Physical Control of Stored-Product Insects: Exclusion Techniques

Exclusion Topics

- Structural considerations
  - Exterior design and maintenance
  - Lighting
  - Doors and windows
  - Incoming inspections
  - Transport vehicles
  - Movement inside
- Product packaging
  - Types of insect pests
  - Insect entry
  - Package design
  - Package improvement

Exclusion: Preventing insects from outside entering a building or a package!

Complex Environments

Exterior Maintenance

- Rock (not bark) perimeter
- No ground cover (plants) near buildings
- No standing water
- No fruit trees

Exterior Design

- Avoid window ledges
- Few windows
- Concrete foundation above ground
- Drainage on roof
- Garbage vestibule (far away from building on a concrete pad)

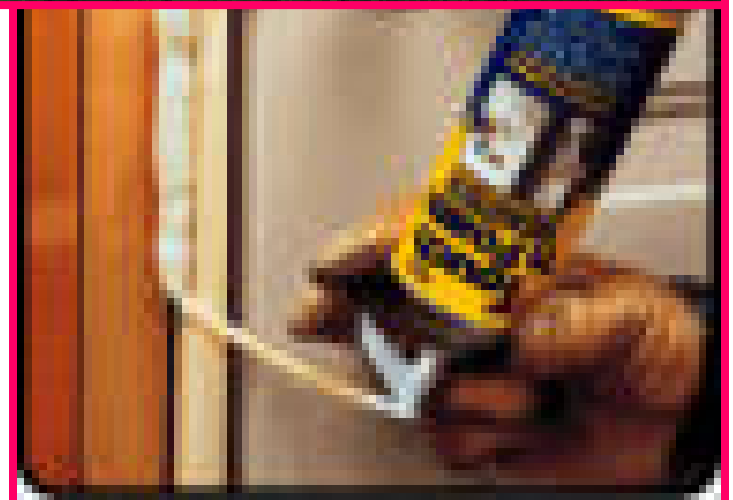
Lighting

- White lights away from buildings
- High pressure sodium lights near buildings
- No lights near doors and windows

Lights should be away from buildings. Increases site Security. Makes the building exterior well lit.

Doors and Windows

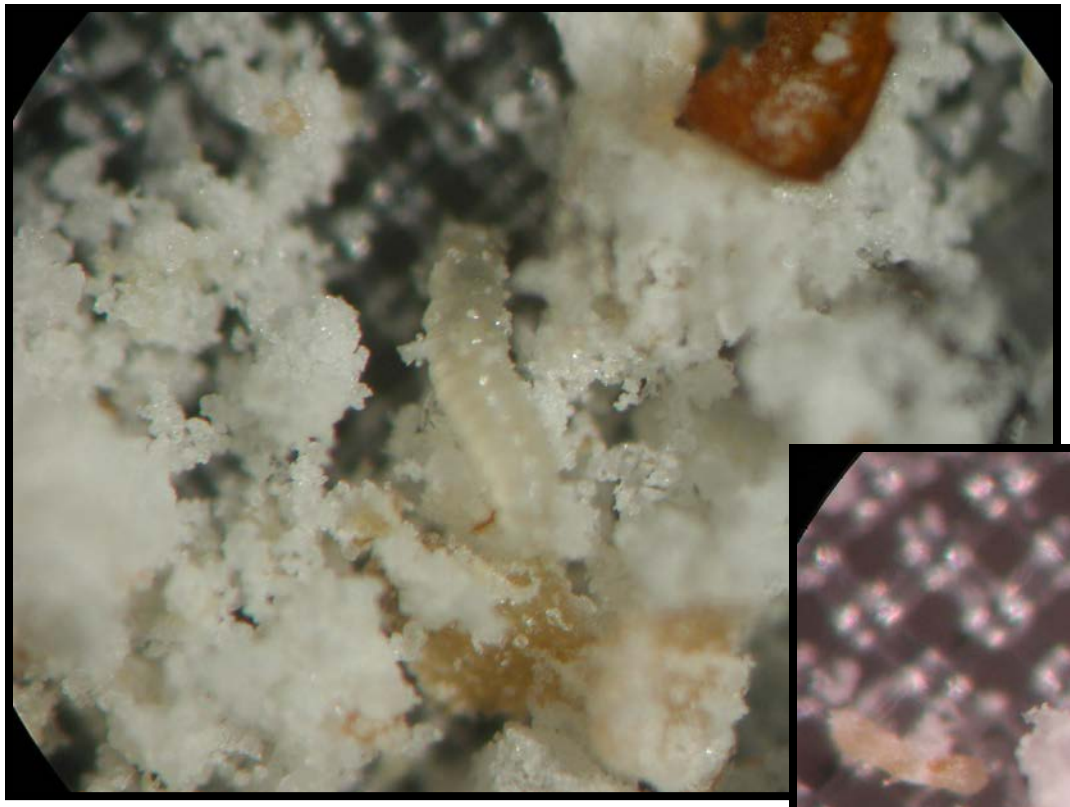
- Properly screen windows
- Seal cracks
- Sweeps below doors
- Attention to overhead doors



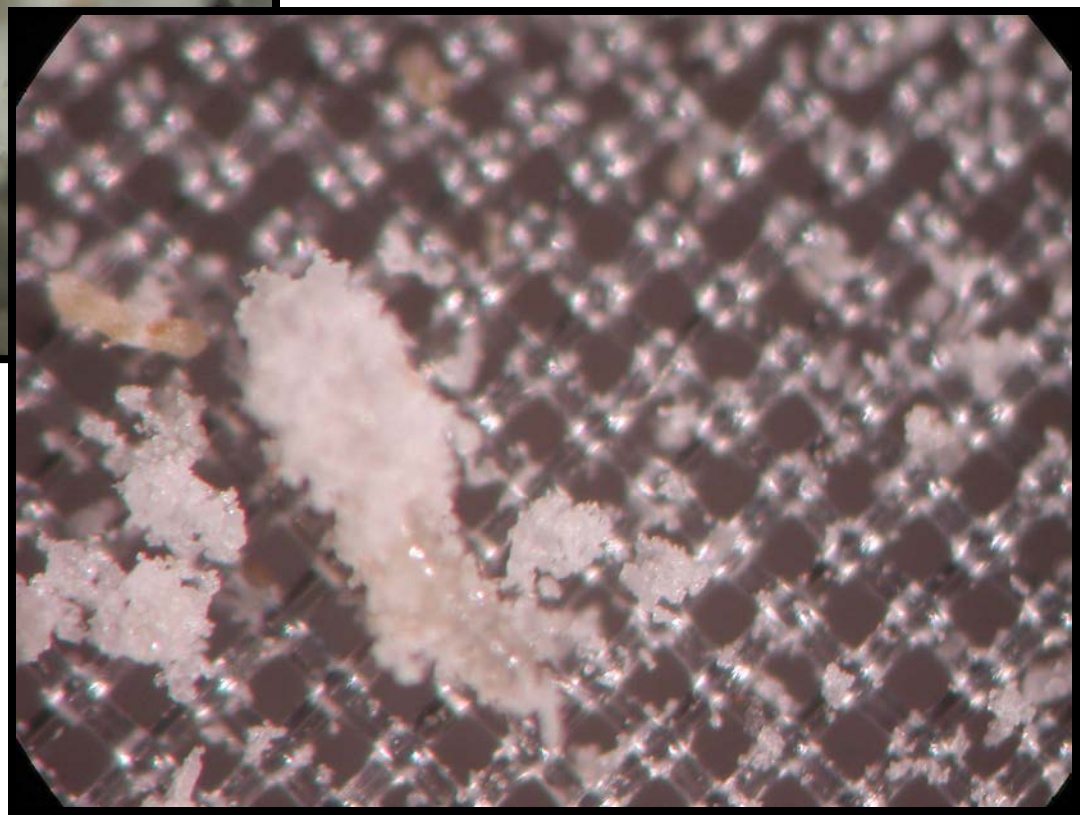

BUG SHIELD™

Pest Exclusion by Meshes

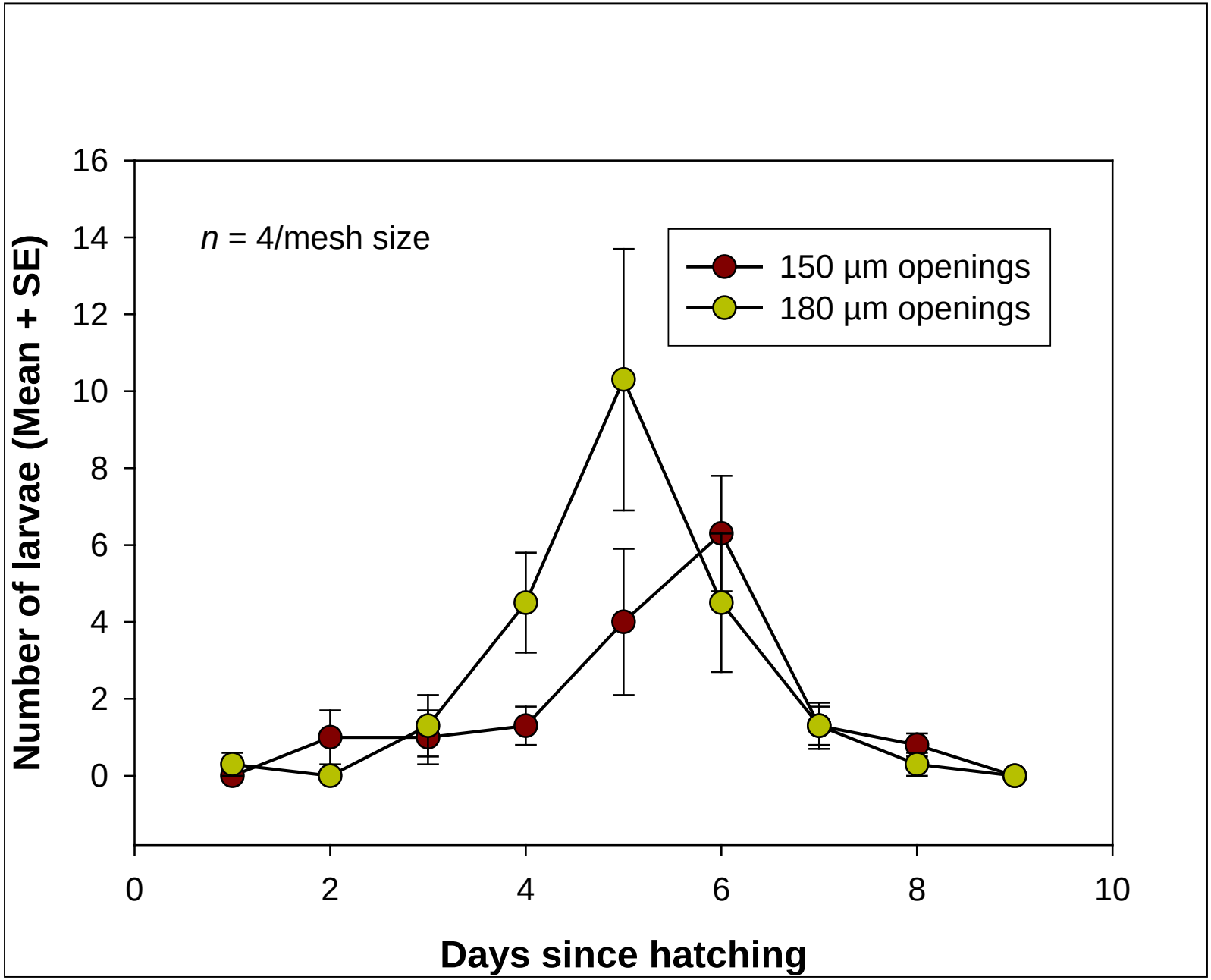
First Instars of Red Flour Beetle



Instars photographed on 150 µm mesh



Exclusion Test: Red Flour Beetle



Foreign Material (FM) Removal

- FM of same shape and size as food product is difficult to remove
- String, paper, plastic, and wood
- Generally, foreign material passes over the screen
- Several screens may be used for more efficient FM removal
- Make sure that scalper's mesh does not contaminate the product (use zinc plated or series 400 stainless steel wire, silk screens, nylon screens)
- Understand influence of high temperature on screen integrity

