Two-Year Report on the Progress Toward
The Recommendations of the

Study of the Plight of Virginia's Beekeepers

Submitted to:

Senate Committee on Finance
Senate Committee on Agriculture, Conservation, and Natural Resources

House of Delegates Committee on Appropriations
House of Delegates Committee on Agriculture, Chesapeake and Natural Resources

Submitted by:

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Executive Summary

Funds provided by the General Assembly to Virginia Tech through Cooperative Extension have been used to implement the recommendations contained in the Study of the Plight of Virginia Beekeepers (Virginia Senate Document Number 20). Four initiatives were identified in the document and recommended for funding; the development of a pest management program for colony management, the development of a queen breeding program, the development of an Africanized honey bee response program, and the development of a pollination program. Significant progress has been made in each of the four areas during the two years, including the identification and characterization of a new disease problem (*Nosema ceranae*), the establishment of 5 teaching research apiaries, the development of a queen production program that has provided training for 198 beekeepers, the initiation of an Africanized honey bee survey and response program, and the study of pollination needs in 6 different cropping systems. Program development and implementation has been a collaborative effort of Virginia Polytechnic Institute and State University/Virginia Cooperative Extension (VT) and the Virginia Department of Agriculture and Consumer Services (VDACS). Continuation of the programs will be dependent on continued funding.

Background

The beekeeping industry in Virginia has declined significantly over the past twenty years. The number of bee hives and the number of beekeepers in the Commonwealth has decreased by over 50% since the mid 1980's. This decline has resulted largely from the introduction of exotic bee pests and diseases; however, other problems have also impacted the industry. In 2006 Senate Joint Resolution Number 38 requested the Virginia Department of Agriculture and Consumer Services to study the plight of the beekeepers and to identify possible remedies to the problems identified in the study. The resulting document, Virginia Senate Document 20, The Study of the Plight of Virginia Beekeepers, detailed the major problems faced by the industry and identified initiatives in four areas that would help stimulate recovery of the beekeeping industry. In 2007 the General Assembly appropriated $250,000 to fund the initiatives recommended in the Study. Last year the General Assembly passed legislation to protect the unused funds and allow for their continued use during the 2008-2009 fiscal year. Governor Kaine signed the request on April 11, 2008 to protect the unused funds allocated in 2007. This report presents a summary of the program accomplishments made during the two years.

The initiatives identified in the Study of the Plight of the Virginia Beekeepers included the following areas:

1. Development of an integrated pest management program that is tailored specifically for Virginia to address pest and disease problems affecting honey bees, particularly with regard to the occurrence of *Varroa* mites in bee hives.

2. Support a multi-regional queen rearing program for the production and distribution of a pest and disease resistant line of honey bees that is productive, sustainable and free from the aggressive behavior by bees contaminated by Africanized Honey Bees (AHB).

3. Implement programs to (i) assess the risk, monitor the occurrence, and reduce the adverse impact of AHB; and (ii), educate the public as to the importance of honey bees to agriculture, environment, and the economy.

4. Promote the use of honey bees by farmers to increase crop production and quality, and encourage pollination services of beekeepers so as to eliminate Virginia's reliance on the import of honey bee hives from other states.

The progress in each of these four areas is presented in the following sections.

Integrated Pest Management

The development of effective pest management programs for Virginia beekeepers involved five separate initiatives. These included the initiation of research studies on IPM and best management practices, the establishment of regional apiaries for research and extension outreach, the development and distribution of training programs for Extension, the development of a Master Beekeeper Program, and the development of management protocols for beekeepers.

Research Studies on IPM Best Management Practices

Annual colony losses for Virginia beekeepers have averaged over 30% for the past eight years. A number of factors contribute to these losses, but colony health has been a major factor in colony decline. Problems with *Varroa* mite parasites, diseases, poor nutrition and colony collapse all contribute to the colony health problems faced by the beekeeper. The recent discovery of two new honey bee disease pathogens in the U.S. (Israel Acute Paralysis Virus [IAPV] and *Nosema ceranae*, a microsporidian) has further complicated the issues of colony health. In addition an over-reliance on chemical miticides for *Varroa* control has increased colony stress and exacerbated other health related problems.

