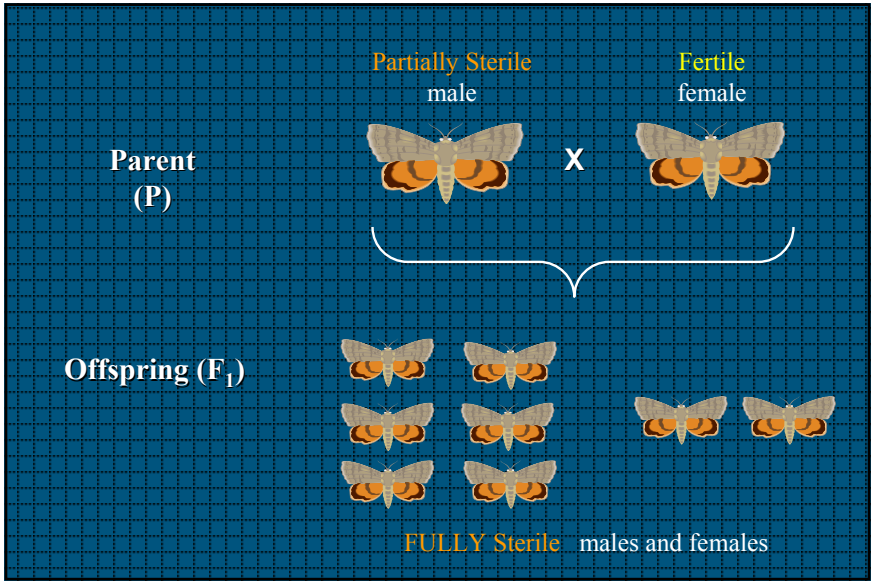
Effect of Radiation on *Cactoblastis cactorum* Percent Egg Hatch



Parent (P)



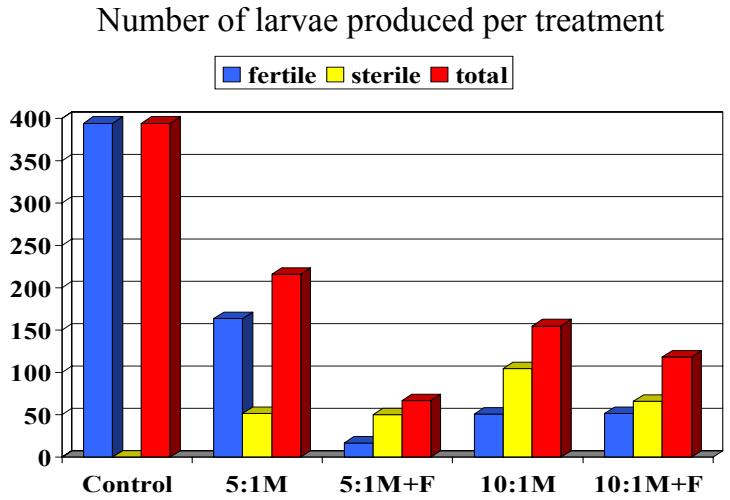
NO Offspring (F_1)

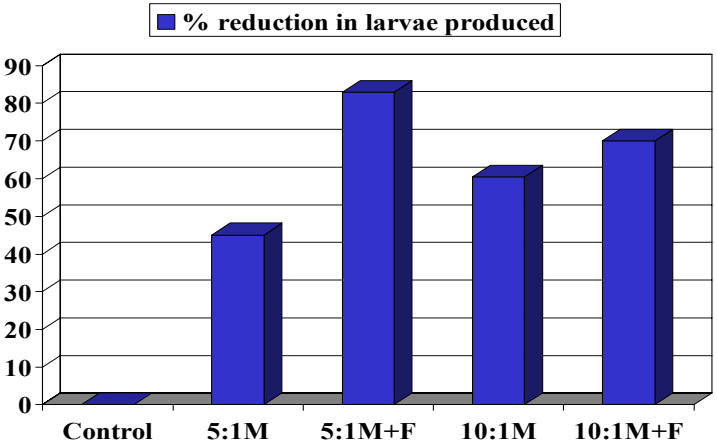


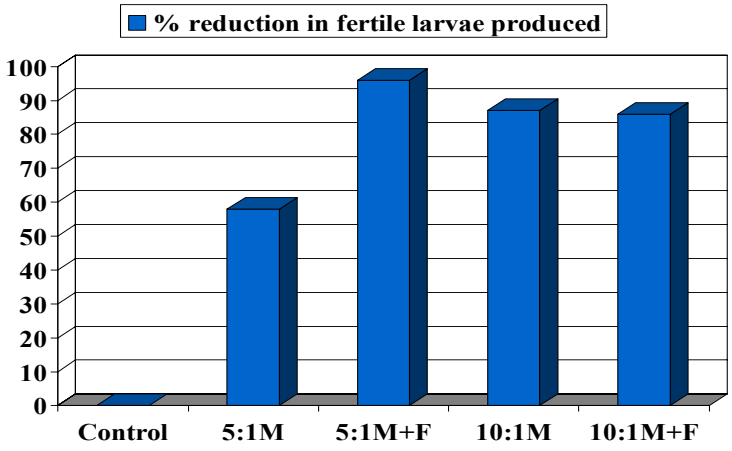
SIT/IS field-cage experiment

20 cages
5 treatments
4 replicates of each

Control = 10 fertile males + 10 fertile females
Control + 5:1 irradiated (I) males only
Control + 5:1 (I) males + (I) females
Control + 10:1 (I) males only
Control + 10:1 (I) males + (I) females

