Colony Collapse Disorder
2007-2008 Accomplishment Report

Topic I: Survey and Data Collection

Goal 1: Determine the extent of CCD in the United States

1. Refine CCD symptomology to determine what CCD is and what it is not.

[ARS-Pettis]

2. Develop and conduct an expanded, systematic, Nationwide, epidemiological survey, based on existing models.

Accomplishment:

Colony losses shown to increase over previous beekeeping season. ARS and the Apiary Inspectors of America surveyed U.S. honey bee colonies and estimated total losses, from a variety of causes, to be more than 35% from the fall of 2007 to the winter of 2008. This data indicates an increase over the 31% losses recorded during the 2006-2007 season.

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Goal 2: Determine current status of honey bee colony production and health

1. Develop an annual NASS survey that includes information on pollination services, colony loss, and honey production.

There are currently no resources for this activity.

2. Develop a long-term annual APHIS survey on the overall health status of U.S. honey bees.

Ongoing Research:

Oregon colony health being surveyed. Oregon State University researchers are distributing a survey to Oregon apiculturists to assess what diseases and pests are impacting their hives and what control methods are being used, chemical and cultural. A copy of the survey can be found on the Honey Bee Diagnostic Service Web page at www.science.oregonstate.edu/bpp/insect_clinic/bees.htm.

PROJECT CONTACT: OSU Extension Service

Topic II: Analysis of existing samples

Goal 1: Identify and characterize pathogens associated with CCD

1. Analyze samples using:
    - High-throughput sequencing for pathogen detection in individual colonies.
    - Microarray analysis and quantitative gene expression studies to determine stressor or pathogen effects on bee gene expression.
    - Integrated Virus Detection System (IVDS) for identifying pathogens by particle size.

Accomplishments:

Virus load and nosema levels linked to CCD. ARS researchers conducted a comprehensive genetic survey of honey bee colonies with CCD collected in California, Florida, and the Mid-Atlantic states from January and February 2007, examining them for pathogen levels and degree of immunity. Colonies from certain geographic locations showed greater genetic immunity to pathogens than others. Researchers found the greatest predictor of CCD was the total virus load on a given colony, and to a lesser degree, the nosema ceranae pathogen. Bacterial levels and levels of two other nosema species were not significantly linked to CCD.

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Elevated nosema levels found in bee colony survey. In a random sampling of honey bee colonies from across the Western U.S., ARS found unexpectedly high levels of the nosema ceranae pathogen (many with over one million spores per bee). The study showed that colonies from the Pacific Northwest and Upper Midwest, particularly Minnesota and Washington, had significantly higher levels of the disease than those from other states. Findings suggest that difficulties in meeting strength requirements for almond pollination may be due to the high levels of nosema.

PROJECT CONTACTS:
Frank Eischen (Feischen@weslaco.ars.usda.gov)
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[IVDS bullet from DoD, Charles wick]

Accomplishments:

Variety of pathogens identified in colonies with CCD. Using a bioinformatics tool known as BLAST (Basic Local Alignment Search Tool) to compare nucleotide and protein databases, Pennsylvania State University researchers identified 18 pathogens from CCD-affected colonies.

PROJECT CONTACT: Diana Cox-Foster, PSU

New pathogen screening service established. The Oregon State University Extension Service has established a Honey Bee Diagnostic Service pilot project in Oregon, in conjunction with the Oregon State University Insect Identification Clinic. Screening services are now available for American foulbrood, European foulbrood, chalkbrood, stonebrood, nosema, varroa mites, tracheal mites, and insect pests (wax moth, hive beetle, bee louse, etc.). More Information on the service can be found at http://web.science.oregonstate.edu/bpp/insect_clinic/bees.htm.

PROJECT CONTACT: OSU Extension Service

Pilot bee survey developed. With support from the Apiary Inspectors of America and Penn State Department of Agriculture, ARS developed a pilot bee survey to screen bees from 20 states for the Israeli acute paralysis virus. Researchers have proved the concept of using bee inspectors for collecting and processing bee samples by molecular-genetic techniques.

