Order Code RL33938

CRS Report for Congress

Recent Honey Bee Colony Declines

March 26, 2007

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Prepared for Members and Committees of Congress

Congressional Research Service

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Summary

This report examines the recent sharp decline in U.S. honey bee colonies, which scientists are now calling the Colony Collapse Disorder (CCD). This phenomenon first became apparent among commercial migratory beekeepers along the East Coast during the last few months of 2006, and has since been reported nationwide.

Honey bees are the most economically valuable pollinators of agricultural crops worldwide. Many scientists at universities and the U.S. Department of Agriculture (USDA) frequently assert that bee pollination is involved in about one-third of the U.S. diet, and contributes to the production of a wide range of fruits, vegetables, tree nuts, forage crops, some field crops, and other specialty crops. The monetary value of honey bees as commercial pollinators in the United States is estimated at about $15 billion annually.

Honey bee colony losses are not uncommon. However, current losses seem to differ from past situations in that

- colony losses are occurring mostly because bees are failing to return to the hive (which is largely uncharacteristic of bee behavior),
- bee colony losses have been rapid,
- colony losses are occurring in large numbers, and
- the reason why these losses are occurring remains still largely unknown.

To date, the potential causes of CCD, as reported by the scientists who are researching this phenomenon, include but may not be limited to

- parasites, mites, and disease loads in the bees and brood;
- known/unknown pathogens;
- poor nutrition among adult bees;
- level of stress in adult bees (e.g., transportation and confinement of bees, or other environmental or biological stressors);
- chemical residue/contamination in the wax, food stores and/or bees;
- lack of genetic diversity and lineage of bees; and
- a combination of several factors.

On March 29, 2007, the House Subcommittee on Horticulture and Organic Agriculture is to hold a hearing to review the recent honey bee colony declines reported throughout the United States. Based on information presented to Congress, both by scientists researching recent bee colony declines and by agricultural producers who may be potentially affected by these losses, Congress could consider options for subsequent action in this area.

This report will be updated after the House Subcommittee hearing to report additional information from the hearing and possible congressional response to this current situation.

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Recent Honey Bee Colony Declines

This report examines the recent sharp decline in U.S. honey bee colonies, or the so-called Colony Collapse Disorder (CCD). This phenomenon first became apparent among commercial migratory beekeepers along the East Coast during the last few months of 2006 and has since been reported nationwide.

This report is organized in three parts. First, it provides an overview of the importance of honey bee pollination to U.S. agricultural production, especially specialty crops. Second, it describes the extent and symptoms of CCD and how it differs from previous honey bee colony losses. Third, it discusses some of the reasons why scientists believe honey bee colonies are being affected by CCD.

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Importance of Honey Bee Pollination

Honey bees (genus *Apis*) are the most economically valuable pollinators of agricultural crops worldwide.[1] In the United States, bee pollination of agricultural crops is said to account for about one-third of the U.S. diet, and contribute to the production of a wide range of fruits, vegetables, tree nuts, forage crops, some field crops, and other specialty crops.[2]

The monetary value of honey bees as commercial pollinators in the United States is estimated at about $15 billion annually[3] (**Table 1**). This estimated value is measured according to the additional value of production attributable to honey bees, in terms of the value of the increased yield and quality achieved from honey bee

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[1] Some other known animal pollinators are stingless bees, bumble bees, and other bees; wasps, hover flies and other flies; beetles; thrips; ants; butterflies; moths; bats; and hummingbirds and other birds.

[2] Interview with Dr. Jeff Pettis, USDA's Agricultural Research Service, Jan. 23, 2007, at [http://podcasts.psu.edu/taxonomy/term/62]. Staple crops, such as wheat, corn, and rice do not rely on insect pollination and are mostly wind pollinated.

