

# Integrated Pest Management (IPM): Mistakes and Solutions

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# Pest control versus management

- Control = elimination
  - Hard to measure or accomplish in “real world” situations
  - “absence of evidence *is* NOT evidence of absence”
- Management = maintain populations at acceptable levels
- Management is with reference to an action level
  - Is my pest level above or below an established threshold?
  - Do we have action levels for pests in grain and processing facilities?
  - There is zero level for some pests (Is this realistic or can this be measured with some level of certainty?) [Sampling issue]

# 1. Not correctly identifying the pest



© Agriculture Western Australia

# Pest identification

- Helps in knowing more information about its biology, ecology, behavior, and response to pesticides or pesticide alternatives
- Information can be accessed from the web
- Information can be obtained from professionals in the field
- There are people who help in identification of pests (mostly at universities)

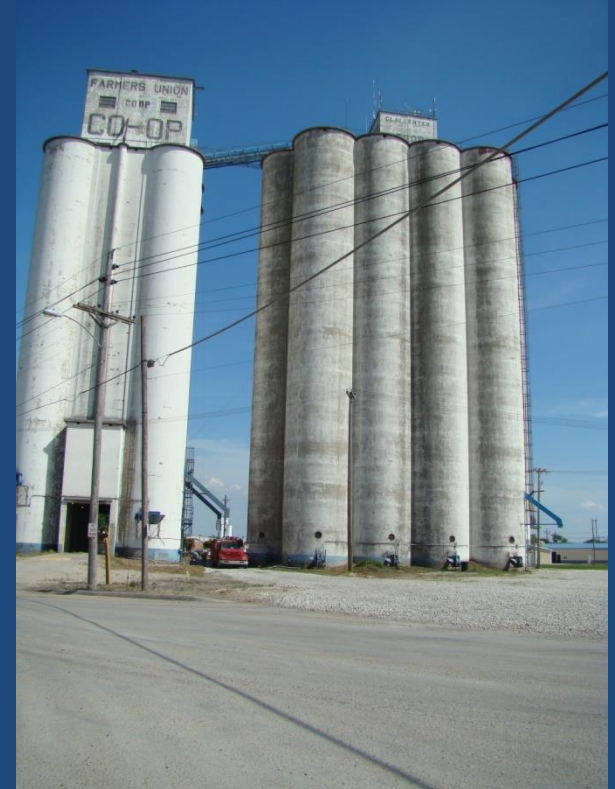


2. Not understanding what species  
are associated with raw and  
processed grain

# Raw grain storage structures



Steel bins



Concrete silos

# Poor storage structures- Africa

Wetter Regions



Foulde



Gbaya



Barn, across ethnic groups



Improved crib, many ethnic groups

Dryer Regions



Kanouri



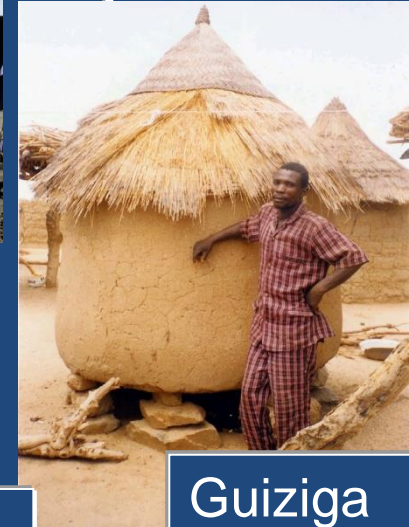
Massa



Duru



Moundang



Guiziga

From: Dr. E. N. Nukenine



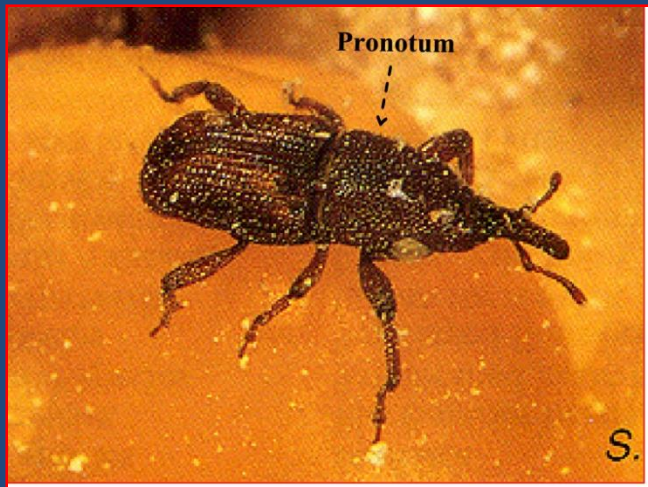
A photograph showing a long, symmetrical row of industrial flour mill machinery in a factory. The machines are light-colored with prominent vertical blue pipes and horizontal metal ducts. They are arranged in two rows on either side of a central aisle, receding into the distance. The scene is lit by overhead fluorescent lights, and a window is visible on the left side. The text "Loulis flour mill, Greece" is overlaid in the lower-left area.