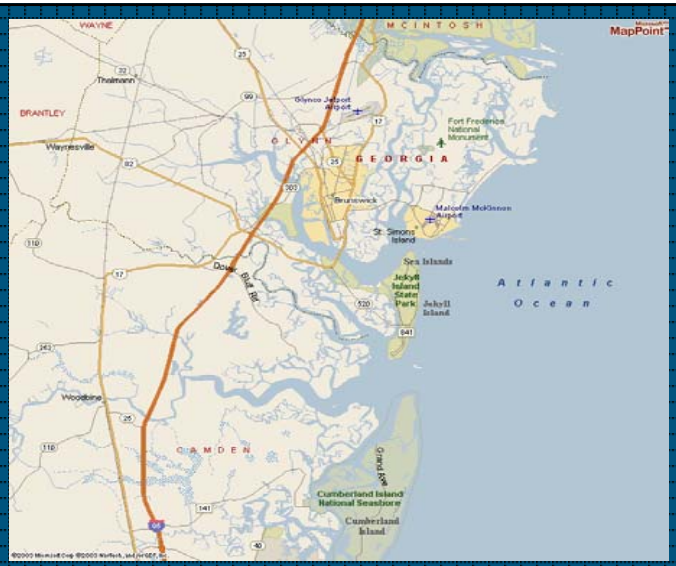


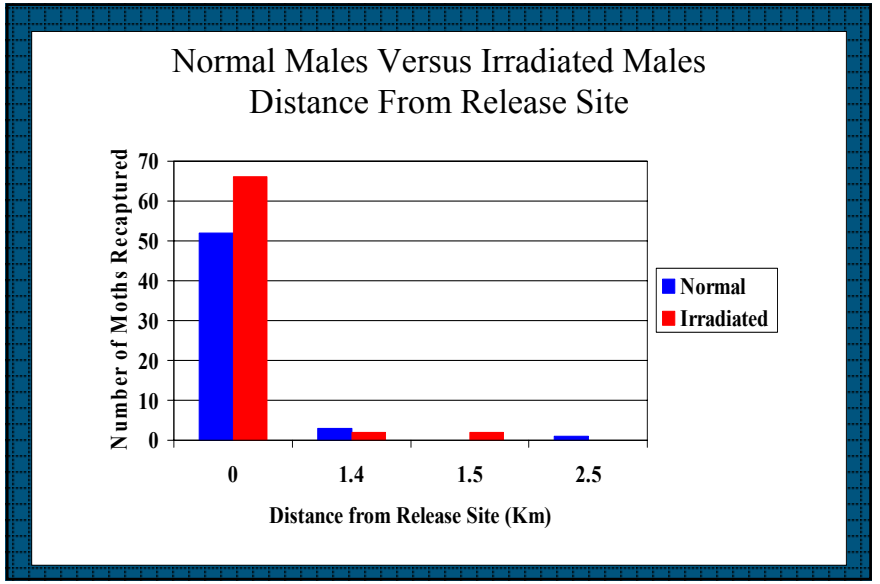




SIT/IS release/recapture study

600 normal males + 600 irradiated males released
10 traps at release site
5 release dates
9.8% total recapture



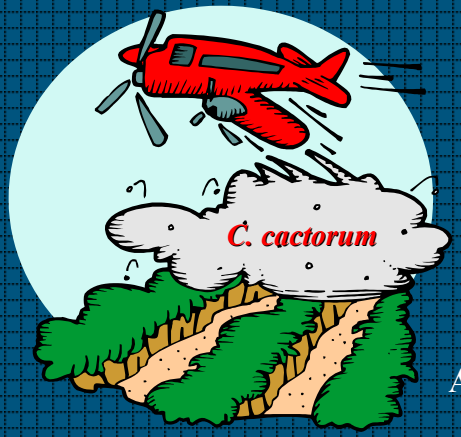


Where are we with *Cactoblastis cactorum* ?

Ground release vehicle

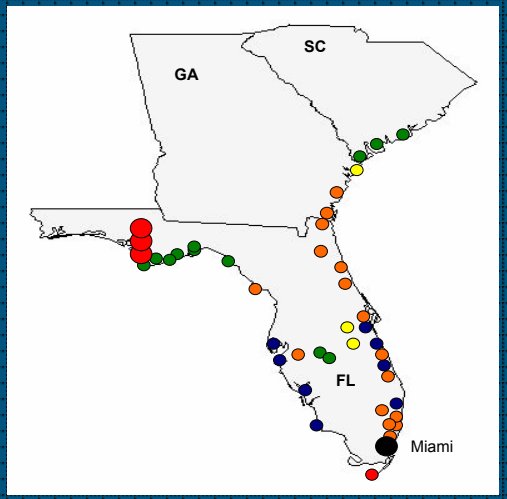
Ground release vehicle

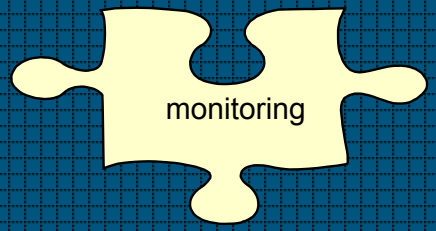
Adults being released



Aerial release

Placement of a barrier to stop westward spread



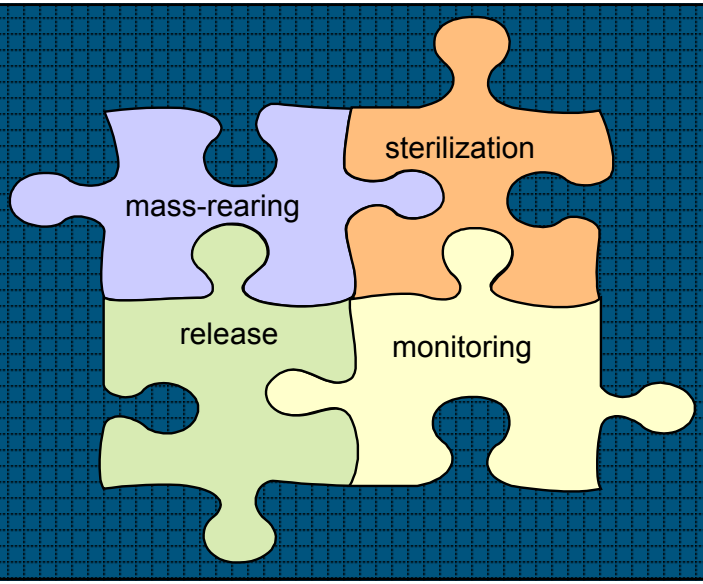


- NOW – virgin female-baited sticky traps, either fertile or sterilized
- In FUTURE – pheromone-baited traps

Summary/conclusions SIT/IS

1. 200 Gy is an effective dose
2. Field-cage study shows irradiated moths can reduce the wild population
3. Low release ratios were efficacious
4. Irradiated males were recaptured at the same rate as fertile males in release-recapture field trials

"SIT/IS has great potential for *C. cactorum*"



Where do we go from here?

1. Demonstrate SIT/IS efficacy under field-conditions
2. Improve insect rearing
3. Improve and expand population monitoring
4. Develop release technology
5. Select barrier site
6. Initiate clean-up for population suppression

Discussion Section
Cactus Moth (*Cactoblastis cactorum)* Planning Meeting
Miami, Florida, December 9 - 10, 2003

A Note About the Discussion and These Notes:

The following notes were collected during an open discussion section at the December 2003 cactus moth meeting in Florida. To a large extent they represent the unfiltered thoughts, ideas and comments of the meeting attendees. They in no way represent the official positions of any organization nor commit any organization or individual to any action. They should be read as intended – an opportunity to see some of the issues "put on the table" and the ideas presented to best address those issues.

1. Economic/Risk/Impact Analysis

-Define extent and nature of threat.

-Getting from "good to do" to "doing it" - need a good definition of problem to pick right objective – stakeholders/resources.

-APHIS needs to define its role and relationships.

APHIS has not determined its role in *Cactoblastis* beyond developing options and coordination of a strategic plan.

-Lynn Garrett's needs - data: identify resources; spread modeling - some resources avail at USDA APHIS PPQ's Center for Plant Health Science and Technology (CPHST).

-Environmental risk as an approach to defining problem in US, tough to make case as economic risk, define potential environmental risk and impact on Mexico.

-How do we quantify environmental risks?

-APHIS programs informed by stakeholder input.

-*Cactoblastis* is both an agricultural and invasive pest that affects ecosystems.

-Department of Interior USGS unit in Ft. Collins could help with environmental analysis.

