

Conservation Biological Control: Can it Work in the Cotton System?



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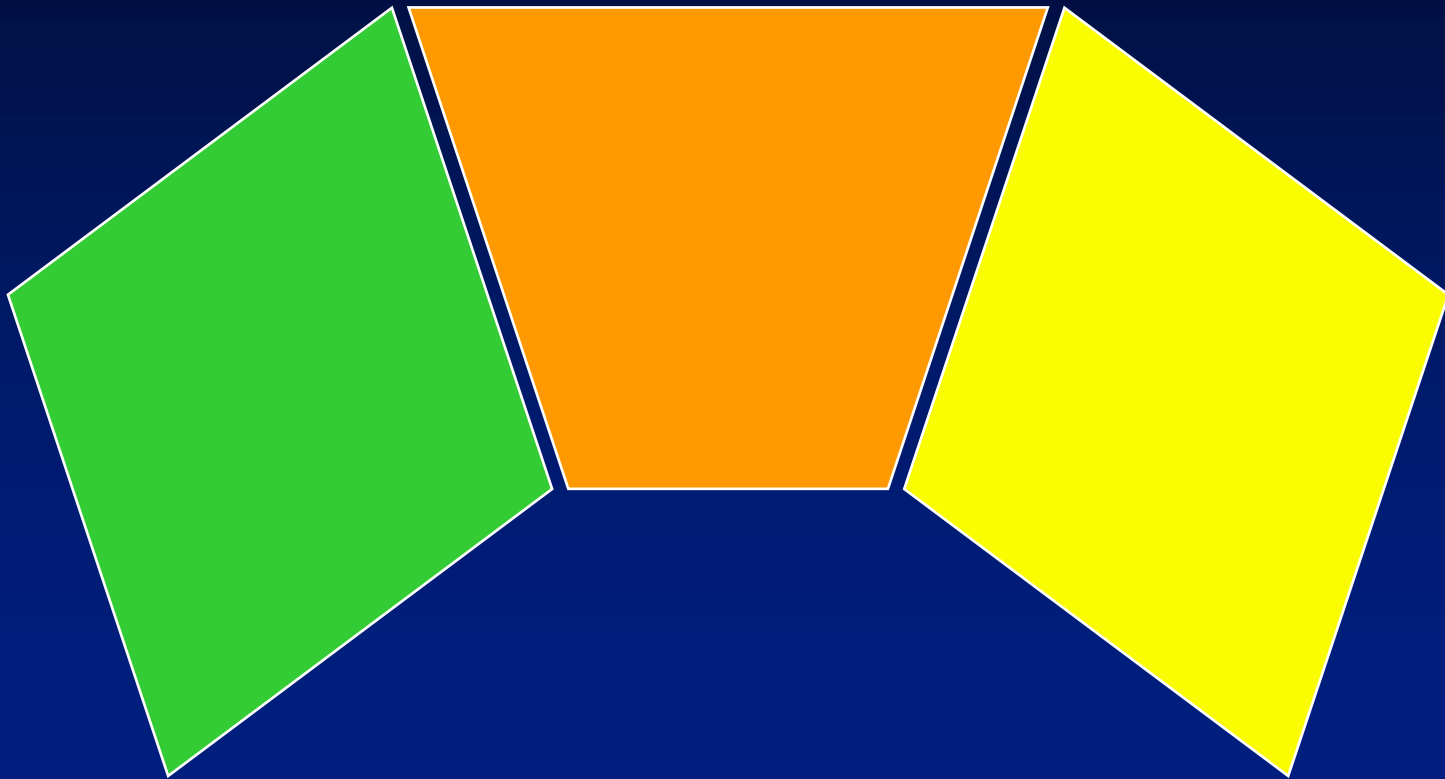
Conservation Biological Control

“ Manipulation of the environment to favor natural enemies, either by removing or mitigating adverse factors or by providing lacking requisites.”

DeBach 1974

Biological Control - Approaches

Conservation

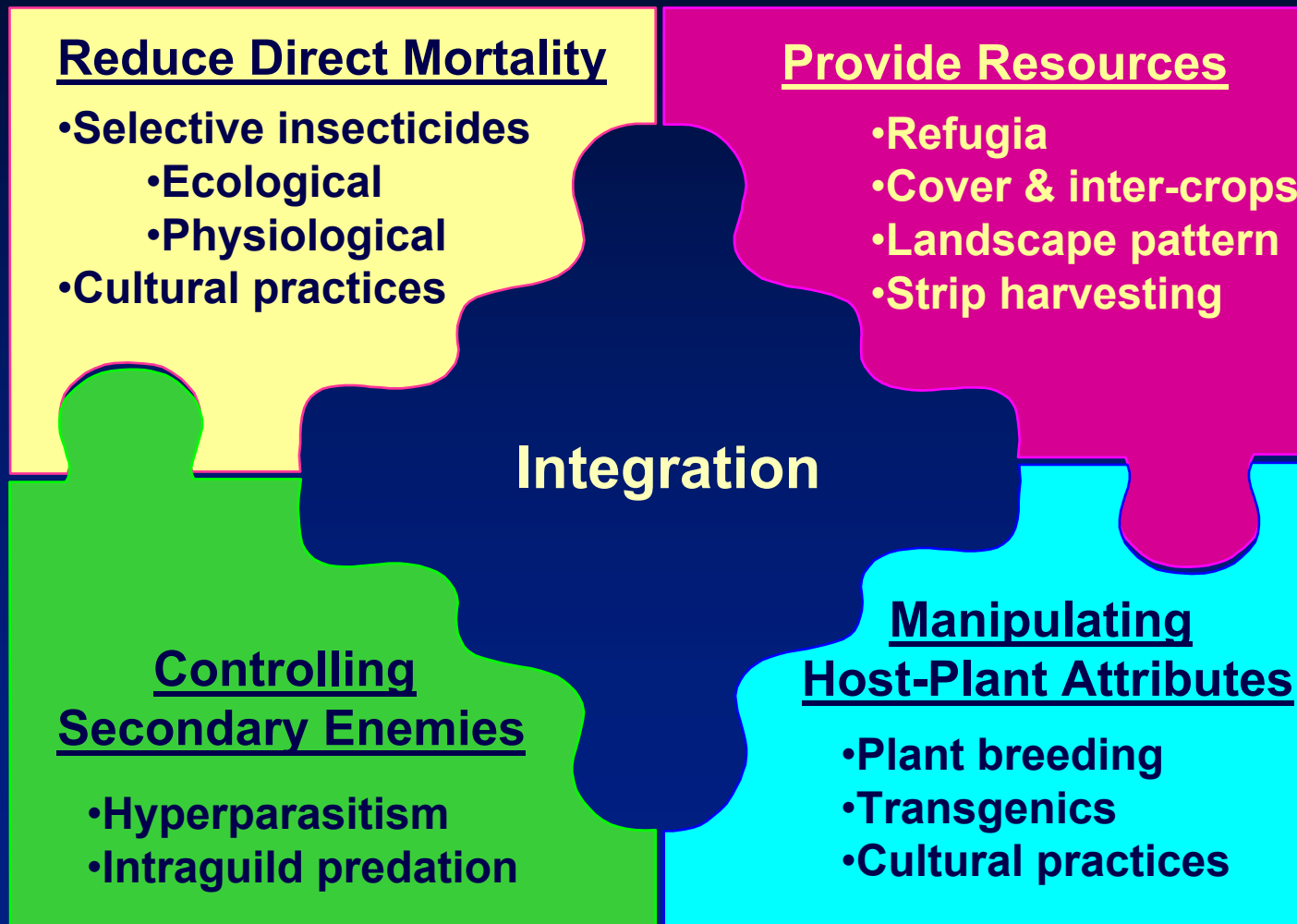


Classical

Augmentation

Conservation Biological Control

Approaches



After
Rabb, Stinner
& van den Bosch
1976

Conservation Biological Control

Components

**Survey & Identification
of Potentially Important
Natural Enemies**

**Study of Biology & Ecology;
Determination of Factors
Constraining or Enhancing
Biological Control**

**Implementation &
Evaluation**

Progress



Survey

**Is there potential for natural
biological control?**

Natural Enemy Complex - Western U.S.

Parasitoids

30+ species

Hyposter
Copidosoma
Microplitis
Lysiphlebus
Chelonus
Eretmocerus
Encarsia
Anaphes
Leiophron

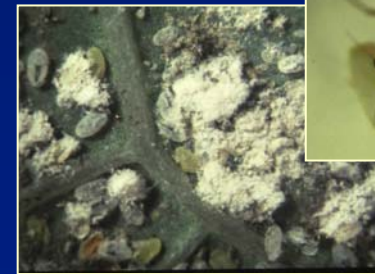
Predators

50+ species

Geocoris
Orius
Nabis
Zelus
Collops
Hippodamia
Drapetis
Chrysoperla
Misumenops

Pathogens

Various viruses, bacteria & fungi



Natural Enemies – Pectinophora gossypiella



Arizona/California

Predators

≈23 species described
9 species (immunological ID)

Parasitoids

4 native species described (rare)
16 exotic species introduced
(0 established)



Pathogens

3+ Viruses and bacteria

Natural Enemies – Bemisia tabaci

Worldwide

- ❖ 114+ Predators
(various methods)



- ❖ 50+ Parasitoids



- ❖ 11+ Fungi



Arizona Cotton

- ❖ 20 Predators
(immunological ID)

- ❖ 3 Native parasitoids
- ❖ Many exotic parasitoids introduced
 - ❖ 2 established

- ❖ 2 Fungi?

Natural Enemies – Lygus hesperus

Arizona/California

Predators

10+ species described
5 species (immunological ID)



Parasitoids

3 native species described
2 exotic species introduced
(both established in CA)