[3] Morse, R.A. and N.W. Calderone, *The Value of Honey Bees as Pollinators of U.S. Crops in 2000*, March 2000, Cornell University, at [http://www.masterbeekeeper.org/pdf/pollination.pdf]. Other studies show a range of estimated values from $5.7 billion to $19.0 billion (see National Research Council, *Status of Pollinators in North America*, 2006).

pollination, including the indirect benefits of bee pollination required for seed production of some crops. About one-third of the estimated value of commercial honey bee pollination is in alfalfa production, mostly for alfalfa hay. Another nearly 10% of the value of honey bee pollination is for apples, followed by 6-7% of the value each for almonds, citrus, cotton, and soybeans.

A number of agricultural crops are almost totally dependent on honey bee pollination (90-100%), including almonds, apples, avocados, blueberries, cranberries, cherries, kiwi fruit, macadamia nuts, asparagus, broccoli, carrots, cauliflower, celery, cucumbers, onions, legume seeds, pumpkins, squash, and sunflowers. Other specialty crops also rely on honey bee pollination, but to a lesser degree. These crops include apricot, citrus (oranges, lemons, limes, grapefruit, tangerines, etc.), peaches, pears, nectarines, plums, grapes, brambleberries, strawberries, olives, melon (cantaloupe, watermelon, and honeydew), peanuts, cotton, soybeans, and sugarbeets.[4] Another study found that pollinators are essential for the production of some U.S.-grown crops, particularly macadamia nuts, squash, and pumpkins.[5]

In the United States, most pollination services are provided by commercial migratory beekeepers who travel from state to state and provide pollination services to crop producers. These operations are able to supply a large number of bee colonies during the critical phase of a crop's bloom cycle, when honey bees pollinate a crop as they fly from flower to flower collecting nectar and pollen, which they carry back to the nest.[6] The latest *Census of Agriculture* by the U.S. Department of Agriculture (USDA) reports that there were about 17,000 operations with 2.4 million bee colonies in 2002.[7] The majority of these, more than 2 million bee colonies, are reported to belong to commercial migratory beekeepers. About one-third of all colonies are in California (about 20%) and Florida (10%). The Dakotas accounted for another 7% each of all bee colonies, and Texas and Montana accounted for another 5% each. Other states with a large number of bee colonies were Minnesota, Idaho, Michigan, Washington, Wisconsin, Oregon, and New York, which together accounted for about 20%. While these operations also produce honey for commercial sale, it is their value as crop pollinators that provides the greatest economic impact in the production of food and feed crops.

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[4] Ibid.

[5] Klein, A-M, B.E. Vaissière, J.H. Cane, I. Steffan-Dewenter, S.A. Cunningham, C. Kremen, and T. Tscharntke, "Importance of pollinators in changing landscapes for world crops," *Proceedings of the Royal Society B: Biological Sciences*, Vol. 274, No. 1608, Feb. 7, 2007.

[6] Some "spillover" pollination occurs free of charge, including pollination from colonies owned by part-time beekeepers and hobbyists, or pollination of adjacent fields from commercial hives.

[7] USDA, *2002 Census of Agriculture,* Table 19. Other estimates by Cornell University indicate that the number of colonies in the early 2000s may have been greater, at 2.9 million colonies in 2000.

Table 1. Estimated Value of the Honey Bee to U.S. Crop Production, by Major Crop Category, 2000 Estimates

Crop Category (ranked by share of honey bee pollinator value)	Dependence on Insect Pollination	Proportion of Pollinators That Are Honey Bees	Value Attributed to Honey Bees[a] ($ millions)	Major Producing States[b]
Alfalfa, hay & seed	100%	60%	4,654.2	CA, SD, ID, WI
Apples	100%	90%	1,352.3	WA, NY, MI, PA
Almonds	100%	100%	959.2	CA
Citrus	20% - 80%	10% - 90%	834.1	CA, FL, AZ, TX
Cotton (lint & seed)	20%	80%	857.7	TX, AR, GA, MS
Soybeans	10%	50%	824.5	IA, IL, MN, IN
Onions	100%	90%	661.7	TX, GA, CA, AZ
Broccoli	100%	90%	435.4	CA
Carrots	100%	90%	420.7	CA, TX
Sunflower	100%	90%	409.9	ND, SD
Cantaloupe/honeydew	80%	90%	350.9	CA, WI, MN, WA
Other fruits & nuts[c]	10% - 90%	10% - 90%	1,633.4	—
Other vegetables/melons[d]	70% - 100%	10% - 90%	1,099.2	—
Other field crops[e]	10% - 100%	20% - 90%	70.4	—
Total	**—**	**—**	**$14,563.6**	**—**

