Hybridized Honey Bees: A problem for North Carolina?

(revised for BIO 181 labs October 2023)

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The Concern

Spread of Honey Bees into North America → NC?

Why is this a Problem?

Crop pollination

- Beehives are often contracted to be placed temporarily into fields and orchards to help pollinate crops.
- Over 100 different crops reply on honey bee pollination, accounting for $20 billion per year in added agricultural produce.
- African Honey Bees (AHB) are much less amenable to transport and movement in agricultural contexts.

Bees in North America

- The US has over 4000 species of native bees (over 500 in NC), but they are not suitable for large scale managed agriculture.

- European settlers introduced European Honey Bees (EHB), *Apis mellifera,* to North America in the 1600s for honey.

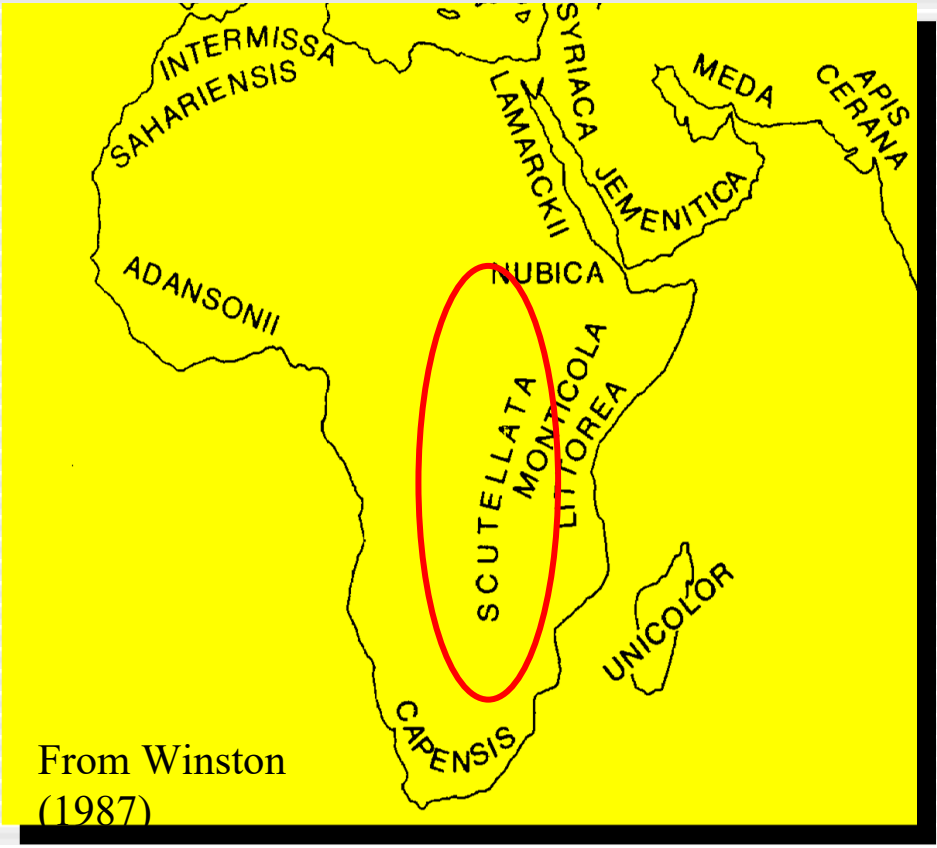
European Subspecies

- *Apis m. mellifera*
- *Apis m. ligustica*
- *Apis m. carnica*
- *Apis m. caucisica*

History of African Honey Bees in the New World

- The African Honey Bee (AHB) subspecies, *Apis mellifera scutellate*, evolved in sub-Saharan Africa. They are adapted to tropical habitats.

- They were imported to Brazil to improve honey production and the apiculture industry in that warmer more tropical environment.

