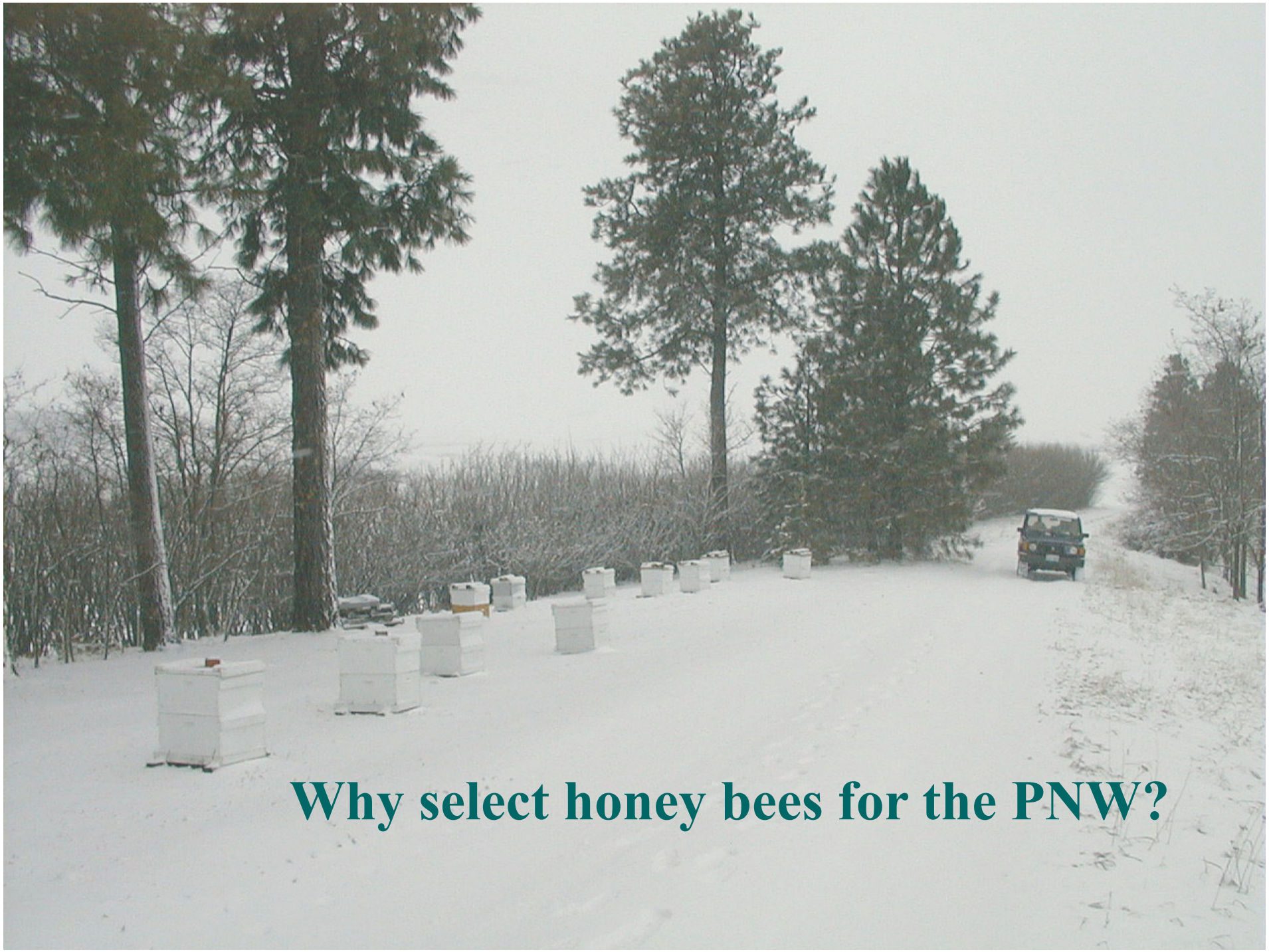
A cooperative beekeeper/university bee breeding program for Washington State and the PNW

Steve Sheppard, Marina Meixner
Washington State University, Department of Entomology

- WSU honey bee breeding program – some details and current status

- The relationship between breeding practices and genetic variation in U.S. honey bee populations. What can we do?


Why select honey bees for the PNW?

Interest to develop stocks that exhibit improved adaptation to PNW conditions and reduced need for chemical controls of pests and diseases

WSU bee breeding program -

1998-2001 - selection for apicultural traits and hygienic behavior among an initial starting population of 50 - 75 queens of diverse genetic sources

2002-2006 – expansion of selection program for apicultural traits and hygienic behavior among an additional sampling of >200 queens from nearly all commercial sources of honey bee germplasm. (USDA-IFAFS grant to CornelI, WSU, USDA-ARS)

WSU bee breeding program -

2007 - 2010 – continue selective breeding program for honey bees adapted to PNW conditions and requiring reduced chemical inputs

2008-2010 – import additional honey bee germplasm from Old World sources to incorporate into breeding program.

