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**ARS Honey Bee Health and Colony Collapse Disorder**



Honey bees are a critical link in U.S. agricultural production. Pollination by managed honey bee colonies adds at least \$15 billion to the value of U.S. agriculture annually through increased yields and superior-quality harvests. But managed honey bees have come under serious pressures from many different stresses, which has resulted in beekeepers losing many colonies.

One problem plaguing honey bees since 2006 has been Colony Collapse Disorder (CCD), which is a syndrome specifically defined as a dead colony with no adult bees and with no dead bee bodies but with a live queen, and usually honey and immature bees, still present. CCD is not a general term that covers all managed honey bee colonies that are lost due to any reason. No scientific cause for CCD has been proven. Most research has pointed to a complex of factors being involved in the cause of CCD, and possibly not all of the same factors or the same factors in the same order are involved in all CCD incidents.

But CCD is far from the only major threat to the health of honey bees and the economic stability of commercial beekeeping in the United States. In fact, the number of managed colonies that beekeepers have reported losing specifically from CCD has been waning since 2010. But the beekeeping industry continues to report losing a high percentage of their colonies each year to other causes.

Major factors threatening honey bee health can be divided into four general areas: parasites and pests, pathogens, poor nutrition, and sublethal exposure to pesticides. In reality though, these factors tend to overlap and interact with one another, which complicates issues. In addition, there are other issues that have impacts on honey bee health such as the narrow genetic base of honey bees in the United States.

The Agricultural Research Service (ARS), USDA's in-house scientific research agency, is striving to enhance overall honey bee health and improve bee management practices by studying honey bee diseases and parasites and how best to control them, as well as basic honey bee biology and genetics. ARS scientists also are working on projects as diverse as studying the biological interaction of simultaneous exposure to sublethal amounts of pesticides and infection by nosema fungi to long-term storage of honey bee semen to preserve genetic resources. In addition, ARS researchers are cooperating with other Federal agencies and State departments of agriculture, universities, and private companies in a variety of projects to improve honey bee health.

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**Colony Collapse Disorder (CCD)**

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**Why Should the Public Care About What Happens to Honey Bees?**

About one mouthful in three in our diet directly or indirectly benefits from honey bee pollination. Commercial production of many high-value and specialty crops like almonds and other tree nuts, berries, fruits and vegetables depend on pollination by honey bees. These are the foods that give our diet diversity, color, and flavor.

Honey bees are not native to the New World; they were brought here from Europe in the 1500s and 1600s by colonists. But many of our crops also came from the Old World and evolved in the same places as honey bees. There are native pollinators in the United States, but honey bees are more prolific and easier to manage, especially on a commercial level for pollination of a wide variety of crops. Almonds, for example, are almost completely dependent on honey bees for pollination. In California, the almond industry makes use of almost three-quarter of all managed honey bee colonies in the United States, brought from all over the country during one short window of time in January and February each year.

**Latest News about ARS Honey Bee Research**

[Bees Abuzz Over Rapini](#)

[USDA Research Identifies Factors for Faster Commercial Honey Bee Queen Failure](#)

**Additional Information**

- [2014 USDA HB Forage Nutrition Summit Report](#)
- [Attractiveness of Agriculture Crops to Pollinating Bees](#)
- [Varroa Summit 05-19-2015](#)

## Honey Bee Health Problems

**Parasites and pests:** Varroa mites (*Varroa destructor*) are essentially a modern honey bee plague. The Varroa mite has been responsible for the deaths of massive numbers of honey bee colonies since its arrival in the United States in 1987. A native of Asia, Varroa normally parasitizes the Asian honey bee, *Apis cerana*, which is a different species from the European or western honey bee, *Apis mellifera*, on which this country primarily depends for crop pollination.

Varroa mites directly damage honey bees by attaching and sucking the bees' equivalent of blood (hemolymph fluid) somewhat like ticks. They also indirectly damage honey bees because, similarly to mosquitoes, Varroa mites also transmit an array of pathogenic viruses to honey bees such as deformed wing virus.

Beekeepers have identified Varroa mites as their single most serious problem causing colony losses today.

Small hive beetles, native to sub-Saharan Africa, were first found in the United States in 1996 and had spread to 30 States by 2014. Large beetle populations are able to lay enormous numbers of eggs. These eggs develop quickly and result in rapid destruction of unprotected combs in a short time. If large populations of beetles are allowed to build up, even strong colonies can be overwhelmed in a short time.

