Bee Health in North America
Understanding Colony Decline

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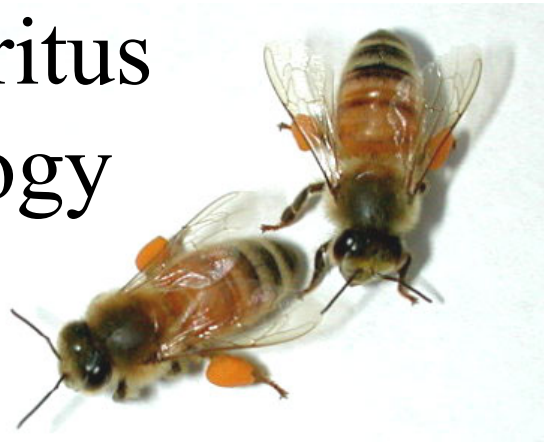

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There are approximately 3500 species of bees in North America (Tripplehorn and Johnson. 2005)

Osmia sp.
mason bee

Andrena sp.
mining bee

Halictid family
sweat bee

Bombus griseocollis
bumble bee queen

Xylocopa virginica
carpenter bee

Peponapis pruinosa
squash bee

Non-*Apis* Bees as Pollinators

- Many species of non-Apis bees are important contributors to the crop pollination
- Increased interest in the management and utilization of non-*Apis* bees for crop pollination
- Need to protect these pollinators through increased conservation efforts and careful pesticide use

Apple Caneberry Cucurbits

Percentages of honey bees ( ) and non-*Apis* ( ) bees visiting crop flowers.

Adamson, Roulston, Fell & Mullins. 2012. Environ Ent 41:813-821

Value of Bee Pollination

- Worldwide basis - the value of pollination is estimated at $225 billion per year (Gallai et al. 2009)
  - ✓ 87 of the leading global food crops are dependent on pollinators
- In the U.S. the estimated benefits of honey bees to agricultural crop pollination: $15 billion per year
- In U.S. 2 - 2.5 million honey bee hives are rented annually for the pollination of crops

Current Status of Honey Bees

- Honey bee populations have declined significantly in the U.S. in last 60 years
- In Virginia the number of managed colonies is down over 50% since the mid 1980's
- Current annual losses of managed hives average 30% in Virginia

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U.S. losing bees and beekeepers

Updated 4/9/2008 11:14 AM | Comments 8 | Recommend 8

Enlarge By Kalim A. Bhatti, USA TODAY

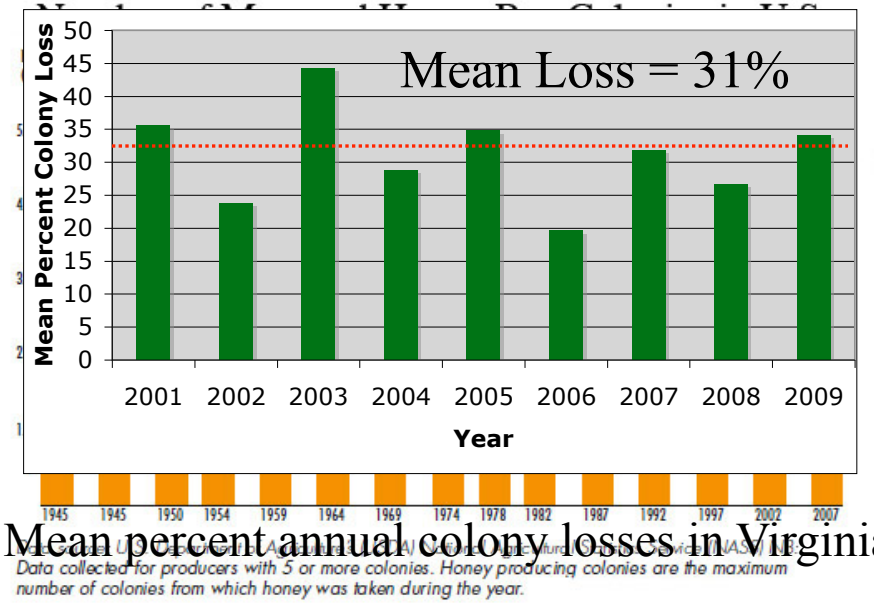
Beekeeper David Hackenberg works on his hive in Lewisburg, Pa., April 29, 2007. Hackenberg has lost nearly $400,000 from the mysterious bee deaths across the country.

