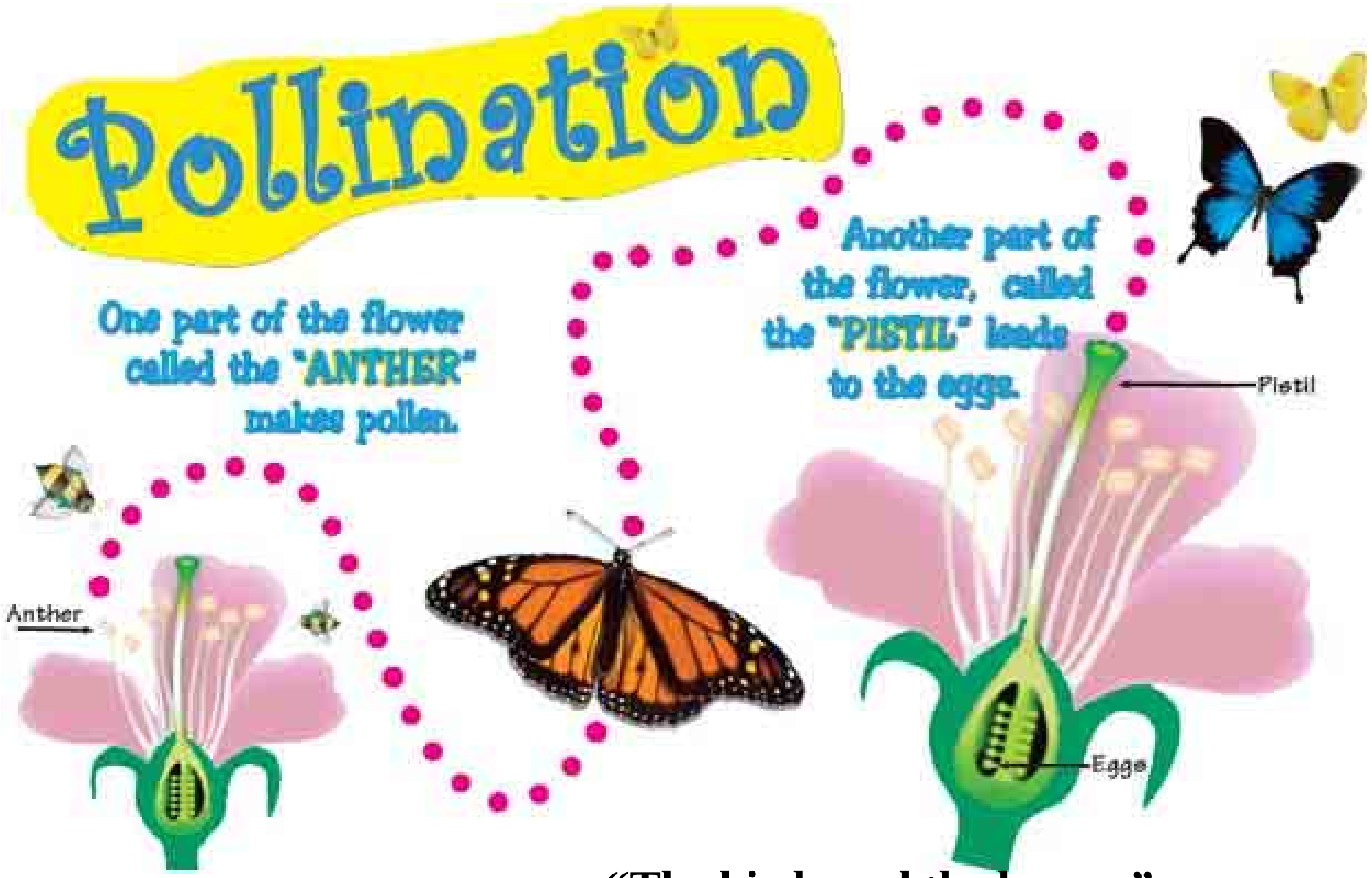
Bees—internationally recognized for their role in pollination…



“The birds and the bees…”

http://kidsgrowingstrong.net/images/pollination2.jpg

Pollination

--the process by which pollen grains, containing male sex cells, are transferred to stigmas, female floral parts, to bring about fertilization, a necessary step in producing seeds

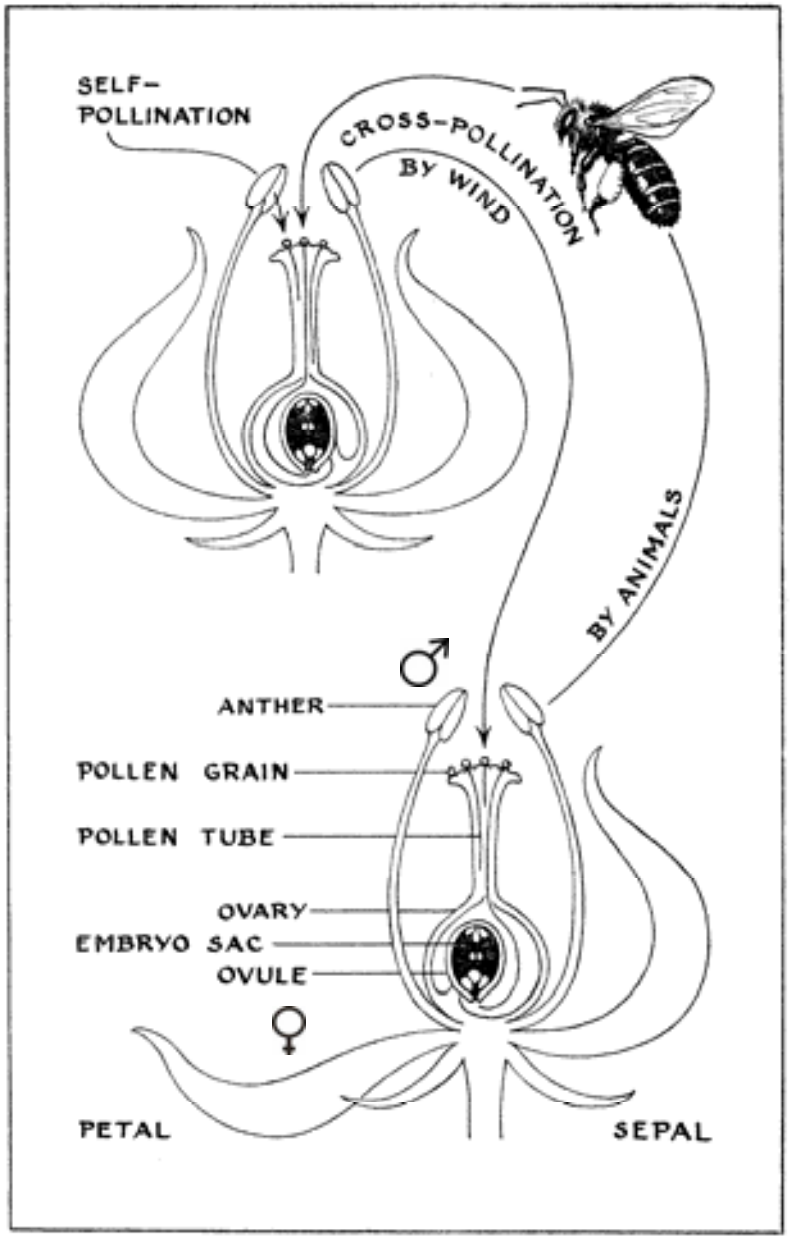


Figure 1. Diagram of self- and cross-pollination.

5

http://www2.umt.edu/geograph/edlund/g446/meeuse.html

For about 75% of the planet's 240,000+ species of flowering plants, the process depends on animal partners, which deliver pollen with greater precision than wind, water, or other abiotic agents

Sexual reproduction generates variation, which is essential for survival in a changeable world. It's the main reason flowering plants (with their pollinator partners) dominate most terrestrial communities

Given that more than 400,000 species planet-wide are engaged in this process, it's remarkable how little is known about it.
Humans have been blissfully unaware of their dependence on pollinators for most of their existence on the planet; as ecological interactions go, animal-mediated pollination is rare, rapid, and easily overlooked

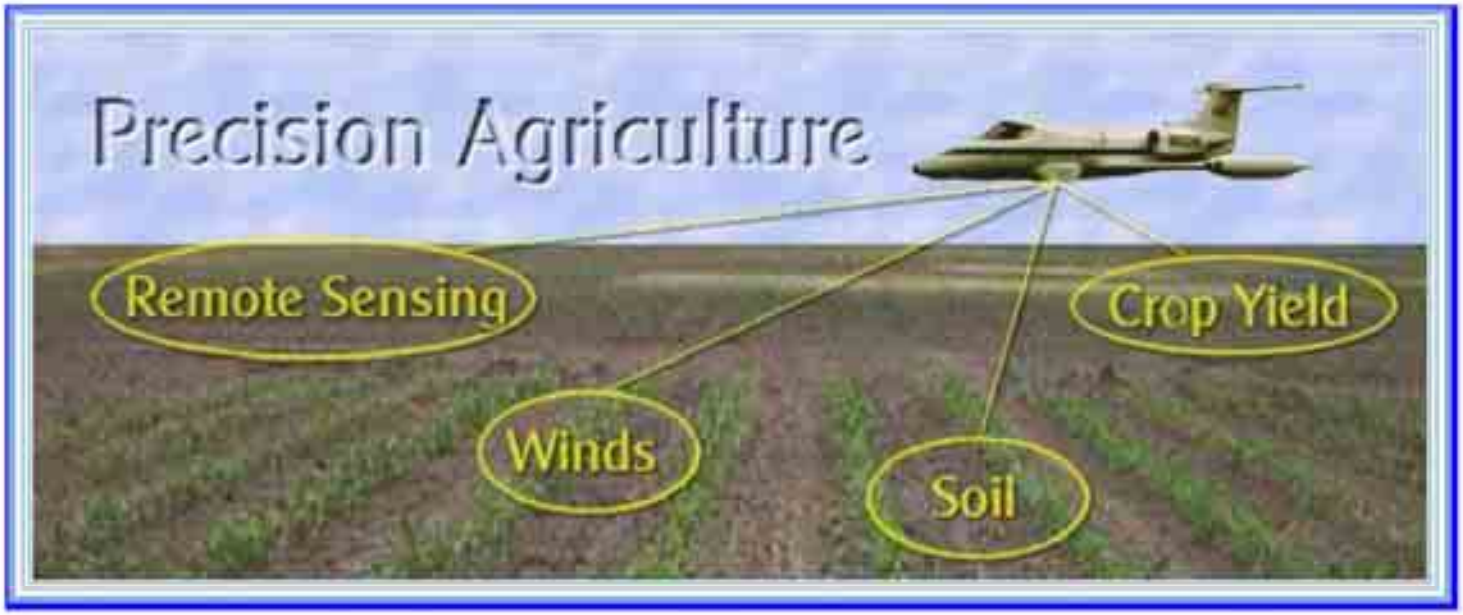

Diane Schmidt

Plant requirements for survival

- Sunlight
- Water
- Nutrients
- Protection from pests
- Pollination (for 75%)

History of agricultural technology

- Fertilization: 10,000 BCE (manuring)
- Irrigation: 6,000 BCE (Mesopotamia)
- Chemical pest control: 400 BCE (Theophrastus)



What is precision farming?

- Knowing and caring where you are in a field.

What can precision farming do for me?

- Improve Crop Yield.
- Provide information to make better management decisions.
- Reduce chemical and fertilizer costs through more efficient application.
- Provide more accurate farm records.
- Increase profit margin.
- Reduce pollution.

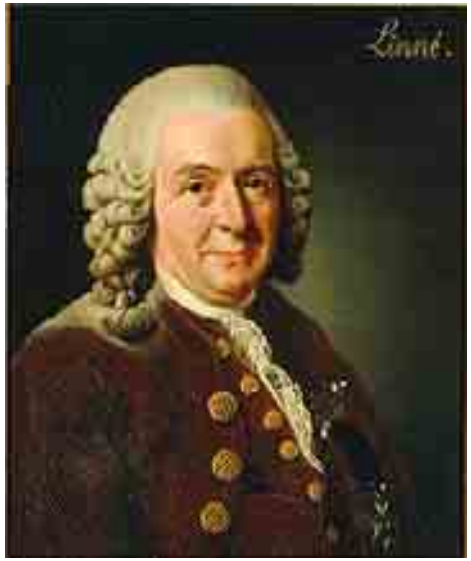
www.ghcc.msfc.nasa.gov

History of agricultural technology

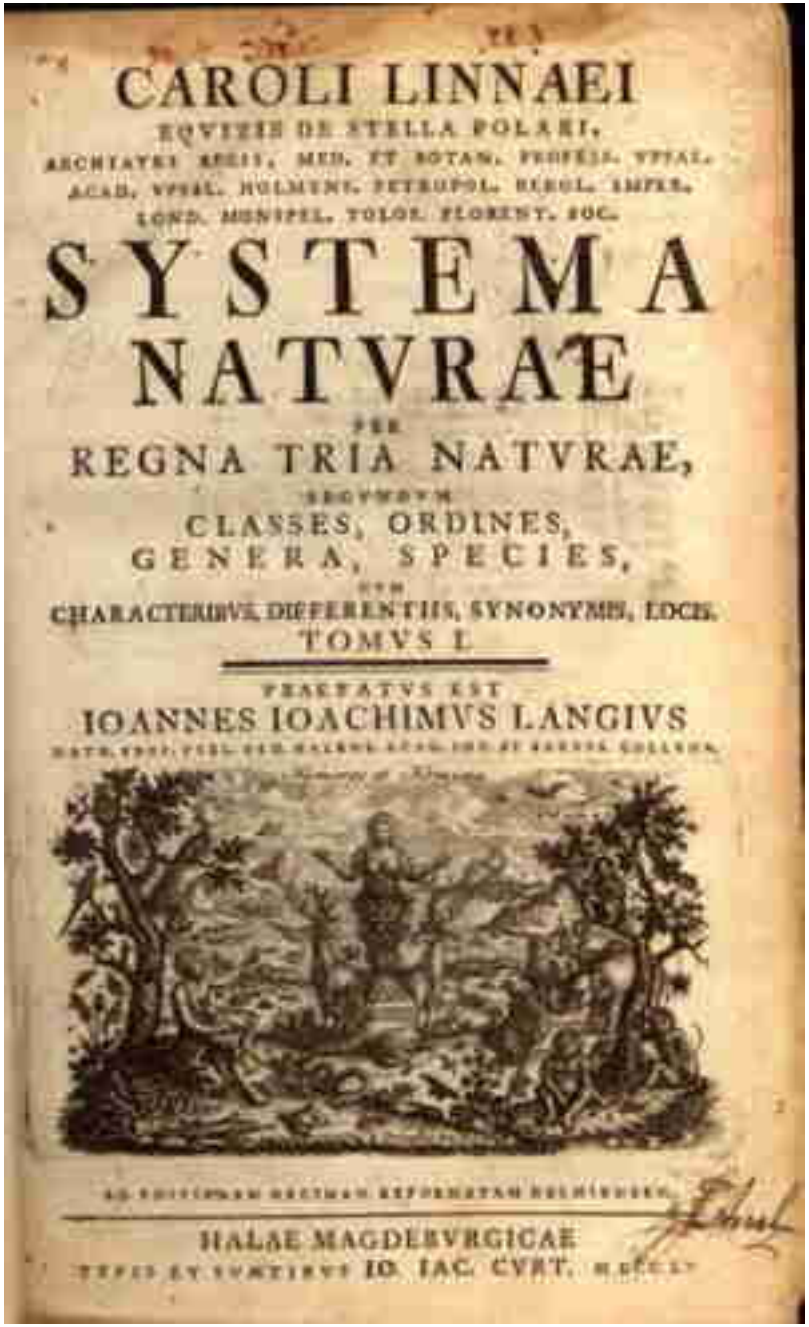
- Fertilization: 10,000 BCE (manuring)
- Irrigation: 6,000 BCE (Mesopotamia)
- Chemical pest control: 400 BCE (Theophrastus)
- Pollination: 17th century (R. J. Camerarius)