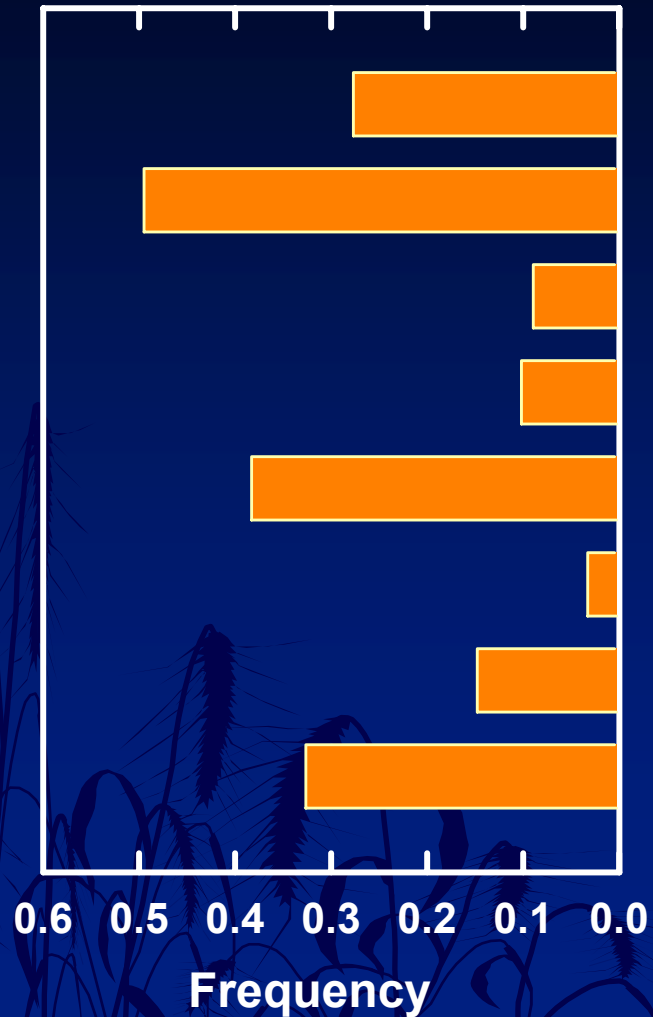


Pathogens

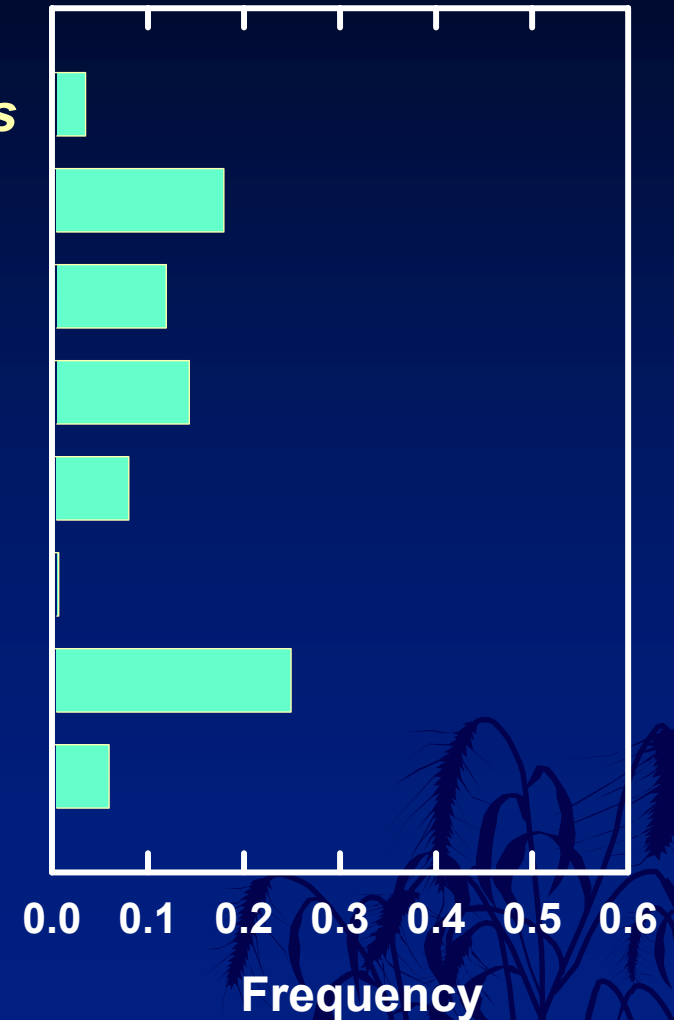
2+ Fungi

Qualitative Gut Analyses

Whitefly

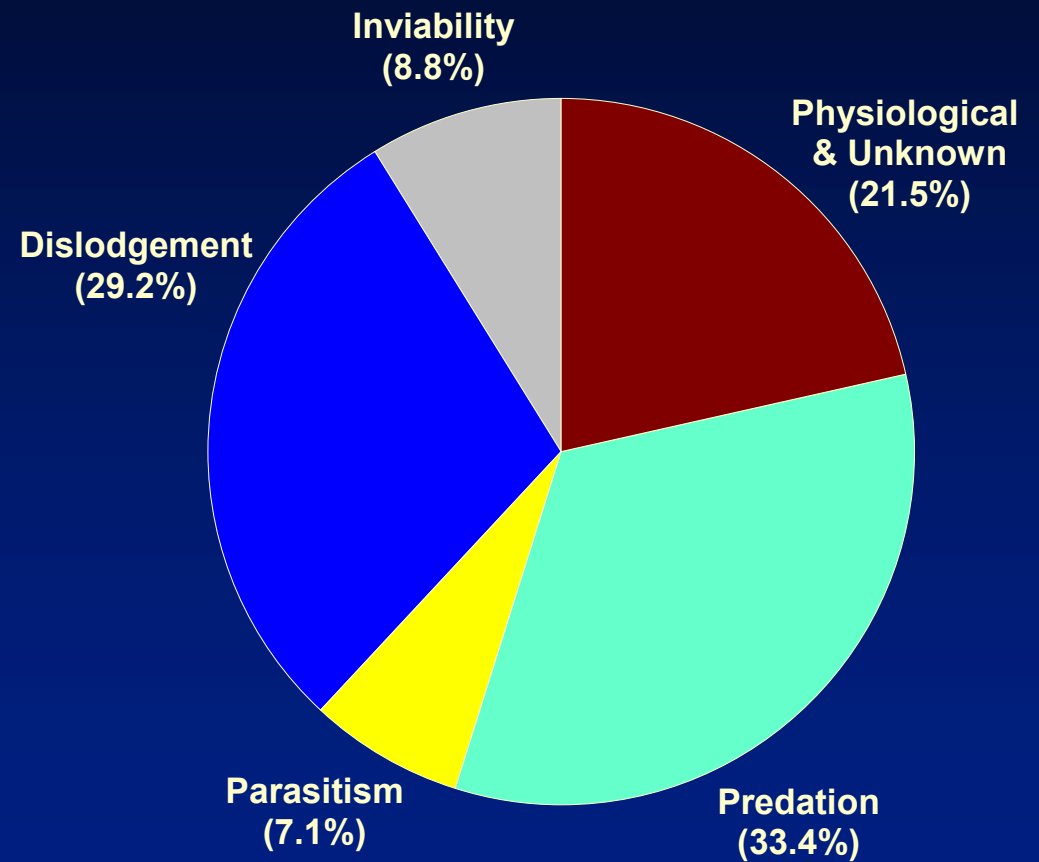
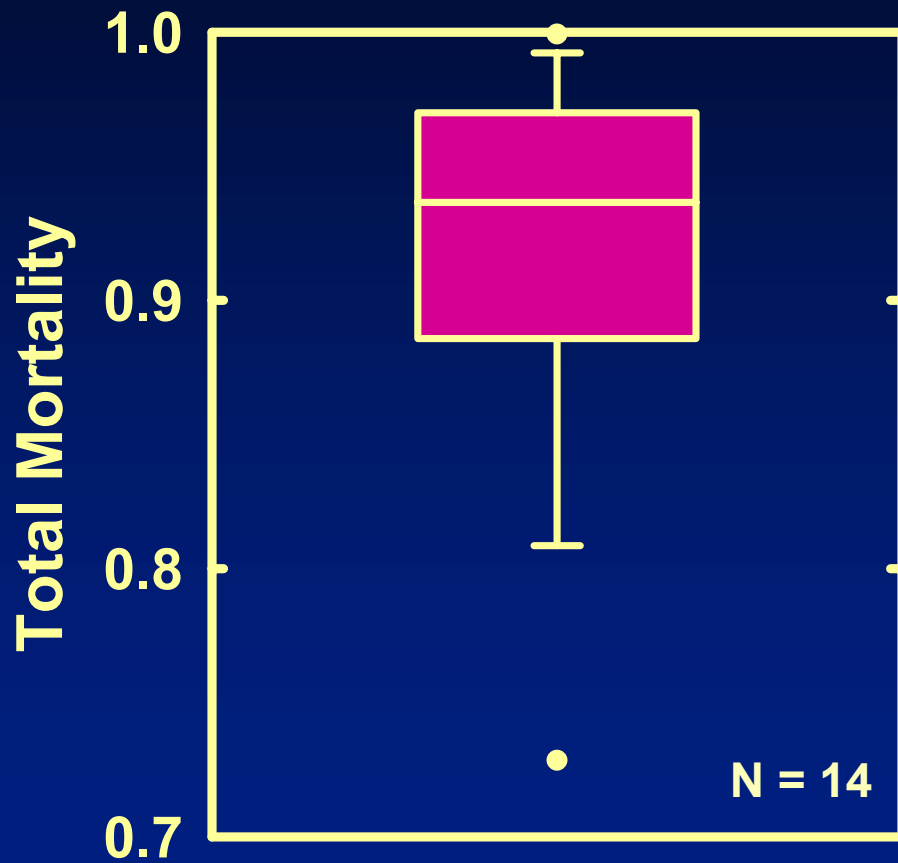


Pink bollworm



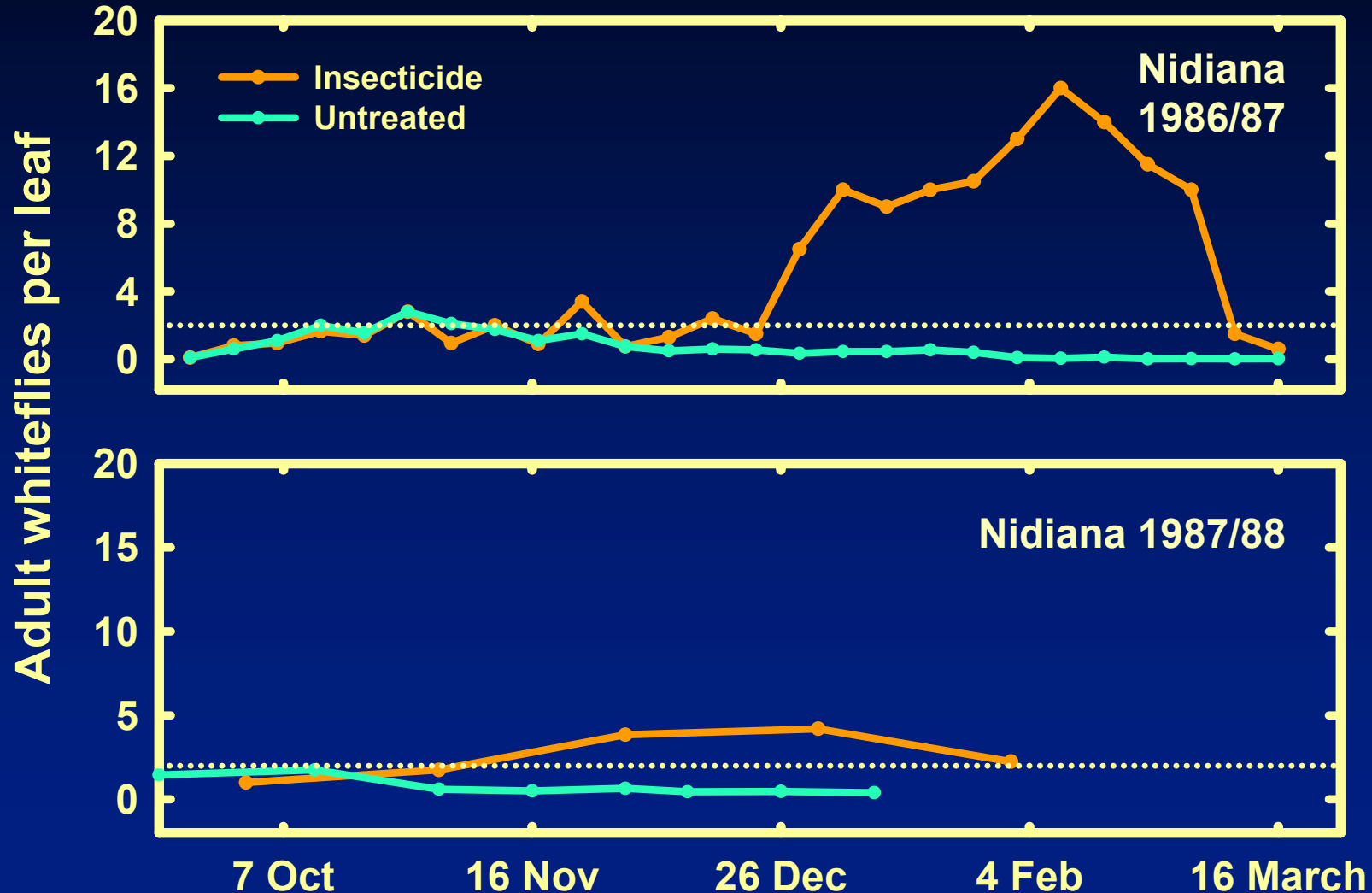
Natural Mortality of Bemisia

(Arizona Cotton)



Biological Control Potential?

(Sudan Cotton, Abdelrahman & Munir 1989)



Biological Control Potential?

(some more examples)

- Elveens et al. 1973. Secondary outbreak induction of **beet armyworms** by experimental insecticide application in cotton in California. *Environ. Entomol.* 2:497
- Ehler et al. 1973. An evaluation of some natural enemies of **cabbage looper** on cotton in California. *Environ. Entomol.* 2: 1009
- Stoltz & Stern. 1978. Cotton arthropod food chain disruption by pesticides in the San Joaquin Valley, California. *Environ. Entomol.* 7: 703 (*Thrips, beet armyworm, cabbage looper*)
- Trichilo & Wilson. 1993. An ecosystem analysis of **spider mite** outbreak: physiological stimulations or natural enemy disruption. *Exp. Appl. Acarol.* 17: 291

Reducing Constraints

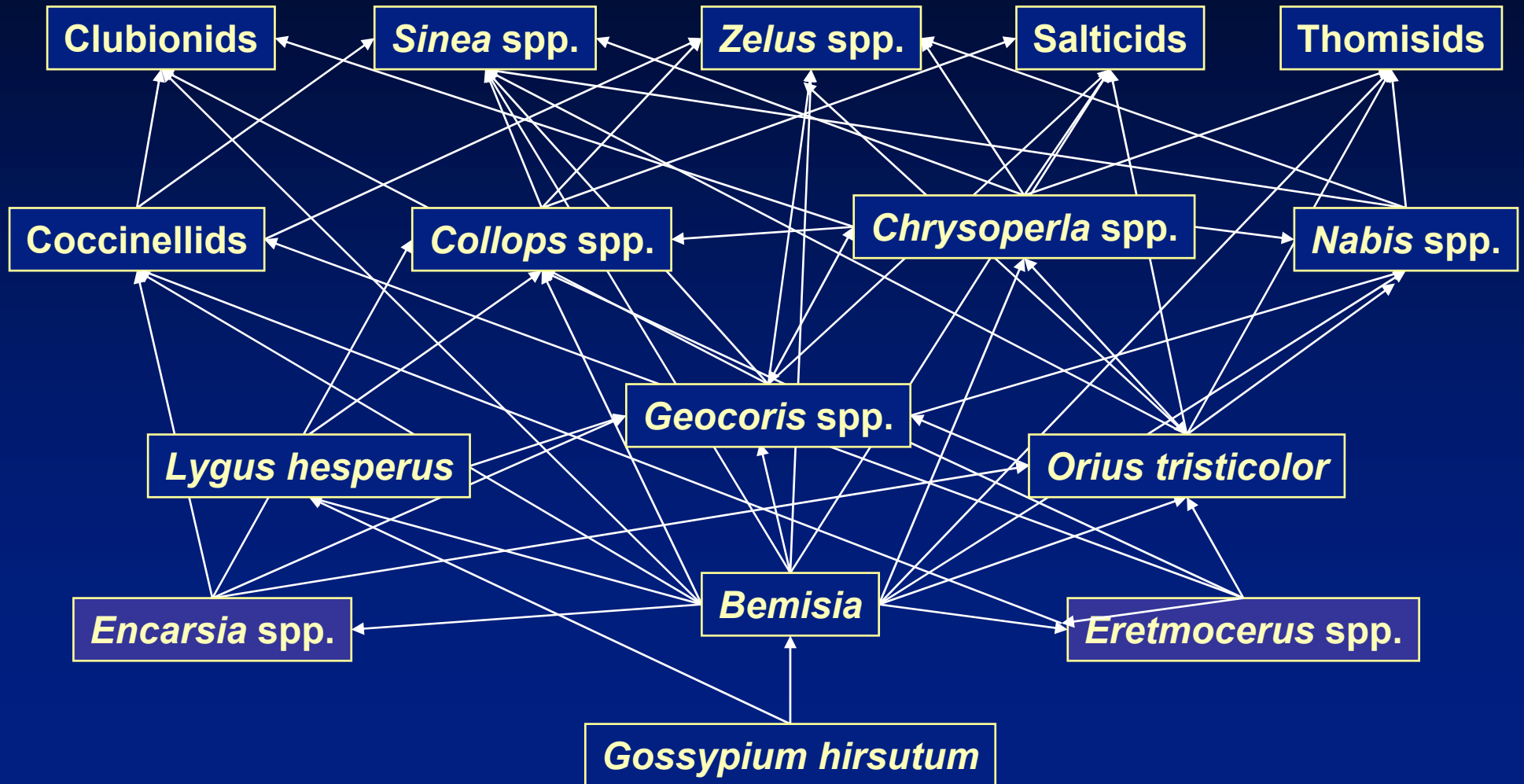
Controlling Secondary Enemies

- Hyperparasitism
- Intraguild predation

***Encarsia* parasitizing
Eretmocerus in *Bemisia***



Sorting out the Players



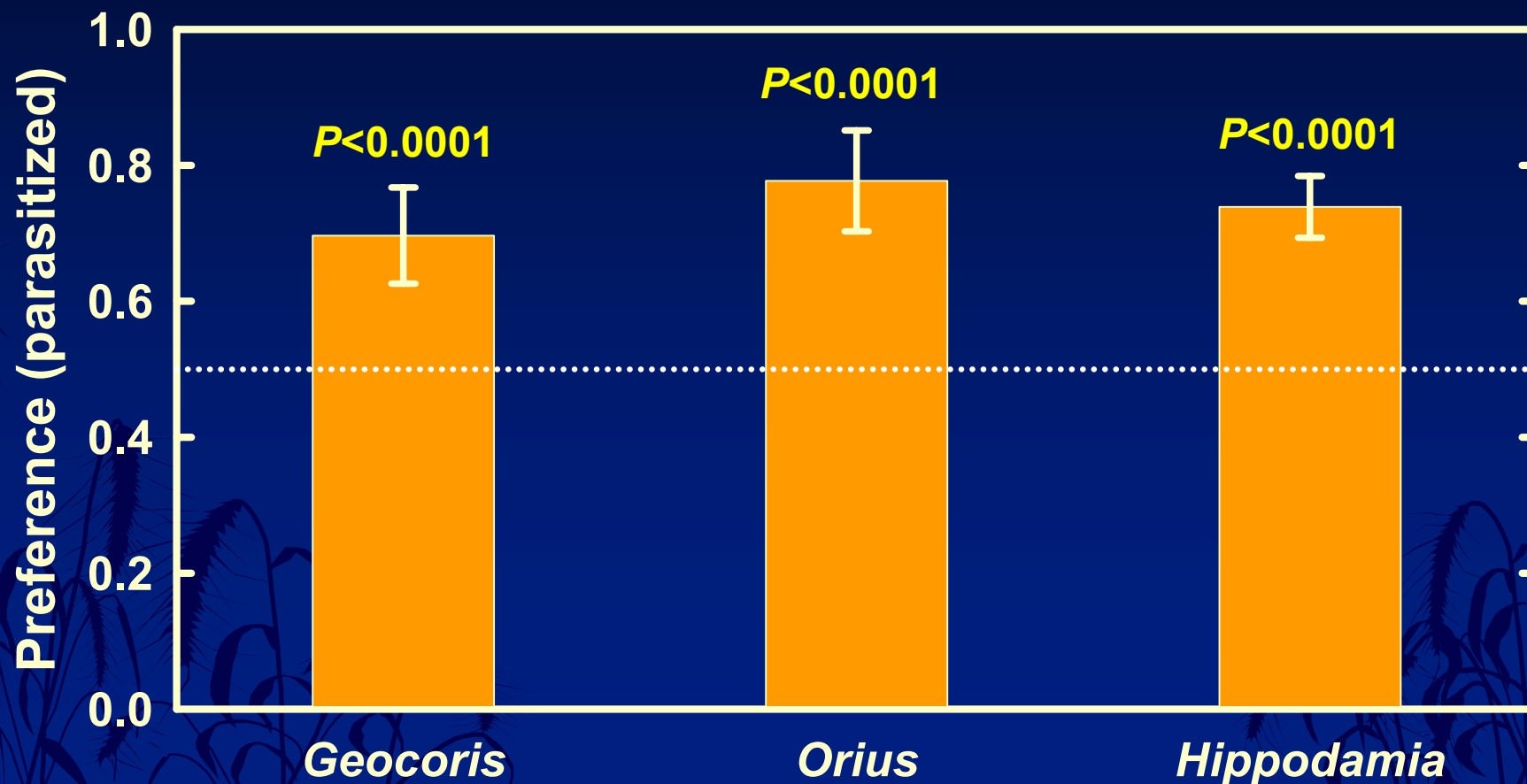


VS.