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2. Isolate, purify, and quantify microbes associated with CCD.

[Ask PSU and ARS-Beltsville.]

Goal 2: Identify pests associated with CCD and quantify pest levels associated with the disorder

1. Use standard sampling methods to analyze samples for tracheal and varroa mites and nosema spp.

Accomplishment:

Link between varroa/nosema and colony health studied. In a survey of commercial beekeepers in Florida and California, scientists analyzed the varroa mite and nosema levels in 12 beekeeping operations, all of which had bees in poor health. Studies revealed that two of these operations had elevated varroa mite levels, while nosema was present in only low levels and did not appear to be significantly impacting colony health. Results indicate that a cause unrelated to varroa or nosema is playing a role in the poor health of the colonies. Researchers continue to analyze pollen and beeswax for pesticide residues and viruses.

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Goal 3: Identify pesticides or environmental contaminants associated with CCD

1. Examine wax, pollen, honey, and adult bee samples for pesticides and environmental contaminants.

AND

2. Determine whether interactions between pesticides applied inside bee hives and pesticides applied to crops contribute to CCD.

Accomplishments:

Low imidacloprid levels found on watermelon plants. In studies on pesticide residues in the pollen and nectar of watermelon plants, scientists found low levels of the pesticide imidacloprid in treated plants. An experiment to analyze bee exposure is planned for the fall of 2008.

PROJECT CONTACTS:
Galen Dively, University of Maryland, Galen@umd.edu
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Accomplishments:

Wide range of pesticide exposure found for honey bees. Connecticut researchers have determined that honey bees are exposed to a wide variety of pesticides, with concentrations varying significantly over short time periods. Researchers are examining hives at urban, suburban, and rural locations for differences in pesticide exposure by time and location.

PROJECT CONTACT: Connecticut Agricultural Experiment Station

High fluvalinate and coumaphos found on honey bee samples. Pennsylvania State University researchers analyzed pollen, nectar, honey, brood, adult bees, wax, and royal jelly samples from CCD- and non-CCD affected bee hives and found extremely high levels of the acaricides fluvalinate and coumaphos, which were present in nearly all samples, with 47 other pesticides and metabolites identified.

PROJECT CONTACT: PSU

Ongoing Research:

Pesticide and virus analysis continues. ARS-Beltsville researchers and cooperators continue to analyze pollen and beeswax for pesticide residues and viruses.

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Goal 4: Develop analytical tools to assess bee health

1. Develop the use of molecular markers to determine the physiological status of bees and as indicators of bee health.

Accomplishment:

New molecular targets identified for monitoring bee health. ARS researchers studied honey bee stress responses to fungal pathogens and identified a number of molecular targets not previously associated with immune or stress responses in insects. These findings could lead to the development of a new technique for monitoring stress levels in diseased and healthy honey bee colonies.

PROJECT CONTACT: Katherine Aronstein (Kate.Aronstein@ars.usda.gov)

Topic III: Research to identify factors affecting honey bee health including attempts to re-create CCD symptomology

Goal 1: Confirm or eliminate potential environmental stressors as contributing causes of CCD.

1: Test effects (lethal and sub-lethal) of neonicotinoids and other pesticides used for crop protection.

Accomplishments:

High toxicity of pesticides identified. Pennsylvania State University researchers found two common pesticide adjuvants to be highly toxic to adult honey bees at a dose of 1% in artificial nectar.

PROJECT CONTACT: PSU Researchers

Ongoing Research:

Pesticide toxicity to honey bees studied. The University of Florida is testing the effects of Amitraz and imidacloprid (common pesticides) on honey bee susceptibility to varroa mite infestations.

PROJECT CONTACT: University of Florida Researchers

Pesticide exposure and toxicity studied. Pennsylvania State University researchers are investigating whether chemical pesticides are a key factor in declining honey bee health and CCD, analyzing the total pesticide exposure of honey bees and tracking the acute and sublethal effects of the exposure over time. Scientists will evaluate the effects of pesticides individually and in combination to determine if they suppress honey bee immune systems, interfere with learning and memory, or alter chemical senses of the bees. This research will aid in the development of safe, new pesticides for mite and pest control.