Apis mellifera
Western honey bee
Technology for pollen delivery

Although honey bees have been semi-domesticated for thousands of years, management for the purpose of pollination delivery is a post-Enlightenment phenomenon



That plants have sexual organs is a relatively new concept. Carolus Linnaeus 1707-1778 used the sexual organs of plants to devise a system of classification and shocked his contemporaries.
The Reverend Samuel Goodenough, Bishop of Carlisle remarked,
“To tell you that nothing could equal the gross prurience of Linnaeus’s mind is perfectly needless”

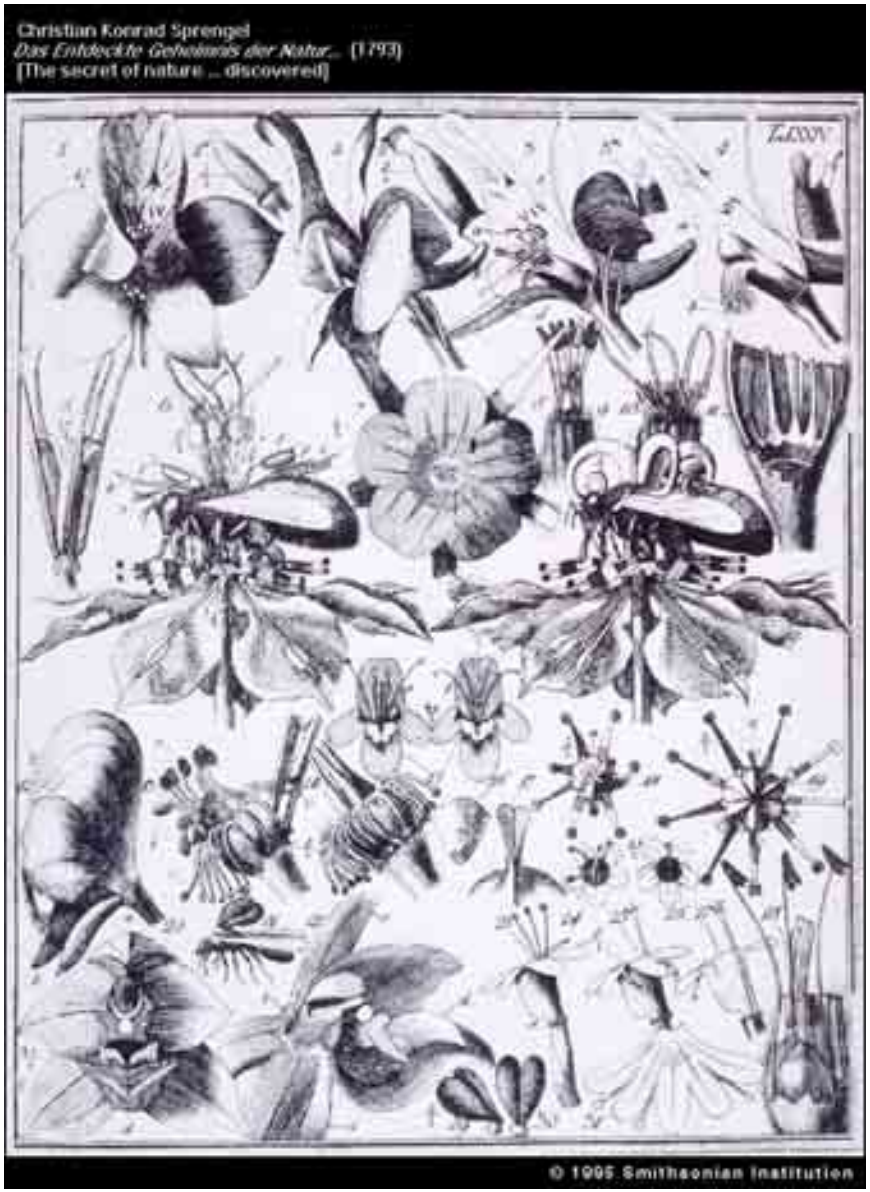

CAROLI LINNAEI
EQVITIS DE STELLA POLARI,
SYSTEMA
NATVRAE
PER
REGNA TRIA NATVRAE,
SECVNDVM
CLASSES, ORDINES,
GENERA, SPECIES,
CVM
CHARACTERIBVS, DIFFERENTIIS, SYNONYMIS, LOCIS.
TOMVS I.
PRAEFATVS EST
IOANNES IOACHIMVS LANGIVS
HALAE MAGDEBVRGICAE

Joseph Gottlieb Kölreuter (1733-1806), professor of natural history at the University of Karlsruhe, Germany

Kölreuter was the first to demonstrate that insect visitation is necessary for seed production in many important fruits, vegetables, and ornamental flowers. He applied his knowledge by developing techniques for artificial fertilization and by conducting the first cross-hybridization of two plant species

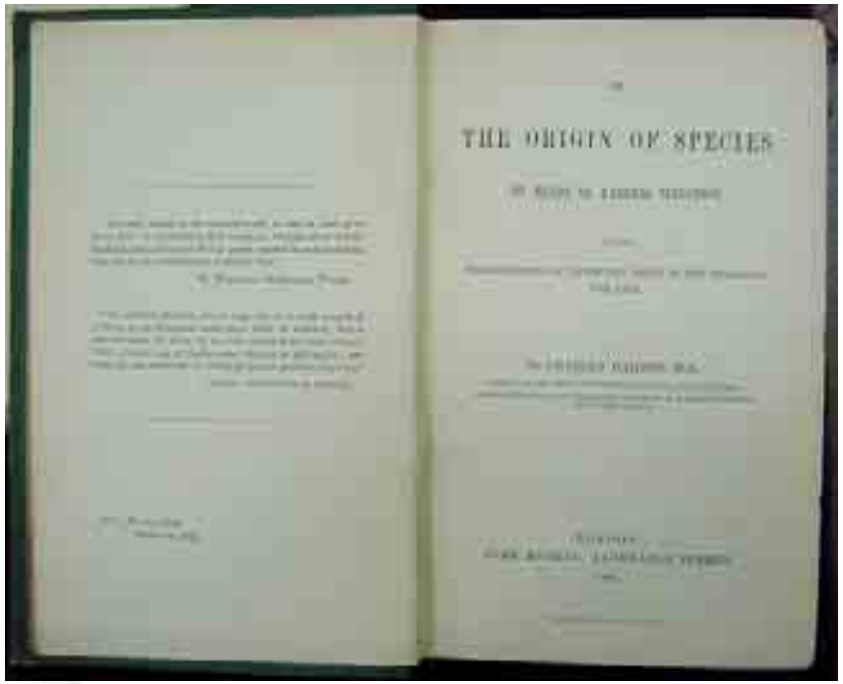
Christian Konrad Sprengel (1750-1816)

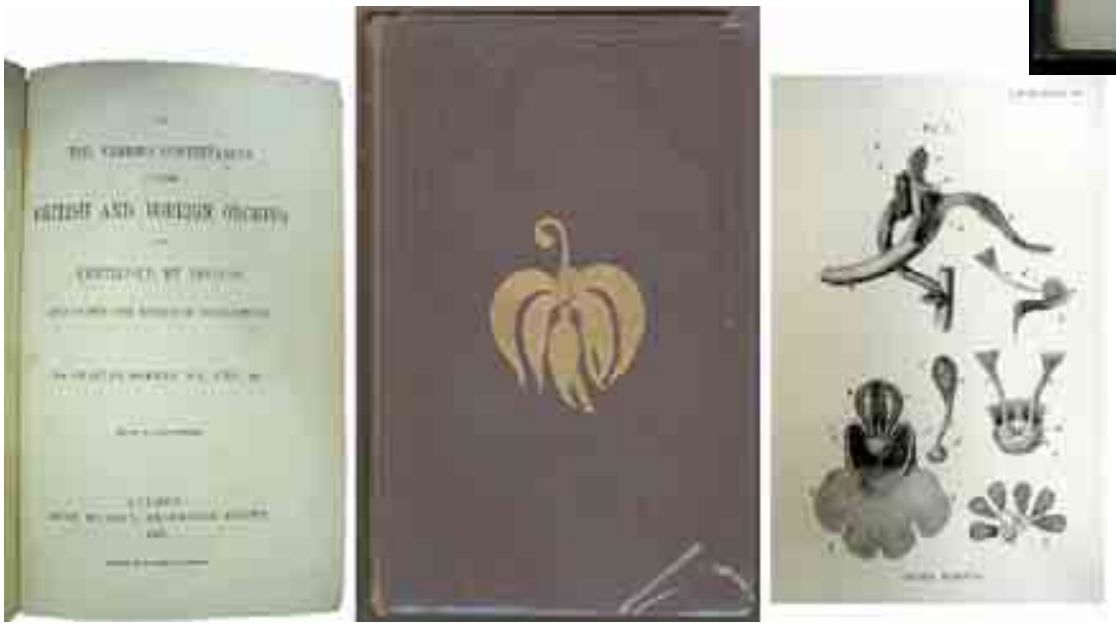
C.K. Sprengel 1793, *Das entdeckte Geheimniss der Natur im Bau und in der Befruchtung der Blumen*
(followed by *Die nützlichkeit der bienen und die nothwendigkeit der bienenzucht, von einer neuen seite dargestellt)*



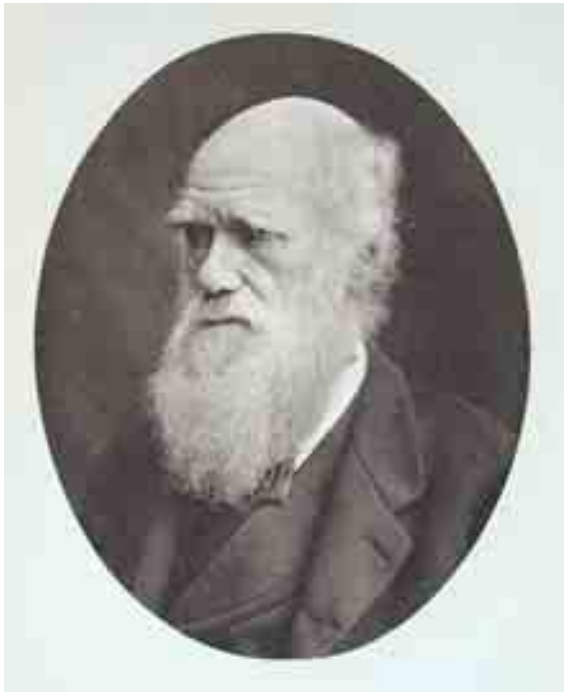
http://www.sil.si.edu/Exhibitions/Science-and-the-Artists-Book/biohtm

Darwin C. 1859. On the Origin of Species by Means of Natural Selection. London: Murray. 365 pp.
("coadaptations of organic beings to each other and to their physical condition of life")





Darwin C. 1862. On the Various Contrivances by Which British and Foreign Orchids Are Fertilized. London: Murray. 365 pp.



Attributes of honey bees conducive for use as managed pollinators

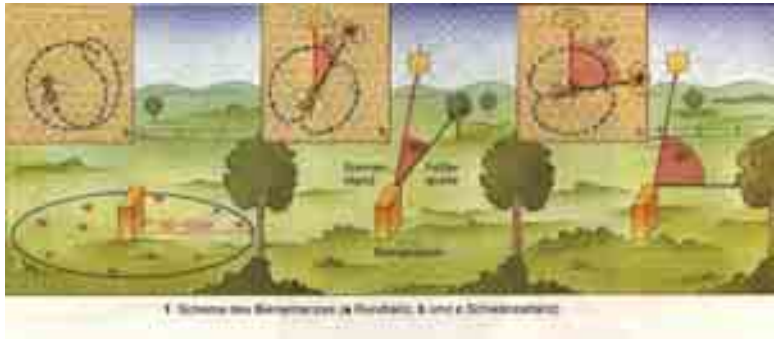
Large colony size for servicing extensive monocultures

Elaborate communication system to promote flower fidelity

Extremely broad diet

Ability to learn to handle many kinds of flower types

Cavity-nesting habit well-suited to management purposes



http://www.graviton.demon.co.uk/Honey%20bee%201798.jpg

Today, honey accounts for only about 25% of the value of the apiculture industry in the United States

Pollination by honey bees--a 15+ billion dollar service to US agriculture (>90 crops)

- **Direct result**:almond, apple, avocado, blueberry, cantaloupe, cherries, cranberries, cucumber, citrus, plums, peaches, pumpkin, strawberries, watermelon, zucchini
- **Indirect result**: *dairy products* (from alfalfa and clover hay), *seeds* (carrots, celery, onion), *higher yields* (peanuts, soybeans, olives, grapes)

Portfolio effect

- diversification of holdings minimizes risk and volatility

Photo: MAAREC

Decline in commercial beekeeping in the United States

- 1976: number of beekeepers estimated at 212,000 (U.S. International Trade Commission)
- 1991: number of beekeepers estimated at 139,000 (Bee Culture Magazine)
- 1992: number of beekeepers estimated at 125,000 (Bee Culture Magazine)

http://gears.tucson.ars.ag.gov/dept/abf.html

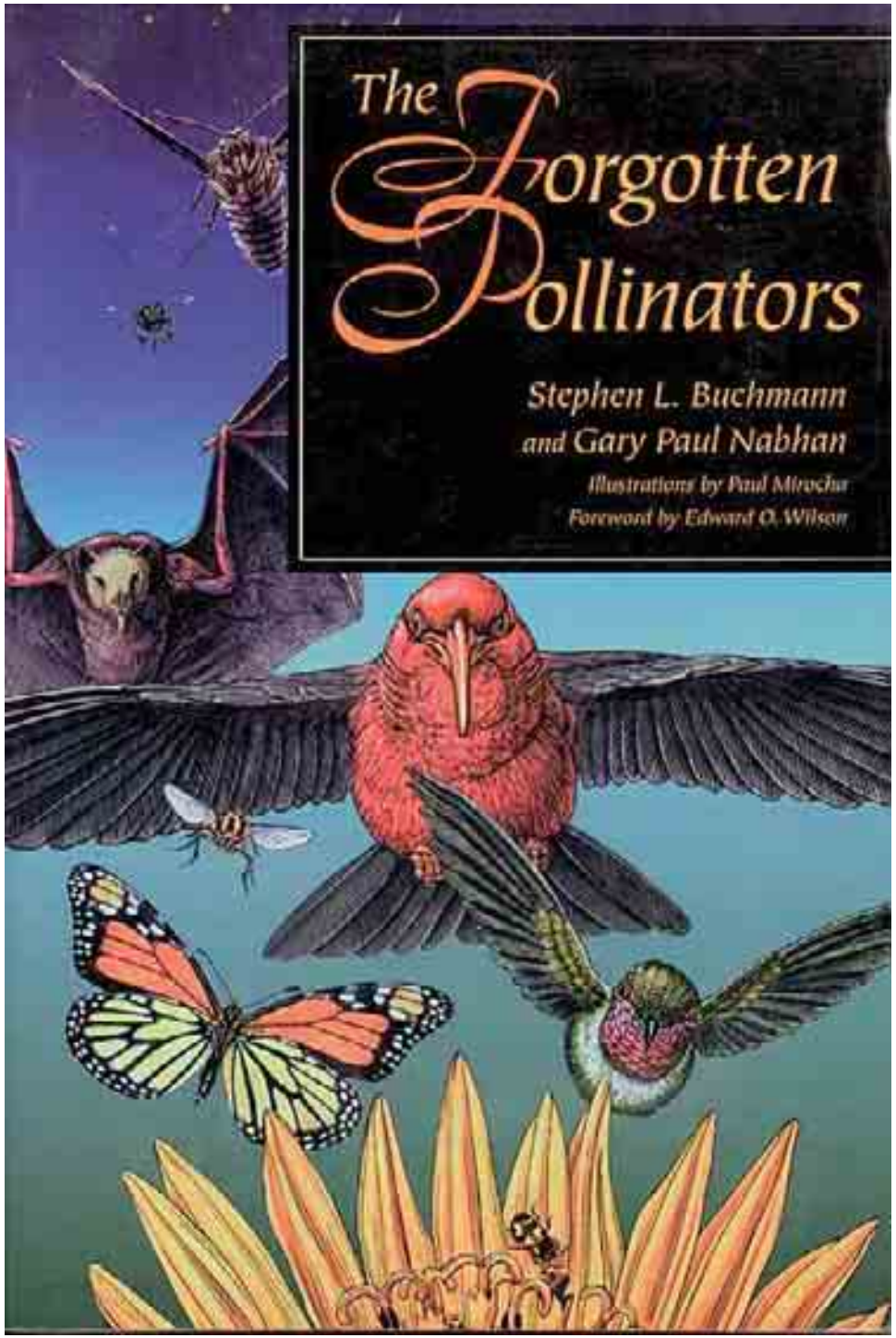
Africanized bees (1990)

