# Inherited Sterility to Combat Invasive Species That Harm The Environment and Agriculture

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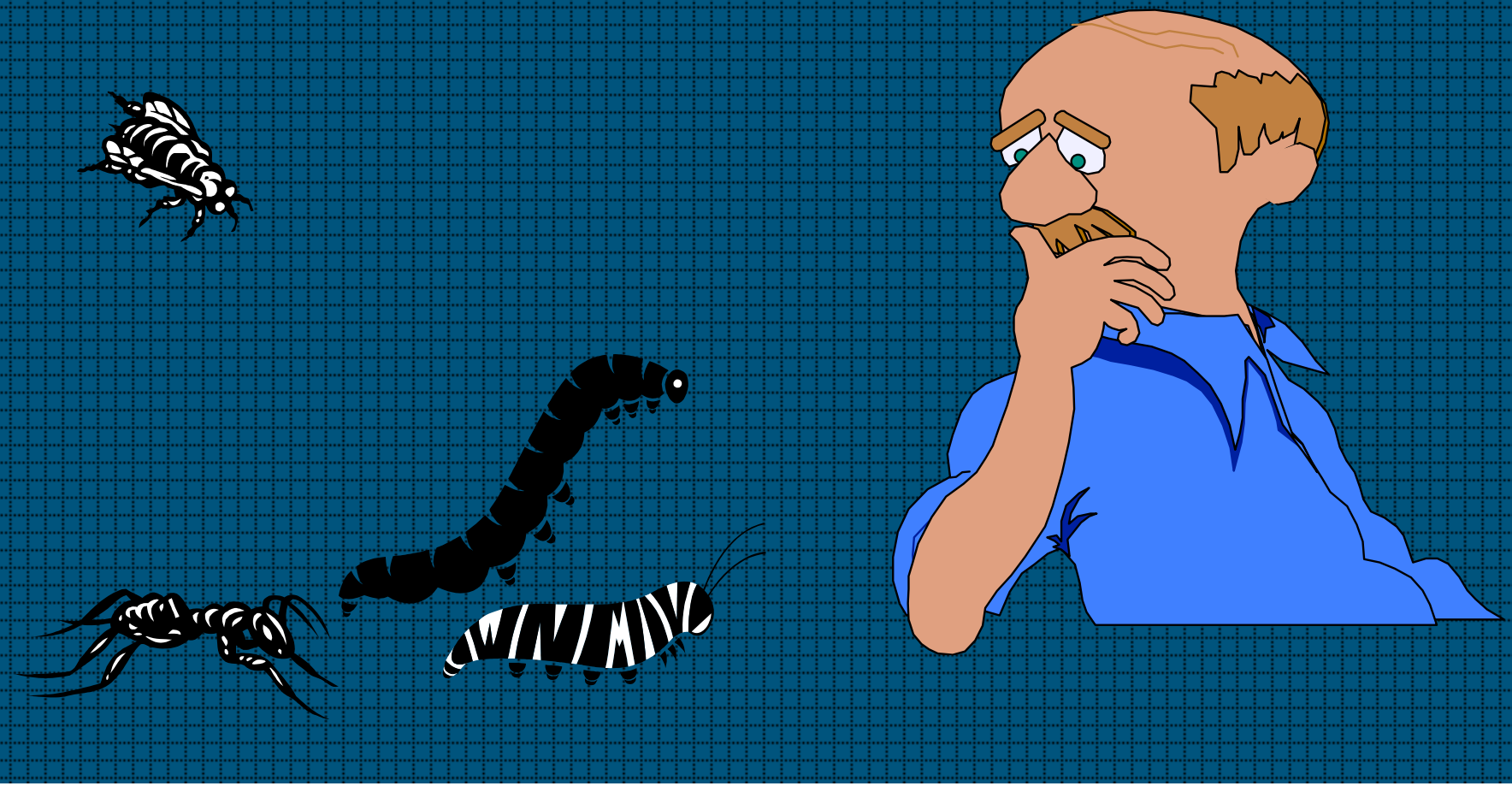
# We are under attack by alien species!!



- Invasive plant pests are constantly threatening the abundant plant resources and the plant-based industries of the United States

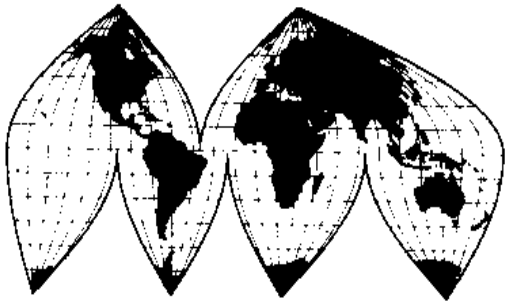
- Furthermore, appropriate preparedness and response strategies are not available in case of, or in advance of, most invasive pest introductions

Safeguarding American Plant Resources
National Plant Board Review 2001
USDA-APHIS-PPQ
http://www.safeguarding.org/

# Needs

- Methods for pest risk mitigation at the point of origin, i.e., offshore, is the most viable approach to pest exclusion and mitigation
- Emergency response methods and guidelines for potential pests
- Proactive development of eradication tools for potential invasive organisms based on risk analysis programs