2008-2010 – increase stock availability and impact for PNW beekeepers through distribution of selected honey bees directly via “collaborative apiaries”, breeder collaborators and promotion of regional breeding efforts and short courses. (USDA-SARE grant to WSU)

The initial question:

What kind of bees do we want?


I choose you !

Evaluation of colonies during season for performance

- Overwintering ability
- Temperament
- Honey yield
- Disease “resistance”
- Hygienic behavior
- Spring buildup
- Mite resistance (SMR now VSH)

Selection …

Each colony was assigned a performance score for each of the traits under consideration

A final score was calculated for each queen by summing individual trait scores, minus all penalty points for undesirable traits.

To select the breeder queens for the next generation, queens were chosen from colonies with the highest overall scores.

By 2003, we had selected 8 maternal sub-lines.

In subsequent generations, 20-30 daughter queens were assessed from each maternal sub-line each year

For each line, the highest performing daughter was selected as the mother of the next generation

For 6 sub-lines, the 4th generation of daughters was produced in 2006, 2 other sub-lines have been under selection for 8 generations

Aren’t genetics too complicated?

2 traits in more detail….

Temperament

Assessment of temperament

- Temperament is assessed continuously throughout the season.
- Score assigned whenever a colony is handled
- The average score is calculated and used as selection criterion