-The environmental / economic analysis being discussed here is different from the Environmental Assessments and Environmental Impact Statements defined in the National Environment Protection Act. This is what affect Cactoblastis will have on ecosystems and economics if not controlled.

-Environmental Assessments and Environmental Impact Statements defined in the National Environment Protection Act may be needed before any controls actions are implemented.

-Some see an imminent threat but need people to collect data to define threat. Where are the resources?

-Conservation community involved for 10 yrs. How can conservation community be involved as a stakeholder?

-Narrow window of opportunity before it spreads beyond FL. Need to pull everyone together to secure funding – need to move quickly. Need to get environmental analysis out.

-Analysis being done by National Institute of Invasive Species Science (NIISS) at Colorado State University with IAEA funds, all players need to contribute to make as robust as possible.

-Can talk to NIISS members and associates to get word out. Also use Federal interagency committee on terrestrial animals.

-Environmental/Ecological impact is priority in US.

-In Mexico, both economic agricultural and ecological impacts are important.

-Establish low, medium and short term goals, identify those things that can be done right away. We have some good information to work with. – These should be the goal of this session and our report.

-PPQ Center for Plant Health Science and Technology (CPHST) risk assessments – need to work with CPHST – decide on where this fits on CPHST's priority list. Cooperators need to work with CPHST. NIISS should take lead, their draft is due in Mar 04.

-Can we use NEPA environmental Assessment or Environmental Impact Statements as model?

-Who helps NIISS and CPHST identify appropriate model documents?

-Development of a document that defines options and the potential effects of those actions was proposed.

-How would our economic / environment analysis process be used to define the threat of *Cactoblastis* to the US?

-APHIS may not have the expertise to author this type of document.

-Economic analysis: what data are available?

Digging deeper in literature

Data from other groups – existing data

Lynn G. needs collaboration for environmental side

Lynne Caughlan at CSU may help gather info.

-NatureServe will assist. / Rachael Muir can help.

-Rachael: impact analysis is technical, need to develop a good solid science based document that anticipates/feeds process but is not a policy doc. Produced at CSU it will fuel working through process – can take to policy makers at State and Federal level. Target Texas and Arizona.

-Goal of meeting should be an information document for policy makers, policy document, itself, may be next.

-Agricultural, environmental, risk pathway analysis, risk map for US showing areas of greatest impact needed.

-Could this be a prototype for species that having overlapping impacts, agricultural and environmental.

-This project is bigger than what is in place at CSU. CSU to produce precursor to the larger environmental/economic analysis.

-Risk mapping technology available at CPHST: climate data, GIS referenced.

-Defining uncertainty is large part of environmental analysis.

-IAEA paying $25,000 for environmental impact study of Southwest US and Mexico. Probably need additional resources.

-Mexico willing to facilitate CPHST visit with some funding from IAEA/APHIS, estimate cost 2,000 dollars.

-CPHST has expertise, access to data, recommend they do economic and environmental analysis – direct approach to the CPHST director.

-Setting overall priorities needs to come from the APHIS Executive Team.-Need to remember a biological reality: late March emergence and possible movement west.

-Could there be a release of emergency funds for pilot studies – need to identify who to contact and how to secure funds – Probably not available at APHIS.

-Are we getting ahead or ourselves – emergency funds for what? What are we going to do? Are technologies there?

-Funding issues: Congress earmarks or makes available. Emergency Commodity Credit Corporation (CCC) requested funds not really feasible unless program and support identified.

-Who's going to do a comprehensive economic or environmental analysis: Lynn Garrett, Bill Gregg, Rachael Muir, Sara Simonson (others?), Roger Magarey (risk mapping).

-Gregg offers 10K for environmental side.

-APHIS: notification to Executive Team needed to get APHIS attention.

-Demonstrate cooperate effort when going to policy decision-makers – set precedent for future.

-Accountable point person needed to oversee process.

-Lynn Garret offered to pull together a "white paper" quickly to take advantage of window of opportunity. He volunteers to coordinate effort.

-When due / what's going to be in it?

-Missing: a point person for planning what we are going to do on the ground to stop spread.

-Ken Bloem at ARS has expertise to run the on-the-ground program.

-Recommend a short concise analysis/assessment.

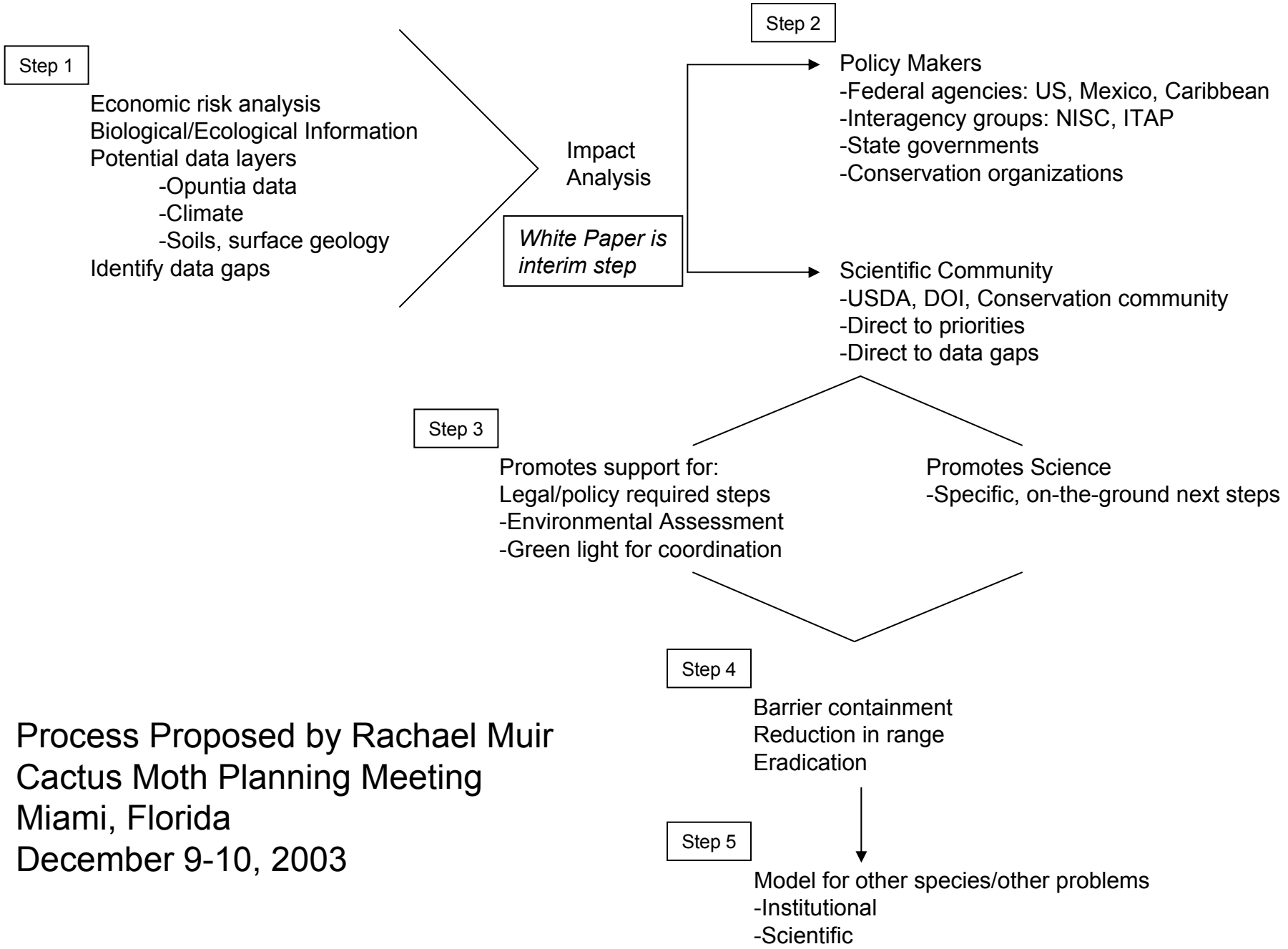
-Need to get started on a document and work from there.