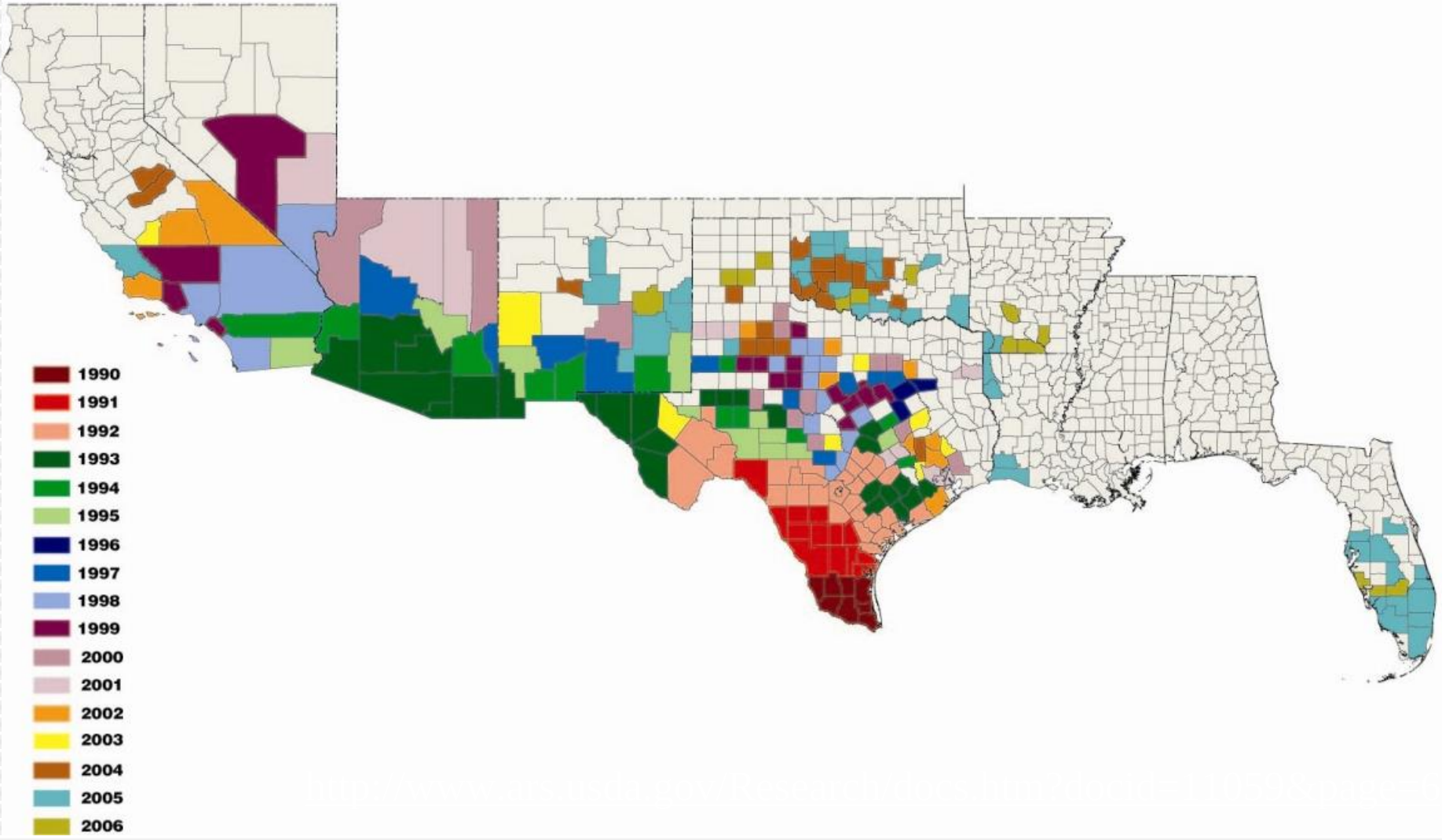


History of African Bees in the New World

- Introductions of *AHB* into Brazil began in 1956. Within 50 years, this tropically adapted subspeices colonized most of South America and all of Central America.
- AHB entered the U.S. in 1990 through south Texas and is now permanently established throughout the southwestern states and southern California.
- Throughout its range in the New World, the AHB shows a remarkable ability to displace resident EHB colonies.

Spread of Hybridized Honey Bees by Year, by County Updated 2007

First found in southern Texas in 1990, Africanized honey bees are now found in much of the South.



Some terminology

- European honey bees (EHB)
  - Behaviorally acceptable stock
- Hybridized honey bees (AfHB)
  - Genetic hybrids
    - European queens mated with African drones
- African honey bees (AHB)
  - African queens mated with African drones

Hybridized honey bees

European honey bees

An AHB worker (left) and EHB worker (right). African and European bees look virtually identical, although African workers and queens develop faster in the larval stage. AHBs sometimes have a darker color than EHBs, but color is too variable in both subspecies to be used as a reliable identification mechanism. The two subspecies differ more in how they behave rather than how they look.

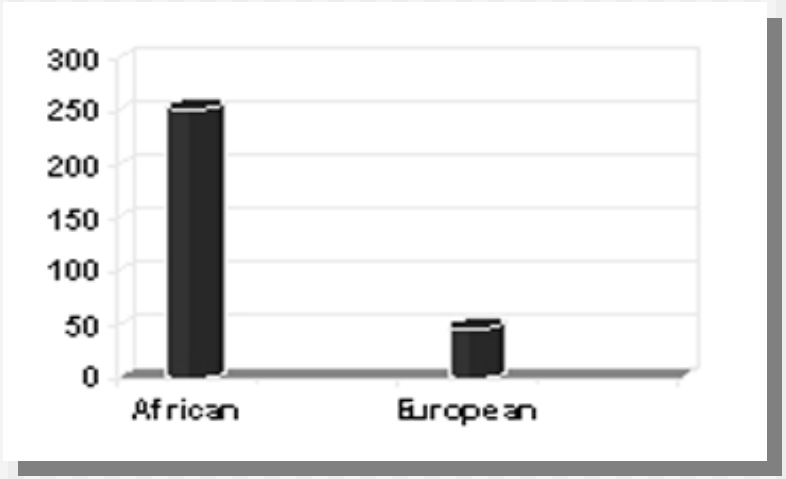
Characteristics of EHBs

- Low level of defensive behaviors.
- Adapted to put more energy into honey production and exhibit less swarming.
- Amass large stores of honey to survive cold winters when few/no flowers in bloom.
- Most behavioral and morphological genes are recessive.

Characteristics of AfHBs & AHBs

- High level of defensive behavior for hive protection.
- Limited stored honey.
- Adapted to put more energy into reproduction, quicker development, and more swarming.
- Low effort to amass honey to survive cold winters. Not an issue for tropical areas.
- Most behavioral and morphological genes are dominant.

Defensive behavior



The African honey bees (AHB), are well known for its high degree of nest defense (left). On the right are data comparing the number of bees captured while defending their colony in the first 30 seconds after a disturbance. About 5 times more African bees leave the colony than European bees in the same time interval. AHB workers also produce more alarm pheromone than EHB workers, which excites other workers to sting, and further contributes to greater colony defensiveness.