PROJECT CONTACT: R. L. Unger, PSU (Runger@psu.edu)

Sublethal effects of common miticides studied. In a separate but related project, Pennsylvania State University researchers are investigating the possible sublethal effects of the two most commonly used pesticides in beehives in the U.S.: Apistan and Check Mite+. Researchers are evaluating the sublethal effects of these pesticides on adult bees, brood development, and honey production, and on worker bee learning and memory.

PROJECT CONTACT: W. M. Hood, PSU

2: Test the effects of current miticides used in hives on worker bee longevity and colony health.

Ongoing Research:

Impact of common miticides studied. Pennsylvania State University researchers are evaluating the impact of in-hive miticide use on honey bees, which is suspected to decrease immune function, lead to increased virus levels, and impact honey bee lifespan and health. Researchers will investigate the impact of the common miticides CheckMite, Apistan, and formic acid-flash treatment on virus levels, honey bee immune function, lifespan, reproductive physiology, and overall health.

PROJECT CONTACT: R. L. Unger, PSU (Runger@psu.edu)

3: Test the effects of antibiotics (especially new ones such as Tylosin) on the increase in pathogens (e.g., nosema ceranae) and the overall viability of bees over winter.

4: Test effects of supplemental protein and carbohydrate [e.g., high fructose corn syrup (HFCS)] feedings on bee health.

Accomplishment:

Artificial diet shown to build colony strength in pest- and pathogen-stressed colonies. Researchers found that by feeding a pollen-supplemented diet to varroa-infested honey bee colonies, more colonies could meet strength standards for almond pollination than those not fed the supplements (77% compared to 45%). Likewise, the diet was tested on pathogen-infested colonies, where nearly three times as many supplemented colonies met almond pollination standards compared to those not fed the supplemental diet.

PROJECT CONTACT: Frank Eischen (Feischen@weslaco.ars.usda.gov)

Tucson Bee Diet shown to be an effective pollen substitute for colony growth and strength. Scientists compared the effects of a new protein supplement diet (MegaBee-the Tucson Bee Diet) to other commercially available diets, pollen, and high fructose corn syrup (HFCS) feedings in terms of consumption rate, brood production, and colony growth. The study showed that MegaBee was consumed at rates comparable to pollen, and that brood production and adult population growth in colonies fed MegaBee was comparable to those fed pollen and significantly greater than those fed other commercial diets or HFCS. This research indicates that the MegaBee diet can be a useful tool for building bee populations in the spring or when flowering plants are limited or unavailable.

PROJECT CONTACT: Gloria DeGrandi-Hoffman Gloria.Hoffman@ars.usda.gov)

HFCS inversely linked to worker longevity. The effects of high fructose corn syrup (HFCS) on worker longevity were tested on newly emerged worker bees. Workers fed a sucrose solution lived significantly longer, on average, than those fed HFCS.

PROJECT CONTACT: Blaise W. LeBlanc (Blaise.Leblanc@ars.usda.gov)

HFCS chemical impurity found. Researchers found a heat-formed impurity, hydroxymethylfurfural (HMF), in HFCS that is highly toxic to bees. Researchers determined the storage conditions, including temperature, container type, and time in storage that predict the formation of the contaminant. This impurity gives a possible explanation for the reduced lifespan of worker bees fed HFCS.

PROJECT CONTACT: Diana Sammataro (Diana.Sammataro@ars.usda.gov)

Also see Part III-Goal 4, page 13.

Ongoing Research:

Benefits of supplemental feeding for migratory beekeeping studied. ARS has been studying the effects of supplemental feeding on CCD-affected honey bee colonies used for California almond pollination. This study will continue in the Central Valley of California during 2008-2009.

PROJECT CONTACT: Frank Eischen (Feischen@weslaco.ars.usda.gov)

5: Test effects of availability and quality of natural food sources on bee health as affected by climatic factors (e.g., drought).

6: Test effects of management practices (e.g., nutrition, migratory stresses) on bee health.