Source: Compiled by CRS using values reported in Morse, R.A., and N.W. Calderone, *The Value of Honey Bees as Pollinators of U.S. Crops in 2000*, March 2000, Cornell University, at [http://www.masterbeekeeper.org/pdf/pollination.pdf].

a. Attributed value is the additional value of production attributable to honey bees, in terms of the value of the increased yield and quality achieved from honey bee pollination, including the indirect benefits of bee pollination required for seed production of some crops. Calculated from total average production value (1996-1998).

b. For most commodities, major producing states reflect reported 2006 production ([http://www.nass.usda.gov/QuickStats/]). Melon production is based on reported 2002 harvested acreage.

c. Apricots, avocados, blueberries, brambleberries, cherries, cranberries, grapes, kiwi fruit, macadamia nuts, olives, peaches, pears, nectarines, plums, and strawberries.

d. Asparagus, cauliflower, celery, cucumbers, pumpkins, squash, watermelon, and vegetable seeds.

e. Peanuts, canola (rapeseed), and sugarbeets.

Each year, an estimated more than 2 million bee colonies are rented for U.S. crop pollination. Available limited information indicates that the greatest number of honey bee colony rentals are for apple and almond production, followed by clover seed, cherries, and pears.[8] Rental fees collected by commercial beekeepers for pollination services may vary by crop type, and often tend to be lower for some seed crops and higher for berry and tree crops. In recent years, pollination fees paid by crop producers have increased. For example, fees paid by California's almond industry have risen from a reported $35 per colony in the late 1990s to about $75 per colony in 2005.[9] More recent estimates of fees for pollinating almond trees are even higher, at $150 per colony or more. Among the reasons for higher pollination fees are expanding almond acreage and relatively high honey prices, but also fewer available honey bees for pollination due, in part, to colony declines and bee mortalities. About 1.4 million colonies of honey bees are used to pollinate California's current 550,000 acres of almond trees.

Extent and Symptoms of Colony Collapse Disorder

Starting in the last three months of 2006, a seemingly new phenomenon began to occur based on reports of an "alarming" number of bee colony losses and die-off along the East Coast. By the end of 2006, beekeepers on the West Coast also began to report "unprecedented" losses.[10] Because of the severity and lack of precedent, scientists coined a new term, Colony Collapse Disorder (CCD), for this phenomenon.

Much of the current research on CCD is being conducted by scientists at Pennsylvania State University, University of Montana, USDA's Agriculture Research Service (Beltsville bee laboratory), and the Pennsylvania and Florida Departments of Agriculture. Many of these researchers also participate in the CCD Working Group, which includes Bee Alert Inc., the Florida and Pennsylvania Departments of Agriculture, Pennsylvania State University, and USDA. Up-to-date information is regularly posted to the website of the Mid-Atlantic Apiculture Research and Extension Consortium (MAAREC), which represents beekeeping associations in New Jersey, Maryland, Delaware, Pennsylvania, and West Virginia.

Past Honey Bee Population Losses

Honey bee colony losses are not uncommon. A recent report by the National Research Council (NRC) documents the extensive literature on honey bee population losses due to bee pests, parasites, pathogens, and disease. Most notable are declines due to two parasitic mites, the *Varroa destructor* and the tracheal mite (*Acarapis*

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[8] Burgett, M., *1999 Pacific Northwest Honey Bee Pollination Survey*, Oregon State University.