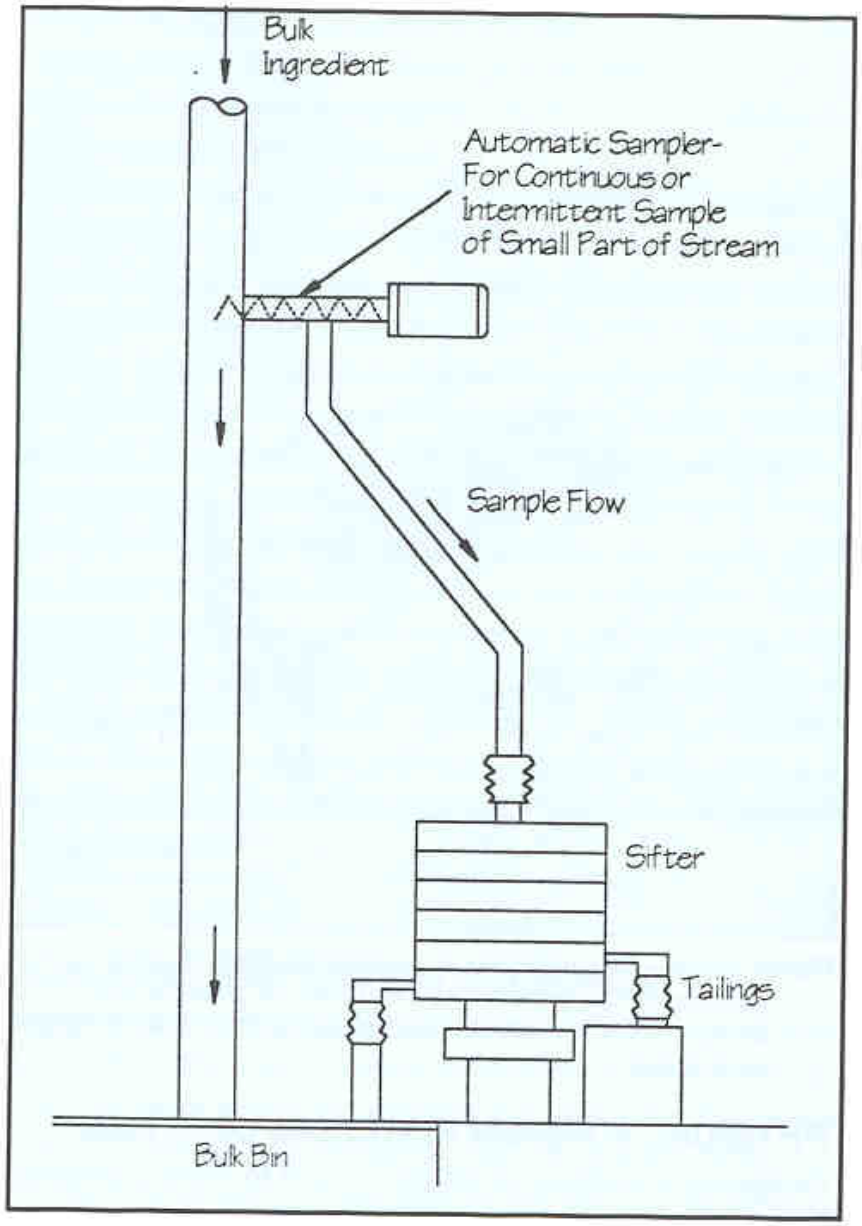


Figure 12-50 –Periodic or continuous sampling of incoming ingredients

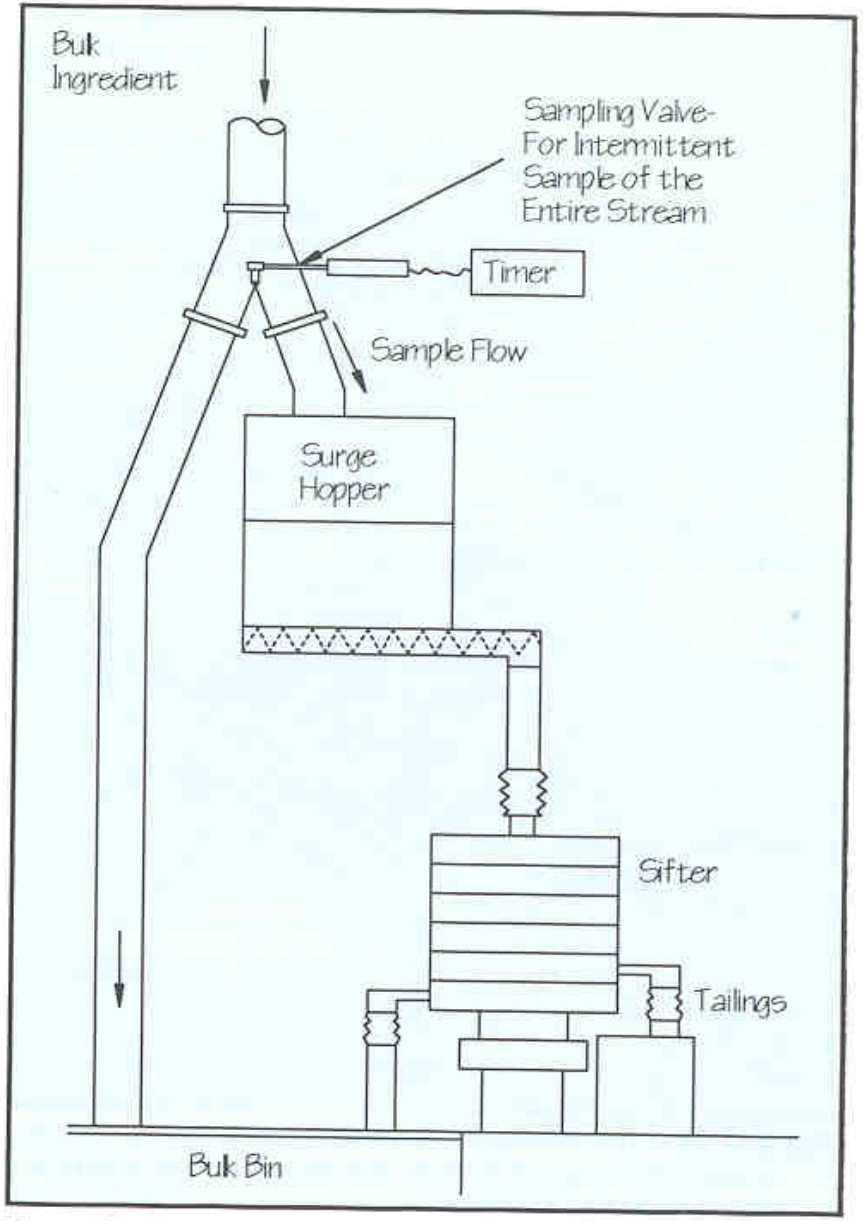


Figure 12-51 – Momentary sampling of a complete stream of incoming ingredients

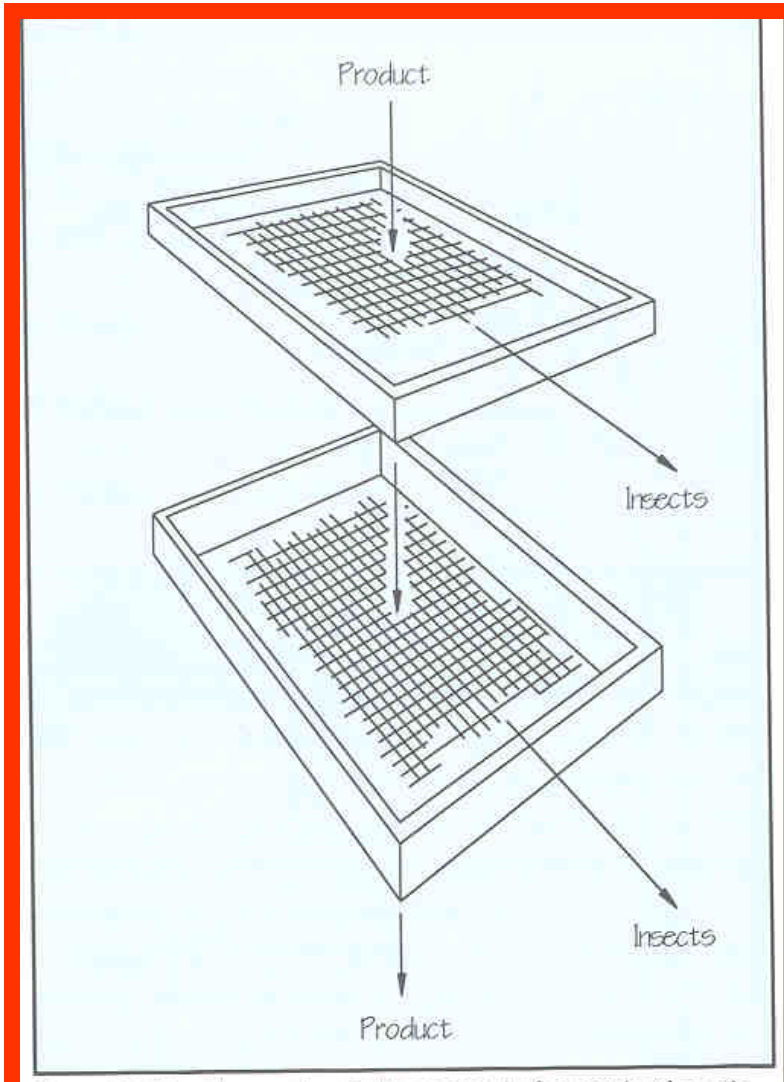


Figure 12-52 – The most reliable method of removing insects passes the product through the sifting screen and tails the insect over the screen.

