Prepared Testimony of Diana Cox-Foster
Professor Department of Entomology
The Pennsylvania State University
before the
U.S. House of Representatives
Committee on Agriculture
Subcommittee on Horticulture and Organic Agriculture
on
Colony Collapse Disorder in Honey Bee Colonies in the United States
March 29, 2007

Introduction

Chairman Cardoza and Members of the Subcommittee on Horticulture and Organic Agriculture,

Thank you for the opportunity to appear before you today representing the researchers in the Colony Collapse Disorder Working group. I am a Professor of Entomology at Pennsylvania State University and have over 25 years experience in insect physiology, pathology, molecular biology and evolution. In addition, I have active experience in disease biology through involvement in biodefense issues in agriculture. For the last 10 years, I have conducted extensive research on the interaction of honey bees with varroa mites and bee diseases, focusing on viral diseases. In honey bees, Dr. Nancy Ostiguy and I have been examining viral disease incidence as correlated with honey bee colony deaths in association with varroa mites. My expertise is a reason why beekeepers approached me in November 2006 with colonies deaths having unique symptoms. These were the first recognized instances of Colony Collapse Disorder.

The Colony Collapse Disorder Working Group is collaboration among researchers from Penn State University, the Pennsylvania Department of Agriculture (PDA), the USDA-ARS, the Florida Department of Agriculture and Consumer Services, North Carolina State University, the University of Illinois, the University of Delaware, and others. In addition, experts from Bee Alert, Inc., Montana, have joined in the study. The goals of the CCD Working Group are to 1) identify potential causal factors common to CCD colonies and not associated with strong, healthy bee colonies, 2) determine how such factors can underlie CCD by experimentally reproducing CCD symptoms, and 3) devise preventative measures to disrupt CCD and ensure strong colonies for pollination.

As you know and have heard in the testimony by the USDA-ARS, honey bees are essential for the pollination of over 90 fruit and vegetable crops worldwide. The economic worth of the honey bee is valued at more than $14.6 billion in the U.S. In Pennsylvania alone, honey bees and pollination are worth $65 million annually through fruit crops, forage, and bee products (most notably honey). In addition to agricultural crops, honey bees also pollinate many native plants in the ecosystem. Populations of honey bees are in jeopardy due to the 1988 introduction of varroa mites, recognized previously as a major threat to bee colonies in the U.S. Down from a peak of 80,000 colonies in 1982, an estimated 38,500 colonies in September 2006 are being managed in

the Commonwealth of Pennsylvania. Recently, increased deaths in bee colonies with unique symptoms (termed Colony Collapse Disorder (CCD)) seriously threaten the ability of the bee industry to meet the diverse pollination needs of fruit and vegetable producers within the State and across the United States. These symptoms have now been reported in 24 states across the continental United States and in two Canadian provinces.

In Pennsylvania since 1930, bee colonies have regularly been inspected for disease; and thus, Pennsylvania provides a good database to monitor changes in incidences of bee diseases. To determine the scope of CCD, Dennis vanEnglesdorp, the State Apiarist with the Pennsylvania Department of Agriculture, has conducted recent surveys of Pennsylvania beekeepers that reveal a significant number of colonies collapsing with CCD (responding beekeepers represent 43%, or 17,376, of all Pennsylvania colonies). Beekeepers suffering from CCD managed a total of 8,953 colonies last September and lost an average of 73% of their hives (ranging from 55 to 100%), as compared to beekeepers not experiencing CCD, who lost an average of 25% of their colonies (ranging from 18-31%). Of significance, those reporting CCD own a quarter of all colonies in Pennsylvania. These losses translate into limited pollination resources for Pennsylvania and increased costs to both growers and consumers. In Pennsylvania, the current cost of pollination has increased by 50% and may increase even more as the 2007 season progresses.

The exact impact of CCD across the United States is difficult to gauge since essential data on the number of bee keepers, number of colonies, and death rates are not measured. A preliminary nationwide survey, initiated last month by the Apiary Inspectors of America, suggests that a 17 % loss of colonies is considered normal, which is astonishing, given that one would be hard pressed to find another agricultural commodity sustaining losses of this magnitude on a regular basis. This same survey also found that approximately one-quarter of responding beekeepers suffered CCD. Obtaining an accurate, annual survey of bee colonies in the United States is critical to ensure the health of American agriculture and to help monitor the status of pollinators as a whole.