Varroa mite (1987)

Tracheal mite (1984)

Small hive beetle (1998)

Feral bees were hard-hit but just how hard-hit is impossible to determine, given the general lack of survey data



The Forgotten Pollinators,” by S. L. Buchmann and G. P. Nabhan, 1996

Pollinator policy efforts

- September 1996 Subsidiary Body on Scientific Technical and Technological Advice of Convention on Biodiversity, **Montreal**, to establish an "international pollinator conservation initiative"
- November 1996, Third Conference of the Parties to the Convention on Biodiversity, **Buenos Aires** Decision III.11, pollinators are "priority group"
- October 1998, International Workshop on Conservation and sustainable use of pollinators in Agriculture, **Sao Paolo**--Declaration
- January 1999 Systematics Society of **Southern Africa**, African Pollinator Initiative
- 1999, **North American** Pollinator Protection Campaign, Coevolution Institute
- May 2000, **Keny**a, Fifth meeting of COP, International Initiative for the conservation and sustainable use of pollinators--FAO invited, International Pollination Initiative
- April 2002, IPI approved at COP6, **The Netherlands**
- **2004, National Research Council study approved, with USDA/USGS funding**

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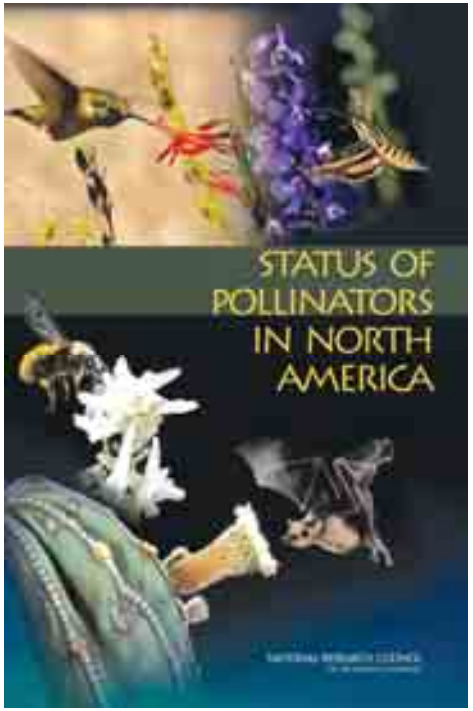
Advisers to the Nation on Science, Engineering, and Medicine

Status of Pollinators in North America

Report Briefing October 2006

•May Berenbaum (chair)
•Peter Bernhard, St Louis University'
•Stephen Buchmann, The Bee Works
•Nicholas Calderone, Cornell University
•Paul Goldstein, Florida Museum of Natural History
•David Inouye, University of Maryland
•Peter Kevan, University of Guelph
•Claire Kremen, University of California-Berkeley
•Rodrigo Medellin, University of Mexico
•Taylor Ricketts, World Wildlife Fund
•Gene Robinson, University of Illinois Urbana-Champaign
•Allison Snow, Ohio State University
•Leonard Thien, Tulane University
•F. C. Thompson, U.S. National Museum
•Dr. Scott Swinton, Michigan State University



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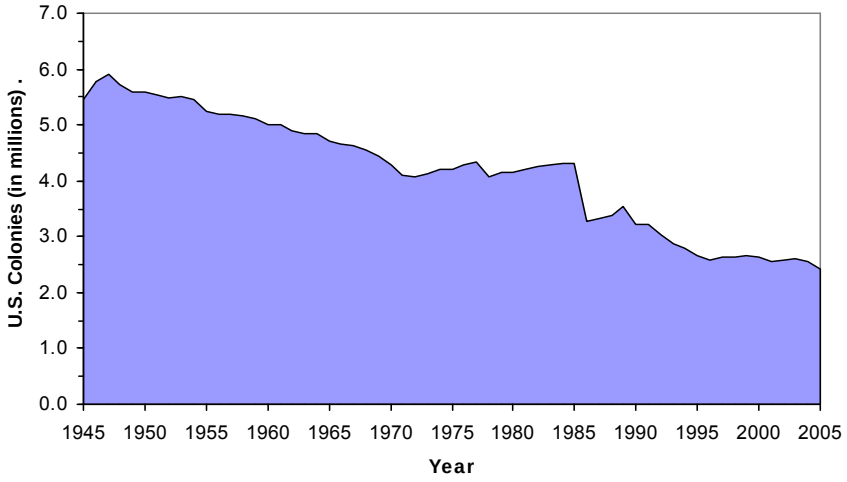
Managed Pollinators

Status

- Long-term population trends for honey bee in the United States are demonstrably downward.
- Similar data are not available for other managed pollinators.



U.S. honey bee colonies, 1945-2005. Data compiled from USDA-NASS

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Causes of decline

Managed and wild species

- Introduced pathogens and parasites
- Habitat degradation and loss

http://www.theses.ulaval.ca/2003/21026/ch02.html

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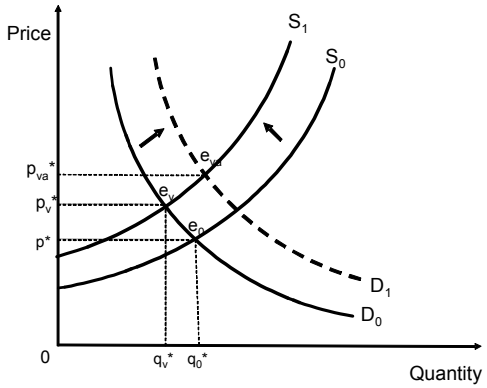
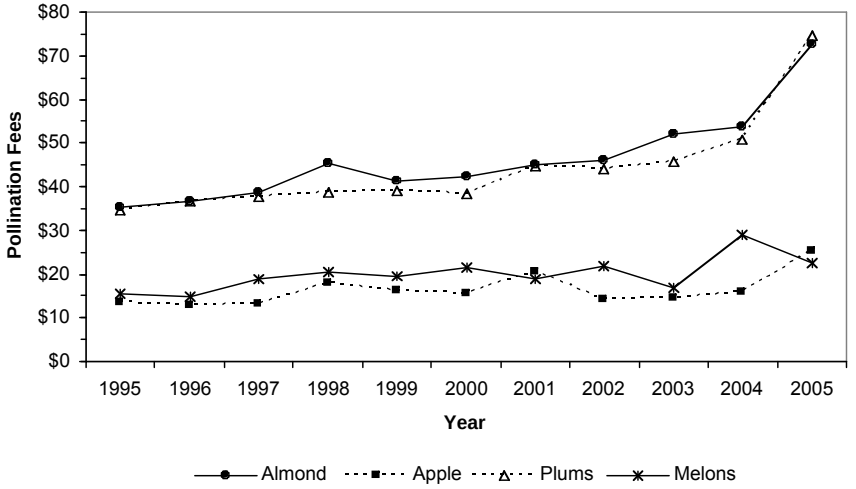
Managed Pollinators

Consequences of Decline

Declines in honey bee supplies in the absence of viable alternative species are exacerbated by increasing demands for pollination services, creating shortages and raising pollination costs





Fall Dwindle Disease: A preliminary report
December 15, 2006

"Fall-Dwindle Disease": Investigations into the causes of sudden and alarming colony losses experienced by beekeepers in the fall of 2006.

Preliminary Report: First Revision

Dennis vanEngelsdorp[1,2],
Diana Cox Foster[2],
Maryann Frazier[2],
Nancy Ostiguy[2],
Jerry Hayes[3]

December 15, 2006
Revised January 5th, 2006

During the months of October, November, and December 2006, an alarming number of honey bee colonies began to die along the East Coast of the United States. West Coast beekeepers are also beginning to report unprecedented losses. This phenomenon, without a recognizable underlying cause, has been tentatively been termed "Fall Dwindle Disease", and threatens the pollination industry and production of commercial honey in the United States. This has become a highly significant yet poorly understood problem for beekeepers. States, like Pennsylvania, can ill afford these heavy losses; the number of managed colonies is less than one half of what it was 25 years ago. Many beekeepers are openly wondering if the industry can survive. There are serious concerns that losses are so great that there will not be enough bees to rebuild colony numbers in order service pollination needs and to maintain economic viability in these beekeeping operations.

Also in October, 2006, reports of mysterious honey bee disappearances began to surface…

Colony Collapse Disorder (CCD)

-- November 2006 Dave Hackenberg lost 400 colonies in Florida

-- Other beekeepers experienced similar sudden losses

A new phenomenon?

-- Bees die away from the hive

-- Queen, grubs, food left behind

-- Scavengers slow to move in

Keith Delaplane

Many Bee Colonies Dead of an Unknown Cause

by E. OERTEL

Entomology Research Division, Agric. Res. Serv., U.S.D.A. Baton Rouge, Louisiana[1]

The term "spring dwindling" used to be seen frequently in beekeeping literature. It related to the rapid death of the bees in a colony in the spring in Northern States until all or nearly all of them were dead. Root (1935) discussed spring dwindling at some length. He also used the term "winter dwindling" to describe the loss of bees that occurred in the winter months in semitropical colonies. Various causes were given for the decline or death of colonies: low vitality, dysentery, poor food, lack of protection, old bees, or lack of pollen.

Bailey (1963) discussed the occasional heavy losses of honey bee colonies reported in England since 1905. Although most of the losses were said at the time to have been caused by the Isle of Wight disease, Bailey believed that the losses were mainly the result of other factors — lack of food, neglect, unfavorable weather, poor beekeeping, or foulbrood. He stated, "Recent cases of large scale losses of bees in autumn in Paraguay, Northern Argentina and Brazil are of bees unable to fly, with their abdomens distended, crawling away from their hives." Bailey suggested that poisonous nectar or pollen was involved.

The following report is concerned with the loss of many colonies of bees in the fall of 1963 and winter of 1963-64. Investigations from beekeepers and a study of the dead or dying colonies, the honey, and the pollen indicate that we are concerned with neither "winter dwindling" nor poisonous honey. If a name is needed, "fall dwindling" could be used.

Thousands of colonies died in south central Louisiana and northeast Texas (see map) and smaller numbers in a small area south of Houston, Texas, and undetermined numbers in California, Arizona, New Mexico, and Alabama.[2] A Louisiana man with 35 years of beekeeping experience stated that he had never before seen anything like it. A beekeeper of Avoyelles Parish, La., reported that he believed the trouble began between October 15 and November 1, 1963. A beekeeper in Ascension Parish first noticed losses on November 1. Combs and bees from dead colonies were brought to the Bee Culture Laboratory December 16, 1963. Through the cooperation of the Agricultural Extension Division, at Louisiana State University[3], an attempt was made early in February 1964 to learn how many colonies in Louisiana died during the fall of 1963 and the winter of 1963-64. Some beekeepers did not answer the inquiry, some reported no losses, and others reported that 50 per cent of their colonies had died. Some lost several hundred colonies and it is believed that around 1,000 colonies were lost by at least one beekeeper. Probably between 4,000 and 5,000 colonies either died or became extremely weak in a relatively small area in Louisiana. Reliable reports from northeast Texas suggested that much the same situation occurred there. We can be sure that several thousand colonies died within a period of about 3 months.

Members of our laboratory visited beekeepers and apiaries in south central Louisiana in an effort to determine what caused the death of the colonies. Colonies were normal some apiaries while in others a mile or two away a few to [illegible] were already dead or had only a [illegible] surviving bees (in some cases [illegible] a queen, apparently the worker bees died in [illegible] field because only a few dead [illegible] could be found in the bottom boards and there was no accumulation of dead bees at the hive entrances. Thus any bees taken for examination were the survivors, rather than the victims. We did not see the colonies in the northeast Texas area, but were informed by reliable observers that conditions there were like those in the affected area in Louisiana.

Dr. E. Oertel

[illegible] A. Carpenter, Assistant Specialist in Entomology.

Approximate locations of many colonies in Louisiana and Texas, 1963-64.

[1] In cooperation with Louisiana State University.

[2] From correspondence of R. Carlton, Louisiana State Entomologist, with State Entomologists and Apiarists, and kindly loaned to this writer.

Oertel. 1965. American Bee Journal

Strange Ailment Wipes Out Colonies of Bees

Laboratories at Work on 'Autumn Collapse' Affecting State's $5 Million Honey Crop

BY ADRIAN HAMILTON
Times Staff Writer

They call it "autumn collapse" and it's got the experts puzzled in laboratories at Berkeley, Beltsville, Md., and Laramie, Wyo. A bee malady, it hits only certain areas and then only in the fall. But, in those apiaries that it does affect, it can kill 90% of the colony.

"Strong colonies, heavy with honey and pollen, suddenly start to decline for no apparent reason during autumn and collapse within six months," Len Foote, supervisor of apiary inspection for the State Department of Agriculture, told a convention of state beekeepers at Sacramento last week.

Officials of the U.S. and California Departments of Agriculture are giving high priority to identifying and controlling the malady because of the threat to honey and crop production.

Worth $5 Million a Year

"The value of honey production in California is around $5 million a year," Foote said, "but altogether about $200 million of crops depend on honey bee pollination for their production."

The bees pollinate fruit crops like apples, prunes and plums and also the seeds of field crops and clovers used as foraging for dairy cattle as well as vegetable seed and almost all of the melon crops.

In addition Sacramento Valley [illegible] some 200 tons of [illegible] ment of Agriculture officials have got together with beekeepers, agricultural commissioners, farm advisors and the USDA to thoroughly investigate the disorder.

Monitoring traps to catch sick and dead bees have been attached to selected colonies in Glenn County, Tehama County and Shasta County. At the same time scientists at USDA Bee Disease Labs at Beltsville, Md., and Laramie, Wyo., and the Invertebrate Pathology Lab at Berkeley, are conducting intensive tests of bees, brood, pollen, water, nectar and honey for possible toxins, pathogens or parasites.

Colonies Monitored

Though no reports of the disorder came in from other states, the California monitored colonies had reached the final stages of collapse by mid-October.

Co-operating beekeepers in the same counties also found signs of autumn collapse in their apiaries. Laboratory tests eliminated all known bee diseases and parasites but, up to now at any rate, have come up with no answer.