Accomplishments:

Transportation proven to stress honey bee colonies. ARS researchers and the Pennsylvania Department of Agriculture provided the first documented evidence that transportation stresses honey bee colonies. During colony transport from California to Florida, brood nest temperatures dropped 2-3^{0}C and brood losses of migratory colonies were ten times greater than for colonies remaining in California. Future trials will investigate the survival of individual bees following transportation and analyze stress indicators in individual bees.

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Impact of long distance migration studied. ARS and Michigan State University scientists are beginning a study on the effects of hive migration on honey bee physiology. Bees transported over long distances have been sampled for indicators of stress.

PROJECT CONTACT:

Bee health predictors studied during hive migration. Kansas State University and the University of Florida are beginning a migratory beekeeping study, measuring varroa mite, tracheal mite, and nosema levels in colonies before and after transport to California to identify any predictors of health.

PROJECT CONTACT:

Goal 2: Confirm or eliminate potential pathogens as contributing causes of CCD.

1: Test pathogenicity of the following CCD-associated microbes against honey bees and non-*Apis* bees:

- Viruses
- Fungi (chalkbrood; stonebrood)
- Microsporidia (nosema)
- Bacteria
- Trypanosomes and other microbes

Accomplishment:

New virus identified as CCD marker. ARS, Columbia University, and Pennsylvania State University researchers analyzed CCD-affected samples and discovered that the pathogen known as the Israeli acute paralysis virus (IAPV) appeared in almost every CCD case. IAPV may be one cause of the collapse or a marker for some other cause. The results were published in the October 12, 2007, issue of *Science*.

PROJECT CONTACT:

Accomplishment:

Three IAPV lineages identified. Pennsylvania State University, ARS, and University of Columbia researchers developed real-time diagnostic assays for IAPV and determined that there are at least three different lineages of the virus, two of which are present in the U.S. One of the lineages (West coast lineage) was likely introduced into the U.S. via Australian packages. Researchers continue to investigate other potential entry routes.

IAPV-resistant bee genotypes identified. Researchers have also conducted studies suggesting that there are bee genotypes in the U.S. resistant to IAPV and other viruses. In studying the effects of IAPV infection on colonies, researchers found that some bees with demonstrated resistance to other pests and pathogens were able to clear IAPV from their colonies.

IAPV found to be highly pathogenic to honey bees. The same researchers found that honey bee colonies fed IAPV experienced dramatic mortality and decline within one month, indicating that IAPV is a highly pathogenic virus. Research continues to analyze samples from each colony, and the experiment is being repeated. This study does not indicate that IAPV is one or the only cause of CCD.

IAPV found to be transmissible to native bees. Researchers also found that IAPV can be transmitted from honey bees to native bees through the pollination process. The impact of the virus on native bees is unknown.

PROJECT CONTACT: Columbia, ARS, and PSU

2: Compare genes expressed in response to specific pathogens or pesticides with those expressed in bees from CCD colonies.

Accomplishment:

Weak immune systems linked to CCD. In studies on bees from different colonies, apiaries, and geographical regions, University of Illinois researchers have determined that immune response genes show decreased expression in bees with CCD.

PROJECT CONTACT: University of Illinois

Ongoing Research:

Pesticide detoxification genes studied. University of Illinois researchers are working to identify the specific honey bee genes responsible for pesticide detoxification and determine which pesticides and other substances the bees can successfully detoxify. Researchers will also study honey bee ability to use their detoxification abilities when under other stresses, such as varroa mites. This work will be useful to help monitor and reduce bee exposure to pesticides and design pesticides that are not toxic to bees.

PROJECT CONTACT: M. R. Berenbaum (Maybe@life.uiuc.edu)

Goal 3: Confirm or eliminate pests as contributing causes of CCD.

1: Test the effects of varroa mites on bee health and robustness, particularly overwintering effects and association with CCD in early spring.

2: Determine the importance of varroa as a vector of viruses associated with CCD or as a general immuno-suppressive agent on the colony itself.