Originally, CCD collapses were reported primarily by commercial migratory bee keepers who move their colonies from one area to another. More recently, it is clear that non-migratory beekeepers are also experiencing CCD. Of particular note, several queen breeders/packagers have experienced severe CCD symptoms in their operations. This causes particular alarm since many bee keepers depend upon these operations for new bee colonies and these losses translate into fewer bee colonies being replaced or started anew this year. It is now clear that CCD is a problem facing all bee keepers; it will have a major impact.

Brief Summary of CCD symptoms

As you have heard, CCD is associated with unique symptoms, not seen in normal collapses associated with varroa mites and honey bee viruses or in colony deaths due to winter kill. The uniqueness of these symptoms has been recognized by members of the CCD working group (Jeff Pettis, USDA-ARS; Dennis vanEnglesdorp, Pennsylvania Department of Agriculture; Jerry Hayes, Florida Department of Agriculture) who have

been actively involved in field diagnosis of bee diseases and colony deaths for numerous years and who are recognized as international experts.

In CCD, the bee colony proceeds rapidly from a strong colony with many individuals to a colony with few or no surviving bees. Queens are found in collapsing colonies with a few young adult bees, lots of brood, and more than adequate food resources. No dead adult bees are found in the colony or outside in proximity to the colony. A unique aspect of CCD is that there is a significant delay in robbing of the dead colony by bees from other colonies or invasion by pest insects such as waxworm moths or small hive beetles; this suggests the presence of a deterrent chemical or toxin in the hive.

In colonies experiencing CCD, we have found that individual bees are infected with an extremely high number of different disease organisms. However, we have found little evidence of parasitization by varroa or tracheal mites. Many of these known bee diseases are commonly associated with stress in bees. Of particular note, we have found all adult bees in CCD colonies are infected with fungal infections. These findings may indicate that the bees are being immunosuppressed, but none of the organisms found in these bees can be attributed as the primary culprits in CCD.

Of special concern, we have found species like *Aspergillus* and *Mucor* among the fungi in CCD colonies. These fungi were previously reported to be bee pathogens in the 1930's and are associated with toxin production; however, since that time, these fungi have been rarely of concern in bee colonies. Determining the role of these fungi in CCD is important not only in terms of solving the mystery of CCD but also in determining how these fungi are related to fungal species that infect vertebrates, including humans. Fortunately, at Penn State University, we have world-recognized experts in fungal identification and fungal toxins; these researchers have teamed with us to address this concern.

The CCD working group has made collections of bees and hive products (wax, honey, and pollen stores) from more than 100 CCD and non-CCD colonies sampled from operations across the country. These samples are being stored in a central location and available to all CCD researchers. In addition to examining these bees and colonies, we have surveyed beekeepers both with and without CCD; these surveys detail the operational practices, operational histories, and environmental conditions experienced by affected and non-affected colonies. These surveys have allowed us to exclude several factors as primary causes of CCD. Based upon these data, we have focused upon three hypotheses underlying CCD, as follows:

1) Are new or reemerging pathogens responsible for CCD?
2) Are environmental chemicals causing the immunosuppression of bees and triggering CCD?
3) Is a combination of stressors (e.g., varroa mites, diseases, nutritional stress) interacting to weaken bee colonies and allowing stress-related pathogens such as fungi to cause final collapse?

Research Foci Addressing CCD

These hypotheses are being addressed simultaneously via extensive collaboration among members of the CCD Working Group. We are sharing specimens, have agreed to share data, and are actively working toward resolving the causes of CCD. Funding to date has been provided by several beekeeper organizations, the National Honey Board, USDA, PDA, Penn State, and the Department of Defense (through SBIR funding to Bee Alert, Inc.); we greatly appreciate this funding for allowing us to begin addressing CCD.

A summary of our activities follows.