Loulis flour mill, Greece





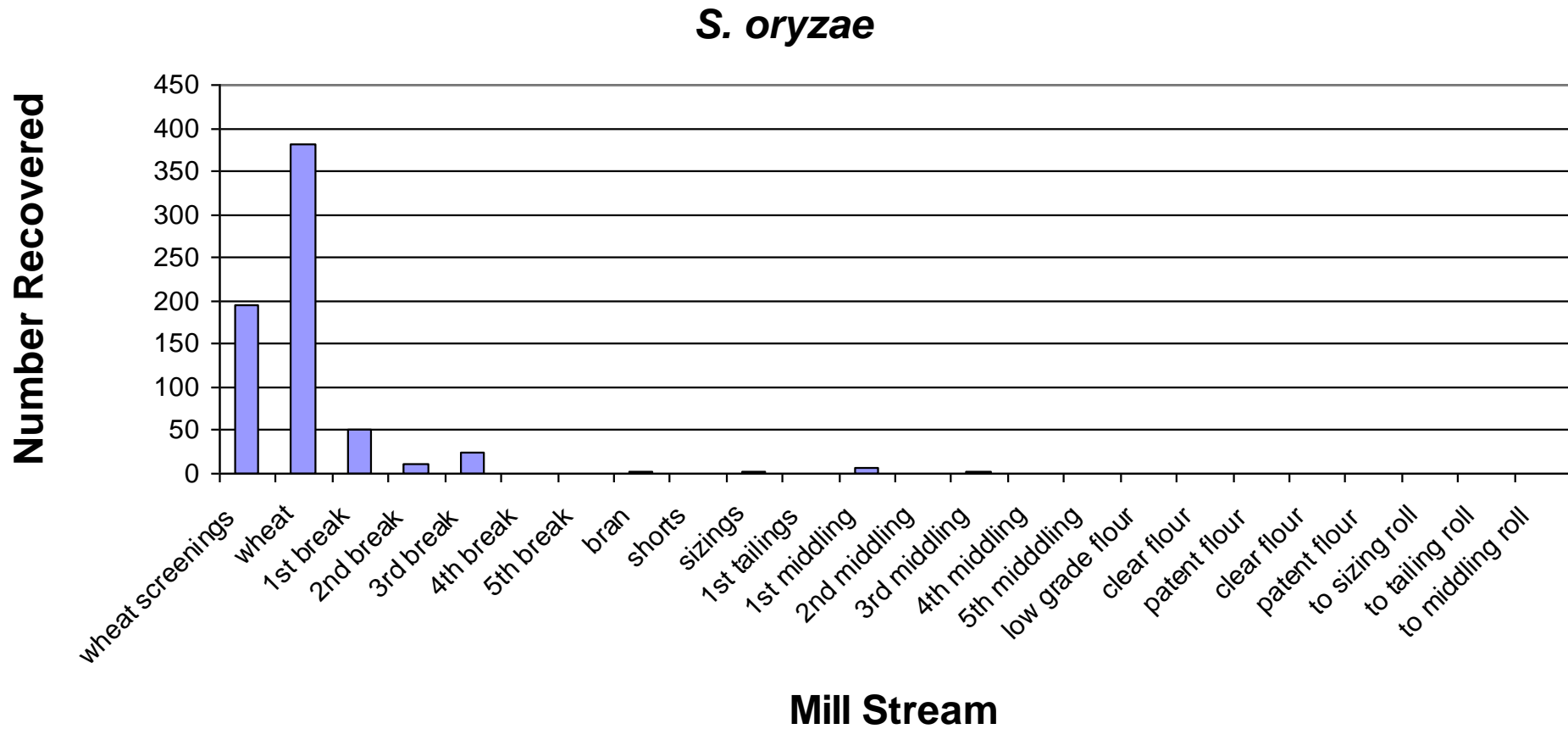




## Internal feeders



# Rice weevil is predominantly in whole grain





Internal feeders  
Females lay eggs outside  
kernels

Moth

Borer

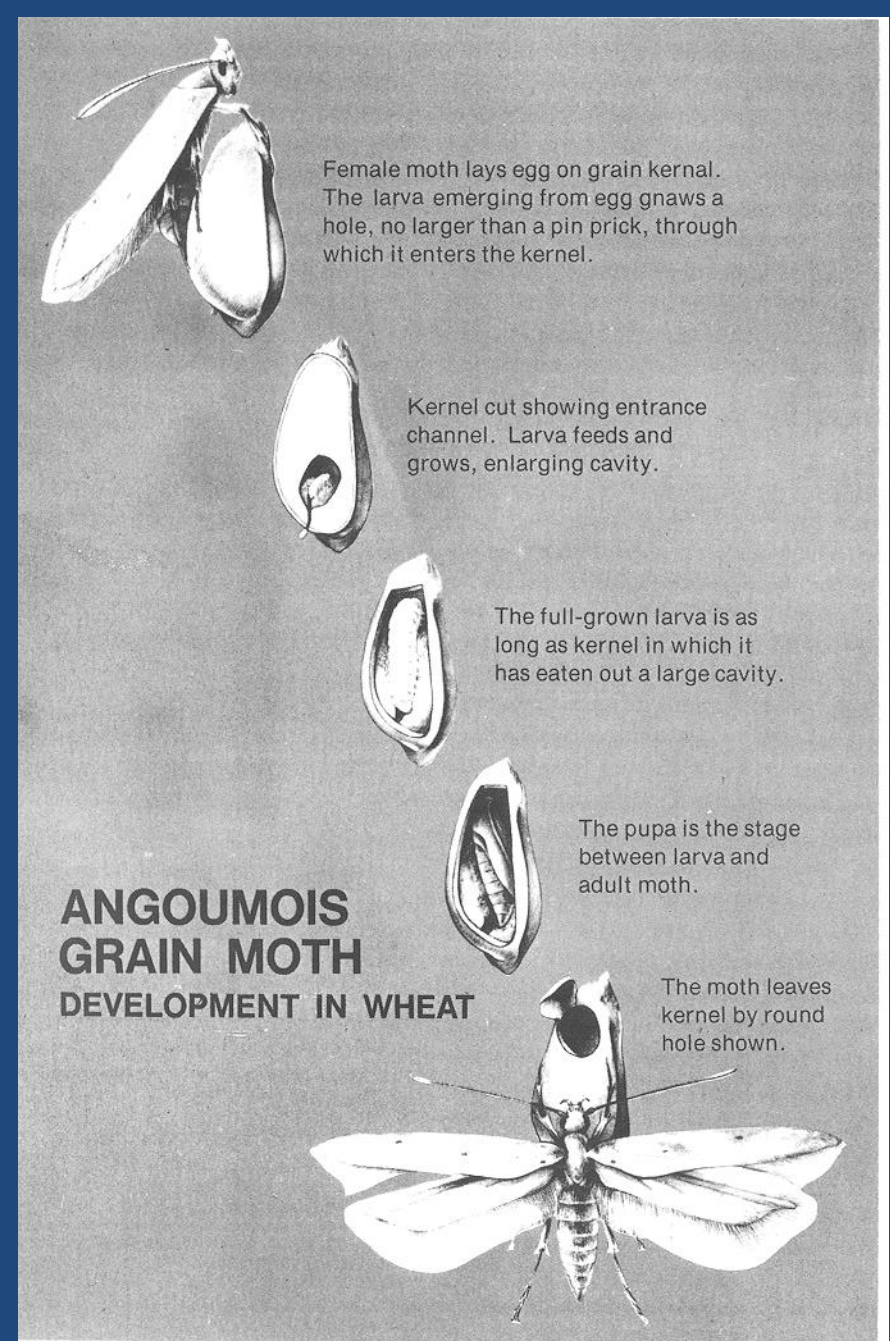
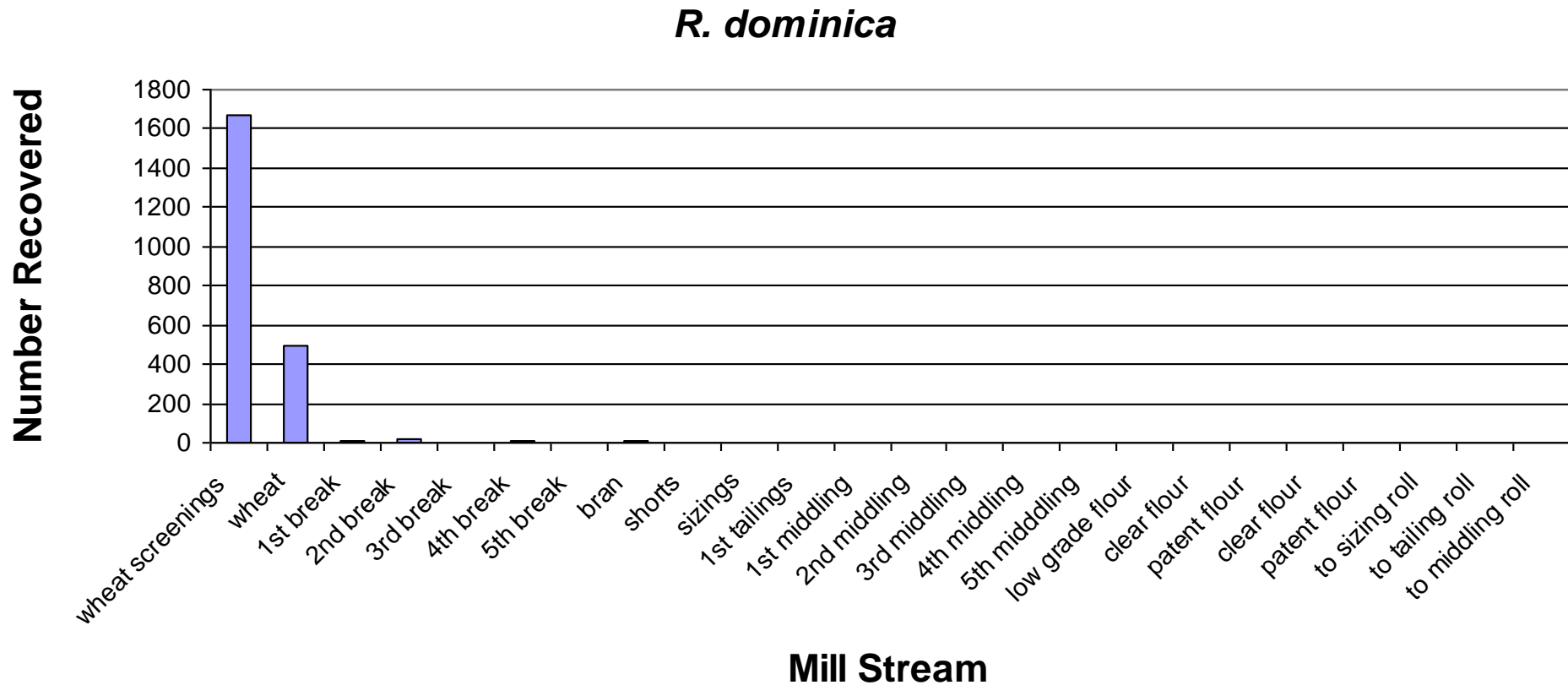


Figure 11.—Life cycle of the Angoumois grain moth on wheat.





# Lesser grain borer is predominantly in whole grain



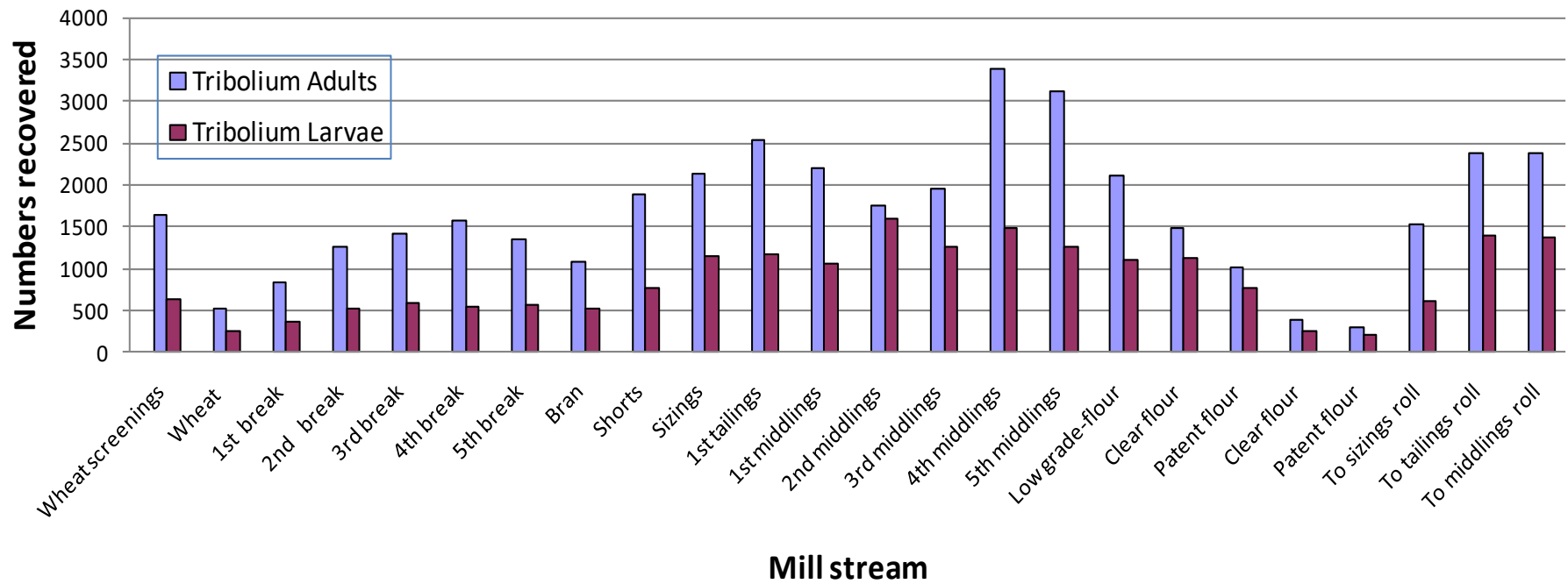
## External feeders

Red and confused flour beetles (*Tribolium* species)



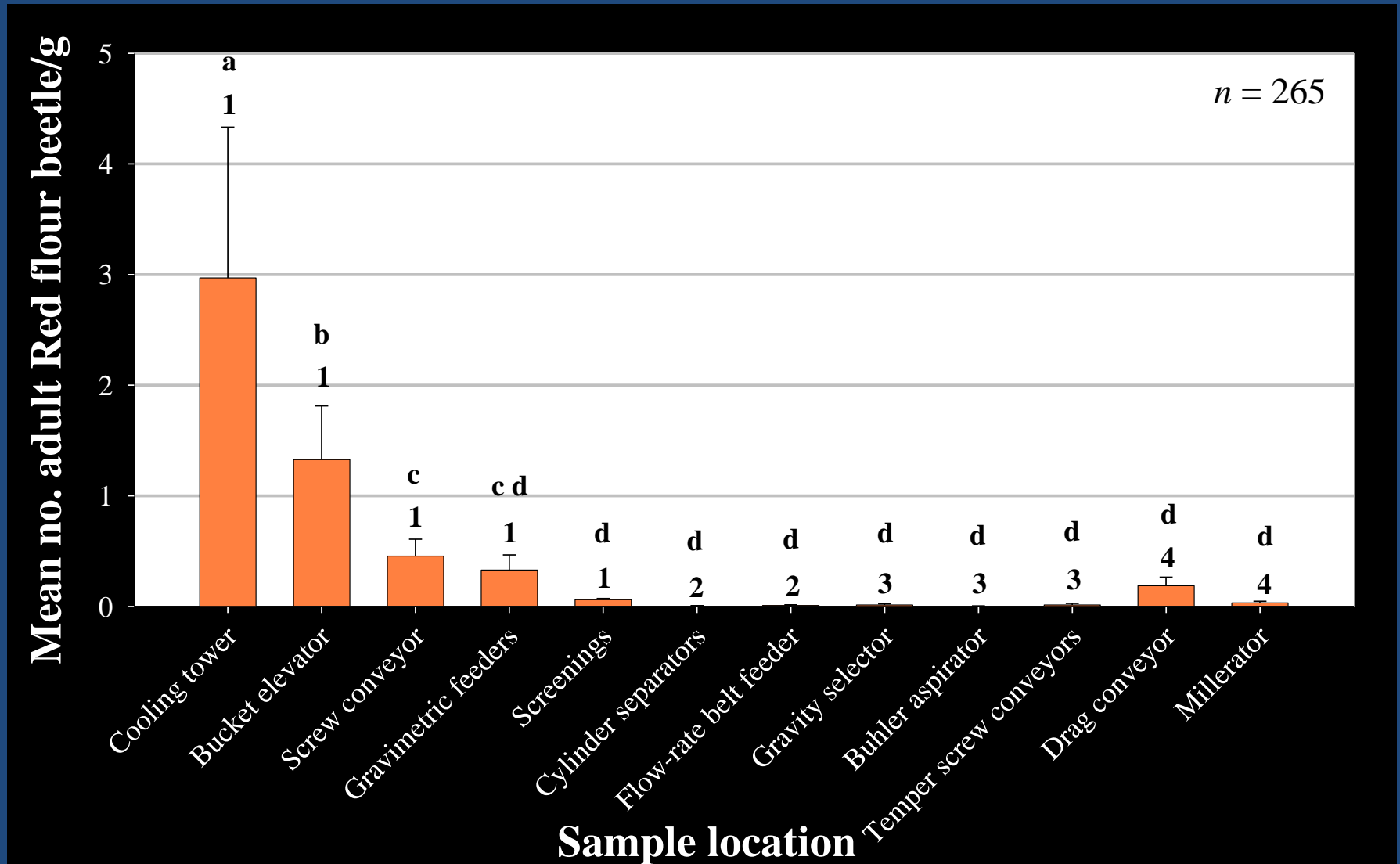
# Flour beetles are found in all mill streams