Goal 4: Determine what factors (or interactions between factors) are most important in their contribution to CCD. This includes environmental factors (e.g., temperature, humidity, and chemical exposure), pathogens and parasites, and bee genetics and breeding.

Ongoing Research:

Interactive effects of pathogens, pesticides, and nutrition to be studied. University of Georgia researchers are investigating the interactive effects of relevant pathogens and parasites, pesticides, and nutrition on honey bee health. Researchers will compare the effects of nosema apis and nosema ceranae, the interactions between nutritional status and nosema diseases, the synergistic and sublethal effects of miticides, and the economic efficacy of varroa IPM methods.

PROJECT CONTACT: K.S. Delaplane (Ksd@uga.edu)

Link between CCD and HFCS, varroa, nosema, other factors studied. Michigan State University is funding a research project on the effects of high fructose corn syrup on honey bee health, as well as how varroa mites, nosema, and other factors contribute to colony mortality during winter.

PROJECT CONTACT: MSU Apiculture Specialist

Topic IV: Mitigative and preventative measures

Goal 1: Develop best management practices for honey bees.

1: Develop best management practices for migratory beekeeping.

Ongoing Research:

BMPs for beekeepers being developed. University of Georgia researchers are developing best management practices for beekeepers and queen breeders and implementing a technology transfer program, including workshops on improving queen selection and propagation and a Web-based Community of Practice.

PROJECT CONTACT: K.S. Delaplane (Ksd@uga.edu)

2: Develop best management practices for pest and pathogen control.

Accomplishments:

Non-chemical trapping device for small hive beetle created. ARS developed a new non-chemical trapping device to control the small hive beetle in honey bee colonies. This new beetle trapping device will help to reduce application frequency of harsh chemicals in bee hives and therefore improve the health of bees and quality of honey bee products.

PROJECT CONTACT: Katherine Aronstein (Kate.Aronstein@ars.usda.gov)

Gamma irradiation discovered to control pathogens and promote colony growth. ARS and PDA determined that gamma irradiation is an effective means of reducing pathogens and promoting colony growth when applied to bee comb. After 9 months, colony survival was approximately 70% on irradiated comb compared to 30% on non-irradiated comb. Analysis of varroa and pathogen levels is on-going.

PROJECT CONTACT:
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Ongoing research:

Small hive beetle trap development continues. The University of Tennessee is testing a bait for use in a small hive beetle trap placed inside honey bee colonies.

PROJECT CONTACT: University of Tennessee

Non-chemical control methods for small hive beetles tested. Researchers at the University of Florida, University of Georgia, and Clemson University are testing the efficacy of non-chemical control methods (resistant stock, trapping, nematodes) at reducing small hive beetle populations. Information gained from these studies will be included in a Best Management Practices guide developed by the American Association of Professional Apiculturists.

PROJECT CONTACT:

3: Establish guidelines for floral gardens to maintain stronger honey bees.

Goal 2: Develop best management practices for non-Apis bees to provide alternative pollinators for crops, gardens, and natural areas.

1: Develop best management practices for pest and pathogen control in non-Apis bees.

Accomplishments:

Chalkbrood reduced in alfalfa leafcutting bees using fungicides. ARS scientists have determined the mode of chalkbrood disease transmission and have established that at least one mode of transmission can be blocked by proper application of fungicides to overwintering cocoons. (Chalkbrood is the most significant disease in alfalfa leafcutting bees, commonly killing as many as 20% of the larvae every year.)

New detection system developed to identify chalkbrood spore contamination levels. ARS developed a DNA-PCR based detection system to assess the number of chalkbrood spores contaminating environmental samples. This detection system will be used this year to evaluate levels of contamination in different bee management systems and to study the transmission of the disease from soil, flowers, and wild bees.

Three year survey of chalkbrood in alfalfa leafcutting bees completed. In a 3-year survey of bees from alfalfa seed growers in different regions of the U.S. and Canada, ARS evaluated alfalfa leafcutting bees for chalkbrood infection and determined that levels varied significantly between states and growers; some congregations of bees were infected with multiple species of chalkbrood. ARS used a new detection system that readily identifies different kinds of chalkbrood infections before symptoms are apparent in the bees.