By Heather Collura, Special for USA TODAY

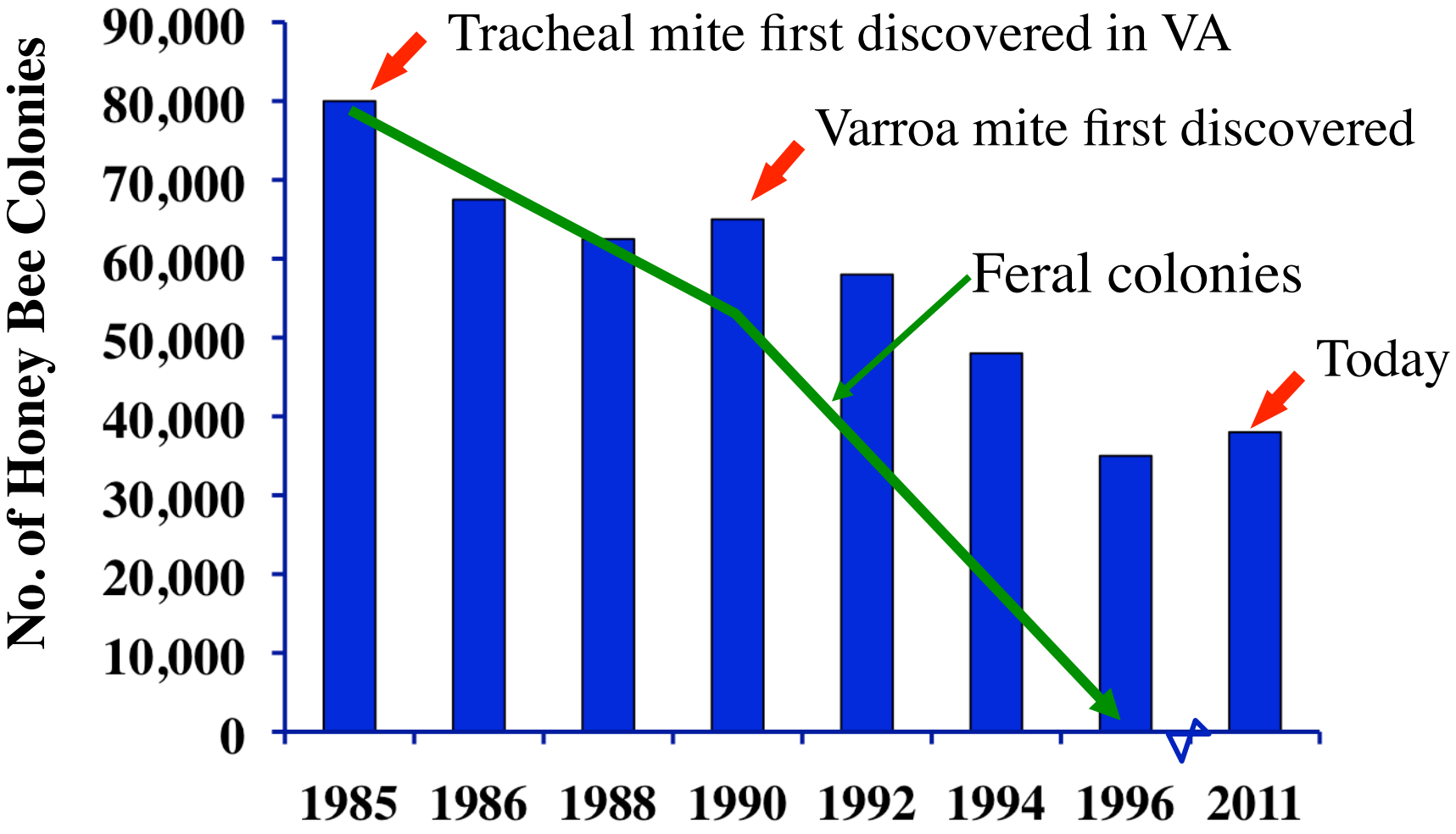
The number of bees is on the decline across the USA, and there's also a shortage of beekeepers.