*Global Invasive Species Programme(GISP)*



SCOPE

CAB *International*

IUCN
The World Conservation Union

*Invasive Alien Species:*
A Toolkit of Best Prevention and Management Practices

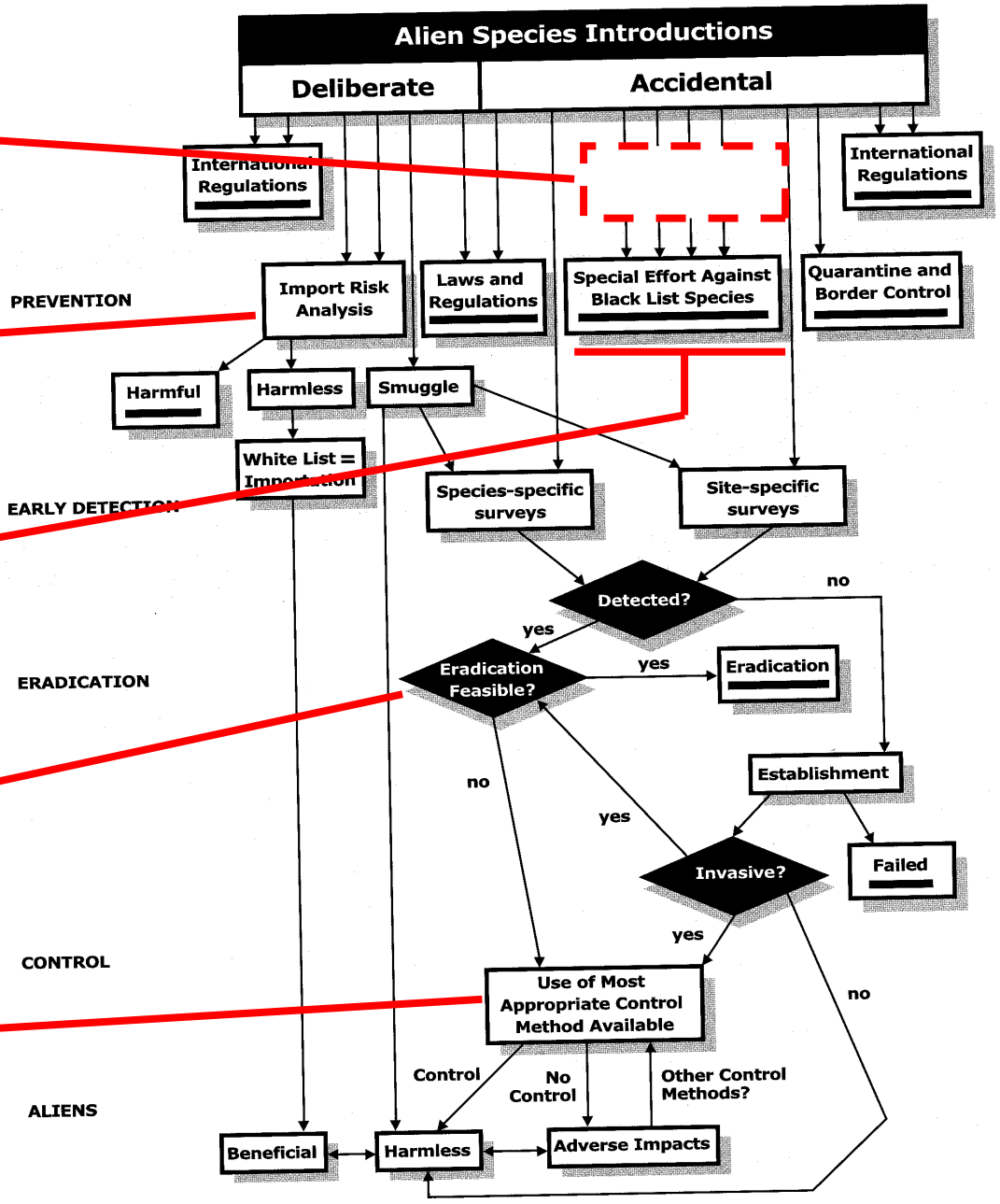
Off-shore IPM/SIT

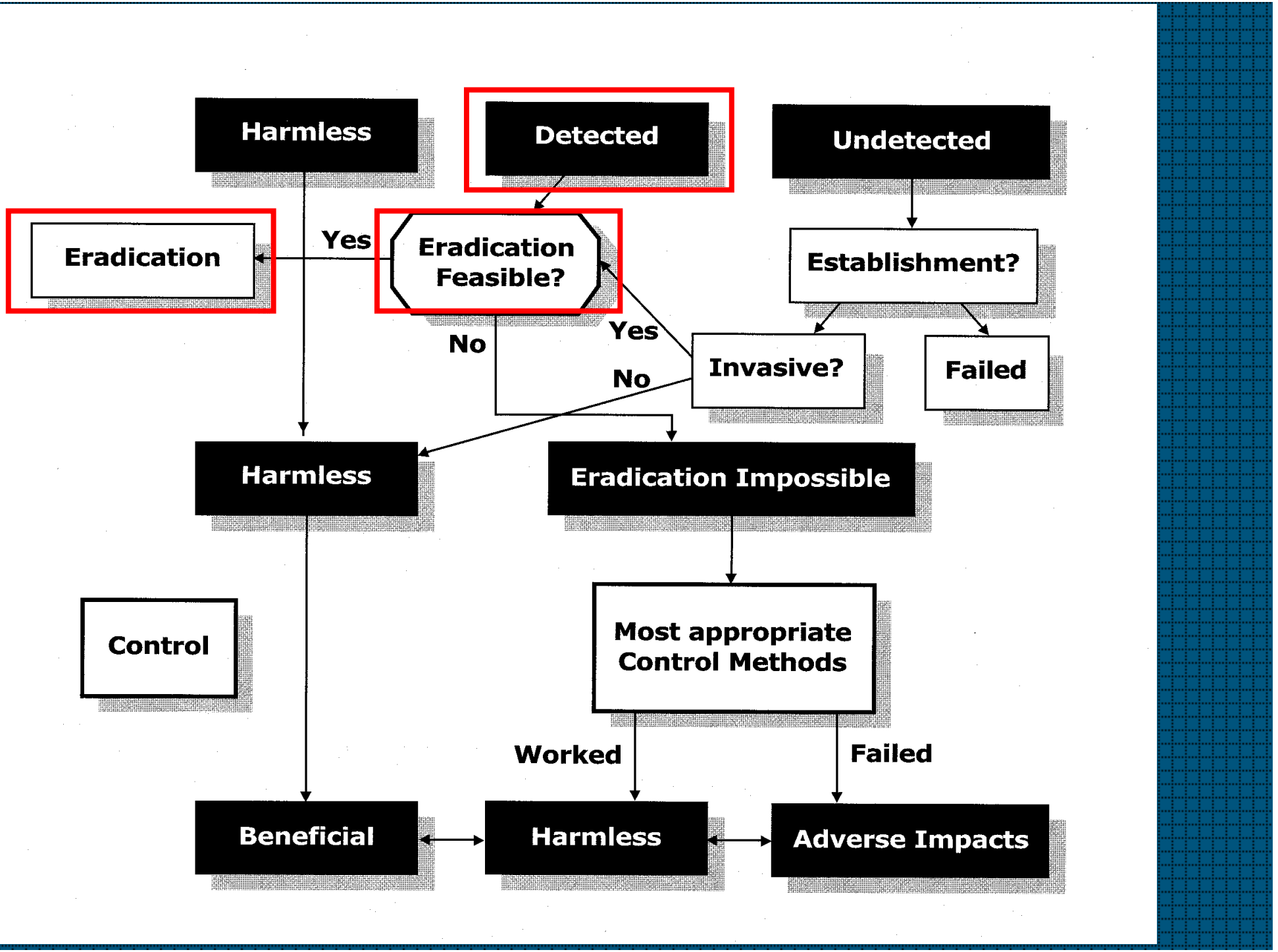
SIT-IS for Host Range Testing

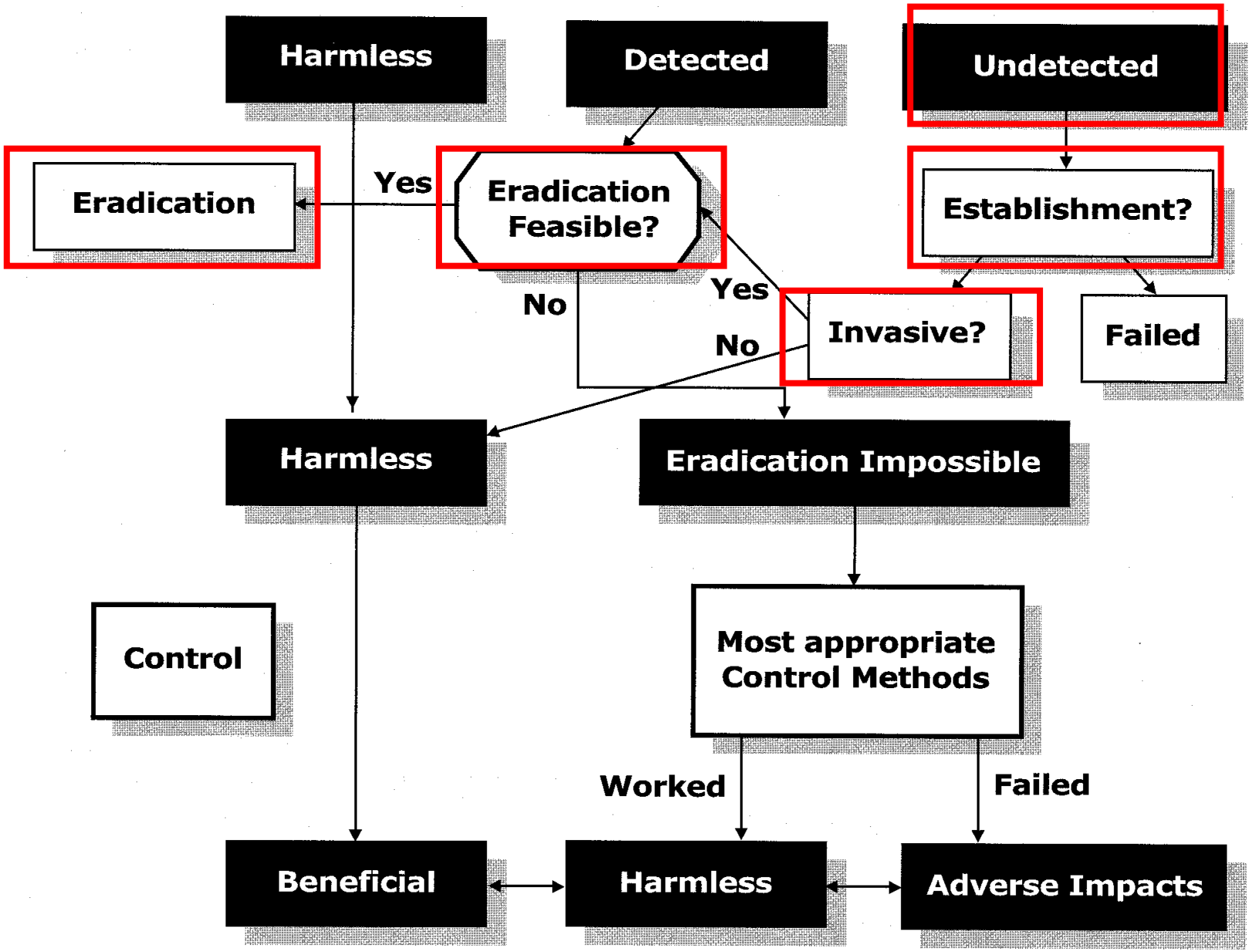
SIT-IS Barrier-Exclusion

SIT-IS

SIT-IS




Harmless
Detected