AHB - This is what 500 stings per minute can look like…

Nesting Behavior

AHB Hives

- Tend to build smaller and/or exposed-comb nests. Less honey stored. 2X-4X More comb for reproduction.
- More apt to abandon nest when conditions are poor.

EHB Hives

- Tend to have larger well insulated nests with excess honey stored for winter survival.

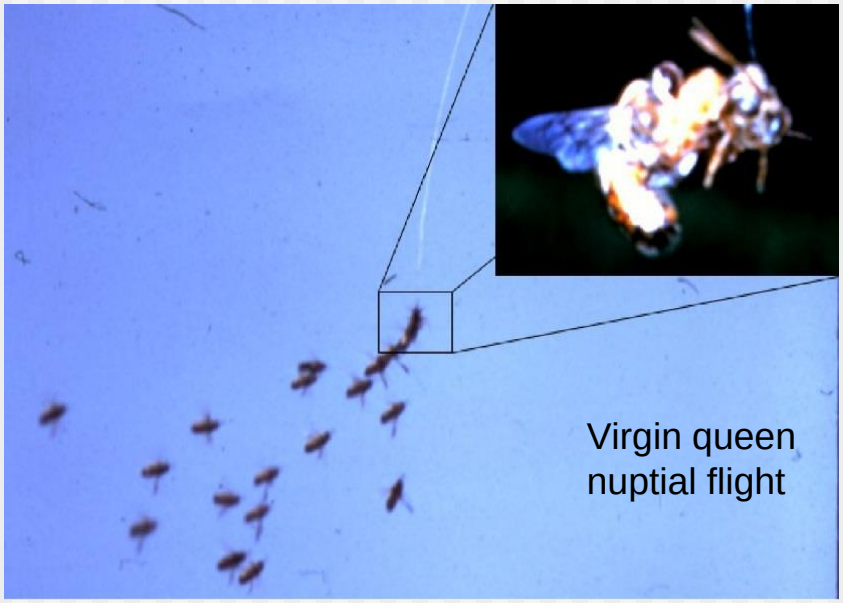
Reproduction & Swarming

AHB Hives

- Faster colony growth.
- Produce more drones (males). Develop same rate. Creates mating advantage by #s.
- Queens and workers develop 1-2 days *faster*.
- Hives swarm 10^{+}X a year.

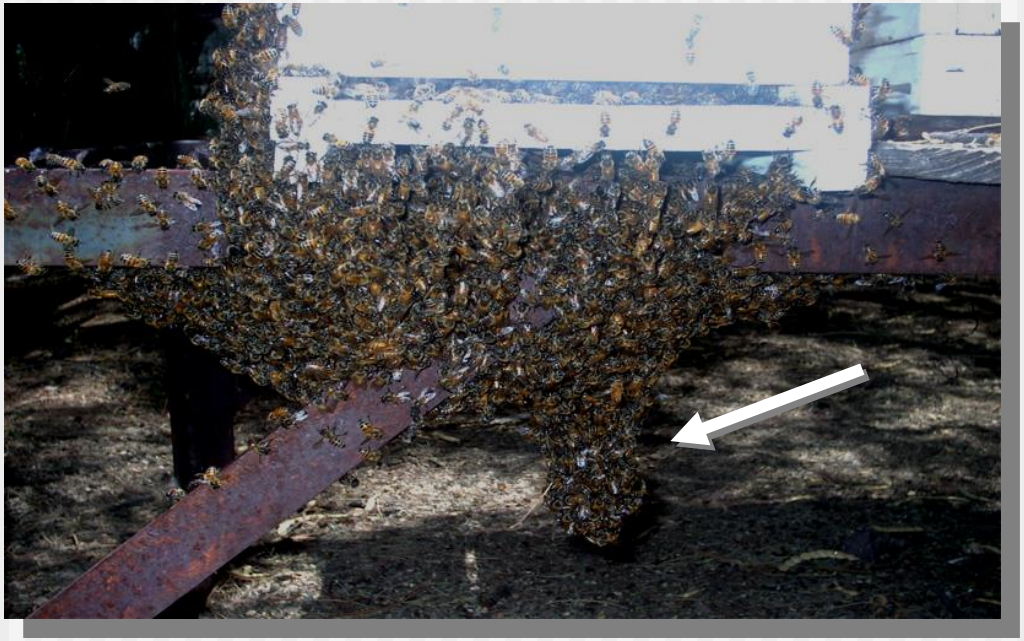
EHB Hives

- Queens develop in 16 days.
- Workers develop in 19-20 days.
- Hives swarms 1-3X a year.



Nest usurpation

An AHB usurpation swarm actively invading a EHB colony. The arrow is pointing to a ball of African bees that are surrounding and protecting the queen.



Parasitic swarms

An African swarm usurping a European colony. Usurpation swarms are small reproductive or absconding swarms that invade an EHB nest, replace the European queen, and take over the colony. Queenless EHB colonies and those with a caged queen are particularly susceptible to usurpation. In southern Arizona, annual usurpation rates can reach 20-30%, suggesting that usurpation is an important factors in the displacement of European in parts of the southwestern U.S. In southern Arizona, peak usurpation activity occurs from October – December, which corresponds to the absconding season for African bees in the Tucson basin.

Queen advantages

A virgin queen (VQ) emerging from a queen cell. AHB-patriline VQs develop faster and emerge sooner than EHB-patriline VQs. This may give AHB queens more opportunities to kill their un-emerged rivals and become the new laying queen of their colony, thereby contributing to the loss of EHB traits.

Queen advantages (cont.)