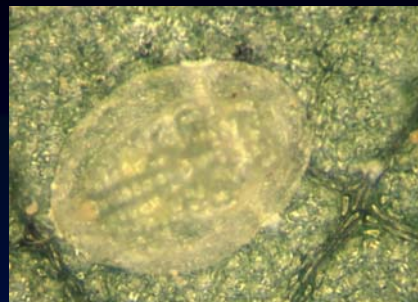
Displaced mycetome stage

Early 4th stage



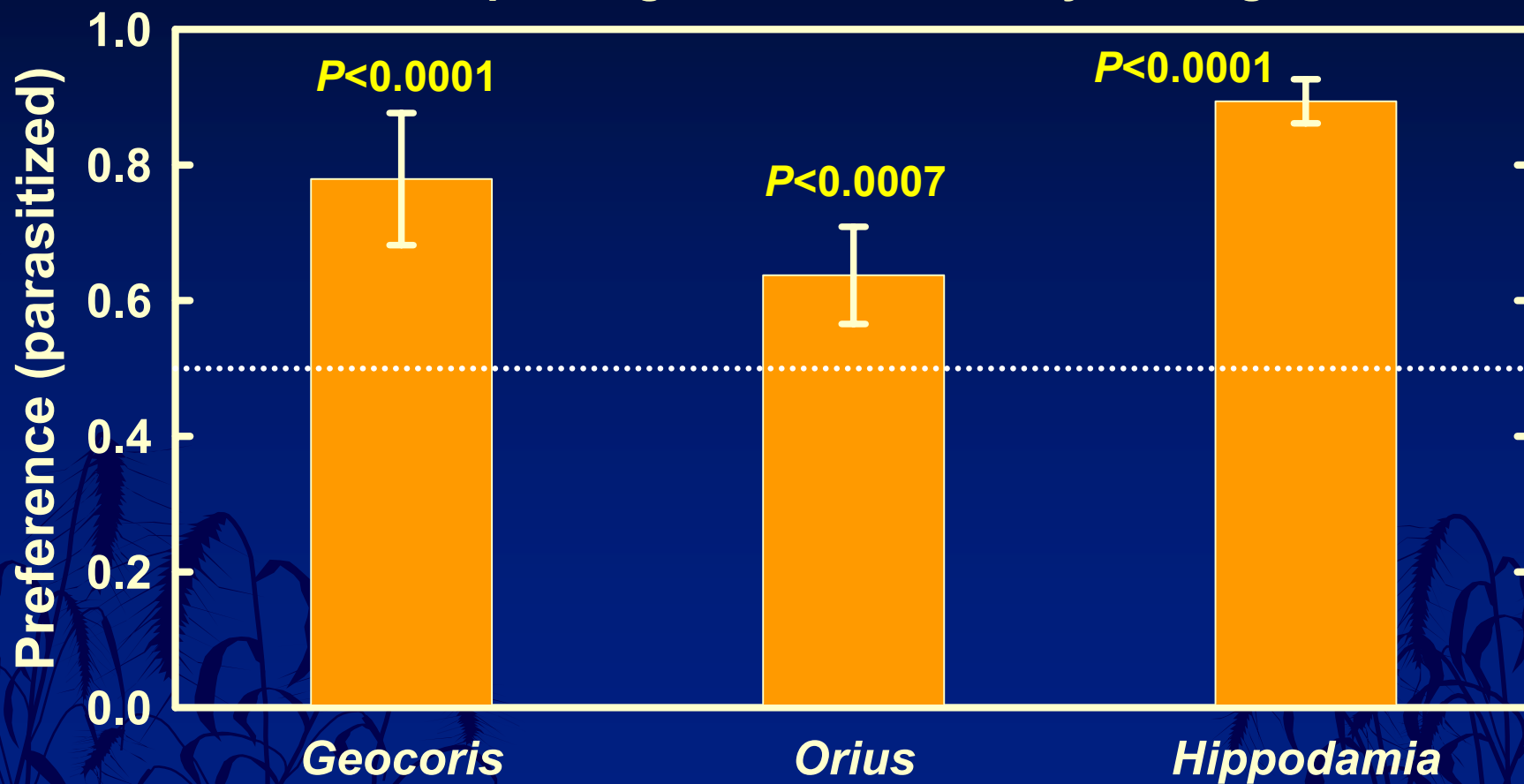


VS.



Pupal stage

Early 4th stage



Visual Predators?

- Late 4th Stage WF (“pupa”)
- Displaced mycetomes stage
- Parasitoid pupa
- Early 4th Stage WF



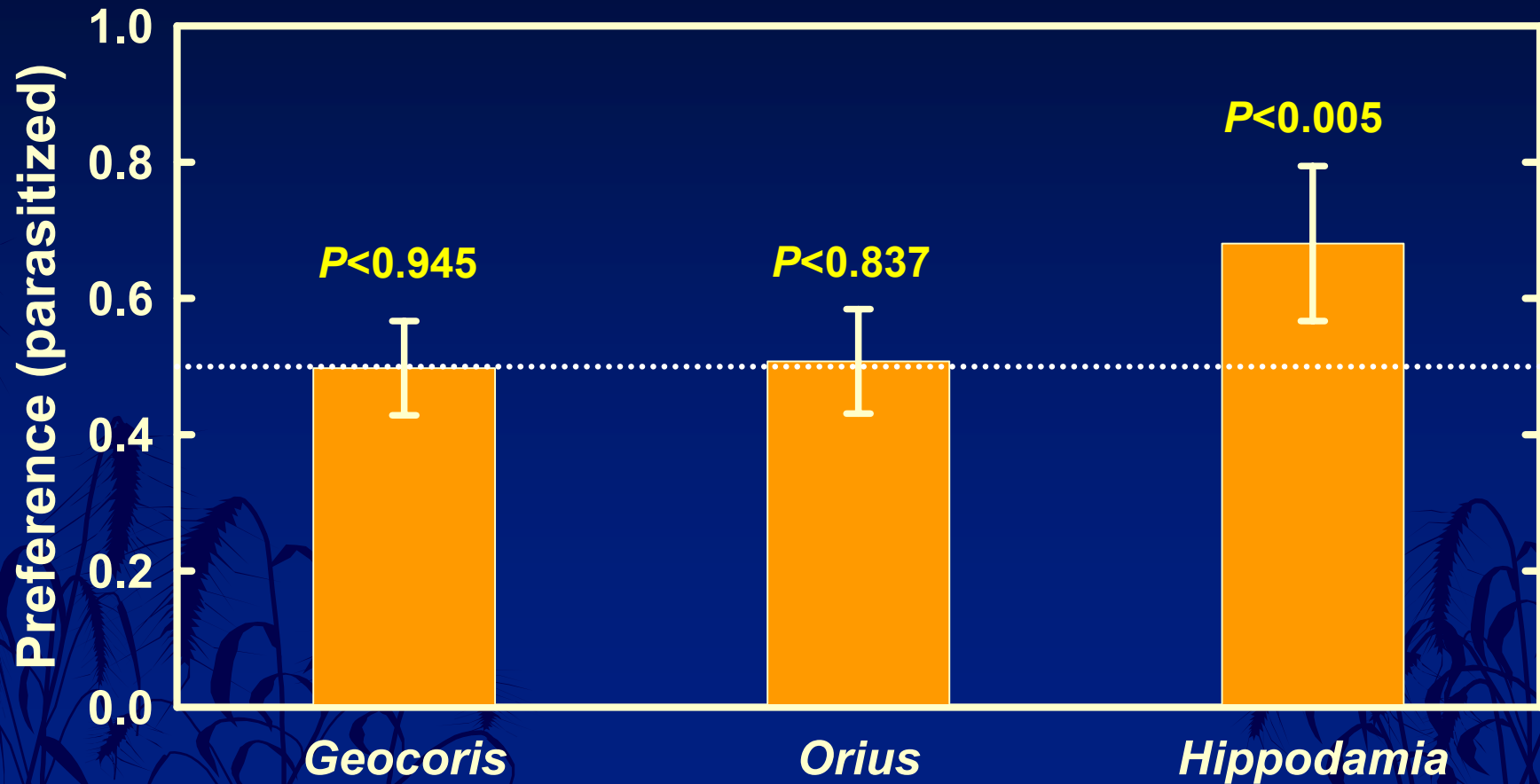


VS.



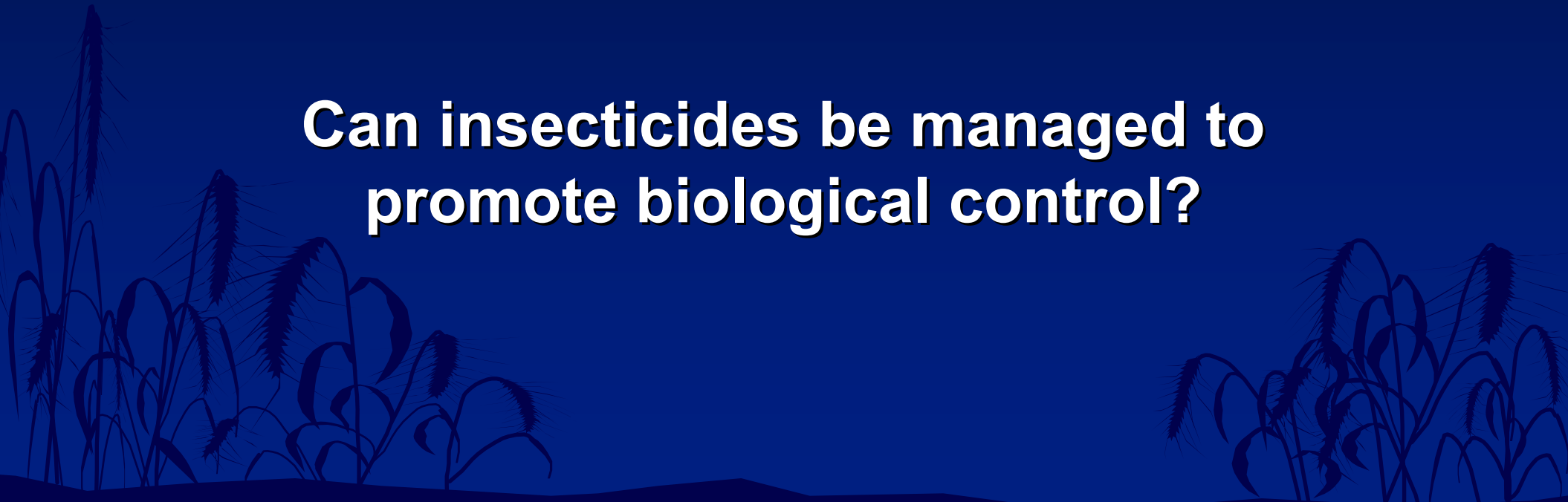
Displaced mycetome stage

Late 4th stage (“pupa”)

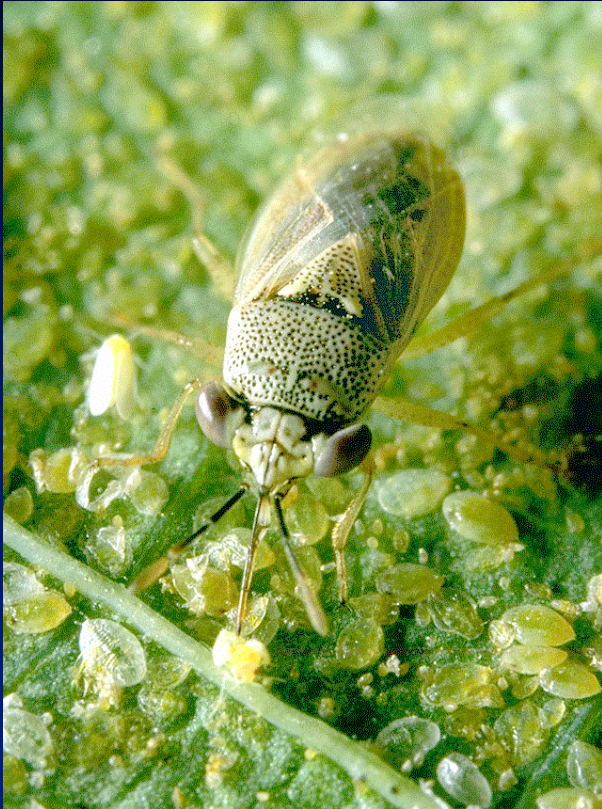


Reducing Constraints

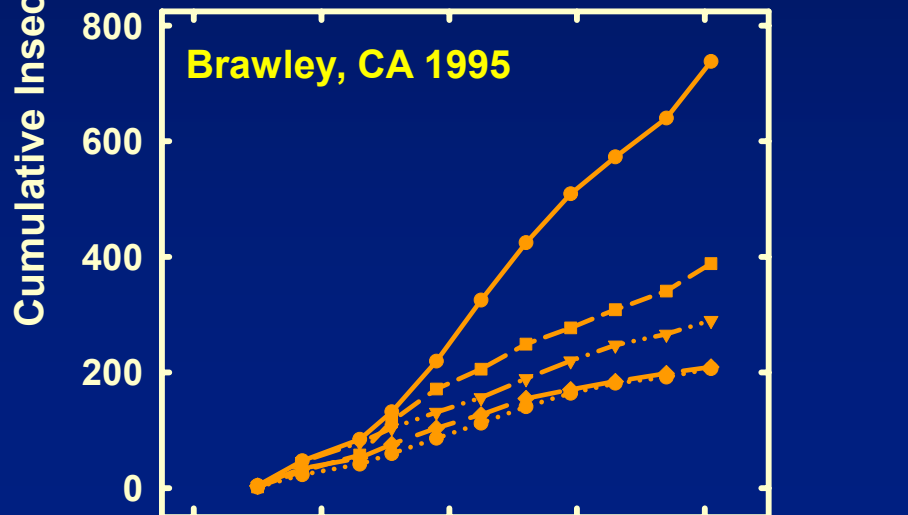
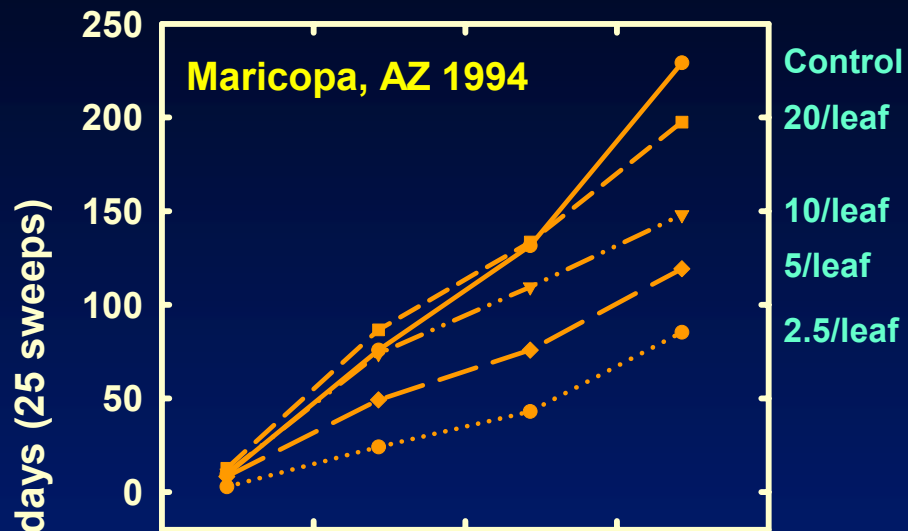
**Can insecticides be managed to
promote biological control?**