Undetected
Eradication
Yes
Eradication Feasible?
Establishment?
No
Yes
Invasive?
Failed
No
Harmless
Eradication Impossible
Control
Most appropriate Control Methods
Worked
Failed
Beneficial
Harmless
Adverse Impacts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*Invasive Alien Species . . .*

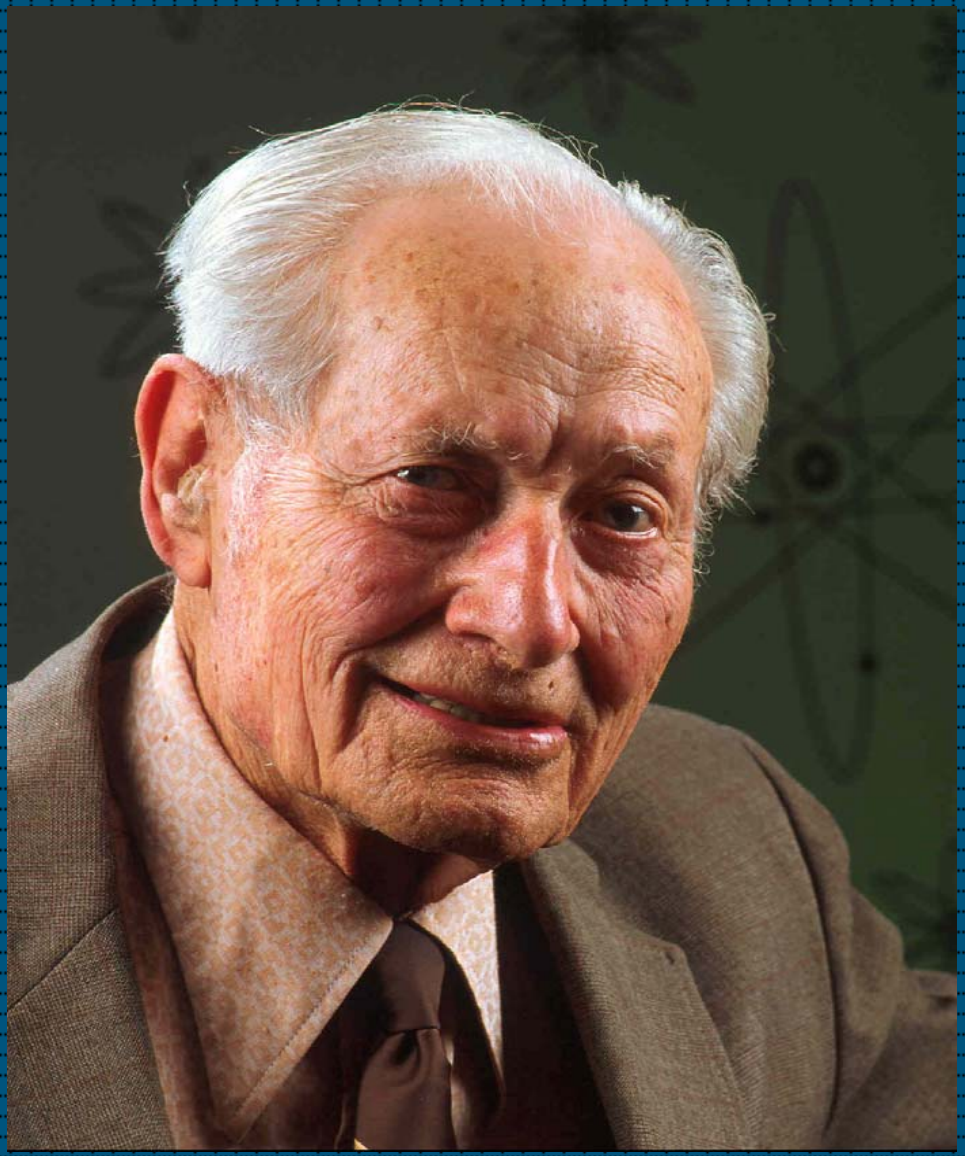
# “When Prevention has failed, Eradication is the Preferred Course of Action”