Two virgin queens fighting to the death. When AHB and EHB-paternity VQs are present in the same colony, the AHB kill more of their rivals and produce more bouts of “piping” (a sound signal that may promote fighting success). AHB VQs also receive more “vibration signals”. Queens can be vibrated hundreds of times an hour, and VQs that receive more signals survive longer and kill more rivals. In combination, the greater fighting ability, piping activity, and vibration signals received results in AHB-paternity queens winning the rival elimination process and becoming the new laying queens of their colonies. This, in turn, results in the rapid loss of EHB characteristics.

Genetic influence

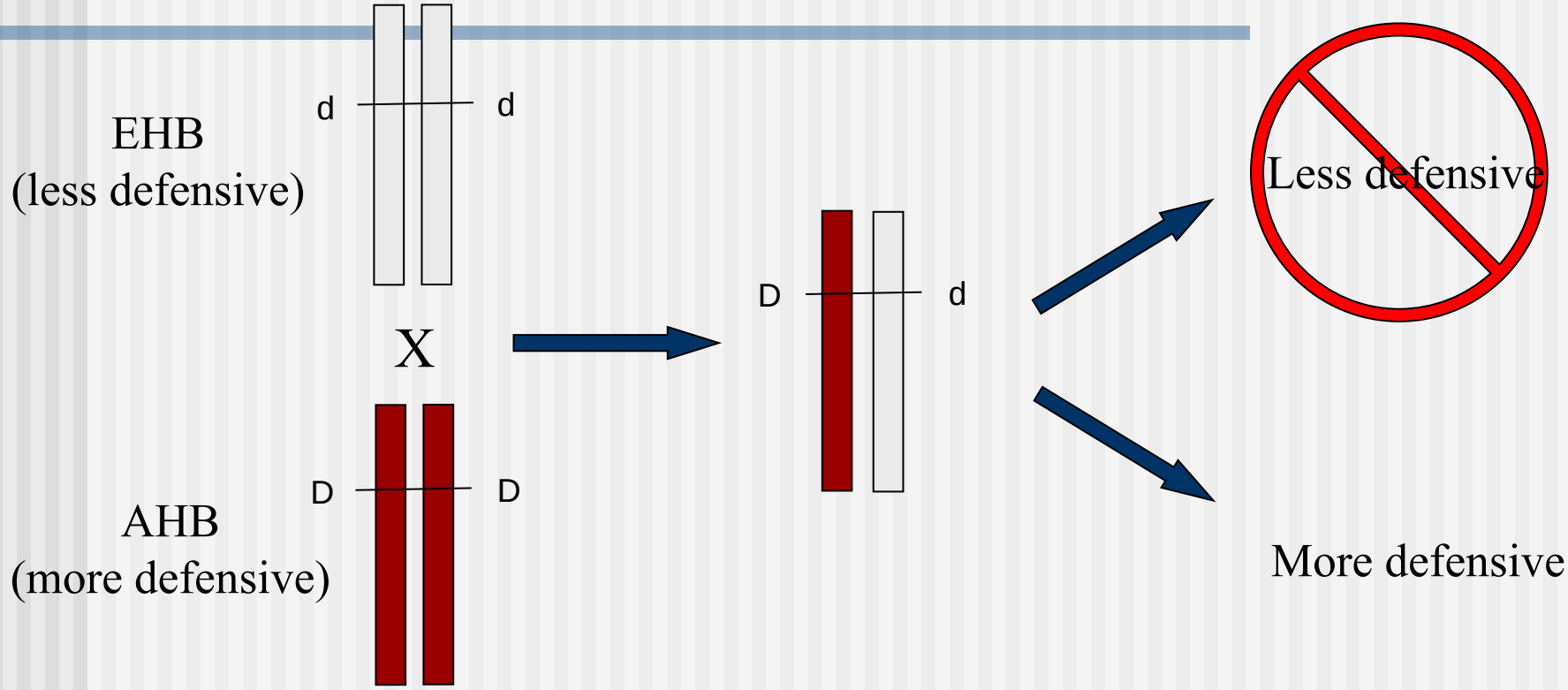
AHB/AfHB Hives

- Can usurp EHB hives and become ecologically and genetically dominant.
- AHB behavioral traits are dominant and are exhibited in fully AHB or in hydrid honey bees (AHB X EHB parents).

EHB Hives

- Hives can be taken over by AHB bees – directly (usurpation) or through mating.
- EHB behavioral traits are recessive and only maintained through EHB x EHB mating.

Genetic dominance



For many genes, such as those for defensive behavior and size, the African genotype is dominant to the European genotype. As a result, hybrid (heterozygotes - individuals with one allele of each type) behave more like their African parent than their European parent.

Negative heterosis

Hybridized (AfHB) worker, drone, and queen honey bees (left to right). AfHB workers and queens have lower metabolic rates than AHB. Also, the left and right forewings of EHB/AHB hybrid workers are less symmetrical than the wings of African workers. This may further reflect incompatibilities between African and European genes that negatively affect larval development. In combination, the physiological and developmental differences might make hybrid bees less competitive and less efficient at foraging, swarming, and mating. As a result, hybrid colonies may not survive well in the wild, which would contribute to the loss of European traits.