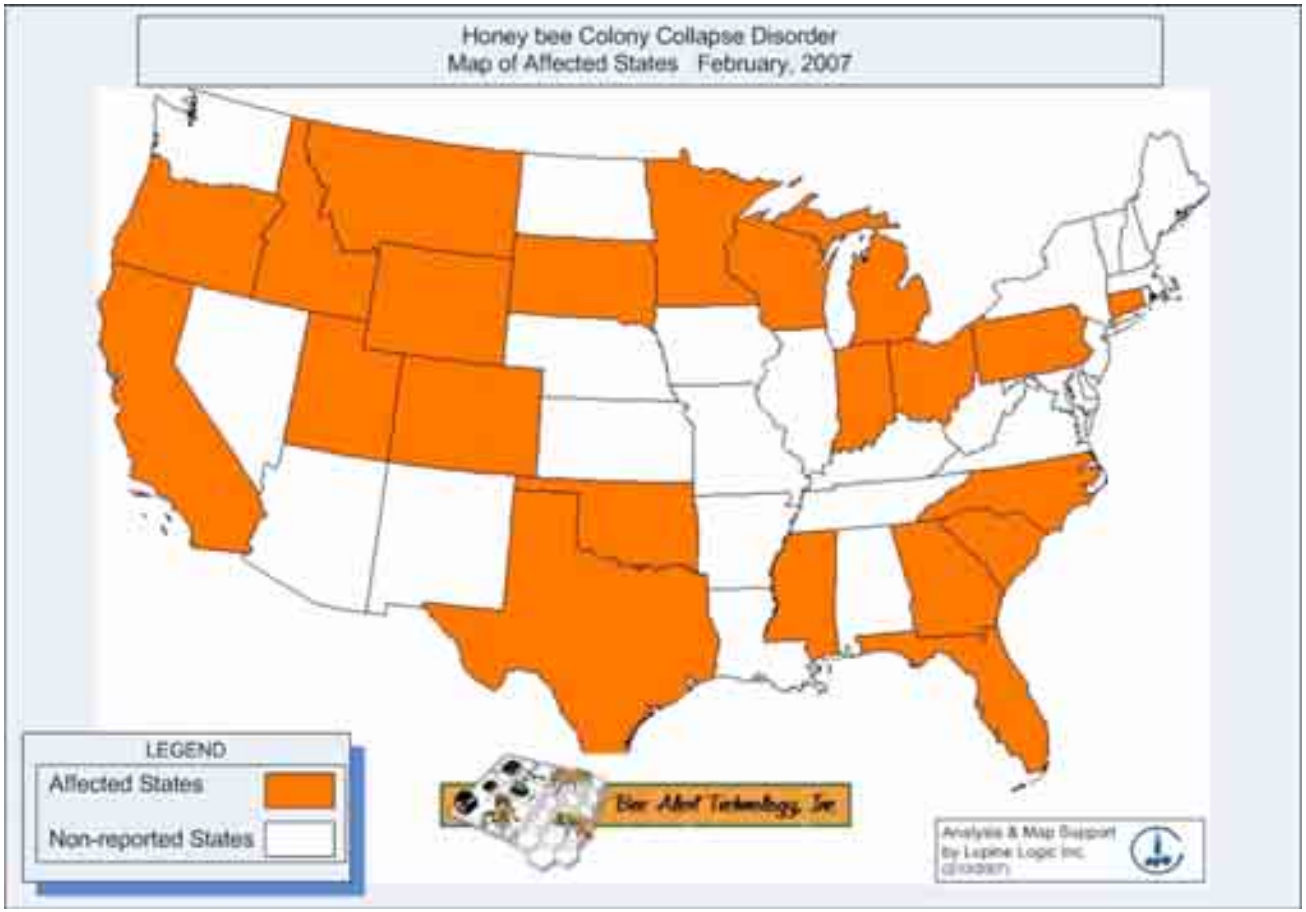
Tests have shown that the possibility of pesticide being responsible is extremely unlikely and that it is probably not an infectious disease.

[illegible] to cure colonies [illegible] quin and Imperial Valleys.

Laboratory reports are expected in the near future and in January officials and scientists will get together to evaluate their findings.

"It's still too early to say but we are hopeful," said Len Foote. "This year it isn't as widespread as last. We know at least that the disorder is not transmittable. But we need to know how widespread it is and would urge beekeepers to immediately contact their county agricultural commissioner or farm advisor if they discover signs of this disorder in their apiaries.

Disappearances have been reported from time to time but Colony Collapse Disorder appeared to be qualitatively and quantitatively different …



By February, massive disappearances had occurred in over 20 states…

Beekeepers and researchers convened a meeting in Florida to discuss the possible causes and consequences

http://www.doacs.state.fl.us/pi/plantinsp/apiary/images/ccdstates.jpg

USDA bee researchers collected samples of afflicted bees in Pennsylvania and Florida in order to figure out what was causing the problems...

REVIEW COLONY COLLAPSE DISORDER IN HONEY BEE COLONIES ACROSS THE UNITED STATES

HEARING

BEFORE THE

SUBCOMMITTEE ON HORTICULTURE AND ORGANIC AGRICULTURE

OF THE

COMMITTEE ON AGRICULTURE
HOUSE OF REPRESENTATIVES

ONE HUNDRED TENTH CONGRESS

FIRST SESSION

MARCH 29, 2007

Serial No. 110-07

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U.S. GOVERNMENT PRINTING OFFICE

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Richard Adam, left and Jim Dean testify before the House Subcommittee on Horticulture and Organic Agriculture.

May 2007 BEE CULTURE

The extensive losses caught the attention of legislators in key states (California, with its $2.5 billion almond industry, and Florida) and the House Agriculture Committee Subcommittee on Horticulture and Organic Agriculture (which oversees apiculture) held a hearing on Colony Collapse Disorder on March 29, 2007

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March 22, 2007

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COLLAPSING COLONIES

Font:

Are GM Crops Killing Bees?

By Gunther Latsch

A mysterious decimation of bee populations has German beekeepers worried, while a similar phenomenon in the United States is gradually assuming catastrophic proportions. The consequences for agriculture and the economy could be enormous.

DDP

Is the mysterious decimation of bee populations in the US and Germany a result of GM crops?

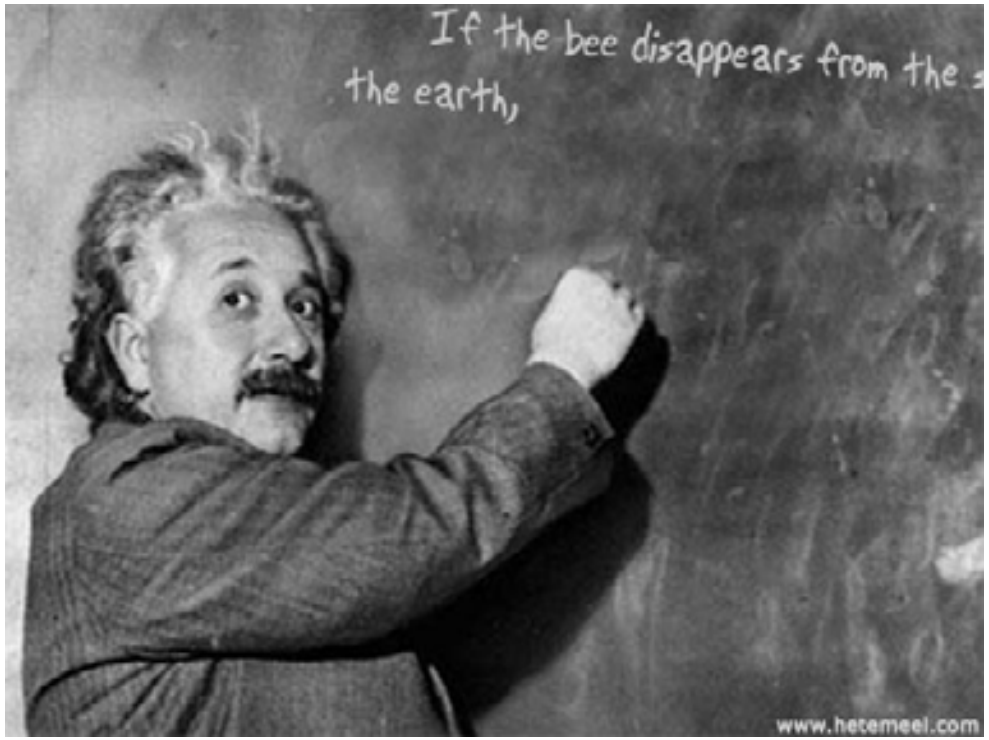
Walter Haefeker is a man who is used to painting grim scenarios. He sits on the board of directors of the German Beekeepers Association (DBIB) and is vice president of the European Professional Beekeepers Association. And because griping is part of a lobbyist's trade, it is practically his professional duty to warn that "the very existence of beekeeping is at stake."

The problem, says Haefeker, has a number of causes, one being the varroa mite, introduced from Asia, and another is the widespread practice in agriculture of spraying wildflowers with herbicides and practicing monoculture. Another possible cause, according to Haefeker, is the controversial and growing use of genetic engineering in agriculture.

As far back as 2005, Haefeker ended an article he contributed to the journal *Der Kritischer Agrarbericht* (Critical Agricultural Report) with an Albert Einstein quote: "If the bee disappeared off the surface of the globe then man would only have four years of life left. No more bees, no more pollination, no more plants, no more animals, no more man."

Mysterious events in recent months have suddenly made Einstein's apocalyptic vision seem all the more topical. For unknown reasons, bee populations throughout Germany are disappearing -- something that is so far only harming beekeepers. But the situation is different in the United States, where bees are dying in such dramatic numbers that the economic consequences could soon be dire. No one knows what is causing the bees to perish, but some experts believe that the large-scale use of genetically modified plants in the US could be a factor.

http://www.spiegel.de/international/world/0,1518,473166,00.html



“Auf einen Satz verweisen betroffene Bienenzüchter und nüchterne Bienenforscher inzwischen immer wieder, einen Satz, den Albert Einstein einmal gesagt haben soll: „Wenn die Biene von der Erde verschwindet, dann hat der Mensch nur noch vier Jahre zu leben; keine Bienen mehr, keine Bestäubung mehr, keine Pflanzen mehr, keine Tiere mehr, keine Menschen mehr...“. . . .

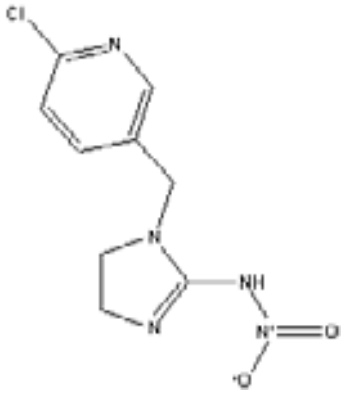
CCD Meeting @ USDA BARC, April 23-24, 2007

On April 23-24, about fifty bee researchers and other interested parties convened at a workshop at USDA BARC to prioritize Colony Collapse Disorder research objectives

Hypotheses to account for colony collapse disorder

Most likely

- Neonicotinoid insecticides
- Novel pathogen or parasite
- Immune suppression relating to management practices
- Declines in nutritional adequacy of diet



Imidacloprid

Less likely

- GM corn pollen
- Cell phones
- Wi-Fi
- Elevated carbon dioxide
- Elevated UVB light
- Osama Bin Laden
- Automobile grilles
- Solar maxima
- Jet chemical contrails
- Fluctuations in the Earth's magnetic field
- Alien abduction
- Bee "rapture"

Order Code RL33938

CRS Report for Congress

Recent Honey Bee Colony Declines

Updated June 20, 2007

Renée Johnson
Analyst in Agricultural Economics
Resources, Science, and Industry Division

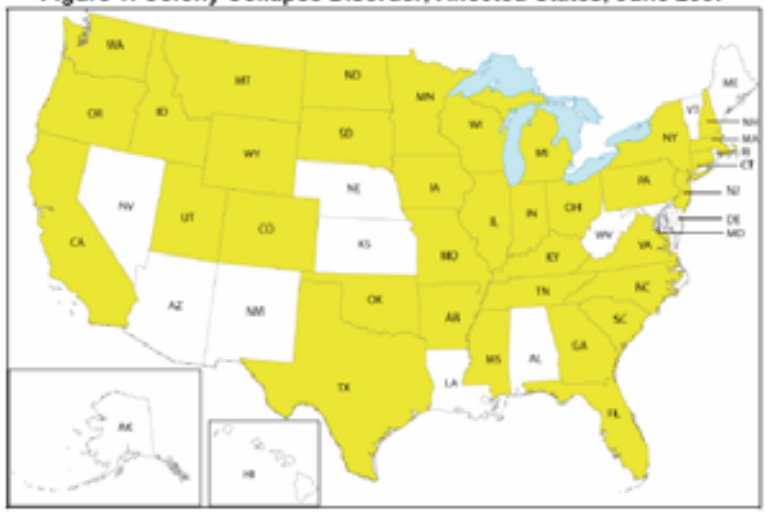
Prepared for Members and Committees of Congress

Congressional Research Service

On June 20, 2007, the Congressional Research Service updated its report on Colony Collapse Disorder

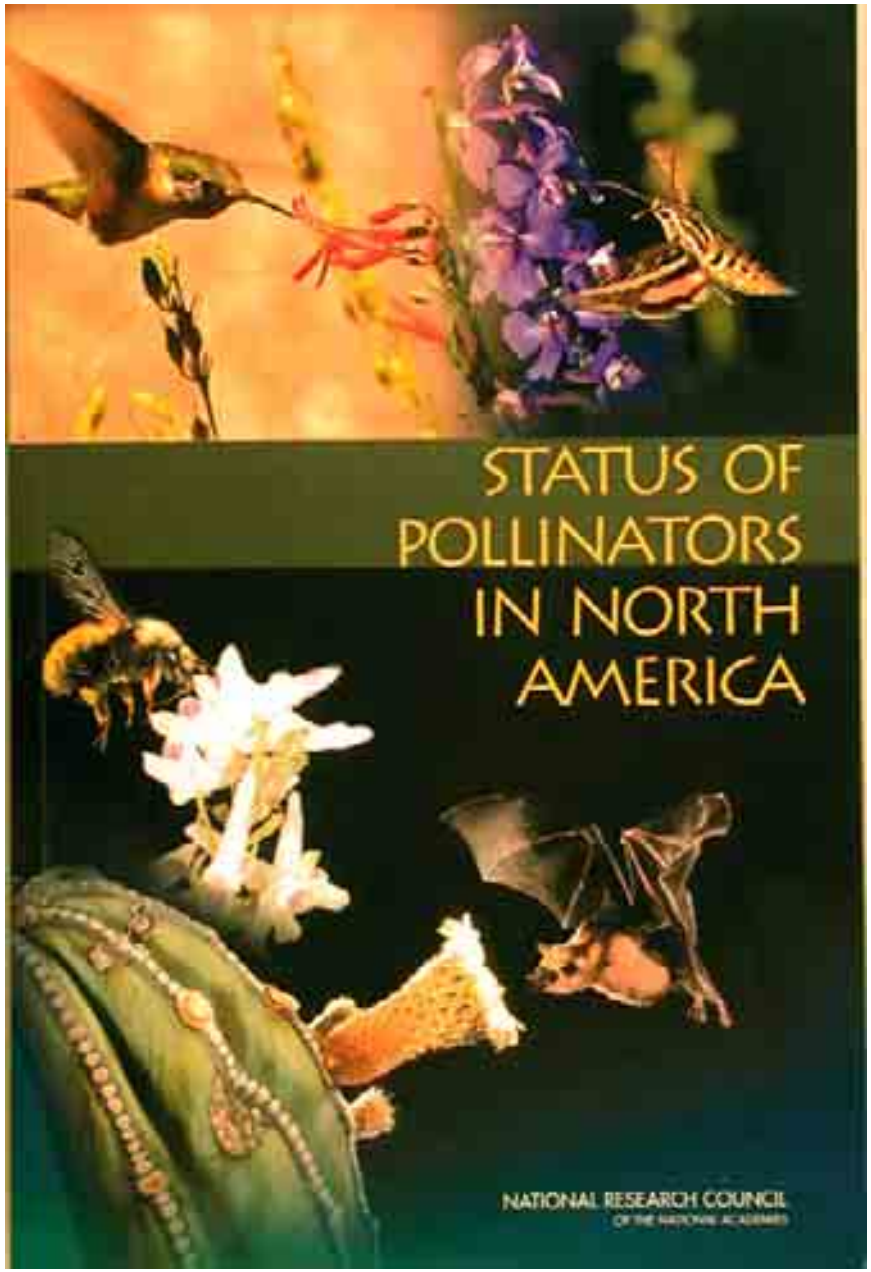
By this point, CCD had been reported in 35 states

Figure 1. Colony Collapse Disorder, Affected States, June 2007



Source: Bee Alert Inc., [http://www.beealert.info/]. Shaded areas show reported affected states.