Assessment of temperament

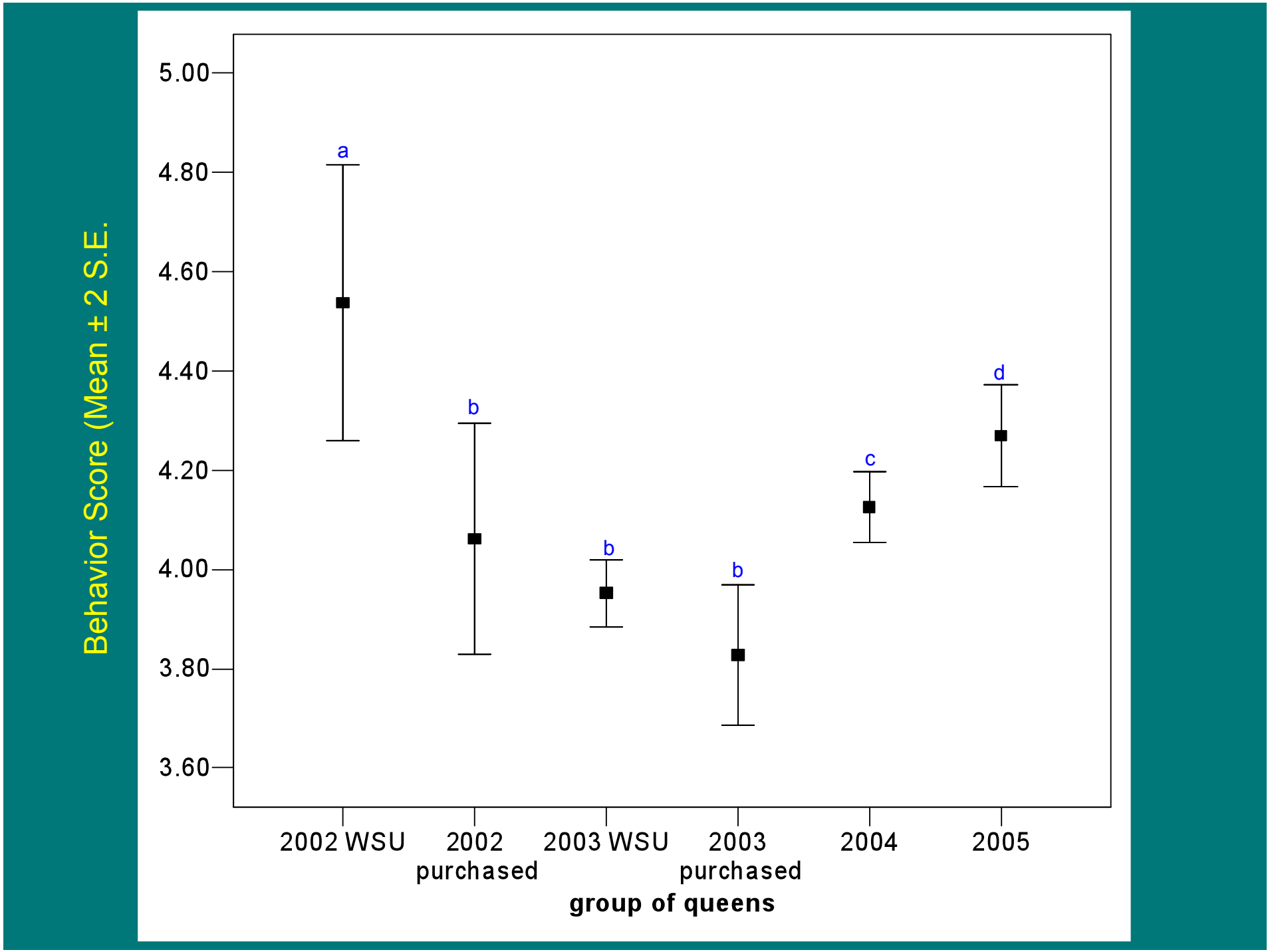
5 – bees very calm and steady on comb

4 – bees calm, not runny

3 – nervous, some runniness.

2 – nervous to defensive

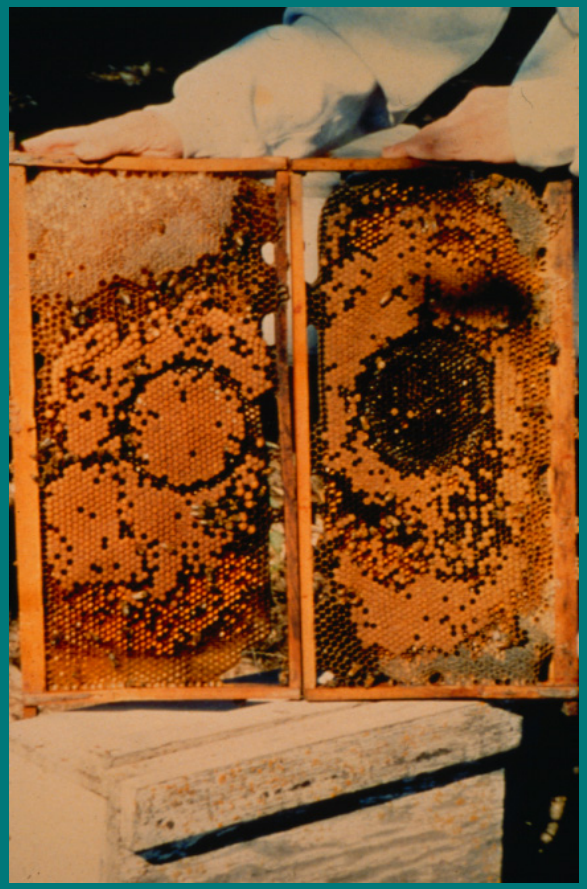
1 – very defensive


Behavior Score (Mean ± 2 S.E.
5.00
4.80
4.60
4.40
4.20
4.00
3.80
3.60
a
b
b
b
c
d
2002 WSU
2002 purchased
2003 WSU
2003 purchased
2004
2005
group of queens

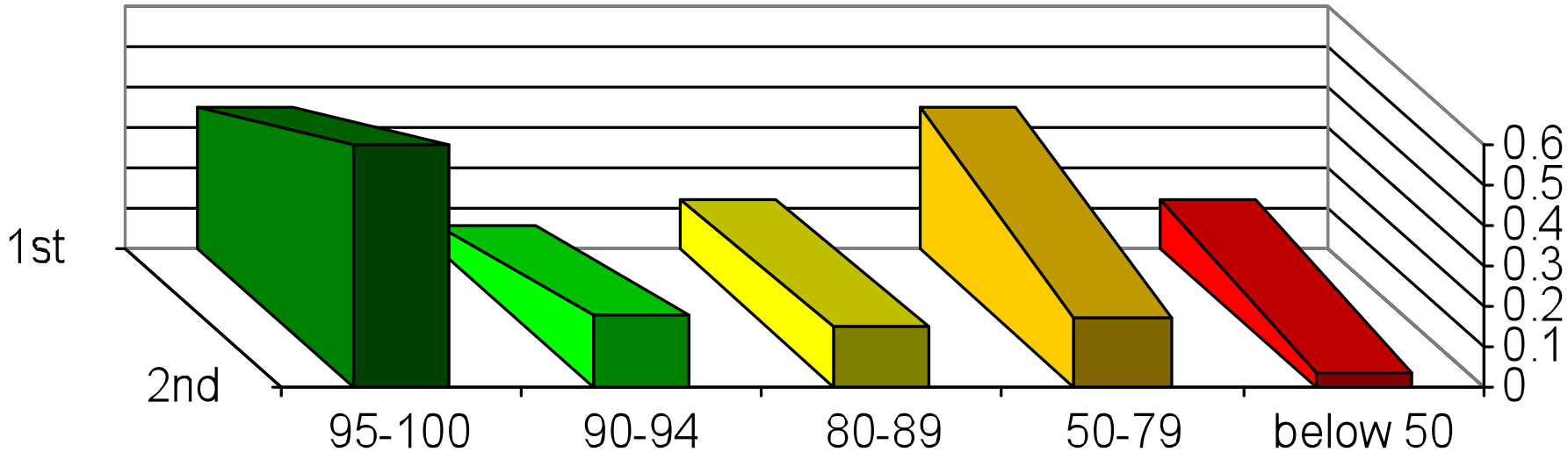
hygienic behavior ?