Are there new or reemerging pathogens responsible for CCD?
It has become clear in recent years that many pathogens have the ability to impair the immune defenses of their hosts. Among the known bee pathogens in CCD bees, none have been identified as having immunosuppressive abilities. We have identified several routes of entry into the United States that may have permitted the inadvertent introduction of new pathogens. In collaboration with Dr. Ian Lipkin and associates at Columbia University and the Northeast Biodefense Center, we at Penn State are identifying the microbes and viruses associated with CCD colonies. We predict that any pathogens that may be linked to CCD will be found in multiple operations having CCD and will not be present in colonies lacking CCD. In this analysis, we will probably isolate many new organisms not previously known to be associated with bees. Determining which microbes are important and linked to CCD will require extensive study. We will also need to investigate new methods to control or disrupt infections by these pathogens.

These studies are being performed in collaboration with Drs. Jay Evans and Jeff Pettis at USDA-ARS and with Drs. May Berenbaum and Gene Robinson at the University of Illinois. These collaborations are utilizing the newly developed knowledge of honey bee genomics and molecular physiology, to let the bees themselves tell us how they are being impacted and what are the most likely causal factors underlying CCD by asking what genes are being turned on and off in the bees. We expect that these analyses will reveal how the bees are responding to potential pathogens, environmental toxins, or other stressors.

Are environmental chemicals causing the immunosuppression of bees and triggering CCD?
It is recognized that environmental toxins or pesticides can impair the immune systems of animals. In insects, sub-lethal effects of insecticides are being increasingly recognized as stressors that may impair immune defenses. Our surveys to date have failed to identify common chemicals or pesticides being used in the various beekeeping operations experiencing CCD. Bee Alert, Inc. is asking whether any environmental chemicals are present in CCD colonies by analyzing volatile chemicals in hives. At Penn State, international experts in environmental chemistry and toxicology (Drs. Chris Mullin, Ralph Mumma and others) are helping to direct the chemical analyses of the hive products. Wax, honey, and pollen stores will be analyzed for pesticides and other toxic compounds. Of particular concern are pesticides being widely used to control insect pests in agriculture, urban environments, and animal systems. Among these are the

neonicotinoids, a class of pesticides that have been extensively adopted for pest management. This class of pesticides is recognized as having extremely low toxicity in humans and other vertebrates and as highly effective in controlling insect pests; however, these chemicals are known to be highly toxic to honey bees and other pollinators. Some research has suggested that these systemic pesticides can translocate or move through plants to become localized in pollen and nectar at concentrations that may affect bees. Research is warranted to address the effects on the bees and other pollinators of these compounds at the concentrations found in pollen and honey made from nectar collected by the bees. It is essential to determine whether these pesticides play a role as a causal factor in the CCD symptoms.

Is a combination of stresses working together to weaken bee colonies and allowing stress-pathogens to cause final collapse?
Several working group members (USDA-ARS, PDA, North Carolina State University, and Penn State) are collaborating to ask what stresses are encountered by bee colonies that are part of migratory operations. Recently, we are beginning to learn from migratory bee keepers that multiple stressors impact their operations and cause significant losses of honey bee colonies. Gaining this baseline information is important in determining how bees are being impacted and how these stresses can be eliminated to ensure adequate pollination of crops.

Finally, the CCD working group recognizes the importance of trying to breed honey bees that are more resistant to diseases and the impacts of parasites such as varroa mites. In addition, we anticipate that different genetic strains will respond differently to various stresses. Researchers at North Carolina State, University of Illinois and Texas A&M are beginning to ask how genetic diversity in bee populations correlates with CCD and resistance traits. Developing new genetic strains of bees for commercial production may be essential to the future of beekeeping.

Closing Remarks
Mr. Chairman and Members of the Subcommittee, I thank you again for inviting me to review the Colony Collapse Disorder affecting honey bees and to highlight some the ongoing activities and research of the CCD working group. It is clear that we are facing several challenges in unraveling the causes of CCD and in developing preventative measures to ensure the health of bees and the pollination industry. I would be happy to answer any questions you may have concerning this serious threat to American agriculture.