The Bee Informed Partnership: Using Beekeeper's Real-World Experience to Solve Beekeepers' Real-World Problems

Dennis vanEngelsdorp, David R. Tarpy, Kathy Baylis, Marla Spivak, Dewey M. Caron, Joseph Connell, Keith S. Delaplane, Susan Donohue, Wayne Esaias, Brian Gross, Jerry Hayes Jr., Eugene J. Lengerich, Jeffery Pettis, Karen Rennich, Robyn Underwood, Robyn Rose, John Skinner, and James Wilkes

The Bee Informed Partnership (BIP) received a 5-year Coordinated Agriculture Project (CAP) grant from the National Institute of Food and Agriculture (NIFA) to use an epidemiological approach to identify risk factors associated with honey bee colony losses. An epidemiological approach identifies factors that contribute to disease occurrence in a population, advocates for and promotes ways to reduce exposure to risk factors, and seeks to reduce disease incidence at the population level.

Epidemiological studies concentrate on understanding the cause(s) of any particular disease or etiology at the population (rather than the individual) level. Epidemiologically, disease itself can be defined broadly as any departure from perfect health. Factors that epidemiologists consider determinants of disease may be biotic (e.g., pathogens) and/or abiotic (e.g., pesticides). The epidemiologist aims to identify ways to minimize exposure to risk factors by encouraging changes in host behavior that mitigate disease in a population.

Managed honey bee (*Apis mellifera* L.) populations have declined in the United States over the last 60 years. These losses are of particular concern because an estimated 35% of the Western human diet benefits from honey bee pollination. Considering the honey bee's role as a pollinator in the commercial production of crops, it is surprising that periodic losses and overall population declines had not been well studied prior to the unusually high losses in the U.S. over the winter of 2006-2007. Subsequent winter losses have averaged about 30% per year, a loss that is nearly double what beekeepers consider sustainable.

The reasons for these unsustainable losses are poorly understood. Some are attributable to Colony Collapse Disorder (CCD), the underlying cause(s) of which remains unknown despite intense empirical investigations; however, in the winter of 2010-2011, the vast majority (>70%) of reported colony losses were not attributed to CCD, as most dead colonies were not missing bee cadavers in the hive or apiary—the hallmark symptom of CCD.

The core of our BIP project consists of a series of coordinated surveys. The first, an annual survey designed to quantify winter losses, is built upon efforts begun by the Apiary Inspectors of America and USDA-Agricultural Research Service (ARS) Bee Research Lab (BRL) in Beltsville, MD who conducted the study from 2006-2010. This series of surveys provides yearly loss data from beekeepers with small to large operations who collectively manage >20% of the nation's bee colonies. Because these surveys are a non-random sample of the industry, we will use epidemiological and statistical methods to quantify and adjust for sampling biases.

In addition to quantifying winter losses, the BIP effort will report the comparative success of different beekeeping management practices. An extensive management survey was conducted in 2011 and the results will be communicated to beekeepers through Web-based toolearly in 2012. Using an extension model of engaging and empowering stakeholders, outreach efforts will focus on utilizing methods that encourage experiential learning and beekeeper-to-beekeeper exchanges.

Our Web-based efforts for reaching target audiences will use interactive tools to enable stakeholders to make informed decisions based on data derived from other beekeepers. This will be achieved by presenting survey data in a simple, easy-to-understand format. We report the news, without spin or bias, and let the beekeeper decide. For example, one of our outputs (average winter loss and 95% Confidence Intervals (CI)) will be presented from a single-factor analysis of management methods reported by responding beekeepers. In Fig. 1, we present average colony loss for beekeepers that reported either applying or not applying a product to control the parasitic mite *Varroa destructor*. We emphasize the intuitive differences between groups through an examination of the 95% CI (i.e., if the 95% CI bars do not overlap, there are statistically

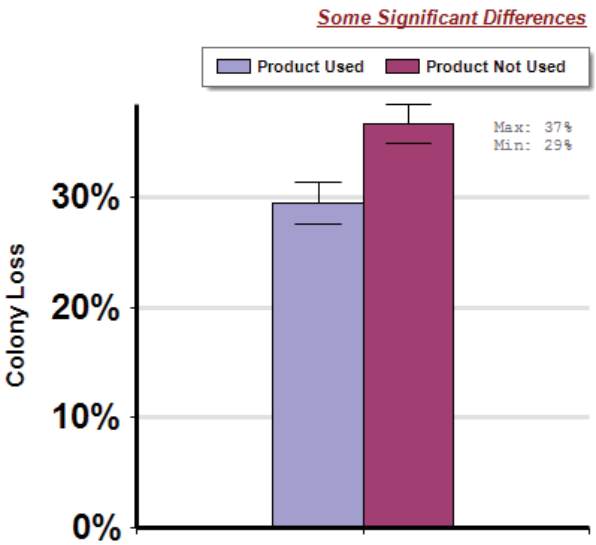

Figure 1: A comparison of average winter colony mortality among beekeepers who reported treating or not treating with a known varroa mite control product at least once to a majority of their colonies between April 2010 and March 2011. This figure will be accompanied with the following interpretation: Beekeepers who reported treating with a known varroa mite control product reported 7 fewer over-wintering colony deaths per 100 managed colonies than those who did not report using a known varroa mite control product. In other words, beekeepers who reported treating lost 20% fewer colonies than those who did not report such use. Sixty-one percent of beekeepers did not report using a varroa mite control product.