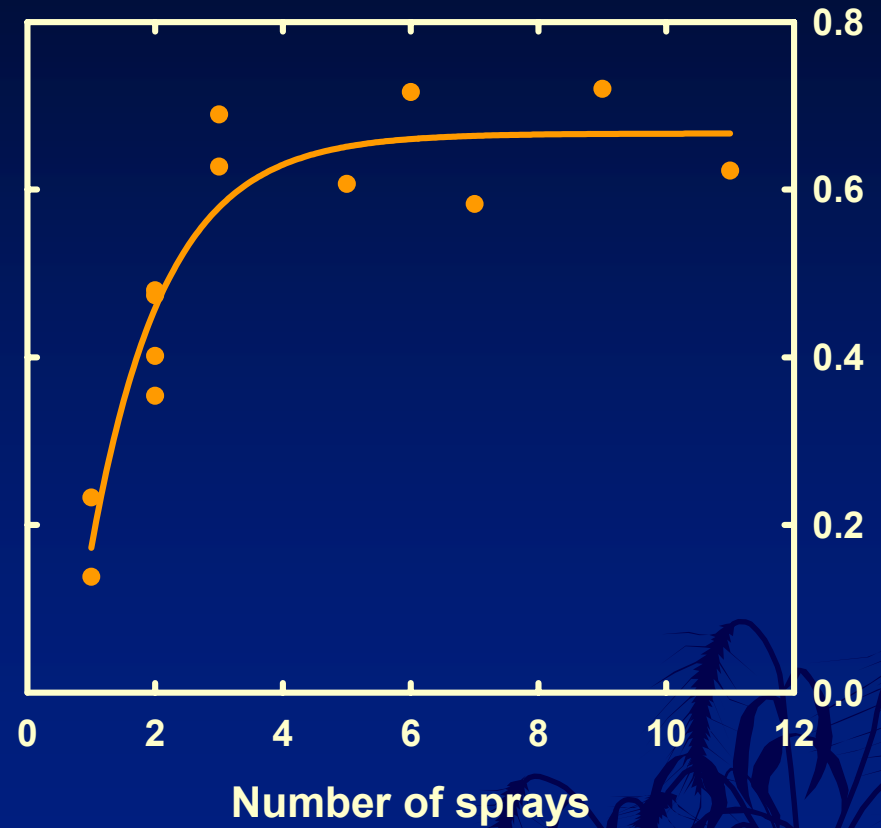
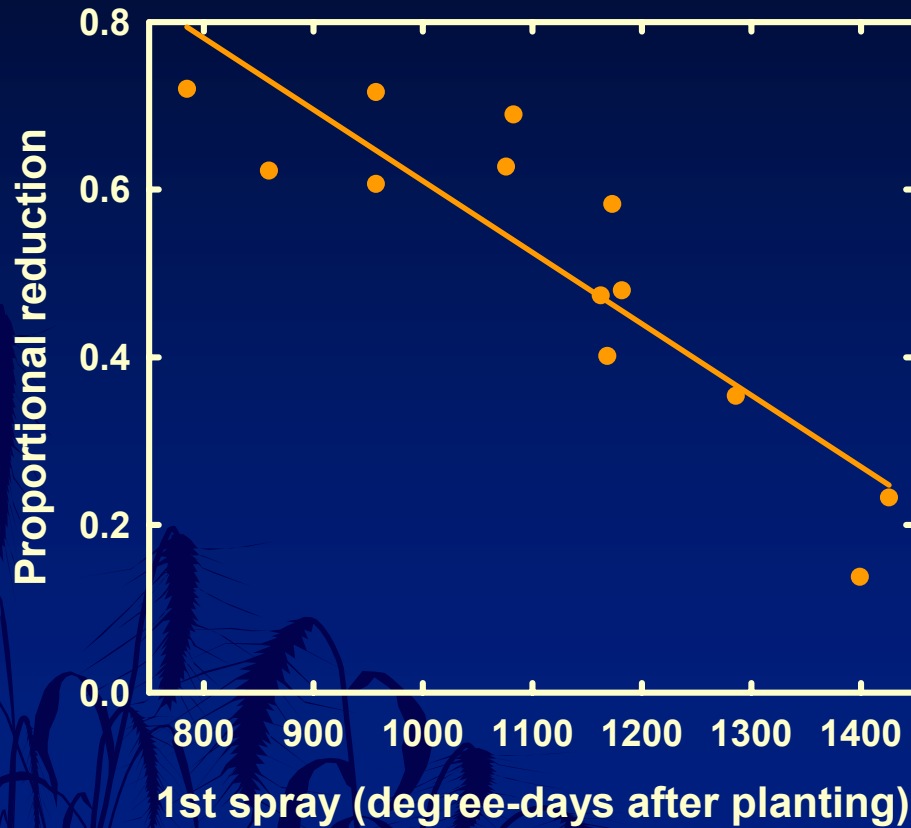
Compatibility?



Conventional Insecticides (by Threshold)

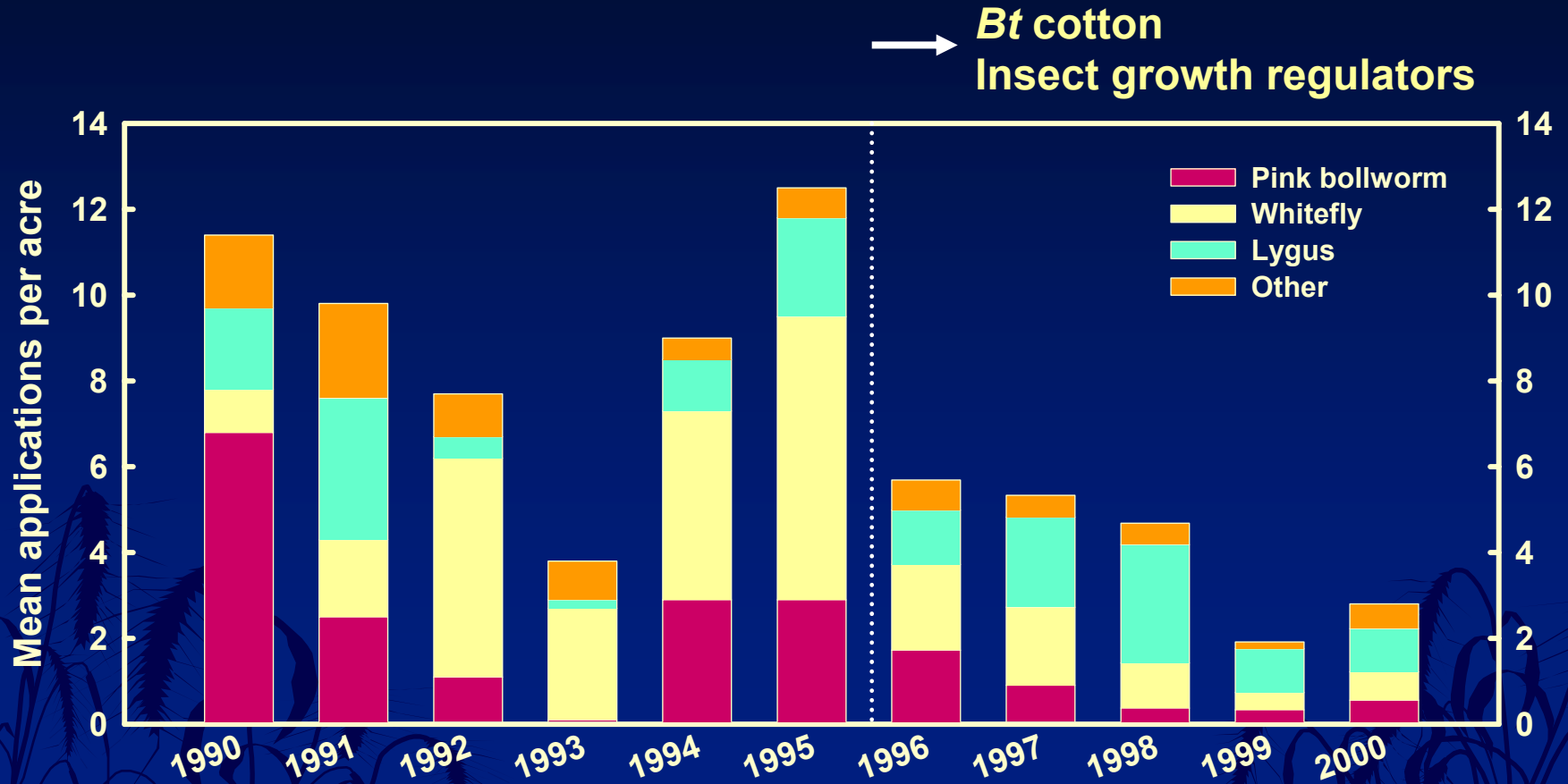


Conventional Insecticides (by Threshold)



Insecticide Use Patterns

Arizona Cotton

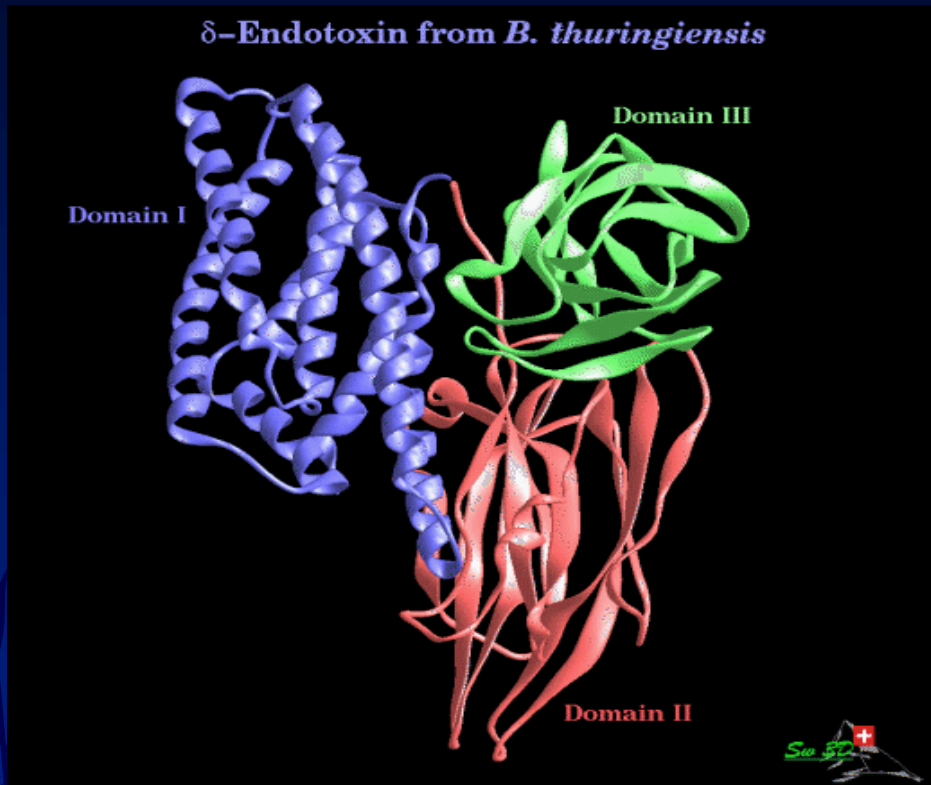


Selective Insecticides?

- ***Bt* Transgenic Cotton**
- **Applaud (Chitin Inhibitor)**
- **Knack (Juvenoid)**



Science or Emotion?



- Resistance management
- Food safety
- Non-target effects

Non-Target Effects

- *Natural enemy abundance*
- *Natural enemy diversity*
- *Natural enemy function*



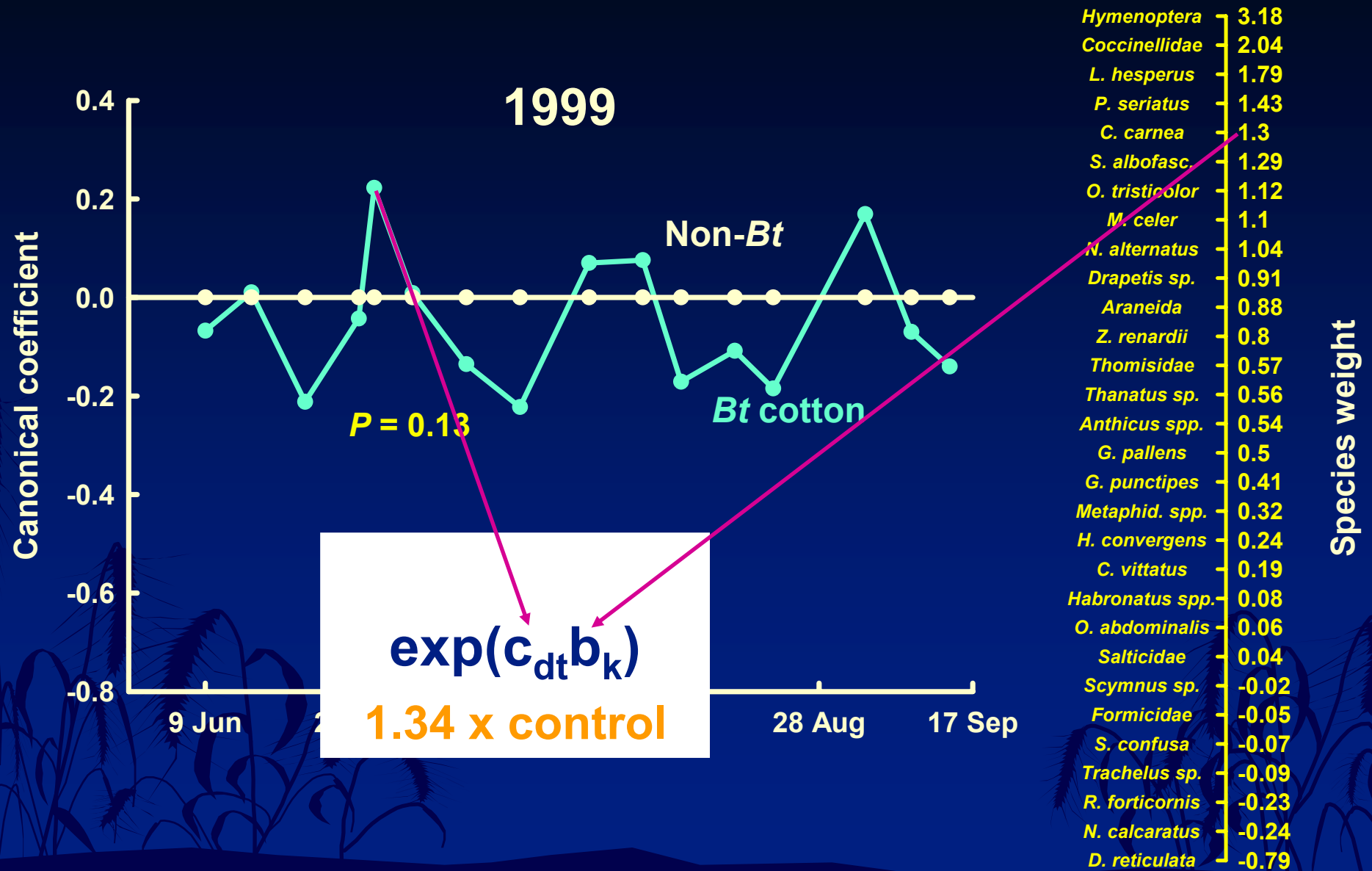
Natural Enemy Abundance

	1999			2000			2001		
<i>Hymenoptera</i>	●	●	0.76	●	●	0.53	●	●	0.47
<i>Drapetis sp.</i>	●●	●●	0.19	●●	●●	0.95	●●	●●	0.34
<i>Chrysoperla carnea</i>	●	●	0.21	●	●	0.28	●	●	0.71
<i>Pseudatomoscelis seriatus</i>	●	●	0.11	●●	●●	0.25	●	●	0.33
<i>Lygus hesperus</i>	●●	●●	0.20	●●	●●	0.42	●●	●●	0.81
<i>Nabis alternatus</i>	●	●	0.14	●	●	0.69	●	●	0.40
<i>Zelus renardii</i>	●	●	0.22	●	●	0.11	●	●	0.12
<i>Orius tristicolor</i>	●	●	0.45	●	●	0.54	●	●	0.49
<i>Geocoris pallens</i>	●	●	0.42	●	●	0.12	●	●	0.73
<i>Geocoris punctipes</i>	●●	●●	0.25	●	●	0.72	●	●	0.86
<i>Hippodamia convergens</i>	●	●	0.16	●	●	0.57	●	●	0.56
<i>Collops vittatus</i>	●	●	0.39	●	●	0.13	●	●	0.75
<i>Misumenops celer</i>	●	●	0.63	●	●	0.92	●	●	0.59
<i>Lepidoptera</i>	●	●	0.04	●	●	0.01	●	●	0.01

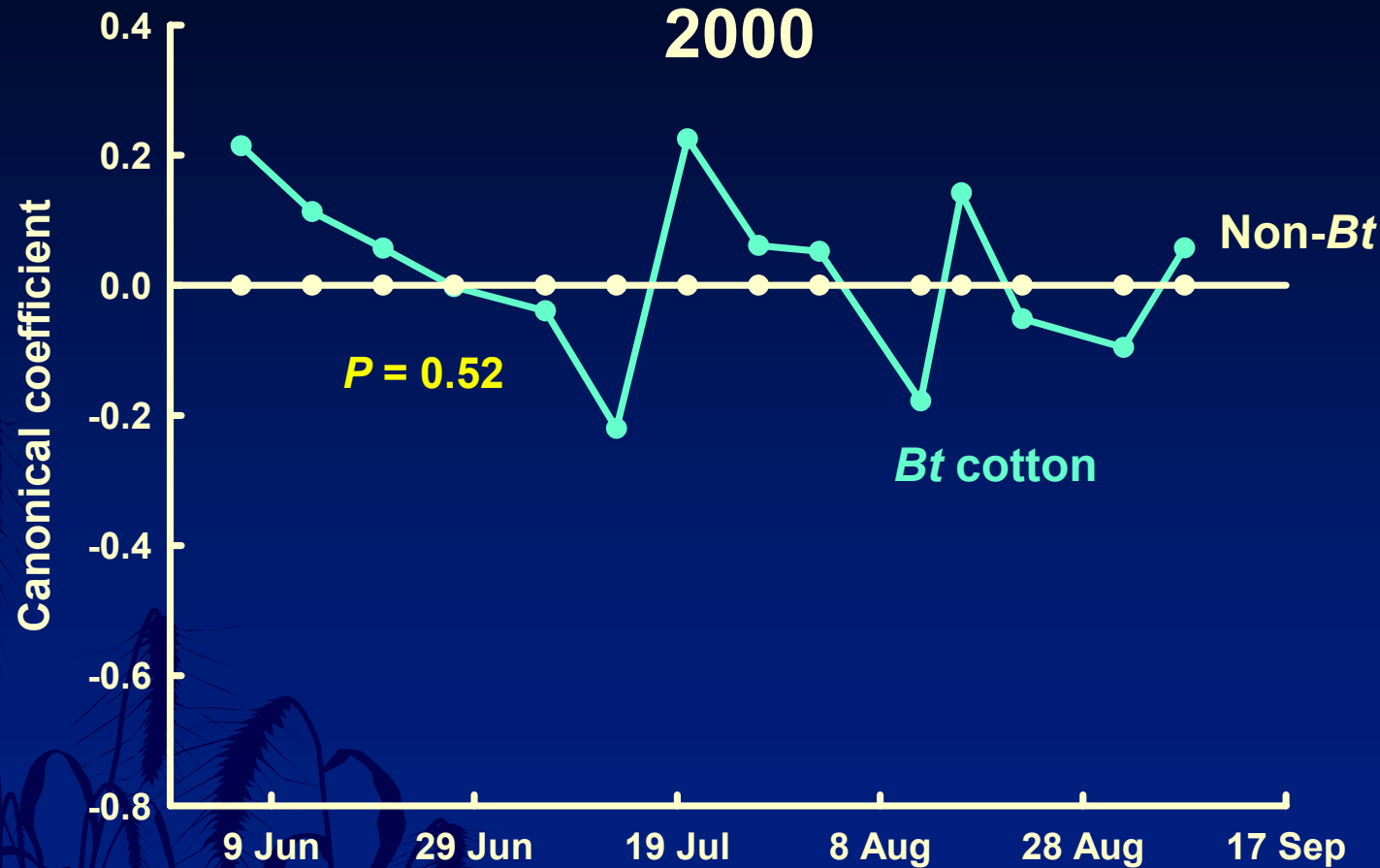
Principal Response Curves Analysis

- **Time-dependent multivariate analysis**
- **Derived from redundancy analysis (constrained form of principal component analysis)**
- **Provides a simple means of visualizing and testing the overall response of a biological community to an environmental disturbance**

Selectivity of Bt cotton

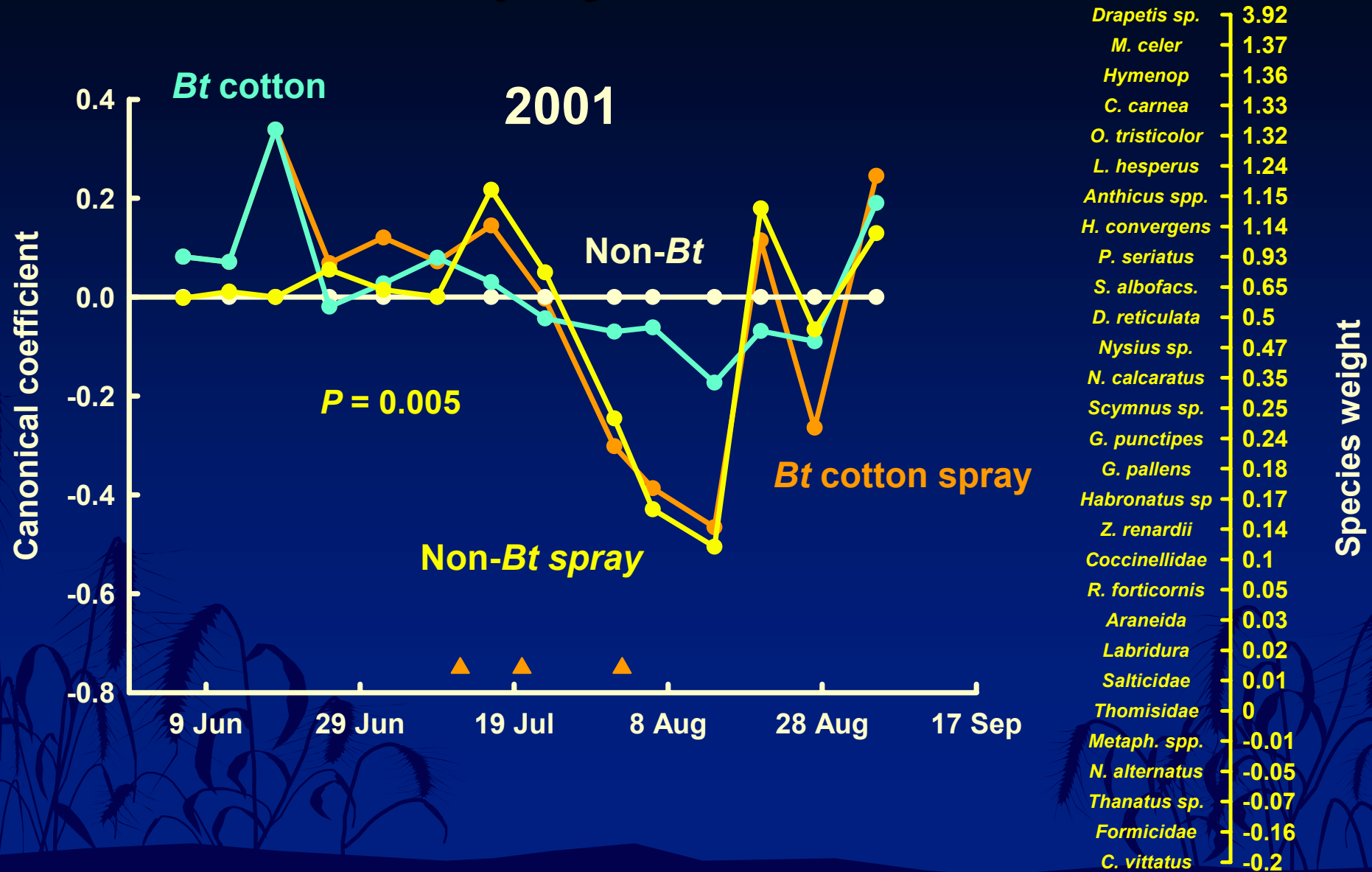


Selectivity of Bt cotton

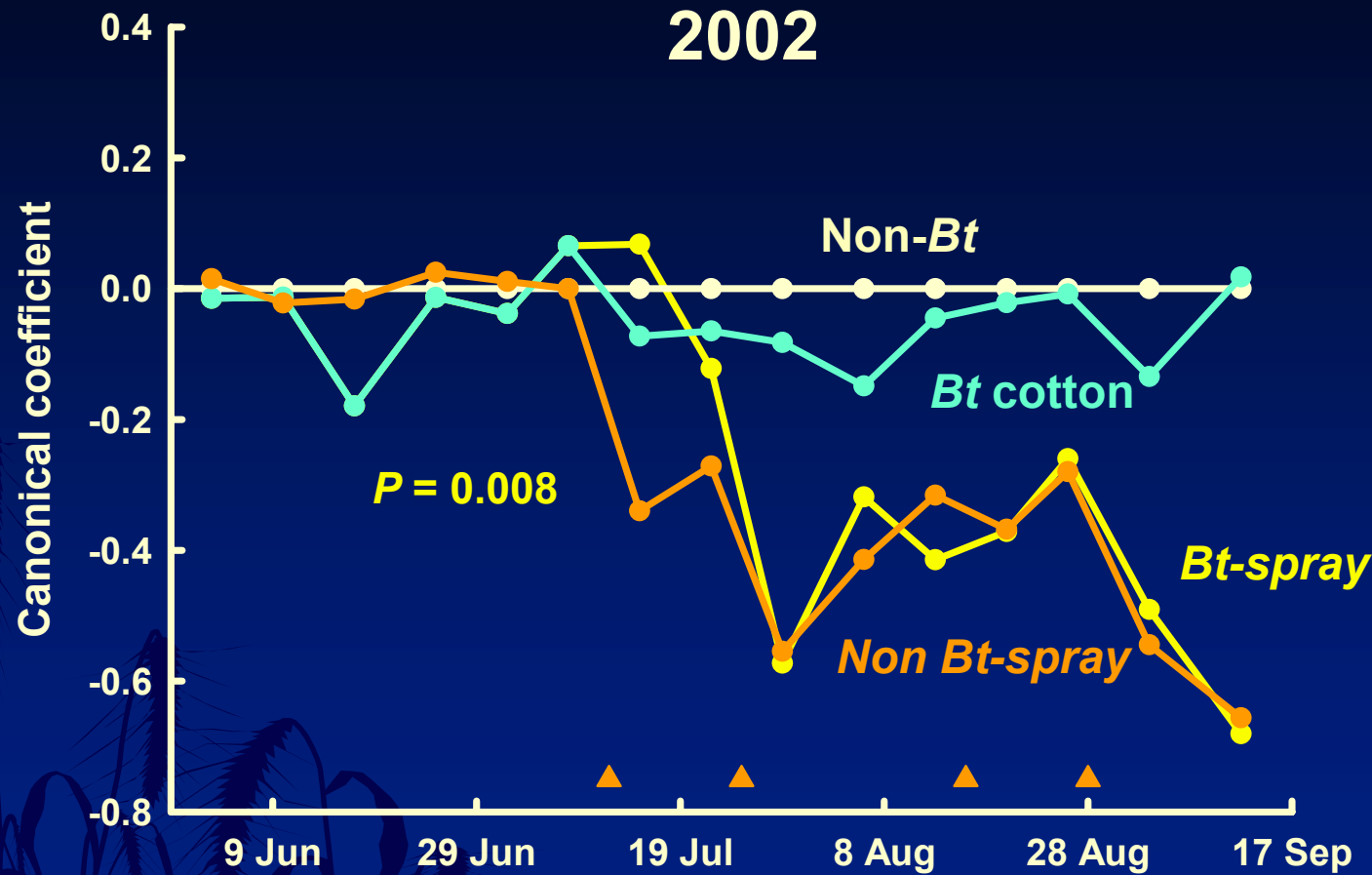


Species	Species weight
<i>C. carnea</i>	2.62
<i>O. tristicolor</i>	2.57
<i>C. vittatus</i>	2.12
<i>H. convergens</i>	1.45
Hymenoptera	1.37
<i>D. reticulata</i>	1.28
<i>N. alternatus</i>	1.2
<i>M. celer</i>	1.08
<i>Drapetis sp.</i>	0.93
<i>G. punctipes</i>	0.64
<i>S. albofasc.</i>	0.55
<i>L. hesperus</i>	0.48
<i>Thanatus sp.</i>	0.26
<i>Habronatus spp.</i>	0.16
<i>S. confusa</i>	0.13
Formicidae	0.12
<i>R. forticornis</i>	0.08
<i>Metaph. spp.</i>	0.06
<i>Scymnus sp.</i>	0
Coccinellidae	-0.01
<i>Labridura spp.</i>	-0.08
<i>P. seriatus</i>	-0.15
Thomisidae	-0.17
Salticidae	-0.24
<i>O. abdominalis</i>	-0.33
<i>Z. renardii</i>	-0.53
<i>Anthicus spp.</i>	-0.54
<i>G. pallens</i>	-0.57
<i>N. calcaratus</i>	-0.58
Araneida	-1.12

Selectivity of Bt cotton



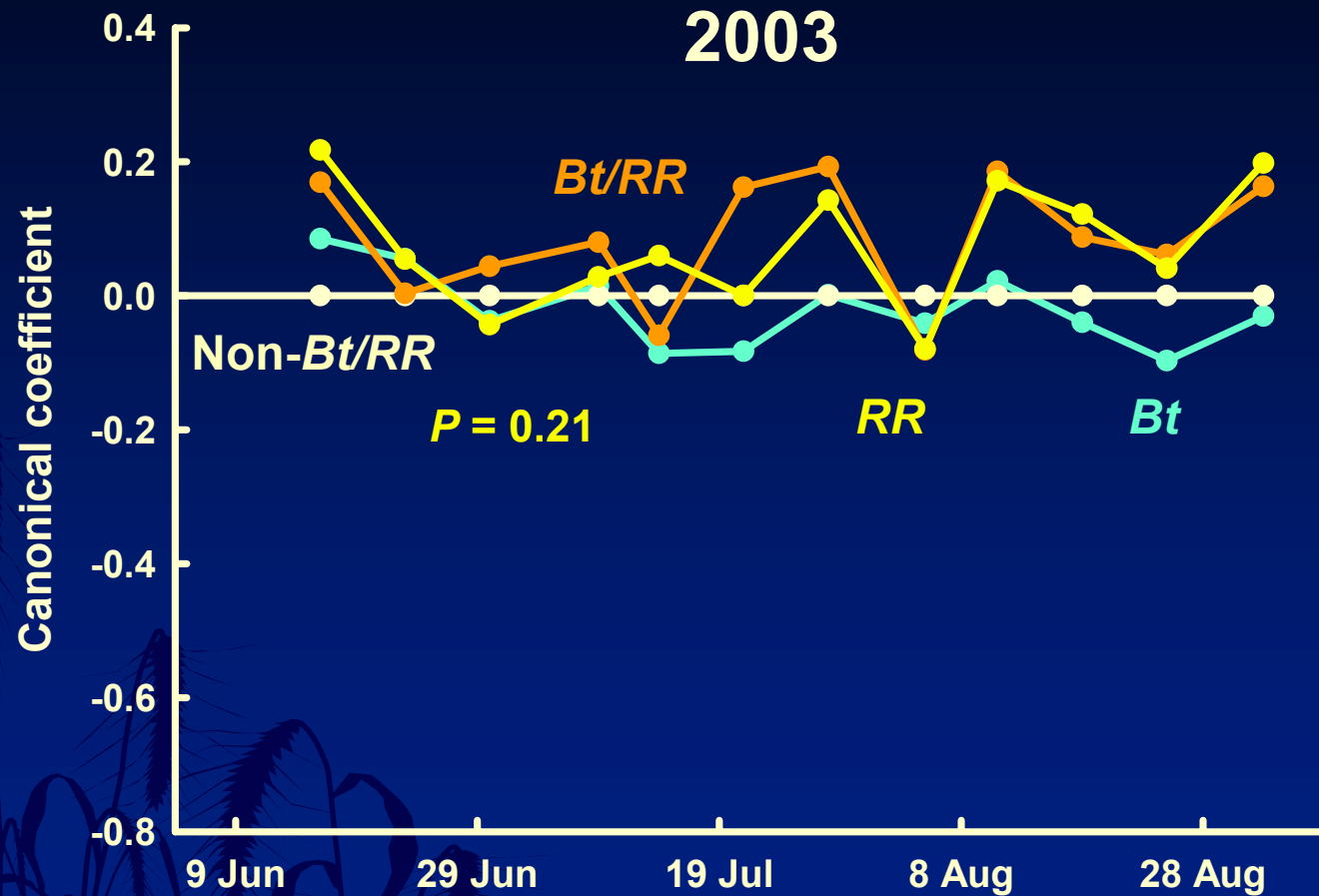
Selectivity of *Bt* cotton



<i>G. punctipes</i>	3.48
<i>G. pallens</i>	2.3
<i>L. hesperus</i>	2.26
<i>N. alternatus</i>	1.81
<i>P. seriatus</i>	1.41
<i>C. vittatus</i>	0.57
<i>M. celer</i>	0.54
<i>D. reticulata</i>	0.5
<i>C. carnea</i>	0.29
Coccinellidae	0.24
<i>H. convergens</i>	0.21
<i>Hymenop</i>	0.17
<i>Z. renardii</i>	0.13
Salticidae	0.11
<i>Anthicus spp.</i>	0.07
<i>Scymnus sp.</i>	0.06
<i>S. albofacs.</i>	0.05
<i>N. calcaratus</i>	0.04
Formicidae	0.03
<i>Metaph. spp.</i>	0.02
<i>Habronatus sp</i>	0.01
Thomisidae	8e-3
<i>Nysius sp.</i>	2e-3
Araneida	0
<i>Thanatus sp.</i>	-2e-3
<i>O. abdominalis</i>	-0.02
<i>R. forticornis</i>	-0.04
<i>O. tristicolor</i>	-0.13
<i>Drapetis sp.</i>	-0.35

Species weight

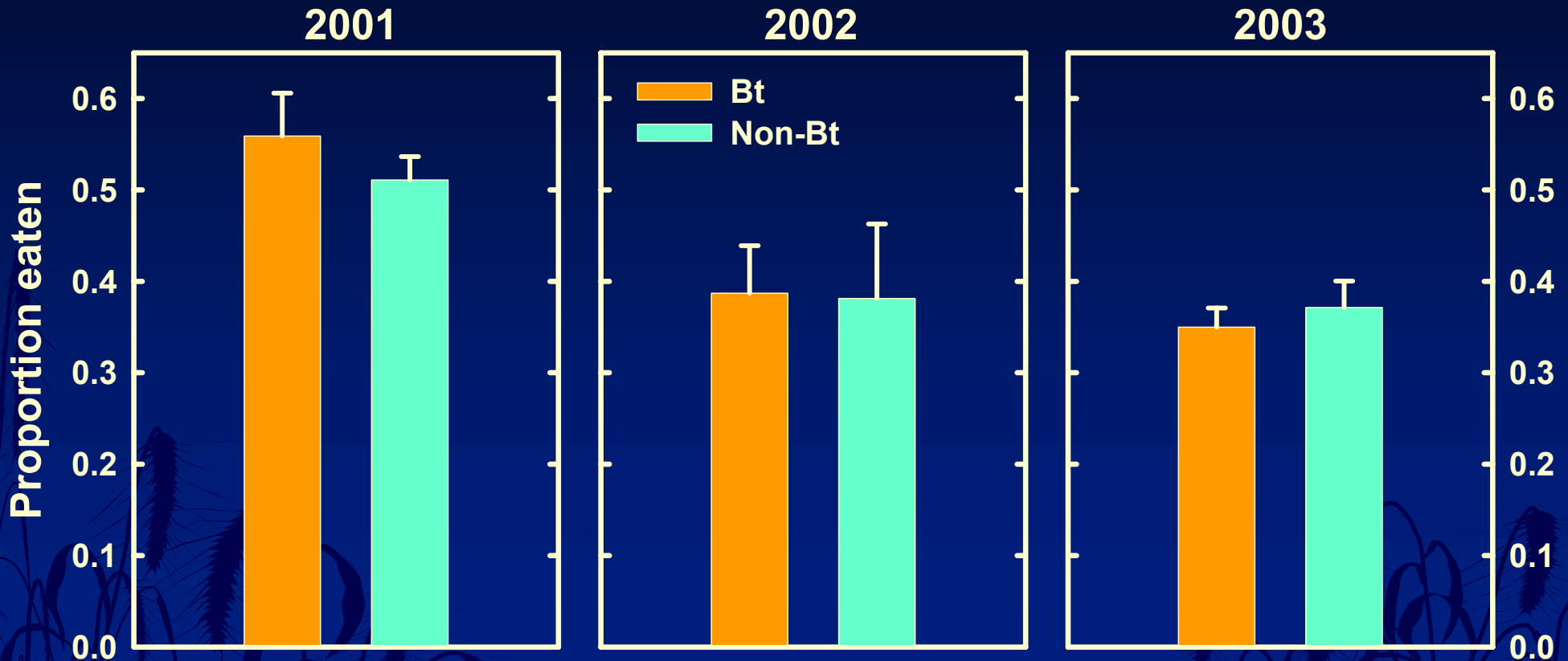
Selectivity of *Bt/RR* cotton



Species	Species weight
<i>G. punctipes</i>	2.5
<i>Araneida</i>	1.88
<i>N. alternatus</i>	1.72
<i>Z. renardii</i>	1.37
<i>M. celer</i>	1.28
<i>O. tristicolor</i>	0.73
<i>L. hesperus</i>	0.56
<i>Thanatus sp.</i>	0.51
<i>C. carnea</i>	0.46
<i>Drapetis sp.</i>	0.41
<i>Habronatus sp</i>	0.3
<i>Salticidae</i>	0.27
<i>Coccinellidae</i>	0.23
<i>Formicidae</i>	0.13
<i>R. forticornis</i>	0.1
<i>Sinea spp.</i>	0.08
<i>P. seriatus</i>	-0.07
<i>Metaph. spp.</i>	-0.19
<i>Nysius sp.</i>	-0.35
<i>H. convergens</i>	-0.41
<i>Scymnus sp.</i>	-0.43
<i>S. albofacs.</i>	-0.49
<i>Thomisidae</i>	-0.63
<i>D. reticulata</i>	-0.75
<i>N. calcaratus</i>	-0.97
<i>C. vittatus</i>	-1.05
<i>Hymenop</i>	-1.39
<i>Anthicus spp.</i>	-1.4
<i>G. pallens</i>	-1.83