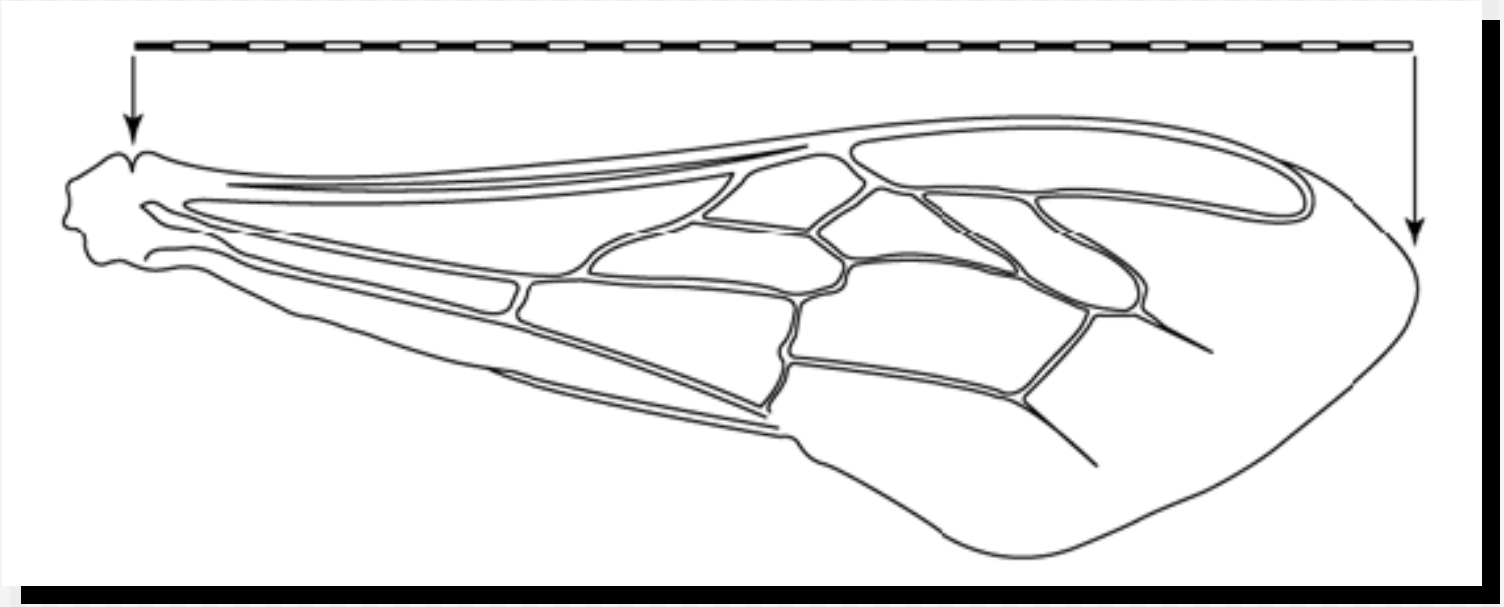
AHB identification

- Two methods used by scientists and officials to distinguish African from European honey bees.
- We will use both methods in lab this week to ID unknown bees.

Morphometrics

Carefully measuring different body parts to distinguish AHB from EHB, since African bees are slightly smaller, on average.

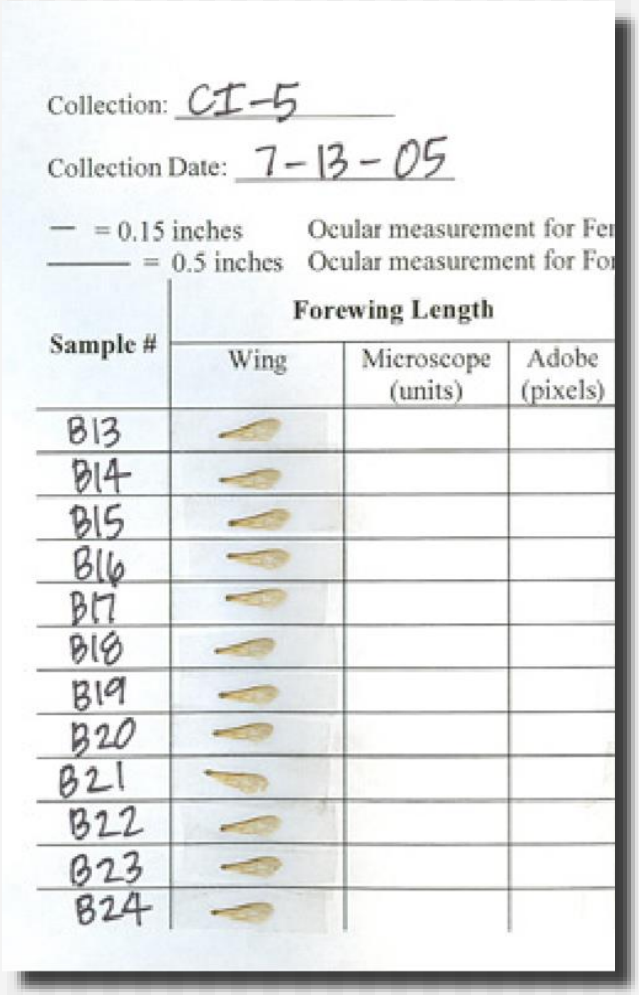
Measurements



- The FABIS method (Fast African Bee Identification System) measures wing lengths of a sample of bees
- The full USDA-ID method measures 23 separate characters and analyzes with principle component analysis

Results from recent survey

A recent survey of bees collected in North Carolina found that two of 19 unknown samples were possible AHB hybrids, and a third sample may have been positively identified as AHB.