Improvements in colony health are critical to the beekeeping industry and require the development and implementation of better management practices, especially with regard to the control of *Varroa* mites. In response we initiated several studies on *Varroa* management. Half of the colonies at three of the newly established research apiaries (see below) have been placed on screen bottom boards (as opposed to solid bottom boards) to test their effectiveness in reducing mite levels and to determine if screen bottom boards affect brood production and / or winter survival. These colonies were monitored over 12 months. We also initiated a research study at the Virginia Tech apiary to examine intra-hive mite distribution with regard to brood distribution, and the potential for manipulating mite populations for better control without the use of chemical miticides.

The studies on the use of screen bottom boards versus solid bottom boards showed no difference with respect to mite infestation levels or the amount of brood at the end of the summer season. Mean 24 hour mite fall in colonies with solid bottom boards was 40.7 ± 9.6

(n=21) compared to 45.4 ± 14.1 for colonies with screen bottom boards (n=14). The number of frames of brood was 6.4 for colonies with a solid bottom versus 6.1 for colonies with a screen bottom. Winter survival was poor in both groups since no treatments were given. Survival for colonies on screen bottom boards was 42.8% versus 45.5% for colonies on solid bottom boards. The results of these studies indicate that screen bottom boards do little to reduce mite populations or improve colony health.

The studies on intra-hive mite distribution were designed to obtain a better understanding of the spatiotemporal distribution of mites and how we might use the information to improve sampling and treatment decisions. In order to conduct the study, mite populations were sampled in a group of experimental hives (consisting of 1 full-depth hive body or 1 full-depth and 1 medium depth) over a 3 day period using modified sticky boards. After the sticky boards were removed and the mite numbers were counted, we used geostatistical approaches and GS+ and Matlab software to analyze the mite sampling data and to build spatial models of mite distributions that can be displayed as surface density maps (Figure 1). We also measured brood distributions in hives and correlated these data with mite distributions. The results of these studies have shown a fairly good correlation of mites and brood (correlation coefficients [r values] varied from 0.3 – 0.58), but the distribution of brood only explains a small portion of the variation in mite distribution. From a practical viewpoint these studies suggest that we cannot use brood manipulation as an effective management tool for mite control, although we still have studies in progress. As part of this study we also found that mite sampling data can be highly variable. We found mite numbers from sticky board samples could vary by as much as 255% in as little as two weeks. These data make it difficult to set mite number thresholds for beekeepers to use when making management decisions for colony treatment. We have set a treatment threshold (drop number) at 60 mites/24 hrs and recommend beekeepers use this number for deciding when to treat.