Wax moths arrived in the United States in 1998 in Florida. This can be a very destructive insect pest, damaging beeswax comb, comb honey, and bee-collected pollen. Wax moths are rarely the initial cause of colony failure but can overcome weak colonies.

**Pathogens:** Since the 1980s, many new exotic pathogens that infect honey bees have been found in this country. These include deformed wing virus, paralytic viruses such as Israeli acute paralysis virus, which was first found in 2004, European foulbrood bacteria, and *Nosema ceranae* fungi, which arrived in 2005. They have all become major problems for U.S. honey bees and beekeepers.

**Poor nutrition:** Honey bees' natural diet comes primarily from nectar and pollen gathered from a wide variety of flowers. Insufficient or incomplete nutrition has come to be recognized as an essential factor that weakens the honey bee's immune systems and is likely to make bees more susceptible to all of the other problems troubling them today.

As demand for pollination services grows, bee colonies often are kept for more time on sites in a mono-crop environment before being moved directly to the next mono-crop area. As more and more land is lost to urbanization and suburbanization, it also means a loss of habitat with a diverse mix of nutritious bee forage plants. In addition, when it comes to helping bee colonies survive the winter and droughts, both times when nectar supplies can be scarce for bees, beekeepers often provide an artificial diet. Scientists are still trying to perfectly duplicate a bee's natural pollen/nectar diet for those times of the year when good forage is not available.

**Pesticides:** The U.S. Environmental Protection Agency (EPA) has strict regulations to protect managed honey bee colonies from incidents of pesticide misuse in formulation or application. Tips and complaints alleging pesticide-related bee incidents may be reported to State or tribal authorities or directly to the EPA Office of Pesticide Programs, [beekill@epa.gov](mailto:beekill@epa.gov), National Pesticide Information Center: <http://pi.ace.orst.edu/erep/> or <https://www.epa.gov/compliance/guidance-inspecting-alleged-cases-pesticide-related-bee-incidents>.

**Sublethal pesticide effects:** A survey of honey bee colonies conducted in 2010 by ARS researchers looked at 170 pesticides or their residues in honey bees, beeswax, and pollen. The data showed no consistent pattern of pesticide that differed between healthy and CCD-affected colonies. The most commonly found pesticide in the study was coumaphos, which is used by beekeepers to treat honey bees for Varroa mites.

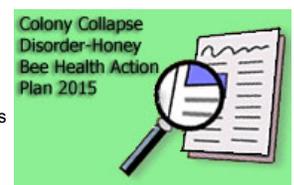
The pesticide class neonicotinoids (for example, clothianidin, thiamethoxam, and imidacloprid) has been accused of damaging or killing honey bees or being the cause of CCD even when the exposure is below the level expected to be toxic. The nicotine-based neonicotinoids were developed in the mid-1990s in large part because they showed reduced toxicity to wildlife compared with previously used organophosphate and carbamate insecticides.

The scientific data about the impact of pesticides and neonicotinoids in particular at environmentally and agriculturally realistic levels is mixed. Some findings have shown that neonicotinoids have sublethal effects on honey bees at or below approved doses and exposures. Documenting such sublethal effects is very difficult due to the many factors that can influence individual situations in field studies and during grower use including timing of use, health and nutritional state of the bees, total mix of pesticides, pathogens and parasites present, crop type, weather during the growing season, and accumulation of pesticides from year to year. Other studies have indicated that healthy colonies appear not to be impacted.

While these four areas are easy to categorize on paper, in reality these factors often may overlap or interact with one another. Honey bees might be able to survive many of these problems if the problems occurred one at a time. But when they hit in any of a wide variety of combinations, the result can weaken and overcome the honey bee colony's ability to survive.

## ARS Research Directions

ARS is focused on directly improving the health of managed honey bees by finding ways to mitigate the impacts of pathogens, pests, and pesticides and enhancing bee nutrition and management. Agency scientists are also working on projects that take a bigger-picture view toward helping honey bees. This includes developing better knowledge about areas such as gut microbes and their interactions with honey bee immune systems, preservation and expansion of honey bee genetic diversity, and evaluating the effect of land management practices on bees to assure better productivity of pollinators.