Collection: CI-5

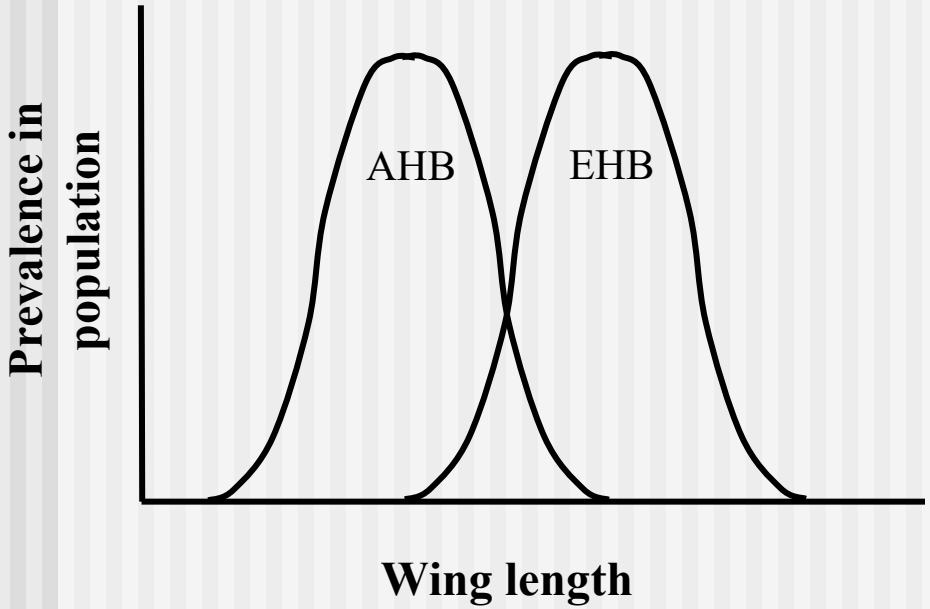
Collection Date: 7-13-05

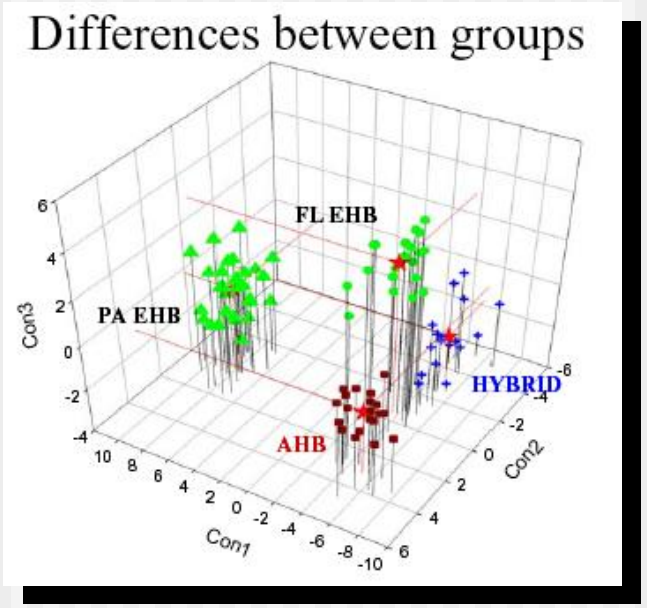
— = 0.15 inches Ocular measurement for Fer

——— = 0.5 inches Ocular measurement for For

Sample #	Forewing Length		
	Wing	Microscope (units)	Adobe (pixels)
B13			
B14			
B15			
B16			
B17			
B18			
B19			
B20			
B21			
B22			
B23			
B24			

Analysis





There is much overlap between the AHB and EHB populations, particularly in hybrid zones, making it difficult to readily diagnose a particular sample.

Morphometrics (overview)

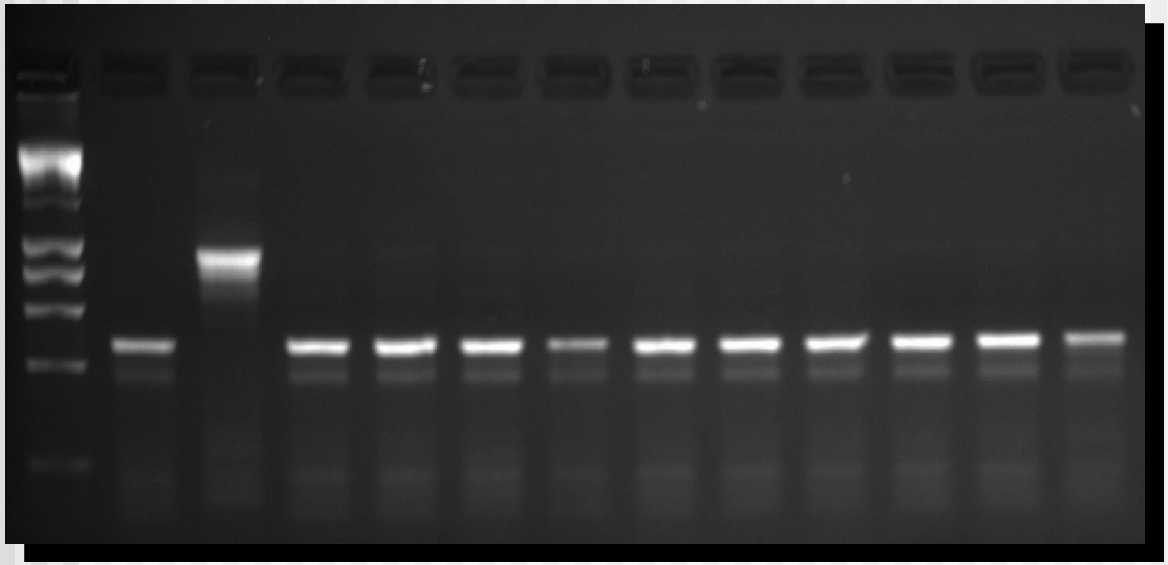
Merits

- Inexpensive
- Measures quantitative traits (with maternal and paternal affects)