The number of commercial beekeepers is dwindling because the business of keeping bees is not as profitable as it once was, according to Jeff Pettis, research leader at the U.S. Department of Agriculture Bee Research Laboratory in Maryland.

That decline in profitability is due in large part, Pettis said, to lower honey prices — the average U.S. price per pound dropped four-tenths of a cent over the past year. Keepers also face difficulty in keeping healthy bees



Mean percent annual colony losses in Virginia



Estimated Number of Honey Bee Colonies in Virginia

Causes of Colony Loss

- Large declines starting in 1980s due to parasitic mite introduction
- Recent declines attributed to Colony Collapse Disorder (CCD)
  - ✓ CCD involves rapid loss of adult bee population, leading to colony death
- In Virginia, most colony losses occur during the winter
  - ✓ Some losses exhibit symptoms of CCD, but colony health is a significant factor
  - ✓ Impact of pesticides and pesticide residues are largely unknown

Effects of the *Varroa* Mite on Honey Bees

- Feeding of the mites causes damage to the developing bees:
  - ✓ feeding damages tissue, can shorten bee's life span
  - ✓ mites vector virus to pupae, DWV (deformed wing virus)
- Mite feeding has been associated with an increased incidence of viral diseases in adults (chronic and acute bee paralysis, IAPV)
- Varroa mites increase stress on colonies, suppress bee's immune system, and increase susceptibility to other diseases such as Nosema
- Major factor in increased winter losses
- Control of varroa mites has been a major concern

Colony Collapse Disorder (CCD)

- Sudden loss of a colony's population of adult bees leading to colony death
- Disorder is characterized by:
  - ✓ An absence of adult bees in colonies with few dead bees, if any, in the hive or in front of the hive
  - ✓ Frequent presence of capped brood in colonies
  - ✓ Presence of food reserves (honey, pollen) that had not been robbed out, and hives not attacked by pests such as wax moths
  - ✓ In colonies that still have bees, characterized by small clusters with a laying queen, not responsive to stimulative feeding

Colony Collapse Disorder

Photographs from a collapsing colony in Georgia. Large amounts of brood but few adults. (photos from Jeff Pettis, USDA)