[9] National Academy of Sciences, National Research Council, *Status of Pollinators in North America*, 2006.

[10] vanEngelsdorp, D. et al., "Fall Dwindle Disease: Investigations into the Causes of Sudden and Alarming Colony Losses Experienced by Beekeepers in the Fall of 2006," Dec. 15, 2006.

woodi), and also colony declines due to the pathogen *Paenibacillus larvae*.[11] Other reasons for bee colony declines reported by the NRC include interspecific competition between native and introduced bees, pathogen spillover effects, habitat loss, invasive plant species that reduce nectar- and pollen-producing vegetation, bee genetics, and pesticides, among other factors.

Mite infestations are a relatively new occurrence. The 1980s saw two periods of large die-offs due to *Varroa* and tracheal mites: The first *Varroa* mite infestation was reported in 1987; tracheal mites were first detected in 1984.[12] *Varroa* mites are also said to have eliminated most feral bee colonies in the mid-1990s.[13] *Varroa* parasitism affects both worker bees and male larvae and can affect the ability of the queen to reproduce. It is associated with viral pathogens and if left untreated can cause colony mortalities usually within six months to two years after the initial infestation. Less is known about the effects of the tracheal mite. The pathogen *Paenibacillus larvae* is the most serious honey bee pathogen and causes American foulbrood (AFB), which is a disease of larval honey bees. AFB resulted in large colony losses in the 1940s, but its incidence has been reduced by the use of antibiotics and increased apiary inspection programs. Nevertheless, mite and pathogen infestations have likely raised beekeeper operating costs to pay for miticides and/or antibiotics, labor and expenses for treatment, improved management and inspection, and colony replacement of dead bees.

Symptoms similar to those observed for CCD have been described in the past, and heavy losses have been documented. It is still not clear whether the current colony losses are being caused by the same factors or if new contributing factors are involved.[14] MAAREC also reports that large beekeeper operations may have experienced higher than normal losses compared with the past few years, and heavy overwintering losses were reported in 2003-2004 for many northern beekeepers.

How CCD Differs from Past Bee Colony Losses

Ways in which current bee colony losses seem to differ from past losses include

- colony losses are occurring mostly because bees are failing to return to the hive (which is largely uncharacteristic of bee behavior),
- bee colony losses have been rapid,
- colony losses are occurring in large numbers, and

[11] National Academy of Sciences, National Research Council, *Status of Pollinators in North America*, 2006.

[12] National Academy of Sciences, National Research Council, *Status of Pollinators in North America*, 2006; Interview with Maryann Frazier, Senior Extension Agent, Pennsylvania State University, Jan. 28, 2007, at [http://podcasts.psu.edu/taxonomy/term/62].

[13] Morse, R.A. and N.W. Calderone, *The Value of Honey Bees as Pollinators of U.S. Crops in 2000*, March 2000, Cornell University, at [http://www.masterbeekeeper.org/pdf/pollination.pdf].

[14] Similar conditions have been termed autumn collapse, May disease, spring dwindle, disappearing disease, and fall dwindle disease.

- the reason why these losses are occurring remains still largely unknown.

The current phenomenon was first called "Fall-Dwindle Disease," but has been renamed CCD because of the unusual characteristics of the honey bee colony declines. First, the condition is not only seasonal but manifests itself throughout the year. Second, the term "dwindle" implies a gradual loss; CCD onset is sudden. Third, the term "disappearance" has been used to describe other types of conditions, which differ from the symptoms currently being associated with CCD. Finally, the term "disease" is usually associated with a biological agent but none has yet been identified.[15]

The first report of CCD was in mid-November 2006 by a Pennsylvania beekeeper overwintering in Florida. By February 2007, large commercial migratory beekeepers in several states reported heavy losses associated with CCD (**Figure 1**). Reports of losses vary widely, ranging from losses of 30-90% of their bee colonies; some beekeepers fear loss of nearly all of their colonies in some cases.[16] Surviving colonies are reportedly weakened and may no longer be viable to pollinate or produce honey. Losses have been reported in migratory operations wintering in California, Florida, Oklahoma and Texas. In late February, some larger non-migratory beekeepers in the mid-Atlantic and Pacific Northeast regions also reported significant losses of more than 50%.[17] Honey bee colony losses also have been reported in Canada and Europe.