-Agree on framework/format of report before it is written to avoid delays later.

-APHIS is not customer for IAEA report, being prepared for US and Mexico impacts.

-Identify someone at PPQ HQ to take lead from program side. Person needs to be decided.

-Target of white paper: State Departments of Agriculture.



Process Proposed by Rachael Muir
Cactus Moth Planning Meeting
Miami, Florida
December 9-10, 2003

2. Detection Surveys, Reporting & Education and Outreach

-Goal: Researchers should not be the primary doers of survey/control; other resources avail thru Cooperative Agricultural Pest Survey (CAPS), cooperative agreements for specific pests with USDA/States. Develop volunteer surveys. *Cactoblastis* discussed at National CAPS meeting in Las Vegas.

-CAPS collects positive and negative data and enters into the National Agricultural Pest Information System (NAPIS), a national database, at the county level.

-CAPS proposals from states for *Cactoblastis* survey is needed.

-Resources already allocated for FY04, might be able to get a pilot study funded.

-Explore use of CAPS survey and priorities.

-Survey goals: Uncertainty around extent of spread? Well defined on coast, but not well surveyed inland, but chances are not there based on non-scientific surveys. Fairly certain of leading edge not popping up in areas where it surprises.

-PPQ needs to show extent of spread and to assign volunteer surveyors.

-Focus needs to be on Florida, Alabama, Mississippi and Louisiana leading edges.

-Northern spread along East Coast reaching limit due to climate.

-In-land movement appears to be slow.

-Potential for greatest spread, impact is westward spread.

-Concern over artificial spread, i.e. WalMart detection in Florida panhandle, need to look beyond leading edge, use sterile female in traps.

-Need public education and component of CAPS for detecting man-made spread.

-Charge National Survey Leader/CAPS/state pest survey specialists with developing survey strategy with researchers.

-Very feasible to send virgin female traps to leading edge states. But need a strategy to define where to survey.

-Live baited traps are very expensive - life expectancy of female ~ week - but less expensive than visual surveys for damage and collecting larval specimens.

-Man-made spread may be most important mode of spread.

-Time to pheromone component development given unlimited resources is unknown – still missing a component and insects are stingy with pheromone. 2 of 4 compounds commercially avail, others need to be synthesized.

-Small increments in funding could help move program forward or focus the research on pheromones. Current limiting factor is not availability of insects – colony avail.

- Develop survey methods with state counterparts, FL, AL, MS, LA timed to March and 2 later emergence peaks.

-Visual survey can be a useful tool – very useful once cacti patches identified. Use out in front of leading edge.

-Also look in retail outlets / wholesale?

-FL State could help with survey 3xs year at nurseries, can identify those nurseries sending cacti west.

-Could FL look at interior spread?

-Need to document *Opuntia* population ahead of the front.

-With lack of funds avail – passive survey possible in cooperation with existing CAPS activities.

-Volunteer network: Nature Conservancy well developed in FL (well staffed and large program), work on variety of properties in S. FL, not in NW FL. Could develop capacity?

-Need to find out capacity in other states. Volunteer programs are not free, not high cost but needs resources/cooperation. Need educational materials *Cactoblastis* program as model of cooperation.

-National wildlife refuge system: Gulf Islands National Seashore, state partners. USGS has $1 million earmark with Mississippi State University Georesources Institute for invasive species monitoring.

-Department of Interior: National Park Service resources on barrier island properties and with USAF at Elgin in south Florida. US FWS National Wildlife Refuge System also.

-Need to identify location for warehousing data and develop one-page data collection form. Develop thru NAPIS.

-Data standardization issues.

-Agree to have some program in place in March 04, if feasible with available resources.

3. Identification, Specimen Screening, Confirmation and Reporting

-Put in place good identification tools for surveyors and others to use. Need state specific keys to narrow down range of fauna. Need to identify state's with Lepidoptera and which what Lepidoptera larvae to include in keys for FI, MS, AL, and LA.

-Group in TX working on keys for adults, not sure cactus moths included. Alma S. to contact TX group and alert them to *Cactoblastis* and need for them to watch for them, also contact Richard Brown at MSU.

-Specimens should be screened at state level, locate state identifiers and alert them to *Cactoblastis*.

-Can we find taxonomists, others who can watch and Identify possible *Cactoblastis* in the West? State Departments of Agriculture? Universities?

-Visual aids, high quality photos, for educational material. Identify sources are needed.

-Could CAPS money be made available to fund a grad student to do specimen screening.

-Retired CSU entomologist might be interested Dr. Paul Opler but will need funds.

-Also need photos of host plants and other pests – comparative pictures especially for those not familiar with the pests of cactus.

-Initial focus on southern states, long-term focus on southwestern states.

-Need host information by state.

-Who will do this? Florida in good shape for ID key, with one correction from Alma Solis. Need info for other states.

3a. Outreach/Education

-Too broad an effort can be inefficient.

-Revisit after other discussion.

4. Regulatory Issues

-Cactus from Puerto Rico and Hawaii prohibited from rest of US but not *Opuntia* species cuttings from Caribbean nations with *Cactoblastis*.

-No state quarantine imposed by western states against FL or GA. Why not?

-States can ask for Federal quarantine or impose on own authority, usually associated with risk to agricultural but traditionally not environmental risk. National Plant Board needs to address.

-How much regulatory risk? One case does not make a major threat but does demonstrate a pathway.

-*Opuntia* small percent of business, less than 1% propagated by nurseries. Occasional infestation but small problem.

-Direct education at the nursery industry level.

-FL cactus: some propagated in FL, others from places like Dominican Republic and Haiti. Come through Port of Miami to Plant Inspection Station. Representative sample: 1 box from each variety from each grower - need phyto / additional declarations.

-If evidence of infestation more samples requested.

-Some small infestations in Miami nursery, take steps to control. Some grow *Opuntia* outdoors.

-Any import risks and inconsistently in regulations need to be discussed at PPQ HQ.

-Cacti is a small percentage of imported plants, how many infested plants found?

-What are practices in Dominican Republic and Haiti to control *Cactoblastis*.

-Consider applying a Best Management Practices approach to all propagative material.

-Internal outreach at inspection stations needed to increase awareness.