Colony Collapse vs. Winter Loss

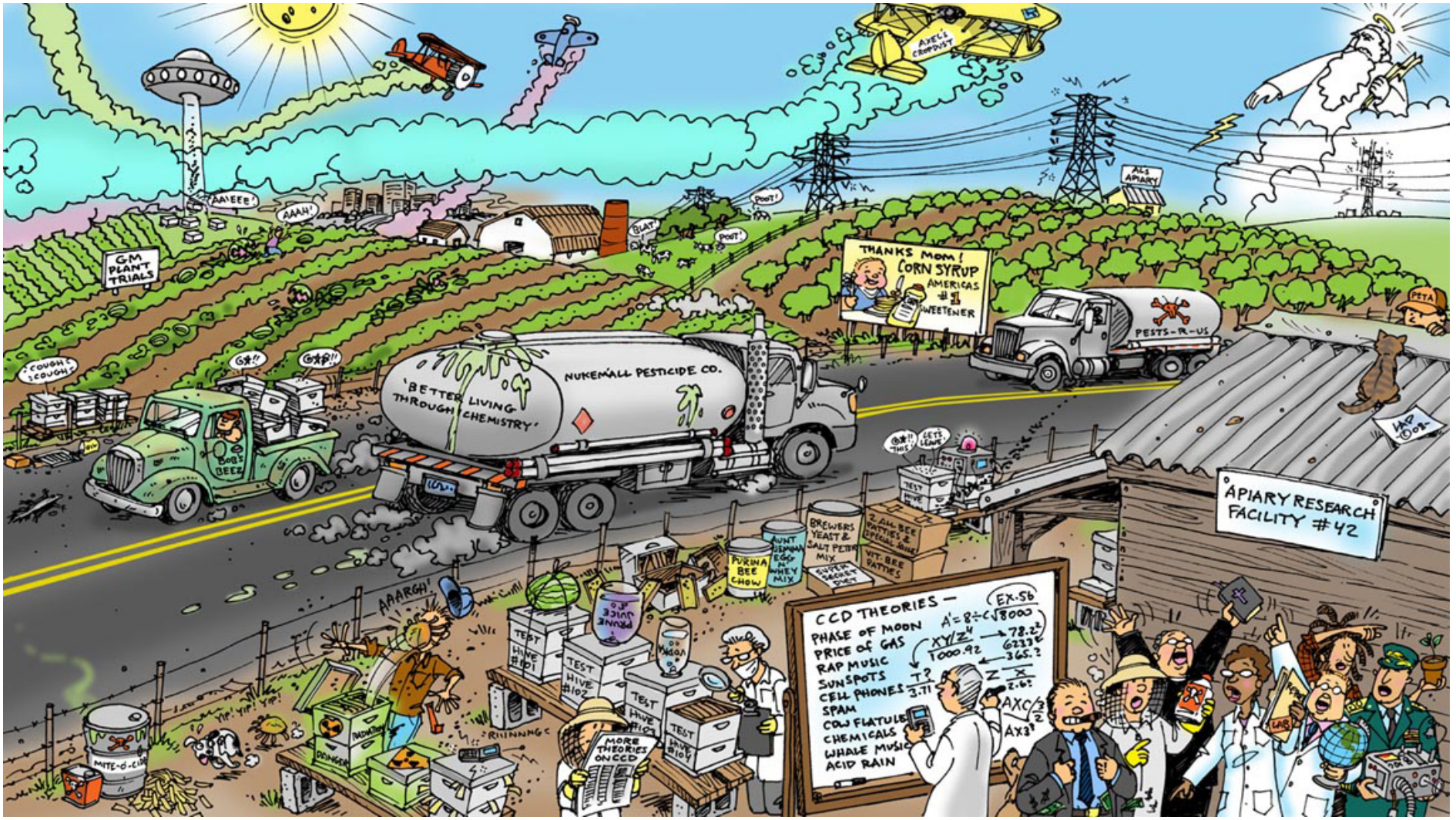
CCD is characterized by an absence of bees, the presence of food reserves, and often capped brood.

Typical winter loss - lack of food, plus presence of dead bees

CCD - A New or Old Problem?

- Similar symptoms reported as early as 1890's:
  Disappearing Disease, first reported in 1915
  - ✓ Large losses of adult bees with no accumulation of dead bees in the hive or at the entrance
  - ✓ Queens were generally the last to be affected
  - ✓ Pollen and honey stores were normal and often abundant in dead hives
  - ✓ No single pathogen was ever identified or associated with the disorder

Causes of Honey Bee Colony Decline



Where Do We Stand On CCD and Colony Decline?

- No specific cause has been identified
  - ✓ No environmental agents or chemicals stand out as being causative agents
- Possible causes of colony decline
  - ✓ Chemical (pesticide) residues/contamination
  - ✓ Parasite loads (especially Varroa)
  - ✓ Pathogens of bees or brood: viruses (ABPV, KBV, IAPV, BQCV, DWV, SBV), *Nosema ceranae*, Idiopathic brood disease syndrome
  - ✓ Queen failure (relative risk colony mortality increases)
  - ✓ Colony stress (compromises immune system, may disrupt social system) - possible causes include poor nutrition, movement (migratory stress), environmental factors (drought, cold temperatures), pesticides

Pesticides and Bees

THE ASSOCIATED PRESS March 21, 2012, 8:45PM ET

Beekeepers ask EPA to ban pesticide, protect bees

By GOSIA WOZNIACKA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THE INDEPENDENT

Plus the award-winning Viewspaper

Poisoned Spring

New kind of pesticide, widely used in UK, may be helping to kill off the world's bees

Is an insecticide made by Bayer killing all of our bees?

Is "Colony Collapse Disorder" just a label for a corporate cover up?