Isolated genes active in infected bees. By studying response genes in the alfalfa leafcutting bee, ARS is working to determine the genetics of immunity to disease and thus the potential for breeding for disease resistance, as well as to evaluate the impact of stressors such as extreme temperature and pesticide exposure on disease susceptibility.

PROJECT CONTACT: Rosalind R. James

Ongoing Research:

Native bee pathogens and insecticides studied. Researchers at the University of Georgia are characterizing new and emerging pathogens and parasites of native pollinators, studying the effects of insecticides on the bees and developing recommendations for more efficient use.

PROJECT CONTACT: K.S. Delaplane (Ksd@uga.edu)

2: Establish guidelines for maintaining stronger populations of non-*Apis* bees in agricultural systems, home gardens, and wildlands.

Accomplishments:

***Osmia aglaia* developed as an affordable, effective pollinator for raspberries and blackberries.** ARS demonstrated that a new, native West Coast bee, *Osmia aglaia*, is as effective as honey bees for pollination of raspberry and blackberry crops, which are worth $200 million annually in the U.S. This bee was shown to be even more consistent and affordable than honey bees. Researchers designed a $25 reusable, durable nesting shelter and support for use of this bee. In 2007, nesting populations were increased to 10,000 bees in commercial cane fruits in Oregon.

Sustainable management of alkali bee shown to be economical for alfalfa seed production. ARS found that the alkali bee, the world's only intensively managed ground-nesting bee, can supply an economical means of pollinating alfalfa for commercial seed production. Surveys indicate that even amid intensive conventional agriculture, a native bee can sustainably multiply to large numbers. The bee pollinates an estimated 4 million pounds of alfalfa seed annually, which produces 1/3 of the $14 billion in U.S. crops requiring bee pollination.

Specialist native squash bee* (Peponapis) *found responsible for most squash and pumpkin pollination in North America. ARS found that the native squash bee (Peponapis) is alone responsible for almost all of the pollination of squash and pumpkin and their wild relatives from Canada to Argentina. The crops are valued at $500 million annually.

Native bees found to be critical to rangeland restoration. In an on-going program to evaluate pollination needs for 15 wildflower species, ARS determined that native bees are critical for farming these wildflowers for seed. Researchers demonstrated that native bees are essential for pollinating biscuit roots (carrot relative), and white globe mallows (cotton relative) are dependent on native bees but can also benefit from honey bees. This knowledge will assist with the pollination and growth of wildflower seeds needed for rangeland restoration.

PROJECT CONTACT: James Cane

Standard sampling protocol developed for assessing native bee populations. In collaboration with other bee researchers in North America, ARS developed a standardized sampling protocol and used it to gather important baseline data on native bee populations in several national parks. Using this sampling methodology, ARS assessed the impact of fire on bee communities and determined that burned landscapes, two years post-fire, supported bee populations up to nine times as large and with several times more species than unburned lands. This protocol will support further studies providing the baseline data on pollinator status recommended by the National Academy of Science.

PROJECT CONTACT: Terry Griswold

Release of too many alfalfa leafcutting bees shown to reduce commercial bees at nesting sites. ARS investigated the optimal stocking density of alfalfa leafcutting bees to maximize alfalfa seed yield while increasing pollinator population. Studies showed that release of a moderate number of bees (30,000/ac) produced a higher percentage of nesting females than low or high numbers (45,000/ac) of releases. This illustrates that according to current practices, too many alfalfa leafcutting bees are released, leading to reduced numbers of commercial bees at nesting sites.

Microclimate linked to prevalence of failed alfalfa leafcutting bee cells in the U.S. ARS studied the effects of microclimate on the occurrence of "pollen balls" in nests of alfalfa leafcutting bees in U.S. and Canada (the malady called "pollen balls" accounts for up to 60% of losses in commercial populations of alfalfa leafcutting bees). Researchers determined that this malady is more likely to occur on hot days, linking microclimate to the prevalence of failed alfalfa leafcutting bee cells in the U.S.