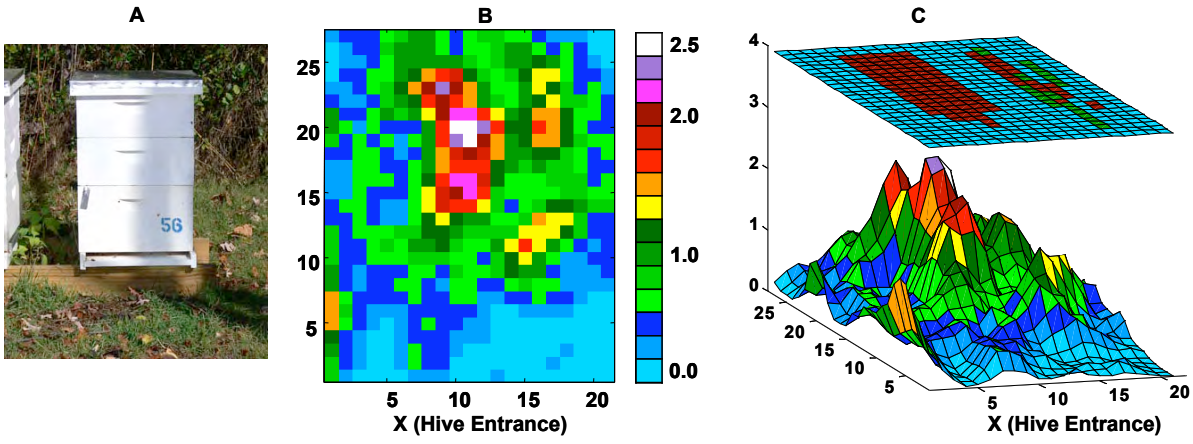

Figure 1. Varroa mite distribution in Hive 56 (A) in relation to capped and uncapped worker brood. (B) 2-D surface map of mite numbers per cell and (C) 3-D map of mite density with a 2-D map overlay of the occurrences of brood with respect to mite density.

The discovery of IAPV and a new *Nosema* pathogen in the U.S. has further complicated the problems of colony health and the development of best management practices. Both of these pathogens have been associated with Colony Collapse Disorder and have become a major concern for the beekeeping industry. However, a major difficulty in this regard was the fact that we did not know whether the virus or the new *Nosema* species was present in Virginia. This problem was further complicated by difficulties of diagnosis, since identification requires the utilization of molecular biology techniques. In an effort to develop the capabilities for diagnosis we initiated a program that has allowed us to identify the presence of *Nosema ceranae* and IAPV in bee samples collected from around the state. We have developed real time polymerase chain reaction (PCR) techniques for the analysis of both pathogens. The analysis of *Nosema* involves the use of TaqMan® assays after the extraction of DNA from bee samples. We have provided over 600 sample kits to beekeepers around the state for the collection of bee samples from their hives. To date we have analyzed samples from approximately 150 hives in 29 different regions around the state (Figure 2). We have done both microscopic examinations of midgut tissue for the presence of *Nosema* spores and PCR analysis. Our results indicate that *Nosema cearane* is the dominant species and that over 60% of the hives are infected. This high rate of *Nosema* is undoubtedly a major factor with regard to the colony health problems our beekeepers have been facing. As a result of this work, we are now recommending that beekeepers treat colonies with the antibiotic fumagilin as part of their late summer or fall management procedures. We also have primers for IAPV identification using real-time PCR and a SYBR® green assay. At this point we have done only minimal surveying for virus infections, and instead put our efforts in the Nosema survey. The collection and analysis of specimens for IAPV analysis is considerably more difficult; IAPV is an RNA virus and special care is needed in specimen handling. Also, there is little beekeepers can do to control virus infections other than work to reduce colony stress and maintain conditions conducive to colony health.

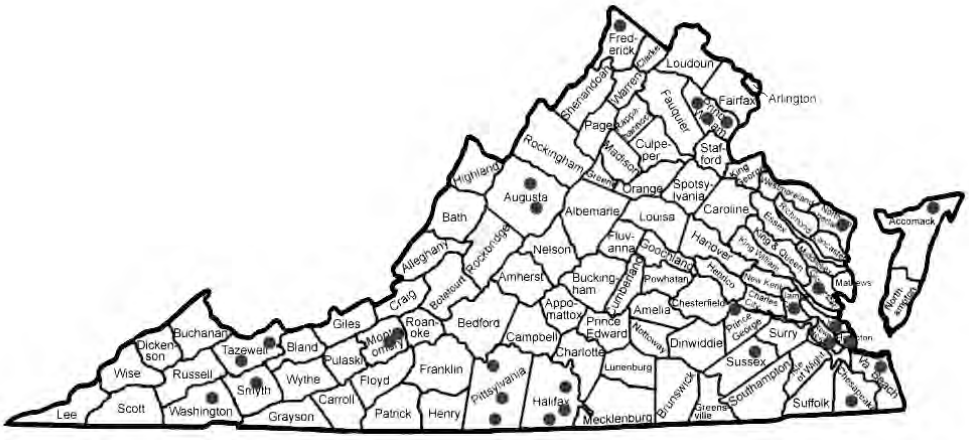

Figure 2. Sampling sites around Virginia where honey bees were collected from hives for a study on the levels of Nosema infection.