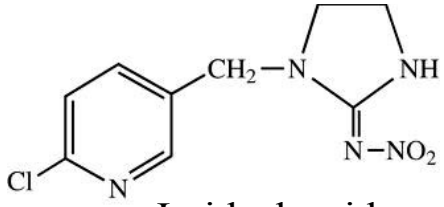
Neonicotinoid Insecticides

Save the Bees — Ban Neonicotinoid Pesticides

4/13/2012 2:12:41 PM

By Cheryl Long

Neonicotinoid Insecticides



Imidacloprid

- Relatively new class of insecticides which act on postsynaptic nicotinic acetylcholine receptors
  - ✓ Mode of action based on nicotine, act on CNS of insects
  - ✓ Higher toxicity to insects than mammals; specific neuron pathway more abundant in insects
- Major neonicotinoids of concern– imidacloprid, thiamethoxam, clothianidin
  - ✓ Major concerns have been their use as seed treatments (corn, canola, sunflower, soybeans) and the release of contaminated dust during planting

Neonicotinoid "Problems"

- Neonicotinoids are highly toxic to bees and have been blamed as a leading cause of CCD and colony decline
- Neonicotinoids are systemic and can lead to contamination of pollen and nectar
  - ✓ Can lead to residues in the hive in pollen (~3ppb) and wax (0.1 ppb) - levels below acute and chronic toxicity levels
- May be released by guttation in seedlings

Guttation droplets

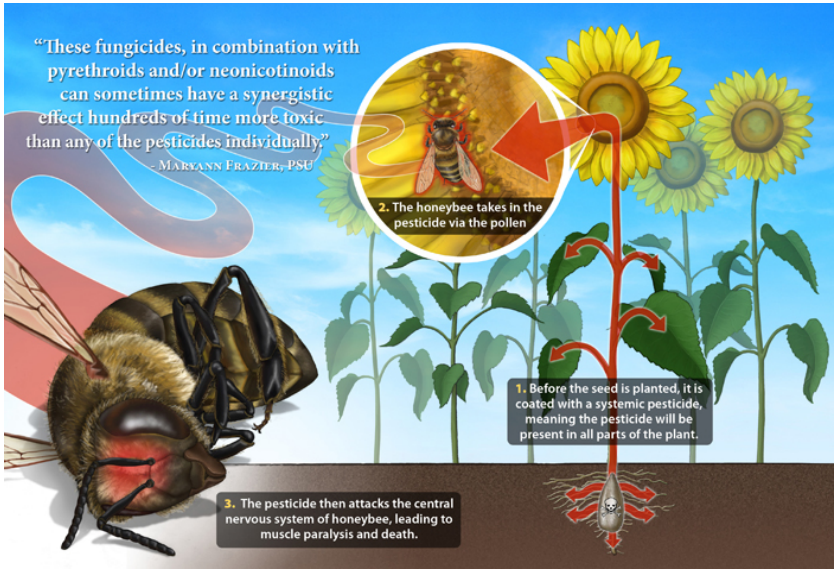
Pollen and nectar collection

Are Neonicotinoids Really the Problem?

- To many beekeepers and popular press – Yes
  - ✓ Use banned in France, Italy and Germany, and for some uses in England.
- Is there evidence for problems – Some
  - ✓ In 2008 - large bee kills in Germany associated with contaminated dust released during the planting of treated corn seed
  - ✓ 2011 bee kills associated with corn planting in Indiana – thiamethoxam and clothianidin detected in planter exhaust materials (talc)

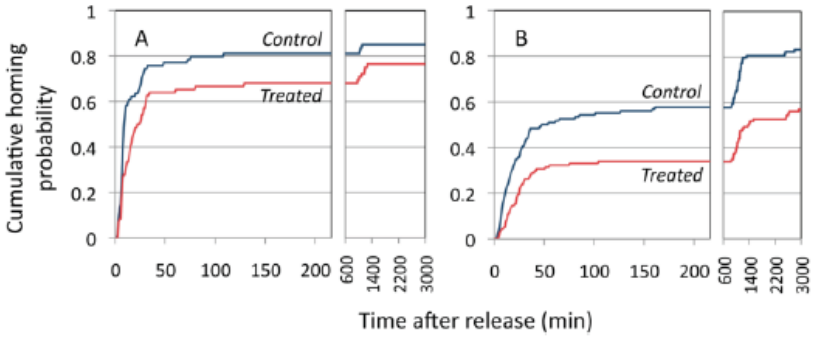
Are Neonicotinoids Really the Problem?