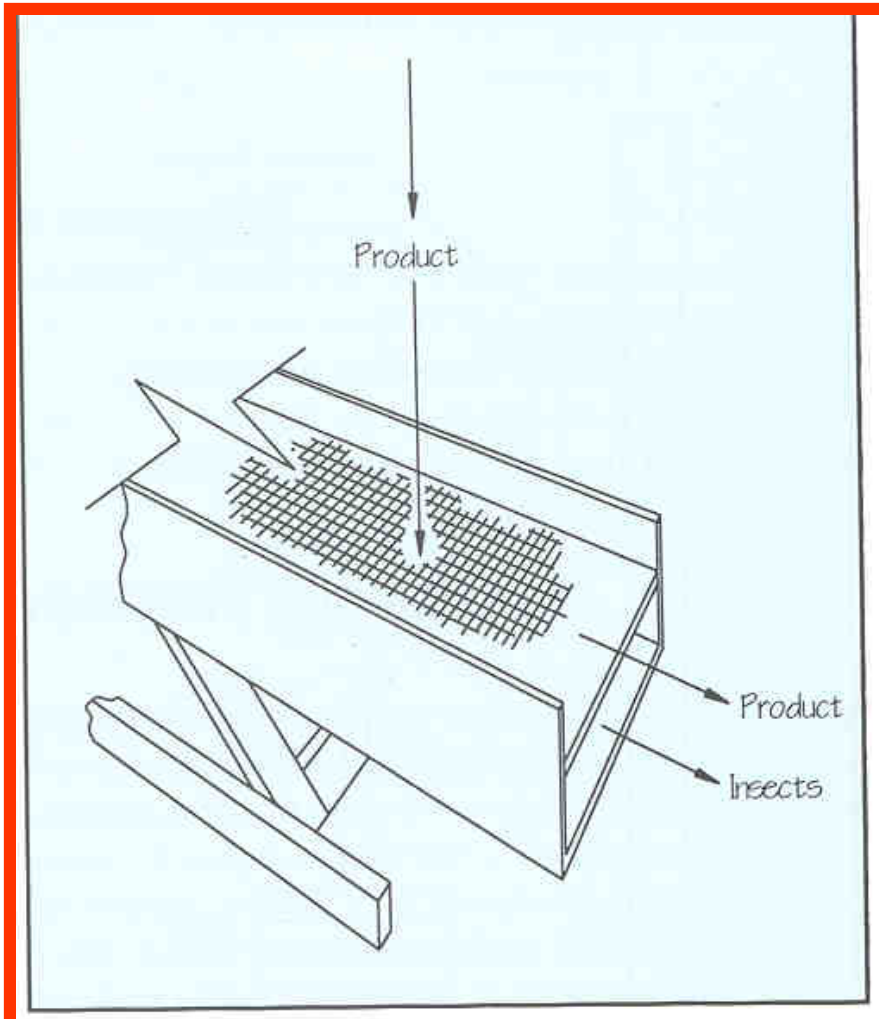


Figure 12-53 – Less reliable as a removal method, but worthwhile as a measurement tool, is passing the product over the screen and passing the insect through as a reject.

Incoming Inspections

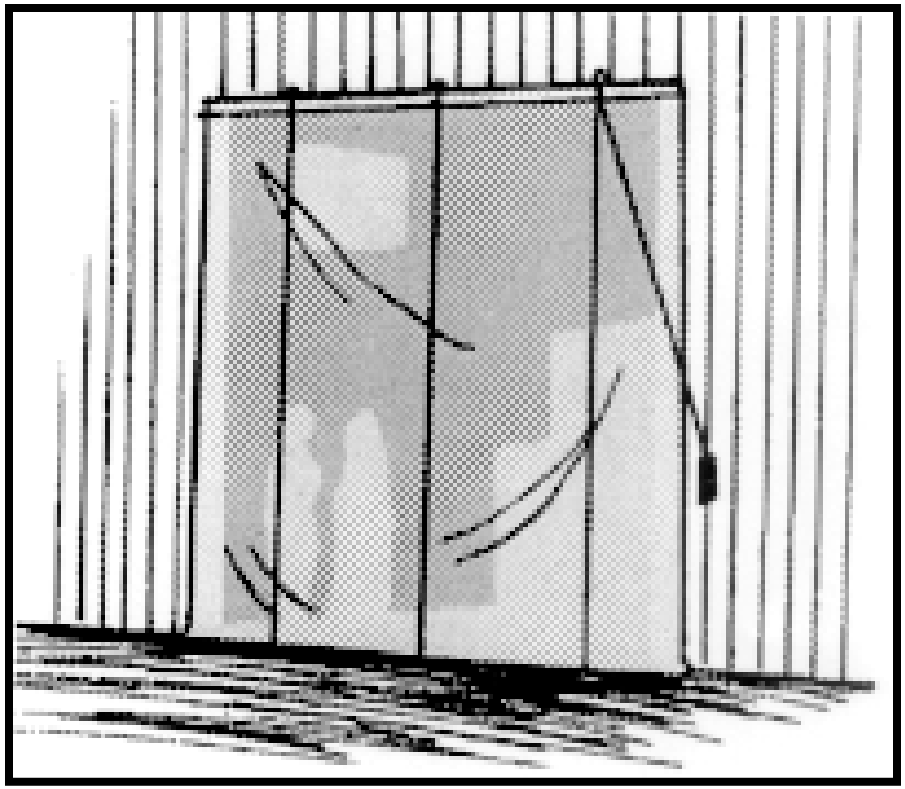
- Pallets
- Used equipment
- Live plants in offices
- Food prep.; receiving
- Grain products
- Spillage on drums

Transport vehicles

- Inbound/outbound inspection
- Seals in place
- Trailers/cars clean

Movement Inside

- Air curtains
- Positive pressure in building
- Plastic strips in doorways
- Seal cracks in walls, floors, bases of equipment, and ceilings



Product Packaging

- A package is a combination of materials, machinery, and economics that together provide protection, unification, and communication

- Outline
  - Types of insect pests
  - Insect entry
  - Package design
  - Package improvement

History of Packaging

- 1618-1648……1st use of paper bags
- 1800's……Canned goods
- 1894……Corrugated paper
- 1911……Paper/paperboard
- 1970……Plastics, metallized films

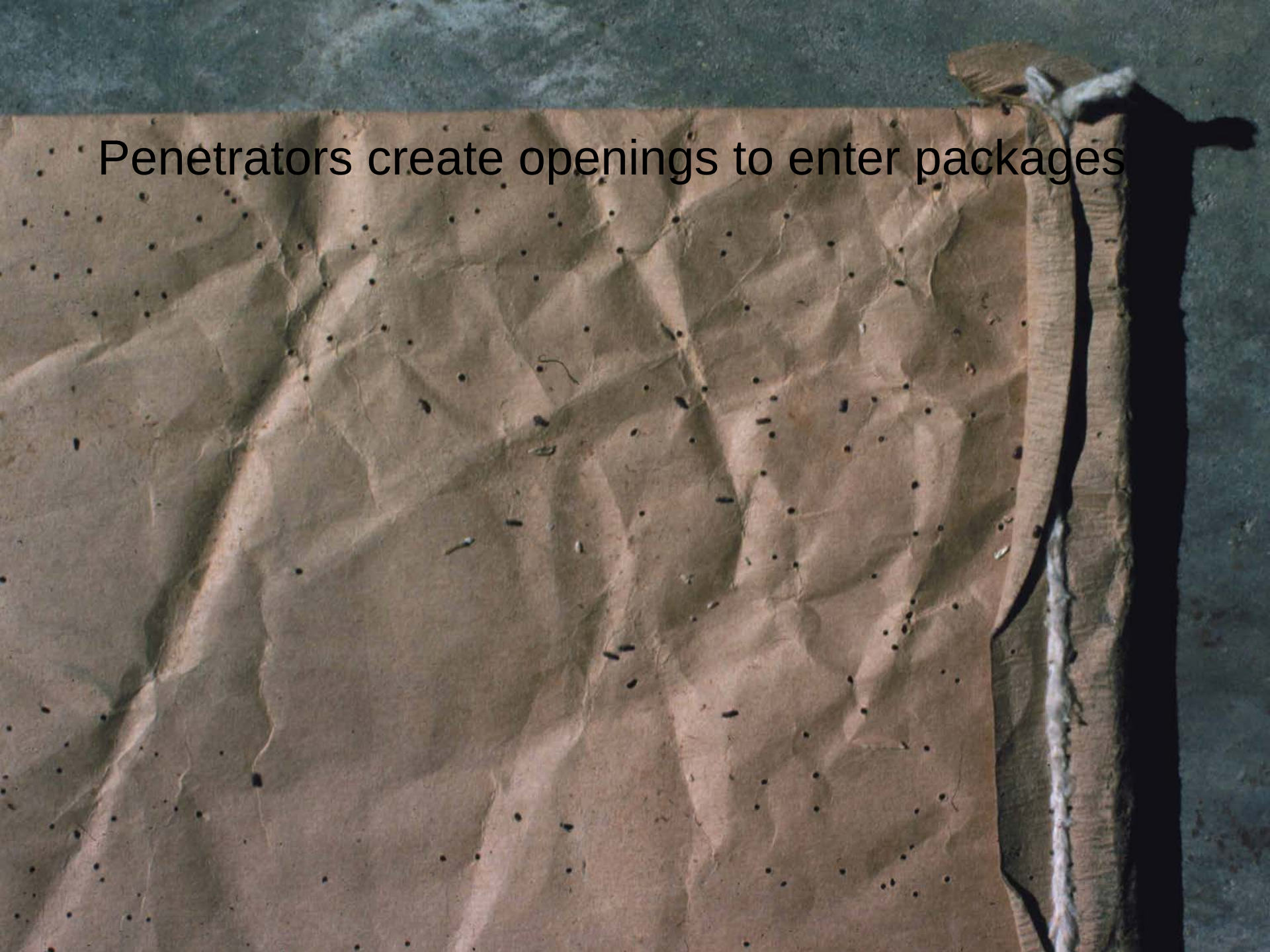
Insects that Attack Packaged Foods

Invaders

- Red and confused flour beetle
- Sawtoothed grain beetle
- Indianmeal moth larvae
- Merchant grain beetle

Penetrators

- Warehouse beetle larvae
- Cigarette beetle larvae
- Indianmeal moth larvae
- Rice weevil
- Lesser grain borer