A survey of approximately 350 beekeepers across the Commonwealth of Virginia was conducted to determine current management practices. In general beekeepers are using less synthetic miticides to control *Varroa* mite infestations. This indicates a reduced potential for chemical contamination and residues in hive products such as wax. Many synthetic pesticides

are known to contaminate wax comb and may persist in comb for several years. Miticide residue buildup can result in sub-lethal complications for honey bees, and can lead to reduced fecundity, worker longevity, and drone production. The survey also indicated a slight rise in hive losses over the winter of 2008-09 to 33 %. The previous year's winter hives loss was 27 %. The 2009 increase in hive losses is an expected result as winter losses exhibit a two-year cycle.

Establishment of Regional Apiaries

Apiaries have been established at four locations around the state for use in research and extension programs. Equipment for the hives was purchased from local supply dealers and then assembled and painted with the assistance of local beekeeping associations. Bees for the hives were obtained from Virginia producers. Apiaries have been established at the Alson H. Smith Jr. Agriculture Research and Extension Center in Winchester, the Hampton Roads AREC in Virginia Beach, the Virginia State University Randolph Farm in Ettrick, and at the Virginia Tech Kentland Research Farm in Blacksburg. The apiaries provide sites for the development and evaluation of colony management techniques, as well as colonies for instructional use in outreach programs. The hives at the Hampton Roads AREC, for example have been used in a queen rearing short course and the hives at the Randolph Farm have been used for an Africanized Honey bee training program for first responders. The hives at these locations have also been used as sentinel colonies for monitoring bee diseases (such as the *Nosema ceranae*). Research projects to evaluate management techniques have been set up at all four sites (see above), however, to date data collection has been minimal due to high colony mortality in several of the yards during the 2008-09 winter.

The apiary at the Randolph Farm is currently maintained by VDACS staff with assistance from local beekeepers. It is anticipated that both research and maintenance of the Randolph apiary will involve VSU students and augment outreach programs for minority farmers. We have also initiated the establishment of a fifth apiary that will be set up at the McCormick Farm in Steeles Tavern. This apiary is being established in collaboration with the Shenandoah Valley Beekeepers Association and will be used as a research and demonstration apiary for sustainable hive management.

Apiculture Training Programs for Cooperative Extension Agents

Three regional programs were organized and presented to a combined group of 52 extension agents during the spring of 2008. The in-service training programs were offered in Harrisonburg (Northern and Northwest Districts), Virginia Beach (Southeast District) and Abingdon (Southwest District). A two-day program was organized and presented to a group of agents in the spring of 2009 to an additional group of 13 agents. The daylong programs consisted of four hours of classroom training on honey bee colony biology and organization, yearly management practices, major problems facing the bee industry, diseases and pests, and the management of mite parasites. The afternoon sessions were devoted to hands-on field demonstrations and included instruction on colony inspection and evaluation, management practices and techniques for sampling and treating colonies for mites. Agents were also provided with a manual and basic equipment for colony inspection. The 2009 in-service

training program was centered on colony health, with a special emphasis on diseases such as foulbrood. The hands on field portion of the course provided training on inspection for disease, as well as basic techniques in honey extraction and handling.

In addition to the agent training program, we are promoting beekeeping as a 4-H program under Plants, Soils and Entomology. Forty hive units were purchased for distribution to 4-H programs for the establishment of youth beekeeping clubs. Currently, extension agents in 5 localities have been provided with equipment to establish new beekeeping clubs and active programs have been started in 3 of these areas.