# The Sterile Insect Technique (SIT)

**Treated insects**
**(sterile or partially sterile)**
**are released into the field and are expected to mate with the wild insects, thus interfering with reproduction.**

# Requirements for SIT-IS

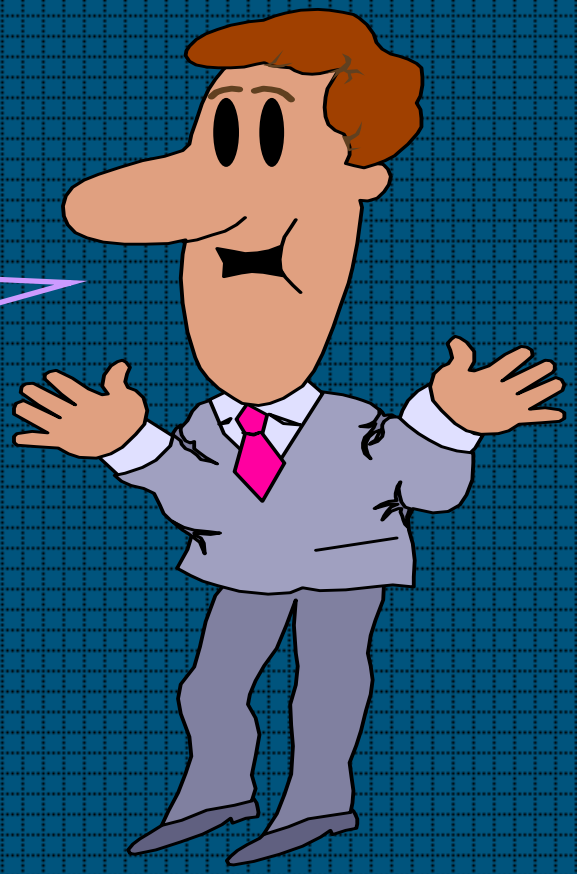
- Methods for mass rearing, distribution & release
- Techniques for sterilization
- Biologically & behaviorally competitive insects
- Technology to accurately assess field populations
- A large (or sufficiently isolated) treatment area
- Adequate released to wild overflooding ratio



Dr. E. F. Knipling

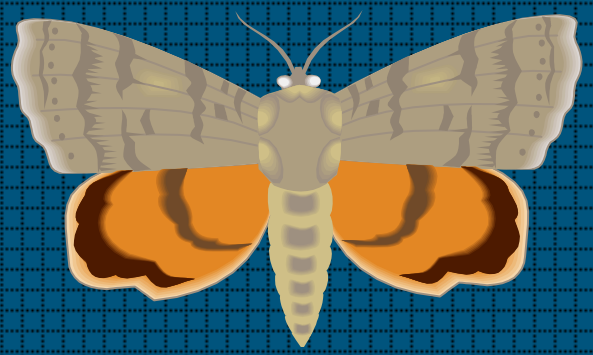
# “The SIT as Birth Control of Insect Pests”

… SIT ? that's the same thing as eradication … right?



# SIT can be successfully used in an area-wide IPM approach for ...

- Control - Suppression
- Prevention - Barriers
- Eradication - Pest-free areas




I wonder …does SIT work for moth pests ?

# Full Sterility (SIT) in Moth Pests

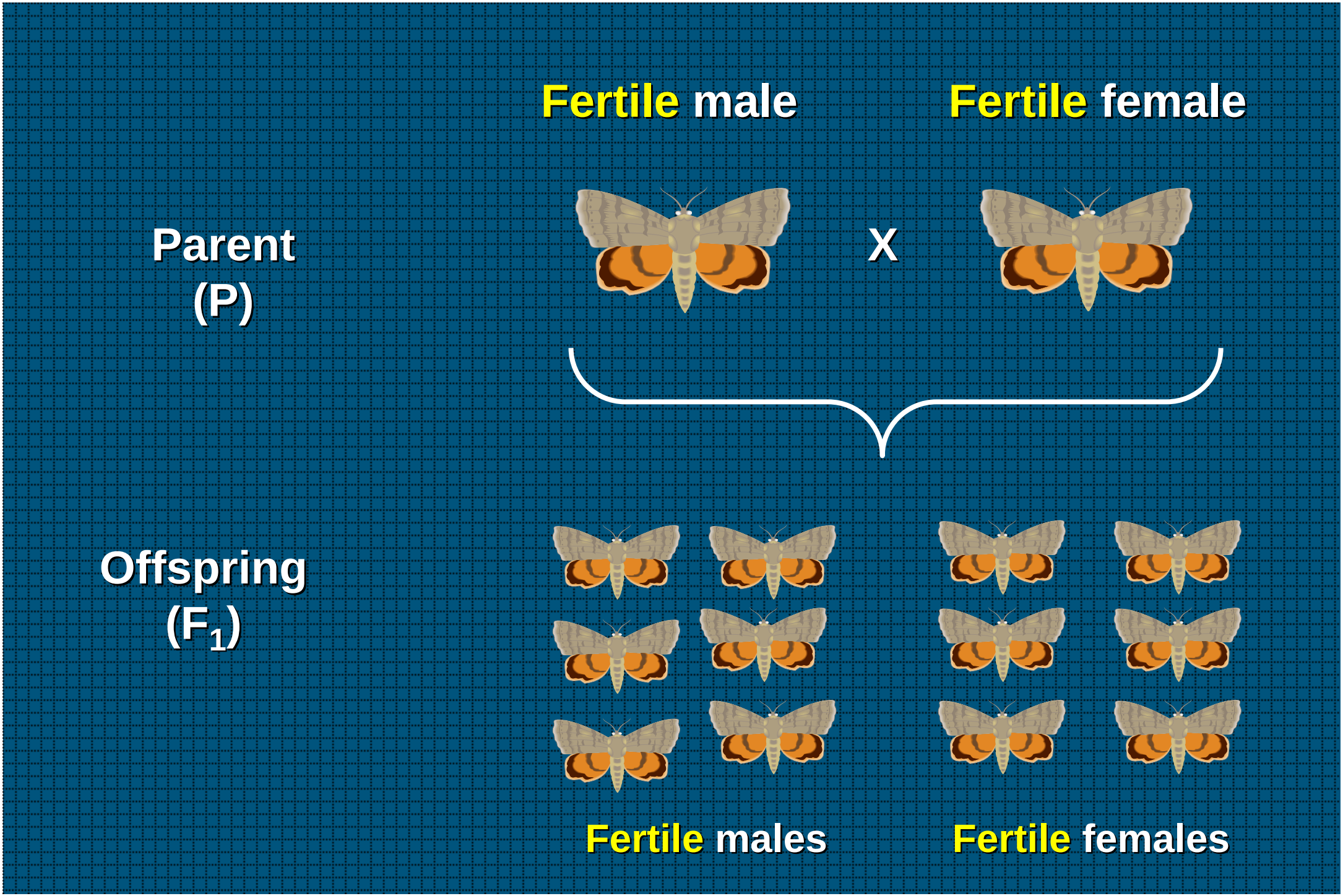
- investigated for many species
- drawback high doses of radiation are required
- Fly pests ~100 Gy vs. Moth pests 300-500 Gy
- reduced competitiveness