- Does the contamination of nectar/pollen cause problems
- Currently no good evidence for problems
  - ✓ Studies with clothianidin treated Canola seed show no effects on bee mortality, longevity, or brood development
- Other concerns for neonicotinoid toxicity
  - ✓ Synergistic effects
  - ✓ Interactions with pathogens



Field of canola (rape)

Efforts to Link Neonicotinoids to Bee Decline



Homing probability of bees released in A. familiar area B. random area

Importance of using field-realistic doses

Sciencexpress

(March 2012)

A Common Pesticide Decreases Foraging Success and Survival in Honey Bees

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Non-lethal exposure of honey bees to thiamethoxam (neonicotinoid systemic pesticide) causes high mortality due to homing failure at levels that could put a colony at risk of collapse. Simulated exposure events on free-ranging foragers labeled with an RFID tag suggest that homing is impaired by thiamethoxam intoxication. These experiments offer new insights into the consequences of common neonicotinoid pesticides used worldwide.

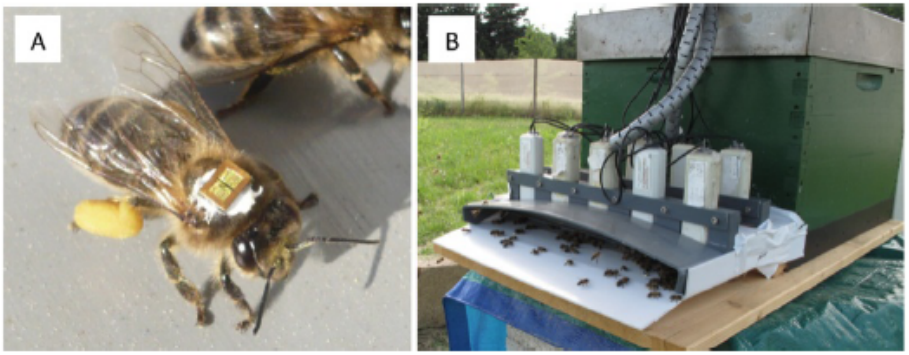


Fig. 1. Honey bee RFID monitoring equipment. (A) A pollen-forager honey bee fitted with a 3-mg RFID tag. (B) A hive entrance equipped with RFID readers for detecting returning marked foragers.

Neonicotinoids and CCD

'There is no link demonstrated between neonicotinoids and the honey bee syndrome known as Colony Collapse Disorder.'

Laboratory studies have shown lethal and sublethal effects on bees; however we do not see high colony losses from the field use of neonicotinoids

Field relevant doses do not appear to affect:

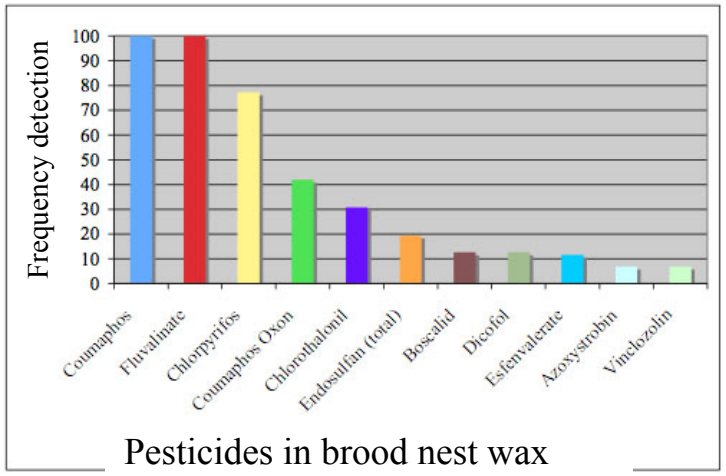
- Learning performance or orientation
- Colony social behavior
- Brood production
- Colony mortality