*Tribolium* by lifestage



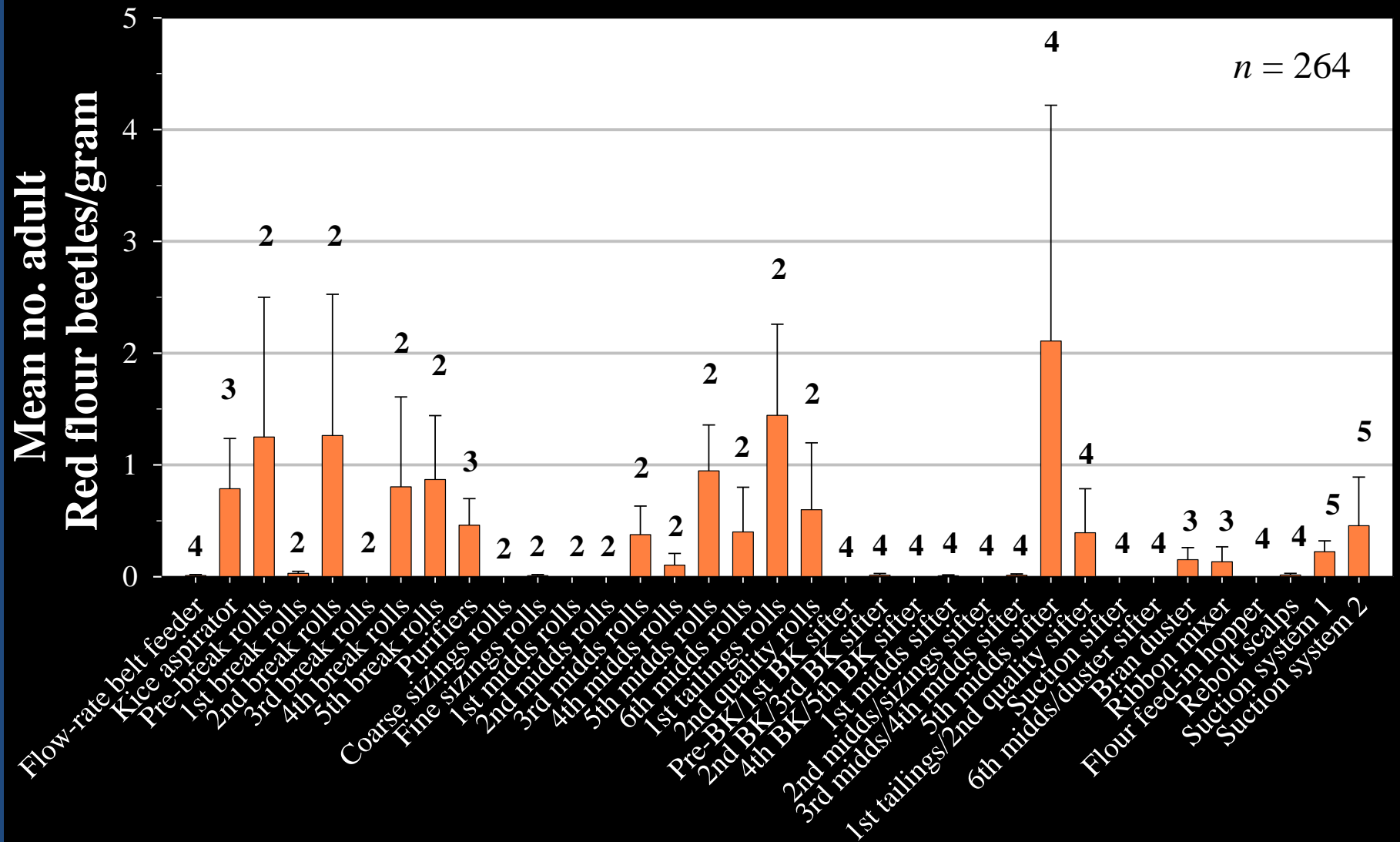
Source: N. E. Good (1937)

# KSU Mill: Cleaning House Product Samples



Means followed by different letters are significant ( $P < 0.05$ ; lsmeans test)

# KSU Mill: Flour Mill Product Samples



3. Not understanding the  
importance of sanitation

# Insects in Grain Residues at Elevators (Arthur et al. 2006)

Number of live adult insects<sup>a</sup> per kg (mean  $\pm$  SE) and percentage residue samples infested with pest insects, by inspection location

Location	<i>Sitophilus</i>	<i>Cryptolestes</i>	<i>Tribolium</i>	<i>Typhaea</i> <i>stercorea</i>	<i>Rhyzopertha</i> <i>dominica</i>	<i>Oryzaephilus</i>	<i>Ahasverus</i> <i>advena</i>	Total	% Infested
Boot pit	40.08 $\pm$ 7.90a	9.31 $\pm$ 2.80ab	10.94 $\pm$ 5.73a	0.14 $\pm$ 0.06a	0.70 $\pm$ 0.35a	1.23 $\pm$ 0.56a	0.11 $\pm$ 0.08ab	62.54 $\pm$ 12.92a	71.1
Dump pit	8.52 $\pm$ 1.54b	6.50 $\pm$ 1.66bc	1.11 $\pm$ 0.27b	0.43 $\pm$ 0.29a	0.44 $\pm$ 0.19a	0.14 $\pm$ 0.04b	0.02 $\pm$ 0.02b	17.16 $\pm$ 2.56b	45.3
Headhouse	3.38 $\pm$ 1.44c	6.88 $\pm$ 2.74bc	1.47 $\pm$ 0.48b	0.09 $\pm$ 0.04a	0.23 $\pm$ 0.08a	0.07 $\pm$ 0.04b	0.01 $\pm$ 0.01b	12.10 $\pm$ 3.48b	29.7
Rail line	8.16 $\pm$ 2.41b	2.61 $\pm$ 1.42c	4.76 $\pm$ 4.30b	1.17 $\pm$ 1.07a	0.14 $\pm$ 0.10a	1.01 $\pm$ 0.95b	0.05 $\pm$ 0.04b	17.89 $\pm$ 5.96b	35.4
Tunnel	37.09 $\pm$ 8.49a	33.97 $\pm$ 20.94a	11.31 $\pm$ 8.20a	0.01 $\pm$ 0.01a	0.80 $\pm$ 0.65a	0.67 $\pm$ 0.54b	0.43 $\pm$ 0.27a	84.28 $\pm$ 25.24a	53.1

Data from 9 elevators and 1,575 samples. Total number of pest insects found = 46,725.



# Impact of Sanitation of Bins (Reed et al. 2003)

Species	Bins cleaned prior to filling		Bins not cleaned prior to filling	
	Mean number/kg $\pm$ standard error	% of population	Mean number/kg $\pm$ standard error	% of population
<i>Cryptolestes</i> spp.	0.7 $\pm$ 0.31*	14.4	2.3 $\pm$ 0.49	8.7
<i>Rhyzopertha dominica</i>	1.1 $\pm$ 1.10	22.6	1.33 $\pm$ 1.24	5.0
<i>Oryzaephilus</i> spp.	0 $\pm$ 0**	0	0.07 $\pm$ 0	0.3
<i>Sitophilus</i> spp.	2.9 $\pm$ 1.44	60.3	13.4 $\pm$ 5.61	50.4
<i>Tribolium</i> spp.	0.1 $\pm$ 0.05	2.1	9.5 $\pm$ 7.21	35.6
All pest species	4.9 $\pm$ 2.01**		26.6 $\pm$ 9.25	
All natural enemies	0.02 $\pm$ 0.01		0.4 $\pm$ 0.32	

Data from 11 elevators, samples from 25 – 138 bins at each elevator.

# Spillage



Prevent unsanitary conditions

# KSU pilot flour mill data, June 15 – October 12, 2002

No. product samples examined	Percentage of samples with insects	No. samples with insects after 8 weeks
439	53.8	80.1%

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Andy Allen and Bh. Subramanyam, 2004. Unpublished data.