# Inherited or $F_1$ Sterility

- radiation dose is lowered so that insects are partially sterile or adjusted so that females are completely sterile and males are partially sterile
- radiation-induced deleterious effects are inherited for 1 or more generations

# Inherited or $F_1$ Sterility

- $F_1$ offspring are more sterile than treated $P_1$ males
- irradiated $P_1$ males produce more $F_1$ male progeny than female progeny
- magnitude of immediate and delayed effects can be varied by dose used (100-250 Gy)

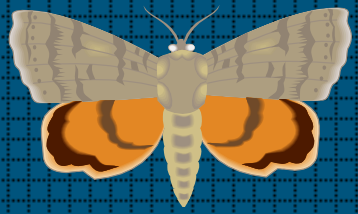

Fertile male
Fertile female
Parent (P)
X
Offspring ($F_1$)
Fertile males
Fertile females

**Irradiated** male

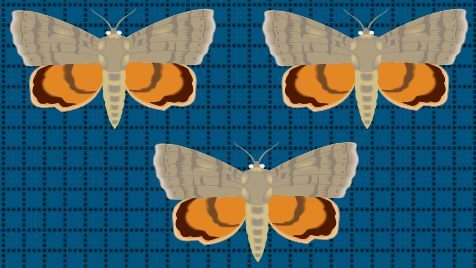
**Fertile** female

Parent (P)

X



Offspring ($F_1$)



**STERILE** males

**STERILE** females

# Joint FAO/IAEA Division

## Use of Nuclear Techniques for the Colonization and Production of Natural Enemies

- Consultants Meeting in Vienna, 1997
- First Co-ordinated Research Meeting in Vienna, 1999

- ***Developmental arrest***
- ***Microbial sterilization***
- ***Reproductive sterilization***

# Reproductive Sterilization

- Provision of sterilized prey to be used as food during shipment, to ameliorate concerns relating to the presence of hitchhiking of pests
- Provision of supplemental food or hosts in the field to increase the initial survival and buildup of released natural enemies
- Reproductive sterilization of weed-feeding insects that are candidates for biological control, for use in open field trials

# Non-Target Effects of Biological Control

Certain scientists believe that introduction of a natural enemy produces conditions that facilitate rapid evolution of changes in important characteristics of the biological control agent, such as host range (e.g., Simberloff & Stiling 1994)

If true, this could make exact determination of the agent's full impacts prior to release virtually impossible (Kauffman & Nechols 1992)

# Question …

Can **IS** be used to verify host range and behaviors of potential exotic weed biological control lepidopterans, and thereby, reduce the concerns of non-target effects?

# Quest …

Find an exotic lepidopteran that is being considered for importation and release against a weed in the U.S.

# Problem …

How can radiation biology research be conducted on a species in quarantine?

# Life Cycle of *Cactoblastis cactorum*

**Adult**

**Larva**

# Life Cycle of *Cactoblastis cactorum*

Photo by D.H. Habeck

**Egg Stick**

**Close up**

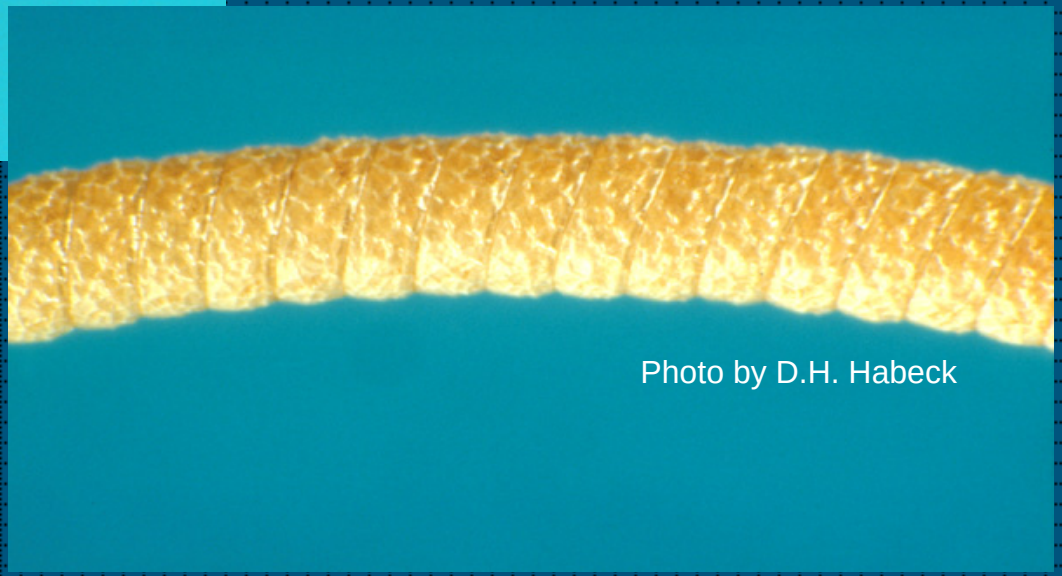


Photo by D.H. Habeck

# Life Cycle of *Cactoblastis cactorum*

Photo by D.H. Habeck

**Cocoon**

**Pupa**

Photo by D.H. Habeck


C18


C18


Following the outstanding success of *Cactoblastis cactorum* to control exotic cacti in Australia, the cactus moth assumed the undisputed role of “Poster Child” for the biological control of weeds

# Key Events

- **1957** - Argentine *C. cactorum* introduced into Caribbean
- **1989** - discovered in Florida
  - introduced by nursery trade, or
  - natural migrant
- **1999** - discovered in Georgia
  - Sapelo Island & coastal areas

# *C. cactorum* in North America: A Workshop of Assessment and Planning

- Sponsored by the USDA APHIS NBCI
- 23 participants (national and international)
- Convened 19-22 Sept. 2000, St. Pete Beach, FL
  - Federal, state and university scientists, private industry, and the general public
- Proceedings published in Fla. Entomol. Dec. 2001

# Concerns

- **Environmental**
  - Natural populations of *Opuntia* cacti in the US and Mexico threatened, including rare and endangered species
- **Commercial**
  - Threat to prickly pear cactus industry
- **Scientific**
  - Safety record of weed biocontrol tarnished

A rare and endangered cactus in the Florida Keys under attack by *Cactoblastis cactorum*, is *Opuntia corallicola* the new "Poster Child" representing non-target effects of BC