Development of a Master Beekeeper Program

A Master Beekeeper Program for Virginia has been developed and implementation is underway. The primary goal of the Master Beekeeper Program is to provide the beekeeping community with knowledgeable, trained individuals in honey bee biology and management. Participants in the program can serve as mentors to new beekeepers, provide training programs at local beekeeping associations, and assist fellow beekeepers in improving their hive productivity. The initial program was developed by Dr. R. Fell at Virginia Tech in collaboration with Keith Tignor, the Virginia State Apiarist at VDACS. The program draft was presented to the Virginia State Beekeepers Association at the annual Fall meeting in November 2007 and placed on the Association webpage for feedback and input. A revised program was placed on the Association webpage in February, incorporating changes in response to beekeeper input. The Master Beekeeper program consists of three levels, Qualified Beekeeper, Certified Beekeeper and Master Beekeeper. A set of requirements has been developed for each level and study guides for the levels have been written and posted on the Association website. Each level of the program includes education requirements, knowledge requirements, and experience in hive management. Certification for each level requires both a written and practical test. The first tests were offered in the summer of 2008 and since that time over 50 individuals have taken the test for the Qualified Beekeeper and approximately 25 have completed the requirements (both written and field tests).

<u>Queen Breeding Program</u>

Establishment of a Queen Production Program; Beekeeper Education and Training Programs on Queen Production

A decline in honey bee queen productivity and longevity has been a concern for Virginia beekeepers over the past several years. The quality of queens obtained from commercial queen breeders has been poor and many of our beekeepers have to replace queens in as little as 3-6 months. Previously queens were expected to be productive for at least two years. We are also concerned about the potential problem of introducing Africanized honey bees through the importation of queens. Many of the commercial queen producers now live in areas where AHB have become established. In response to these problems we initiated a program to increase queen production to provide local sources of replacement queens. As part of this effort, six one-day short course programs on queen honey bee production were organized and presented to beekeeper groups around the state from July 2007 through June 2008. Each

program consisted of four hours of classroom instruction, followed by 3-4 hours of field sessions in which queen production and replacement practices were demonstrated. The programs were attended by 138 beekeepers (an average of 23 per short course). Participants in the program were provided with equipment and manuals for producing quality queens, and some equipment to help encourage them to initiate queen production for their own use and for sale to other beekeepers. Follow up surveys are planned at the end of the 2009 production season to evaluate program success and determine not only the number of beekeepers involved, but also the quality of queens produced. Overall response to the training programs was excellent and we received additional requests to present similar programs in other areas of the state. In 2009 three queen rearing short course programs were presented to an additional 60 beekeepers. We plan to continue the program with the development of a selective breeding program designed to provide quality queens that are adapted to Virginia conditions.

Development of a successful queen production industry in Virginia requires an assessment of beekeeper needs and market potential. VDACS in association with local beekeeping organizations conducted a statewide survey of queen and honey bee replacement purchases and desired qualities of products. Product quality and presence of diseases and pests are the beekeepers' greatest concerns in purchases of packages of bees and nucleus colonies. Responses to the survey indicate that disease and pest resistance, honey production, and winter survival are the characteristics beekeepers consider most desirable in a honey bee queen. The implementation of queen breeding programs which emphasize selection for these characteristics would help reduce hive losses and increase production, and would increase overall income generated by the beekeeping industry. The majority of beekeepers, 72 %, obtain new queens for their hives on a regular basis. Most hives are provided with a new queen within every two years to improve production and sustainability. Annually an average of 8 honey bee queens are either purchased at a cost of approximately $20.00 per queen or raised by each beekeeper in Virginia. Unfortunately, the majority of purchased queens originate from out-of-state sources. Out of state purchases of queens and honey bees are primarily driven by beekeepers unaware of an in-state or local queen/bee producer. Preliminary data from the survey indicate that replacement of winter hive losses and expansion of hive numbers is costing Virginia beekeepers approximately $749,000 annually. In addition there is an estimated $257,000 market for queen production among Virginia's beekeepers. Results of the survey indicate that there is a sustainable market in Virginia for queen and honey bee production, the latter in the form of nucleus hives and packages of bees. Development and promotion of this segment of the beekeeping industry is required to lessen the importation of queens and honey bees into the Commonwealth.