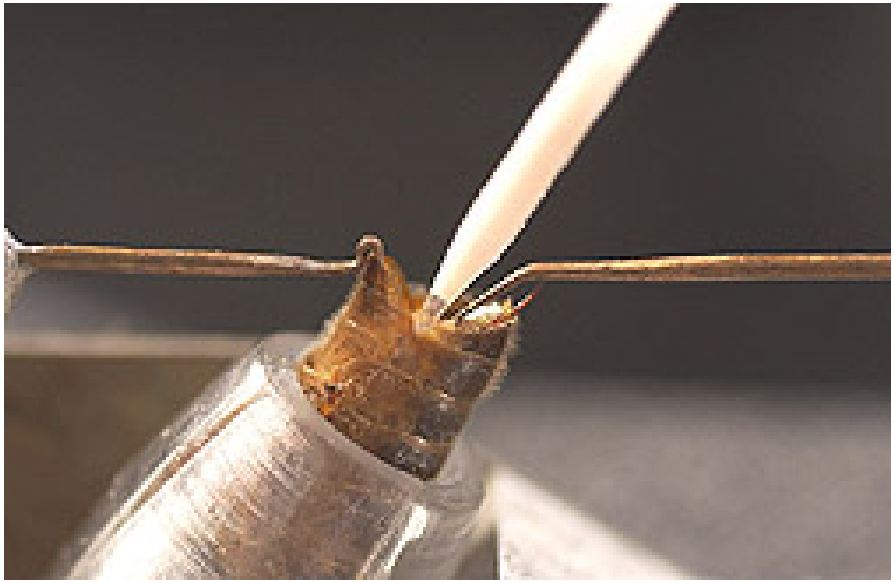
and the NAS report seemed prophetic...



“The U.S. commercial honey bee population was stable from 1996 to 2004, but if it were to continue to decline at the rates exhibited from 1947 to 1972 and from 1989 to 1996, it would vanish by 2035” (p. 118)

The original Langstroth hive.

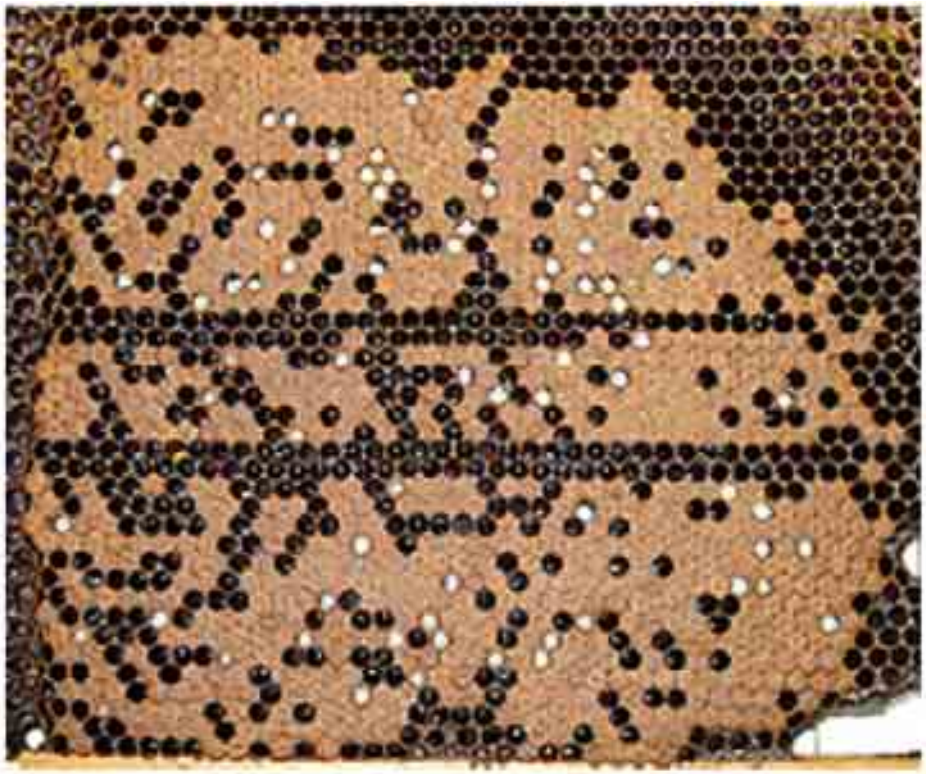
Beekeeping technology is for the most part unchanged since the 19th century. For an industry that contributes about $15 billion annually, it’s remarkably unimproved



Chief 20th century technological innovations in beekeeping include rubber tires and air-conditioning for trucks and artificial insemination instrumentation

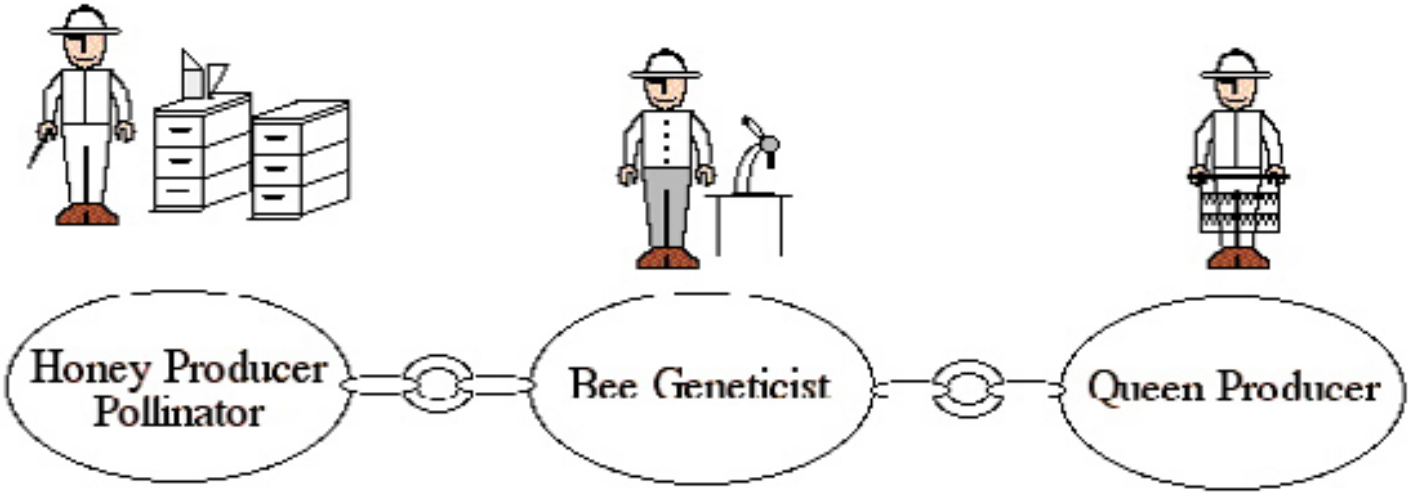
http://www.ars.usda.gov/

A line of honey bees resistant to mites (SMR, “suppressed mite reproduction” or VSH, “Varroa-sensitive hygiene” bee), was selected but it’s not commercially available…



To demonstrate *Varroa*-sensitive hygiene by SMR bees, a highly infested brood comb was cut into halves, and each half was placed in a cage with 2,000 test bees for 24 hours. Shown here is the brood comb of the SMR bees, which removed 215 pupae and uncapped another 178 pupae (90 percent of uncapped cells were infested with *Varroa* mites).
(D214-2)

Links in the Chain of People and Tasks Necessary to Supply Better Bees to the Beekeeping Industry



Task:
Carry out field tests where stock is to be used.

Make plans:
1. On how to get improved stock.
   a. Decide how to do field tests
   b. Select colonies to breed from
   c. Decide when to use natural mating or artificial insemination
2. On how to maintain improved stock over the years.
3. On how to release improved stock.

Produce improved stock for sale to honey producers, bee producers, and/or pollinators.

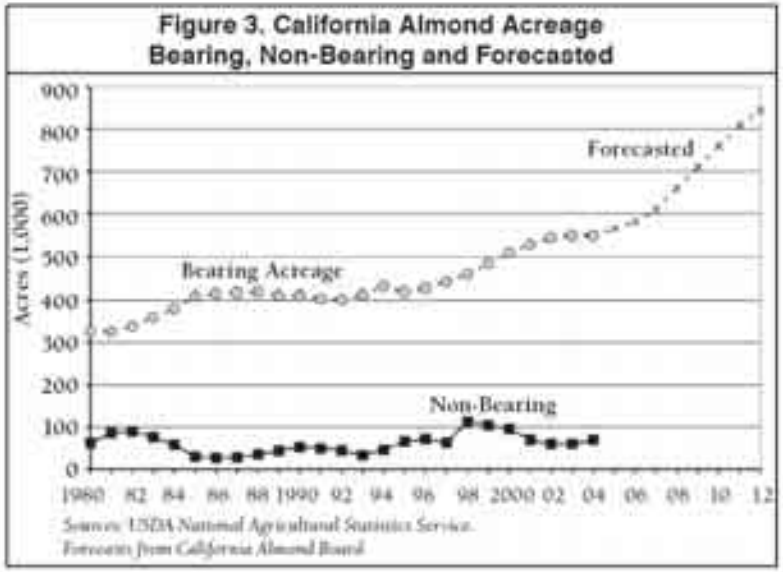
Redrawn from Walter C. Rothenbuhler ABJ March, 1980

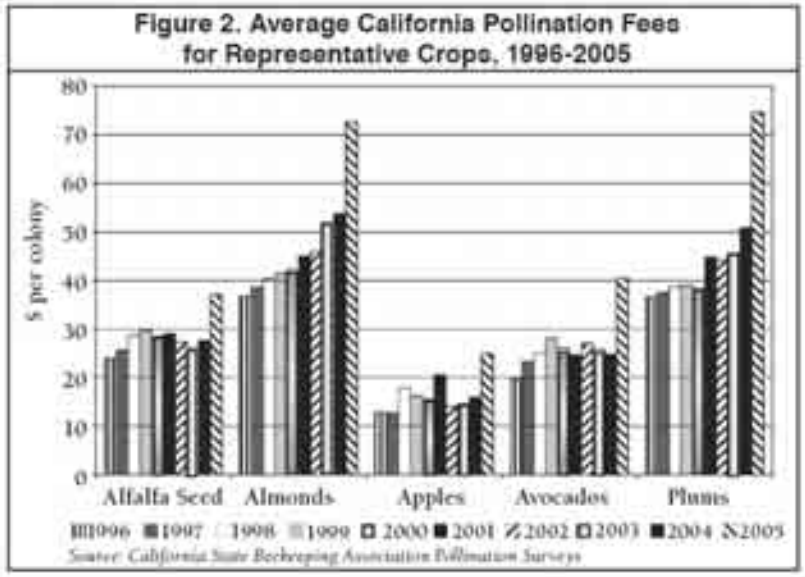
Increasing demand for pollination services is pushing the limits of the system in an unprecedented way

544 hives on the truck,

http://www.indiansummerhoneyfarm.com/slide1.jpg
http://boxer.senate.gov/news/photos/features/farmbill/

If almond acreage continues to expand, by 2012 every honey bee in America will be needed to pollinate just that crop; however, demand for pollination services is increasing for other crops as well.





Bee-conomics and the Leap in Pollination Fees

by

Daniel A. Sumner and Hayley Boriss

Contributions of native pollinators is estimated to be worth $3 billion but prospects of expanding the use of native pollinators are dim

Clean weed-free fields without fences have no nectar or nesting resources

http://www.seaburst.com/cornfield01.jpg

Where have the bees gone?

A new forensic tool for understanding CCD: the honey bee genome (October 2006)

-- use genome-derived tools to find out what's happening

-- or at least find good diagnostics for determining if a colony has CCD or not

Insights into social insects from the genome of the honeybee *Apis mellifera*

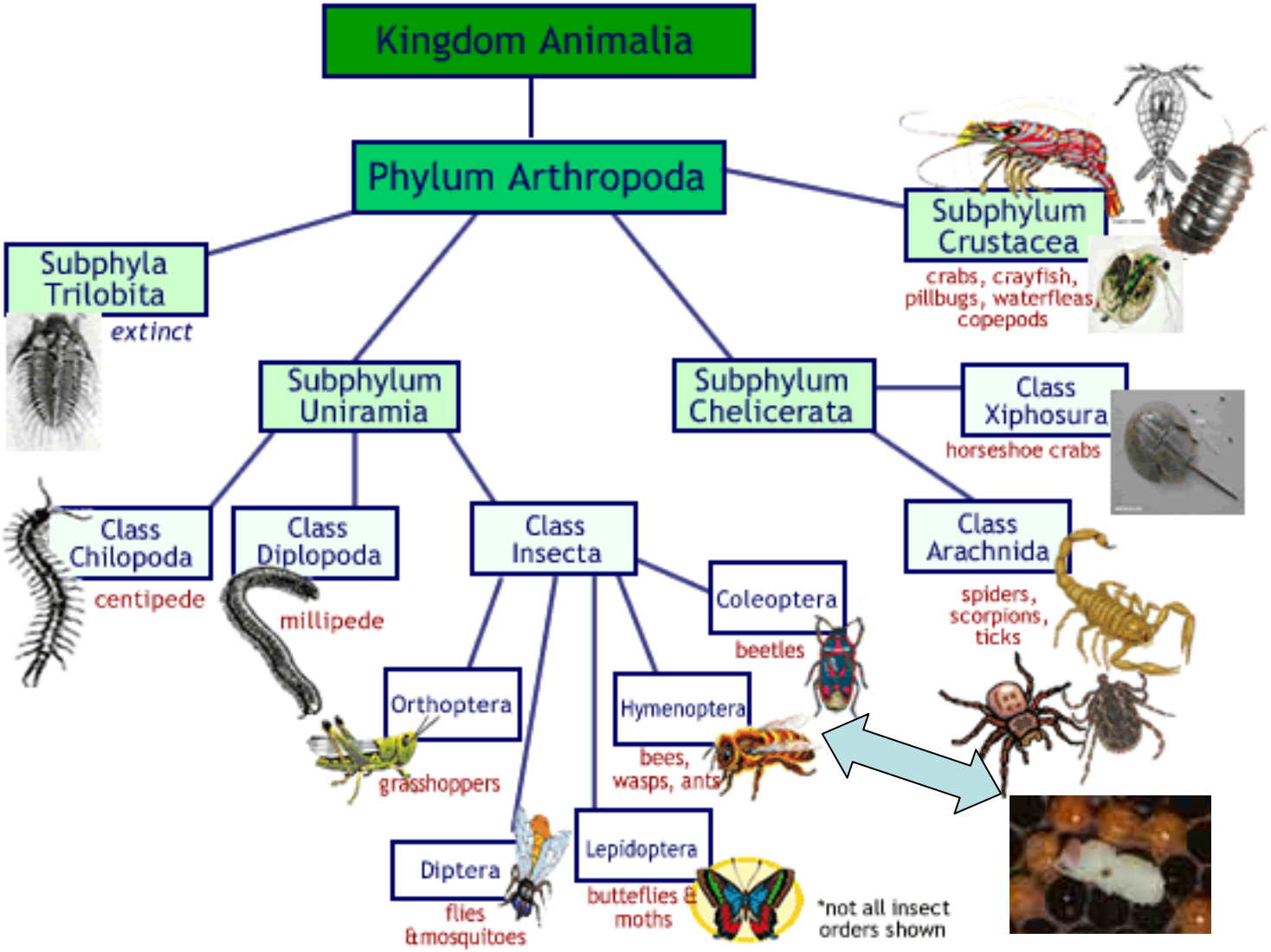
The Honeybee Genome Sequencing Consortium*

Here we report the genome sequence of the honeybee *Apis mellifera*, a key model for social behaviour and essential to global ecology through pollination. Compared with other sequenced insect genomes, the *A. mellifera* genome has high A+T and CpG contents, lacks major transposon families, evolves more slowly, and is more similar to vertebrates for circadian rhythm, RNA interference and DNA methylation genes, among others. Furthermore, *A. mellifera* has fewer genes for innate immunity, detoxification enzymes, cuticle-forming proteins and gustatory receptors, more genes for odorant receptors, and novel genes for nectar and pollen utilization, consistent with its ecology and social organization. Compared to *Drosophila*, genes in early developmental pathways differ in *Apis*, whereas similarities exist for functions that differ markedly, such as sex determination, brain function and behaviour. Population genetics suggests a novel African origin for the species *A. mellifera* and insights into whether Africanized bees spread throughout the New World via hybridization or displacement.