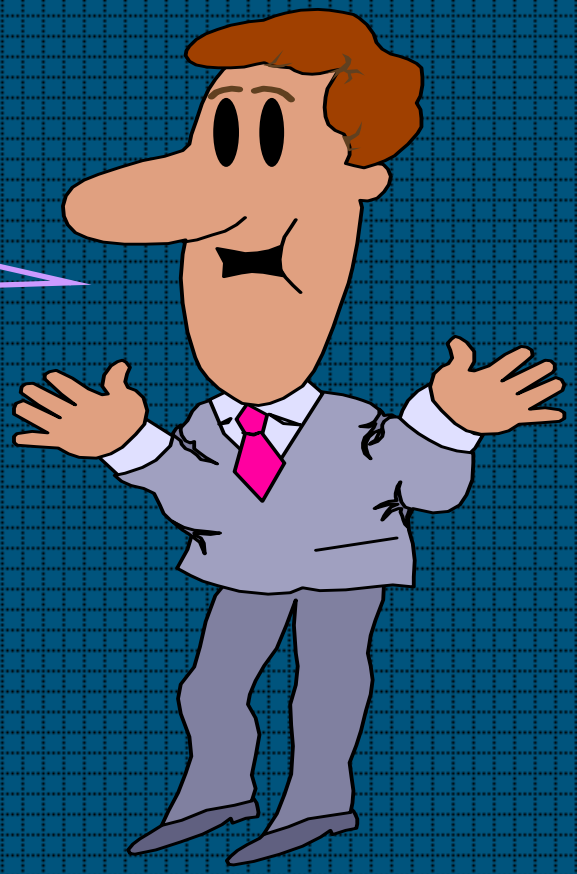
Photo from "A Worm that Turned" published in Natural History, 2000.

# Legacy of *Cactoblastis* ?

". . .The specter of *C. cactorum* moving west from Florida to attack 60 odd species of native *Opuntia* in the USA and south to attack native and commercial *Opuntia* in Mexico is disturbing and illustrates the potential for this insect to have devastating national and international consequences . . ."

( Strong & Pemberton 2001)

How can SIT or Inherited Sterility Help?



# Applications for Research

Test *C. cactorum* against key native *Opuntia* species from across the U.S. to …

elucidate its potential host range

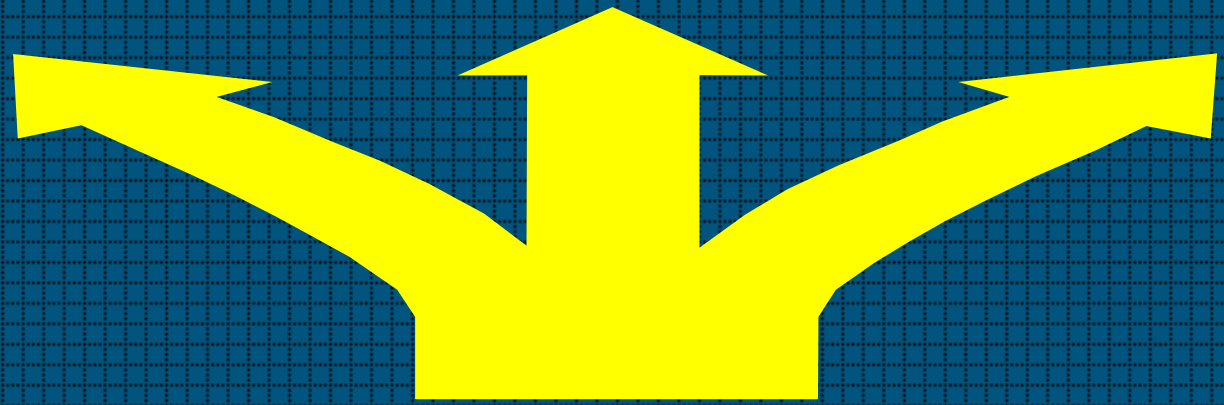
# Applications for Research

Conduct field studies of overwintering and larval development to …
predict potential geographic range

# Applications for Research

Utilize $F_1$ sterile eggs/larvae/pupae to …
determine the potential impact of native parasitoids/predators on the spread of *C. cactorum*

# Conducting Surveys



Beyond the leading edge …

# Applications for Management

Release irradiated moths for control or eradication

Isolated and/or environmentally sensitive areas such as the Florida keys

Leading edge of *C. cactorum*

# Applications for Management

Provision of sterile C*. cactorum* in the field to …
increase the initial survival and buildup of released natural enemies


Hero or Villain?
Friend or Foe?

# How can we respond to a pest invasion?

## Strategies

- Prevent pest from establishing a breeding population
- Eradicate an established pest population
- Develop pest management tactics