-Expansion of E-commerce database. PPQ has internet surveillance data system.

-Could we use the APHIS International Services person in Haiti to increase awareness in Caribbean?

-New Mexico State Plant Regulatory Official and Western Plant Board President, Sherry Sanderson, would be good point of contact for New Mexico, the plant board and the New Pest Advisory Group.

5. Containment Response/Control Strategies

-Biocontrol options/specificity of agents need to be determined. No good candidates with required specificity.

-Continue exploring sterile insect techniques (SIT).

-Explore classical side of biocontrol. A lot is known about innundative techniques. Might be useful on the leading edge. Available agents are generalists and there would be risk to native Lepidoptera. Usually one introduces a large number to last one season: do not over-winter, some habitat specificity.

-Need to identify and consult with known experts in innundative methods.

-Examine non-target effects. But biocontrol may be a more long term solution if specificity can be demonstrated. What are short term approaches?

-Chemical control may not be a very viable option but could it be used in an emergency at a well defined infestation.

-Cultural controls can be useful – very useful in urban areas, landscape plantings and urban areas, but only to mitigate, not control, contain or eradicate.

-Lessons of the citrus canker program in urban areas– the taking of private property. With *Cactoblastis*, problem of

taking landscape plants with no compensation when not doing anything with wild populations.

-Long term urban or agricultural solution: systemic pesticides.

-Might be able to identify people quickly who could test systemic or other chemical treatments.

-Topical sprays available but systemics are not known to be available or effective.

-Industry losing some products to safer but possibly less effective chemicals.

-Problems with systemics: penetration and dilution.

-Contact Southeast ornamentals working group: Russ Mizell.

6. Research Needs Panel Discussion

-Refer to 2000 Tampa Meeting recommendations.

-Pheromone work is the priority

-SIT releases as a validation of technique on a barrier island in Florida, need specific funding for ARS to test.

7. Funding Options

-No funding sources currently available. Need to look to future budget cycles.

-Somebody needs to lobby their representatives, but first need to define options and develop short term and longer term budget proposals.

The Cactus Moth
(Cactoblastis cactorum)

Life Stages, Hosts, and Damage

Life Stages of *Cactoblastis cactorum*: Larva

Photograph by Susan Ellis, USDA APHIS PPQ

Life Stages of *Cactoblastis cactorum*: Larva

Photograph by Susan Ellis, USDA APHIS PPQ

Life Stages of *Cactoblastis cactorum*: Larva

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Photograph by Susan Ellis, USDA APHIS PPQ

Life Stages of *Cactoblastis cactorum*: Larva

Photograph by Susan Ellis, USDA APHIS PPQ

Life Stages of *Cactoblastis cactorum*: Larvae Inside *Opuntia* Pad

Photograph by Susan Ellis, USDA APHIS PPQ

Life Stages of *Cactoblastis cactorum*: Cocoon

Photograph by Susan Ellis, USDA APHIS PPQ

Life Stages of *Cactoblastis cactorum*: Adult

Photograph by Susan Ellis, USDA APHIS PPQ

Life Stages of *Cactoblastis cactorum*: Adult

Photograph by Susan Ellis, USDA APHIS PPQ

Hosts of *Cactoblastis cactorum*: *Opuntia species in Florida Keys*

Opuntia corallicola
(Semaphore Cactus)

Opuntia stricta

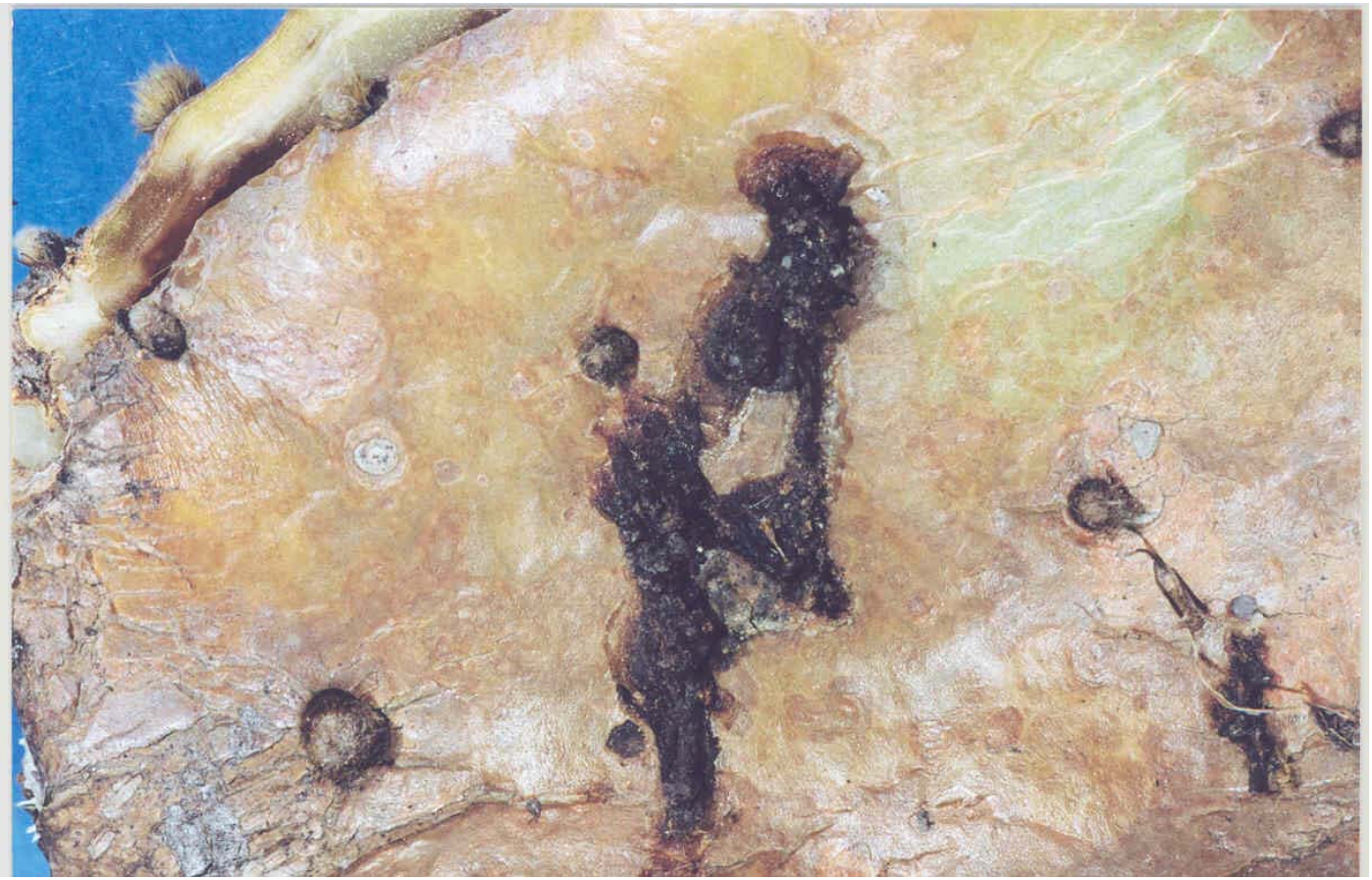
Photographs by Susan Ellis, USDA APHIS PPQ