Symptoms of Colony Collapse Disorder

One of the key symptoms of CCD in collapsed colonies is that the adult population is suddenly gone without any accumulation of dead bees.[18] The bees are not returning to the hive but are leaving behind their brood (young bees), their queen, and maybe a small cluster of adults. What is uncharacteristic about this situation is that the honey bee is a very social insect and colony-oriented, with a complex and

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[15] Van Engelsdorp, D., Cox Foster, D. Frazier, M., Ostiguy, N., and Hayes, J., "Fall Dwindle Disease: Investigations into the Causes of Sudden and Alarming Colony Losses Experienced by Beekeepers in the Fall of 2006," Dec. 15, 2006.

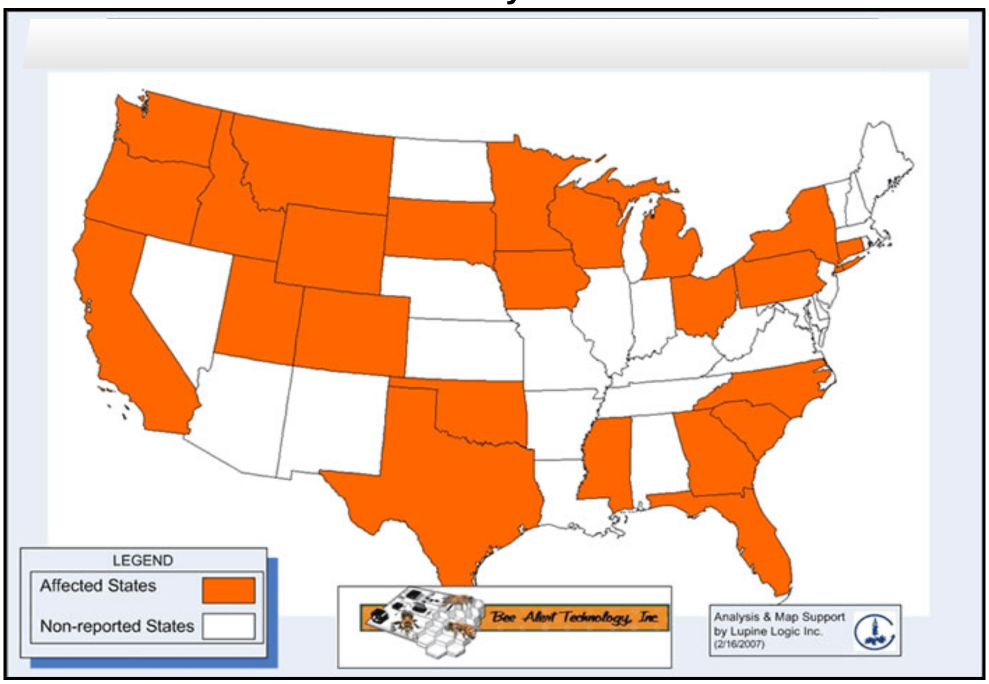
[16] Interview with Maryann Frazier, Senior Extension Agent, Pennsylvania State University, Jan. 28, 2007, at [http://podcasts.psu.edu/taxonomy/term/62]; Van Engelsdorp, et al., "Fall Dwindle Disease: Investigations into the Causes of Sudden and Alarming Colony Losses Experienced by Beekeepers in the Fall of 2006," Dec. 15, 2006; Pastis, S., "Mysterious Bee Deaths Strike Central Valley," *Valley Voice*, [no date], at [http://www.valleyvoicenewspaper.com/vv/stories/beedeaths.htm].