Limitations

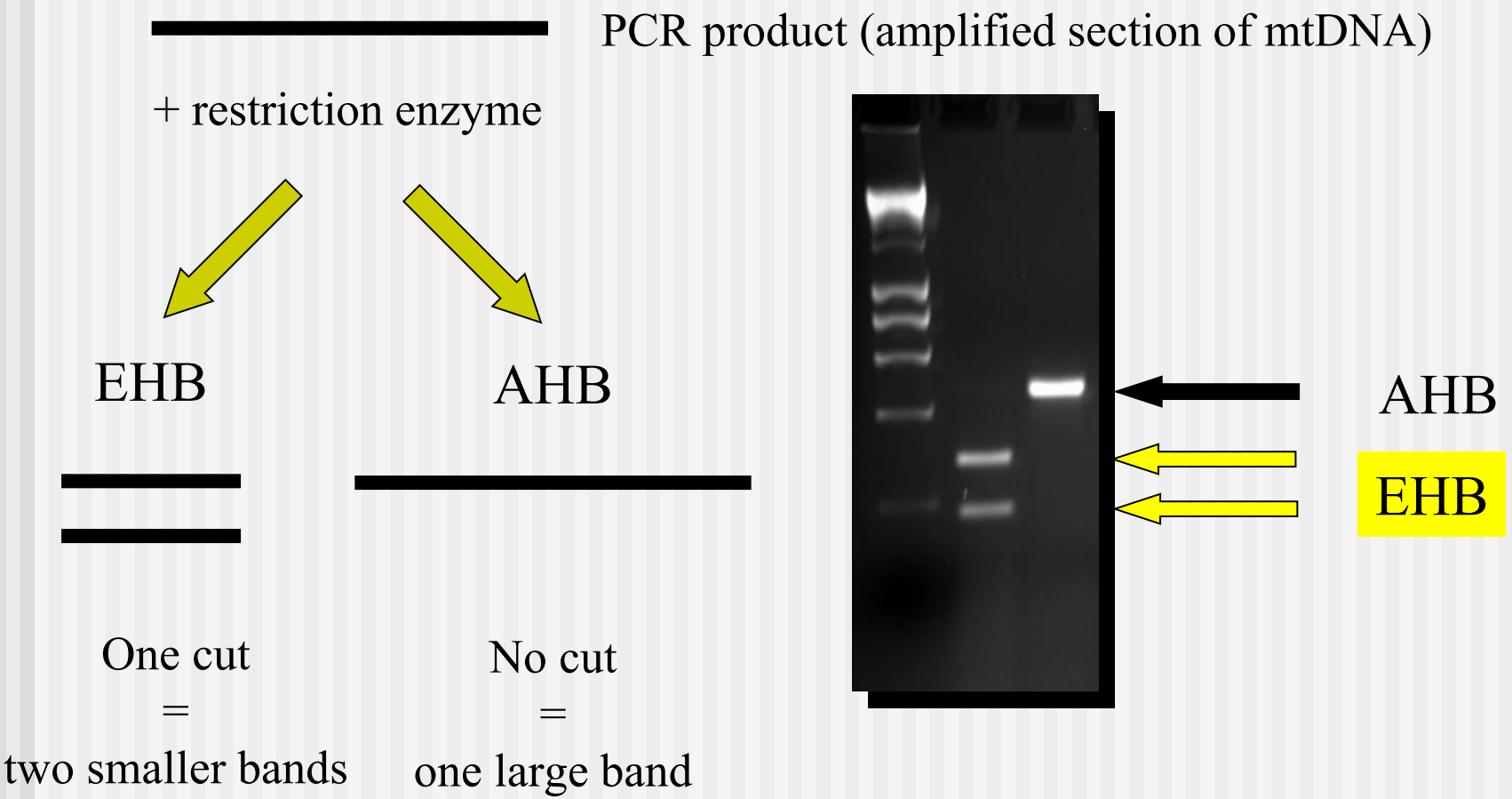
- Need large samples to minimize sampling error
- Time consuming
- Provides only probabilistic results of AHB vs. EHB
- FABIS alone is inaccurate in hybrid zones