Residues in Hive Materials

- Chemical analysis of pollen, honey, bees and beeswax has been conducted
  - ✓ 121 different pesticides and metabolites have been found
  - ✓ 92% of bee, pollen and wax samples contained multiple residues of 2 or more pesticides
  - ✓ ~60% of wax and pollen samples contained at least one systemic pesticide residue (most are fungicides)
  - ✓ Average pollen sample contained 7 residues and the average beeswax sample 8 residues
- Neonicotinoid insecticides identified in < 1% of wax samples, and < 3% of pollen samples
- Two most common residues were miticides used by beekeepers

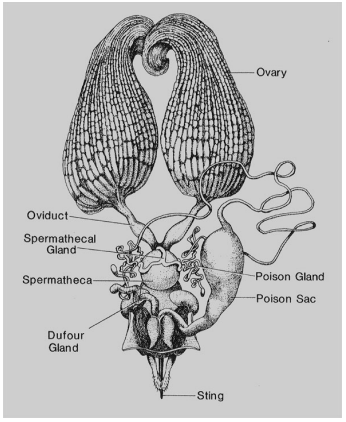
Residues in Hive Materials

- Chemical analysis of beeswax
  - ✓Accumulation of *tau*-fluvalinate, coumaphos in beeswax – 98% of beeswax samples contaminated
    - Mean levels: 7.47 ppm ± .97 ppm
  - ✓Sublethal doses can affect bees - could this be a factor in colony decline?



Miticide Effects on Colony Health

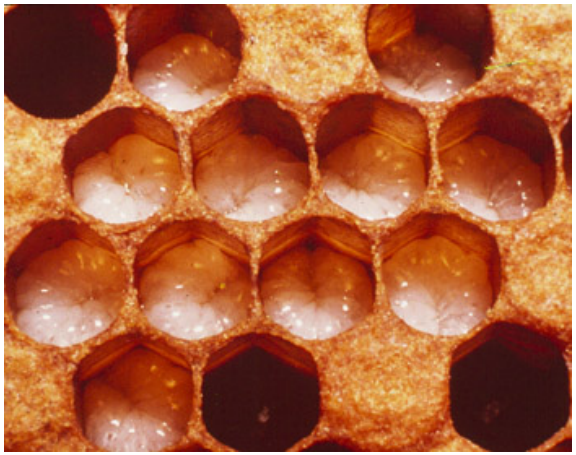
- Decreases drone production
- Inhibits queen rearing, matings unsuccessful
- Reproductive physiology of drones and queens
  - ✓ Reduces sperm production and viability in drones
  - ✓ Causes a loss of sperm viability over time
  - ✓ May affect sperm in the spermatheca of the queen



Burley, Fell & Saacke, 2008. J. Econ Ent 110:1081-1087

Effects of Pesticide Residues in Comb on Colony Health

- Examine sub-lethal effects of pesticide residues in beeswax
  - ✓ Major residues coumaphos and fluvalinate, plus mixture others pesticides
- Pesticide residues in comb
  - ✓ delay larval development and adult emergence
  - ✓ shorten adult longevity
  - ✓ may affect hive labor roles of adults and foraging activity
  - ✓ may affect immune response and disease susceptibility

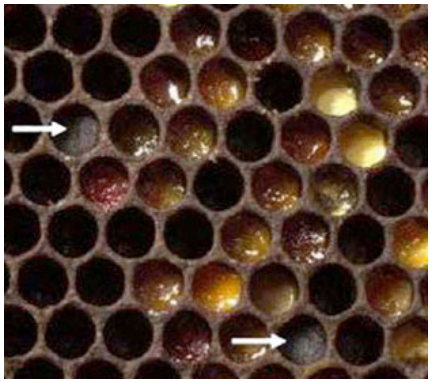


Wu et al. 2011. PLoS One 6(2):e14720

Pesticide Effects on Colony Health

- Fungicides can reduce mycoflora in beebread and may affect natural resistance mechanisms in colony, especially to fungal disease

- Pesticides (including antibiotics) can affect the microbiota of the honey bee, compromising the immune system and overall bee health

