Determination of Economic Thresholds in Stored Products.

Paul Fields
Entomologist
Winnipeg, Canada
fields.paul@gmail.com

IPM in Stored Products Alternatives and Innovation, 21 Feb. 2014, Monterey, Mexico

Did the Fumigation/Heat/Cleaning Work?

Paul Fields
Entomologist
Winnipeg, Canada
fields.paul@gmail.com

Will I pass the audit?

Paul Fields

Entomologist

Winnipeg, Canada

fields.paul@gmail.com

Will I lose customers?

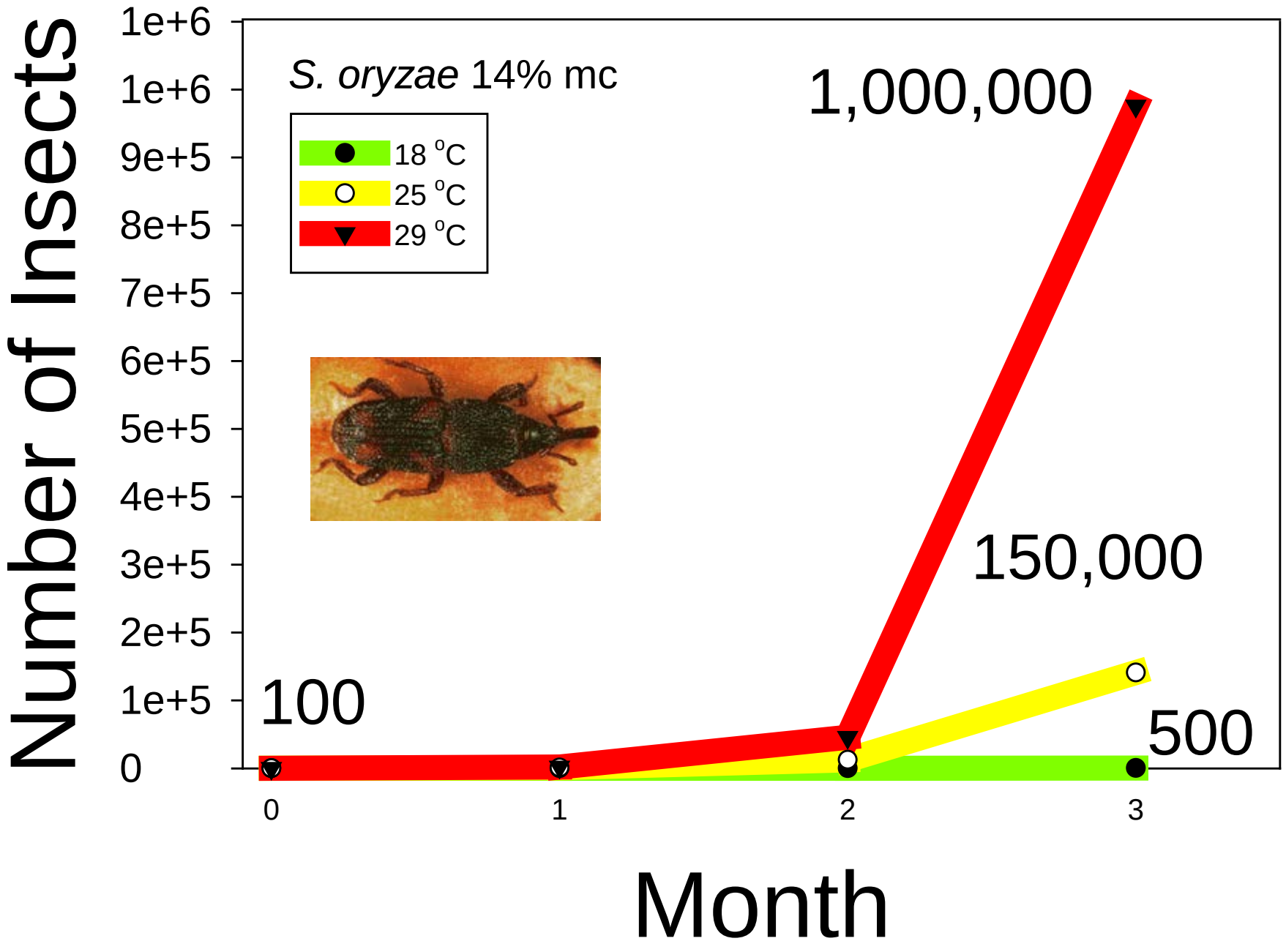
Paul Fields

Entomologist

Winnipeg, Canada

fields.paul@gmail.com

POWER AND SYRED / SPL / BARCROFT MEDIA


Number of Insects
1e+6
1e+6
9e+5
8e+5
7e+5
6e+5
5e+5
4e+5
3e+5
2e+5
1e+5
0
S. oryzae 14% mc
18 °C
25 °C
29 °C
1,000,000
150,000
500
100
0
1
2
3
Month

Food & feed processors

The Dilemma

- Customers want insect-free products without using insecticides.

Economic Threshold

- The economic threshold is the density of a pest at which a control treatment will provide an economic return.[1]

1. Wikipedia

Legal Limits: USA, CDN, MX

- Unacceptable levels
- Pre-milling: over 50 insect fragments /50 g flour
- Post-milling: over 20 insect fragments /50 g flour
- Rodent hairs: 2 hairs/50 g flour

Legal Limits: USA, CDN, MX

- Unacceptable levels
- Pre-milling: over 50 insect fragments /50 g flour
- Post-milling: over 20 insect fragments /50 g flour
- Rodent hairs: 2 hairs/50 g flour
- **Zero tolerance for live insects in flour**

Overview

- Treatments
- Bioassays
- Pheromone Traps
- Rebolt Sifter Tailings
- Measuring gas/heat

Canadian MB Alternative Trials

- Methyl bromide: 7 treatments
- Sulfuryl fluoride (ProFume): 8 treatments
- Phosphine, heat and CO_2 : 2 treatments
- Heat: 6 treatments
- IPM / Sanitation: 1 treatment

- 13 mills, 5 provinces, 5 milling companies, over 9 service providers

MB and SF Fumigations

Phosphine, Heat and Carbon Dioxide

- Carbon dioxide at 3-6%
- Heat at 30-40°C
- Phosphine at 100 ppm, ECO_2FUME
- Sensitive equipment: remove or seal
- Minimizes corrosion

Heat: Portable Steam Heaters

Armstrong International Inc
Mill 3, June 2006

Roo Can Inc.
Mill 2, September 2003

Heat Treatments in Germany

www.thermonox.de

www.biotech.at

Raj Hulasare: Temp Air

- Heat treatment, the future of pest control

How Many Insects?

Flour Mills are Complex Structures

Overview

- Treatments
- Bioassays
- Pheromone Traps
- Rebolt Sifter Tailings
- Measuring gas/heat

Overview

- Treatments
- Bioassays (insects in vials)
- Pheromone Traps (insects on floor)
- Rebolt Sifter Tailings (insects in flour stream)
- Measuring gas/heat

Bioassay

- Put insects at stage of interest in vial
- Expose to gas/heat
- Mortality after treatment

Stage Specific Toxicity for Various Fumigants.

Gas	Insect	CT to kill 95% of the population (g-h/m^3)				Reference
		Egg	Larvae	Pupae	Adult	
sulfuryl fluoride	confused flour beetle	1125	-	-	55	Kenga 1957
	granary weevil	794	14	14	15	Kenga 1957
methyl bromide	confused flour beetle*	-	-	90	60	Heseltine & Thompson 1974
	confused flour beetle*	65	98	251	-	Bell et al. 1988
	rice weevil	37	10	44	27	Krohne & Lindgren 1958
phosphine	Indian meal moth*	77	1	1	-	Bell 1976
	confused flour beetle	2	0.1	0.3	0.3	Lindgren & Vincent 1966

* complete kill.