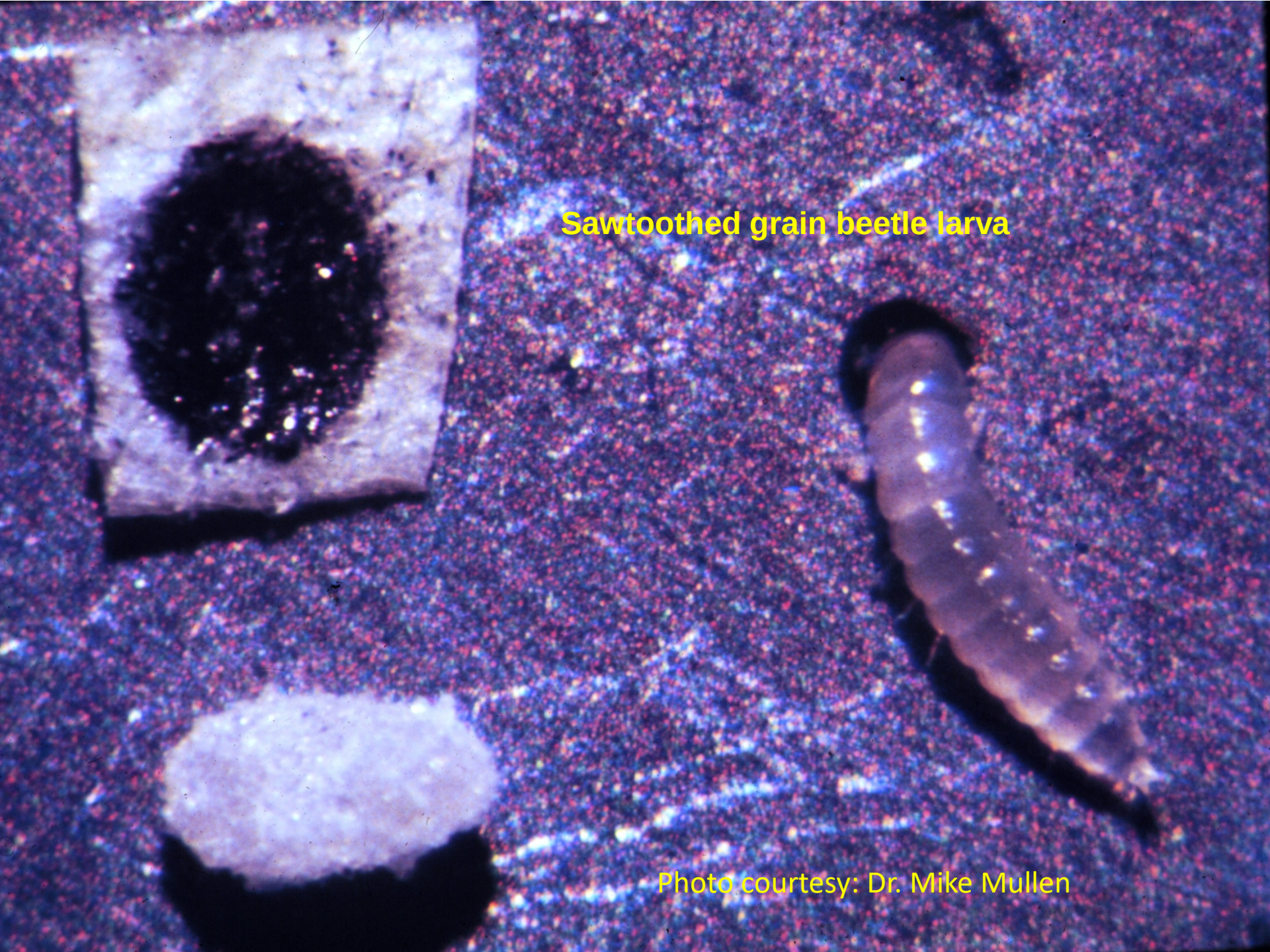

Penetrators create openings to enter packages

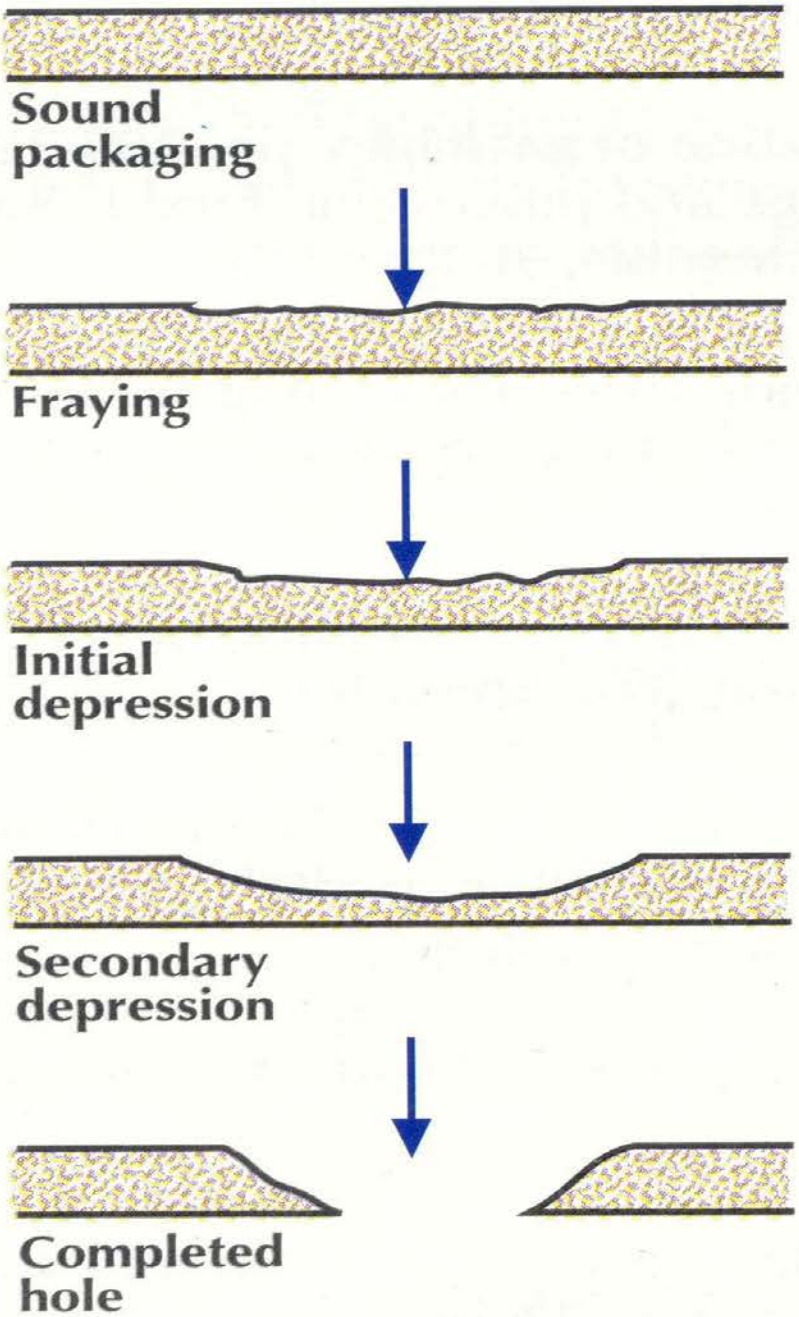
Invaders use natural openings to enter packages

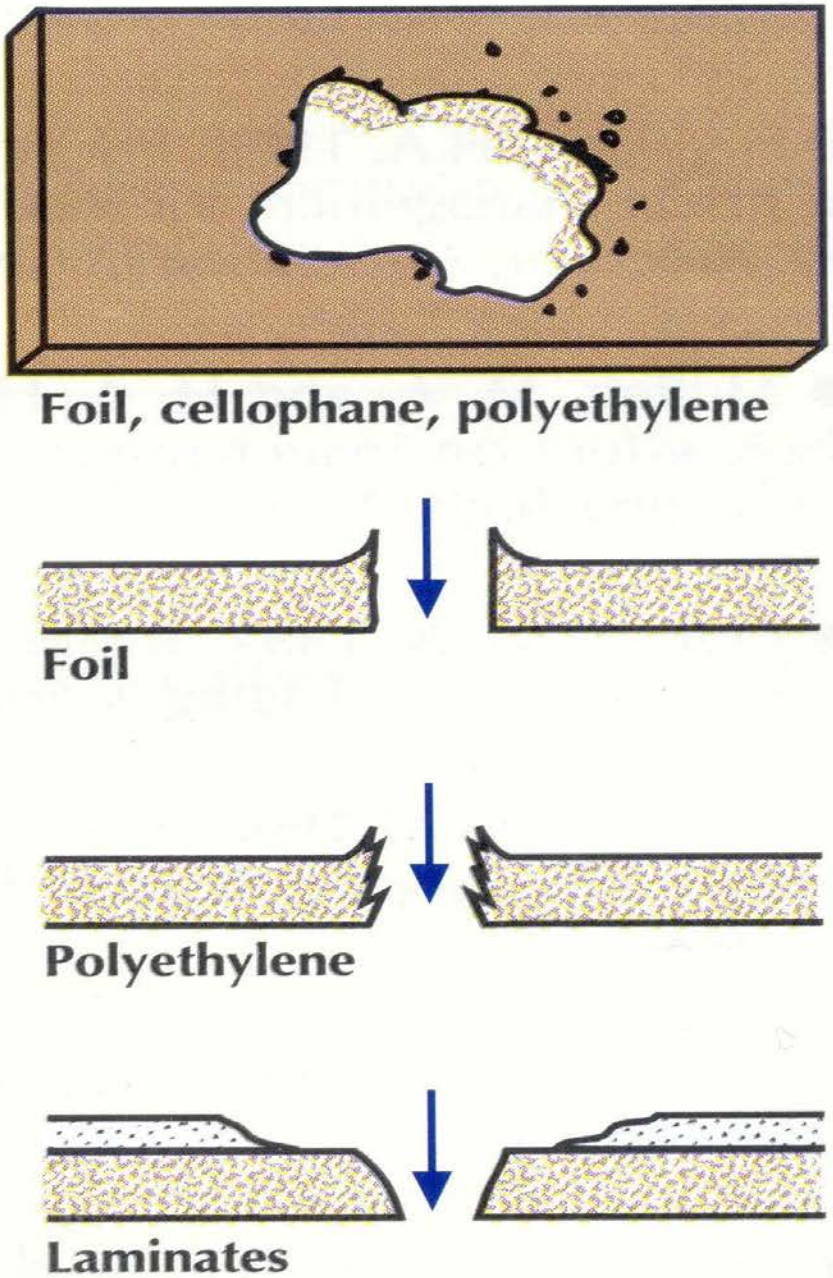
Sawtoothed grain beetle larvae

Photo courtesy: Dr. Mike Mullen

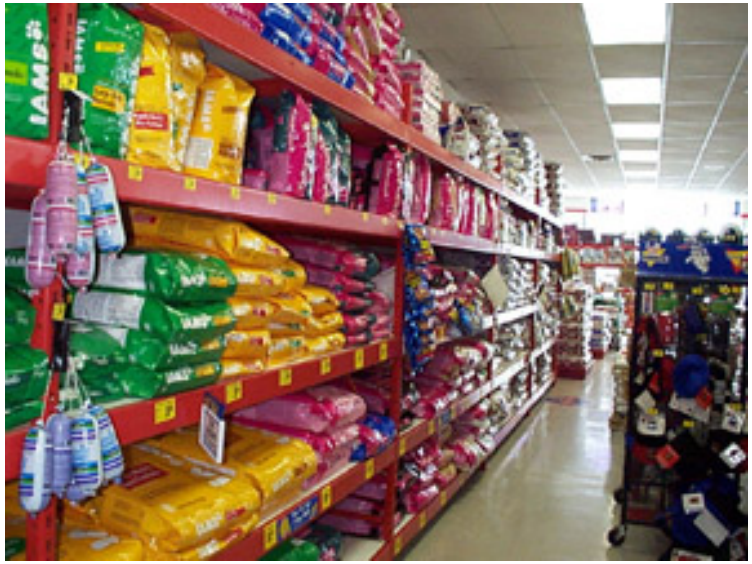

Eggs of the sawtoothed grain beetle
Photo Courtesy: Sharon Mowery, KSU


Sawtoothed grain beetle larva
Photo courtesy: Dr. Mike Mullen


Sound packaging
Fraying
Initial depression
Secondary depression
Completed hole


Foil, cellophane, polyethylene
Foil
Polyethylene
Laminates

Typically infestations occur in retail stores



Infestations can also occur at homes

- If packaged products are stored in the garage or in non-airtight containers
- Unusual case in UK (Baker and Swan 2013)
  - *Tyrophagus longior* (storage mite) in a cupboard

Fig. 1 (A & B). Arrows indicate areas examined. Webbing was found along the serrated edge (green arrow); larval silk threads were observed on the blue portion close to the edge (orange arrow); fecal pellets were observed on the wrapper exterior (white arrow; pellets removed for a close-up photo); and inside of wrapper (red arrow). The pink arrow points to an exit hold made by larvae (see other pictures for a close-up of this hole).