Genetic analyses



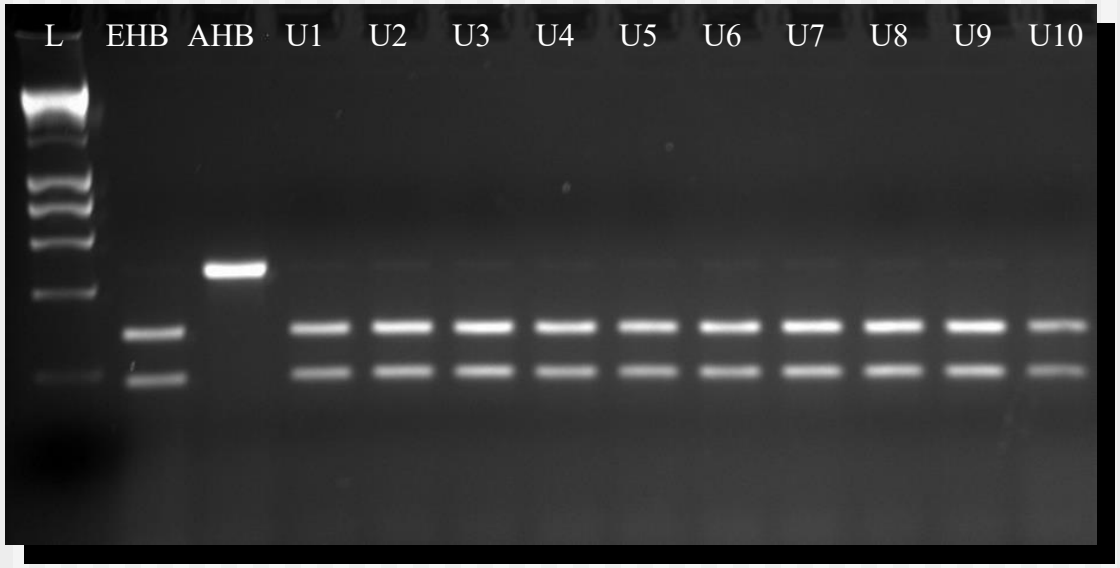
Mitotyping (left) analyzes maternally inherited genetic markers to determine the mother's lineage as either European or African. Other (more expensive) tests can also determine paternity.

Measurements



Results from recent survey

A recent survey found that all samples collected in NC were shown to be of European origin (*including* those which were possible AHB as determined by FABIS analysis). **Thus, there is no evidence that the AHB is in NC at this time.**



Mitotyping (overview)

Merits

- Precise answer (AHB vs. EHB queen/mother)
- Rapid analysis
- Does not require large sample size

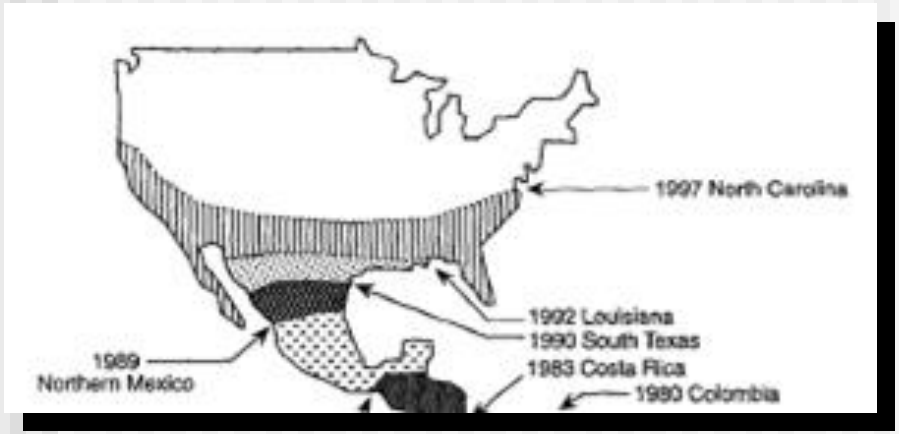
Limitations

- Expensive and equipment is not readily available
- Determines only maternal lineage (thus cannot distinguish hybrids)

Will they ever get to NC?!

It is not a questions of whether or not the AHB will be introduced to NC, as they almost certainly will be, but a question of whether they will become permanently established.

Predicted distribution



From Winston (1992)

Early predictions were based largely on temperature gradients and the distribution of *A. m. scutellata* in its native Africa. A common assumption is that the AHB cannot survive a prolonged winter, which will slow or prevent its movement into northern states. However, we now know that feral AHB populations are established in areas above 5,000 ft in Arizona and New Mexico and can survive through the winter. Thus, at this point, we do not know the extent to which the AHB will spread in the U.S. or how quickly the invasion process will proceed.

An important distinction…

Method of movement #1:
natural dispersal

An established, permanent feral population of AHB

Method of movement #2:
human-assisted transport

Point introductions but *not* an established population

Ultimate distribution

We cannot predict in which regions the AHB will become permanently established or be a “seasonal visitor,” in which colonies may migrate in during spring and summer but die out during the winter. The ultimate distribution of the African bee in the U.S. will depend on a combination of its inherent ability to spread and survive in new areas and human assisted movements that might transport the bee past barriers that otherwise would halt its progression.

What can be done to protect honey bee crop pollination?

Beekeepers should be vigilant

- **Mark** all queens; no exceptions.
- Regularly check hives for unusual external clumping of bees, as these may be parasitic AHB swarms.
- **Requeen** any colony that is unacceptably defensive or contains an unmarked queen; use only queens from a known EHB source.
- **Inspect hives** for behavioral signs of AHB, particularly after they are transported in and out of known AHB areas.
- **Send suspect samples** to authorities for morphometric or genetic testing; place 30 to 50 adult bees in a small container, fill with enough 70% ethyl alcohol to cover the bees, and label with contact information, collection date, and location.
- In a hydridized area, attempt to make all potential AHB nesting sites “bee tight”; avoid storing empty beehives outdoors.

Be proactive

- Emphasize that beekeepers are on the front lines of defense—**beekeepers are part of the solution**, not the problem.
- **Be a good neighbor** and inform anyone who may be in close proximity to your hives; educating them about the benefits of honey bees and the relative risks of AHB should lessen their fears.
- Establish and **maintain lines of communication** between local beekeepers, first responders, and local officials.
- **Education** - Make people aware of the distinction between **yellow jackets and bees**, as many people mistake wasps for honey bees. Increased public awareness of the different types of stinging insects will reduce the number of erroneous AHB reports.

Presentation revised for use in BIO 181 laboratory course October 2023

http://entomology.ncsu.edu/apiculture