significant differences between the groups). In addition, we include an asterisk above bars that are significantly different (P<0.05). The purpose of this reporting is to visually demonstrate the magnitude of differences between the populations. We also include a short descriptive "interpretation" of the results for each figure.

Recognizing that there are geographic differences in management practices, results will be regionalized. In the first year, results can be divided into operations that manage colonies in the southern region, northern region, or both. Migratory beekeepers operating in both northern and southern states are likely to employ management practices that are different from stationary operations. Adding respondents beyond the initial 3,000 will allow resolution of differences in management outcomes in more narrowly defined populations.

The epidemiological approach identifies both risk factors (i.e., Fig. 1) and management practices meant to reduce risk-factor exposure. It is not sufficient to present results without providing an economic context; therefore, an important part of this effort will be to assign economic weight to the implementation of specific management practices.

In this first year, the costs of treatments are being compiled and compared with the benefit of reduced colony replacement costs. For example, using Apiguard (a varroa mite control product that costs $8 per treatment) is correlated with a 30% decrease in over-wintering mortality. If replacement colony costs are $90-$120, then Apiguard is associated with a $30-$40 expected benefit. In this case, our survey data indicate that Apiguard is worth its cost.

Other remedial products may be associated with lower winter losses but may not be cost effective. This analysis only considers the actual purchase cost of treatment and the benefit of not having to replace a hive (i.e., it does not take into account associated costs of labor). In the future, we will consider other costs associated with treatment and their benefits, such as improved honey production from healthier bees.

A critical component of this effort is disseminating information to beekeepers quickly and accurately. Because peer-reviewed results are important for scientific integrity, a science advisory board will be consulted to develop criteria for Web publication (including a peer-reviewed standard for grading and vetting the quality of individual survey outputs). The BIP Web site (http://beeinformed.org) will be the main conduit of information dissemination. This site will engage beekeeper discussion, keep interested parties apprised of on-going field activities, and publicize accomplishments. The eXtension "Honey Bee Health" community of practice (COP; http://www.extension.org/bee_health) will be used to disseminate more "processed" results.

Survey efforts will focus on retrospective interviews and the establishment of technology-transfer teams. These teams will work with selected large beekeeping operations (e.g., queen-rearing operations and migratory beekeepers) to establish disease-monitoring protocols. This is the most resource-intensive aspect of this initiative, but it is necessary because relatively small numbers of beekeepers own a majority of the country's colonies (e.g., migratory operations) or generate a majority of the genetic stock (e.g., queen producers in northern California). By focusing attention on these keystone operations, movement of diseases and pests across the nation can be reduced and the distribution of disease-resistant stock enhanced.

Work with the California Bee Breeding Association has begun. We established a team of professionals to work one-on-one with major queen producers in northern CA to assist with: 1) stock selection and breeding for resistance; 2) enhancement of genetic diversity; 3) disease and pest diagnostics with information on best management practices (BMPs) to reduce chemical treatments; and 4) cooperative research on relevant topics, such as quality of queens and drones and efficacy of treatments. This program will be expanded to include other large queen-production regions (e.g., the southeastern U.S. and Hawaii). Another team will be established to work with migratory beekeeping operations to achieve the same goals. Working directly with the queen-rearing industry and migratory beekeepers will provide a strategic benefit for the improvement of bee health nationwide.

Another core component of our project is the creation and maintenance of a Honey Bee Health Database, which will (a) serve as a repository for new data collected in this initiative and (b) act as a comprehensive site into which data from historical and ongoing efforts can be archived. For example, NASA is transferring to BIP the HoneyBeeNet database that links local nectar flow scale hive data with satellite vegetation phenology to associate seasonal variations in bee foraging with variation in climate.