Testing for hygienic behavior

Sections of comb are treated with liquid nitrogen to kill the brood. 24 or 48 hours later, the percentage of cells cleaned is determined.



Hygienic behavior:
48 hr - test, relative change 1st to 2nd generation

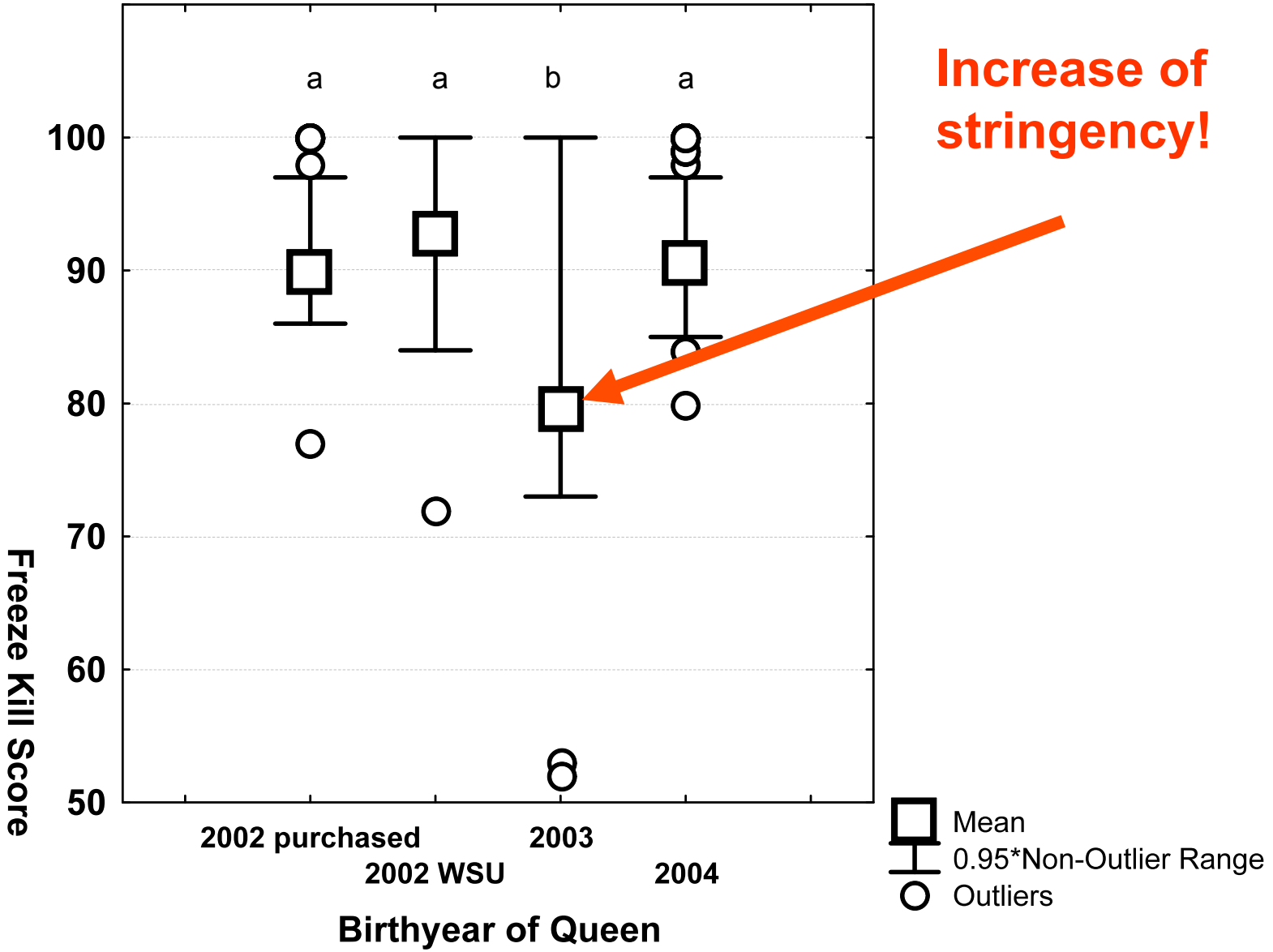


Increasing the **stringency** of the test

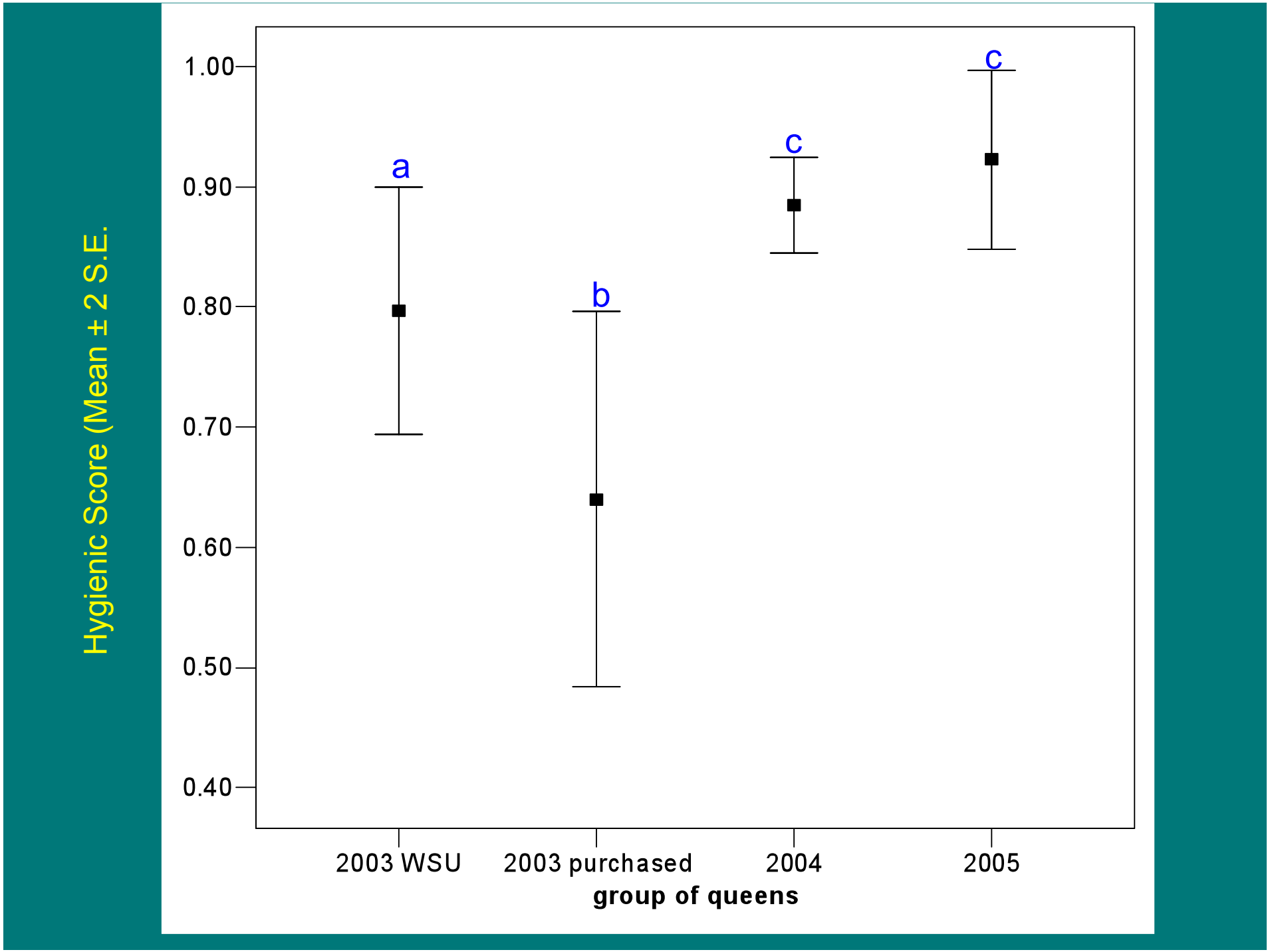
Hygienic behavior is affected by environment and by genetics. For example, bees are more inclined to display this behavior during a nectar flow.

We increased the stringency of the assay by testing for hygienic behavior without a nectar flow and after only 24 hours.

Development of Hygienic Behavior



Increase of stringency!


Hygienic Score (Mean ± 2 S.E.
1.00
0.90
0.80
0.70
0.60
0.50
0.40
a
b
c
c
2003 WSU
2003 purchased
2004
2005
group of queens

Evaluation of selected stock

Key components to the incorporation of selected traits into a honey bee population

Controlled mating

Queens are reared and mated in a mating yard previously tested for mating isolation.

Controlled mating – isolated mating areas

The WSU mating station at Smoot Hill.

Collaborative arrangement for queen cell production in 2006 – Nordelle Terry and Jordan Dimmock (eastern Oregon)

Queen cell rapid transit system– 1955 Piper Tri-Pacer

2005-2006 – started distribution of WSU selected stocks directly to PNW beekeepers through 3 collaborative apiaries with the Washington State Beekeepers Association.