PROJECT CONTACT: Theresa Pitts-Singer

Goal 3: Maintain bees with resistance to parasites and pathogens.

1: Identify traits associated with resistance to parasites and pathogens.

Accomplishment:

Varroa mite resistance traits being identified. Indiana researchers are performing genomic studies to identify genes involved in resistance to varroa mites and also for the aggressive behavior of Africanized honey bees.

PROJECT CONTACT: CSREES, NRI

Ongoing Research:

Resistance traits to viruses, nosema, and varroa mites being identified. Researchers at the University of Georgia are working to identify genes that influence honey bee resistance to pests and pathogens, including viruses, nosema, and varroa mites, and incorporating those resistance traits into bees. In doing so, scientists are studying the management practices correlated with increased genetic diversity of queen bees. The results of this research will be transferred to university breeding programs to support the development of commercially available bee lines more resistant to pests and diseases.

PROJECT CONTACT: K.S. Delaplane (Ksd@uga.edu)

2: Introduce resistance traits into bee stocks favored by the industry.

3: Use genomic technologies and germplasm preservation to maintain quantities of desirable honey bee germplasm.

4: Transition to mite and pathogen-resistant honey bee stocks.

Goal 4: Develop ways to manage mite resistance to miticides and create alternatives.

1: Develop resistance management programs that provide beekeepers with tools for mite management.

Accomplishment:

New acaricide rotation program developed to control varroa mite resistance. In collaboration with industry (Mann Lake Ltd., Elanco, Vita [Europe] Limited, Central Life Sciences, and Bayer), ARS tested several different control methods for the varroa mite and developed an acaricide rotation program that manages development of resistance by varroa destructor. Future studies will continue to develop effective acaricide delivery systems and to test rotational schemes.

PROJECT CONTACT: Frank Eischen (Feischen@weslaco.ars.usda.gov)

2: Develop new methods of managing parasites and pathogens.

Accomplishments:

New biopesticide for varroa mite control developed. ARS discovered that the fungus *Beauveria bassiana* was able to increase varroa mite fall from brood cells without negatively impacting bee health, and developed a new biopesticide consisting of spores of the fungus and a plant wax powder. A patent was filed in 2007, and a company was contacted regarding mass production.

PROJECT CONTACT: William G. Meikle (Wmeikle@ars-ebcl.org)

Ozone identified as a fumigant to eliminate pesticides and insect pests of honey bee hives. ARS determined that high concentrations of ozone can be used to kill wax moths during hive storage and to eliminate pesticide residues in bee nesting materials. Further tests are currently being conducted to determine the concentrations needed to kill pathogens so that nesting materials can be safely re-used year after year.

PROJECT CONTACT: Rosalind R. James

New control method for varroa mites devised. ARS determined that the food additive 2-heptanone and beta plant acids can be highly effective in controlling varroa mite populations in bee colonies. Scientists are developing delivery systems to optimize the amount needed to kill mites without harming bees.

PROJECT CONTACT: Gloria DeGrandi-Hoffman (Gloria.Hoffman@ars.usda.gov)

Integrated control techniques for varroa mites discovered. University of Nebraska scientists have developed techniques to reduce varroa mite populations in colonies before winter. Scientists found that a combination of requeening and treating colonies with oxalic acid creates a break in brood rearing and makes mites vulnerable to treatment, while increasing colony vigor. Current studies are assessing the effects of oxalic acid treatment on queen survival and on the colony's reproductive capacity.

PROJECT CONTACT: University of Nebraska

Goal 5: Improve the regulatory framework to better protect against the introduction of new pathogens, pests, and parasites of bees to meet World Trade Organization (WTO) and International Committee of the World Organization for Animal Health (OIE) requirements for the importation and exportation of honey bees.

1: Develop new molecular detection systems that can be used to detect pathogens, pests, and parasites in introduced bee stocks and bee products used in beekeeping.