A preliminary survey of readily available, pertinent data suggests that, conservatively, over 100,000 honey bee health records could be incorporated from ARS-BRL diagnostics and the USDA Animal and Plant Health Inspection Service (APHIS) National Honey Bee Pest and Disease Survey. The APHIS surveys have been conducted yearly nationwide since 2009 and include apiary-level data on exotic pests as well as general honey bee health (e.g., viral and pathogen load). These reports, combined with newly incorporated data from various initiatives, will provide beekeepers a temporal and geographical context for interpreting results. This context is important for several known bee viruses and the gut microsporidian *Nosema ceranae* (for which the etiology is not fully understood). While survey information will provide beekeepers better insights into the diseases in their own operations,

it is difficult to draw conclusions about economic thresholds outside of narrowly defined conditions; however, if beekeepers are presented with data that provide context (e.g., *Nosema* levels of a given colony are in the 90th percentile for all samples taken in that region and season), then beekeepers will be able to make better-informed treatment decisions even without explicit economic thresholds. A Web-based interface to the Honey Bee Health Database will provide beekeepers confidential access to their data and mechanisms for comparisons to collective data. In addition, a partnership between BIP and the online record-keeping system Hive Tracks will allow beekeepers to utilize the detailed colony data from Hive Tracks for the BIP surveys.

"Economies of scope" describes the existence of benefits from one activity that improve other outputs. One innovative attribute of the BIP project is the potential to link data from multiple surveys with results from specific sampling of colony parasite loads or instances of catastrophic colony losses. Simultaneously observing winter loss rates, disease loads, treatments, and colony productivity enables us to control for multiple factors that affect the efficacy of management practices. Second, having data on disease prevalence in a certain region constitutes improved bee management information for that region. Awareness of potential disease outbreaks enables us to better alert growers of potential pollination shortages. In short, by matching these data from multiple sources, BIP allows beekeepers to benefit from these economies of scope.

The BIP program will focus on utilizing this rich and dynamic dataset to enable beekeepers to objectively evaluate their management practices. Moreover, the policies created to govern access to these data will reflect a philosophy of open access and transparency. Open access will invite a wide range of creative research and extension opportunities with many long-term benefits. While aiming to provide transparency to researchers, beekeepers, and other interested parties, we are also dedicated to preserving stakeholder confidentiality and privacy.

In summary, the vision of the Bee Informed Partnership is to help all beekeepers maintain healthier bees and reduce winter losses. This initiative will help beekeepers improve their colony management practices by providing access to reliable and immediate information that reflects the collective experience, expertise, and practices of their fellow beekeepers. Changes in management practices best suited to a beekeeper's geography, colony count, philosophy, and purpose will be accelerated by using technology as a catalyst. These changes will happen immediately as reports are released in early 2012. A long-term significant benefit of the Bee Informed Partnership is the honey bee health database and associated software for collecting, storing, analyzing, and reporting data. Our hope is that this diverse, dynamic, and accessible information system will provide a significant return on investment for years to come for all stakeholders.

Dennis vanEngelsdorp, Assistant Research Scientist, Department of Entomology, University of Maryland, College Park, MD. **David R. Tarpy**, Associate Professor and Extension Apiculturist, Department of Entomology, North Carolina State University, Raleigh, NC. **Kathy Baylis**, Assistant Professor, Department of Agricultural and Consumer Economics, University of Illinois at Urbana-Champaign, Urbana, IL. **Marla Spivak**, Professor, Department of Entomology; University of Minnesota, St. Paul, MN. **Dewey M. Caron**, Emeritus Professor, Univ Delaware, Affiliate Scientist - Horticulture Dept, Oregon State Univ., Corvallis, Portland, OR. **Joseph Connell**, County Director and Farm Advisor, University of California Cooperative Extension, Oroville, CA. **Keith S. Delaplane**, Professor, Department of Entomology, The University of Georgia, Athens, GA 30602. **Susan Donohue**, Nutrition, Family and Consumer Sciences Advisor, Oroville, CA. **Wayne Esaias**, Research Scientist Emeritus, Goddard Space Flight Center, Greenbelt, MD. **Brian Gross**, Food and Resource Economics, University of British Columbia, Vancouver, BC, Canada. **Jerry Hayes Jr.**, Beeologics Commercial Lead, Monsanto, St. Louis, MO, **Eugene J. Lengerich**. Professor, Departments of Public Health Sciences, Family and Community Medicine, and Health Policy and Administration, The Pennsylvania State University, Hershey, PA. **Jeffery Pettis**, Research Leader, USDA-ARS, Beltsville, MD. **Karen Rennich**, Project Manager, Department of Entomology, University of Maryland, College Park, MD. **Robyn Underwood**, Assistant Professor, Department of Biology, Kutztown University, Kutztown, PA. **Robyn Rose**, National Program Manager, United States Department of Agriculture, Animal Plant Health Inspection Service, Plant Protection and Quarantine, Emergency and Domestic Programs, Riverdale, MD. **John Skinner**, Professor University of Tennessee, Knoxville, TN, Extension Apiculture Specialist, and **James Wilkes**, Professor and Chair, Department of Computer Science, Appalachian State University, Boone, NC.