Table 3 | Gene family size differences with possible effects on honeybee lifestyle

Family	Function	Family compared with *Drosophila*	Possible lifestyle effects
Major royal jelly	Brood feeding	Larger	Brood care; caste development[92]
Insulin/insulin-like growth factors	Ageing, fertility, many others	Variable for different subfamilies	Unique reversal of typical lifespan/fertility trade off
Cuticular proteins	Cuticle stability	Smaller	Protected hive environment allows simpler cuticle
Odorant receptors	Olfaction	Larger	Enhanced pheromone communication; odour-based kin recognition; generalist flower feeder
Gustatory receptors	Gustation	Smaller	Brood feeding; mutualistic flower feeder reduces threat of toxic food
Immunity	Infectious disease protection	Smaller	Paradox: high pathogen load due to sociality
Detoxification genes	Defence against xenobiotics	Smaller	Managed environment; specialized lifestyle

Mite management presented the challenge of finding selective acaricides that do not kill bees



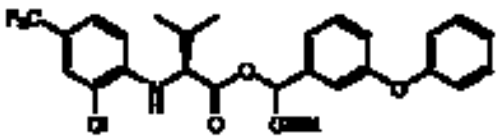
itp.nyu.edu/animals/ 02/taxa.htm

Tau-fluvalinate

615mg per Apistan strip

approx. 0.125 µg/bee/day

0.1 µg/bee recorded 1 yr. after treatment (Haarmann et al. 2002)

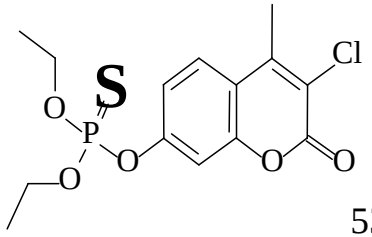


Coumaphos

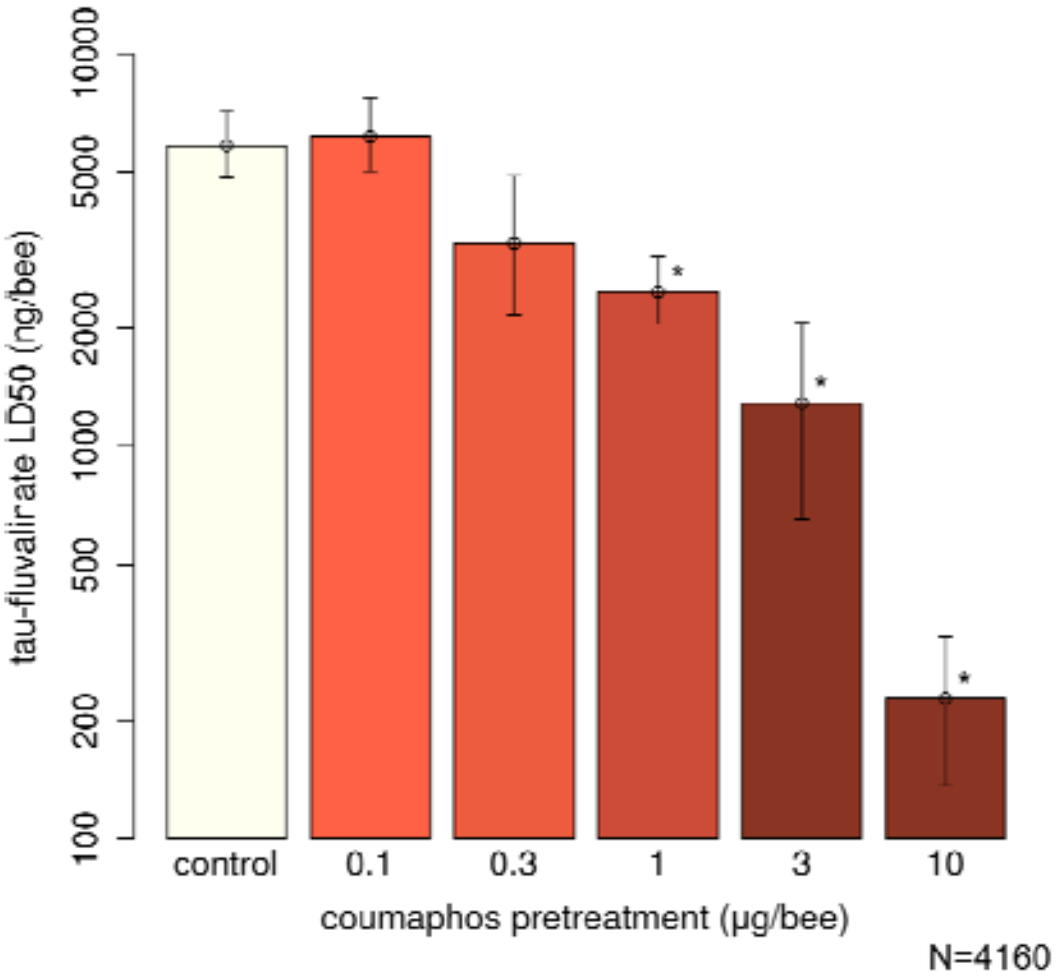
1.4g per CheckMite+ strip

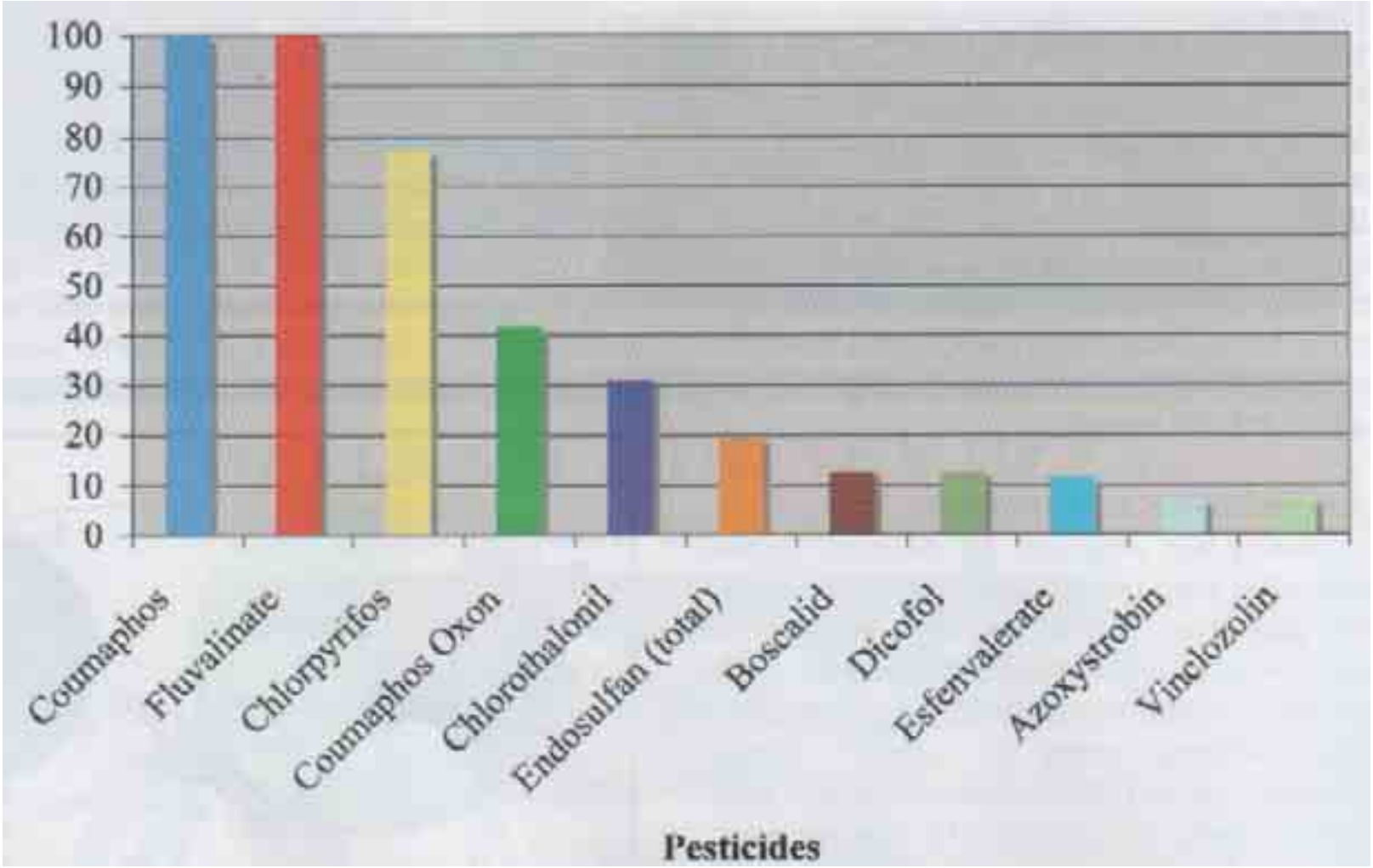
approx. 0.33 µg/bee/day

3.2 µg/bee recorded (Haarmann et al. 2002)☐



Each miticide interferes with detoxification of the other
(Reed Johnson et al. 2009)





Frazier et al., 2008. American Bee Journal.

Coumaphos and fluvalinate are the most frequently detected pesticides in brood nest wax of honey bees—they were present in 100% of samples

In-hive pesticides

Apistan

Agricultural pesticides (particularly neonicotinoids, synthetic neurotoxic analogues of nicotine)

Do neonicotinoids cause CCD?

-- systemic – present in nectar and pollen
-- cause learning problems in bees exposed to high doses
-- imidacloprid banned in France for use on sunflowers (“mad bee disease”)

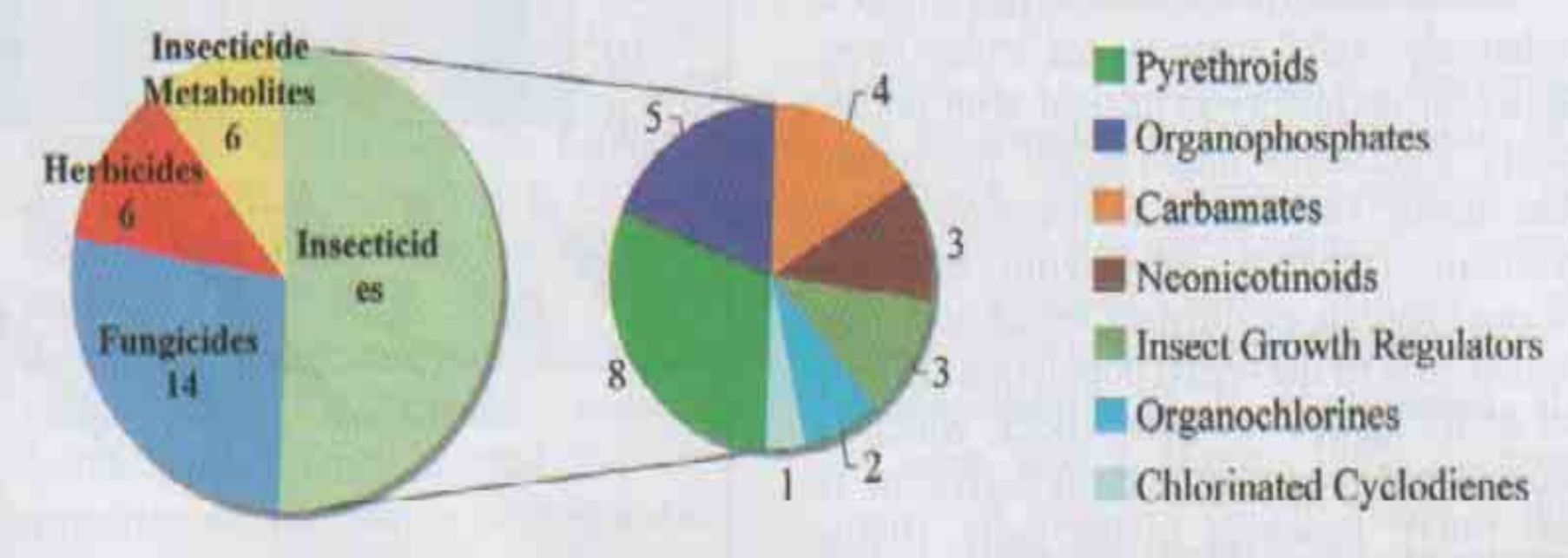
Gaucho

But . . .

-- France STILL has problems after banning imidacloprid

-- Imidacloprid has been used in the U.S. since 1996

-- Only 3 out of 108 pollen samples taken from CCD colonies contained imidacloprid



Frazier et al., 2008. Am. Bee J.

Sciencexpress Report

A Metagenomic Survey of Microbes in Honey Bee Colony Collapse Disorder

Diana L. Cox-Foster,[1] Sean Conlan,[2] Edward C. Holmes,[3,4] Gustavo Palacios,[2] Jay D. Evans,[5] Nancy A. Moran,[6] Phenix-Lan Quan,[2] Thomas Briese,[2] Mady Hornig,[2] David M. Geiser,[7] Vince Martinson,[8] Dennis vanEngelsdorp,[1,9] Abby L. Kalkstein,[1] Andrew Drysdale,[2] Jeffrey Hui,[2] Junhui Zhai,[2] Liwang Cui,[1] Stephen K. Hutchison,[10] Jan Fredrik Simons,[10] Michael Egholm,[10] Jeffery S. Pettis,[5] W. Ian Lipkin[2]*

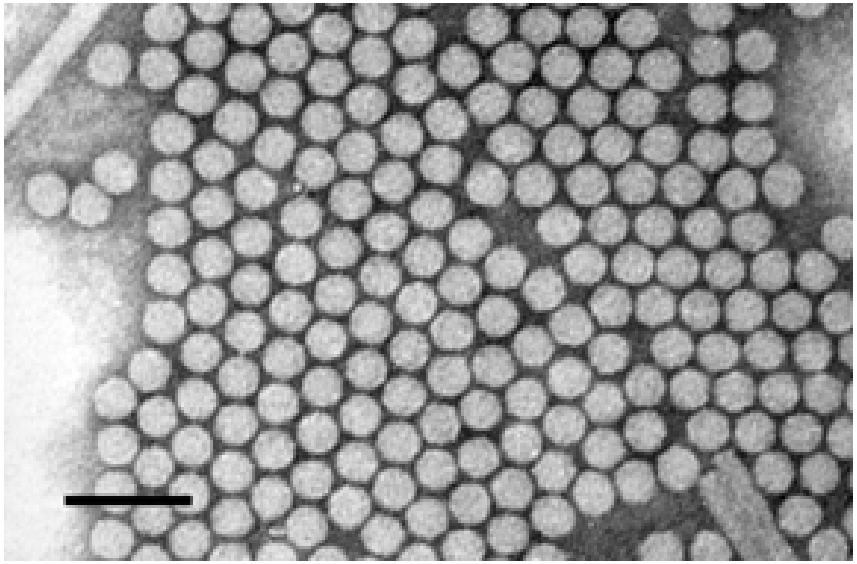
In colony collapse disorder (CCD), honey bee colonies inexplicably lose their workers. CCD has resulted in a loss of 50 to 90% of colonies in beekeeping operations across the United States. The observation that irradiated combs from affected colonies can be repopulated with naive bees suggests that infection may contribute to CCD. We used an unbiased metagenomic approach to survey microflora in CCD hives, normal hives, and imported royal jelly. Candidate pathogens were screened for significance of association with CCD by examination of samples collected from several sites over a period of 3 years. One organism, Israeli acute paralysis virus of bees (IAPV), was strongly correlated with CCD.