Hosts of *Cactoblastis cactorum*: *Opuntia corallicola (*Semaphore Cactus)

(Formerly O. spinosissima)

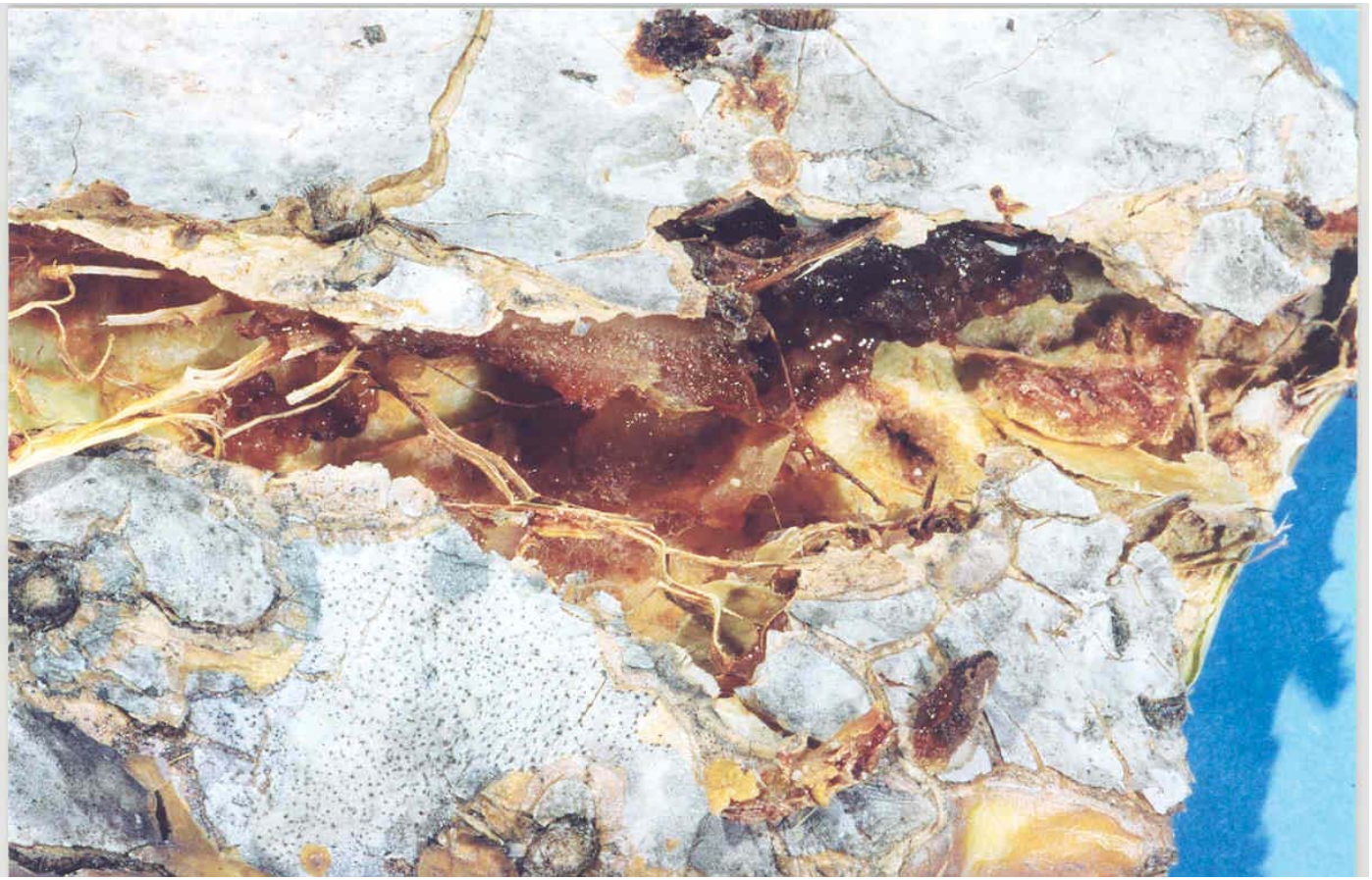
Photograph by Susan Ellis, USDA APHIS PPQ