Accomplishment:

New pathogen identification technique developed. ARS developed a new DNA-based method to identify the honey bee fungal pathogen responsible for chalkbrood disease, *Ascosphaera apis,* in bee samples. This method will allow the rapid detection of this pathogen even before the clinical signs of the disease become visible and will help to monitor/prevent disease spread.

PROJECT CONTACT: Katherine Aronstein (Kate.Aronstein@ars.usda.gov)

New detection system developed to identify chalkbrood spore contamination. ARS developed a DNA-PCR based detection system to assess the number of chalkbrood spores contaminating environmental samples. This detection system will be used this year to evaluate levels of contamination in different bee management systems and to study the transmission of the disease from soil, flowers, and wild bees.

PROJECT CONTACT: Rosalind R. James

2: Explore opportunities to change regulations based on new molecular detection systems.

Accomplishment:

New molecular assay for resistant bacterial strains developed. ARS identified the mechanism of resistance of the bacterial honey bee pathogen (*Paenibacillus larvae*) to oxytetracycline (OTC) antibiotics and developed a new molecular assay for detecting OTC-resistant bacterial strains in bee samples. This new identification method is now available for regulatory officials considering ways of preventing the spread of resistant bacterial strains in bee shipments.

PROJECT CONTACT: Katherine Aronstein (Kate.Aronstein@ars.usda.gov)

Guidelines for bee imports developed. ARS began working with the North American Plant Protection Organization to coordinate regulation and importations of non-*Apis* bees between Mexico, Canada, and the U.S. Initial guidelines were developed for the safe importation of bees to avoid the accidental release of bee pathogens and parasites and to avoid the introduction of bee species that may cause a loss of native bees.

PROJECT CONTACTS:
Rosalind R. James (
James Strange (

3: Establish processes for periodic monitoring of the U.S. honey bee population to determine whether specific pests are present.

Goal 6: Demonstrate improved colony health by integrating research-derived knowledge and tactics into an Areawide Project.

1: Test and verify management approaches for mite control, improved diet, improved bee stock, and changes in migratory practice.

Areawide Project initiated. ARS has initiated an Areawide Project on Honey Bee Health across multiple ARS locations (Tucson, Arizona; Beltsville, Maryland; Weslaco, Texas; and Baton Rouge, Louisiana). The project has several aspects: document the impact of migration on bee colonies, examine the effects of supplemental feeding on colony health, develop more resistant bee lines, and develop better control methods for honey bee pests. Ultimately, the Project aims to develop a set of best management practices for migratory beekeepers to reduce stress on their bee colonies, thereby enabling bees to ward off threats. Specific results of these individual research projects are described elsewhere in this report.

Objective 2: Transfer technology for early spring bee availability for pollination.

Accomplishment:

Supplemental protein diet developed. In collaboration with S.A.F.E. Research and Development, ARS scientists recently developed MegaBee, the Tucson Bee Diet, a supplemental protein diet that is comparable to naturally collected pollen in attractiveness to bees, consumption rates, and stimulation of colony growth. The diet is an important component in addressing the impact of poor nutrition on colony health triggered by insufficient amounts of pollen in the hive, and may also help to prevent CCD. Scientists from several laboratories are developing a liquid delivery system for the diet.

PROJECT CONTACT: Tucson, Arizona

Goal 7: Transmit or disseminate science-based information to manage bees.

1: Develop, maintain, and preserve a secure Web-based site for scientific collaboration (Sharepoint).

2: Develop, maintain, and update a Web-based public Internet site, e.g., eXtension or PIPE (Pest Information Platform for Extension).

Ongoing Work:

CCD outreach and extension efforts underway. CSREES has initiated several extension and outreach efforts to inform the public of CCD research findings and updates. These include the maintenance of several Web sites, such as the Honey Bee Health Community of Practice and eXtension Web site (University of Tennessee, Michigan State University, and Purdue University); the BeeSpotter Web site (University of Illinois), a portal to inform the public about pollinators and gather data on the population status of these insects; and cyberbee.msu.edu (Michigan State University) to provide updates on CCD. Universities have also been working to integrate knowledge about CCD into extension programs and classroom teaching.

PROJECT CONTACT: