Investigating the Q invasion of *Bemisia tabaci* in Florida: Current Status and Update

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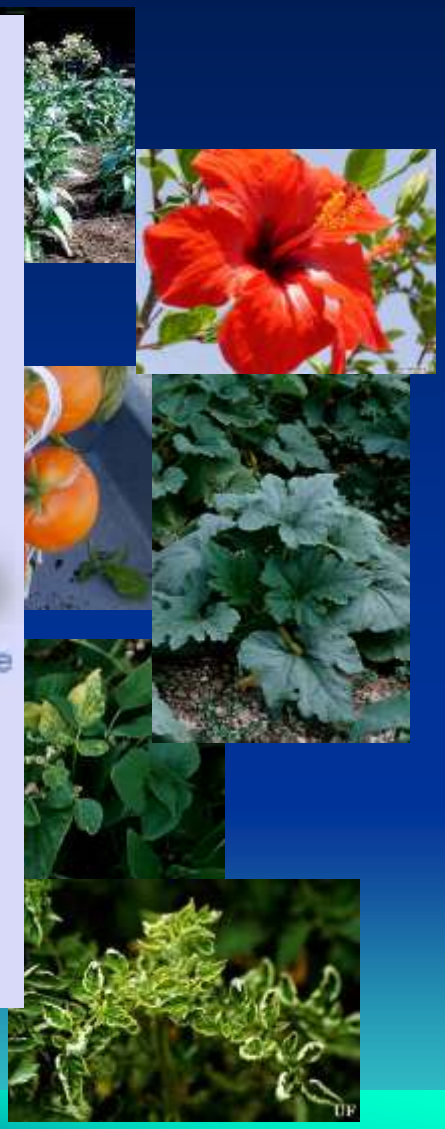
What is a Whitefly Biotype?

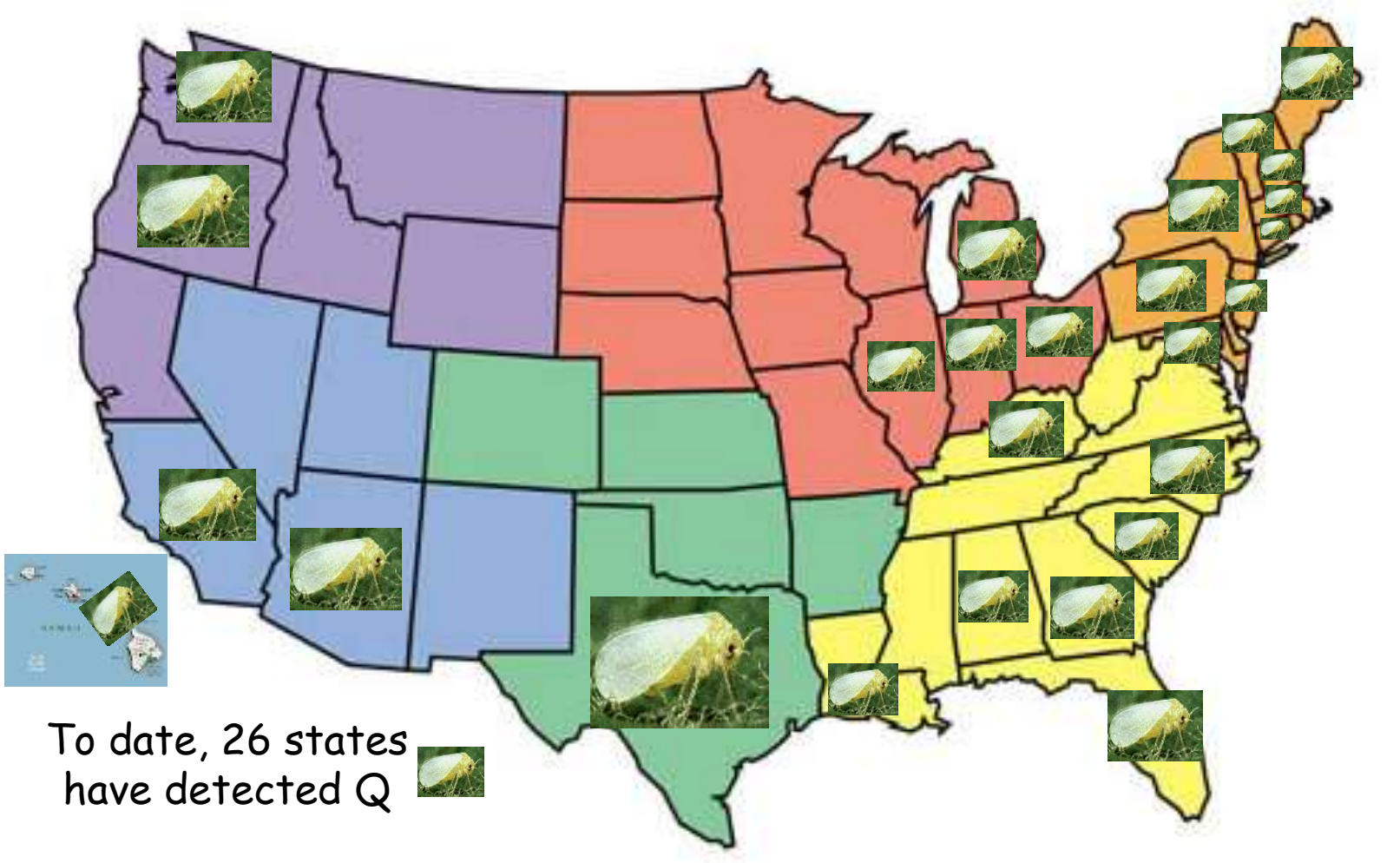
- Strains/host races of *Bemisia tabaci*
- Biotype "A" = Original *B. tabaci* in US
- Biotype "B" = Silverleaf whitefly
  - Asia Minor origin
- Biotype "Q"
  - Predominates in the Mediterranean

New World History of *B. tabaci*

- 1889: A
- 1985: B
- 1987: P
- 1989: T
- 1993: G
- 1995: T



United States "Q" Biotype Detections

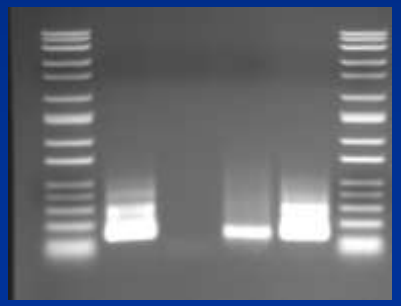


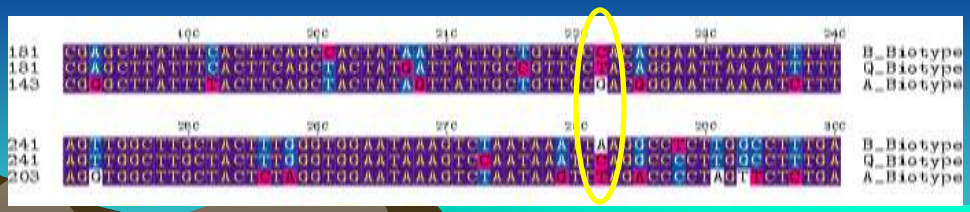
Distinguishing Biotypes of *B. tabaci*

- Biological Characteristics
  - Host range, biotic potential
  - Ability to induce plant disorders
  - Insecticide Resistance

NO Morphological characteristics

- Genetic differences
  - Electrophoresis
  - PCR/Gene Sequencing
  - Diagnostic Microsatellites





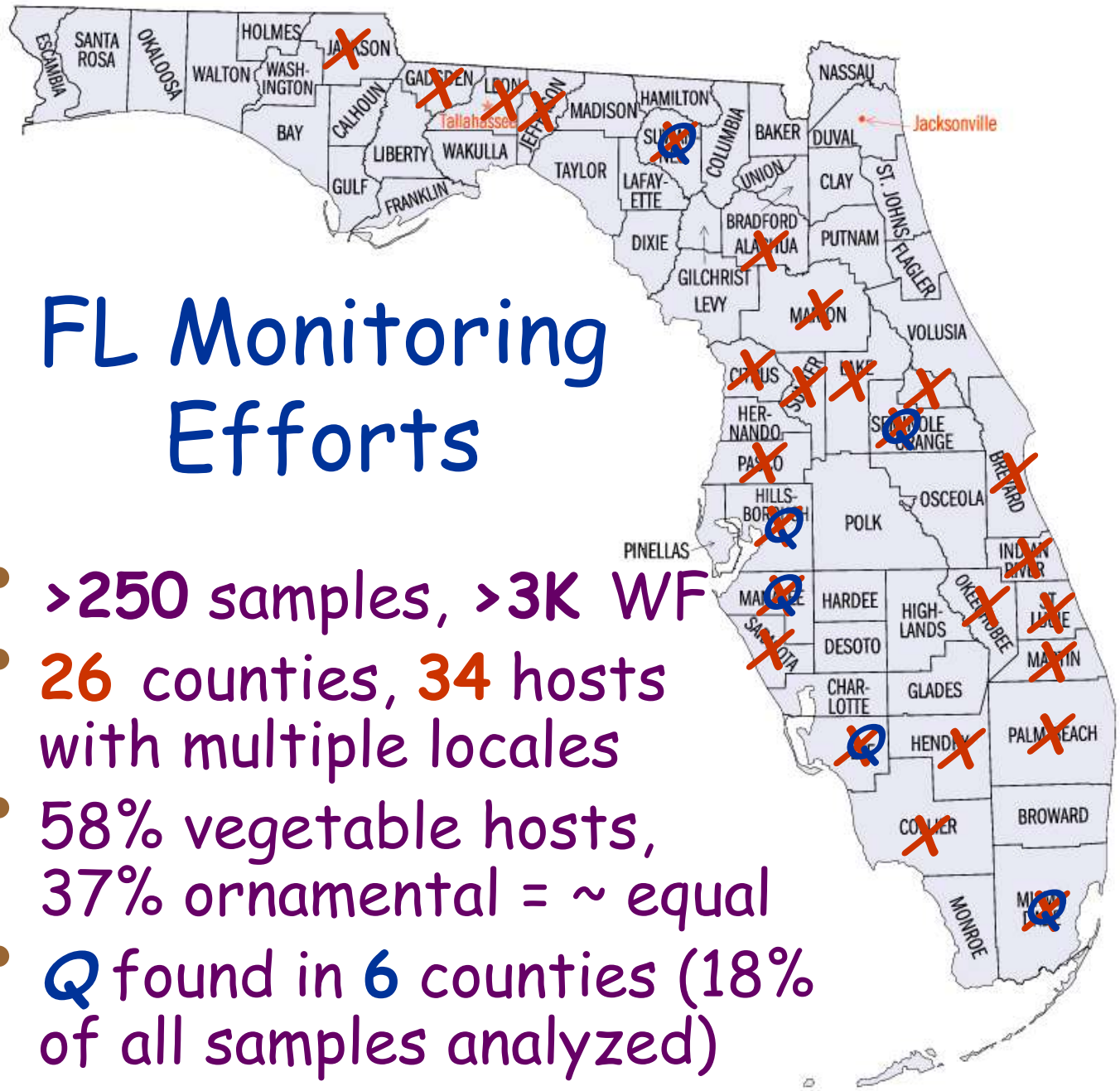
Sampling and Processing

- Ideal sample size = 12 adult female WF

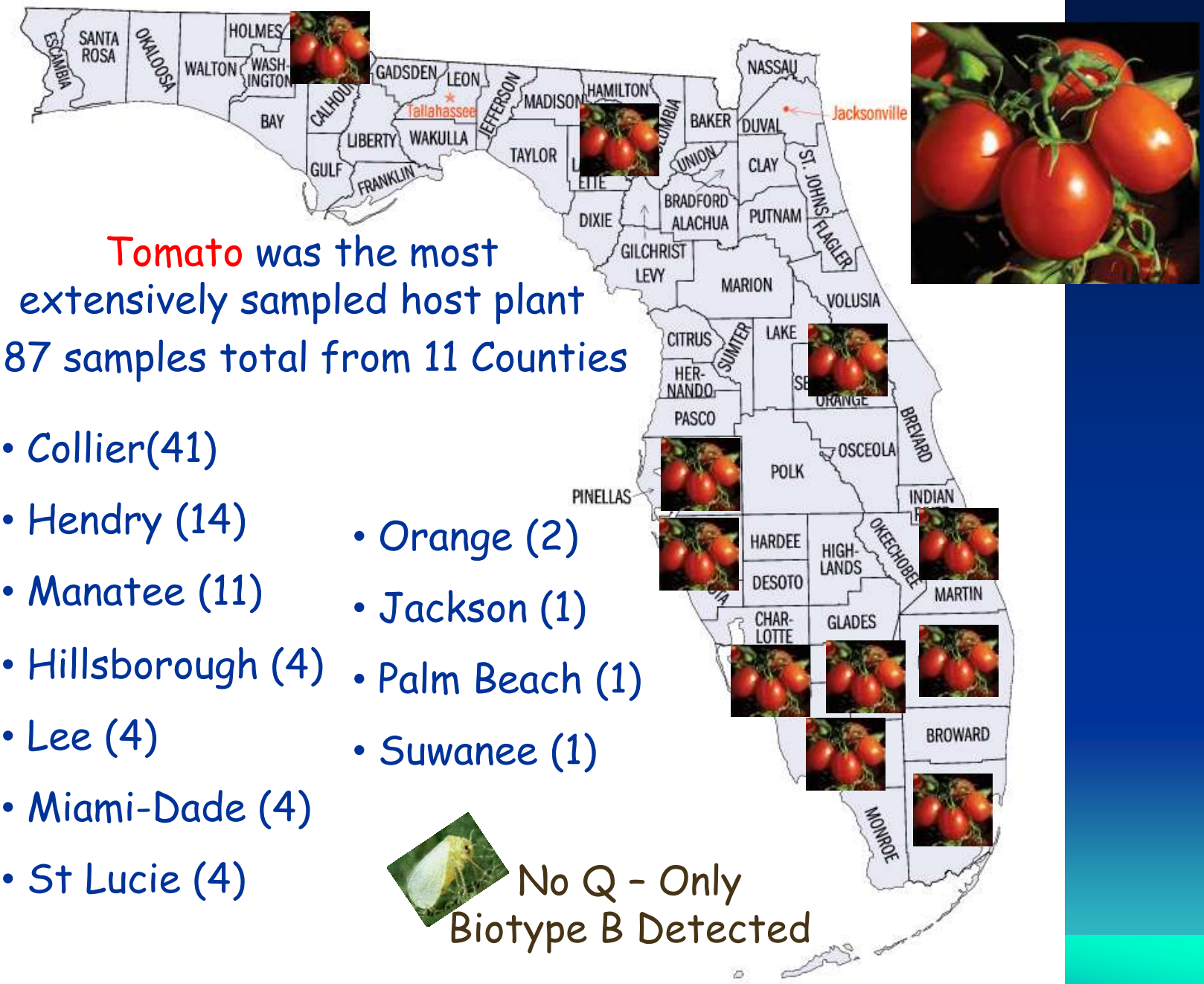
- DNA from a single WF:
  - *mt*COI sequence (mitochondrial genome)
  - Diagnostic microsatellites (nuclear genome)
    - BEM6 $(CA)_8$ IMP
    - BEM23 $(GAA)_{31}$IMP

- From the same sample:
  - *Frequently sent to Frank Byrne/U CA for esterase zymogram confirmation*

FL Monitoring Efforts



- >250 samples, >3K WF
- 26 counties, 34 hosts with multiple locales
- 58% vegetable hosts, 37% ornamental = ~ equal
- *Q* found in 6 counties (18% of all samples analyzed)



Tomato was the most extensively sampled host plant

87 samples total from 11 Counties

- Collier(41)
- Hendry (14)
- Manatee (11)
- Hillsborough (4)
- Lee (4)
- Miami-Dade (4)
- St Lucie (4)
- Orange (2)
- Jackson (1)
- Palm Beach (1)
- Suwanee (1)

No Q – Only Biotype B Detected

Cucurbits: 27 samples surveyed from 8 counties

- **Cucumber (5)**: Collier (2), Hendry (1), Indian River (1), Orange (1)
- **Melon (8)**: Alachua (1), Brevard (1), Collier (1), Hendry (2), Lee (2), Marion (1)
- **Squash (5)**: Collier (4), Hendry (1)
- **Watermelon (9)**: Collier (3), Hendry (2), Lee (4)

No Q – Only Biotype B Detected

More Vegetables:
38 samples from 13 counties

- **Beans (2)**: Lee (1), Orange (1)
- **Cabbage (2)**: Marion (1), Okeechobee (1)
- **Collard Greens (4)**: Leon (2), Orange (2)
- **Eggplant (7)**: Collier (1), Hendry (1), Hillsborough (1), Orange (2) Seminole (1)
- **Lettuce (1)**: St Lucie (1)
- **Okra (2)**: Miami-Dade (2)
- **Peanuts (1)**: Sumter(1)
- **Pepper (9)**: Hendry (1), Miami-Dade (2), Lee (2), Collier (4)
- **Potato (4)**: Lee (3), Manatee (1)
- **Sweet Potato (6)**: Miami-Dade (6)

No Q – Only Biotype B Detected

Biotype B mtCOI Variants

- There were ZIP – ZERO – NADDA variants found w/in Biotype B
- All sequences were 100% IDENTICAL!
- In Florida – a B is a B is a B is a B!

>2,000 individual whiteflies!

*mt*COI Subunit Sequence Variants in the Q-Biotypes

Haplotype Designation	Base Number on the Amplified mtCOI Fragment										
	70	109	232	304	478	502	523	562	634	682	731
~~Q4~~	~~T~~	~~T~~	~~C~~	~~T~~	~~T~~	~~C~~	~~C~~	~~T~~	~~C~~	~~T~~	~~T~~
Q1	C	C	T	C	C	T	T	C	T	T	C
Q2	C	C	C	C	C	C	C	T	T	C	T
Q3	C	G	C	C	C	C	C	T	T	C	T

Q2 to Q3 = 1

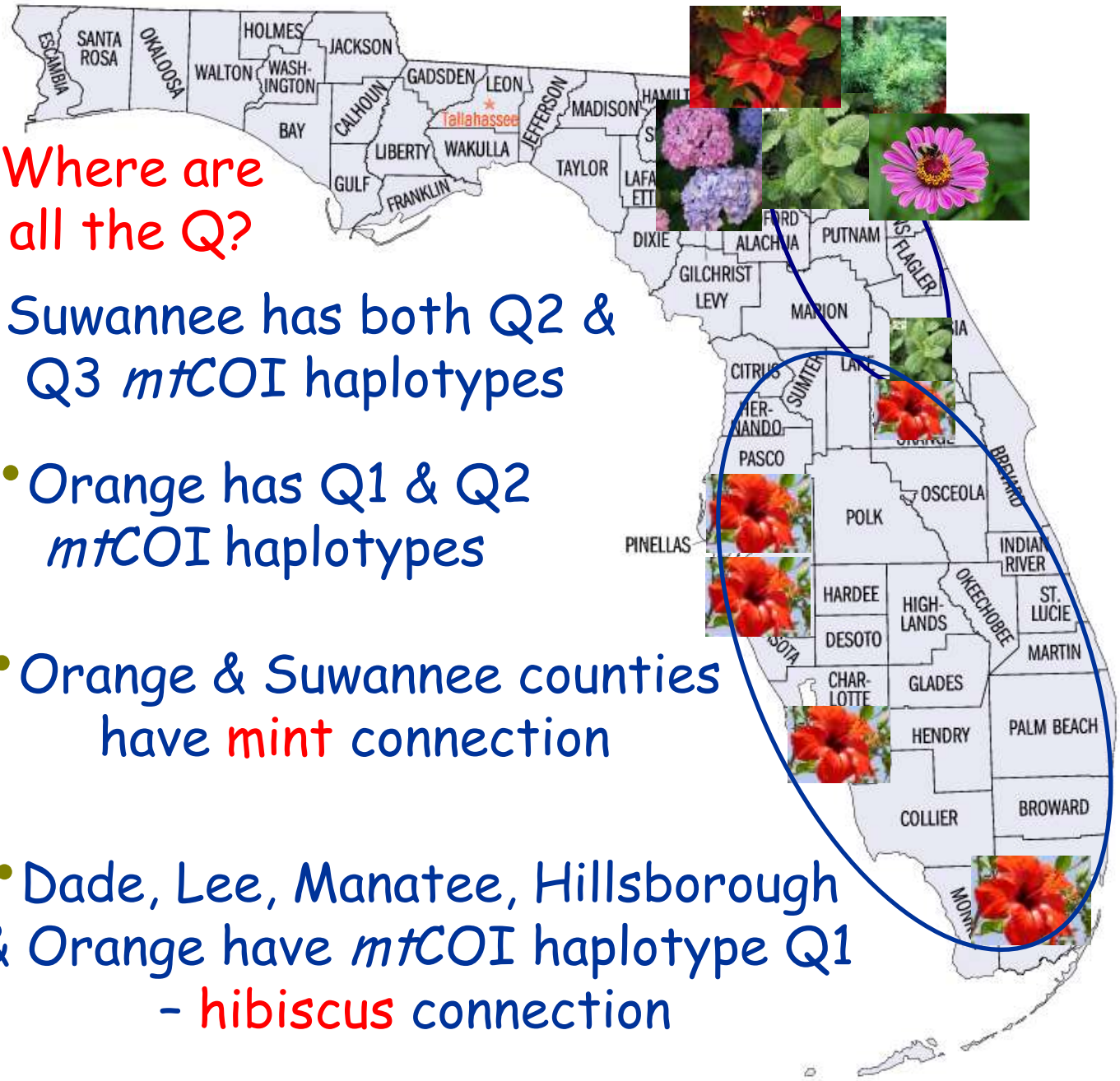
Q3 to Q1 = 6

Q2 to Q1 = 7

Haplotype Q4 (Morocco) was not found in Florida or the U.S.

Where are all the Q?

- Suwannee has both Q2 & Q3 *mt*COI haplotypes
- Orange has Q1 & Q2 *mt*COI haplotypes
- Orange & Suwannee counties have mint connection
- Dade, Lee, Manatee, Hillsborough & Orange have *mt*COI haplotype Q1 – hibiscus connection



Survey Conclusions

- More than one positive Q sample in some counties - 6 counties to date; no new finds in FL since summer of 06.
- Counties identified as positive not overrun with Q; all populations were managed.
- Positive Q IDs only on ornamentals & herbs.
- *ALL* Biotype B whitefly individuals had the same identical *mtCOI* sequence.
- Biotype Q whiteflies had one of four variant *mtCOI* haplotypes.

Biotype Q was known to be tolerant to most chemical classes in 2004

Orthene®

AZATIN®

Flagship™

Distance®
INSECT GROWTH REGULATOR

MARATHON®

Talus®

TriStar®

44 Products Tested from 2005 through 2009

- Acelepryn (DPX-E2Y45)
- Agri-50
- Aria 50 SG
- Avid 0.15EC
- BotaniGard 22WP
- BotaniGard ES
- BugOil
- Celero 16WSG
- Discus
- Distance 0.86EC
- DPX-HGW85
- Dursban
- Eco E-rase
- EcoTrol EC
- Endeavor
- Enstar II
- Flagship 25WG
- Judo 4F
- Kontos
- Marathon II
- Met 52
- MilStop
- M-Pede
- Naturalis B
- NoFly
- Organocide
- Ornazin 3%EC
- Orthene TTO
- Pedestal
- QRD400
- Revoke
- Safari 20SG
- Safari 25WG
- Sanmite
- Scimitar
- Sorbitol Octanoate
- Sucrocide
- Synergy (Suffoil X)
- Talus
- Tame
- TickEx EC
- TriCon (BW420)
- TriStar 30SG
- TriStar 70WSP

Average % Control for Biotype Q
2005 to 2009

Product (active ingredient)	Number of Experiments (68)	% Control Immatures Avg during 3-5 WAT	
		Foliar	Drench
Aria 50SG (flonicamid)	3	49%	50%
Avid 0.15EC (abamectin)	**5**	80%	-
BotaniGard 22WP/ES (*B. bassiana*)	3	51%	-
BugOil	3	73%	-
Celero 16WG (clothianidin)	3	56%	67%
Distance 0.86EC (pyriproxifen)	3	42%	-
Flagship 25WG (thiamethoxam)	6	56%	8%
Judo 4F (spiromesifen)	**6**	77%	-
Kontos (spirotetramat)	**4**	70%	82%
Marathon II 2F (imidacloprid)	6	28%	57%
M-Pede (K salts of fatty acids)	**3**	79%	-
NoFly (*Paecilomyces fumosoroseus S97*)	3	45%	-
Safari 20SG (dinotefuran)	**10**	86%	91%
Sanmite (pyridaben)	**3**	83%	-
TriStar (acetamiprid)	**7**	90%	-

Whitefly Management Plan

WHITEFLY *(BEMISIA TABACI)* MANAGEMENT PROGRAM FOR PLANTS FOR PLANTING[1] INTENDED FOR EXPORT

[1] referred to in the rest of this document as "plants"

This document presents a program to manage *Bemisia tabaci* whiteflies on plants intended for export with the goal of no whiteflies on shipped plants. This program does not require a pesticide application when the first whitefly adult is detected. However, it does outline steps to manage and maintain whitefly populations throughout the initial propagation and active growth stages at levels to enable complete control on final plant material being shipped. Growers should apply pesticides when scouting reports identify population densities at levels where experience and/or extension personnel dictate action be taken. These densities would depend on many factors including the crop, source(s) of infestation, and environmental conditions.

Start with the Line 1 in the "Key to Tables for Suggested Whitefly Applications", and then work your way through the key to the growth stage of your crop. Then refer to the tables (A – F) for suggested products, which are listed with recommended 'yes' or 'no' in the tables for each biotype based on current research. It is highly recommended that any whiteflies in your facility be tested periodically for biotype because more management tools are available for B-biotype than Q-biotype whiteflies. This is especially important if a product does not adequately control whiteflies. A list of laboratories authorized to biotype whiteflies is presented following the program.

Key to Tables for Suggested Whitefly Applications

1. Plants are *Bemisia tabaci* hosts
   - a. Yes 2
   - b. No ..... Table E
2. Plants are cuttings in propagation being rooted
   - a. Yes 3
   - b. No 4
3. Rooting level during propagation
   - a. Mist on, cuttings are newly stuck and not anchored ..... Table A
   - b. Mist off, cuttings are anchored in the soil and able to withstand spray applications ..... Table B
4. Plants are rooted cuttings and ready for shipment
   - a. Yes ..... Table F
   - b. No 5
5. Plant development after transplanting
   - a. Root system is not well developed ..... Table C
   - b. Roots are well developed and penetrating the soil to the sides and bottom of the pots 6
6. Plants are actively growing finished plants or stock
   - a. Plants are more than two weeks from shipment or first cutting harvest ..... Table D
   - b. Plants are two weeks from shipment or first cutting harvest ..... Table E
   - c. Plants or cuttings are 2 – 3 days from shipment ..... Table F

Table A. Cuttings are Not Anchored in Soil

Suggested Products	IRAC Class	B-Biotype	Q-Biotype
Foggers and aerosol generators	Many	Yes	Yes

Table B. Cuttings Able to Withstand Sprays

Suggested Products	IRAC Class	B-Biotype	Q-Biotype
Foggers	Many	Yes	Yes
Avid (abamectin) + pyrethroid or acephate	6 + 3 or 1	Yes	Yes
Beauveria bassiana	n/a	Yes	Yes

Table C. Root System is Not Well Developed

Suggested Products	IRAC Class	B-Biotype	Q-Biotype
Avid (abamectin)	6	Yes	Yes
Distance (pyriproxyfen)	7C	Yes	No
Endeavor (pymetrozine)	9B *	Yes	No
Endosulfan	2	Yes	No
Enstar II (kinoprene)	7A	Yes	No
Sanmite (pyridaben)	21	Yes	Yes
Talus (buprofezin)	16	Yes	No
Tank Mixes			
Avid + Talstar	6 + 3	Yes	Yes
Pyrethroids + acephate	3 + 1	Yes	No
Pyrethroids + azadirachtin	3 + 18	Yes	No

Select products based on the biotype of any whiteflies that are present. **To reduce resistance development,** do not use products listed in Table E that were applied prior to this growing stage. **If multiple cutting harvests are taken from stock plants,** rotate a neonicotinoid drench application (IRAC Group 4) with foliar applications of Judo and Sanmite, including other products as needed from Table D in different IRAC Classes.

guidelines for use rates, reapplication intervals, and gement strategies.

ducts for Plants	IRAC Class	B-Biotype	Q-Biotype
olar Applications:			
imidin)	4	Yes	Yes
nethoxam)	4	Yes	No
etramat)	23	Yes	Yes
dacloprid)	4	Yes	No
uran)	4	Yes	Yes
ns:			
sifan)	23	Yes	Yes
aben)	21	Yes	Yes
nipnid)	4	Yes	Yes

s or Harvested Cuttings are 2 – 3 Days before

lications 2 - 3 days before shipping finished plants or e before each cutting harvest when shipping unrooted **nce resistance development**: avoid applications of sed in the previous growth stage (Table E for finished nd Table B for rooted cuttings).

ducts for ings	IRAC Class	B-Biotype	Q-Biotype
)	6	Yes	Yes
thoxam)	4	Yes	Yes
fen) – targeting plant stage	23	Yes	Yes
Kontos (spirotetramat)	23	Yes	Yes
Safari (dinotefuran)	4	Yes	Yes
Sanmite (pyridaben)	21	Yes	Yes
TriStar (acetamiprid) – targeting adults at this plant stage	4	Yes	Yes

* IRAC Class 9B exhibits cross resistance with IRAC Class 4

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This project was partially funded by the Floriculture & Nursery Research Initiative (USDA-ARS, Society of American Florists, American Nursery & Landscape Association) and the IR-4 Project.

Objectives

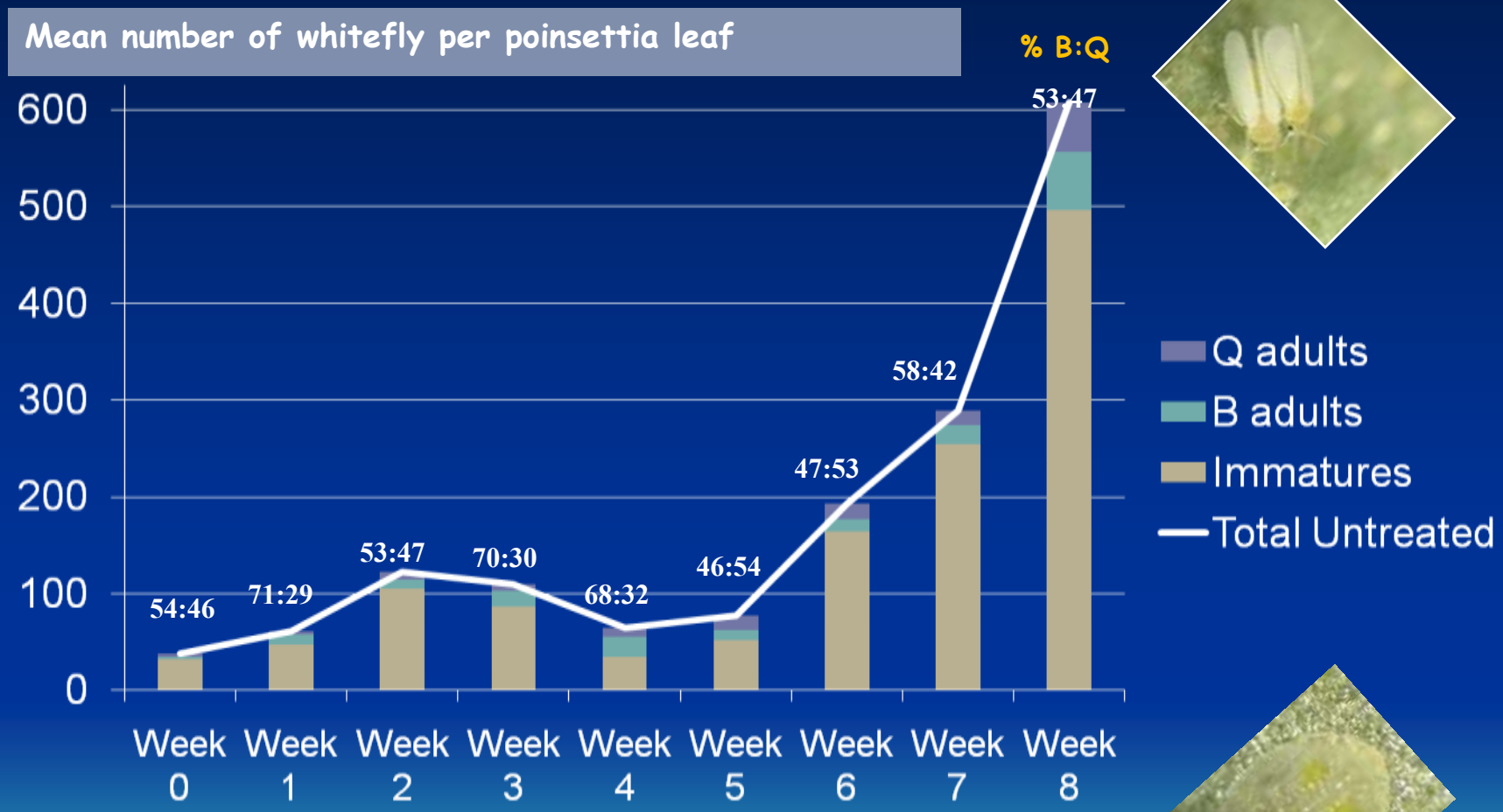
- Test WF Management Program: determine efficacy of different treatment rotations on a mixed population of *Bemisia tabaci*
- Determine the selective efficacy for either B or Q biotype *Bemisia tabaci*
- Observe the impact of the ratio of B to Q biotypes resulting from various insecticides and insecticide rotations

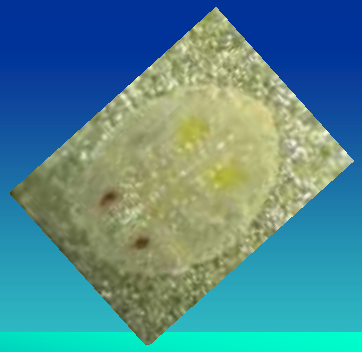
Experimental Design

- RCB design w/5 rep & 4 poinsettia/cage
- Infested with 25B:25Q adult whitefly
- Weekly counts of WF adults/immatures on 2 full leaves/plant (=8/cage or 40/trt)
- 10-12 WF adults biotyped from each cage
- Seven different rotations evaluated
- Each rotation had 3 different chemical classes – one being a neonicotinoid

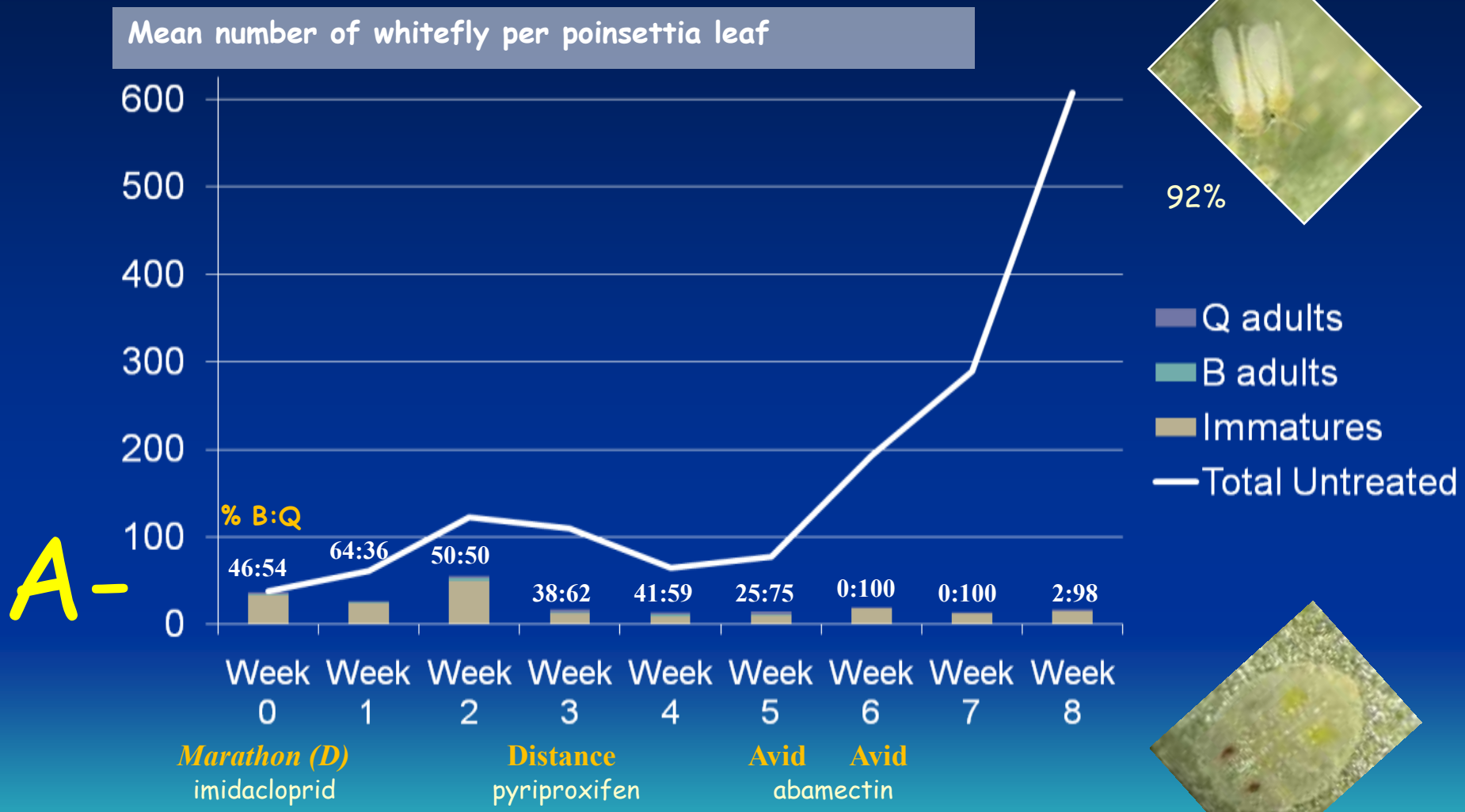

48

Untreated Populations

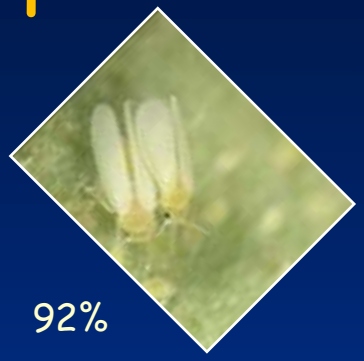


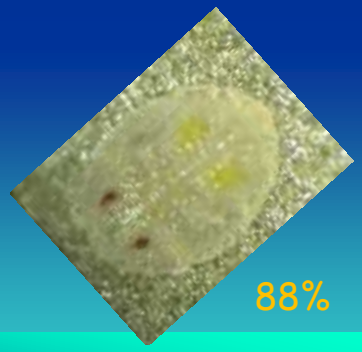


Marathon (D) / Distance / Avid Populations

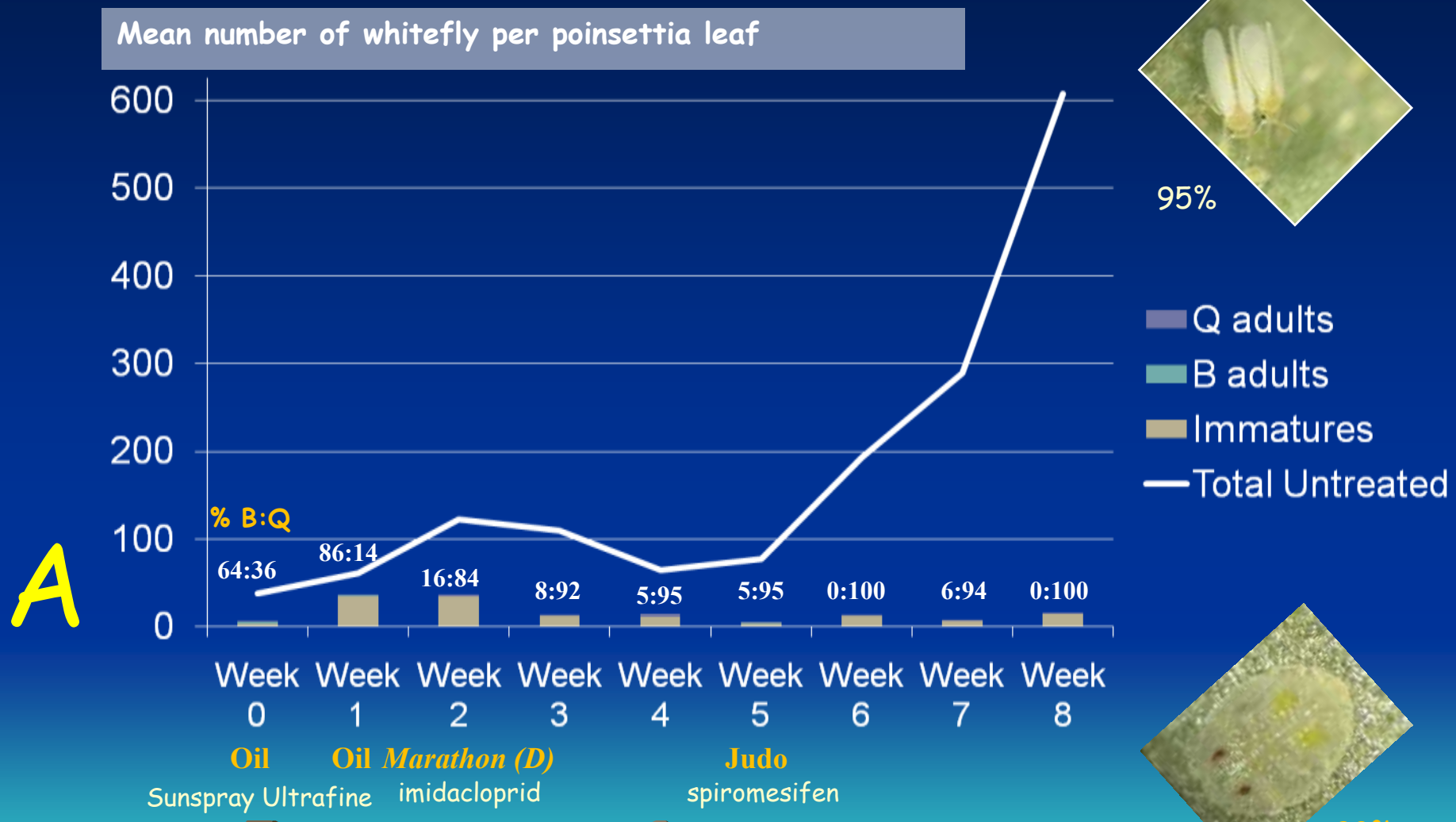


A-

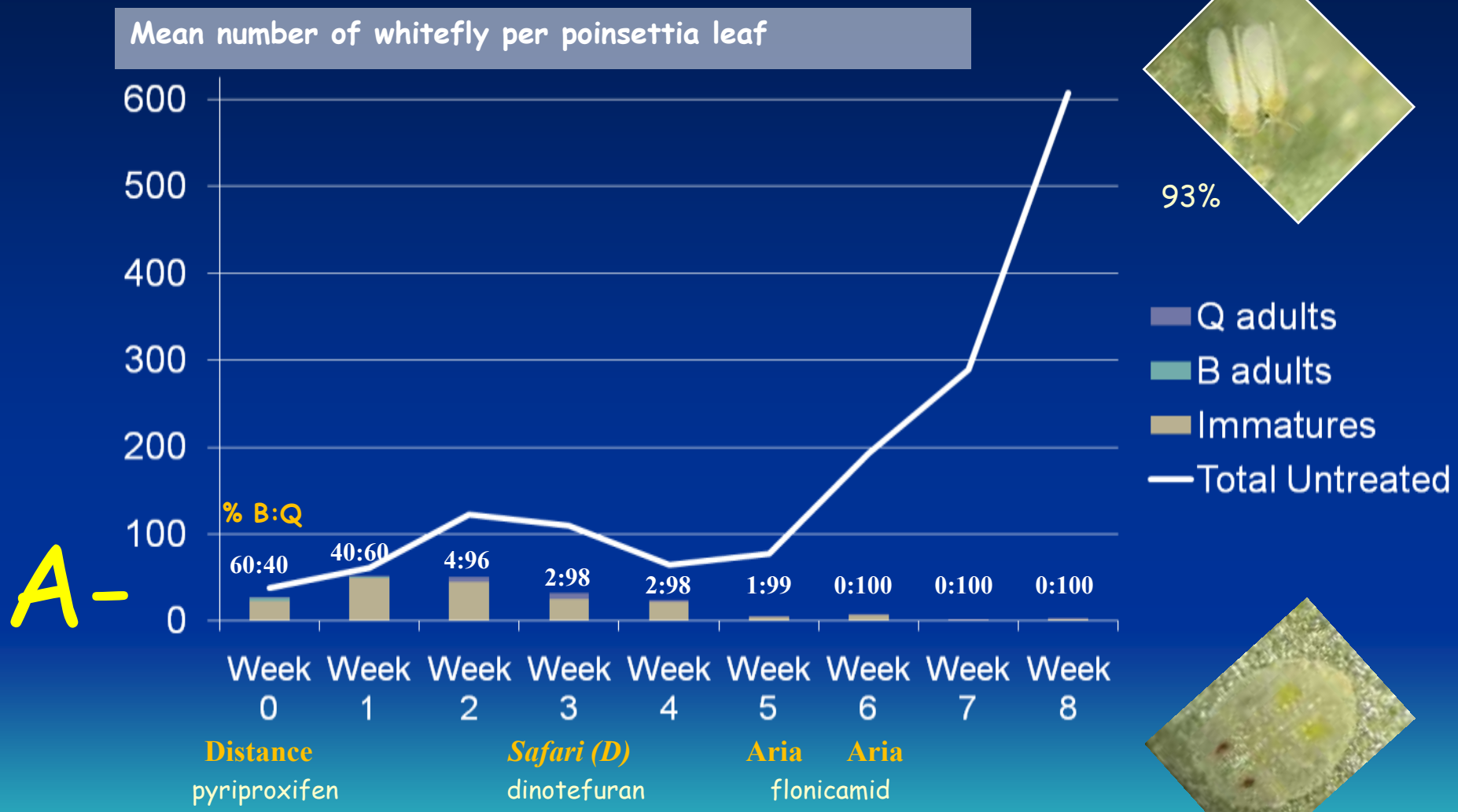




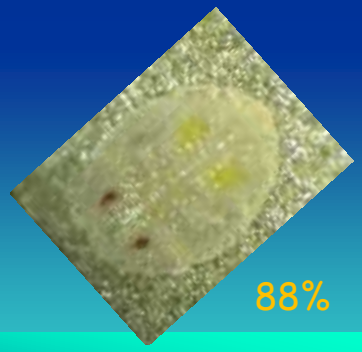
Oil / Marathon (D) / Judo Populations



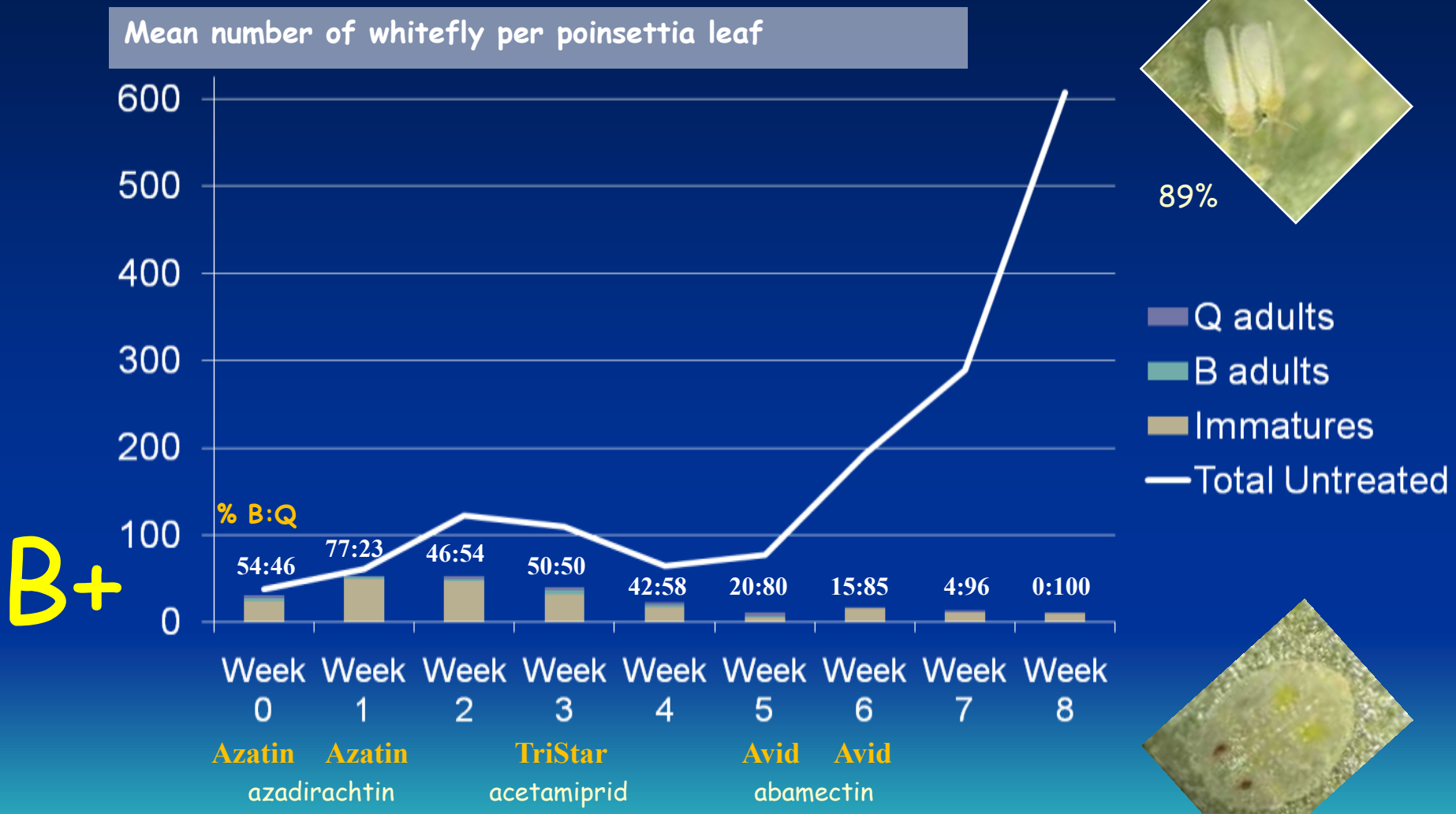
Distance / Safari (D) / Aria Populations



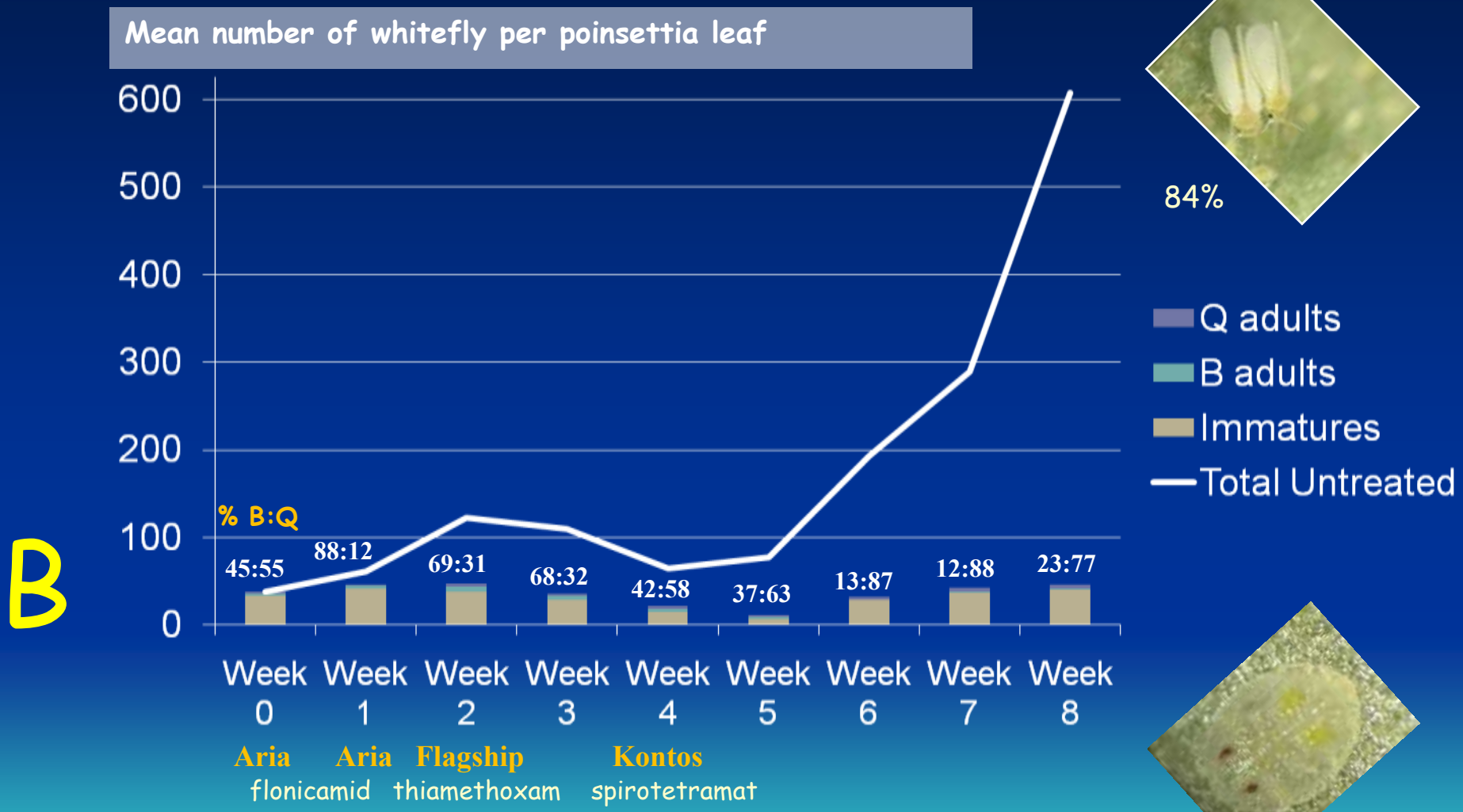
A-



Azatin / TriStar / Avid Populations

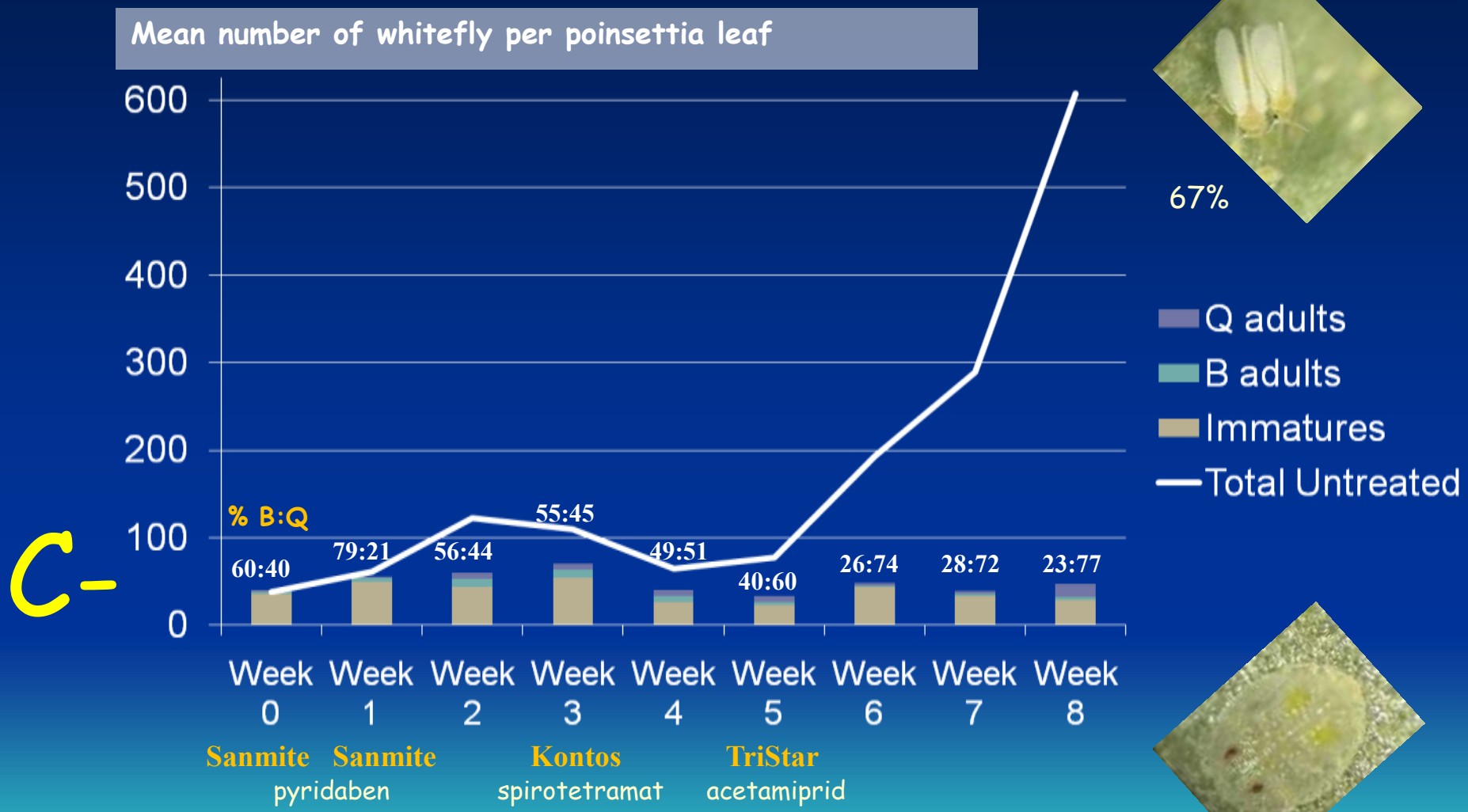


Aria / Flagship / Kontos Populations



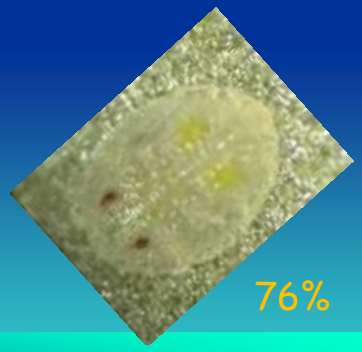
B

Sanmite / Kontos / TriStar Populations



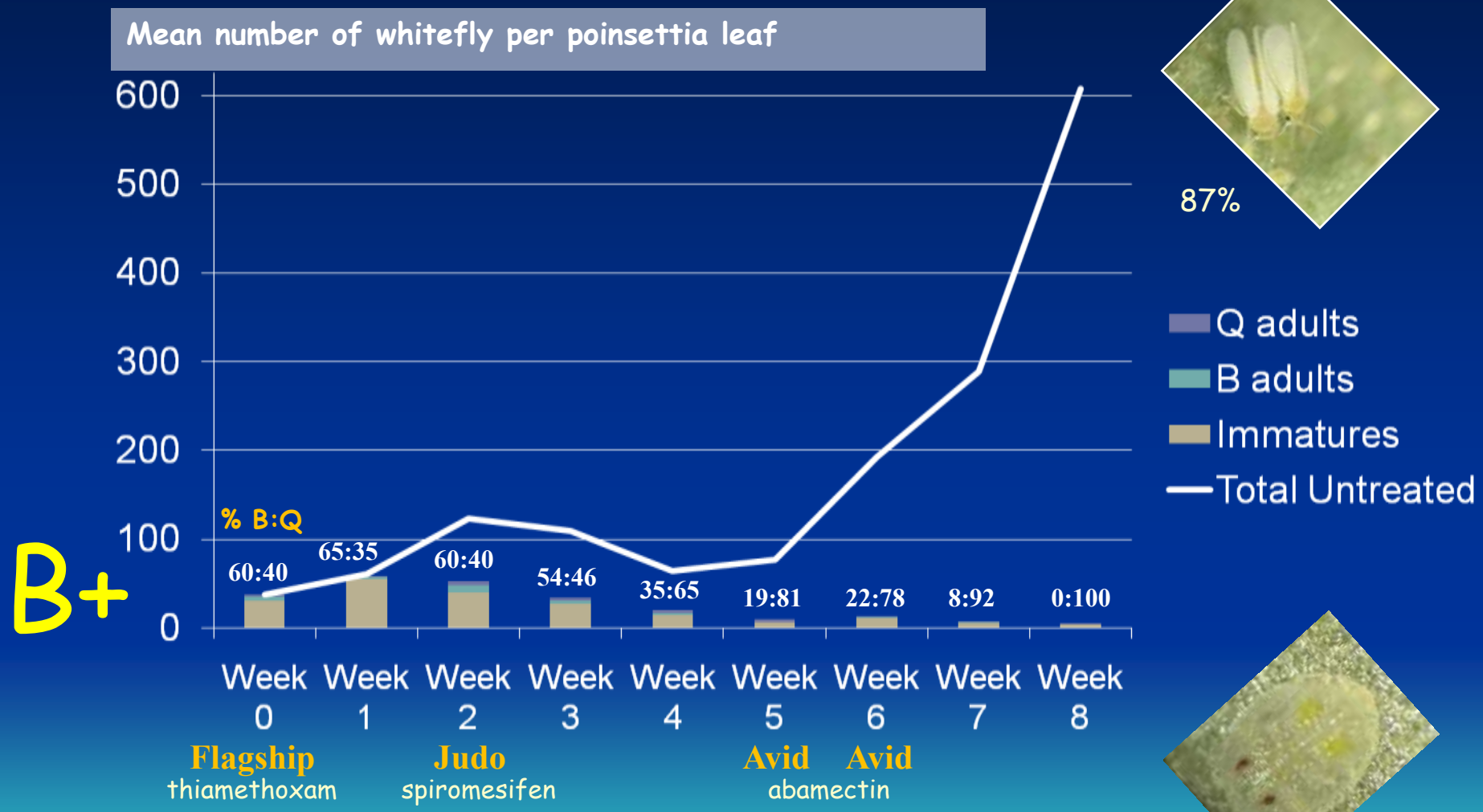
C-

67%



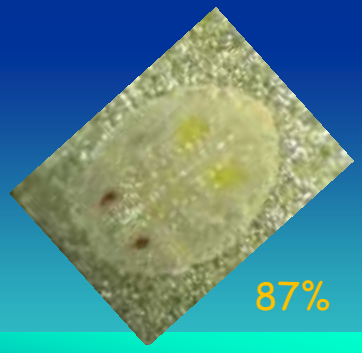
76%

Flagship / Judo / Avid Populations



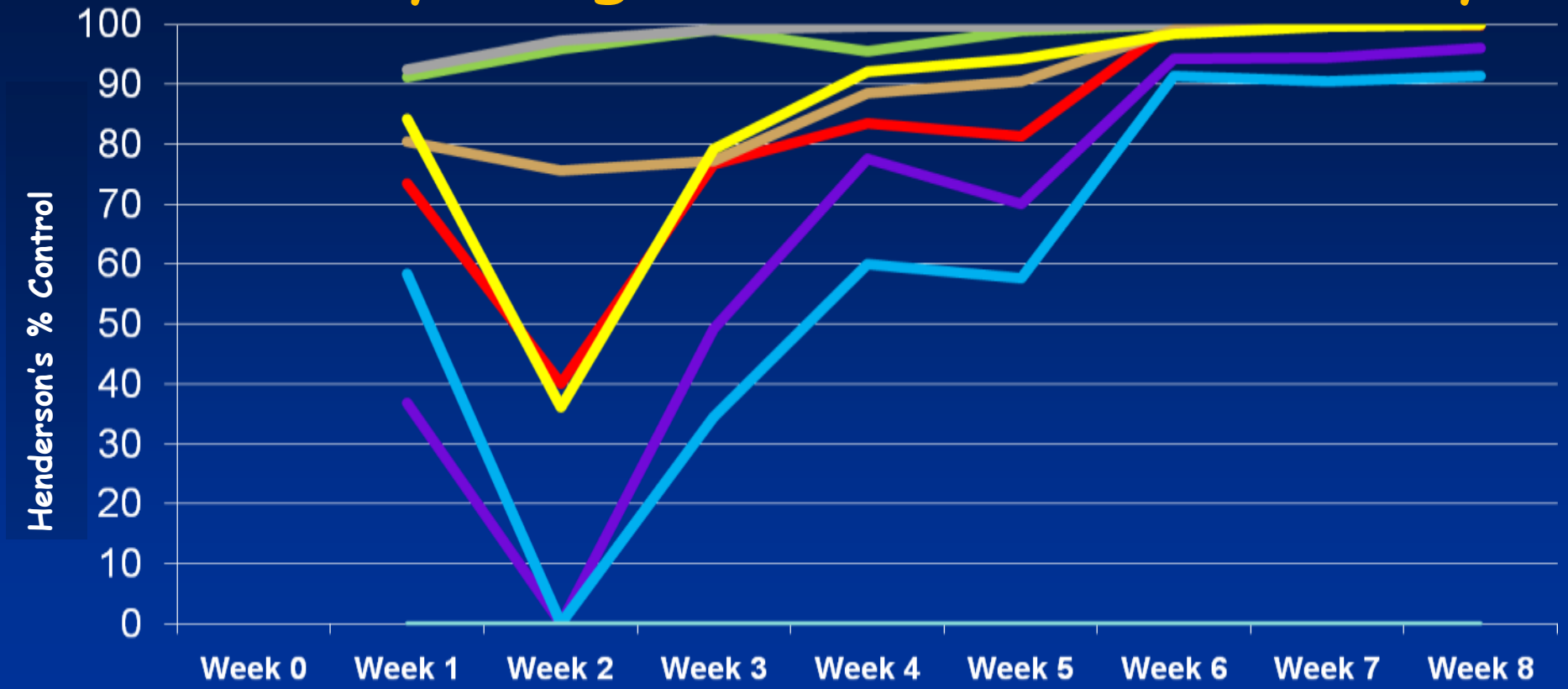
B+

87%



87%

Whitefly Programs: B Adult Efficacy

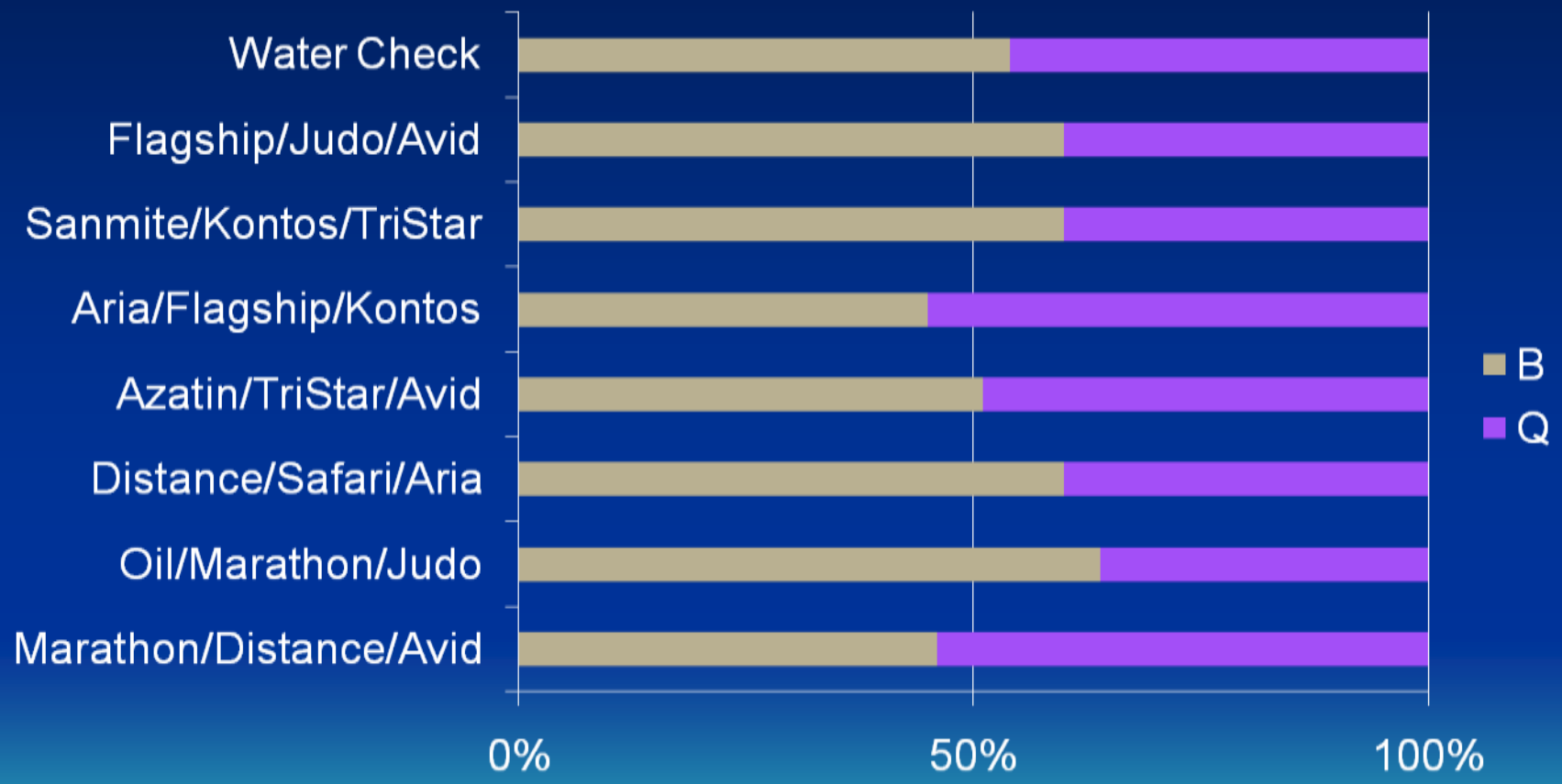


Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Marathon			Distance		Avid	Avid		
Oil	Oil	Marathon			Judo			
Distance			Safari		Aria	Aria		
Azatin	Azatin		TriStar		Avid	Avid		
Aria	Aria	Flagship		Kontos				
Sanmite	Sanmite		Kontos		Tristar			
Flagship		Judo			Avid	Avid		

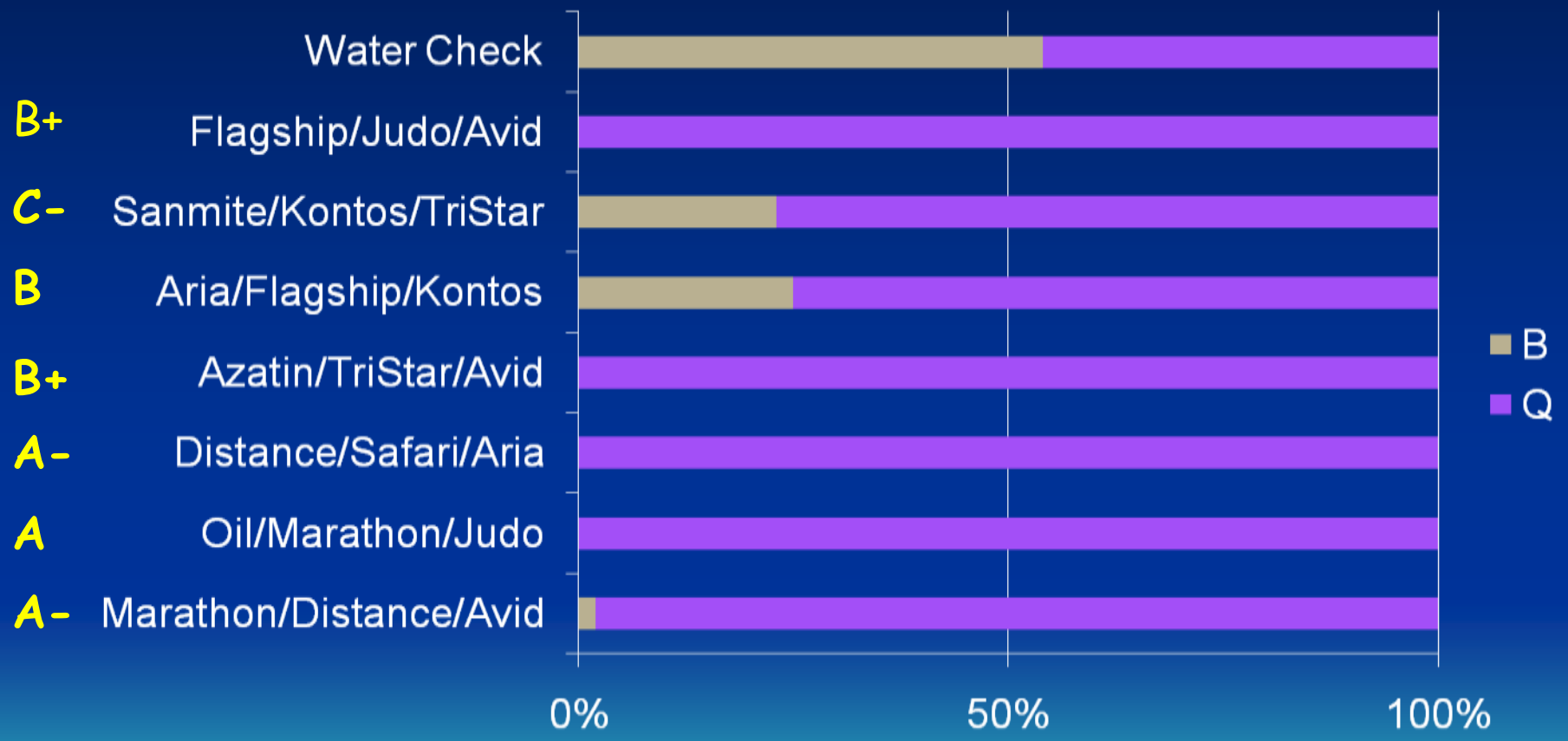
Whitefly Programs: Q Adult Efficacy

Week 0	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Marathon			Distance		Avid	Avid		
Oil	Oil	Marathon			Judo			
Distance			Safari		Aria	Aria		
Azatin	Azatin		TriStar		Avid	Avid		
Aria	Aria	Flagship		Kontos				
Sanmite	Sanmite		Kontos		Tristar			
Flagship		Judo			Avid	Avid		

Whitefly Programs: B:Q Ratio of Adult Populations at Week 0



Whitefly Programs: B:Q Ratio of Adult Populations at Week 8



Results & Summary

- All tested rotational programs managed total populations, but none dropped the population completely to zero
- Using less active materials for resistance management can still result in an effective overall program
- Biotype Q is less sensitive to certain products than Biotype B

Collaborator Acknowledgements

Partially funded by the Floriculture and Nursery *Research Initiative and* I-R4