# Prevent Establishment of Exotic Insect Pests ...

## Examples ...

Medfly

Pink bollworm

# Eradicate Exotic Insect Pests …

## Examples …

Asian longhorned beetle

Medfly

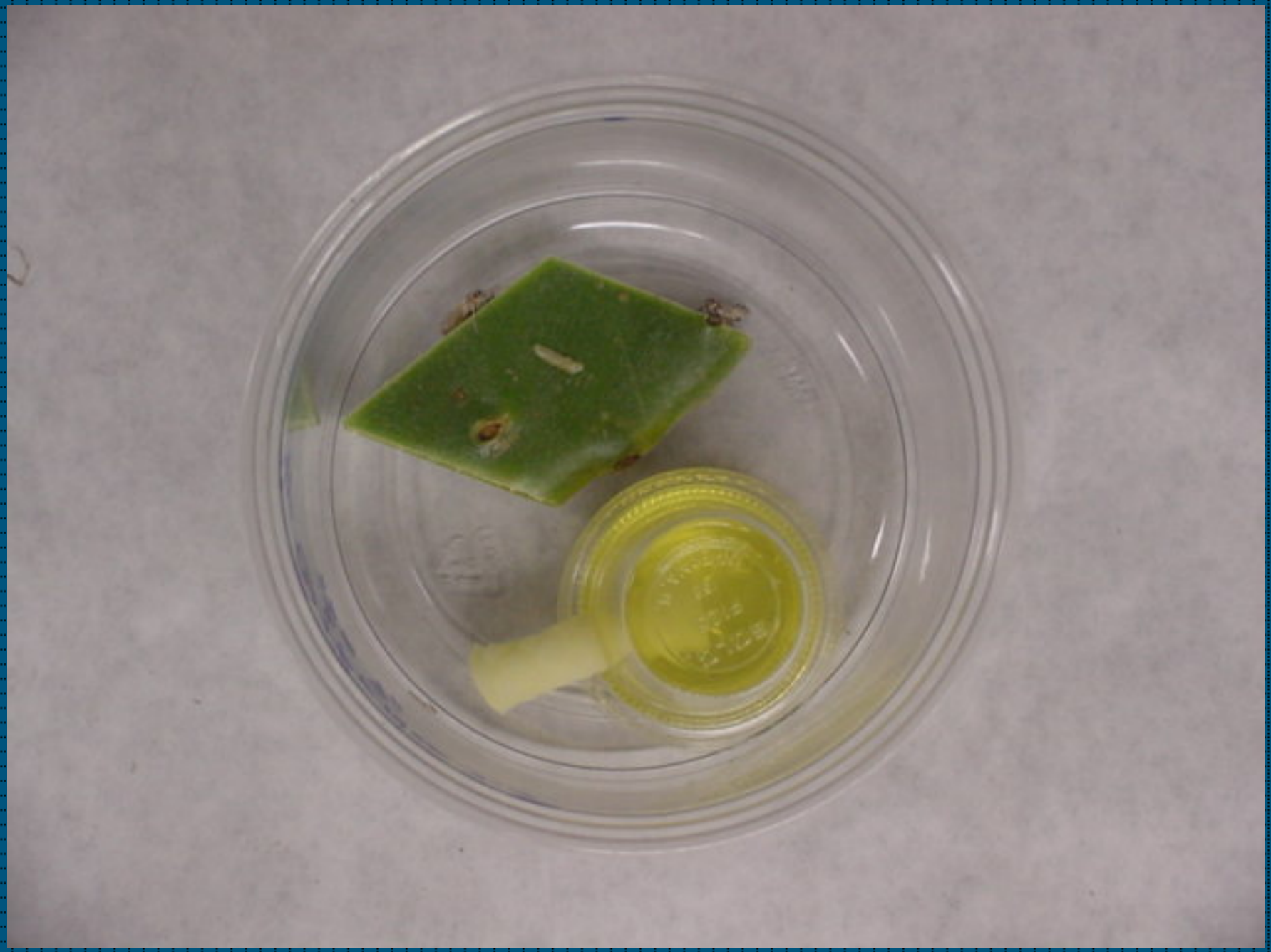
New world screwworm

# Response to an Exotic Pest Infestation

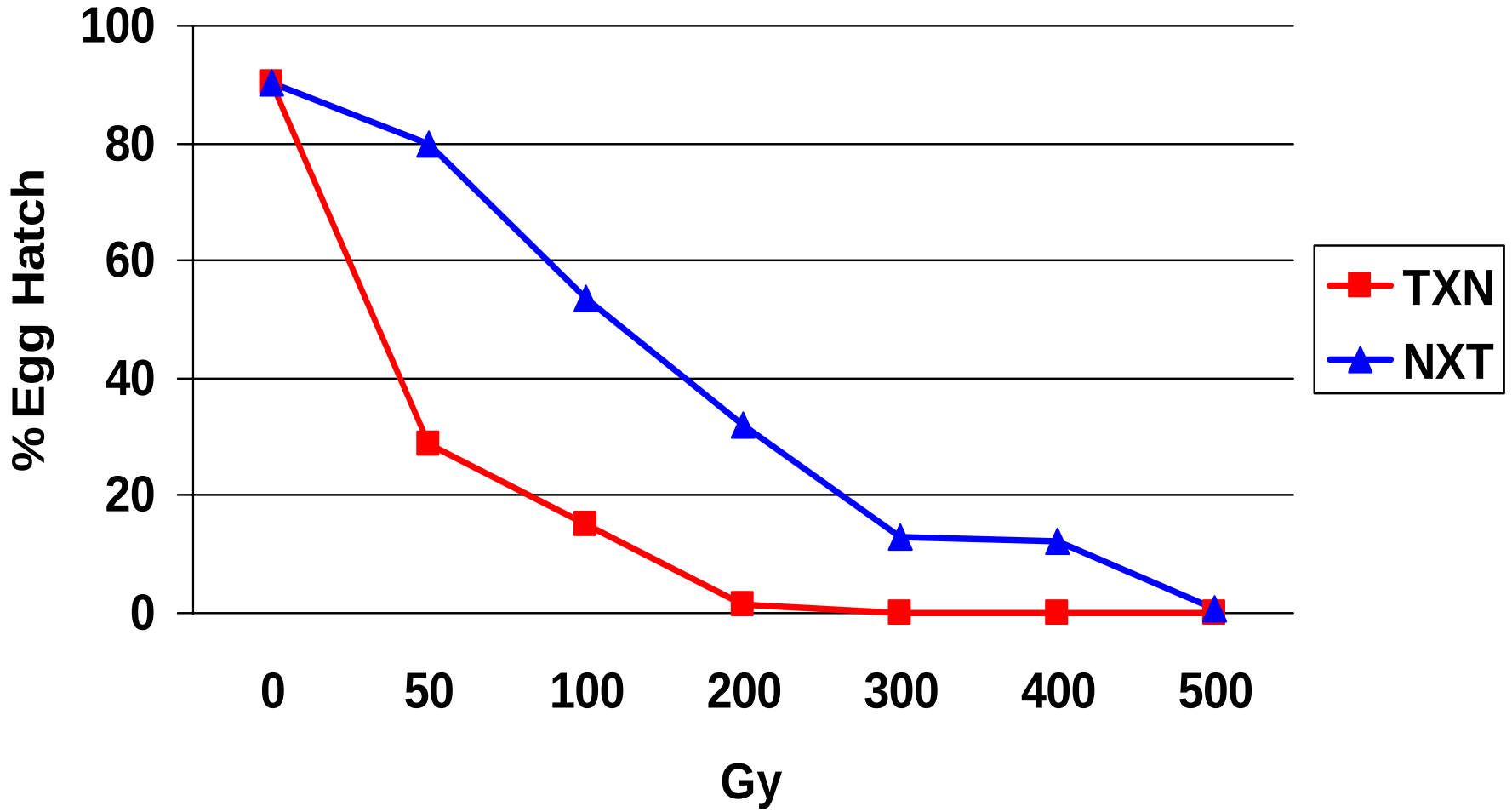
Prepared

Unprepared

Conclusion …
Response protocols should be developed proactively



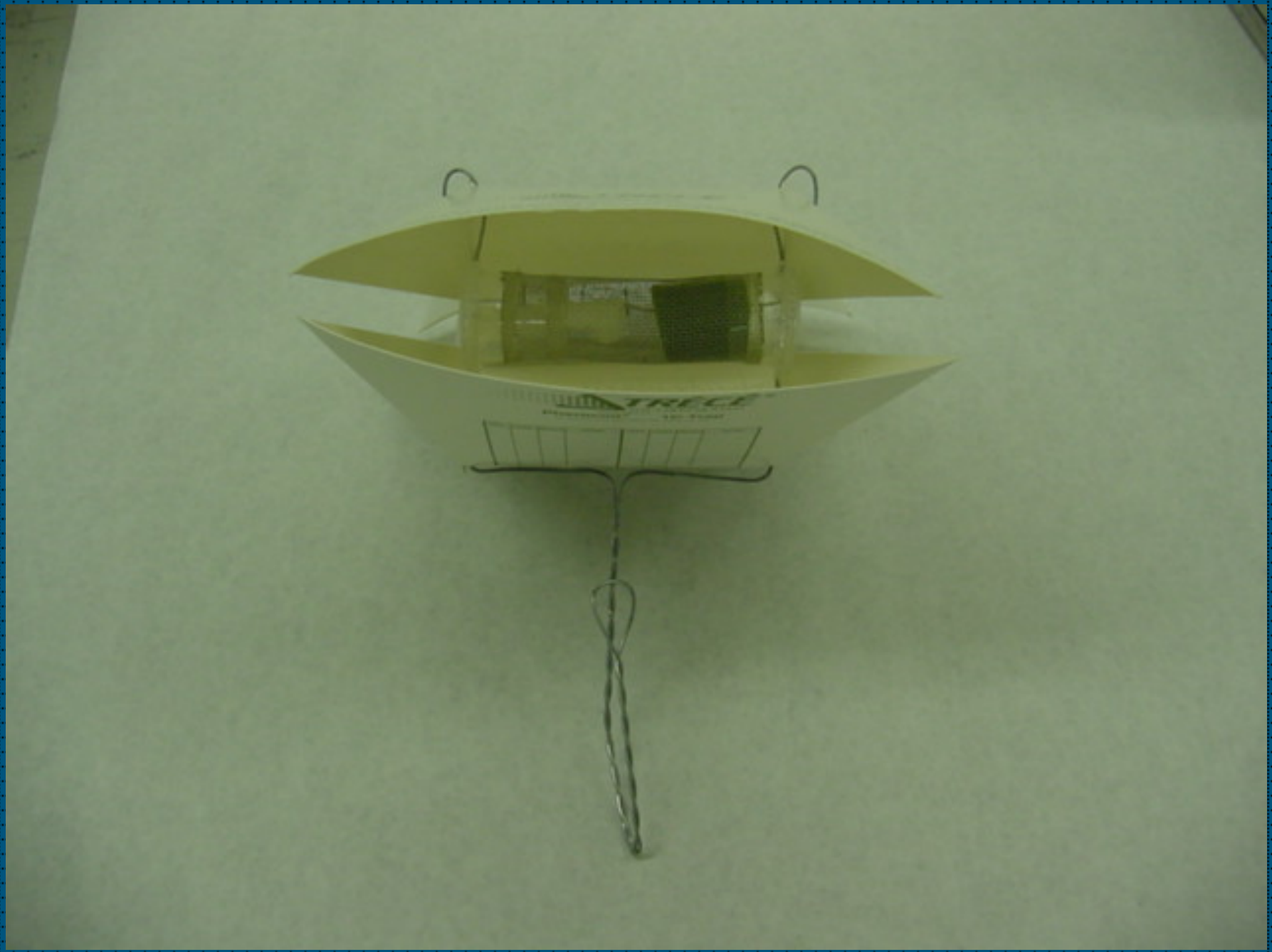
# Effect of Radiation on *Cactoblastis cactorum*
## Percent Egg hatch



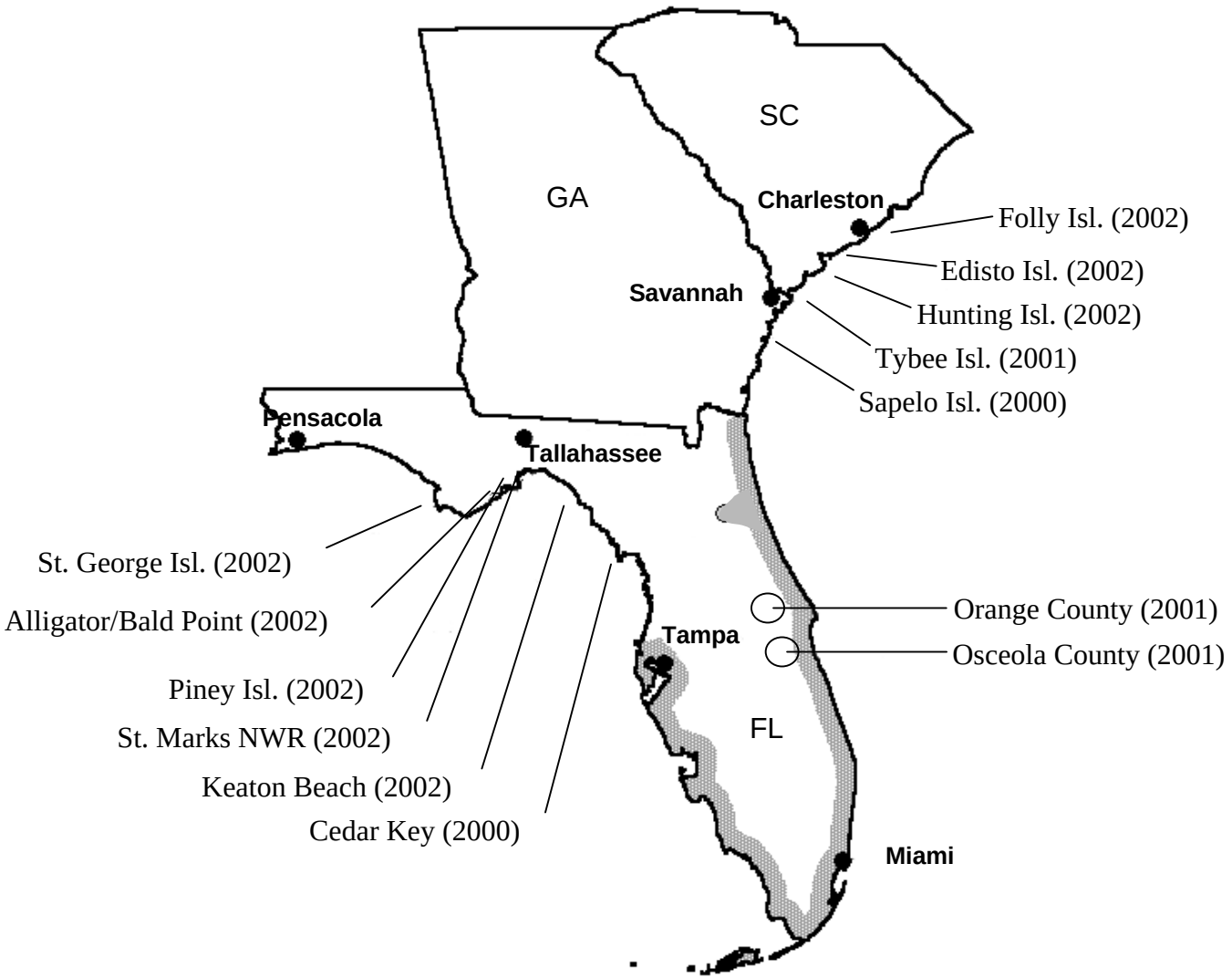

University of Florida
- Department of Entomology and Nematology

Florida Department of Agriculture and Consumer Services
- Division of Plant Industry

http://creatures.ifas.ufl.edu/bfly/cactus_moth.htm




Pherocon
Trécé


SC
GA
Charleston
Folly Isl. (2002)
Edisto Isl. (2002)
Savannah
Hunting Isl. (2002)
Tybee Isl. (2001)
Sapelo Isl. (2000)
Pensacola
Tallahassee
St. George Isl. (2002)
Alligator/Bald Point (2002)
Orange County (2001)
Tampa
Osceola County (2001)
Piney Isl. (2002)
St. Marks NWR (2002)
FL
Keaton Beach (2002)
Cedar Key (2000)
Miami

“Expanding geographical range of *Cactotblastis cactorum* (Lepidoptera: Pyralidae), in North America”

Florida Entomologist (in press)

S. D. Hight, J.E. Carpenter, K.A. Bloem, S. Bloem, R. Pemberton and P. Stiling