Africanized Honey Bee Response

The occurrence of AHB in Florida and other Gulf Coast states has increased the potential for its accidental introduction into Virginia. This pest is not only a threat to honey bees, but also to domesticated animals and the general public. VDACS staff developed a new protocol to survey areas for presence of bee colonies. Previous sampling techniques were shown to be inadequate when competing resources were available. The changes in protocol resulted in improved detection of honey bees in a given area and the determination of hive locations.

Equipment for implementing the sampling protocol was obtained for regional VDACS offices in 2008-09. Rapid identification and eradication of AHB infestations are essential to prevent the establishment of this potentially harmful insect in the state. VDACS staff members are continuing to consult with neighboring and AHB infested states in the development of identification techniques for AHB. In addition the VDACS AHB trapping program was expanded to include truck stops and additional highway rest stops (Figure 3). These locations are likely points of entry of AHB swarms carried on vehicles traveling interstate highways from Gulf Coast states.

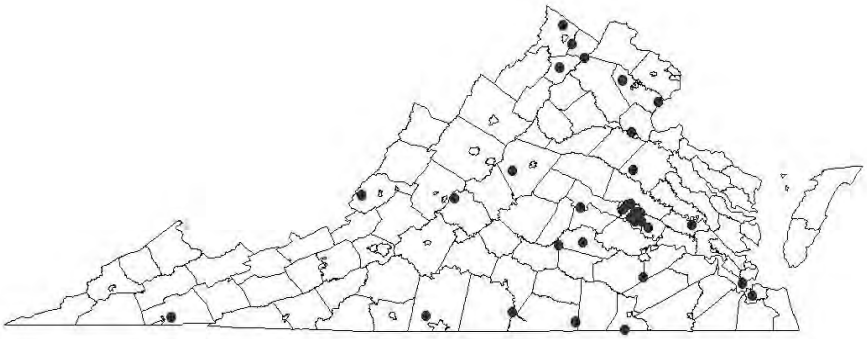

Figure 3: Sampling locations for Africanized honey bees in Virginia utilizing both the field sampling protocol and swarm traps.

Response Guidelines were drafted for emergency responders and the general public. The guidelines include equipment and training requirements for individuals and agencies responding to incidents involving victims of honey bee stings. The guidelines are intended for use with AHB incidents. However, the recommendations provide assistance to emergency management personnel in handling other stinging insect situations. Revision of the VDACS AHB Action and Bee Spill Action Plans was completed to incorporate results of AHB response programs in infested states. A series of training programs based on the guidelines was developed for emergency responders to stinging incidents. The training programs involve police officers, fire fighters, and rescue squad members in coordination with local beekeepers. Emphasis of the program is minimizing the impact of stinging insects, including honey bees, on individuals and pets. Participants receive training in identification of stinging insects and proper response procedures for incidents involving victims of insect stings. A training workshop was provided by VDACS staff in collaboration with Cooperative Extension to emergency responders from Chesapeake, Virginia Beach, Suffolk, and Poquoson.

VDACS staff obtained advanced training from the U.S. Department of Agriculture (USDA) in the identification of AHB, and other honey bees pests and diseases. Laboratory equipment for the diagnosis of pests and diseases of the honey bee was obtained for each Plant and Pest Services regional office and subunit through a USDA Specialty Crop Grant awarded to VDACS. Beekeepers were encouraged to provide honey bee specimens from hives exhibiting unusual or unexplained defensive behavior, a characteristic of AHB. The overall response resulted in an increase in samples for AHB analysis. All samples were determined to be of European honey bee origin, indicating a continued absence of AHB in Virginia's hives and feral population.