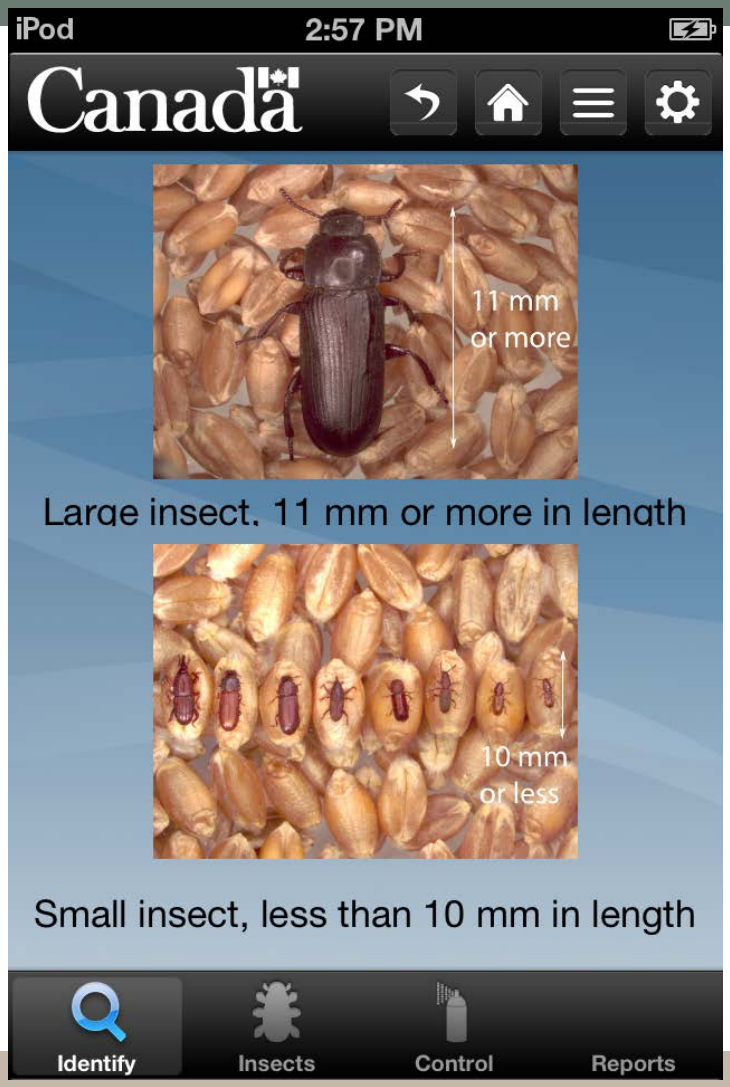
Most Resistant Stage

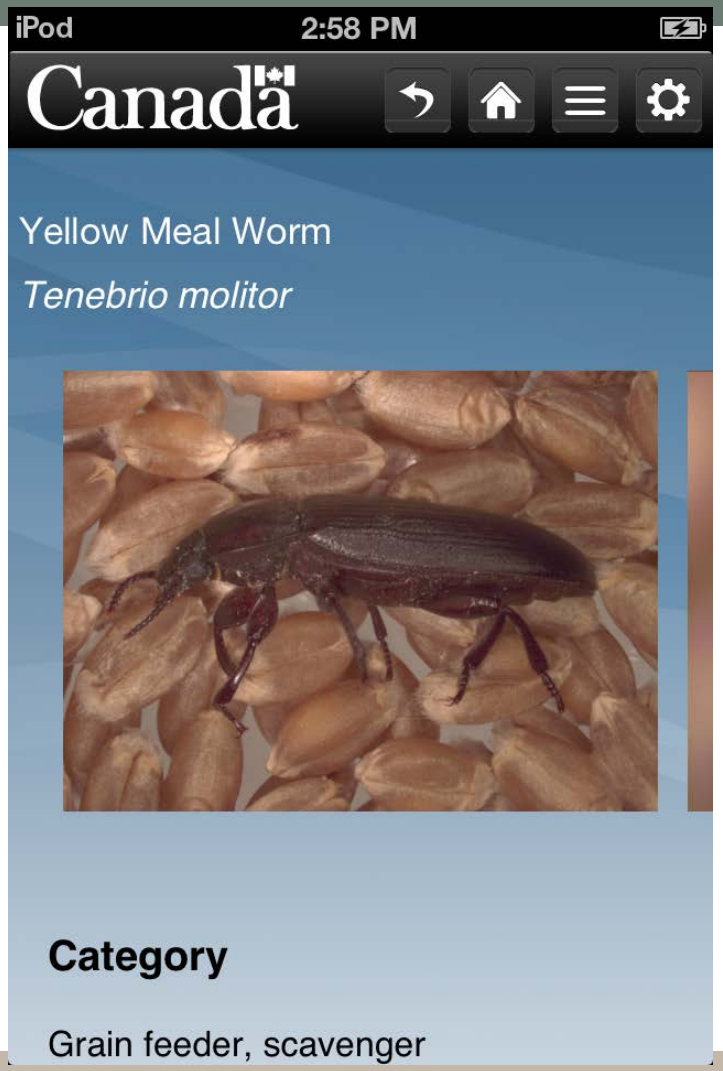
- Depends on species, control method

- MB: Pupae, 2x
- SF (Profume) : Egg, 20-50x
- PH_3: Egg, 5-70x
- Heat: Young larvae, 2-8x (*T. castaneum*)
- Cold: Adult, 5x (*C. ferrugineus*)

Online Tool for Insect ID

Canadian Grain Commission





Bioassays

- Boring science
- Good public relations
- Simple to run
- Does not give real time data

Insect Bioassays: Methyl Bromide

- MB:
  - 7 trials
  - 100% adult mortality
  - 1 trial, 98.8% egg mortality
- PH_3+CO_2+Heat:
  - 2 trials
  - 100% adult mortality
  - 99% egg mortality

Insect Bioassays: Sulfuryl Fluoride

Mill	Date	Treatment	Conc.-Time ($g\text{-}h/m^3$)	Mortality (%)	
				Adult	Immatures
4a	Dec. 2004	SF	457	100	64
4a	Oct. 2005	SF	1096	100	96
8	July 2006	SF	832	100	99.6
5	Aug. 2006	SF	1280	100	99.7
10	Aug. 2008	SF	675	100	75
11	Sep. 2008	SF	750	100	81
12	Sep. 2008	SF	652	100	96
13	Oct. 2008	SF	768	100	93

Insect Bioassays: Heat

Mill	Date	Treatment	Maximum Temperature (^{0}C)	Mortality (%)	
				Adult	Immatures
1	Aug. 2003	Heat: forced air*	64	100	99.6
1	Aug. 2006	Heat: forced air*	56	100	100
7	Sept. 2006	Heat: forced air*	57	100	100
2	Sept. 2003	Heat: steam**	55	87	89
3	June 2006	Heat: steam***	57	94	99.6

* Temp-Air

** Roo Can portable heaters

*** Armstrong International portable heaters

Demonstration of Efficacy

Link to video of insects under heat

Overview

- Treatments
- Bioassays
- Pheromone Traps (insects on floor)
- Rebolt Sifter Tailings

Pheromone Traps

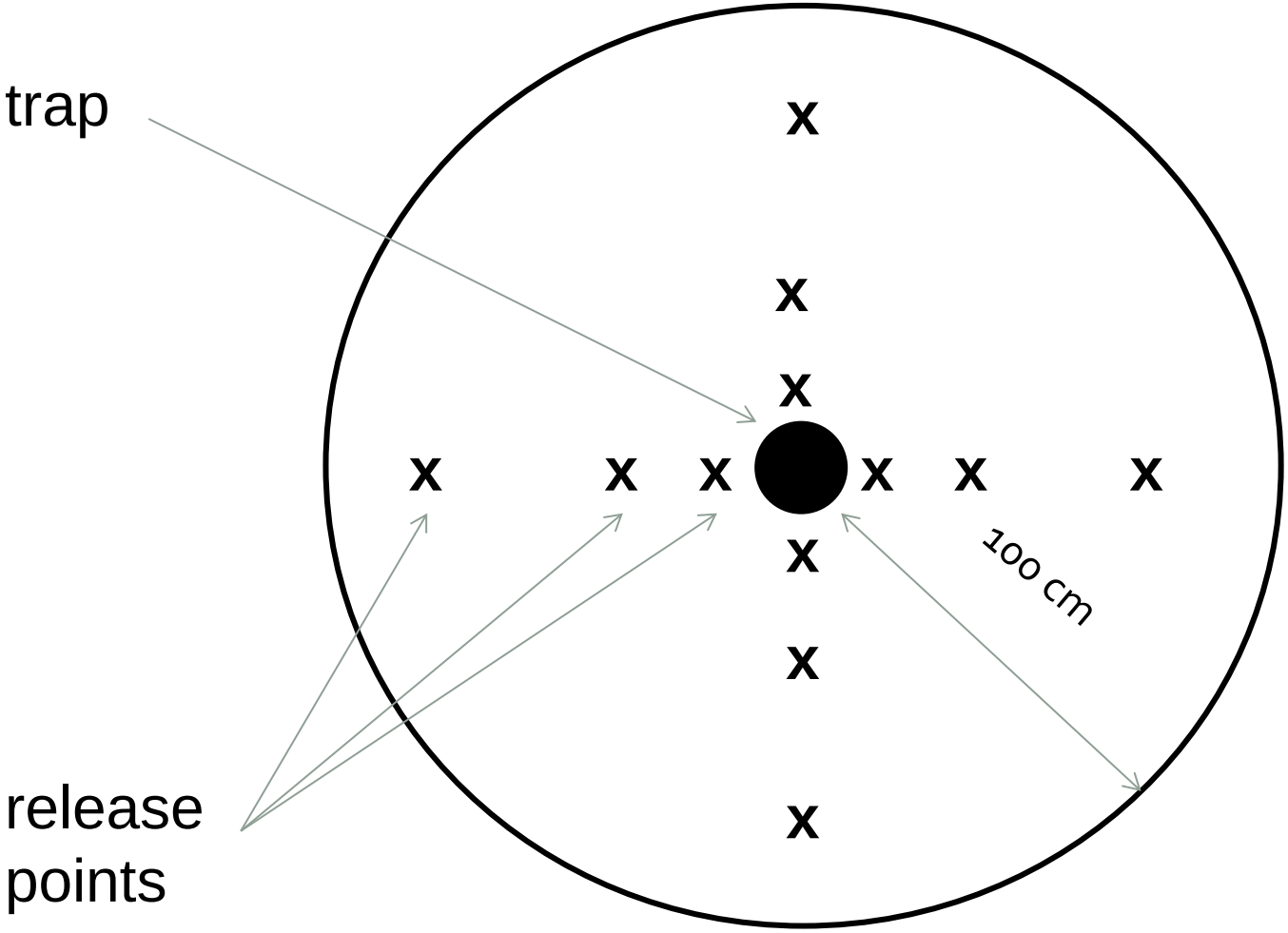
- pheromone baited
- 5-10 traps/floor
- sifter and roll floors
- weekly counts
- expressed as % of pretreatment populations

Tribolium Traps

Dome trap - Trécé

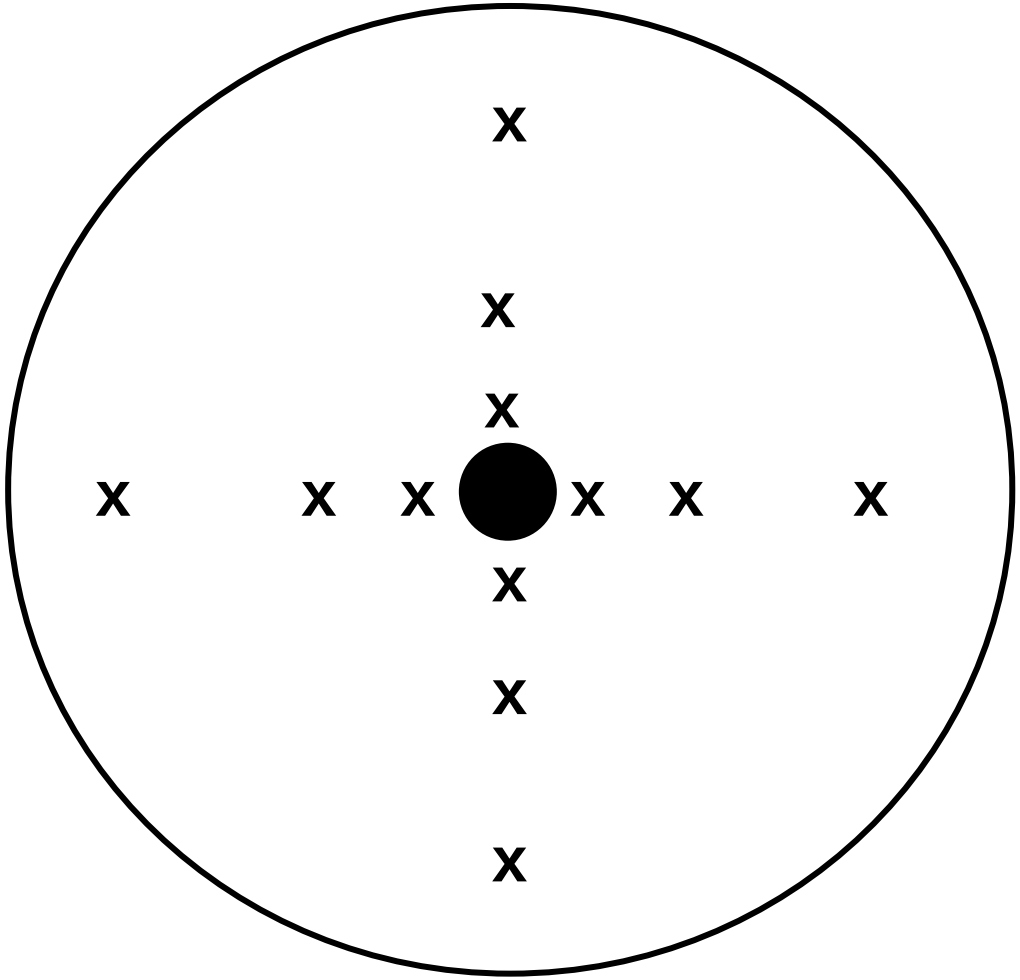
Pheromone = 4R,8R-dimethyldecanal
Food bait = cereal oil

Release and Recapture Study



Release and Recapture Study

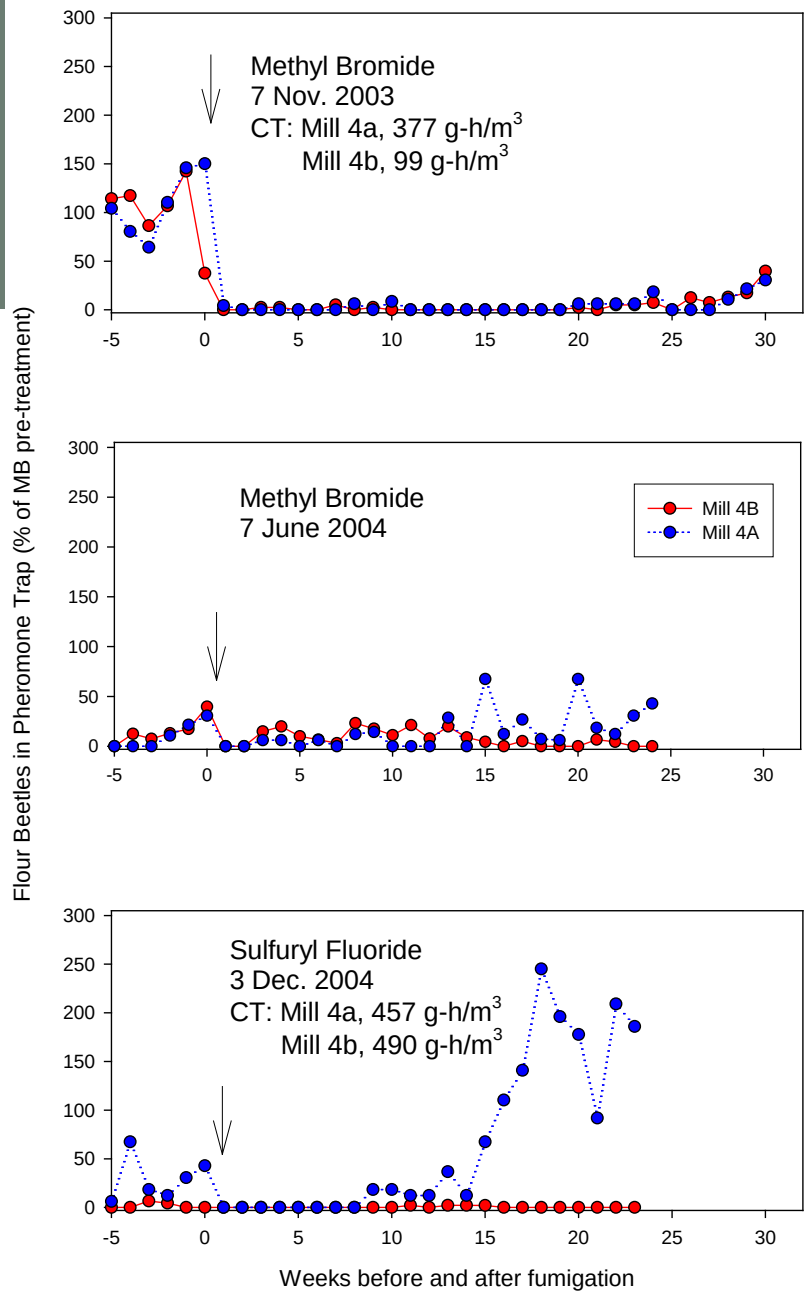
- Males released
- Timed until
  - Exited bullseye
  - Caught in trap
  - 10 minutes up



Release and Recapture Study

Treatment	Not in trap	In trap
Pheromone	130	2

Pheromone Traps



Sulfuryl Fluoride

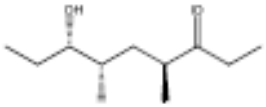
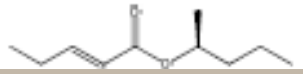
Mill 4a, 457 gh/m3
Mill 4a, 1096 gh/m3
Mill 5, 1280, gh/m3
Mill 8, 836 gh/m3

Trap Catches Roll Stand (% pre-treatment)

800
700
600
500
400
300
200
100
0

-10 -5 0 5 10 15 20 25 30

Weeks Post Treatment

Scientific Name / Common Name	Pheromone Structure	Pheromone Name / Ratio
Anthrenus verbasci(L.) Varied carpet beetle		(E)-5-Undecenoic acid
Attagenus unicolor (Brahm) Black carpet beetle		(E,Z)-Tetradecadienoic acid
Dermestes maculatus De Geer Hide beetle		11 isopropyl ketones: (Z)-5-dodecenoate, (Z)-7-dodecenoate, (Z)-9-dodecenoate, tetradecanoate, dodecanoate, (Z)-5-tetradecenoate, (Z)-9-tetradecenoate, hexadecanoate, (Z)-9-hexadecenoate, oleate
Lasioderma serricone(F.) Cigarette beetle		(4S,6S,7S)-7-hydroxy-4,6-dimethylnonan-3-one
Prostephanus truncatus (Horn) Larger grain borer		1-Methylethyl (E)-2-methyl-2-pentenoate (2) 1-methylethyl (E,E)-2,4-dimethyl-2,4-heptadienoate (1)
Rhyzopertha dominica (F.)		(S)-1-Methylbutyl (E)-2-methyl-2-pentenoate

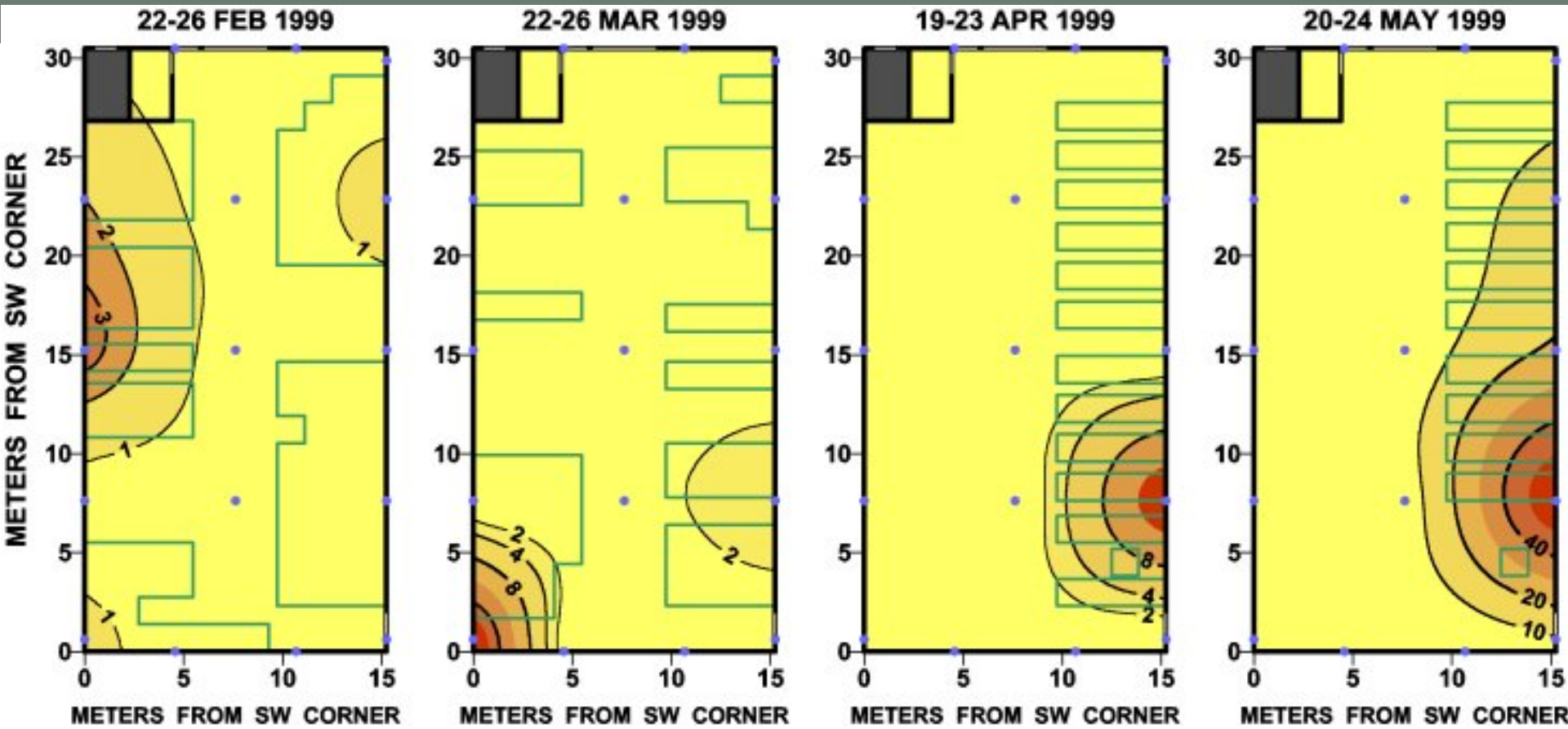
Different Insects, Different Pheromones

- Swords, P. and A., V.R. 2010. Summary of commercially available pheromones of common stored product moths. 10th IWCSSP
- Swords, P. and Van Ryckeghem, A. 2010. Summary of commercially available pheromones of common stored-product beetles. 10th IWCSSP

Precision Trapping

- Pinpoints location of infestation
- Need 10 to 50 times more traps/area
- Analysis data with spatial statistics
- Or use triangulation

Precision Trapping



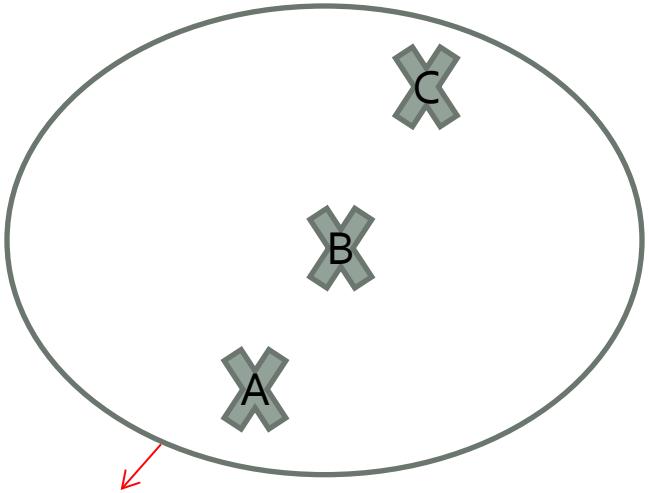
Distribution of merchant grain beetle in a botanical warehouse.
Arbogast et al. 2002.

Methods: Grain Samples

A- 10 cm from edge

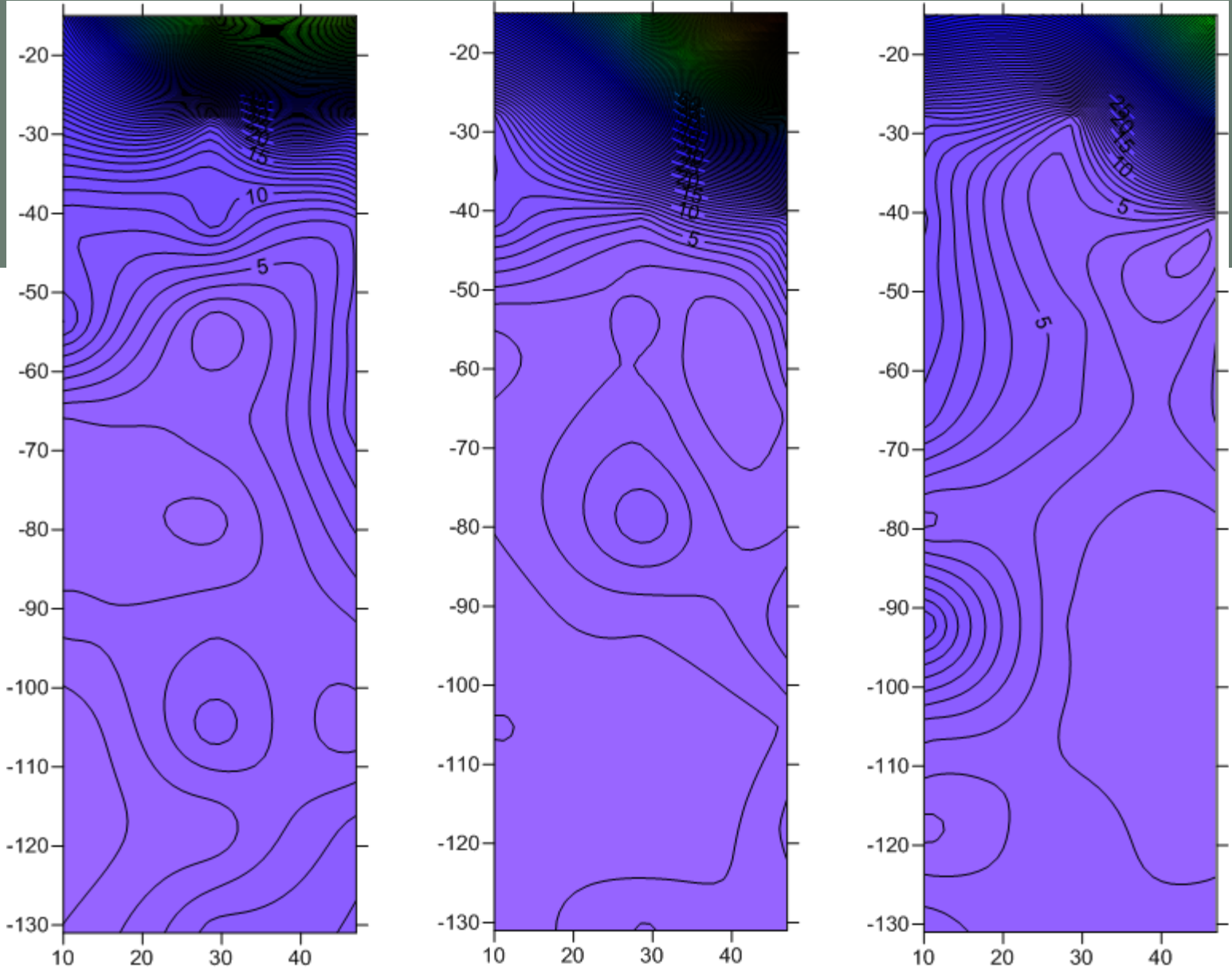
B- Centre

C- 10 cm from edge



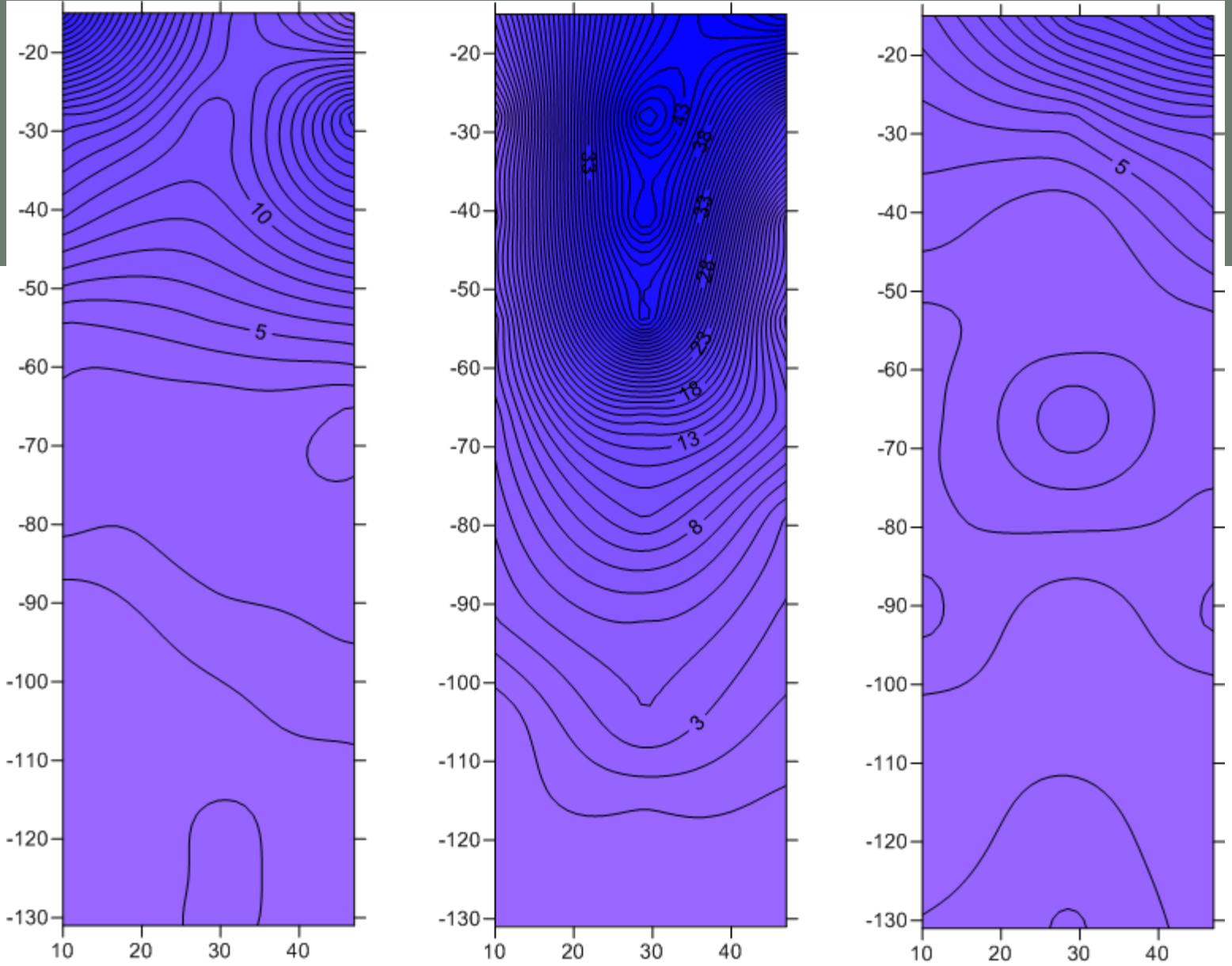
Grain samples: 0, 2, 4, 7, 14, 21 d

Barrel of wheat



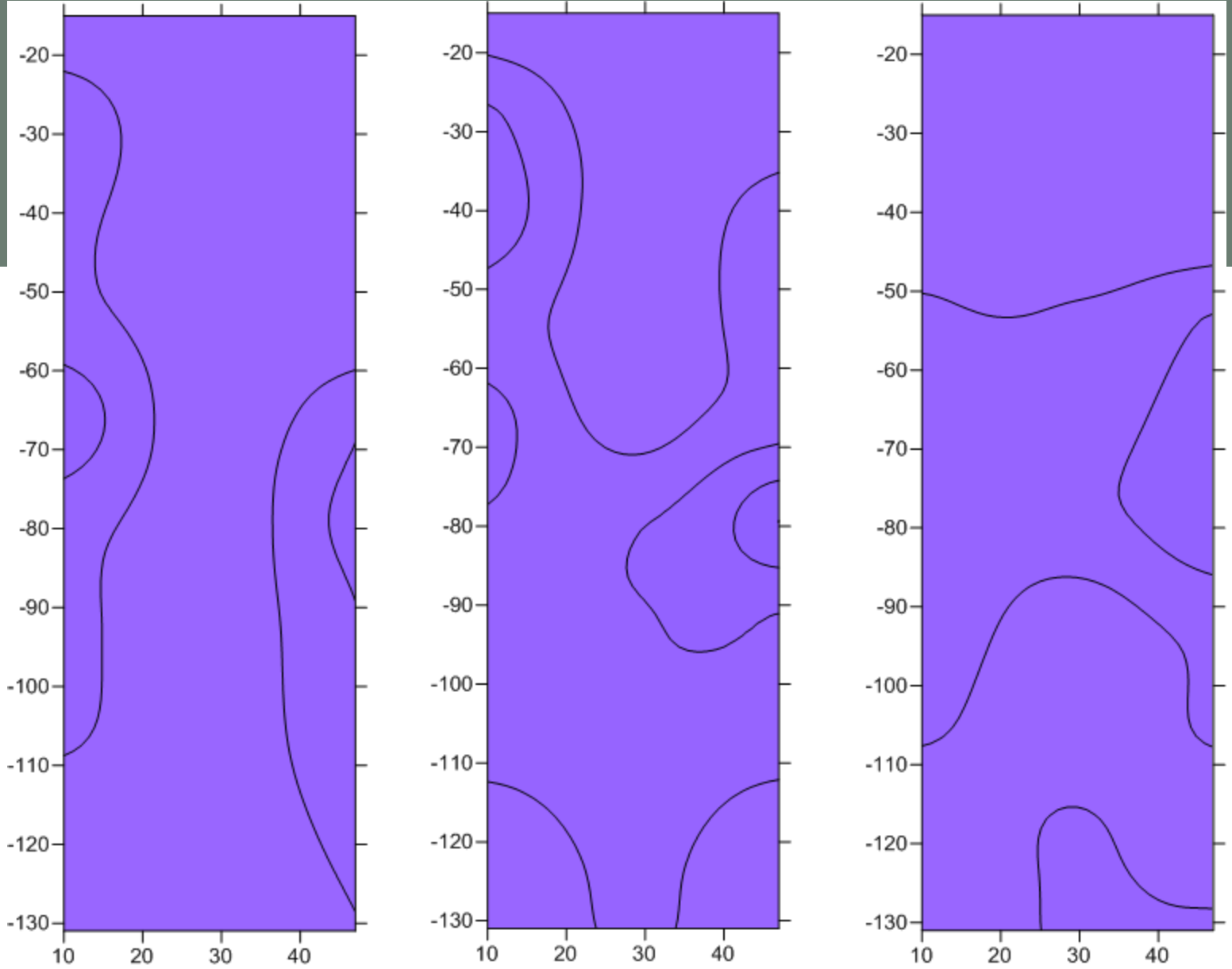
R. dominica live

Day 0



Barrel 1 Barrel 2 Barrel 3

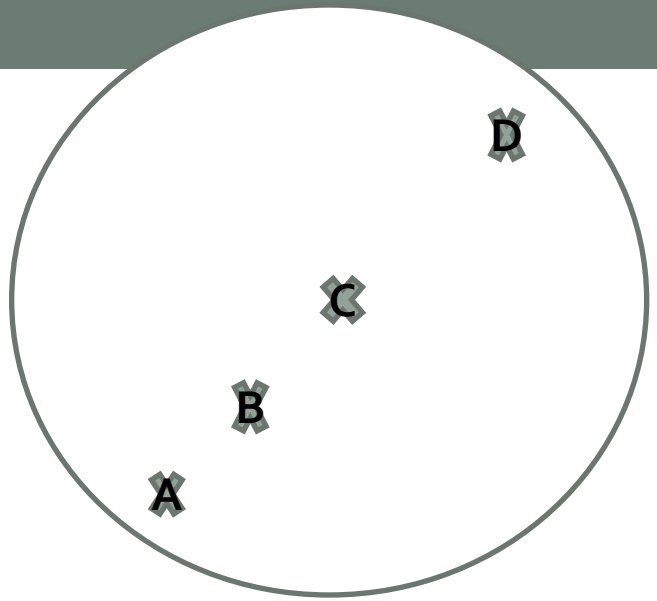
R. dominica live Day 2



Barrel 1 Barrel 2 Barrel 3

R. dominica live Day 4

Methods: Temperatures



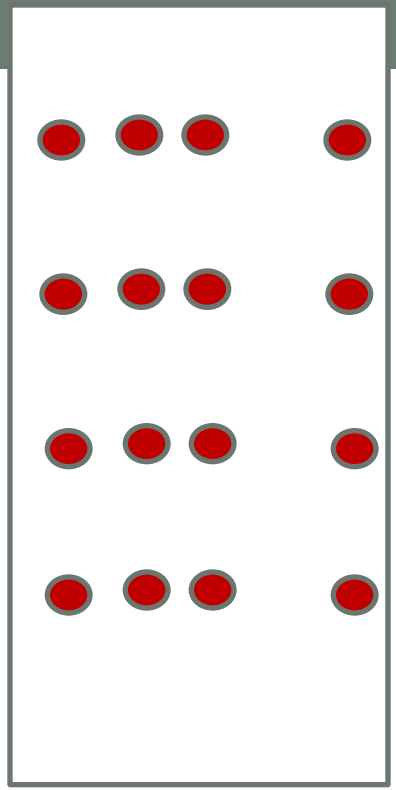
A- 10 cm from edge

B- 20 cm from edge

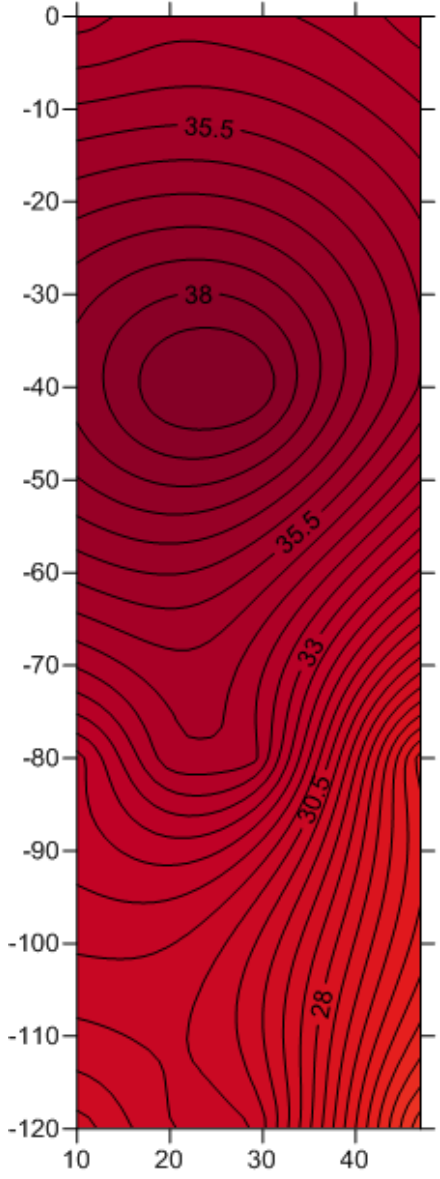
C- 50 cm from edge (Center)

D- 10 cm from edge

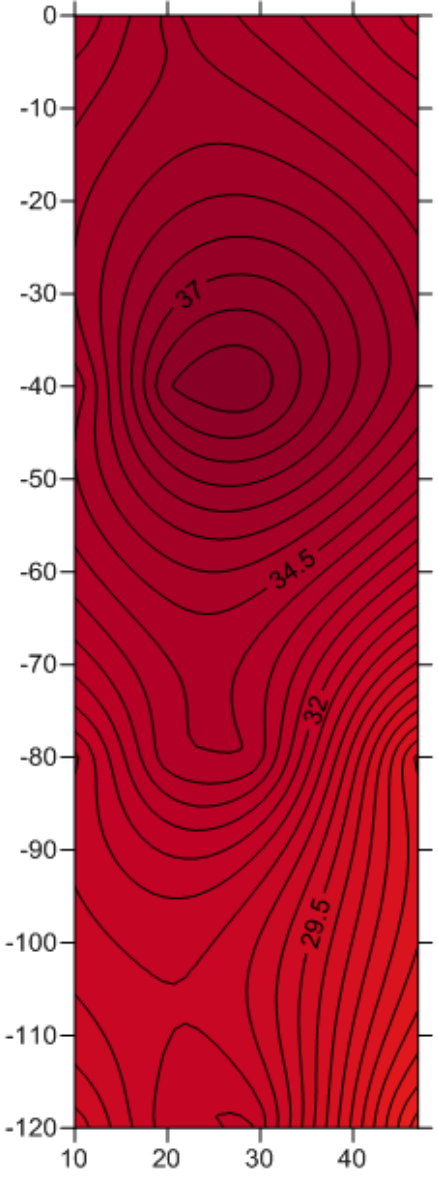
R. dominica



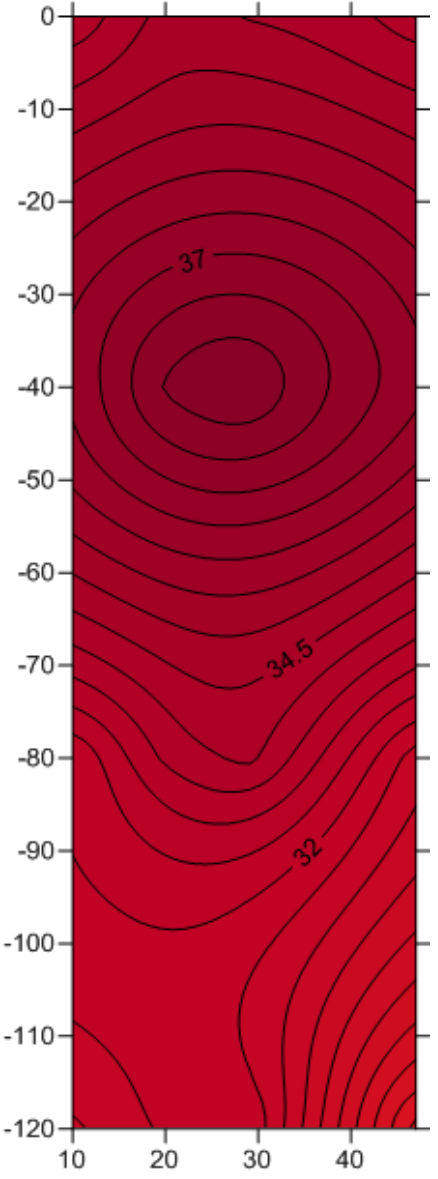
Barrel of wheat



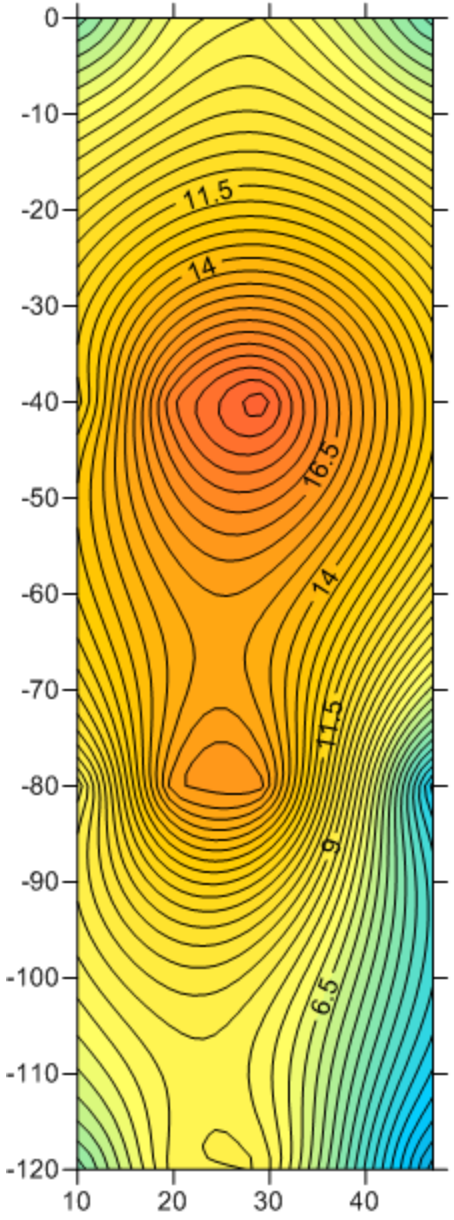
Barrel 1



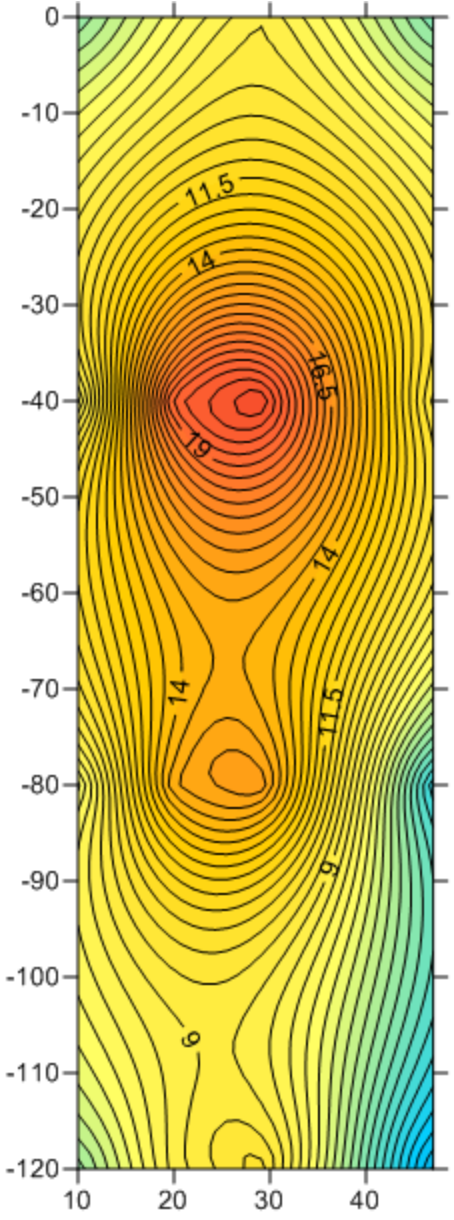
Barrel 2



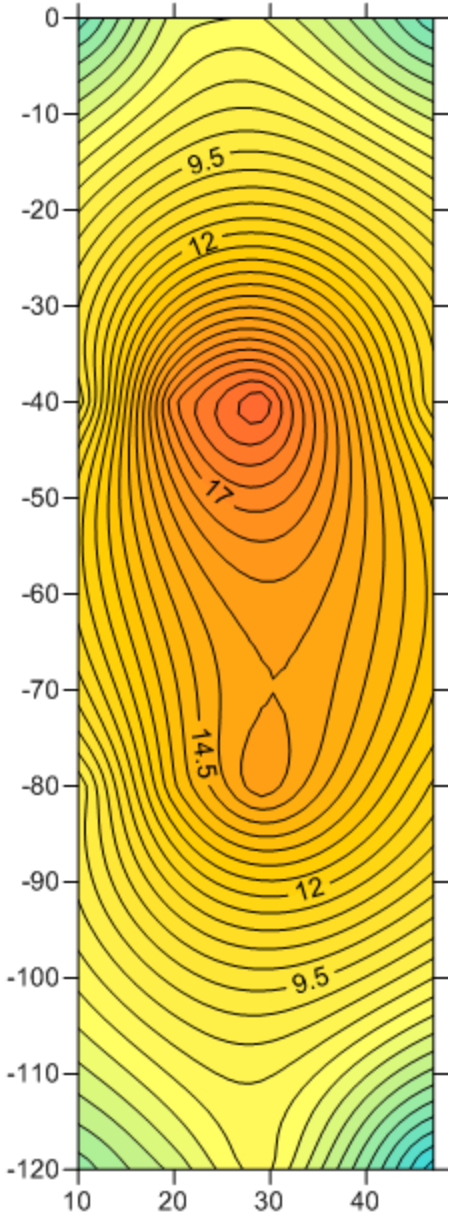
Barrel 3
Day 0



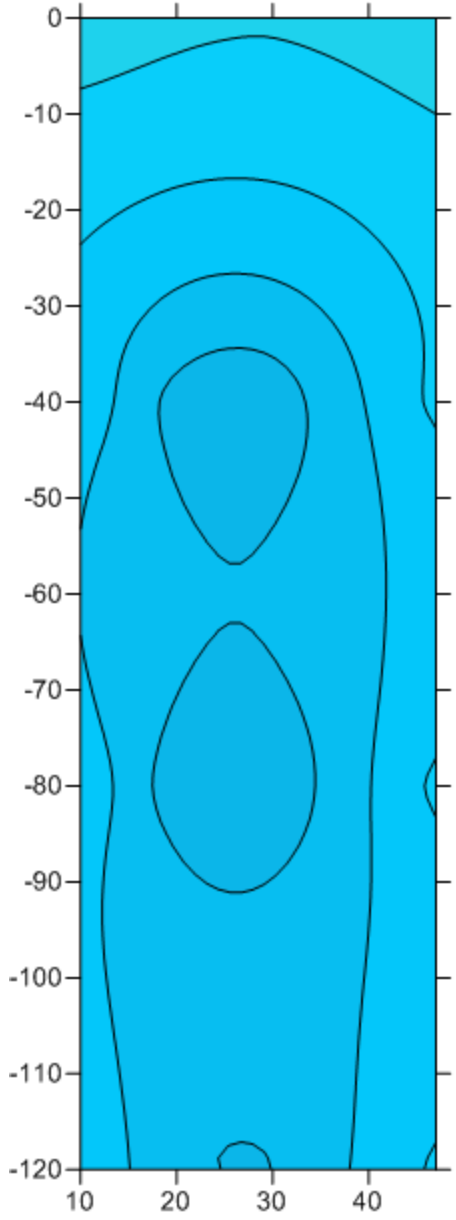
Barrel 1



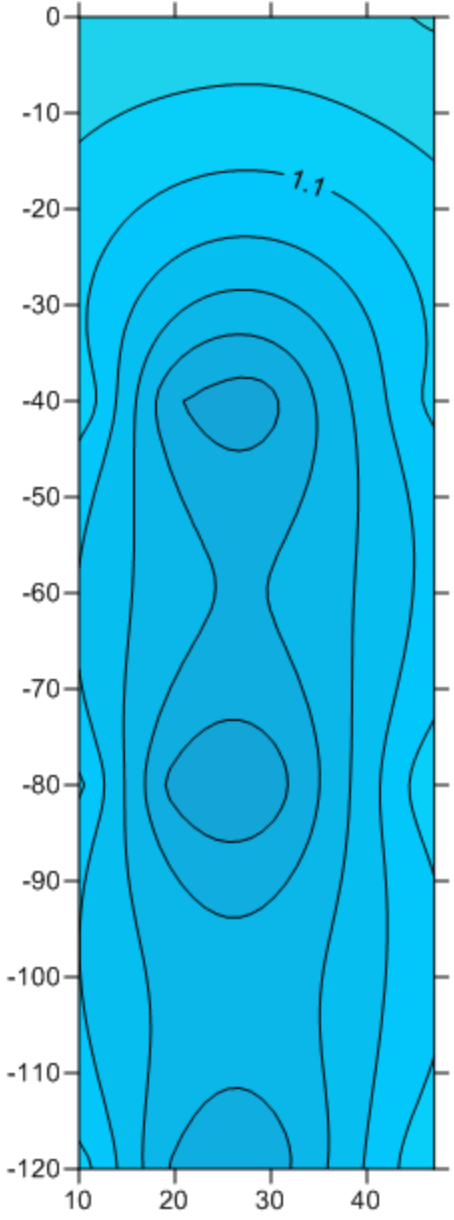
Barrel 2



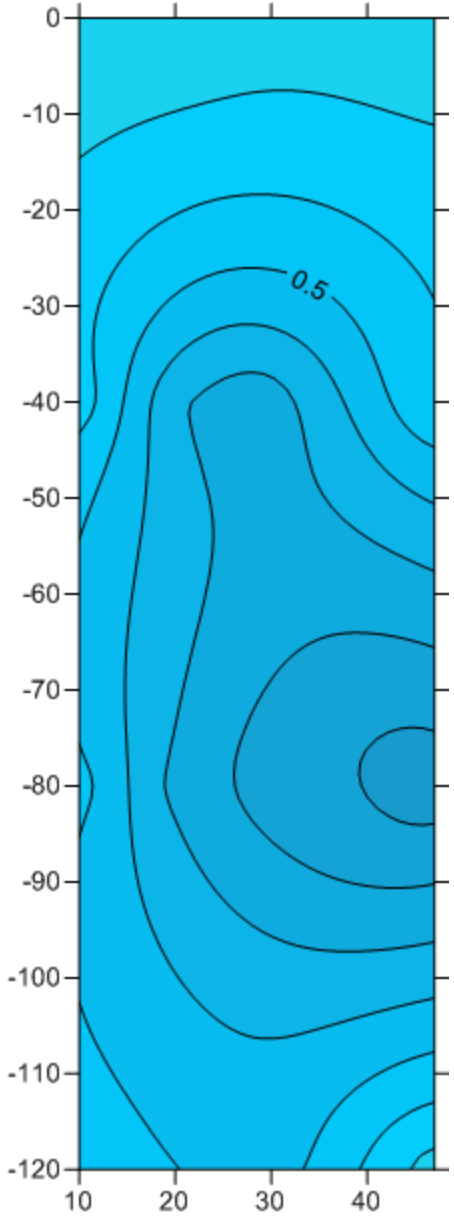
Barrel 3
Day 2



Barrel 1



Barrel 2



Barrel 3
Day 21

Italian Flour Mills

Mediterranean flour moth, *Ephestia kuehniel*

Pheromone Mass Trapping

Jerry Heaps

- Insect Growth Regulators (IGR's) and mating disruption

Overview

- Treatments
- Bioassays
- Pheromone Traps
- Rebolt Sifter Tailings

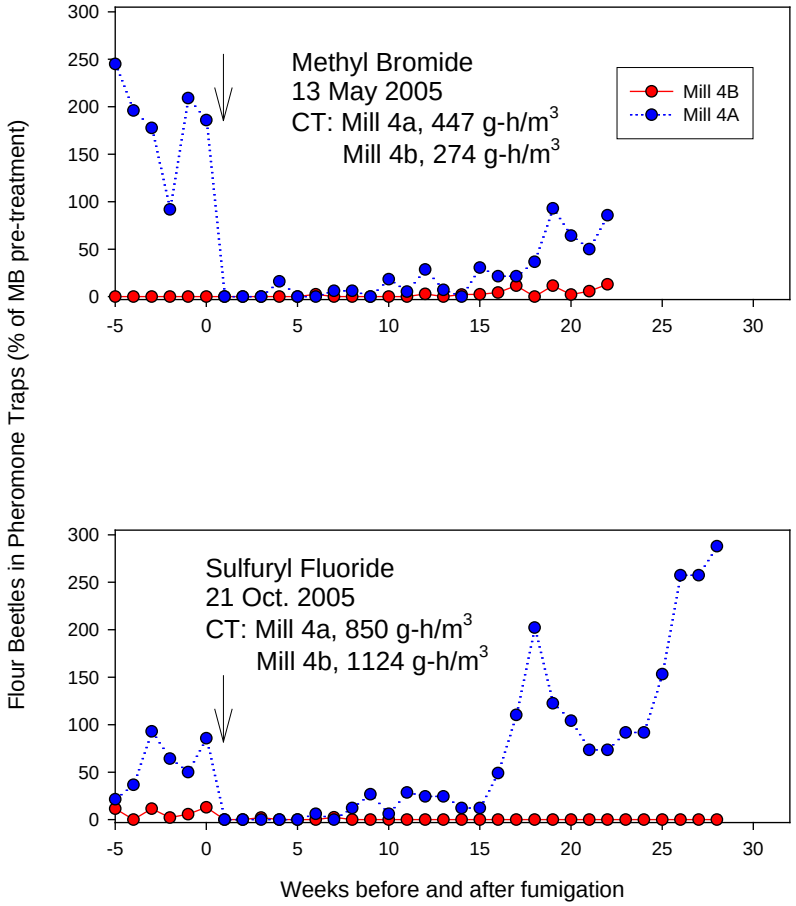
  (insects in flour stream)

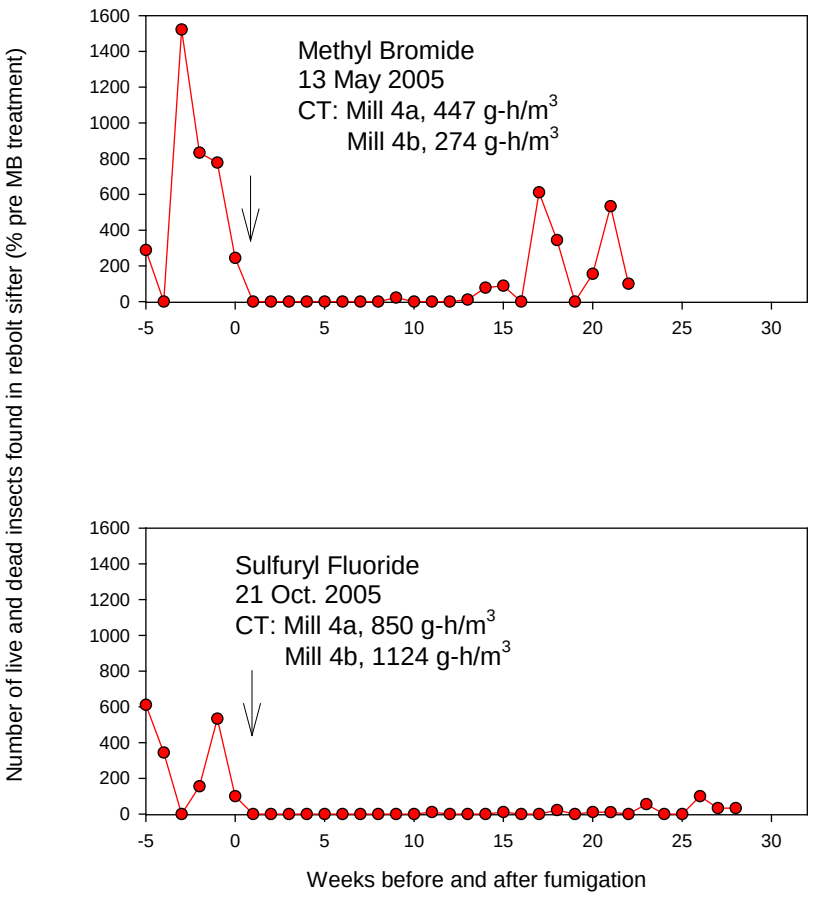
Rebolt Sifter Tailings

- Sift insects out of flour
- Usually just before load-out bins
- Pin mill before or after
- Every load, once a day or 3x/wk
- Only larvae and adults
- Eggs pass through

Pheromone Trapping

Rebolt Sifter Tailings





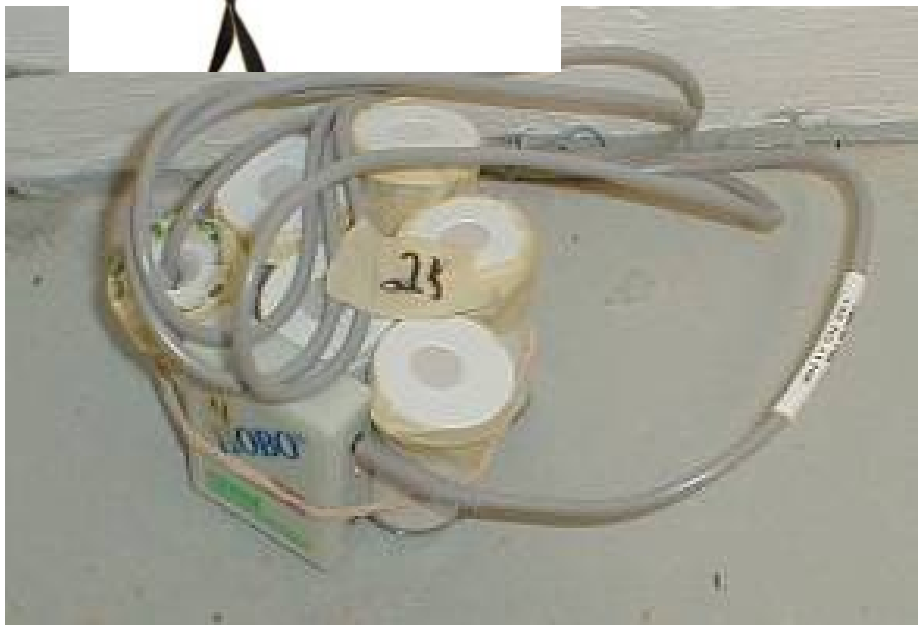
During Cleaning

- When cleaning equipment, sifters, roll stands, etc…
- Note number of insects,
  - None = 0 insects
  - Low = 1-10 insects
  - Medium = 10-20 insects
  - High = 20+
- Document, follow trends over time

Overview

- Treatments
- Bioassays
- Pheromone Traps
- Rebolt Sifter Tailings
- Measure gas/heat

Measuring Temperatures



Detailed Monitoring of Gas
Ellen Thoms: Dow AgroScience

Take Home Message

- Adults in vials easy to kill
- Adult bioassays in fumigation useless
- Pheromone trapping gives numbers
- Rebolt sifter tailings variable
- Mature control techniques: fumigation, heat, bioassays not needed.

Acknowledgements

- Participating flour mill companies
- Grant Duke, Tannis Mayert, Noel White (Agriculture and Agri-Food Canada)
- Gordon Harrison (Canadian National Milling Association)
- Abell Pest Control, PCO Services, Maheu and Maheu, Steritech Group Inc.
- Armstrong International, Cytec Canada, Dow AgroSciences, Roo-Can International, Temp-Air
- James Campbell for some images

Links

- Insect Identification: Canadian Grain Commission
- KSU Heat Treatment Workshop
- KSU Stored Product Text Book
- International Working Conferences on Stored-Product Protection

Acknowledgements

- Participating flour mill and pasta companies
- Grant Duke, Tannis Mayert, Noel White (Agriculture and Agri-Food Canada)
- Abell Pest Control, PCO Services, Maheu and Maheu, Steritech Group Inc., Groupe Cameron Inc.
- Armstrong International, Cytec Canada, Dow AgroSciences, Roo Can International, Temp-Air
- Images: James Campbell

Copyright

- This powerpoint is covered by MIT Copyright
- http://en.wikipedia.org/wiki/MIT_License
- Free to use any part of talk,combination and redistribution, as long as talk also covered by MIT Copyright.
- Can not use and charge for use.

MIT Copyrighted

- Copyright (C) 2014 Paul Fields

Links to internet images

- http://www.hellopro.co.uk/Igrox_Pest_Management_Services_Ltd-20647-noprofil-1001585-71460-0-1-1-fr-societe.html
- http://www.insectslimited.com/store/beetles/pantry-patrol-display-case.html