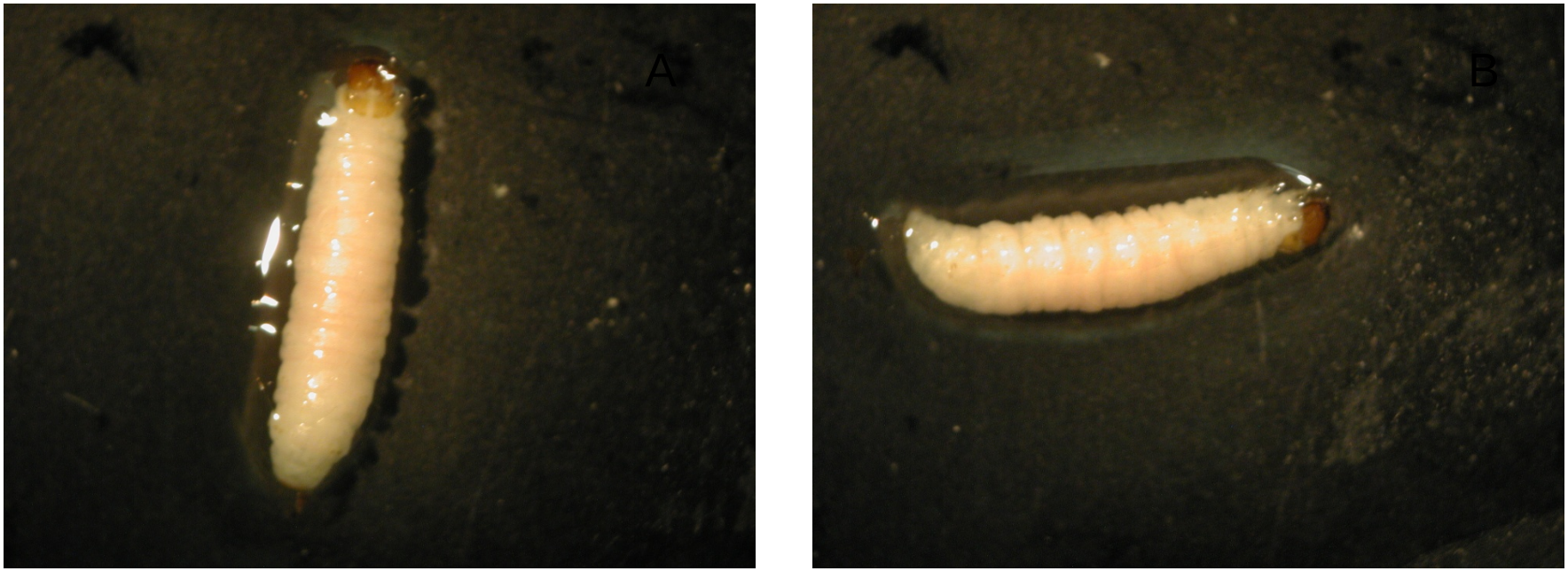
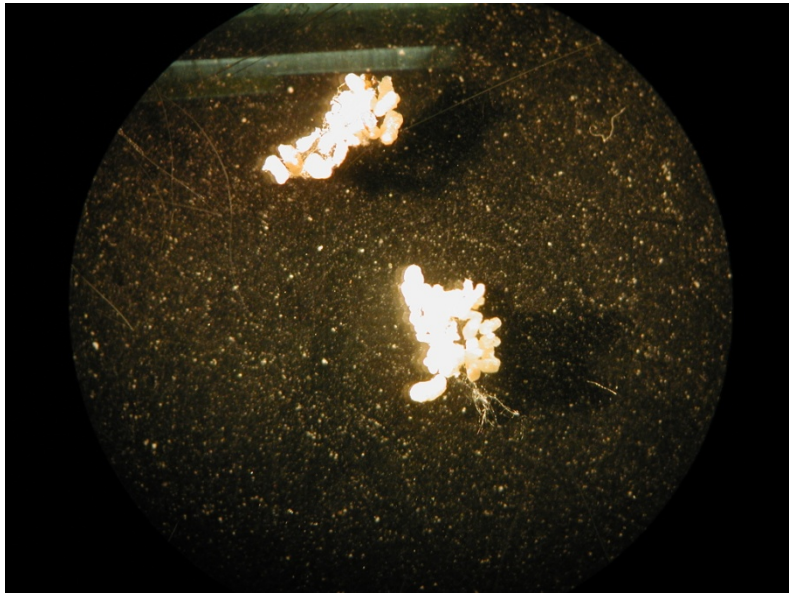


Fig. 2. Fully-gown Indianmeal moth larvae that was alive when the sample was shipped for my assessment. A. Dorsal view of larvae (the larvae is a female). B. Lateral view of larvae.



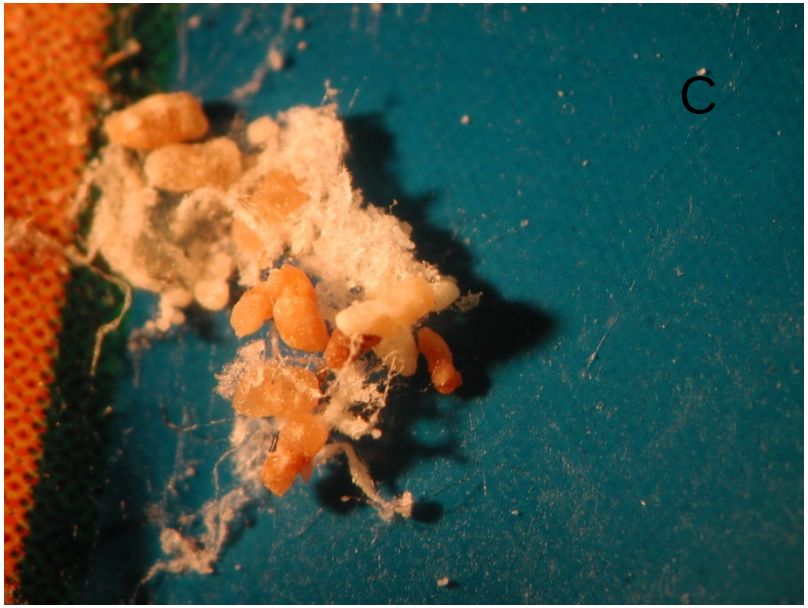


Fig. 3. Fecal pellets produced by Indianmeal moth larvae found outside the wrapper. Pellet clusters under low magnification (A) and high magnification (B and C). Color differences were caused by different light intensities used.

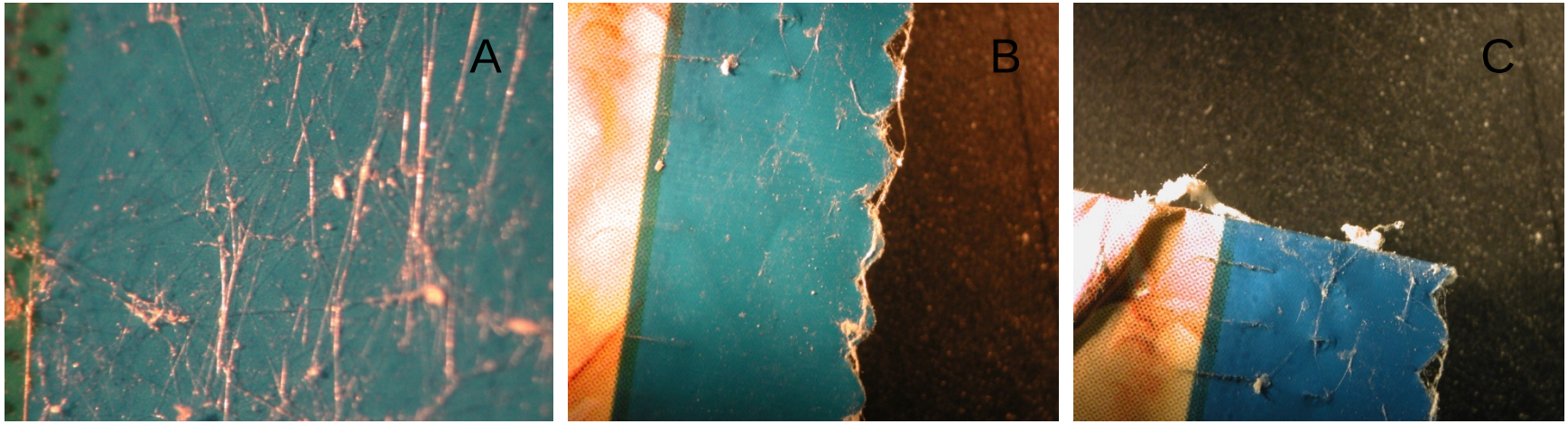
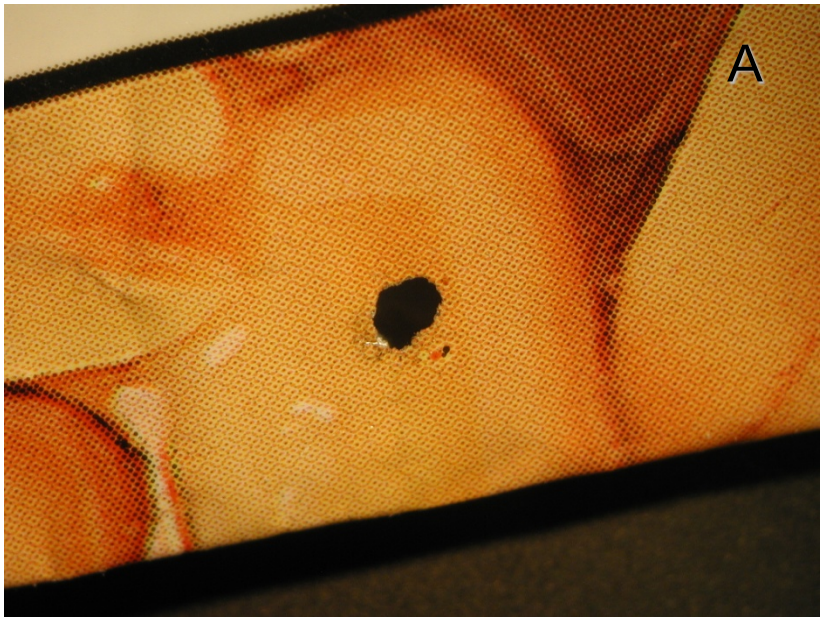
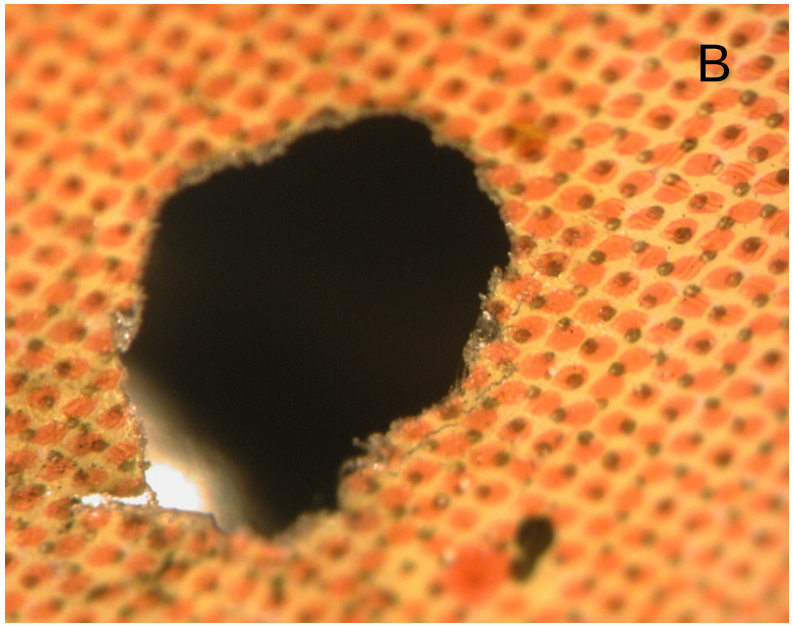


Fig. 4. Silk threads produced by Indianmeal moth larvae on the package (A), on the serrated edges of the package (B), and below the serrated edges (C).