Cactoblastis cactorum Larvae Damage: *Optunia* Dry Pad



Photograph by Susan Ellis, USDA APHIS PPQ

Cactoblastis cactorum Larvae Damage: *Opuntia* Dry Pad

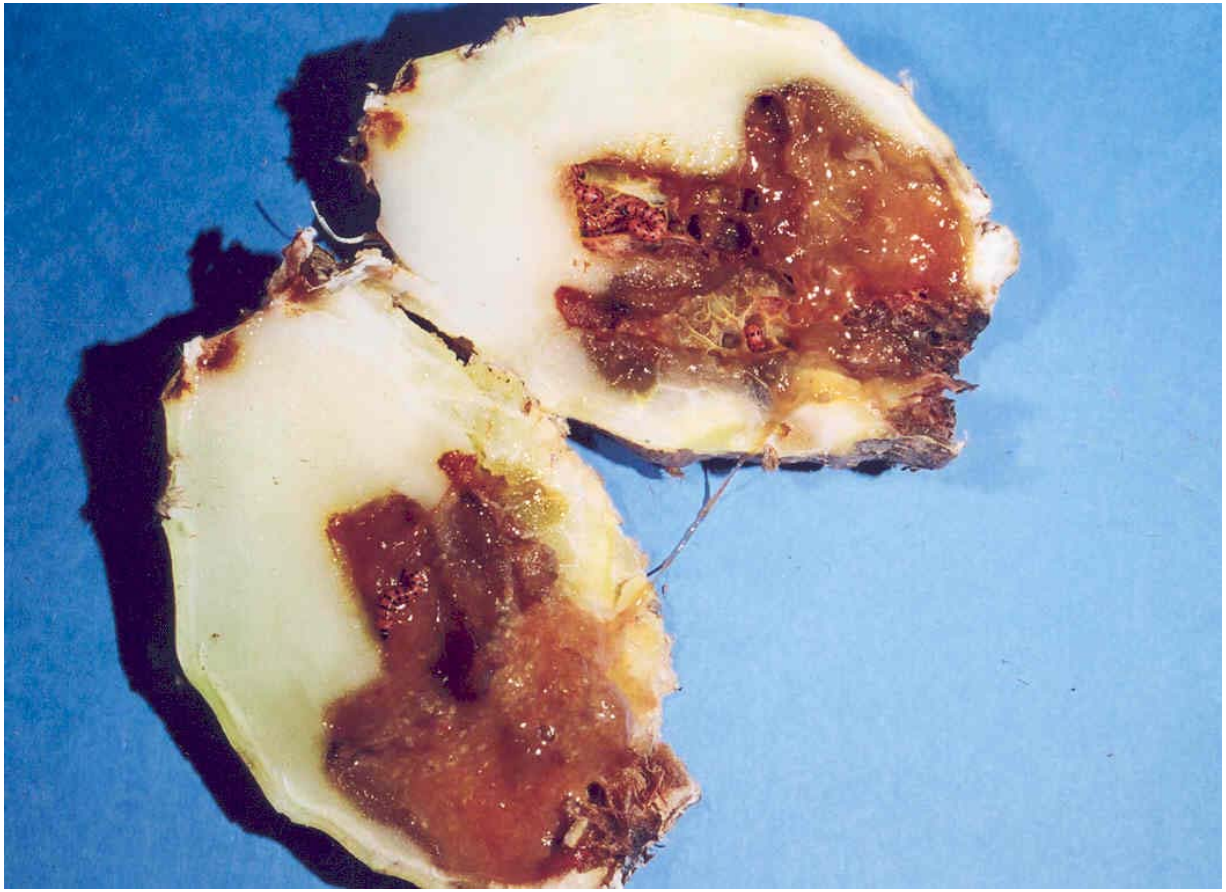


Photograph by Susan Ellis, USDA APHIS PPQ

Cactoblastis cactorum Larvae Damage: *Opuntia* Green Pad

Photograph by Susan Ellis, USDA APHIS PPQ

Cactoblastis cactorum Larvae Damage: *Opuntia* Pad



Photograph by Susan Ellis, USDA APHIS PPQ

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Miami, Florida, December 9 - 10, 2003

Hosted and Sponsored by USDA, APHIS, PPQ
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Bloem, Kenneth
Scientist
USDA/APHIS/PPQ/CPHST
Florida A&M University, Tallahassee, FL
(850) 219-5754
Kenneth.Bloem@aphis.usda.gov

Bloem, Stephanie
Research Entomologist
Center for Biological Control
Florida A&M University, Tallahassee, FL
(850) 219-5756
ksbloem@nettally.com

Bulluck, Russ
Staff Scientist
USDA/APHIS/PPQ/CPHST
National Science Program, 1017 Main Campus Drive, Suite 2500, Raleigh, NC 27607
(919) 513-2804
russ.bulluck@aphis.usda.gov

Carpenter, Jim
Research Entomologist
USDA-ARS-CPMRU
2747 Davis Road, Bldg. #1, Tifton, GA 31794
(229) 387-2348
jcarpent@tifton.usda.gov

Deuben, Barabara
Chemist
USDA-ARS-CMAVE
1700 SW 23rd Dr., Gainesville, FL 32608
(850) 219-5754
bdueben@gainesville.usda.ufl.edu

Ellis, Susan
Assistant Staff Officer
USDA/APHIS/PPQ/PDMP
Unit 137, 3D81, 4700 River Road, Riverdale, MD 20737
(301) 734-5741
susan.e.ellis@aphis.usda.gov

Enkerlin, Walther
Technical Officer
International Atomic Energy Agency (IAEA)
Div. of Nuclear Applications in Food and Agriculture, Wagramer Strasse No. 5, A-1400
Vienna, Austria
(43 1) 2600-26077
w.enkerlin@iaea.org

Epsky, Nancy
Research Entomologist
USDA-ARS-SHRS
13601 Old Cutler Rd., Miami, FL 33158
(305) 254-3641
NEpsky@saa.ars.usda.gov

Floyd, Joel
Program Manager
USDA/APHIS/PPQ/PDMP
Unit 137, 3D68, 4700 River Road, Riverdale, MD 20737
(301) 734-4396
joel.p.floyd@aphis.usda.gov

Frank, Phil
Project Leader
Department of the Interior, USFWS
28950 Watson Blvd., Big Pine Key, FL 33043-0510
(305) 872-2239
keydeer@fws.gov

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Garrett, Lynn
Agricultural Economist
USDA/APHIS/PPQ/CPHST
CPHST, USDA, APHIS, PPQ, 1017 Main Campus Drive, Suite 2500, Raleigh, NC 27607
(919) 513-2127
Lynn.J.Garrett@aphis.usda.gov

Gordon, Doria
Senior Ecologist
The Nature Conservancy
PO Box 118526, University of Florida, Gainesville, FL 32611
(352) 392-5949
dgordon@tnc.org

Gregg, William P.
Program Coordinator
U.S. Geological Survey
BRD, Invasive Species, 12201 Sunrise Valley Drive, MS301, Reston, VA 20192
(703) 648-4067
william_gregg@usgs.gov

Griffiths, Karolynne
Supervisory PPQ Officer
USDA/APHIS/PPQ
4380 Oakes Road, Suite 812, Davie, FL 33314
(954) 585-1078
karolynne.m.griffiths@aphis.usda.gov

Head, Jeffrey
State Plant Health Director
USDA/APHIS/PPQ
Mail Stop 9655, Mississippi State, MS 39762
(662) 325-3140
jeffrey.l.head@aphis.usda.gov

Heath, Bob
Research Leader
USDA-ARS-SHRS
USDA-ARS-SHRS, Miami, FL
(305) 254-3643
rheath@saa.ars.usda.gov

Herrick, Nathan
Research Assistant
USDA-ARS-CMAVE
Center for Biological Control, Florida A&M University, Tallahassee, FL
(850) 219-5754
bugs333@juno.com

Hight, Stephen
Research Entomologist
USDA-ARS-CMAVE
1650 Summit Lake Drive, Suite 103, Tallahassee, FL 32317
(850) 219-5754
hight@nettally.com

Hubbard, Fred
Manager, Plant Inspection Services
Florida Department of Agriculture and Consumer Services
13603 Old Cutler Rd., Miami, FL 33158-1334
(305) 252-4362
lodygal@doacs.state.fl.us

Lenis, Fernando
Entomologist/Identifier
USDA/APHIS/PPQ
Miami, FL 33159
(305) 526-2825
fernando.e.lenis@usda.gov

Participant List
Cactus Moth (*Cactoblastis cactorum)* Planning Meeting
Miami, Florida, December 9 - 10, 2003

Hosted and Sponsored by USDA, APHIS, PPQ
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In cooperation with the Interagency Committee on Invasive Terrestrial Animals and Pathogens

Mahr, Dan
Vice President
Cactus and Succulent Society of America
Department of Entomology, University of Wisconsin, 1630 Linden Drive, Madison, WI 53706
(608) 262-3228
Dmahr@entomology.wisc.edu

Muir, Rachel
Ecologist
US Geological Survey, Natureserve
c/o NatureServe, 1101 Wilson Blvd., 15th Floor, Arlington, VA 22209
(703) 908-1837
racherl_muir@natureserve.org

Muiznieks, Britta
Rerstoration Biologist
Department of the Interior, USFWS
PO Box 370, Key Largo, FL 33037
(305) 453-3777
Britta_Muiznieks@fws.gov

Parker, Paul
Laboratory Director
USDA/APHIS/PPQ/CPHST
Pest Detection, Diagnostic & Management Laboratory, Edinburg, TX 78539-9803
(956) 580-7301
paul.e.parker@aphis.usda.gov

Pemberton, Robert
Research Entomologist
USDA-ARS-IPRL
3205 College Ave., Ft. Lauderdale, Florida 33312
(954) 475-0541 ex. 106
bobpem@saa.ars.usda.gov