[17] MAAREC, "Colony Collapse Disorder," at [http://maarec.cas.psu.edu/FAQ/FAQCCD.pdf]

[18] vanEngelsdorp, D. et al., "Fall Dwindle Disease: Investigations into the Causes of Sudden and Alarming Colony Losses Experienced by Beekeepers in the Fall of 2006," Dec. 15, 2006; Interview with Maryann Frazier, Penn State, Senior Extension Agent, Jan. 28, 2007, at [http://podcasts.psu.edu/taxonomy/term/62]; Interview with Jerry Hayes, Chief of the Apiary Section at Florida's Department of Agriculture, March 2, 2007, at [http://www.loe.org].

organized nesting colony. Failing to return to the hive is considered highly unusual. An absence of a large number of dead bees makes an analysis of the causes of CCD difficult. Also there is little evidence that the hive may have been attacked. In actively collapsing colonies, an insufficient number of adult bees remain to care for the brood. The remaining workforce seems to be made up of young adult bees. The queen is present, appears healthy and is usually still laying eggs, but the remaining cluster is reluctant to consume feed provided by the beekeeper, and foraging is greatly reduced.

Figure 1. Honey Bee Collapse Disorder, Affected States, February 2007



Source: Mid-Atlantic Apiculture Research and Extension Consortium (MAAREC), February 2007, [http://maarec.cas.psu.edu/pressReleases/CCDMap07FebRev1-.jpg].

Possible Causes of Colony Collapse Disorder

To date, the potential causes of CCD, as reported by the scientists who are researching this phenomenon, include but may not be limited to[19]

- parasites, mites, and disease loads in the bees and brood;
- known/unknown pathogens, such as fungal diseases;
- poor nutrition among adult bees;
- lack of genetic diversity and lineage of bees;

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[19] Interview with Maryann Frazier, Penn State, Senior Extension Agent, Jan. 28, 2007, at [http://podcasts.psu.edu/taxonomy/term/62]; MAAREC, "Colony Collapse Disorder," at [http://maarec.cas.psu.edu/FAQ/FAQCCD.pdf].

- level of stress in adult bees, as indicated by stress-induced proteins (e.g., transportation and confinement of bees, or other environmental or biological stressors);
- chemical residue/contamination in the wax, food stores and/or bees, including exposure to new types of agricultural pesticides as well as exposure to chemicals that beekeepers use to control mites; and
- a combination of several factors.

Some practices and conditions have been tentatively removed from the list of possible causes of CCD. These include feeding practices, chemicals used by beekeepers (such as antibiotics and miticides), use of bees (primarily for honey production versus pollination), and queen source.[20] However, the scientists who are researching this phenomenon note these could contribute to the risk of bee colonies developing CCD.

High levels of bacteria, viruses, and fungi have been found in the guts of the recoverable dead bees. Some researchers have speculated that these high infection levels may be compromising the immune system of the honey bees.[21] Others have speculated that because most of the reported colony losses are among large commercial migratory operations, which may move bees two to five times during a growing season, the current disorder may be the result of accumulated stress, and factors such as confinement and temperature fluctuations. These stresses may increase the colony's susceptibility to disease and may also increase its potential exposure to other diseases and parasites.[22]

Of the possible causes of CCD being examined, one that has become the subject of debate is whether certain chemicals or combinations of chemicals could be contributing to CCD, including some pesticides and possibly some fungicides. One class of insecticide being studied are neonicotinoids, which contain the active ingredient imidacloprid, and similar other chemicals, such as clothianidin and thiamethoxam. Honey bees are thought possibly to be affected by such chemicals, which are known to work their way through the plant up into the flowers and leave residues in the nectar and pollen. The scientists studying CCD note that the doses taken up by bees are not lethal, but they are concerned about possible chronic problems caused by long-term exposure. As noted by the NRC, some studies report sublethal effects of pesticides on bee foraging behavior that may impair the navigational and foraging abilities of honey bees.[23] Concerns about imidacloprid, as

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[20] Most queens are purchased from suppliers in Florida, California, Texas, Georgia, and Hawaii, or from suppliers in Canada and Australia.