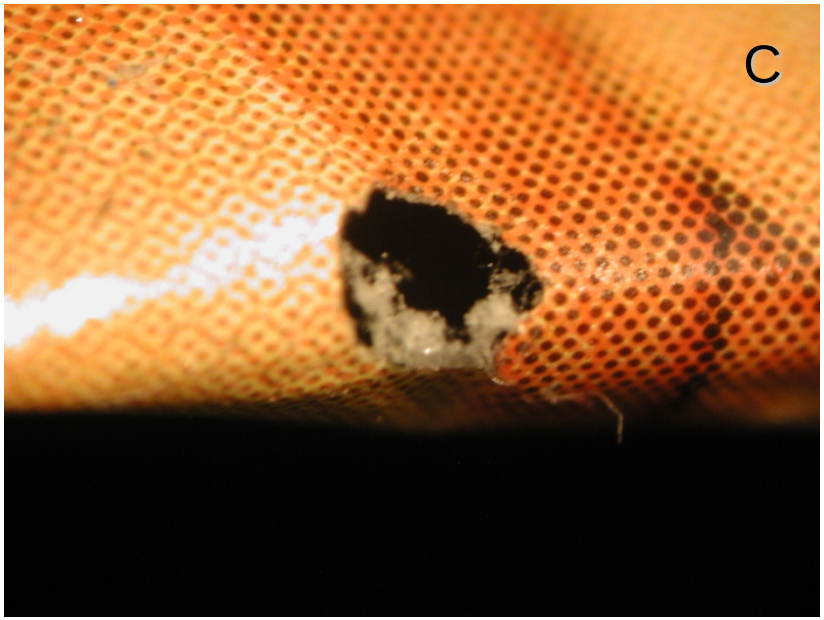
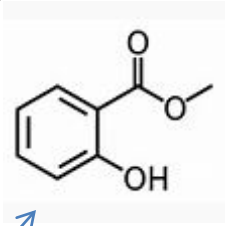


Fig. 4. A & B. Close-up of exit hole shown in Fig. 4A.
C. Close-up of exit hole shown in Fig. 4B.

How Are Packages Improved?

- Better seals and closures
- Overwraps
- Odor barriers
- Repellent materials (methyl salicylate)
- Liners
- Membranes

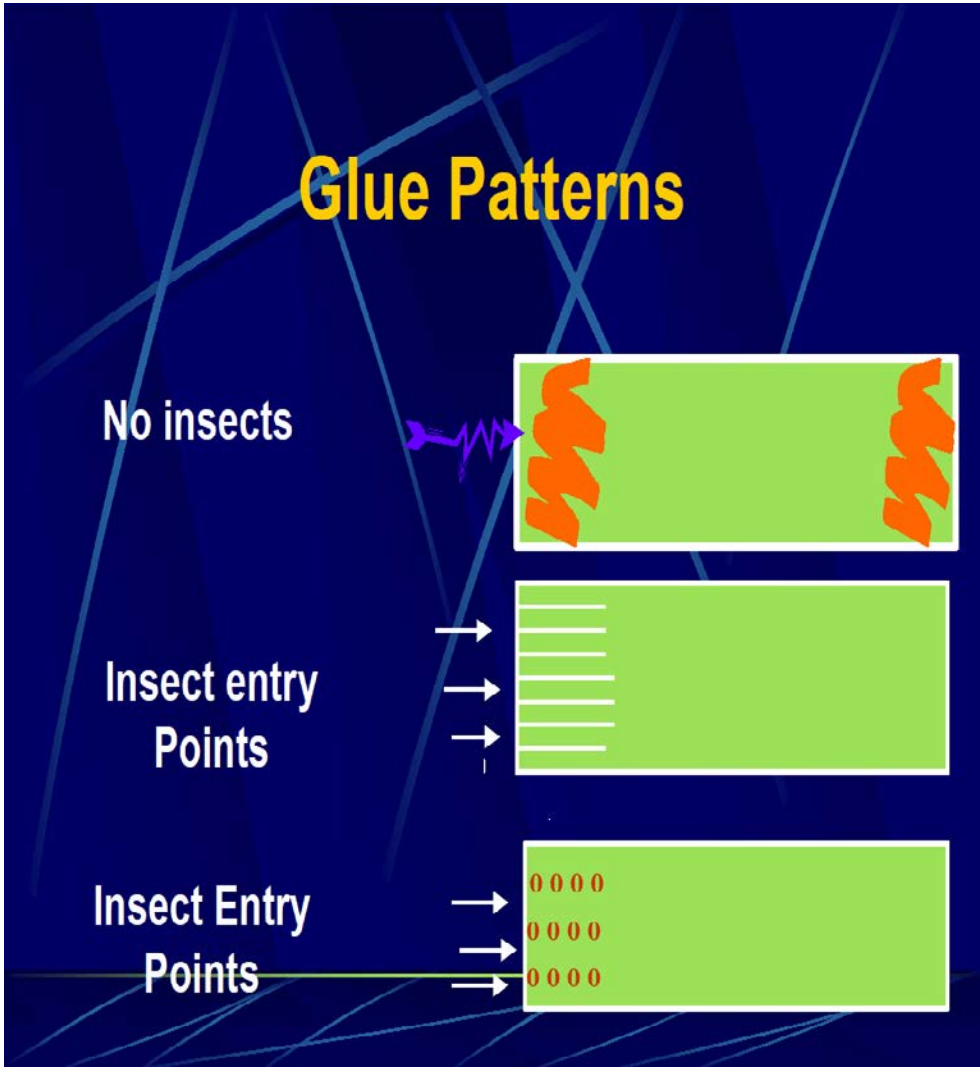
Has a plastic overwrap (odor barrier)



Methyl salicylate (oil of wintergreens)

Glues

- Hot melt is better than cold melt for insect resistance because of flowability
- Low temp hot melts are safer because they melt at 250ºC compared to 350ºC
- Complete coverage is essential for infestation control



Packages

- Standard has been multiwall paper bags with woven closure
- Multiwalls are easily torn apart by hungry pets and often entered by insects
- Standup pouches are becoming more popular

- Paper packages can let aroma out making the contents susceptible to insect infestation
- Volatile flavor compounds cannot leave the package and the product will not smell in the store or the kitchen
- Polyethylene bags with an odor barrier are gaining popularity

Gold Medal Flour Zip Pack

- This represents the first change in flour packaging in over 70 years
- It is a 4.25-pound resealable Zip-Pak that stands up, opens wide, and is easy to scoop.
- It also has good insect resistance

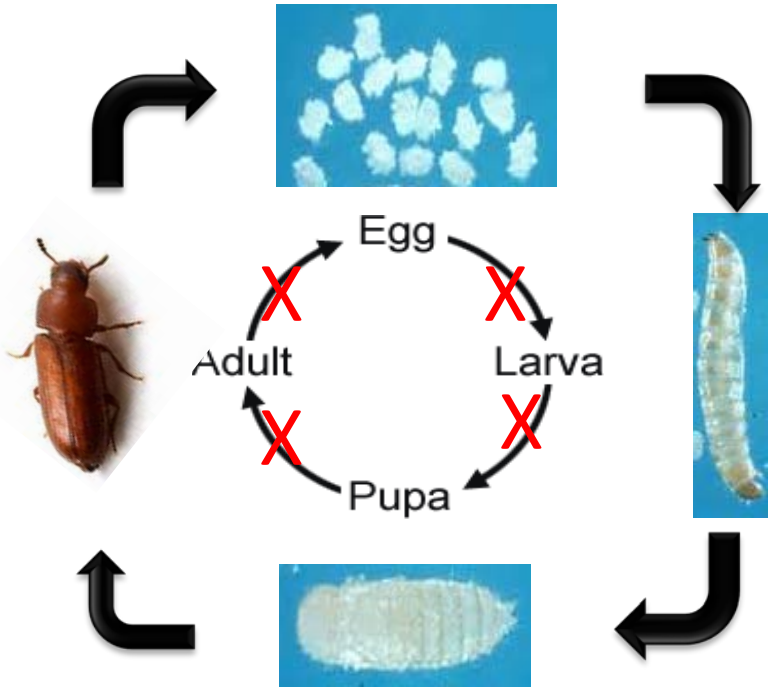
New packaging technology

- ProvisionGard Technology LLC (www.provisongard.com)
- Can be applied to bags, cartons, and boxes
- Outside or inside of packaging coated with an insect growth regulator, *S*-methoprene (Diacon IGR)
- Water-based coating

ProvisionGard™ The Science

Food packaging coating that eliminates insect infestations

IGR
(Insect Growth Regulator)



Chemical	Toxicity (LD50)
Water	90000 mg/kg
Methoprene	34000 mg/kg
Vitamin C	11000 mg/kg
Table Salt	3000 mg/Kg
Caffeine	192 mg/kg

EPA Methoprene Tolerance

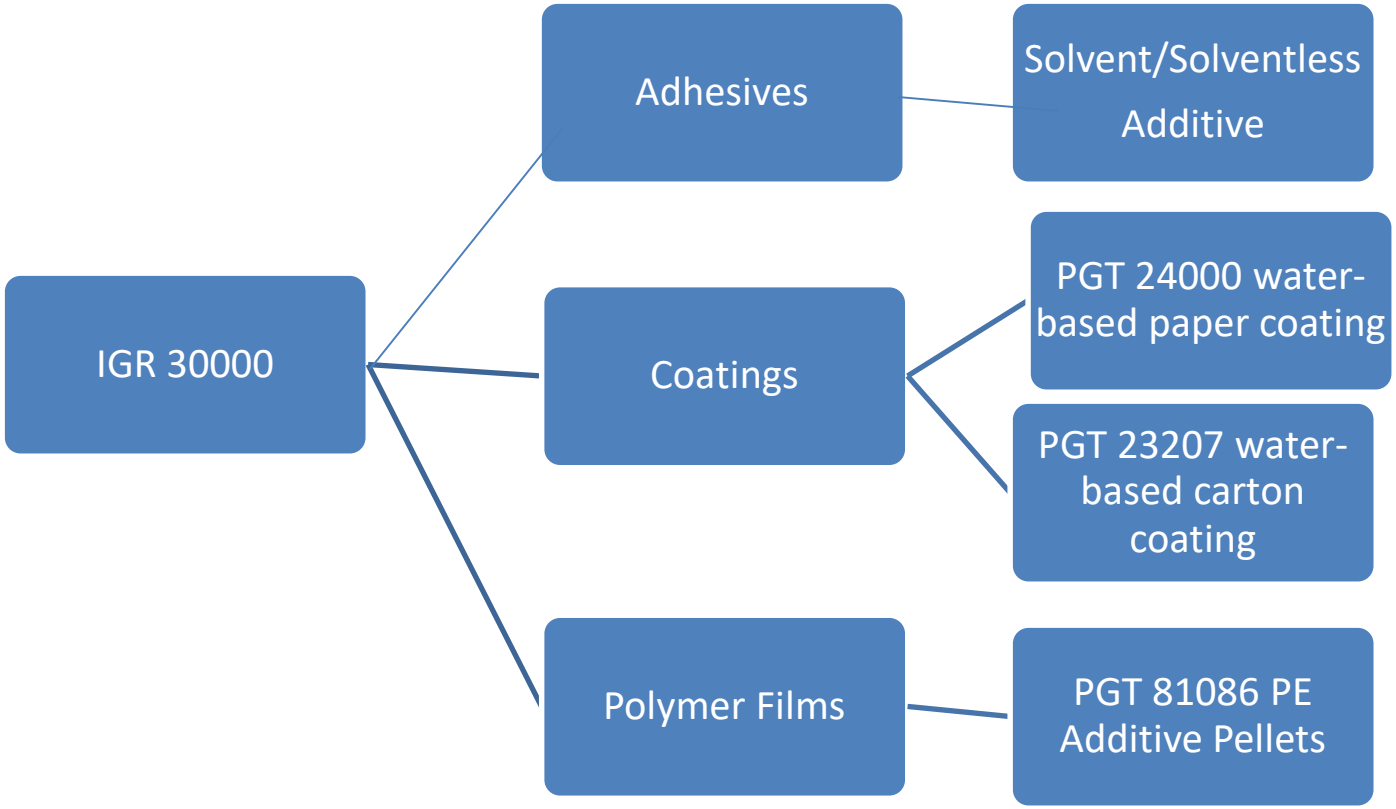
40CFR §180.1033

Methoprene is exempt from a tolerance in and on all Food commodities when used to control insect larvae.