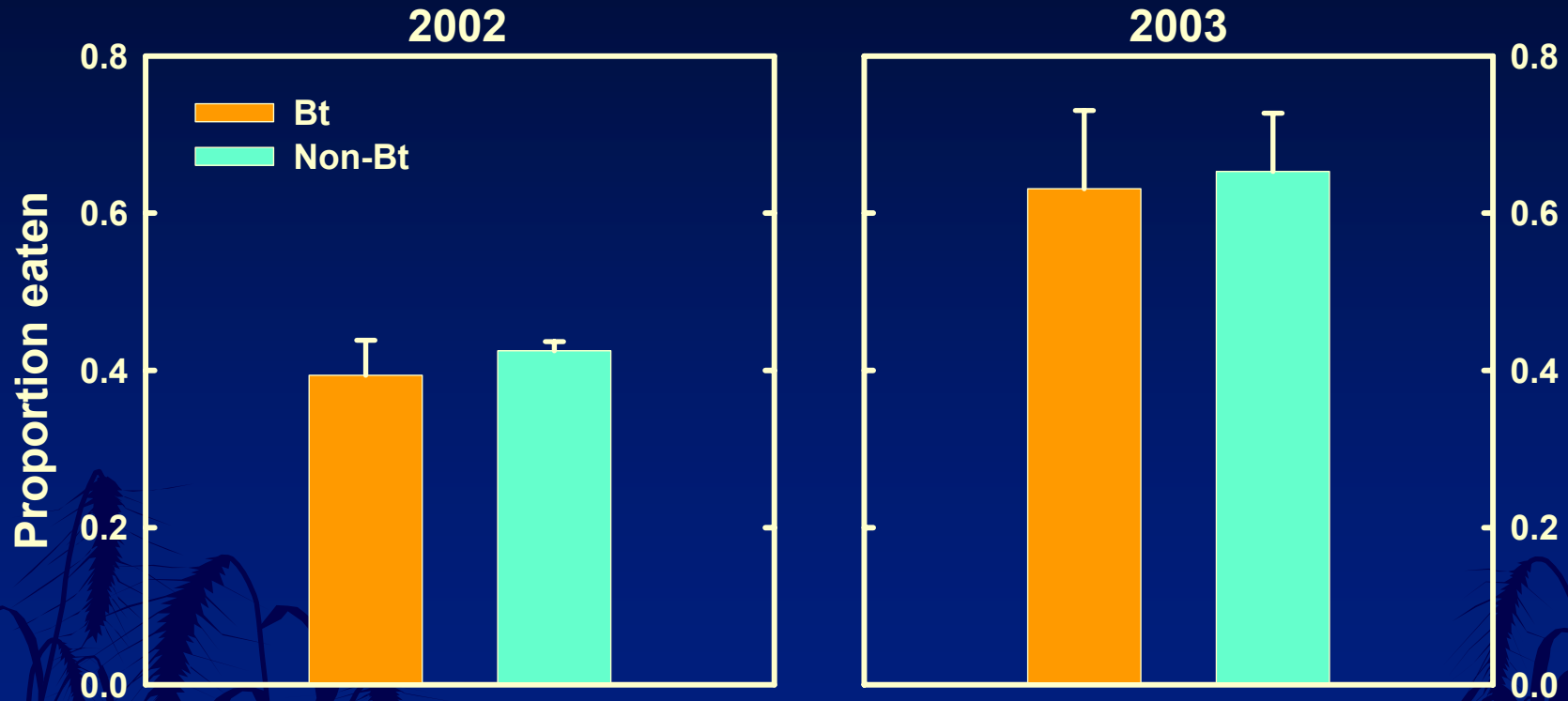
Natural Enemy Function

Predation on Pink Bollworm Eggs



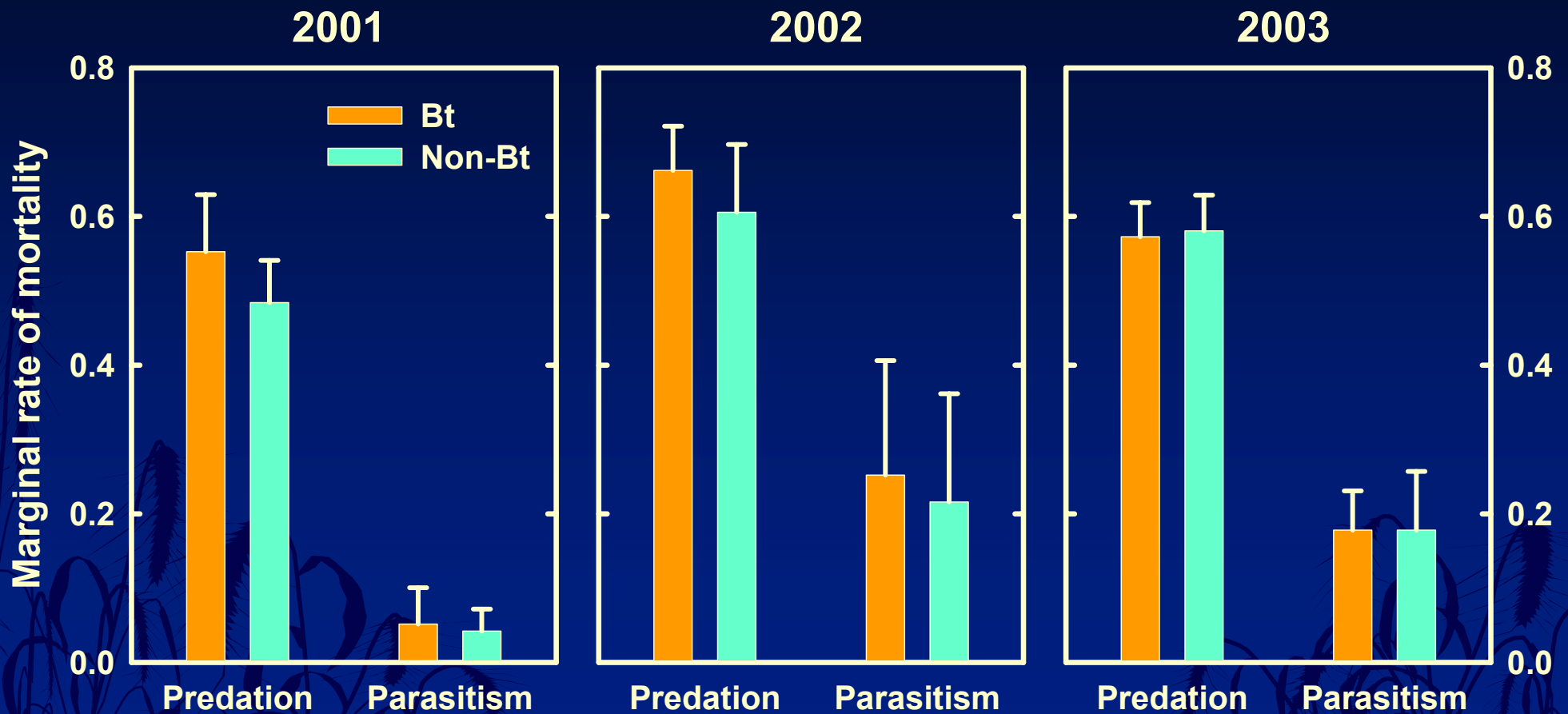
Natural Enemy Function

Predation on Pink Bollworm Pupae



Natural Enemy Function

Mortality of Whitefly Nymphs



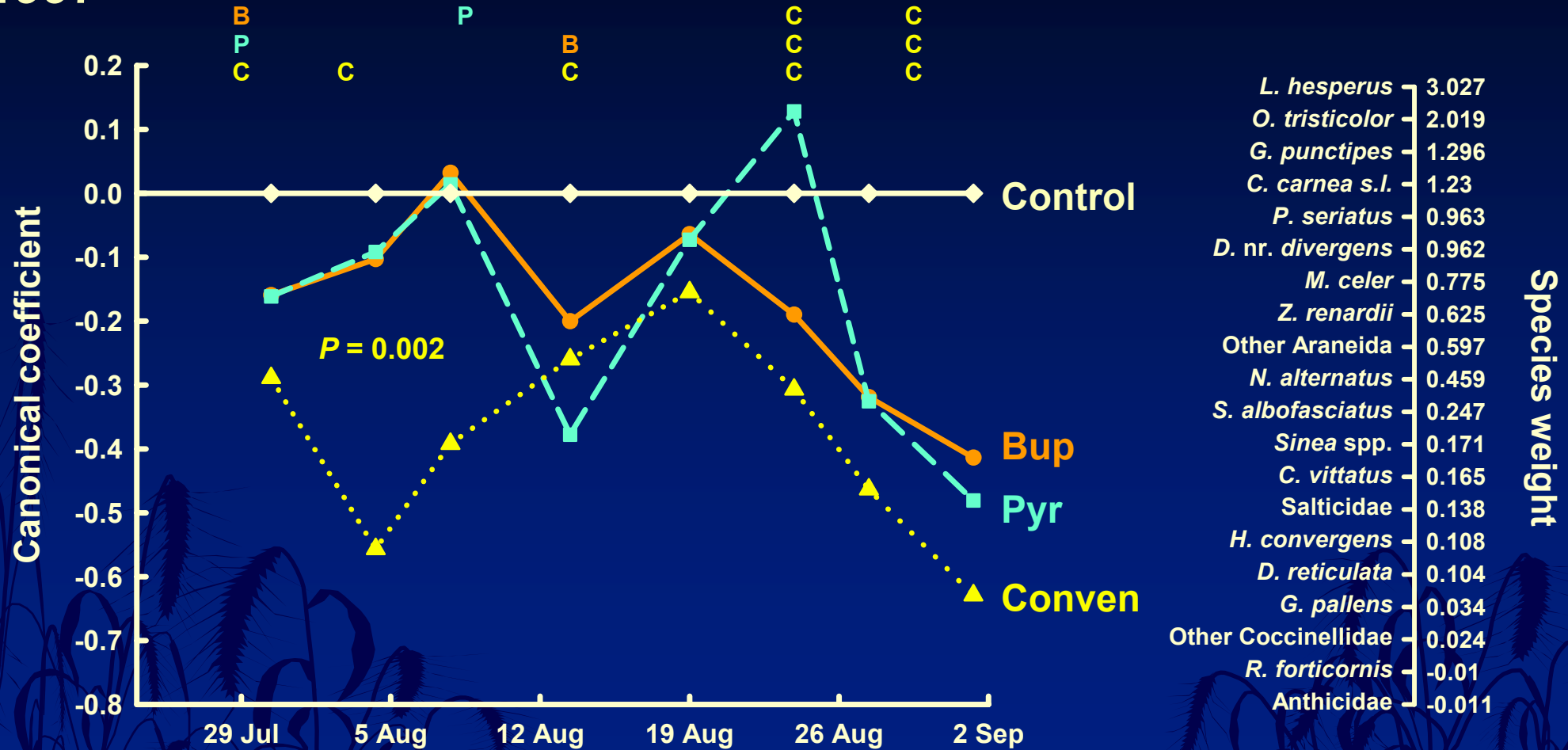
Selective Insecticides?

- ***Bt* Transgenic Cotton**
- **Applaud (Chitin Inhibitor)**
- **Knack (Juvenoid)**



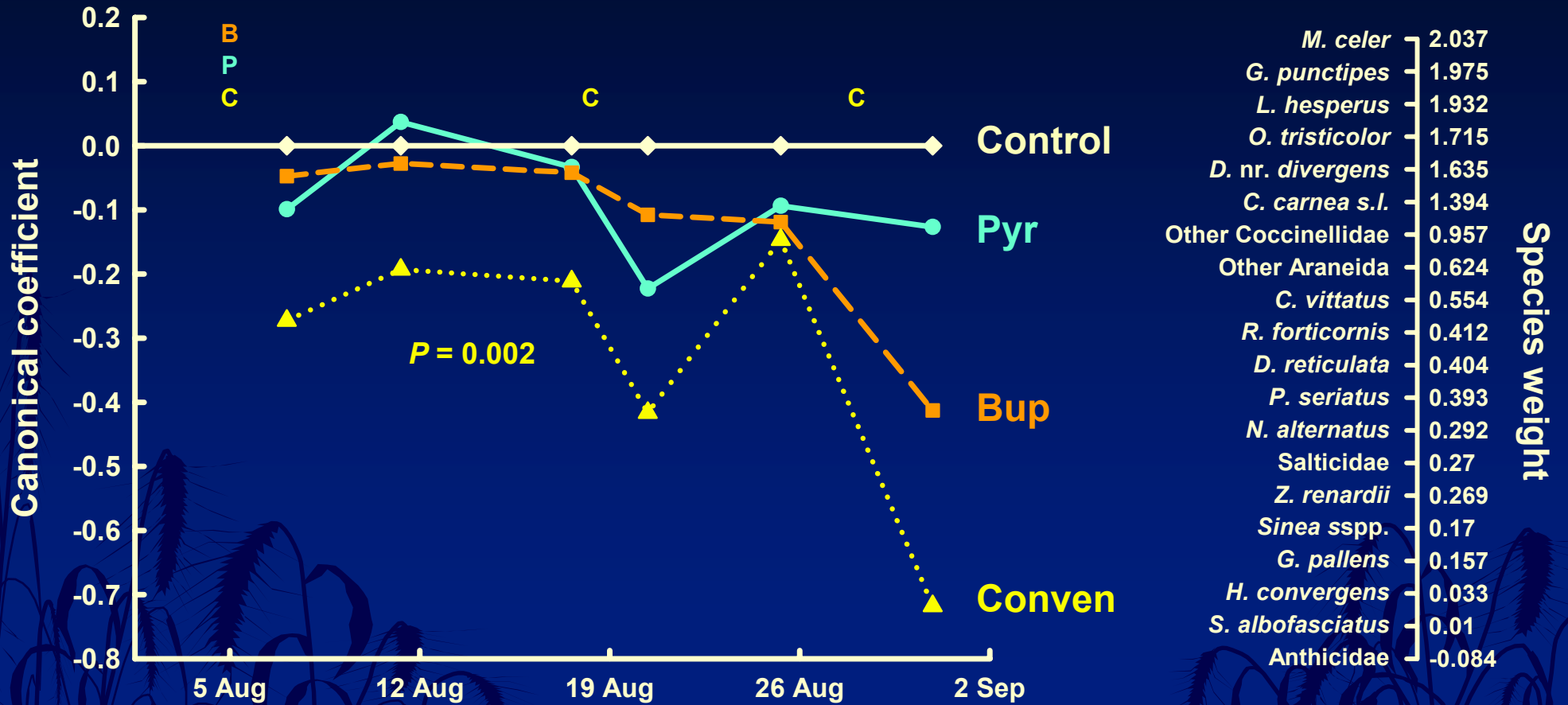
Selectivity of IGRs

1997



Selectivity of IGRs

1999



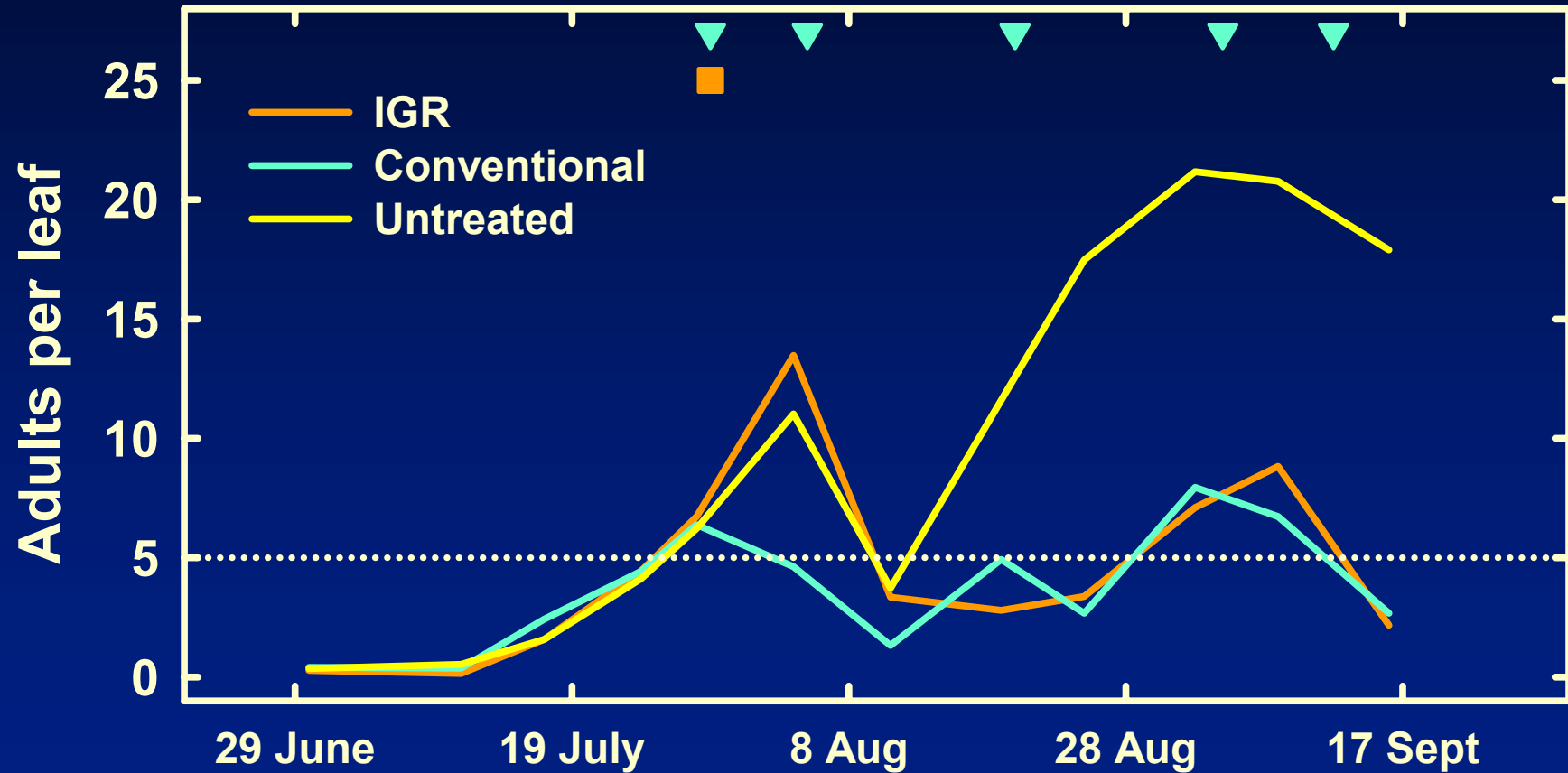
Implementation & Evaluation

Can conservation contribute to pest control?