# Sanitary design aspects





# Sanitary Design Aspects











- Eliminate standing water through good design and repair of grounds outside and inside the mill





4. Not having an established threshold for pests and a pest sampling program

# Defect action levels

<http://www.fda.gov/Food/GuidanceComplianceRegulatoryInformation/GuidanceDocuments/Sanitation/ucm056174.htm>

- GIPSA standard for infested grain
  - Wheat, rye, and triticale
  - 2 live insects/kg of grain
  - Barley, canola, corn, oats, sorghum, soybeans, sunflower seeds, mixed seeds
  - 1 live weevil, or other 5 live injurious insects, 10 or more live injurious insects
- At time of sale
  - 32 IDK/100 grams (wheat)
- In processed food
  - 75 insect fragments/50 g of flour (wheat)



# Grain bulk

- Probe sampler
- Spear or trier





Vacuum probe for  
bulk-stored grain



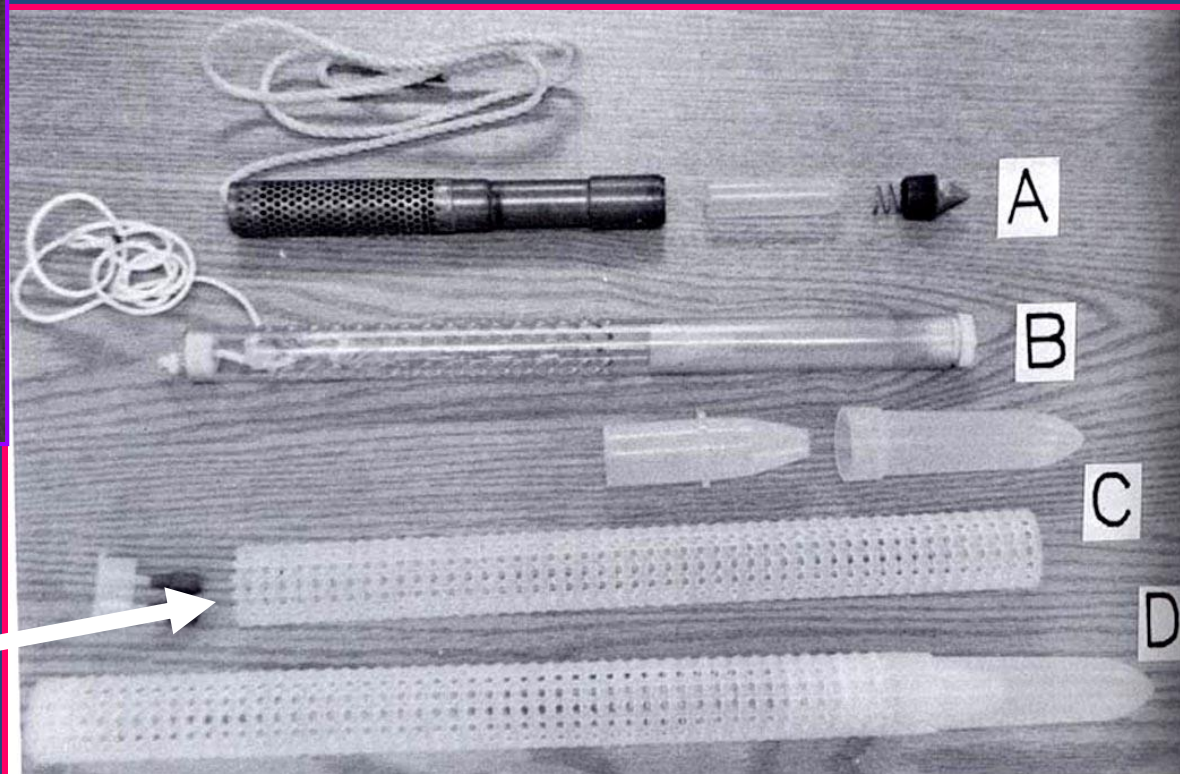
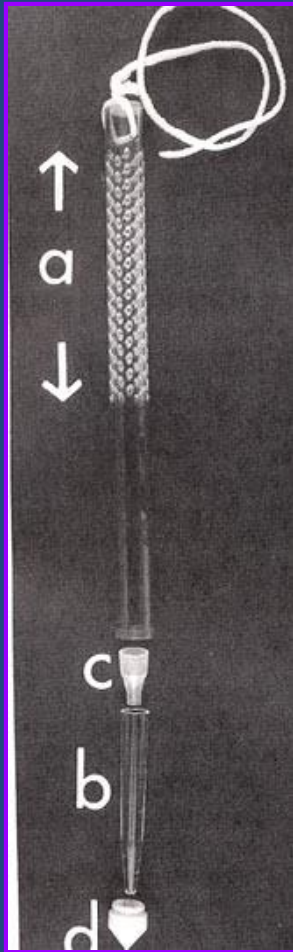
# Pitfall Cone Trap



- 95 mm x 125 mm cone-shaped with holes
- Very sensitive
- For surface area of the grain bulk

# Probe traps

- ❖ 370 mm x 27 mm
- ❖ Funnel and collecting tube
- ❖ Can be inserted into the grain bulk



Trece.com



# Trap retrieval is critical!





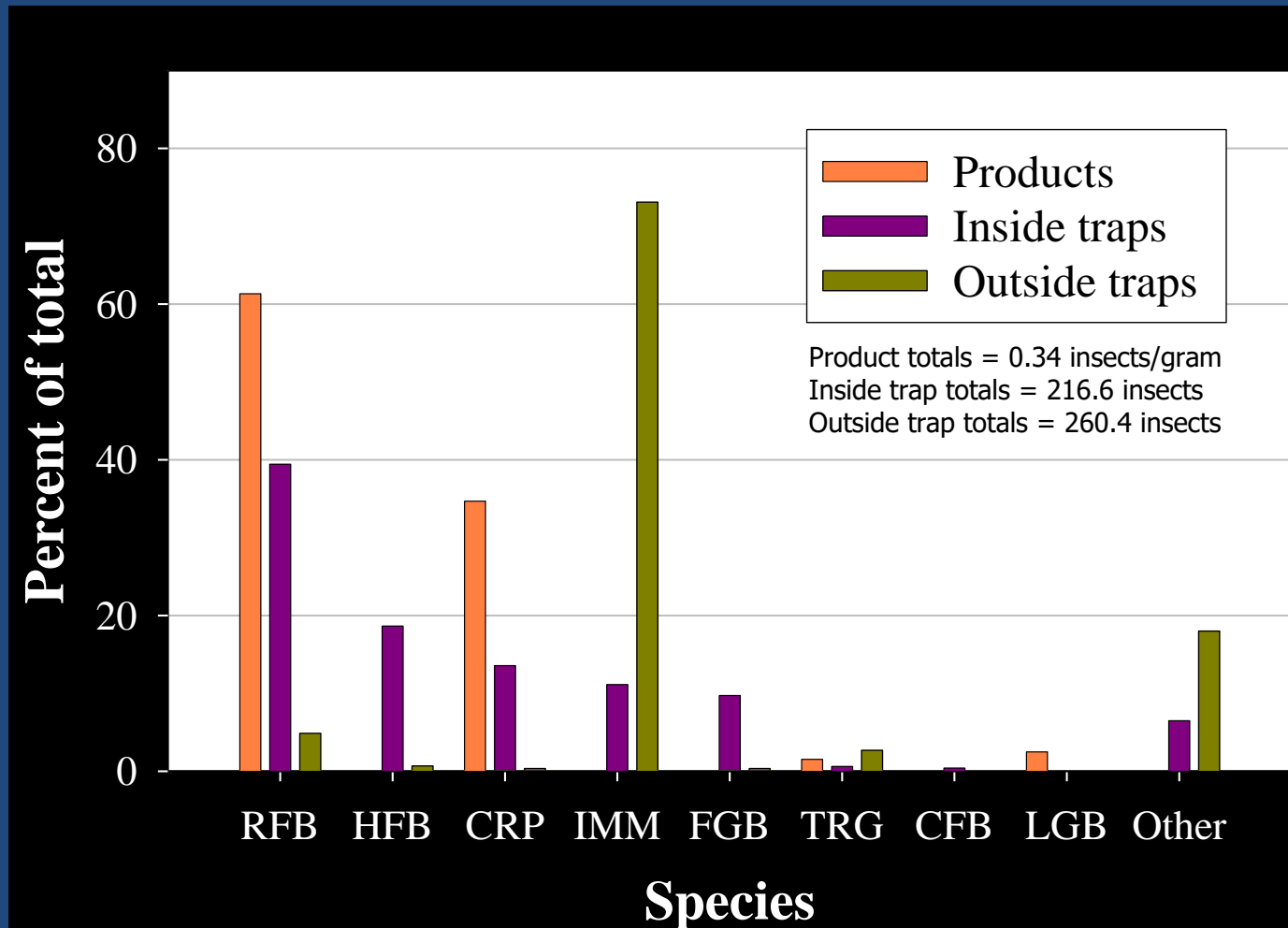
Automated counts of insects in grain  
(OPIsystems.com)

Stormax Insector

5. Not understanding that pests are  
also present outdoors

# Flour Mill 1: Inside and Outside Mill

Allen & Subramanyam, 2004; unpubl. data)



IMM=Indianmeal moth, RFB=Red flour beetle, HFB=Hairy fungus beetle, RGB=Rusty/flat grain beetle, FGB=Foreign grain beetle, TRG=Warehouse beetle, CFB=Confused flour beetle, LGB=Lesser grain borer, STGB=Sawtoothed grain beetle, CAD=Cadelle

# Insects Outdoors

*Trogoderma variable*  
Warehouse beetle



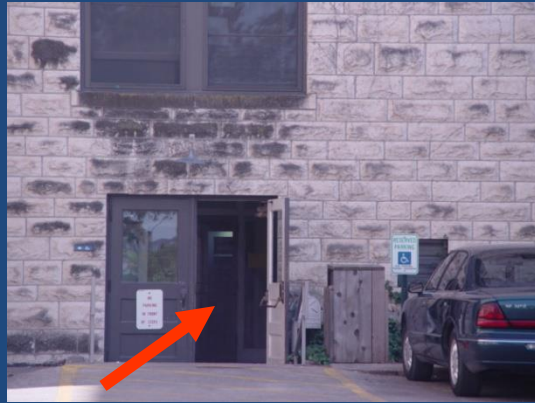
*Plodia interpunctella*  
Indianmeal moth