ProvisionGard™ Commercially Available Products

PGT IGR 30000 EPA Labeled Additive for use on Food, Feed and Tobacco Packaging

EPA Registration Number 81390-2



ProvisionGard™ Commercially Available Products

Press Ready Water-base Coating

Applied to Paper Packaging

Multiwall Bags
Cartons- Cereal, Mixes etc.
Corrugate Boxes
Bulk Shipping Containers
Paper Canisters-Flour/oatmeal

Film Extrusion Ready PE Pellets

Extruded into Film Packaging

Woven Poly Bags
Blown film
Stretch film
Shrink overwrap films
Super Sacks

IGR 30000 Additive

Mixed into Adhesives

Form and fill plastic bags
Stand up PET Pouches
Two Play Film Bags

Passes odor and taste testing

Objectives

- The rice packages with PG adhesive additive were evaluated against:

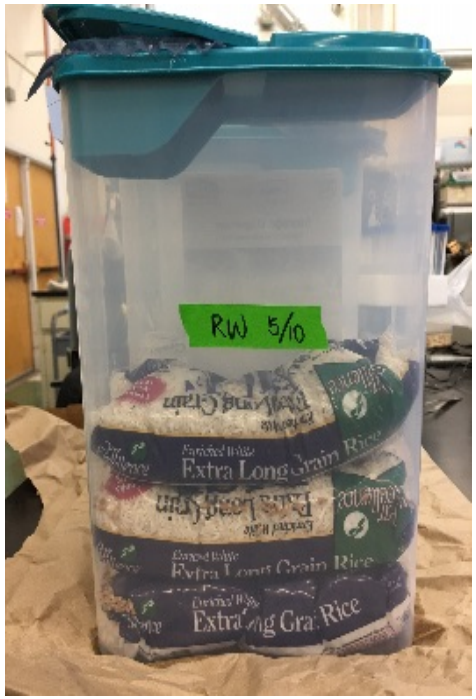
The Indian meal moth, *Plodia interpunctella* (Hübner)

The red flour beetle, *Tribolium castaneum* (Herbst)

The rice weevil, *Sitophilus oryzae* (L.)

Materials and Methods

- Rice was packaged in 0.45 kg (1 lb) and 9.1 kg (20 lb) film bags
- Three bags of 1 lb rice were placed in one 0.23 L plastic container as one sample unit
- Three bags of 20 lb rice were placed in one 53 L plastic container as one sample unit
- All sample units were kept on the shelf at room conditions (25°C and 28% r.h.) for three months
- After 3 months counts were taken of larvae and/or adults that emerged from eggs



Materials and Methods

- **<u>Indian meal moth (IMM)</u>**

One hundred eggs (<24 h old) were placed inside a black rubber ring of 2.5 cm diameter on the top bag in the container along with 5 g of Indian meal moth diet (poultry mash: honey: glycerin: water = 1000 g: 150 ml: 150 ml: 75 ml)

- **<u>Red flour beetle (RFB)</u>**

One hundred eggs (<72 h old) were placed inside a black rubber ring along with 5 g of whole wheat flour

- **<u>Rice weevil (RW)</u>**

Fifty RW adults were placed on the top of the bag along with 5 g of wheat kernels

Results for Indian meal moth

Fig.1. Mean + SE counts of Indian meal moths in control and PG treated 1 lb rice packages (*n* = 3).

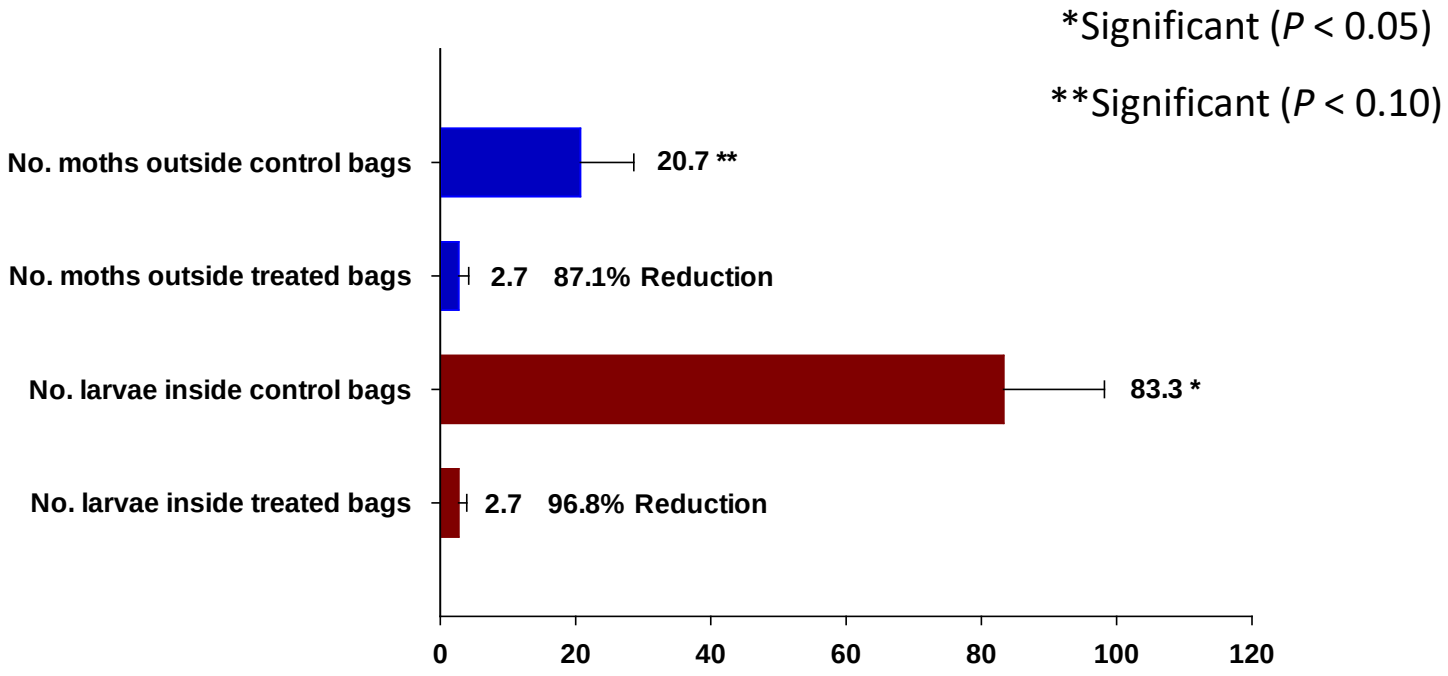
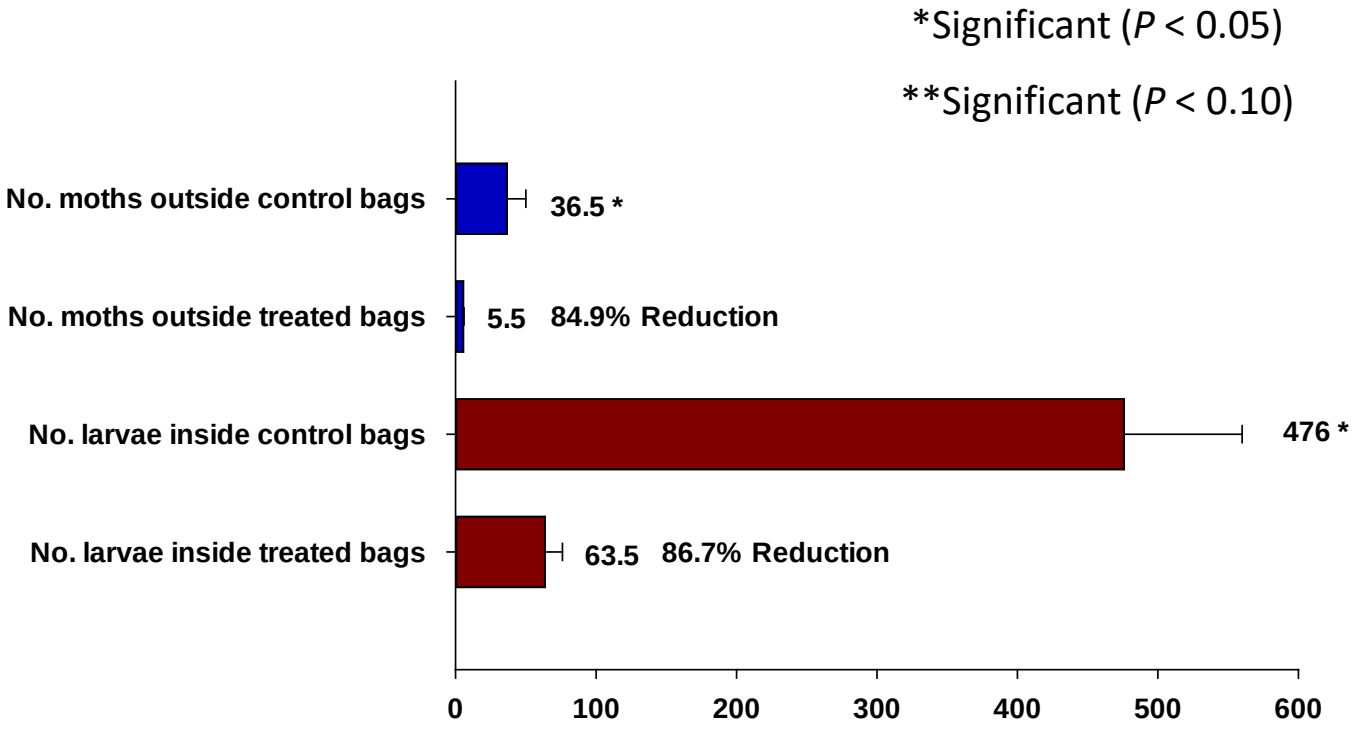


Fig. 2. Mean + SE counts of Indian meal moths in control and PG treated 20 lb rice packages (*n* = 2).



Results for Red flour beetle

Fig. 4. Mean + SE counts of red flour beetle larvae and adults in control and PG treated 1 lb rice packages (*n* = 3).