[21] Interview with Jerry Hayes, Chief of the Apiary Section at Florida's Department of Agriculture, March 2, 2007, at [http://www.loe.org].

[22] vanEngelsdorp, D. et al., "Fall Dwindle Disease: Investigations into the Causes of Sudden and Alarming Colony Losses Experienced by Beekeepers in the Fall of 2006," Dec. 15, 2006. A 10% die-off is not uncommon following transportation.

[23] National Academy of Sciences, National Research Council, *Status of Pollinators in North America*, 2006.

reported by beekeeping associations in the United Kingdom and France[24] and by some U.S. beekeepers,[25] have focused on its potential to affect complex behaviors in insects, including flight, navigation, olfactory memory, recruitment, foraging, and coordination. However, the NRC and some scientists who study CCD note there is conflicting information about the effect of these pesticides on honey bees. Still, the U.S. Environmental Protection Agency has identified some of these chemicals as highly toxic to honey bees,[26] and use of some of these pesticides has reportedly been discontinued in parts of Europe because of their potential effects on pollinators.[27]

Congressional Response

Prior and existing laws have been enacted to support the U.S. beekeeping sector and to ensure continued pollination for agricultural crops. For example, in 1970, Congress authorized the Beekeeper Indemnity Program.[28] This program was administered by USDA and partially compensated beekeepers for colony losses due to exposure to agricultural pesticides that had been approved by the federal government. Beekeepers who exercised reasonable precautions to avoid pesticide damage but still lost bees were eligible to apply for indemnity payments after January 1, 1967. This program expired in 1977.

The existing federal Honeybee Act authorizes USDA's Animal and Plant Health Inspection Service (APHIS) to regulate the importation of honey bees and related material to prevent the entry of honey bee diseases and parasites, as well as undesirable subspecies of honeybees.[29] Several states also have apiary inspection programs to prevent the spread of diseases such as AFB and parasitic mites. Funding is provided for a range of pollinator and bee disease research programs within USDA.

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[24] Northwest Coalition for Alternatives to Pesticides, "Imidacloprid, Fact Sheet," *Journal of Pesticide Reform*, Spring 2001, at [http://www.moraybeekeepers.co.uk/imiacloprid]; Apiculteurs de France, "Composite Document of Present Position Relating to Gaucho, Sunflower and Bees, at [http://www.beekeeping.com/articles/us/gaucho/manifestation_paris_us.htm].

[25] Pastis, S., "Mysterious Bee Deaths Strike Central Valley," *Valley Voice*, [no date], at [http://www.valleyvoicenewspaper.com/vv/stories/beedeaths.htm].

[26] For example, see EPA's fact sheet on clothianiden, issued May 3002, at [http://www.epa.gov/opprd001/factsheets/clothianidin.pdf].

[27] vanEngelsdorp, D. et al., "Fall Dwindle Disease: Investigations into the Causes of Sudden and Alarming Colony Losses Experienced by Beekeepers in the Fall of 2006," Dec. 15, 2006; Interview with Jerry Hayes, Chief of the Apiary Section at Florida's Department of Agriculture, March 2, 2007, at [http://www.loe.org].

[28] Section 804 of the 1970 Agricultural Act, P.L. 91-524. The program was extended in 1973, authorizing payments to eligible beekeepers through December 31, 1977.

[29] USDA, APHIS "Plant Protection and Honeybee Acts," at [http://www.aphis.usda.gov/plant_health/permits/organism/plant_protection_honeybee_acts.shtml]. Regulations on import permits for bees are at 7 CFR 322. The act was originally enacted Aug. 31, 1922.

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