For more information about ARS honey bee research programs, see [ARS National Program #305 Action Plan -- 2013-2018](#)

## ARS News about Honey Bees

[Bees Abuzz Over Rapini](#)

[USDA Research Identifies Factors for Faster Commercial Honey Bee Queen Failure](#)

[New ARS Bee Genebank Will Preserve Genetic Diversity and Provide Breeding Resources](#)

[Camelina Cover Crops a Boon for Bees](#)

[Newly Named Bacteria Help Honey Bee Larvae Thrive](#)

[Research Shows Honey Bee Diseases Can Strike in All Seasons](#)

[Colony Collapse Disorder: An Incomplete Puzzle](#)  
*Agricultural Research* magazine July 2012

[Colony Collapse Disorder: A Complex Buzz](#)  
*Agricultural Research* magazine May/June 2008

[Pathogen Loads Higher in Bee Colonies Suffering from Colony Collapse Disorder](#)

[Honey Bees with Colony Collapse Disorder Show their Genes](#)  
[Still Seeking a Cause of Colony Collapse Disorder](#)  
[Imported Bees Not Source of Virus Associated with Colony Collapse Disorder](#)  
[Genetic Survey Finds Association Between CCD and Virus](#)

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#### **Best Recommendation for Beekeepers**

Since little is known for sure about the cause(s) of CCD, mitigation must be based on improving general honey bee health and habitat and countering known mortality factors by using best management practices. This includes supplemental feeding in times of nectar/pollen scarcity.

#### **Best Recommendations for the Public**

The best action the public can take to improve honey bee survival is not to use pesticides indiscriminately. In particular, the public should avoid applying pesticides during mid-day hours, when honey bees are most likely to be out foraging for nectar and pollen on flowering plants.

In addition, the public can plant pollinator-friendly plants—plants that are good sources of nectar and pollen such as red clover, foxglove, bee balm, joe-pye weed, and other native plants. (For more information, visit [www.nappc.org](http://www.nappc.org).)



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#### **Recent ARS Honey Bee Scientific Publications**

[Population growth of \*Varroa destructor\* \(Acari: Varroidae\) in honey bee colonies is affected by the number of foragers with mites, \*Experimental and Applied Acarology\*, 2016](#)

[\*Parasaccharibacter apium\*, gen. nov., sp. nov., improves honey bee \(Hymenoptera: Apidae\) resistance to \*Nosema\*, \*Journal of Economic Entomology\*, 2016](#)

[Nectar production in oilseeds: Food for pollinators in an agricultural landscape, \*Crop Science\*, 2016](#)

[Brood removal influences fall of \*Varroa destructor\* \(Mesostigmata: Varroidae\) in honey bee \(Hymenoptera: Apidae\) colonies, \*Journal of Apicultural Research\*, 2016](#)

[How hives collapse: Allee effects, ecological resilience, and the honey bee. \*PLoS One\*, 2016](#)

[The fungicide Pristine® inhibits mitochondrial function in vitro but not flight metabolic rates in honey bees, \*Journal of Insect Physiology\*, 2016](#)

[Sperm viability and gene expression in honey bee queens \(\*Apis mellifera\*\) following exposure to the neonicotinoid insecticide Imidacloprid and the organophosphate Acaricide Coumaphos, \*PLoS One\*, 2016](#)

[The effects of Imidacloprid and \*Varroa destructor\* on the survival and health of European honey bees, \*Apis mellifera\*, \*Insect Science\*, 2016](#)

[Evidence of \*Apis cerana\* sacbrood virus infection in \*Apis mellifera\*, \*Applied and Environmental Microbiology\*, 2016](#)

[A scientific note on detection of honey bee viruses in the darkling beetle \(\*Alphitobius diaperinus\*\), an inhabitant in \*Apis cerana\* colonies, \*Apidologie\*, 2016](#)

[Hybrid origins of Australian honey bees \(\*Apis mellifera\*\), \*Apidologie\*, 2015](#)

[Honey bee colonies provided with natural forage have lower pathogen loads and higher overwinter survival than those fed protein supplements, \*Apidologie\*, August 2015](#)

[Prevalence and reproduction of \*Tropilaelaps mercedesae\* and \*Varroa destructor\* in concurrently infested \*Apis mellifera\* colonies, \*Apidologie\*, May 2015](#)

[Israeli acute paralysis virus: epidemiology, pathogenesis and implications for honey bee health and Colony Collapse Disorder \(CCD\), \*PLoS Pathogens\*, July 2014](#)