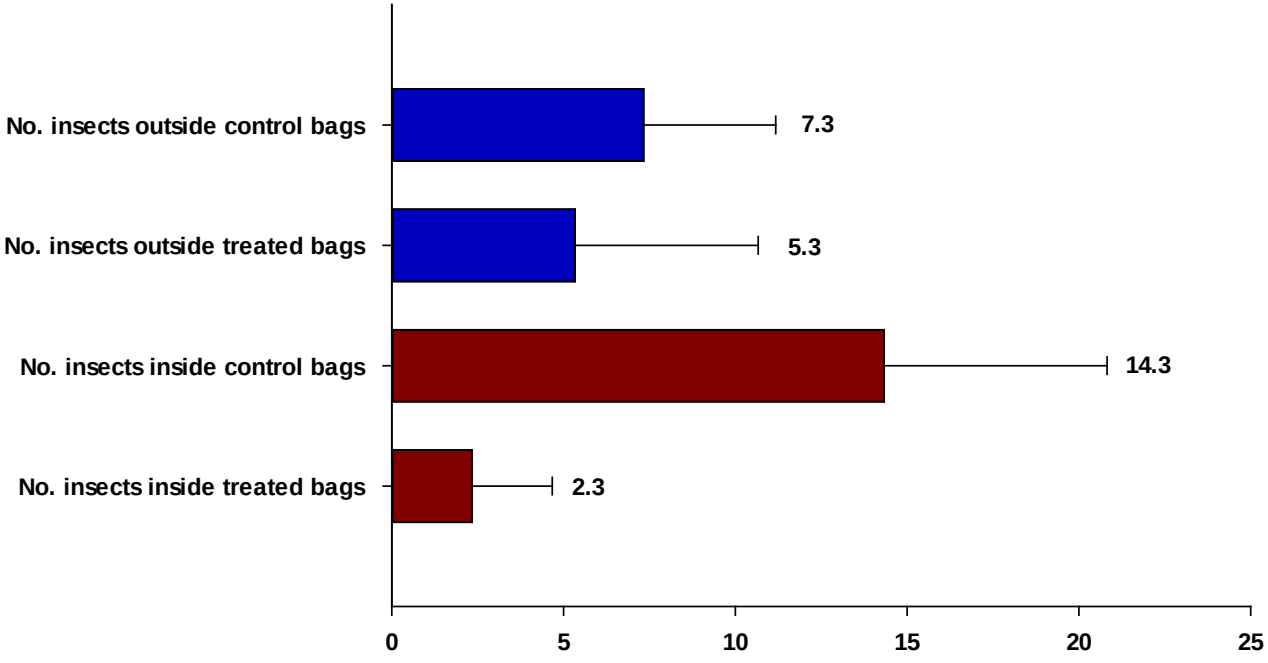
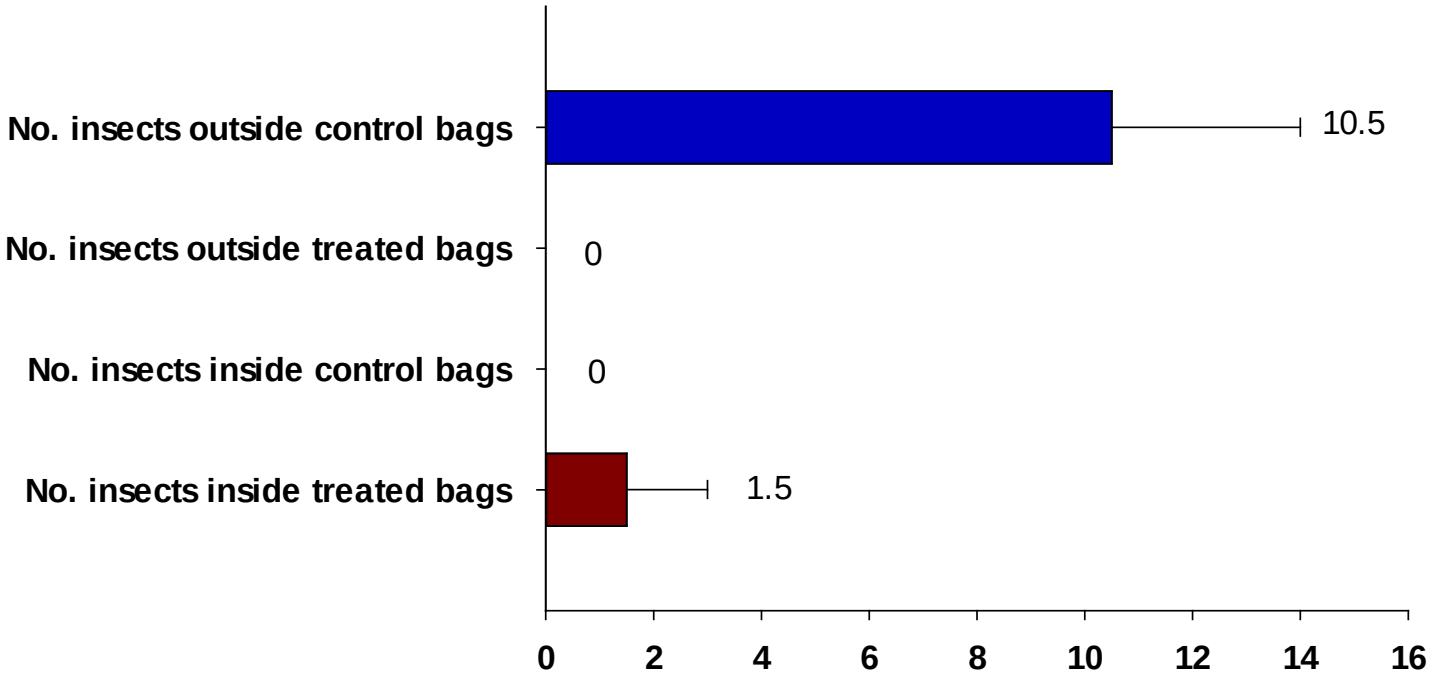


Fig. 5. Mean + SE counts of red flour beetle larvae and adults in control and PG treated 20 lb rice packages (*n* = 2).



Results for Rice weevil

Fig. 6. Mean + SE counts of rice weevil adults in control and PG treated 1 lb rice packages (*n* = 3).

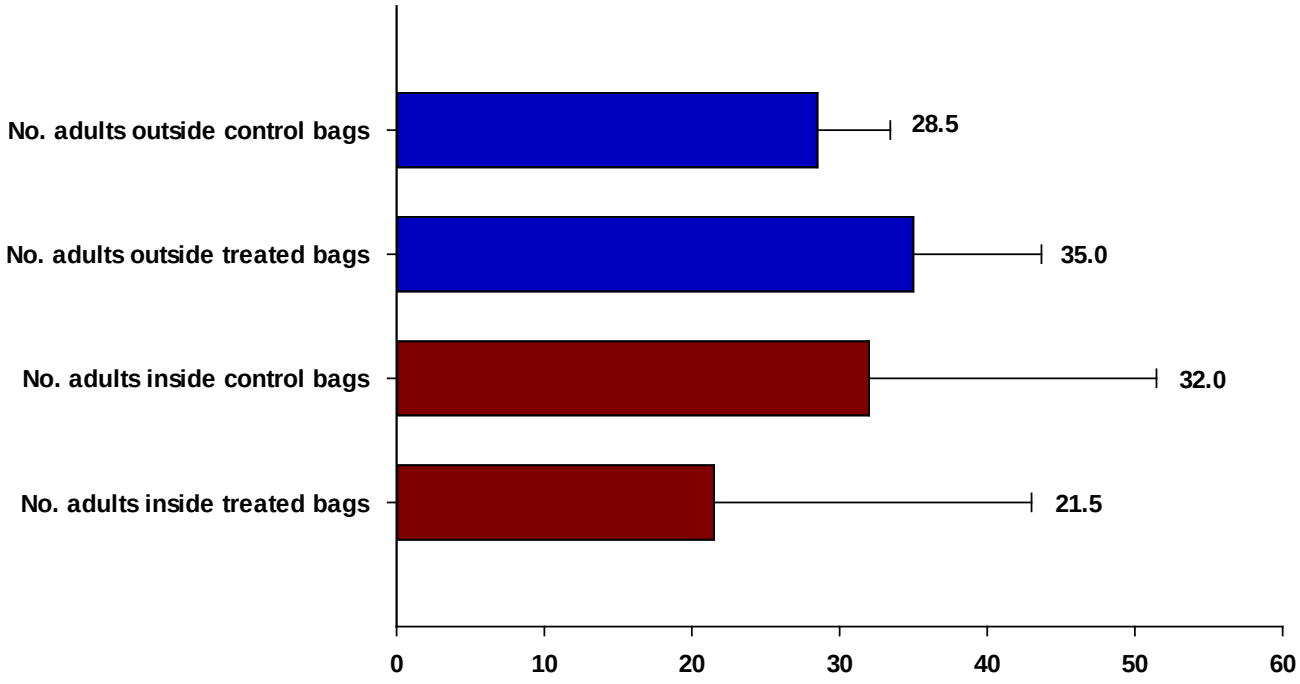
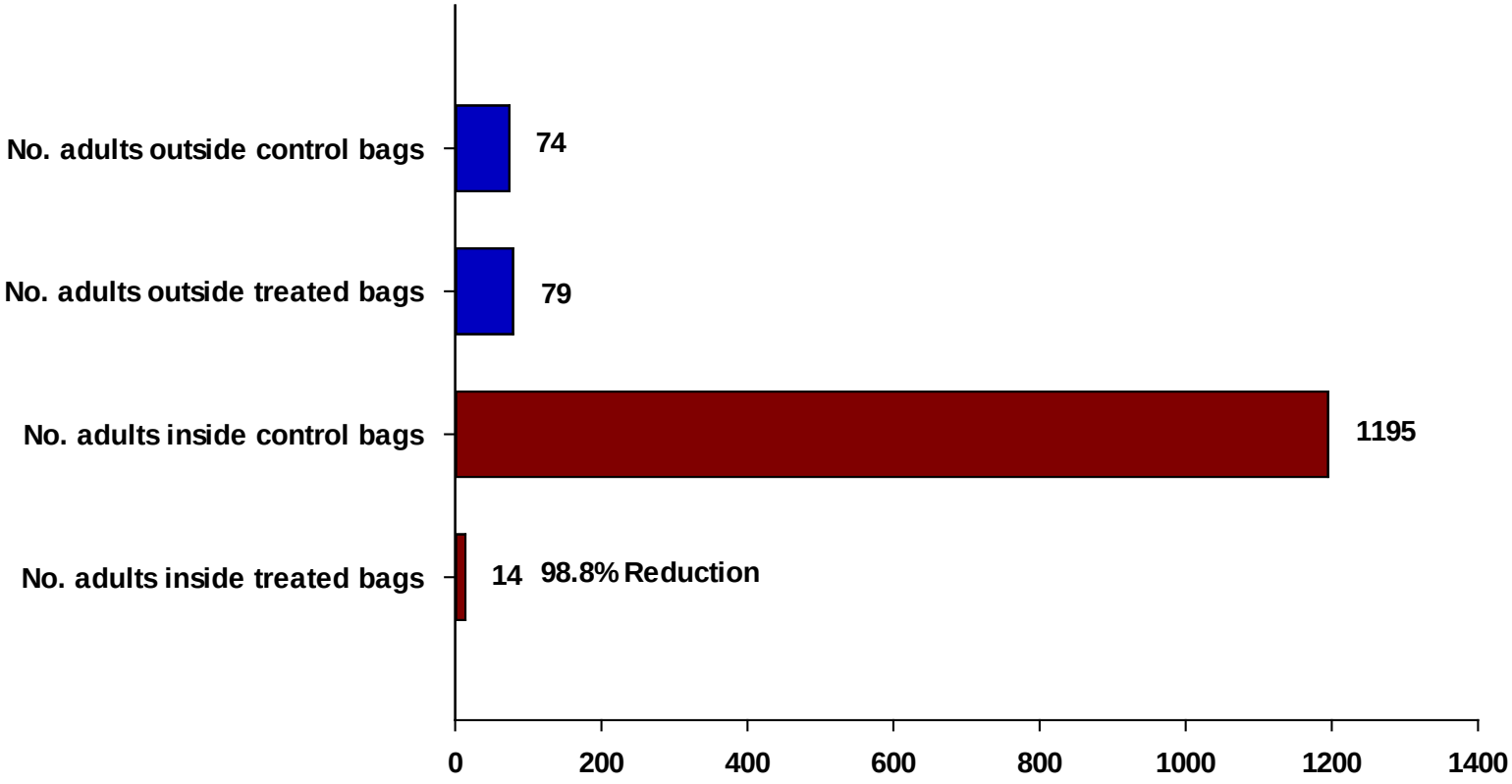


Fig. 7. Mean + SE counts of rice weevils in 20 lb control and PG treated packages (*n* = 1)



Conclusions

- PG treated packages also reduced the number of moths that developed from eggs initially placed on the bags.

- PG treated packages seem to have some potential to mitigate red flour beetle infestation. Red flour beetles are secondary pests of grains and do not survive well on whole grains, and require ground or broken kernels to survive and reproduce. Therefore, differences between treatments were not discernable.

- PG treated packages protect rice against rice weevil infestation, especially in tests with the 20 lb bag. Rice weevils require higher grain moisture contents (>12%) to actively lay eggs and reproduce.


OPEN
Picante Sauce
Gerber
2ND FOODS
NET WT. 4 OZ (113g)