Average daily capture rate from 6/7/00 to 10/11/00



# Pest Entry Points



- No open doors
- Screen windows
- Seal entry points



A good pest exclusion practice



Another exclusion practice





Tight seals around loading dock doors







Pigeon



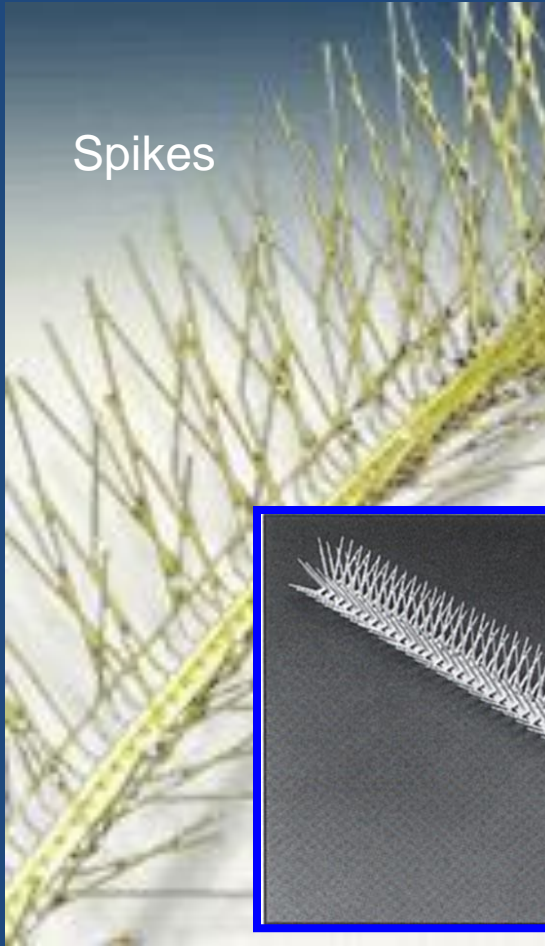
# Netting to Exclude Birds



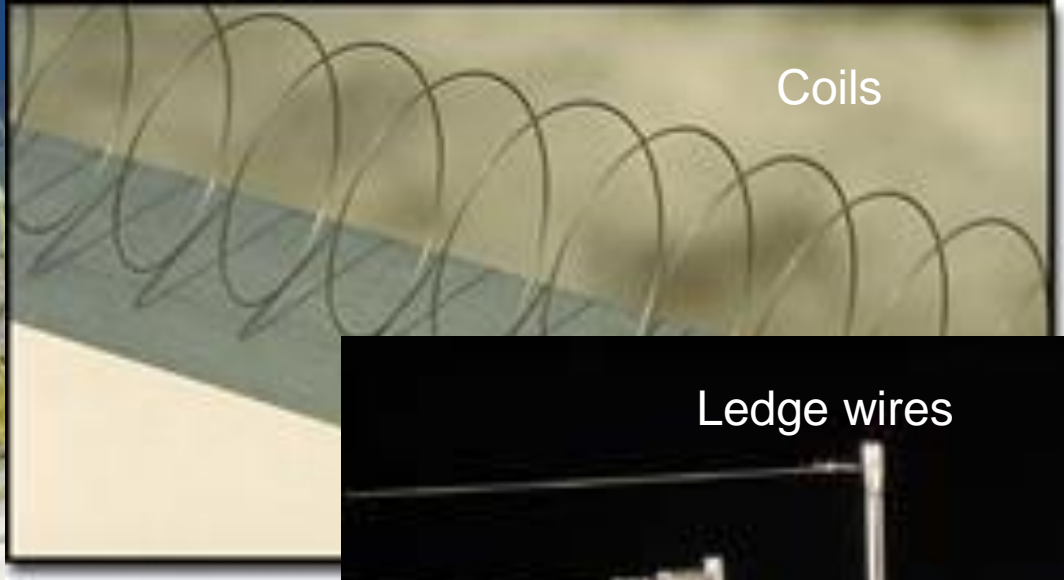


# Tactile Deterrents for Birds

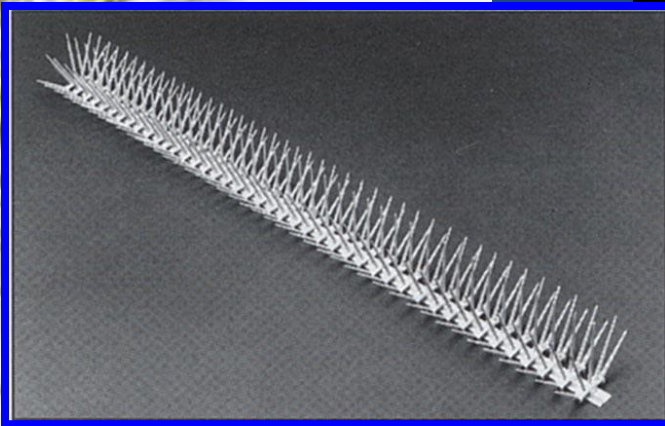
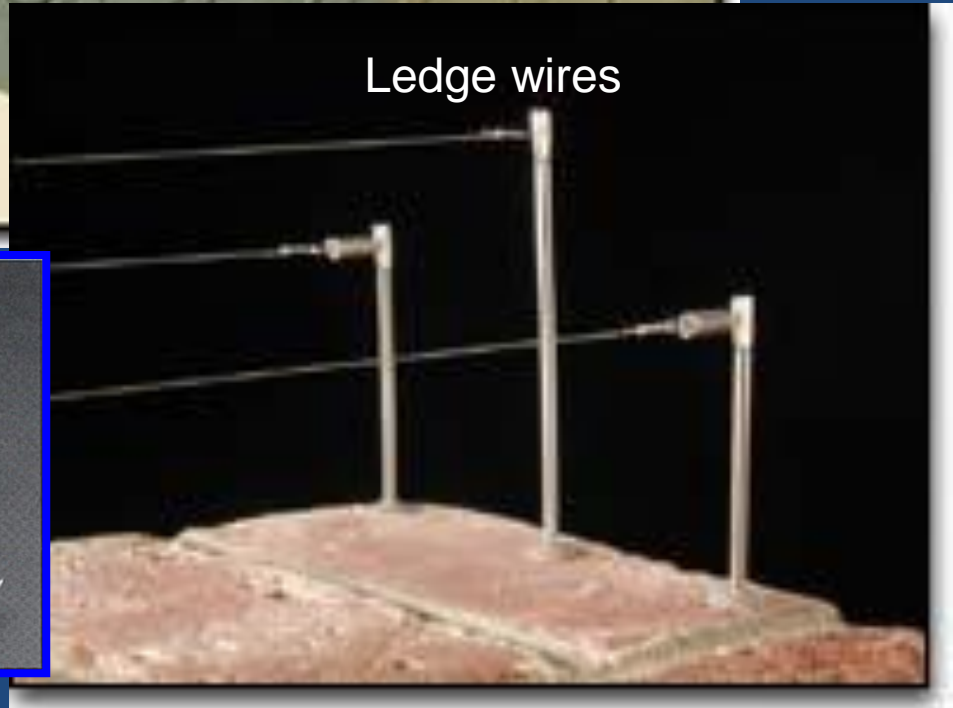
Spikes



Coils



Ledge wires



## 6. Applying a liquid pesticide to infested grain



Calibration is essential











## 7. Poor fumigation/pesticide application practices



# Fumigation



Gas monitoring and personal protective equipment are essential

8. Not selecting a reliable pest management service provider

# Good Service Characteristics

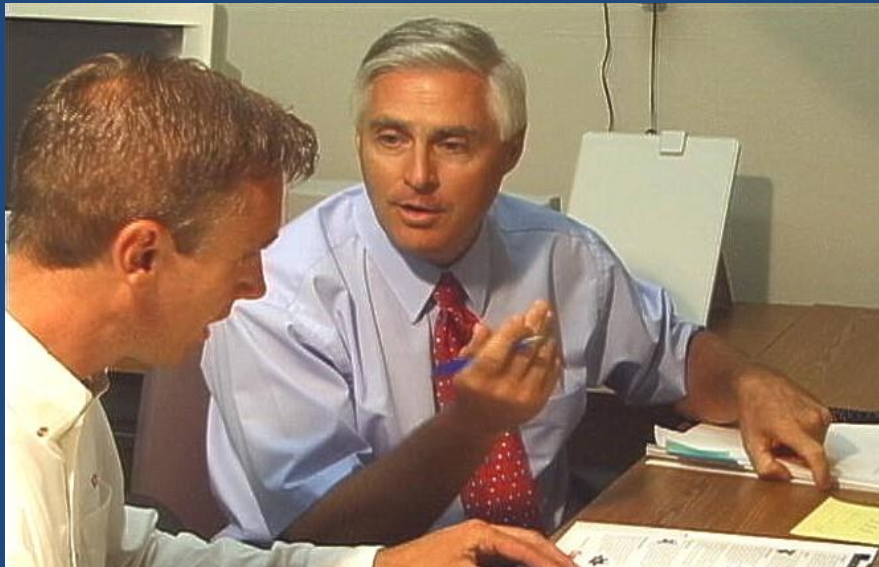


- Professional
  - Ethical
  - Neat
  - Clean
  - Client confidentiality

Courtesy: Ole Dosland



# Good Service Characteristics



- Reputable
  - Knowledgeable
  - Experienced
  - Honest
  - Listens

Courtesy: Ole Dosland

# Good Service Characteristics



- Communication
  - Documentation
  - In person
  - On phone



Courtesy: Ole Dosland

9. Having a light above the door



# Lighting

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





Have good lighting everywhere

## 10. Poor trash disposal practices



# Improper garbage disposal promotes pest activity



Keep dumpster on a concrete pad  
Weekly garbage disposal

# 11. Poor inspection practices

# Transport vehicles

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





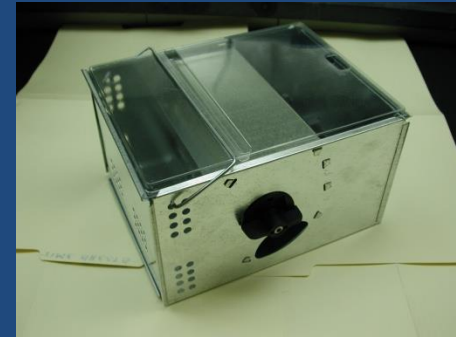
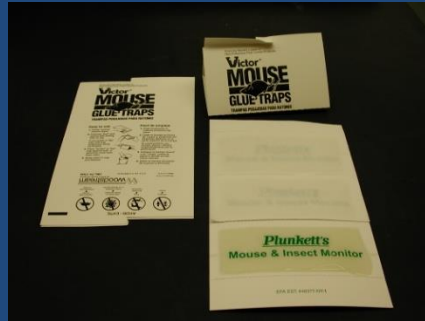
# Warehouse and mill

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



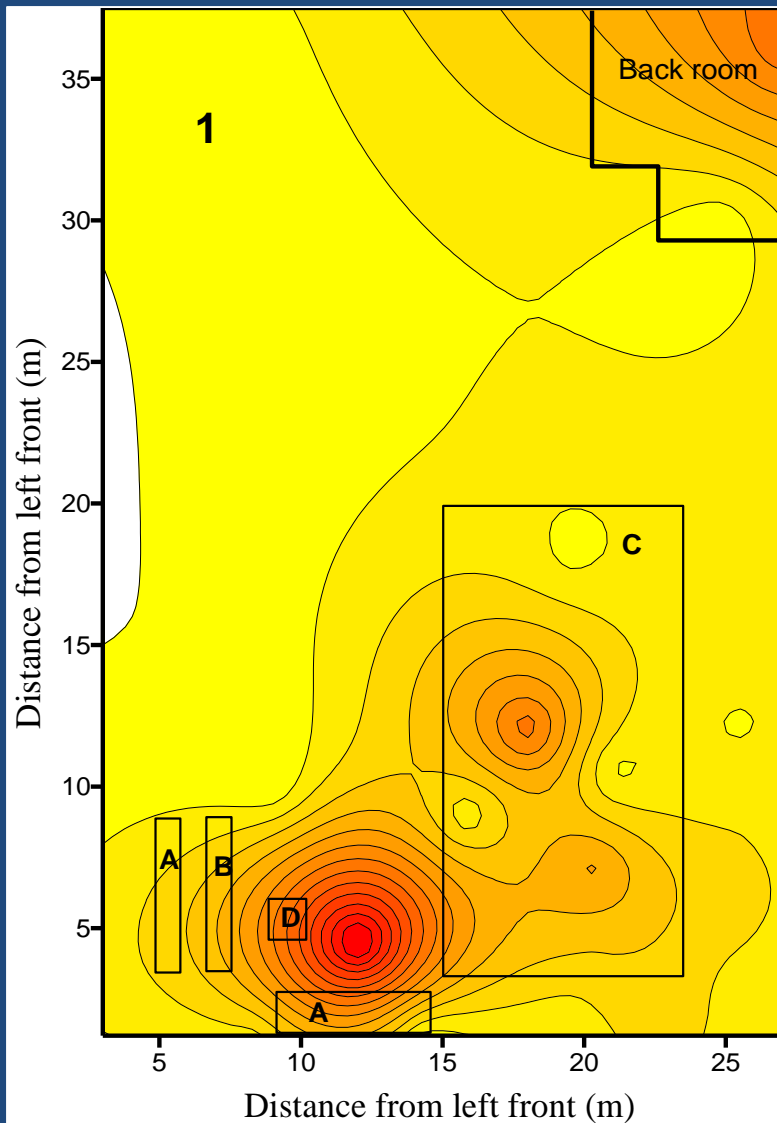
12. Not monitoring fumigant gas concentrations or pest numbers over time

# Traps and Mechanical Devices



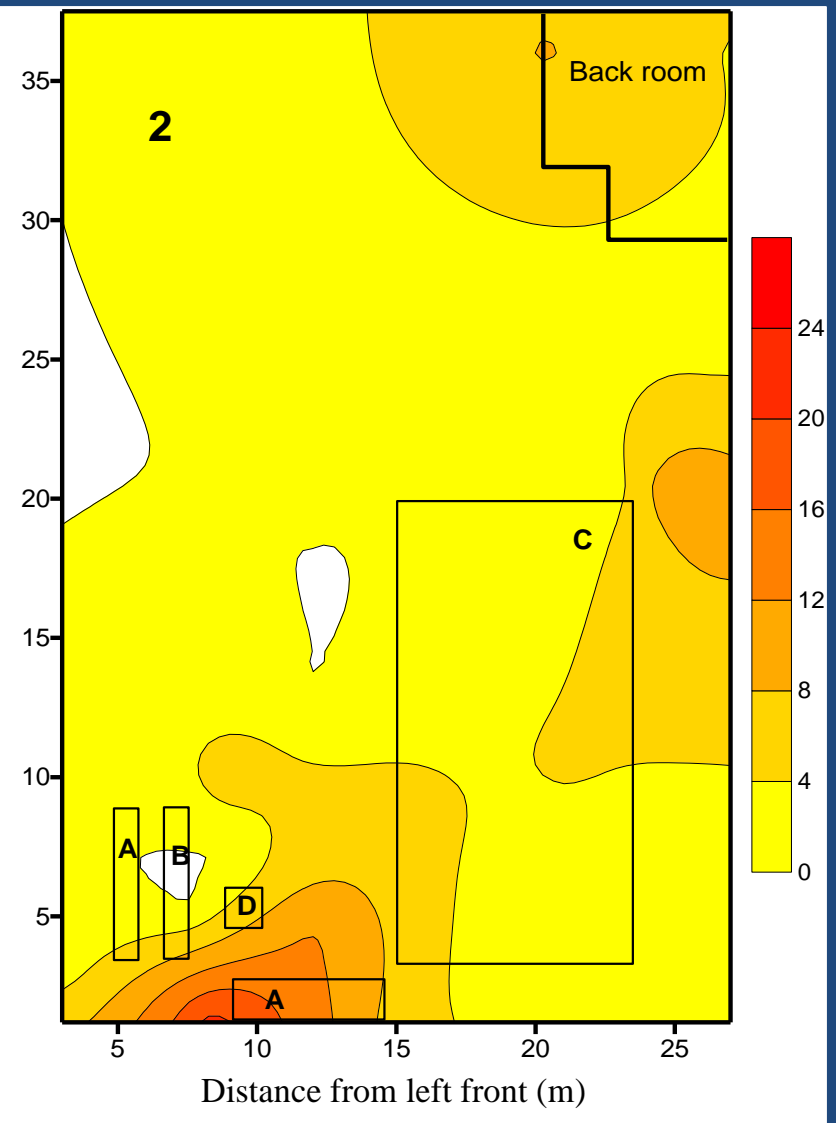


# Beetles



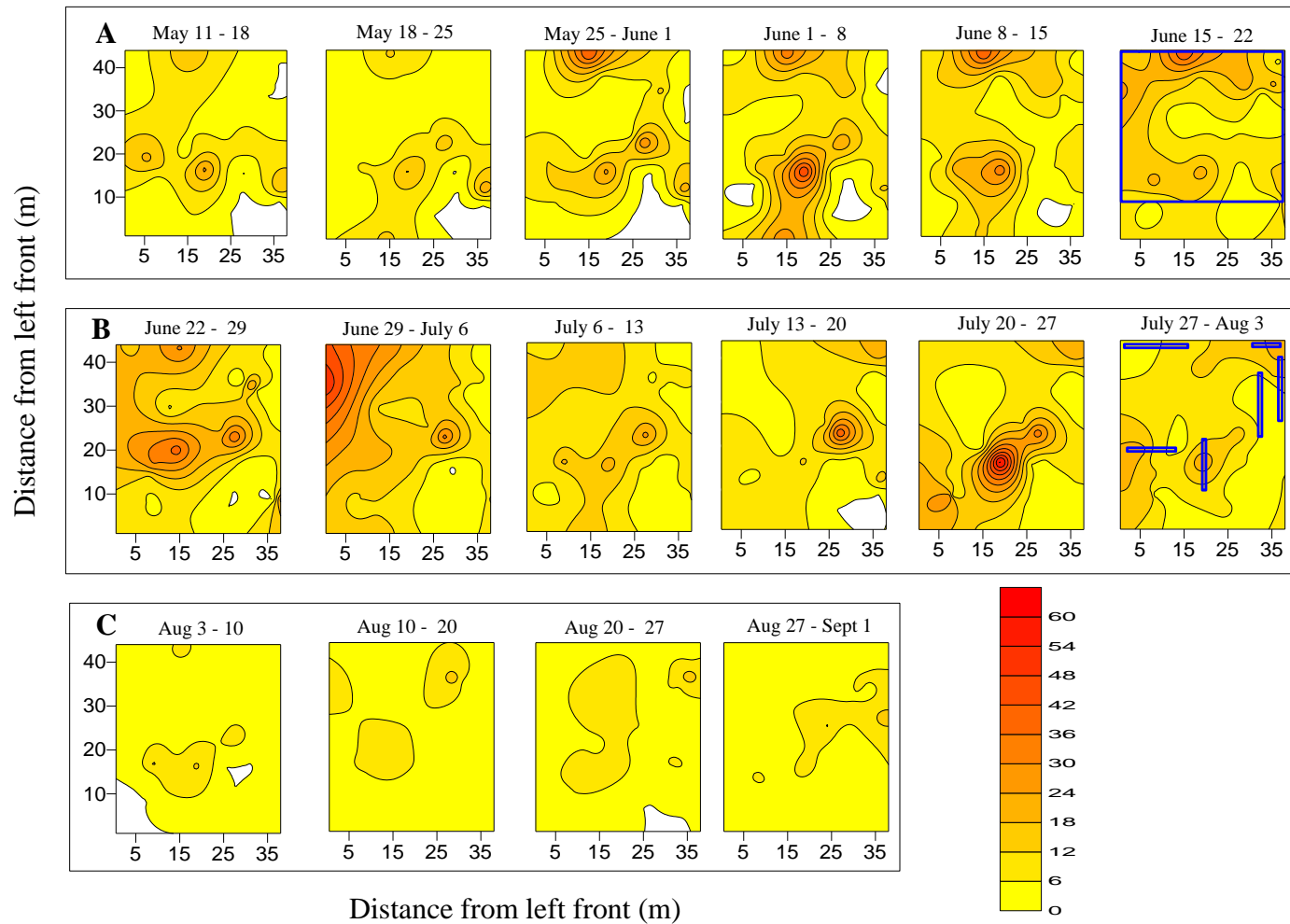
# PSA1

# Indianmeal moths



A=Wild bird food B=Small animal food C=Cat and dog food  
D=Food bar table

# Indianmeal Moths in a Retail Store



Before sanitation

After sanitation  
before Tempo

After Tempo

*Sequential contour maps*

# Aluminum Phosphide

## Different formulations for different uses

- Tablets
  - 3 g, releases 1 g of phosphine
- Pellets
  - 0.6 g, releases 0.2 g of phosphine
- Sachets
  - 34 g, releases 11 g of phosphine
- Linear gas generation until 80%, then the generation becomes nonlinear
- Gas release differences among formulations
  - Pellets > tablets > sachets