Provide beekeeper access to WSU genetic stock to graft their own cells or mate their virgins with drones produced from program queens.

2006 - One cooperator produced 3000 F1 hybrids for testing in a commercial beekeeping operation that includes indoor wintering and migratory almond pollination

2007-2010 - continue distribution of selected stocks directly to interested PNW beekeepers through expansion of WA-OR-ID collaborative apiaries.

- continue testing of stocks in PNW-CA operations to evaluate whether the selected stocks are viable in migratory operations that require a rapid build-up/ response to feeding

Why is Genetic Variation Good?

- Variation is a prerequisite for selection, both natural and artificial
- Honey bees are more sensitive to inbreeding than other commercial stock

Concerns for genetic diversity in U.S. populations

- Introduction of small founder populations by importation to the U.S.
- Probable reduction of feral and managed populations by *Varroa destructor*
- Use of a small number of breeder queens to produce replacement queens for managed honey bee population

A small story from the US queen production industry. With about 2.7 million colonies of honey bees…

A project to …

- Compare the genetic composition of U.S. managed honey bee populations to a parallel sample set collected in 1993-1994
- Quantify genetic variability of U.S. managed populations

Collection protocol

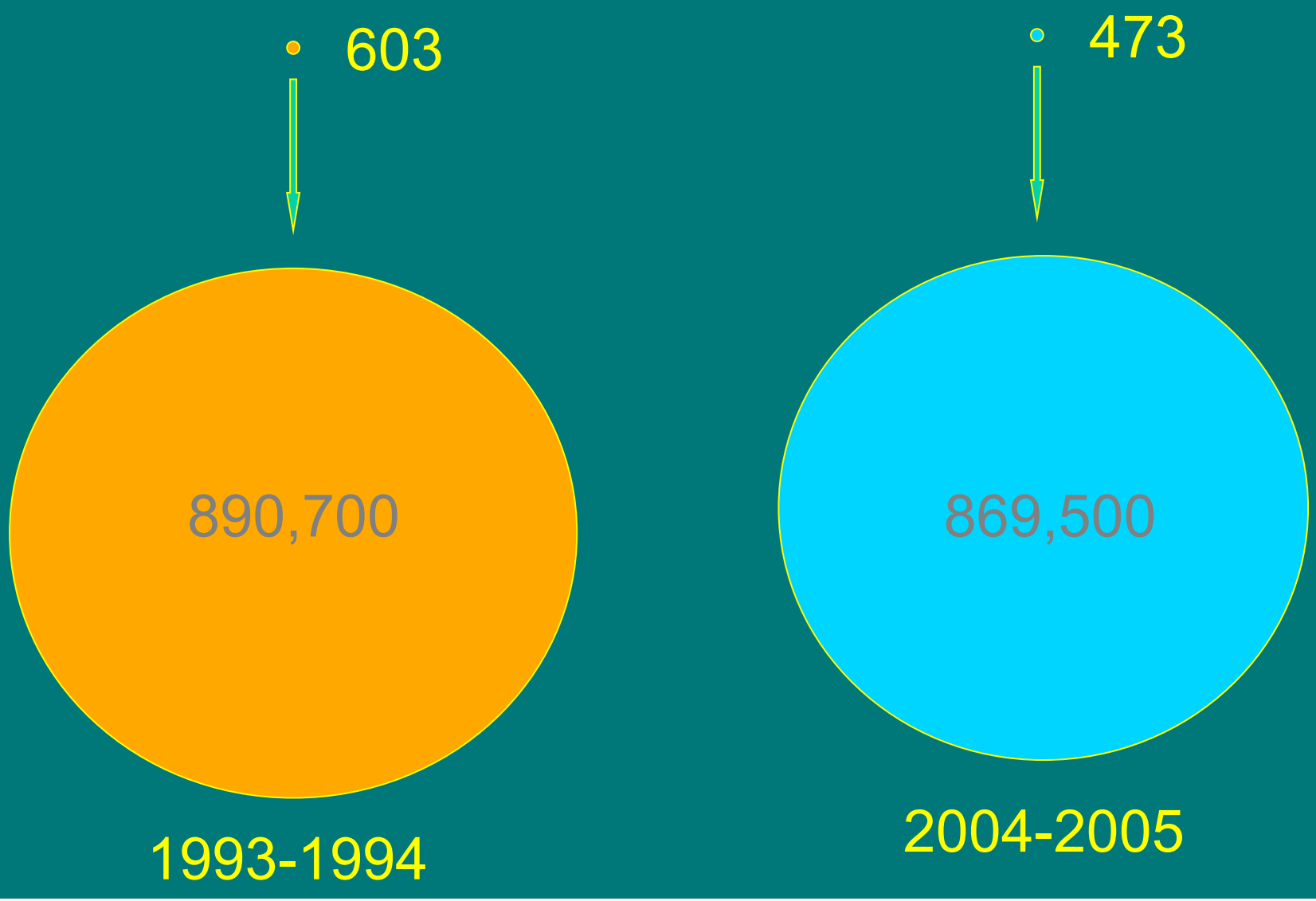
1993-1994:

- Honey bees collected from 320 queen mother colonies (from 44 commercial queen producers from the western and southern regions)

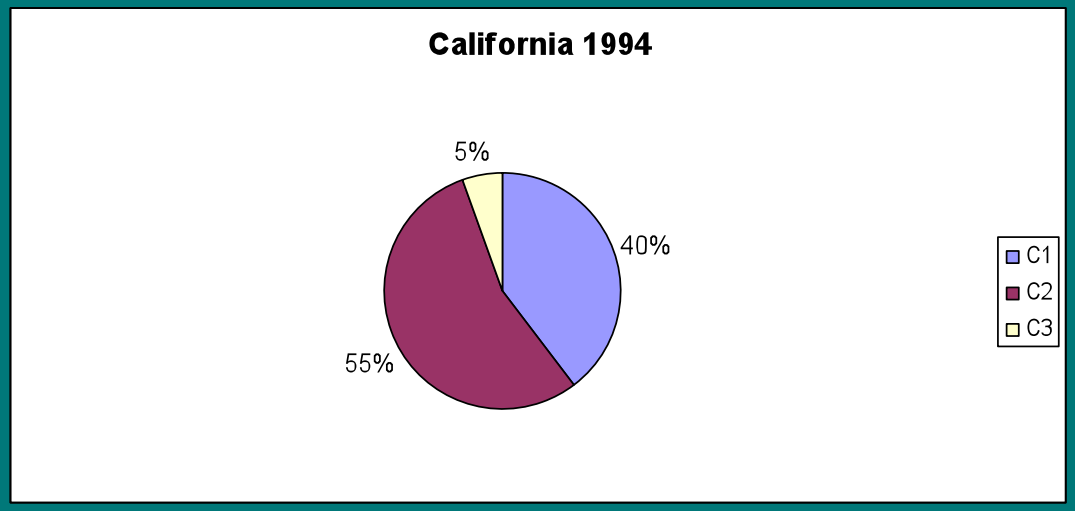
2004-2005:

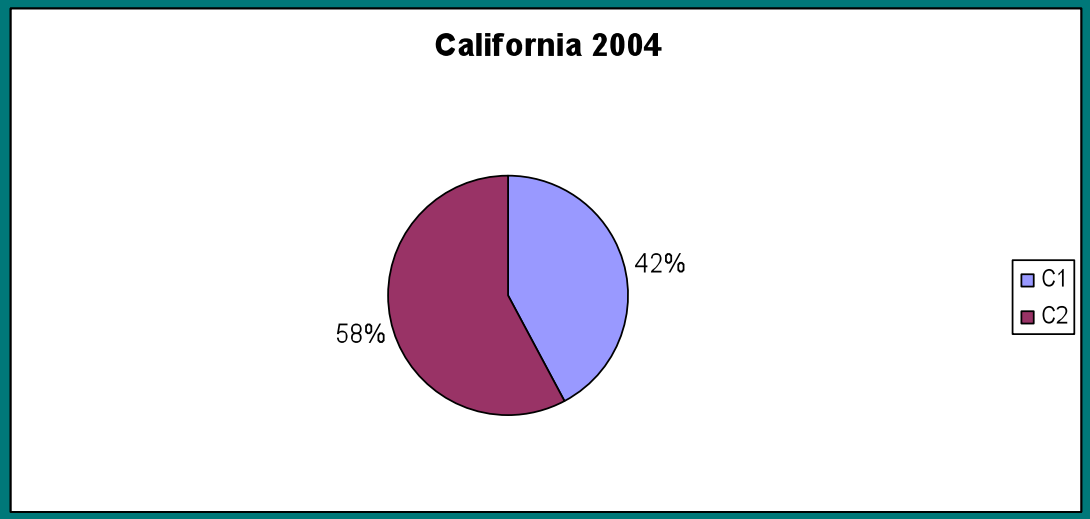
- Honey bees collected from 358 queen mother colonies (from 34 commercial queen producers from the western and southern regions)

Commercial queen production numbers



MtDNA haplotypes -western population 1994, 2004





Microsatellite results: California

1994: 128 different alleles were detected in 10 loci

2004: 92 of the alleles found in the 1994 queen breeding population were still present in 2004, a loss of 36 alleles

- The loss of alleles was highly significant (p-value = .004)

- The loss of existing alleles over the ten year sample period was possibly due to genetic drift/population bottlenecks caused by *Varroa destructor* and breeding practices