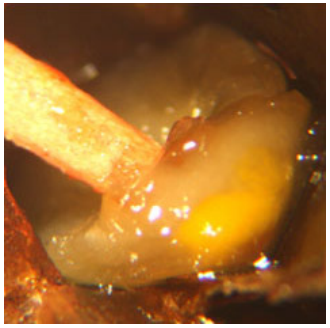


'entombed' pollen

- Pesticide spray adjuvants (such as organosiloxane surfactants) may affect learning and increase bee mortality

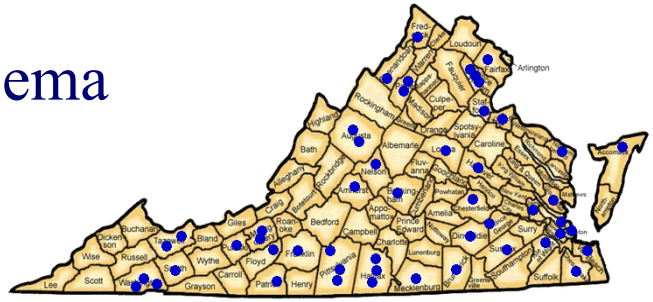
Bee Pathogens and Colony Health

- Honey bee colonies with CCD have higher pathogen levels and are co-infected with a larger number of pathogens than non-CCD colonies
- Israel Acute Paralysis Virus found in 96% of CCD colonies, but other viruses are common (Deformed wing virus, Black queen cell virus, Kashmir bee virus)
- Fungal pathogens *(Nosema spp)* have been reported as a possible cause of colony decline
- Idiopathic brood disease syndrome (IBDS) increases risk of colony mortality by ~ 4X

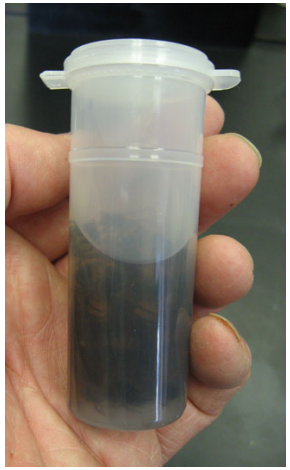


Status of *Nosema* in Virginia

- Conducted a statewide survey in 2009
  - ✓ Goal to determine the prevalence of Nosema and which species were present
  - ✓ Analyzed samples from 305 hives



- Samples were analyzed for *Nosema* using spore counts and a molecular analysis (multiplex real-time PCR)
- Based on molecular analysis 69.3% of hives were infected with *N. ceranae*, but only 2.7% with *N. apis*
- Prevalence and infection levels do not indicate a significant cause of bee decline

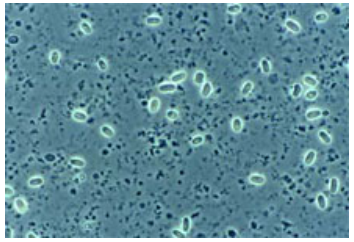


Samples from individual hives

(Traver and Fell. 2011. Jour Invert. Path.)

Pesticide/Pathogen and Pathogen/ Pathogen Interactions

- Pesticide exposure may impact honey bee susceptibility to *Nosema* infection and mortality of infected bees (Alaux et a. 2010, Vidau et al. 2011, Pettis et al. 2012)
  - ✓ Caveat: effects not yet demonstrated in natural colonies
    Pesticides are known to affect the immune systems of insects and could affect the susceptibility of bees to diseases
- *Nosema* has been implicated in synergistic effects with other pathogens (BQCV)
- Varroa mites weaken the immune system of bees and may trigger viral multiplication



Nosema spores

Varroa on pupa

Bee Health and Colony Decline in Context

- Annual colony losses average ~30% in U.S.; approximately 10% of colonies that die have CCD-like symptoms
- Colony mortality is the product of multiple factors and CCD may be the result of multiple stresses
  - ✓ Major mortality factors include starvation, queen failures, parasitic mites, pathogens, nutritional fitness, pesticides
- There is no evidence that specific insecticides like the neonicotinoids have a more significant role in colony decline

Collaborators and Acknowledgements

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