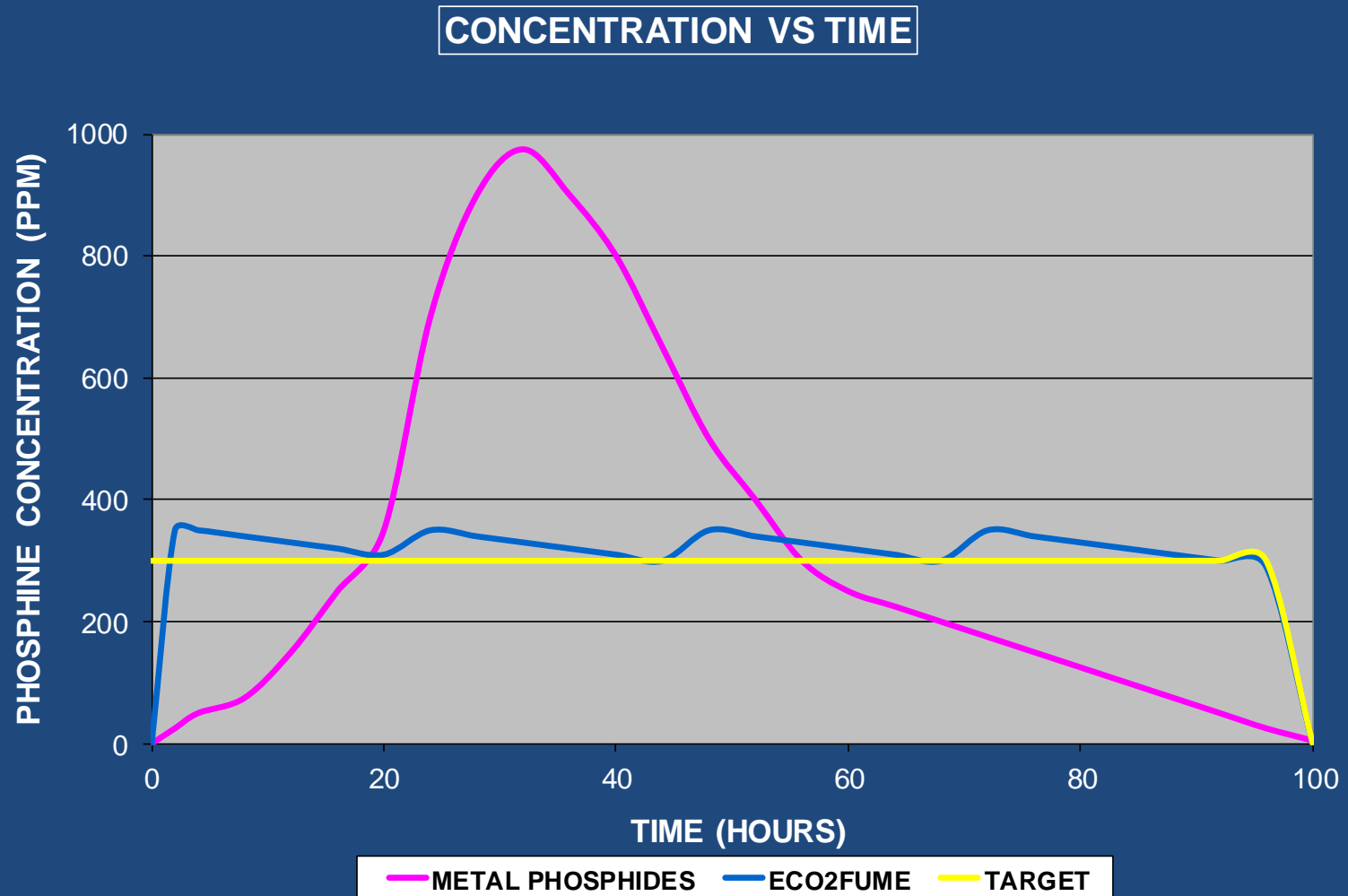




# Phosphine Can be Used to Treat Commodities in Various Storage Structures



# Choice of formulation and sealing can help hold an effective concentration



# Whole facility treatments for mills

Methyl bromide



Heat treatment



Sulfuryl fluoride

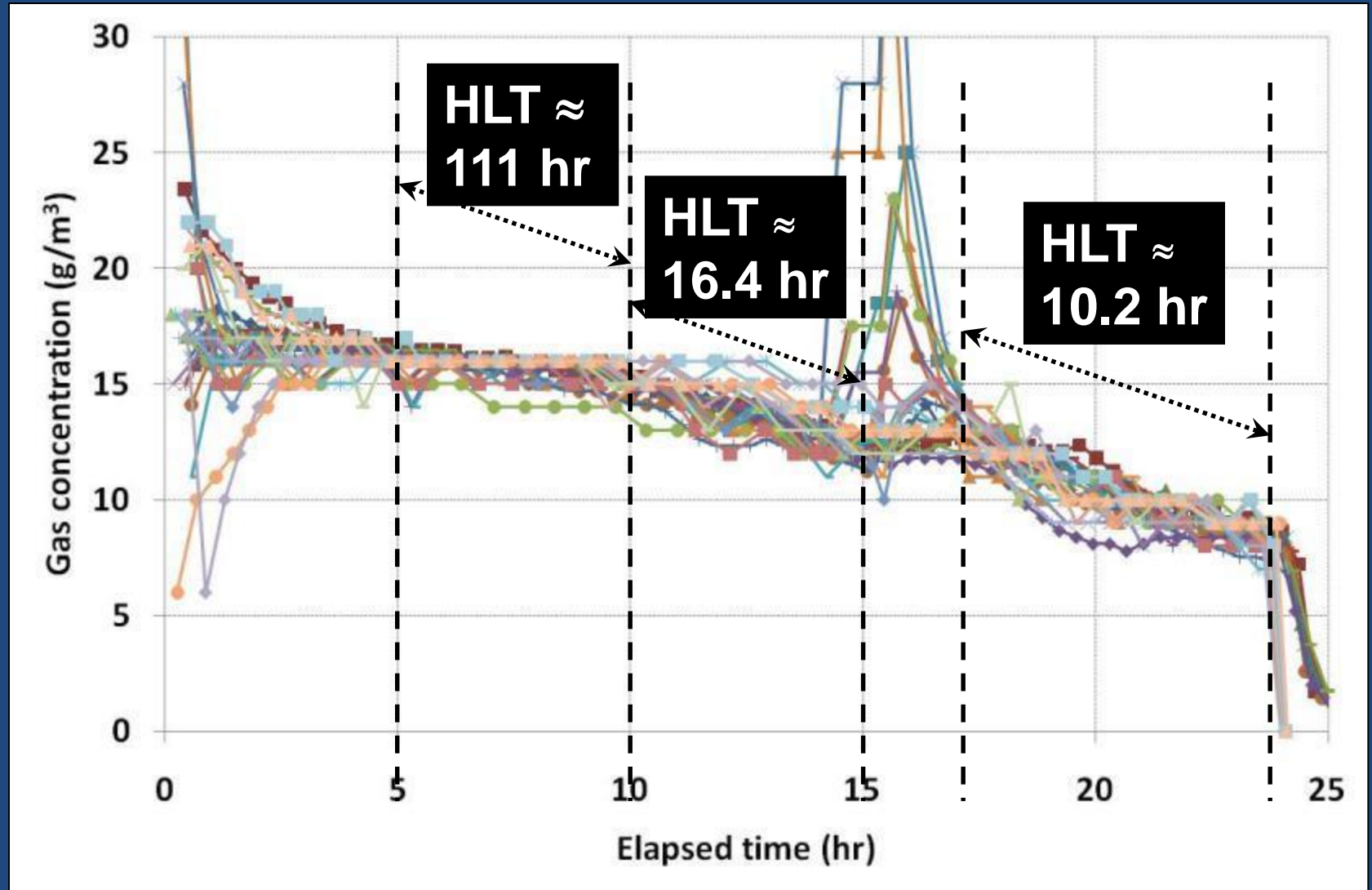




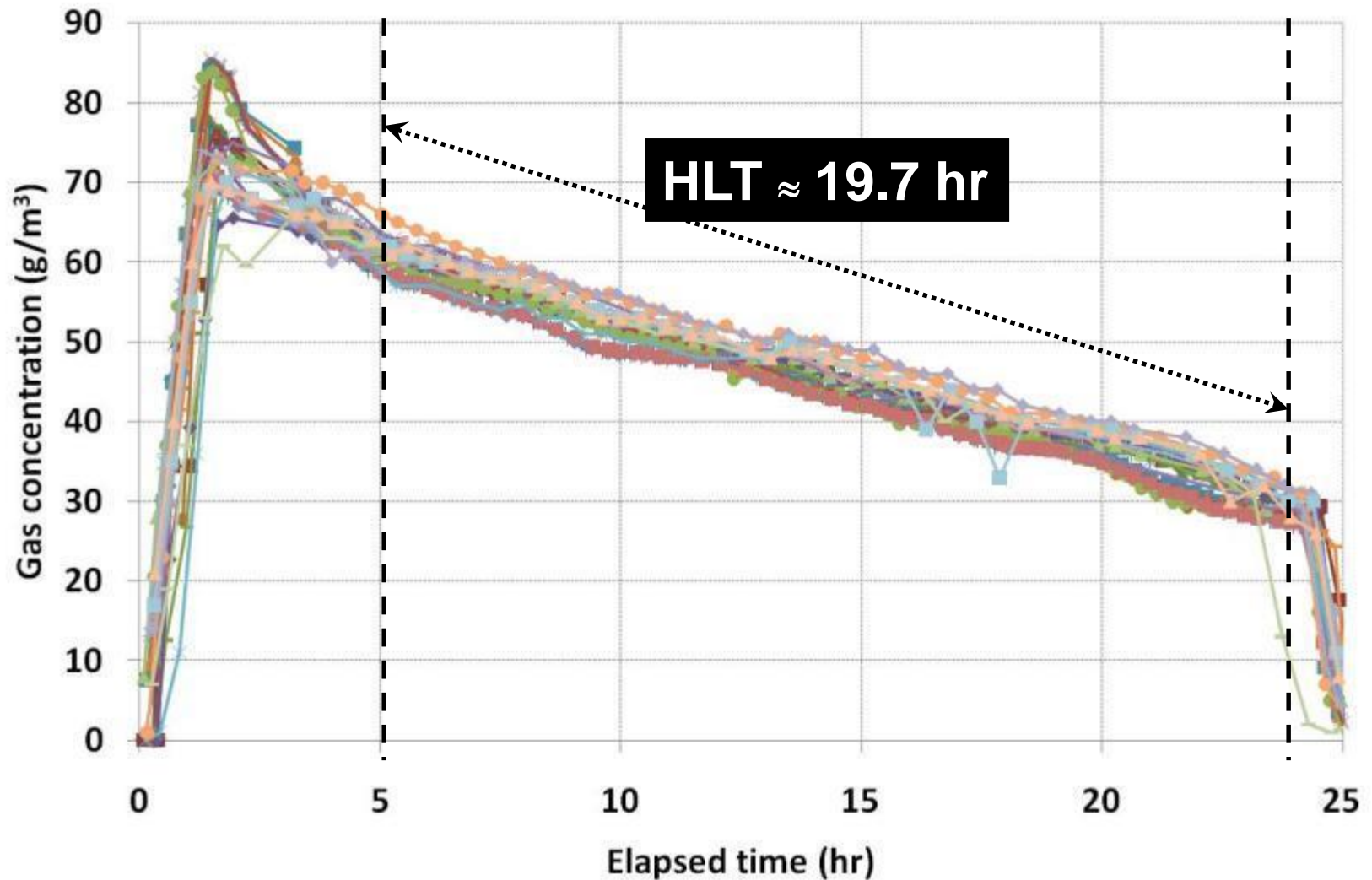
# K-State Flour Mill



# Gas Concentration: MB1



# Gas Concentration: SF1





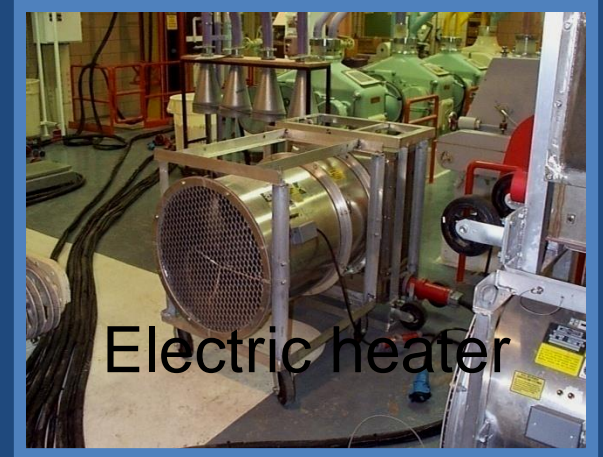
❖ Heat treatment: Raising the ambient air temperature to 122-140°F (50-60°C), and maintaining these temperatures for 24-36 hours