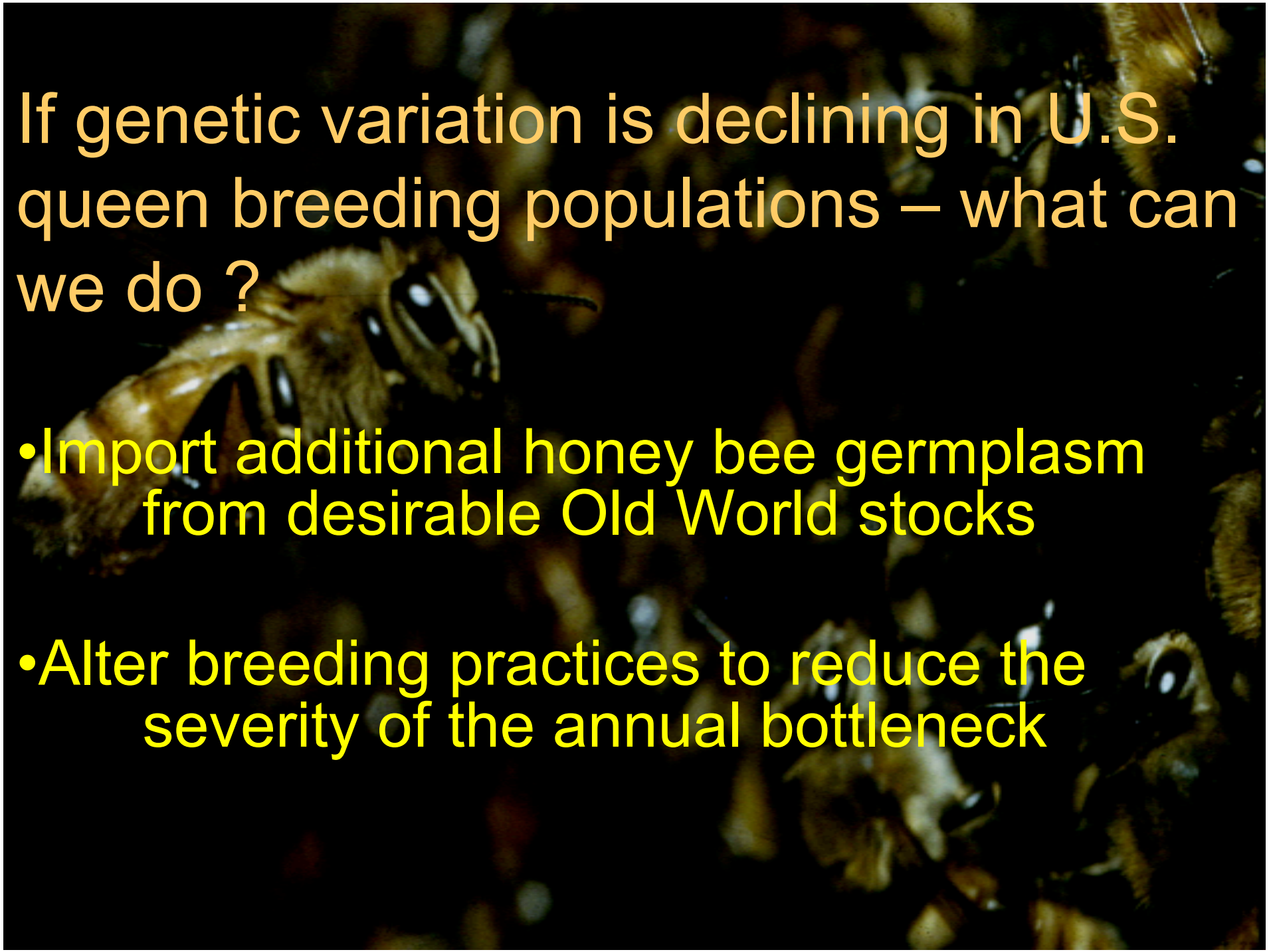
23 previously undetected alleles were also found in the 2004 California breeding population

- The gain of 23 “new” alleles in the western managed population over the decade could reflect contributions from new introductions of Russian or Carniolan strains, from Africanized honey bees or from genetic material moved in from the southern queen breeding region

- Reference populations are being analyzed to uncover the possible sources of the new alleles found in the western queen breeding population

- Data from the 1993 and 2005 southern queen breeding region and the 1992 feral population are now being analyzed

Quantification of the genetic diversity in U.S. honey bee populations can provide a scientific basis from which to consider additional honey bee importations



If genetic variation is declining in U.S. queen breeding populations – what can we do ?

- Import additional honey bee germplasm from desirable Old World stocks
- Alter breeding practices to reduce the severity of the annual bottleneck

Thanks are due to:

USDA-IFAFS, USDA-SARE, CMYK Foundation, WSBA, numerous undergraduate student helpers