[Functionality of \*Varroa\*-Resistant Honey Bees \(Hymenoptera: Apidae\) When Used for Western U.S. Honey Production and Almond Pollination, \*Journal of Economic Entomology\*, April 2014](#)

[The microbial communities associated with honey bee \(\*Apis mellifera\*\) foragers, \*PLoS One\*, March 2014](#)

[Finding the missing honey bee genes: lessons learned from a genome upgrade, \*BMC Genomics\*, January 2014](#)

[Crop pollination exposes honey bees to pesticides which alters their susceptibility to the gut pathogen \*Nosema ceranae\*, \*PLoS One\*, July 2013](#)

[Pathogen webs in collapsing honey bee colonies, \*PLoS One\*, August 2012](#)

[Pesticide exposure in honey bees results in increased levels of the gut pathogen, \*Naturwissenschaften\*, February 2012](#)

[Predictive markers of honey bee colony collapse, \*PLoS One\*, February 2012](#)

[Coordinated responses to honey bee decline in the USA, \*Apidologie\*, May-June 2010](#)

[High levels of miticides and agrochemicals in North American apiaries: Implications for honey bee health, \*PLoS One\*, March 2010](#)

[Weighing risk factors associated with bee colony collapse disorder by classification and regression tree analysis, \*Journal of Economic Entomology\*, October 2010](#)

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#### ARS Honey Bee Research Laboratories

- [Bee Research Laboratory](#)  
Beltsville, MD  
  
CCD overview: <http://ars.usda.gov/Services/docs.htm?docid=15908>
- [Carl Hayden Bee Research Center](#)  
Tucson, AZ
- [Honey Bee Breeding, Genetics and Physiology Research Unit](#)  
Baton Rouge, LA
- [Pollinating Insect Biology, Management, Systematics Research Laboratory](#)  
Non-Honey Bee Pollinators  
Logan, Utah

#### U.S. Honey Bee Losses

The total number of managed honey bee colonies has decreased from 5 million in the 1940s to about 2.66 million today, according to a USDA-National Agricultural Statistics Service (NASS) survey. There are many factors that may have contributed to this long-term slide, a number of them economic or cultural through the 1980s. These may have included a drop in the number of farms, especially small farms after World War II, accompanied by increasing opportunities for off-farm jobs for farm wives who often sold honey and honey products. In addition, drops in prices of honey started the downward slide in the number of colonies. In the late 1980s, the onset of *Varroa* mites and other bee health issues played a role in another drop in numbers of managed colonies. Typical average annual losses jumped to about 15-22 percent of managed colonies.

When Colony Collapse Disorder (CCD) began to be reported in 2006/2007, annual losses of honey bee colonies rose again. CCD has since waned, but high losses have continued, averaging about 30 percent. It is not known if this is because beekeepers are better at ascribing losses to particular causes, if causes have shifted, or if other factors have changed.

There has been a recent increase in the overall total number of managed honey bee colonies. This is being driven mostly by an increasing demand for almond pollination, which is tightly clustered in just a few weeks in late January and early February. California almond acreage grew to 1,020,000 in 2014, up 5 percent from 2013. In 2010, it was 810,000 acres — a 2 percent increase from 2008's 795,000 acres. Almond growers are the largest single users of honey bee pollination and need the colonies all in a short period of time.

To meet the increasing demand, beekeepers are splitting hives and buying more queens to create more colonies, which ends up with greater total numbers of colonies. But they are still losing higher percentages of their colonies now than they were 10 years ago before CCD and all the other bee health problems surfaced. The two numbers are different measures: total colonies vs. percent loss.

#### Survey Reports Latest Honey Bee Losses

[May 2016](#)  
[May 2015](#)  
[May 2014](#)  
[Winter 2012/2013](#)  
[May 2012](#)  
[May 2011](#)  
[April 2010](#)  
[May 2009](#)  
[May 2008](#)

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#### CCD History

In October 2006, some beekeepers began reporting losses of 30-90 percent of their hives. While colony losses are not unexpected, especially over the winter, this magnitude of losses was unusually high.

The main symptom of CCD is very low or no adult honey bees present in the hive but with a live queen and no dead honey bee bodies present. Often there is still honey in the hive, and immature bees (brood) are present. *Varroa* mites, a virus-transmitting parasite of honey bees, have frequently been found in hives hit by CCD.