Gas heaters



Steam heater



Electric heater



Duct carrying heat from gas heaters

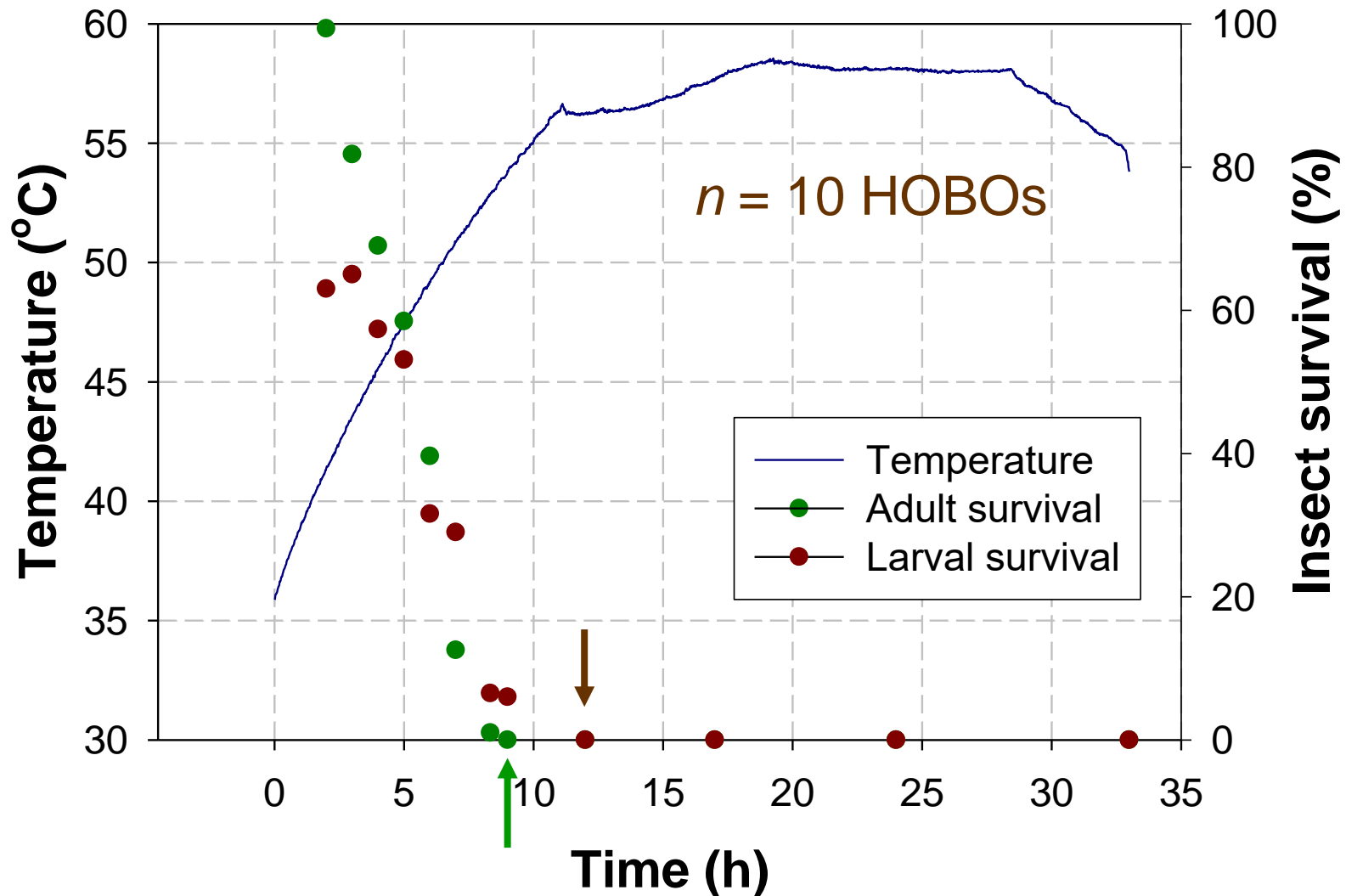


Fan

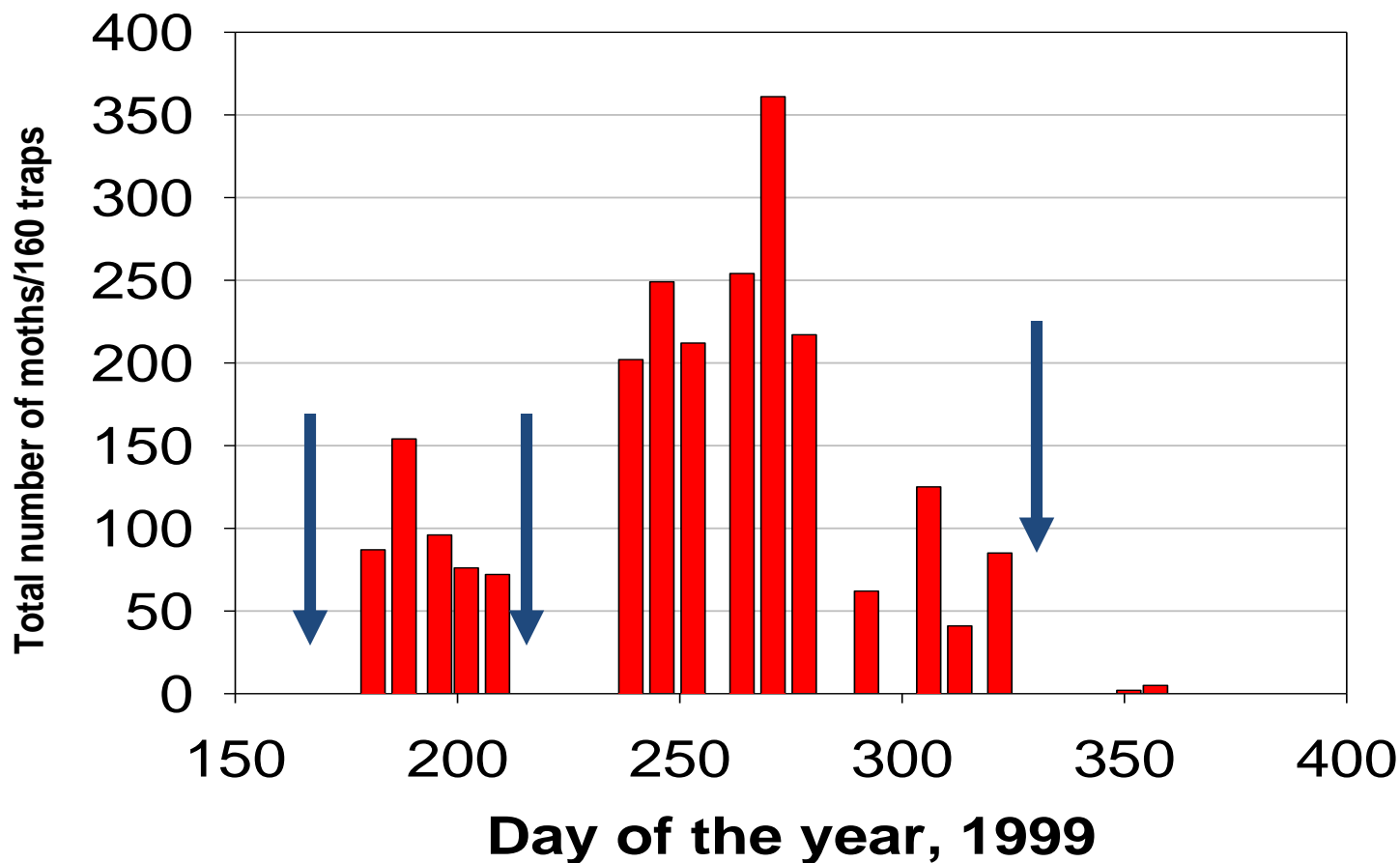
Once a Year

# Red flour beetle adult and young larval survival as a function of temperature

Aug 31-Sep 2, 2007



# Total Number of Male Moths Captured Before and After Heat Treatments (KSU Pilot Flour Mill, June 23-December 23, 1999)





# Captures of Red Flour Beetles (*Tribolium castaneum*)

Mean number of adults/trap/week

Date	Press room ( $n=35$ )	Flour room ( $n=10$ )	Outside ( $n=5$ )
5/30/2006	0.46	0.40	0.50
6/14/2006	0.20	0.42	0.65
6/28/2006	0.32	0.65	0
7/11/2006	0 (100%)	0.09 (86%)	0
7/25/2006	0.03	0.10	0.38
8/8/2006	0	0.05	0.50
8/23/2006	0.01	0.05	0.20

13. Not wearing proper protective  
apparel or clothing



<http://pesticidepics.org/>



# Fumigation



Gas monitoring and personal protective equipment are essential

## 14. Poor pallet spacing

## Improper stocking or storage practices

Give 12 inches of space between the wall and pallets

Pallets, 6 inches off the floor



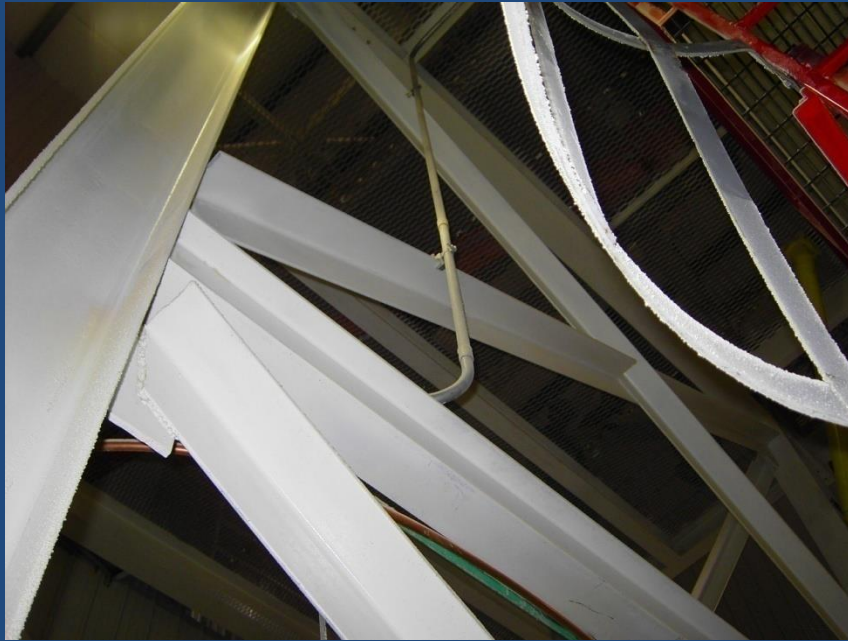
15. Not removing unused  
equipment or not being clean and  
organized

Sort, Set in order, Shine,  
Standardize, Sustain



# Eliminate Flat Surfaces and Remove Unused Equipment

Flat surfaces



Storage of unused equipment



# Conclusions

- Know your pests
- Know your facility
- Know how sanitation is related to pest activity
- Inspect and monitor pests
- Pest management service provider is NOT a magician
- Get yourself trained and familiar with sanitation and pest management

Thank you