Perez-Sandi y Cuen, Mayra
External Consultant
SAGARPA/CONABIO, Dirección General de Sanidad Vegetal
20 Agosto 53-15, San Diego Chuorbusco, Coyoacon 04120, Mexico DF, MX
01 55 55 54 82 76
rayma@internet.com.mx

Pernas, Tony
Everglades National Park Manager
Department of the Interior, National Park Service
950 N. Krome Avenue, Homestead, FL 33030
(305) 224-4246
EVER_Information@nps.gov

Richard, Robert D.
Western Region Program Manager
USDA/APHIS/PPQ
USDA/APHIS/PPQ, 2150 Centre Ave, Bldg B MS 3E10, Fort Collins CO 80526- 8117
(970) 494-7565
robert.d.richard@aphis.usda.gov

Sanchez Anguiano, Hector
Director de Protección Fitosanitaria
SAGARPA, Dirección General de Sanida
GMO Perez Valenzuela, 127 Cor del Carmen, Coyoacan, CP 04100, Mexico DF, MX
55 54 4214
hsanchez@sonasica.sagarpa.gob.mx

Shannon, Mike
State Plant Health Director
USDA/APHIS/PPQ
7022 N W 10th Place, Gainesville, FL 32605
(352) 331-3990
Mike.Shannon@aphis.usda.gov

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Simonson, Sara
Ecologist
National Institute of Invasive Species Science
Natural Resource Ecology Laboratory,
Colorado State University, Fort Collins, CO
80523-1499
(970) 491-0410
saras@nrel.colostate.edu

Solis, M. Alma
Research Entomologist
SEL, USDA, Smithsonian Institution
P.O. Box 37012, National Museum Natural
History, E-517, MRC 168, Washington, DC
20013-7012
(202) 382-1785
asolis@sel.barc.usda.gov

Stewart, John
Eastern Region Sr. Program Manager
USDA/APHIS/PPQ
920 Main Campus Drive, Suite 200, Raleigh,
NC 27606
(919) 716-5546
John.C.Stewart@aphis.usda.gov

Stiling, Peter
Research Biologist
University of South Florida, Dept of Biology
University of South Florida, Fl 33620
(813) 974-3754
pstiling@chuma1.cas.usf.edu

Troubatchov, Andrew
Nurseryman
Costa Nursery
22290 SW 162 Avenue, Goulds, FL 33170
(800) 327-7074 ext. 131
andrewT@costanursery.com

Tyler, Laura
Ecologist
National Institute of Invasive Species Science
Natural Resource Ecology Laboratory,
Colorado State University, Fort Collins, CO
80523-1499
(970) 491-7127
tylutki@lamar.colostate.edu

Writer, James
Science and Technical Liaison
USDA/APHIS/PPQ/PDMP
Unit 137, 3D81, 4700 River Road, Riverdale,
MD 20737
(301) 734-7121
james.v.writer@aphis.usda.gov

Zimmermann, Helmuth
Research Biologist
Plant Protection Research Institute
P/Bag X134, Pretoria 0001
riethgz@plant2.agric.za

Attendees of the Cactus Moth (*Cactoblastis cactorum)* Planning Meeting
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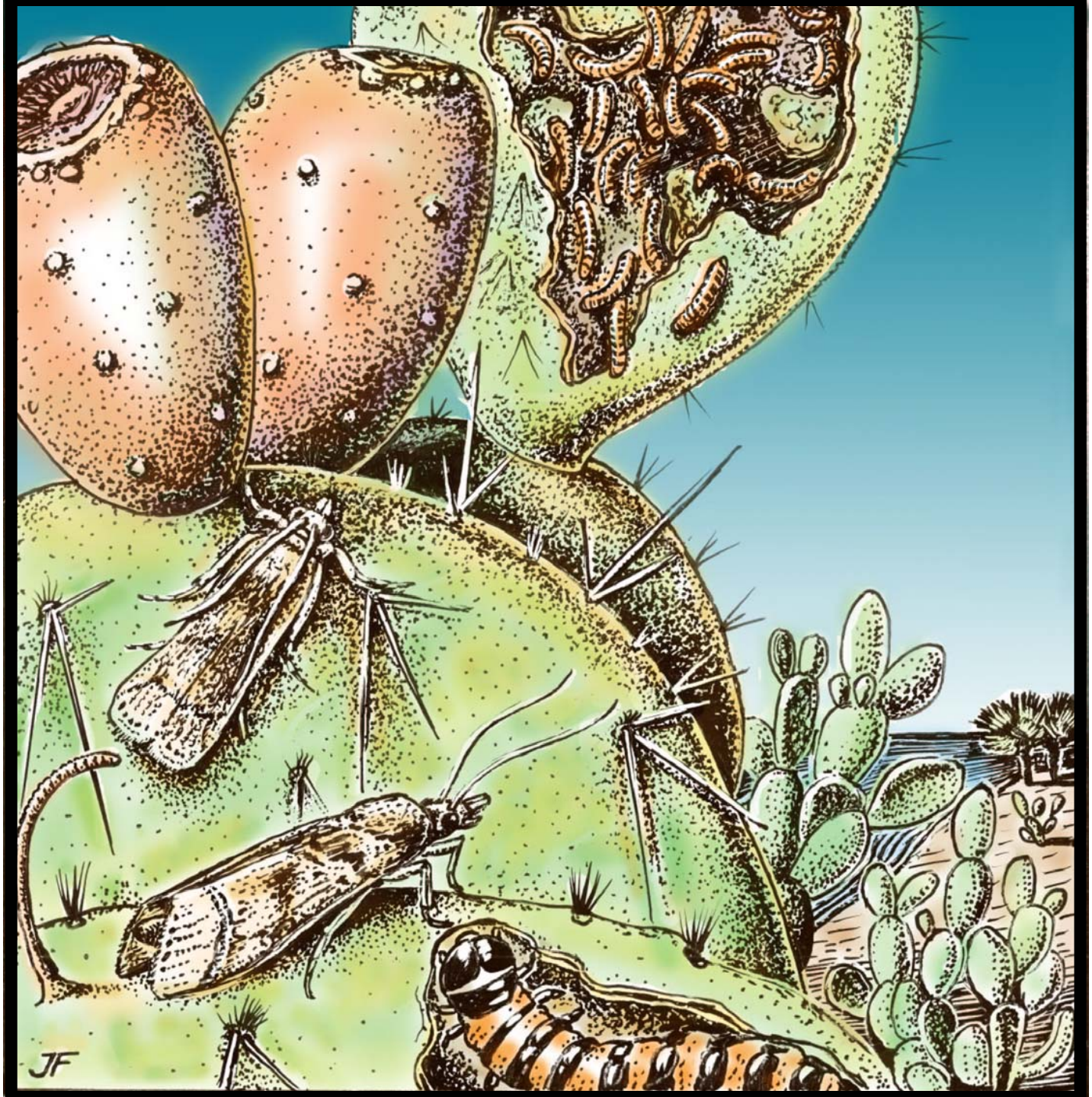
JF