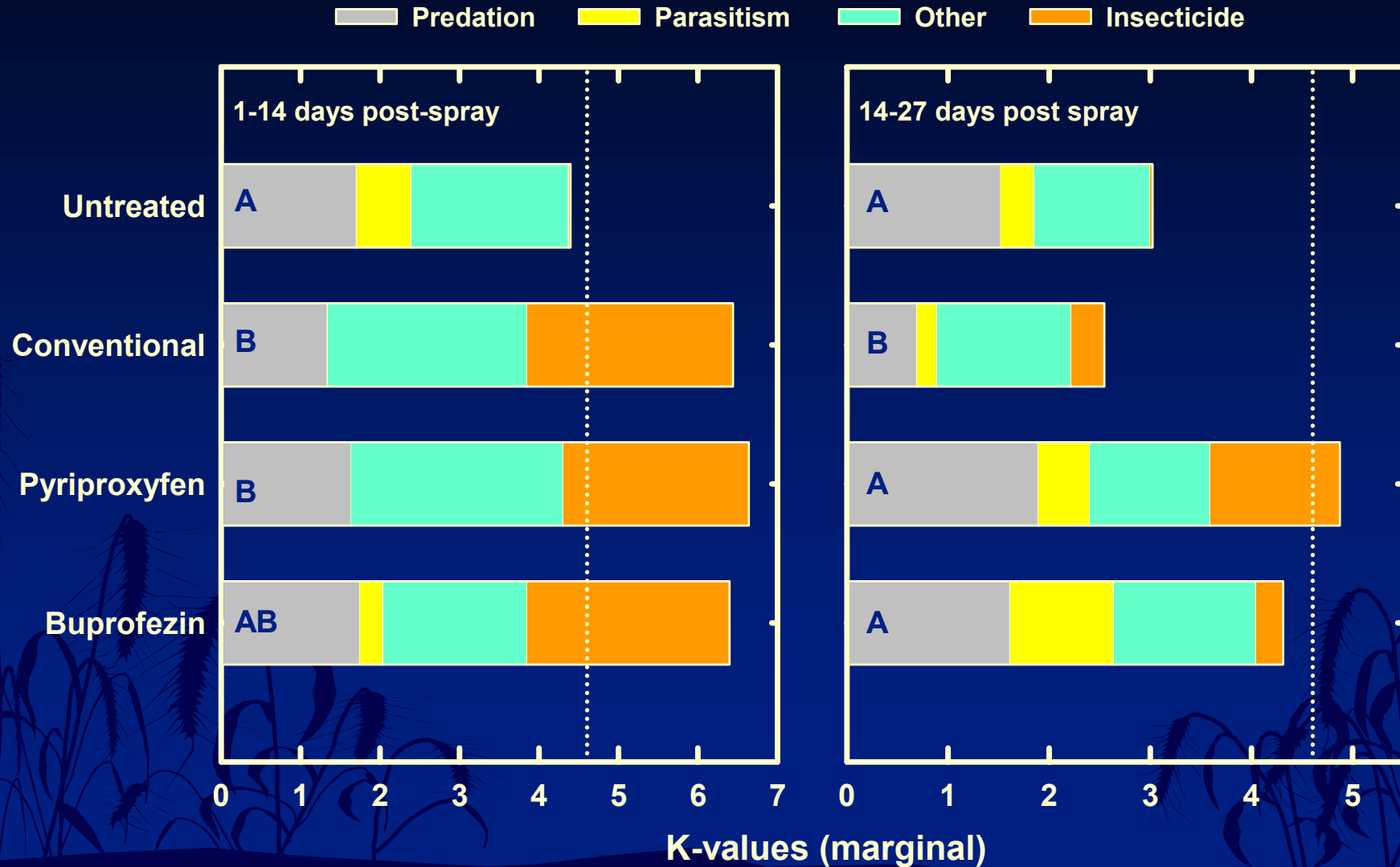
Whitefly Pest Management

1997

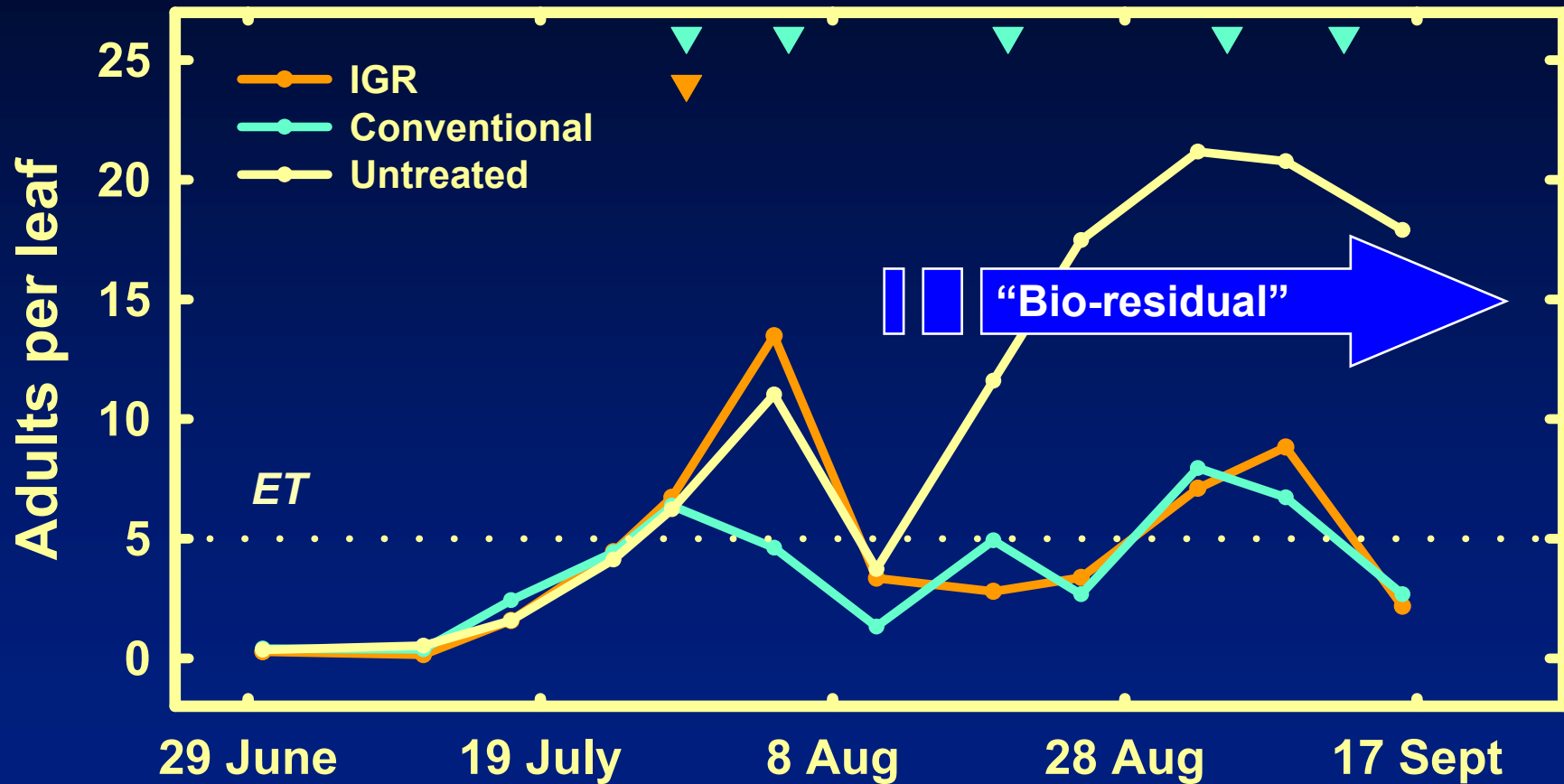


Life Table Analyses

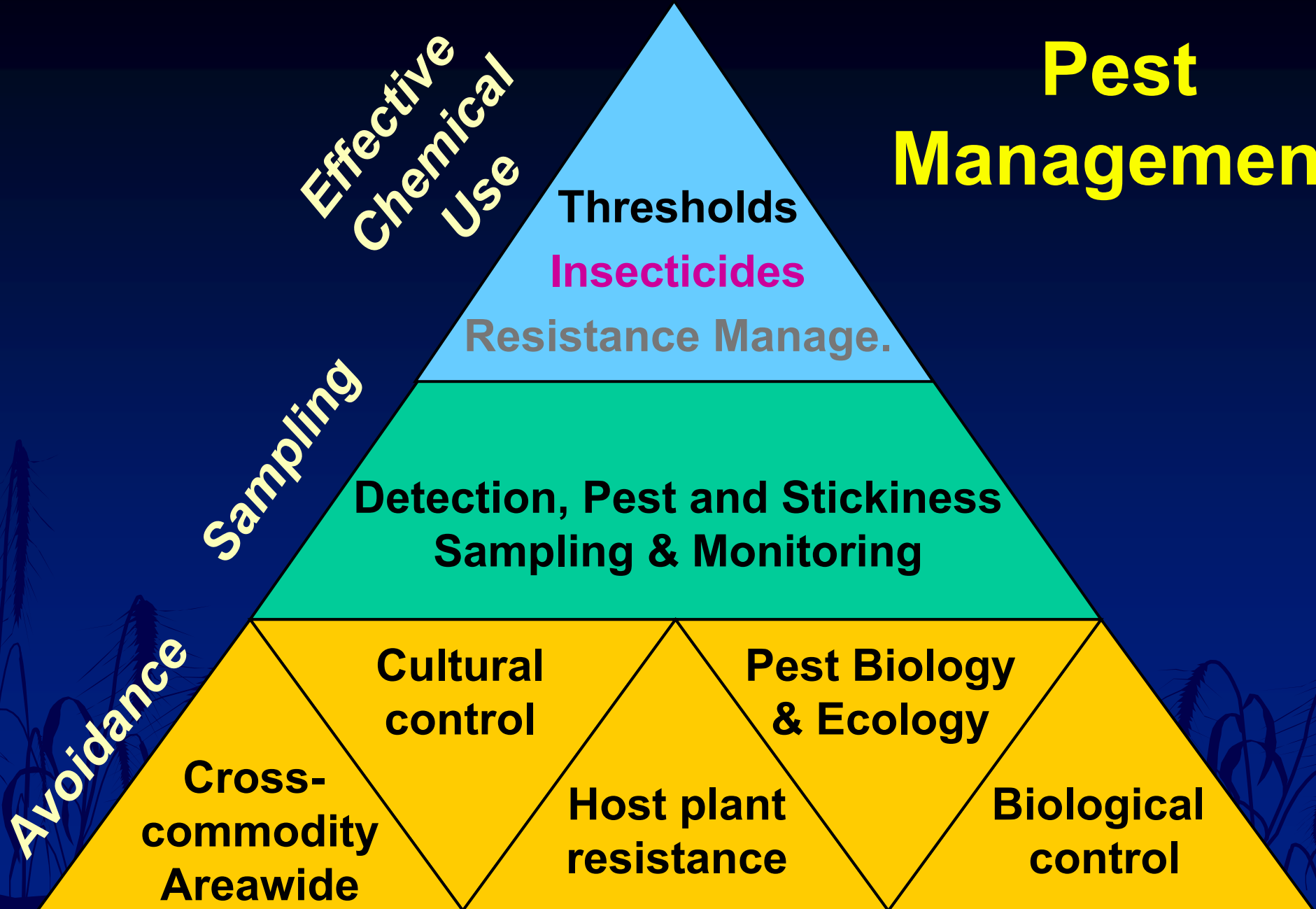
1997



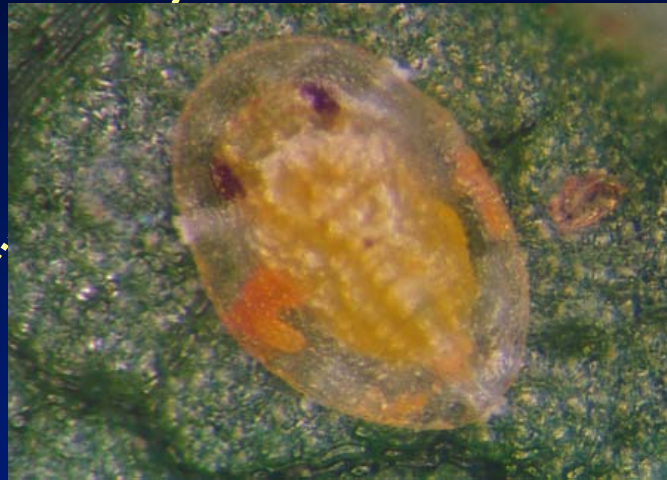
Impact of Conservation



Pest Management



Foundation of IPM



**Cross-commodity
Areawide**

**Cultural
control**

**Host plant
resistance**

**Pest Biology
& Ecology**

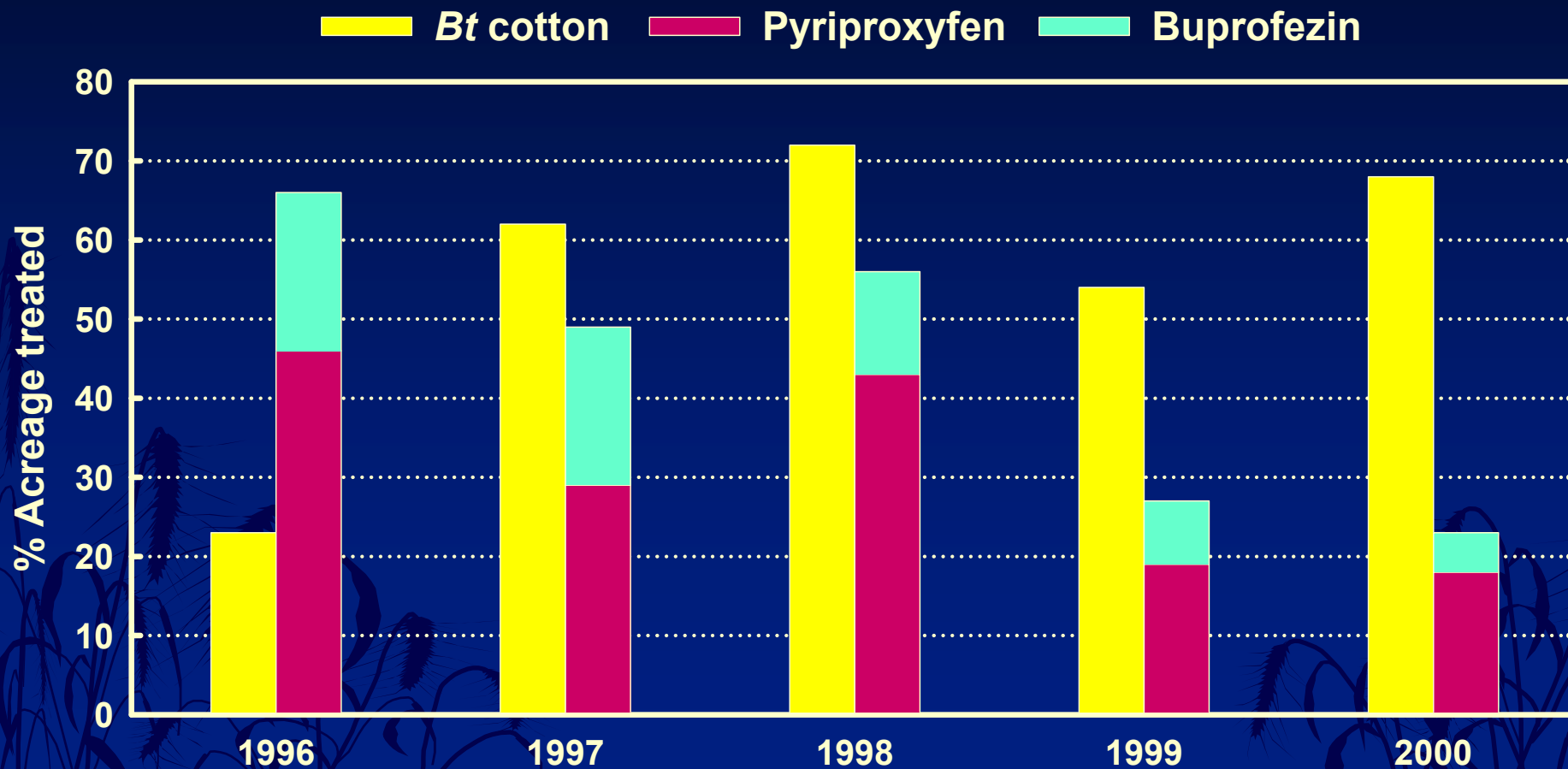
**Biological
control**

Some mitigating factors



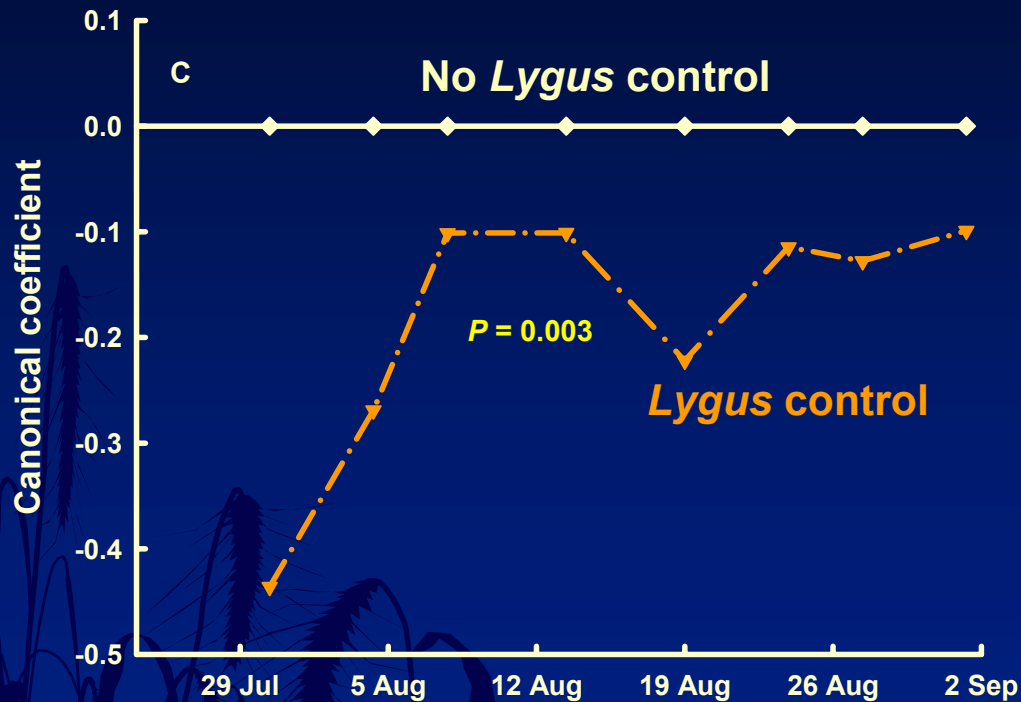
Selective Insecticide Use

Arizona Cotton

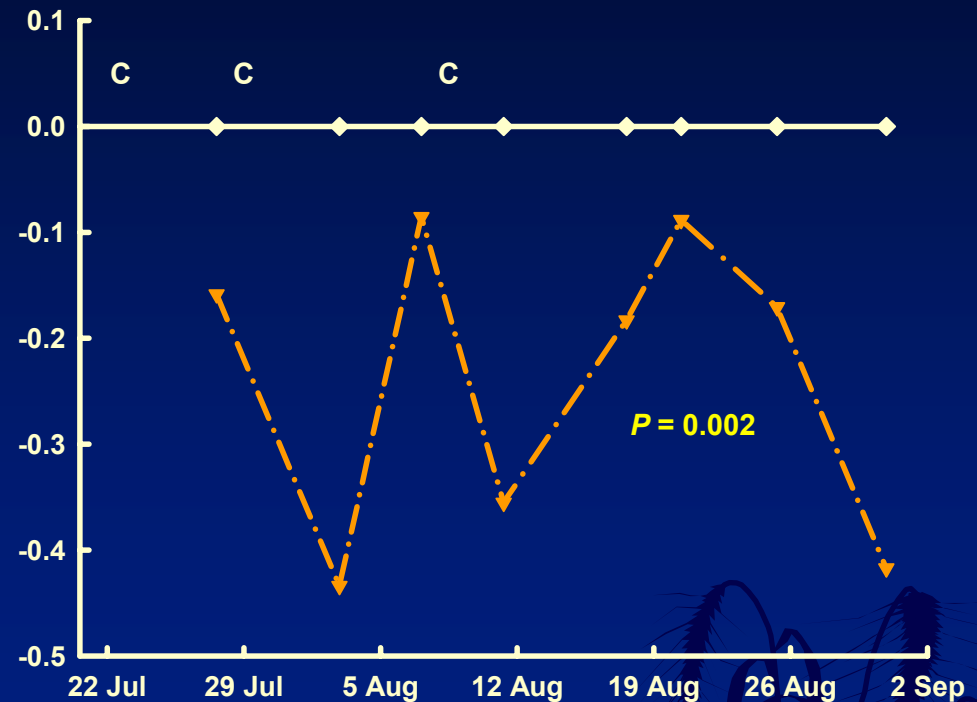


Lygus Control - no selective options!

1997



1999





Thanks to

Peter Ellsworth

Virginia Barkley

Becci Burke

Kim Beimfohr

Luis Cañas

Jonathan Diehl

Jeanette Martin

Donna Meade

Greg Owens