Agent	Number of positive samples *n* (% positive of samples tested)			Positive Predictive Value (%)	Sensitivity (%)	Specificity (%)
	CCD (*n* = 30)	non-CCD (*n* = 21)	Total (*n* = 51)			
IAPV	25 (83.3%)	1 (4.8%)	26 (51.0%)	96.1	83.3	95.2
KBV	30 (100%)	16 (76.2%)	46 (90.2%)	65.2	100	23.8
N. apis	27 (90%)	10 (47.6%)	37 (72.5%)	73.0	90.0	52.4
N. ceranae	30 (100%)	17 (80.9%)	47 (92.1%)	63.8	100	19.0
All 4 agents	23 (76.7%)	0 (0%)	23 (45.0%)	100	76.7	100

Using a viral metagenomics approach, Cox-Foster et al. 2007 demonstrated that Israeli Acute Paralysis Virus is associated with colony collapse

Israeli Acute Paralysis Virus (IAPV)

- First described in Israel in 2004
- Israeli version causes shivering of wings and paralysis
- Never before reported in the U.S.
- IAPV was reported in 83% of CCD colonies
- IAPV was also found in Australian bees imported for almond pollination in 2005 (after Congress lifted the 1922 ban on importation)



Australians took issue with any implication that their bees were involved…

HISTORICAL PRESENCE OF ISRAELI ACUTE PARALYSIS VIRUS IN THE UNITED STATES

by YANPING CHEN and JAY D. EVANS*
USDA-ARS, Bee Research Laboratory, Beltsville, MD 20705

High bee colony losses in the United States this past year can be attributed in part to an unresolved syndrome termed Colony Collapse Disorder (CCD). An extensive genetic survey found one virus, Israeli Acute Paralysis Virus (IAPV), to be strongly associated with CCD. Using DNA sequencing and phylogenetic analyses, we provide evidence that IAPV was present in U.S. bees collected several years prior to CCD, and prior to the recent importation into the U.S. of honey bees from Australia and New Zealand. While downplaying the importance of bee importation for the appearance of CCD, these results indicate an urgent need to test specific strains of IAPV for their disease impacts.

Some of the research colonies used in the study

Gathering field samples for analysis

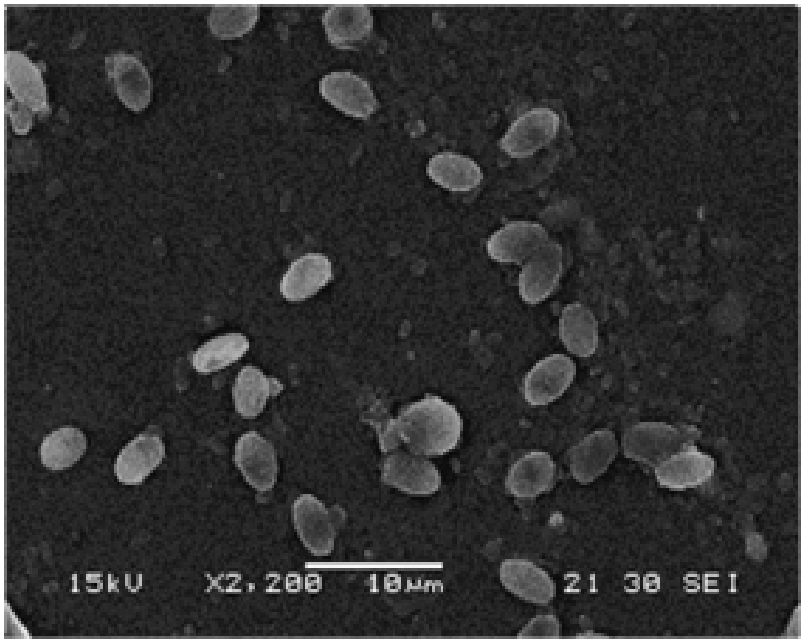
But IAPV wasn't the answer…

-- healthy colonies in the U.S. had IAPV in 2001

Chen and Evans. 2007. American Bee Journal.

An unusual fungal pathogen, *Nosema ceranae*

MAERC

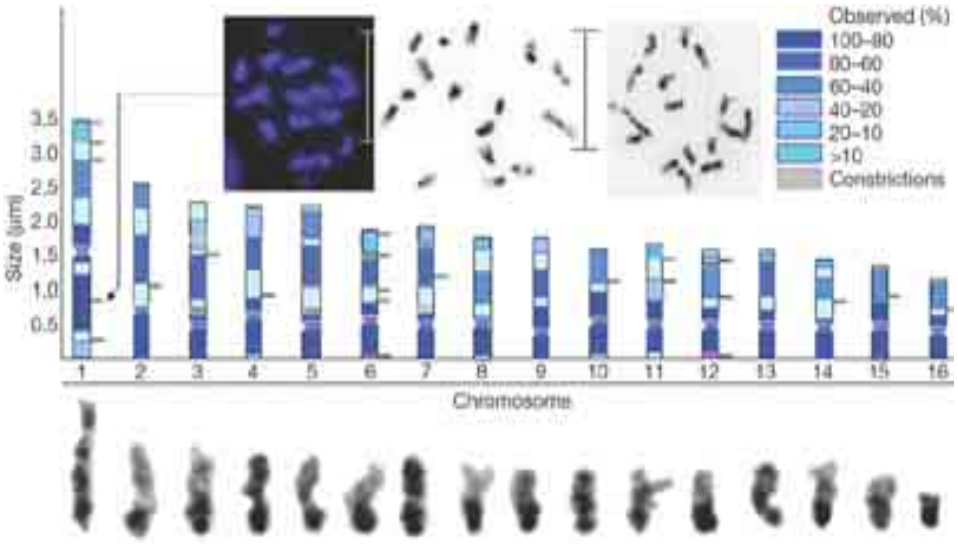


***N. ceranae* causes CCD?**
-- no diarrhea (in contrast with *Nosema apis*)

--100% of CCD colonies

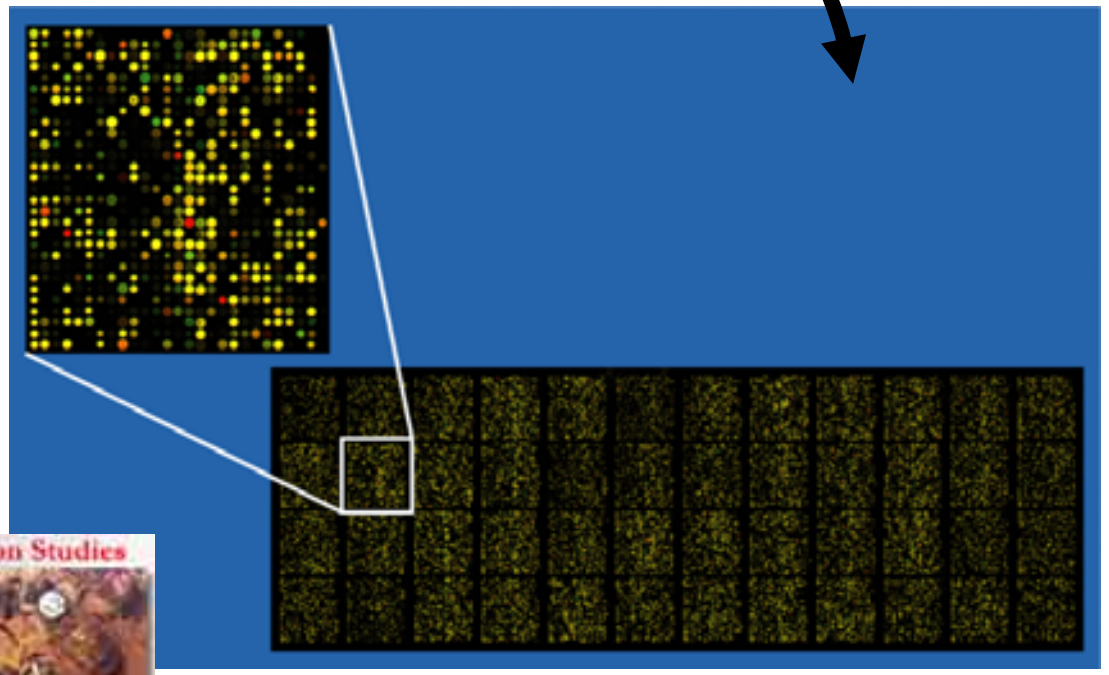
But . . .
-- *N. ceranae* in US since 1995

-- present in 81% of non-CCD colonies



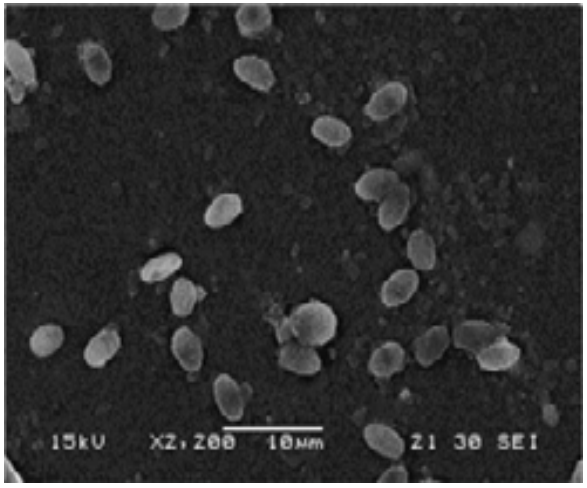
10,157 genes

Honey bee whole genome microarray (UIUC-Gene Robinson)



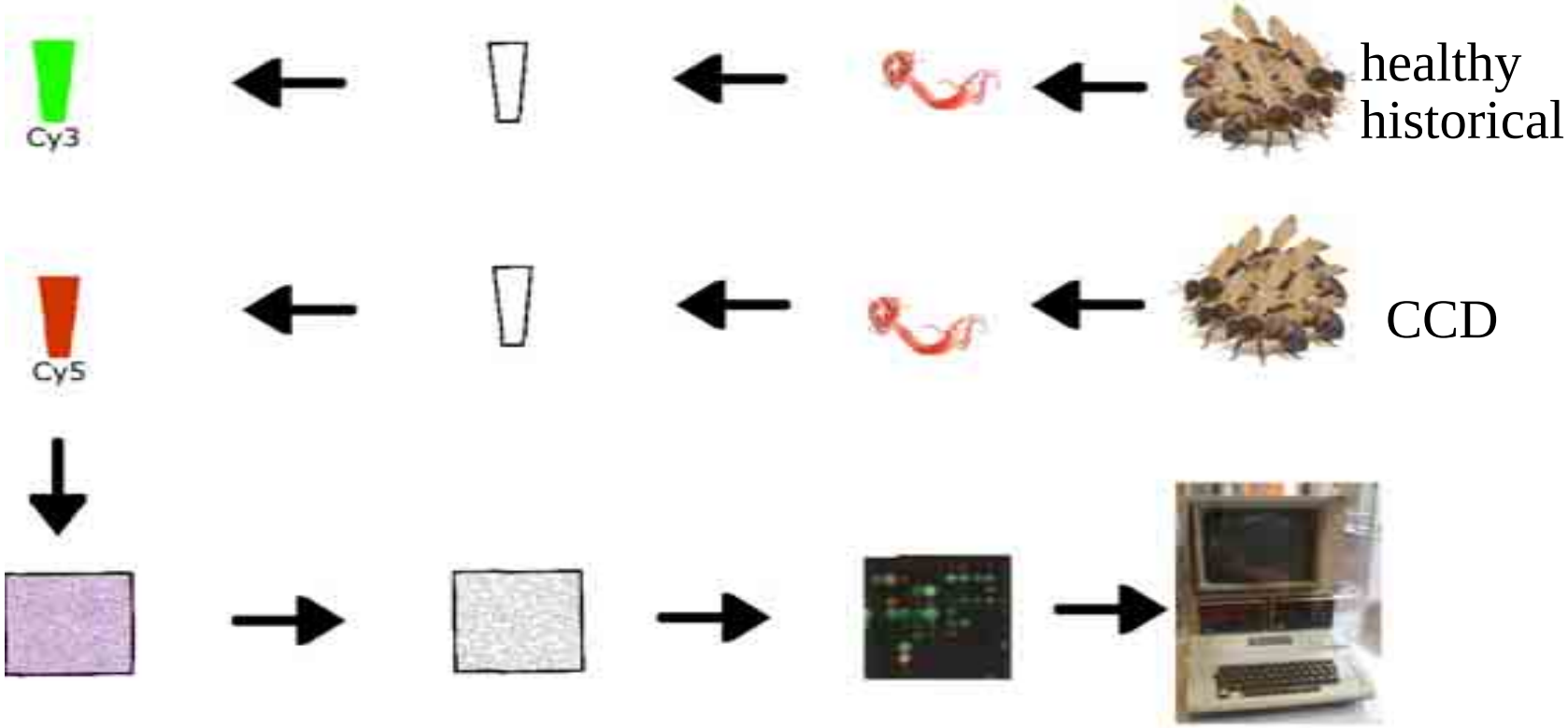
Gene expression, turning genes on or off, is a bee's first response to stress

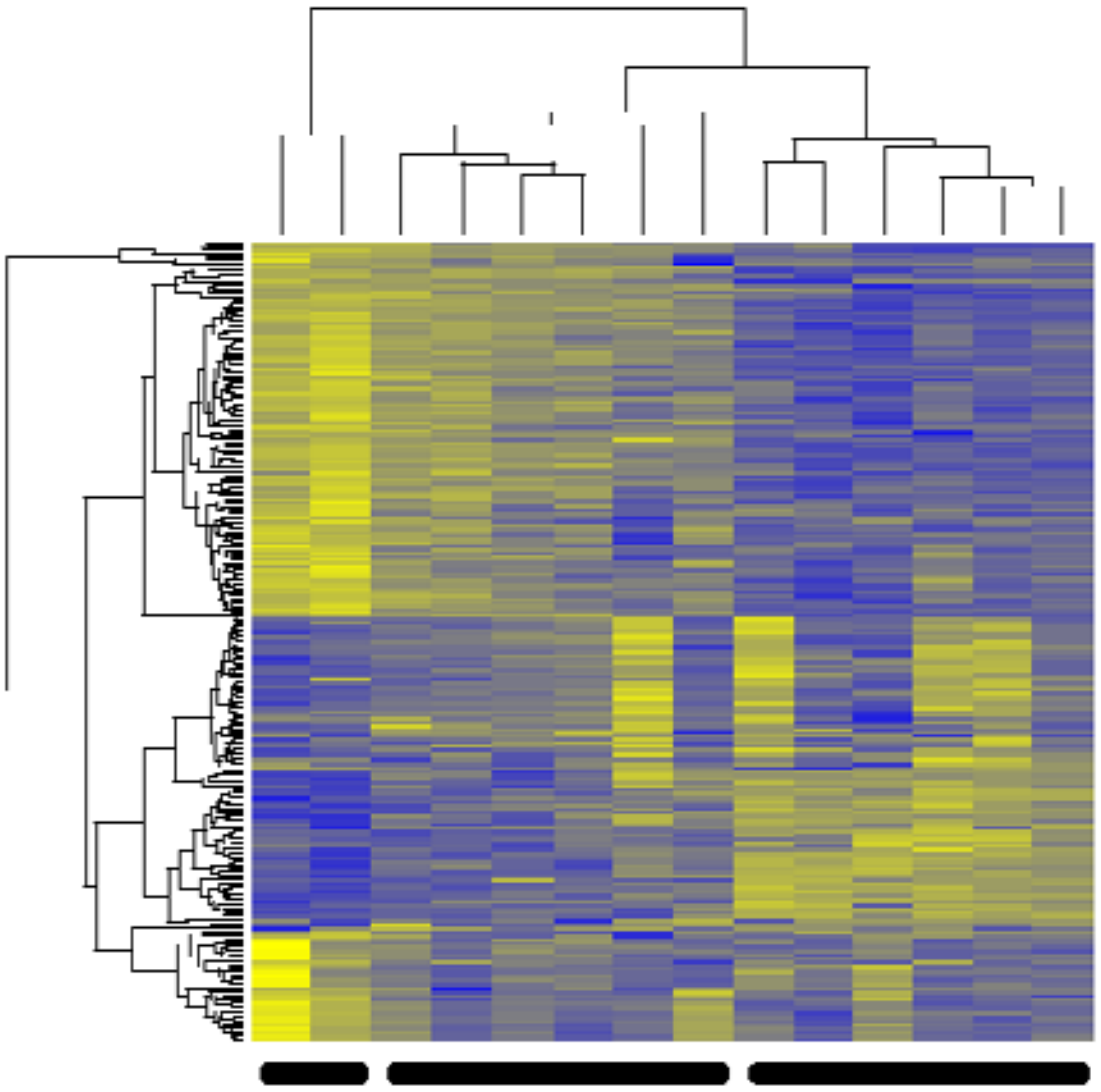
↑ detox genes



↑ immune genes

Microarray analysis compares gene expression in “healthy” (pre-CCD) and CCD bees





Heat map displays differences between CCD and “historical” bees

Yellow--upregulated

Blue--downregulated

← antibacterial proteins (apidaecins) down in CCD

← “programmed cell death” genes up in CCD

← **“unknown” genes might be diagnostic for CCD (ribosomal RNA fragments)**

Picorna-like viruses…

Table 3. Prevalence of pathogens in CCD and healthy bees

Year	Status	State	Colonies	ABPV	KBV	IAPV	DWV	SBV	Number of viruses	*Nosema* *apis*	*Nosema* *ceranae*	Number of pathogens
2006	Healthy	MA/PA	14	0%	14%	7%	64%	36%	1.21 ± 0.80	0%	50%	1.71 ± 0.99
	CCD	FL	24	38%	38%	25%	46%	8%	1.54 ± 1.67	8%	42%	2.04 ± 2.03
	CCD	CA	57	51%	21%	21%	58%	30%	1.81 ± 1.41	40%	60%	2.81 ± 1.74
2007	Healthy	CA	14	86%	7%	14%	29%	7%	1.43 ± 1.02	7%	86%	2.36 ± 1.00
	CCD	CA	16	69%	44%	25%	44%	6%	1.88 ± 0.72	0%	94%	2.81 ± 0.83