This is not the first time that beekeepers are being faced with unexplained losses. The scientific literature has several mentions of honey bee disappearances—in the 1880s, the 1920s, and the 1960s. While the descriptions sound similar to CCD, there is no way to know for sure if those problems were caused by the same agents as CCD.

There have also been unusual colony losses before. In 1903, in the Cache Valley in Utah, 2000 colonies were lost to an unknown "disappearing disease" after a "hard winter and a cold spring." More recently, in 1995-96, Pennsylvania beekeepers lost 53 percent of their colonies without a specific identifiable cause.

In June 2007, ARS and the National Institute of Food and Agriculture (NIFA), USDA's extramural research grants agency, co-chaired a workshop of scientists and stakeholders to develop a Colony Collapse Disorder Action Plan. This plan identified areas where more information was needed and developed a research priority list for additional research projects related to finding the cause/causes of CCD.

## Cell Phones and CCD

Despite a great deal of attention having been paid to the idea, neither cell phones nor cell phone towers have been shown to have any connection to CCD or poor honey bee health.

Originally, the idea was provoked by the media making a connection between CCD and a very small study done in Germany. But that study looked at whether a particular type of base station for cordless phones could affect honey bee homing systems. However, despite all the attention that this study has received, the base station has nothing to do with CCD. Stefan Kimmel, the researcher who conducted the study and wrote the paper, e-mailed *The Associated Press* to say that there is "no link between our tiny little study and the CCD-phenomenon ... Anything else said or written is a lie."

In addition, apiaries are often located in rural areas, where cell phone coverage can be spotty. This makes cell phones or cell towers unlikely culprits.

In addition, apiaries are often located in rural areas, where cell phone coverage can be spotty. This makes cell phones or cell towers unlikely culprits.

Research from ARS and other institutions has provided new management recommendations that beekeepers have begun to adopt. For example, it is now recommended that beekeepers feed honey bees more protein during times of nectar shortage such as during times of drought or in the winter. As part of this, ARS has developed a new bee diet, Megabee, now available to beekeepers. The feeding of supplemental nutrients may help to decrease winter colony losses.

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In 2008, Germany revoked the registration of the neonicotinoid clothianidin for use on seed corn after an incident that resulted in the die-off of hundreds of nearby honey bees colonies. Investigation into the incident revealed that the die-off was caused by a combination of factors, including the failure to use a polymer seed coating known as a "sticker": weather conditions that resulted in late planting of corn while nearby canola crops were in bloom, attracting honey bees; use of a particular type of air-driven equipment used to sow the seeds, which blew clothianidin-laden dust off the seeds and into the air as the seeds were ejected from the machine into the ground; dry and windy conditions at the time of planting, which blew the dust into the nearby canola fields where honey bees were foraging; and a higher application rate than had been authorized was used to treat for a severe root worm infestation.

ARS researchers also have been analyzing samples from healthy and CCD-struck colonies and applying a variety of stressors from the four categories of possible causes to colonies in hopes of provoking a colony response that duplicates CCD.

While a number of potential causes have been championed by a variety of researchers and interest groups, none of them have stood up to detailed scrutiny. Every time a claim is made of finding a "smoking gun," further investigation has not been able to make the leap from a correlation to cause-and-effect. Other times, not even a scientific correlation has been demonstrated in the study claiming to have found "the cause" of CCD.

Researchers have concluded that no one factor is the cause of CCD. Most likely, CCD is caused by multiple factors. It is not possible to know at this time if all CCD incidents are due to the same set of factors or if the factors follow the same sequence in every case.

Studies are being conducted by ARS scientists and collaborators to look at the combined impact of two or more factors on honey bees-most recently the impact of exposure to the neonicotinoid imidacloprid and Nosema. While the dual exposure indicated some sublethal effects on individual honey bees, the overall health of the colony did not show an adverse effect.

## Annual Reports of CCD Research Progress

[2012 CCD Progress Report](#)

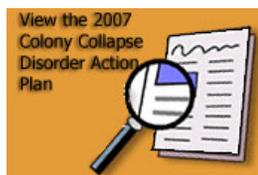
[2011 CCD Progress Report](#)

[2010 CCD Progress Report](#)

[2009 CCD Progress Report](#)

[2007-2008 CCD Progress Report](#)

## CCD Action Plans



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