Van Engelsdorp et al. (PLoS One, 2009) also found consistently higher pathogen loads in CCD bees…

Colony Collapse Disorder: A Descriptive Study

Dennis vanEngelsdorp[1,2], Jay D. Evans[5], Claude Saegerman[3], Chris Mullin[2], Eric Haubruge[4], Bach Kim Nguyen[4], Maryann Frazier[2], Jim Frazier[2], Diana Cox-Foster[2], Yanping Chen[5], Robyn Underwood[2], David R. Tarpy[6], Jeffery S. Pettis[5]*

1 Pennsylvania Department of Agriculture, Harrisburg, Pennsylvania, United States of America, 2 Department of Entomology, The Pennsylvania State University, University Park, Pennsylvania, United States of America, 3 Department of Infectious and Parasitic Diseases, Epidemiology and Risk analysis applied to the Veterinary Sciences, University of Liege, Liege, Belgium, 4 Department of Functional and Evolutionary Entomology, Gembloux Agricultural University, Gembloux, Belgium, 5 United States Department of Agriculture (USDA) – Agricultural Research Service (ARS) Bee Research Laboratory, Beltsville, Maryland, United States of America, 6 Department of Entomology, North Carolina State University, Raleigh, North Carolina, United States of America

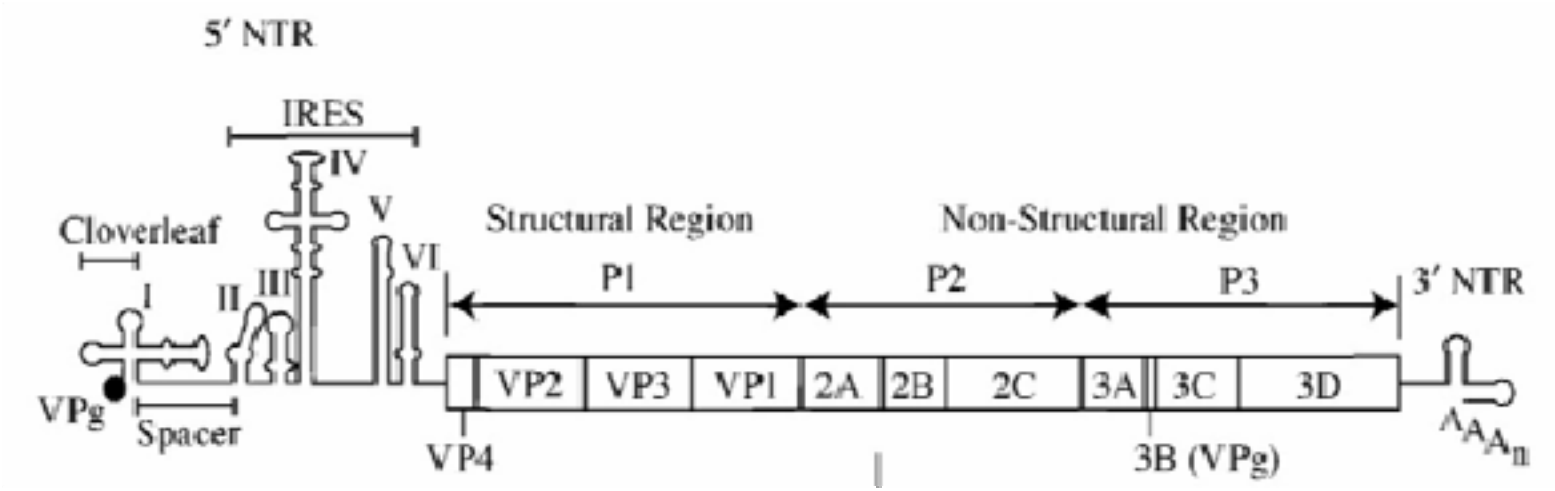
Abstract

Background: Over the last two winters, there have been large-scale, unexplained losses of managed honey bee (*Apis mellifera* L.) colonies in the United States. In the absence of a known cause, this syndrome was named Colony Collapse Disorder (CCD) because the main trait was a rapid loss of adult worker bees. We initiated a descriptive epizootiological study in order to better characterize CCD and compare risk factor exposure between populations afflicted by and not afflicted by CCD.

Methods and Principal Findings: Of 61 quantified variables (including adult bee physiology, pathogen loads, and pesticide levels), no single measure emerged as a most-likely cause of CCD. Bees in CCD colonies had higher pathogen loads and were co-infected with a greater number of pathogens than control populations, suggesting either an increased exposure to pathogens or a reduced resistance of bees toward pathogens. Levels of the synthetic acaricide coumaphos (used by beekeepers to control the parasitic mite *Varroa destructor*) were higher in control colonies than CCD-affected colonies.

Conclusions/Significance: This is the first comprehensive survey of CCD-affected bee populations that suggests CCD involves an interaction between pathogens and other stress factors. We present evidence that this condition is contagious or the result of exposure to a common risk factor. Potentially important areas for future hypothesis-driven research, including the possible legacy effect of mite parasitism and the role of honey bee resistance to pesticides, are highlighted.

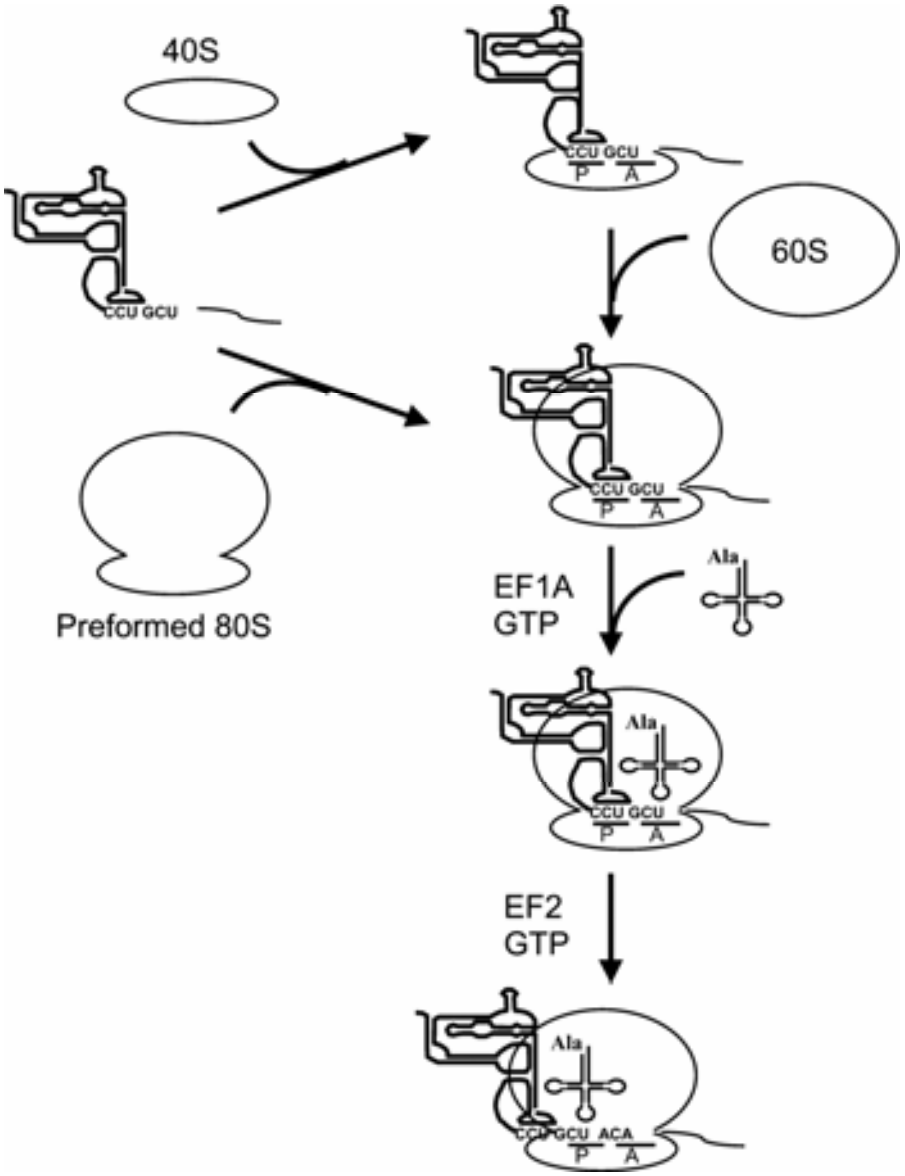
Citation: vanEngelsdorp D, Evans JD, Saegerman C, Mullin C, Haubruge E, et al. (2009) Colony Collapse Disorder: A Descriptive Study. PLoS ONE 4(8): e6481. doi:10.1371/journal.pone.0006481



The 5' non-translated region (NTR) of picornaviruses and picorna-like viruses (Dicistroviridae) contains a functional domain called the internal ribosome entry site (IRES) (members of the Dicistroviridae possess two open reading frames translated by two IRESes). The IRES is used by a virus to hijack the translation machinery in the host so the host translates viral mRNA instead of its own mRNA

Wikipedia

Figure 1 Model illustrating the recruitment of ribosomal subunits by the diverse IRES elements located in the insect Dicistroviridae viruses



Multiple viral infections are increasingly common…

ELSEVIER

Journal of Invertebrate Pathology 87 (2004) 84–93

www.elsevier.com/locate/yjipa

Multiple virus infections in the honey bee and genome divergence of honey bee viruses☆

Yanping Chen[a,*], Yan Zhao[b], John Hammond[c], Hei-ti Hsu[c], Jay Evans[a], Mark Feldlaufer[a]

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Received 17 May 2004; accepted 19 July 2004
Available online 28 September 2004

Abstract

Using uniplex RT-PCR we screened honey bee colonies for the presence of several bee viruses, including black queen cell virus (BQCV), deformed wing virus (DWV), Kashmir bee virus (KBV), and sacbrood virus (SBV), and described the detection of mixed virus infections in bees from these colonies. We report for the first time that individual bees can harbor four viruses simultaneously. We also developed a multiplex RT-PCR assay for the simultaneous detection of multiple bee viruses. The feasibility and specificity of the multiplex RT-PCR assay suggests that this assay is an effective tool for simultaneous examination of mixed virus infections in bee colonies and would be useful for the diagnosis and surveillance of honey bee viral diseases in the field and laboratory. Phylogenetic analysis of putative helicase and RNA-dependent RNA polymerase (RdRp) encoded by viruses reveal that DWV and SBV fall into a same clade, whereas KBV and BQCV belong to a distinct lineage with other picorna-like viruses that infect plants, insects and vertebrates. Results from field surveys of these viruses indicate that mixed infections of BQCV, DWV, KBV, and SBV in the honey bee probably arise due to broad geographic distribution of viruses.

Apidologie

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Apidologie 39 (2008) 310-314
DOI: 10.1051/apido:2008007

Incidence of acute bee paralysis virus, black queen cell virus, chronic bee paralysis virus, deformed wing virus, Kashmir bee virus and sacbrood virus in honey bees (*Apis mellifera*) in Denmark

Steen Lykke Nielsen, Mogens Nicolaisen and Per Kryger

University of Aarhus, Faculty of Agricultural Sciences, Department of Integrated Pest Management, 4200 Slagelse, Denmark

Received 31 July 2007 - Revised 13 December 2007 - Accepted 13 December 2007 - Published online 10 April 2008

Abstract - Samples of adult honey bees from apiaries with unusually high winter mortality and brood from hives with symptoms of disease were tested for presence of acute bee paralysis virus (ABPV), black queen cell virus (BQCV), chronic bee paralysis virus (CBPV), deformed wing virus (DWV), Kashmir bee virus (KBV) and sacbrood virus (SBV) by RT-PCR. All six viruses were detected, but the frequencies varied significantly: SBV was detected in 78 apiaries, DWV in 55, ABPV in 11, CBPV in 4, BQCV in 1 and KBV in 1. This is the first record of KBV in Denmark. A large majority of the bee samples were infected with one or more viruses. Single, dual and triple infections were observed. Nucleotide sequences of the PCR products from each virus were determined and found to be 98-99% identical to GenBank accessions except CBPV, which was only 88-90% identical to known CBPV sequences.

…all over the world…

…probably as a result of globalization of trade…

ELSEVIER

Journal of Invertebrate Pathology 98 (2008) 235–238

www.elsevier.com/locate/yjipa

Short Communication

Prevalence of pathogenic bee viruses in Hungarian apiaries: Situation before joining the European Union

Petra Forgách [a], Tamás Bakonyi [a,b], Zsuzsanna Tapaszti [a], Norbert Nowotny [b], Miklós Rusvai [c,*]

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[b] *Zoonoses and Emerging Infections Group, Clinical Virology, Clinical Department of Diagnostic Imaging, Infectious Diseases and Clinical Pathology, University of Veterinary Medicine, Vienna, Veterinärplatz 1, A-1210 Vienna, Austria*

[c] *Department of Pathology and Forensic Veterinary Medicine, Faculty of Veterinary Science, Szent István University, István u. 2, H-1078 Budapest, Hungary*

Received 9 August 2007; accepted 12 November 2007
Available online 19 November 2007

Abstract

A survey on the occurrence of six honeybee-pathogenic viruses was carried out using one-step RT-PCR assays. Samples were collected between 1999 and 2004 in 52 Hungarian apiaries located in different regions of the country. The results of the assays on samples of adult honeybees and *Varroa destructor* mites were compared to similar surveys from France and Austria. The study demonstrates geographical differences in the prevalence of honeybee viruses between Hungary and the older EU member states. The results could serve as a basis for monitoring further changes in the distribution of honeybee viruses in Europe.

Although the microarray analysis doesn't directly identify a cause, it provides tools for genome-enabled diagnosis so that beekeepers will have earlier opportunities to take action

Curing CCD won’t

- protect bees against future pests or pathogens (increasingly likely with globalization of trade)
- provide “crop insurance” in the form of alternative pollinators
- maintain wild populations of pollinators to insure the vitality of both managed and natural plant communities

It’s unlikely that honey bees will go extinct (there are close to two dozen races across the globe), but the beekeeping industry in the U.S. might not survive; prospects for survival of wild pollinators are impossible to assess without baseline data

Unlike sunshine, pollination is not an inexhaustible resource

Häagen-Dazs

honey, please don't go

hd hb

Thanks!

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