Pollination Program

Research on Hive Number and Quality for Pollinating Virginia Crops

The decline in the number of honey bee colonies in Virginia has reduced the hives available for crop pollination. Fruits and vegetable producers have an increasingly difficult time in obtaining the honey bees they need for the pollination of their crops. In addition a general decline in pollinator abundance has increased the problems faced by Virginia growers. In response we initiated studies on the number and diversity of bee pollinators in several different cropping systems to get a better understanding of the extent of these problems, and to provide data that can serve as a baseline for the development of new recommendations for the pollination of specific crops.

During the 2008 field season, bee pollination was examined at three apple orchards, three blueberry farms, fifteen vegetable farms with summer and/or winter squash (including pumpkin), cucumber, melon, watermelon, and a few other crops not dependent on insect pollination, such as tomato, peppers, eggplant, and caneberry. Two of the major objectives of this research were to understand the relative importance of native bees versus honey bees in crop pollination, and to understand the role of farm management practices and landscape variability on bee presence.

As part of the study, 7627 bees were observed visiting flowers on these crops in the 2008 field season. Honey bees represented 16% (1263 bees) of the total, whereas 6364 were native bees (83%). Of the total number of bees, 3201 (42%) were bumble bees and 2443 (32%) were medium-sized bees. The size of the bee is important to pollination since research indicates the larger the bee, the greater its pollen load, and its potential effectiveness as a pollinator. While honey bees were more abundant on certain crops and earlier in the season, this research indicates that native bees provide substantial insurance for successful pollination when honey bee populations are threatened. Some of the results related to specific crops are presented below.

- **Apples and blueberries**—Native bees were found to be more abundant on flowers at two of three apple orchards despite the presence of honey bee hives, with andrenid bees making up the vast majority of native medium bees (Figure 4). For blueberries, little difference was found in honey bee and native bee visits at the two sites, but one site had many more Andrenid bees than honey bees, despite the presence of honey bee hives.

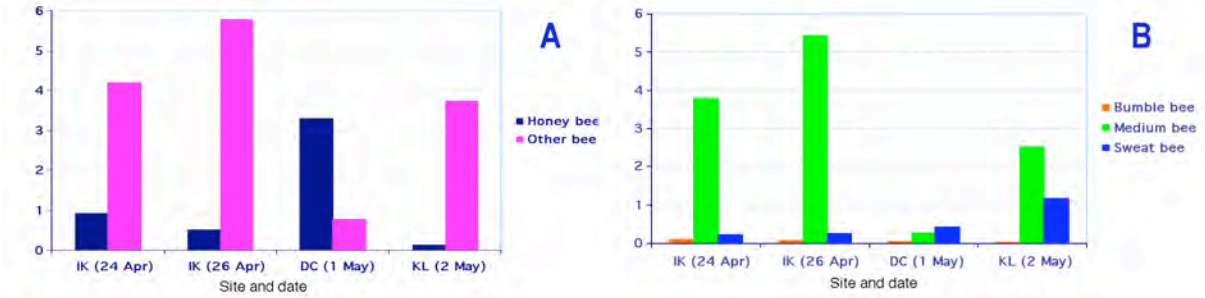

Figure 4. Apples. Mean honey bee versus native bee visitors to apple flowers (A). B shows that medium bees were the most abundant native bees. On apples, medium bees were nearly all andrenid bees.

- **Summer and winter squash**—Honey bees were prevalent from June through early July, while native bees accounted for nearly all flower visits from early July through late August. Despite the presence of honey bee hives at two sites, virtually no honey bees were observed, likely due to competing forage. In areas where squash is planted prior to emergence of squash bees, honey bees colonies greatly enhance early production. Many of the native bees have an annual life cycle and thus population numbers vary considerably on a seasonal basis.

These studies are continuing through the summer of 2009. Programs to increase beekeeper interest in pollination and the development of educational programs to promote pollination will be continued, depending on the availability of funding.

Recommendations to Growers

Native bees provide valuable insurance for agricultural crops traditionally pollinated by honey bees. They also enhance pollination of crops such as tomatoes, raspberries, and blackberries that do not require insect pollination, except in greenhouse settings. Practices that benefit honey bees also benefit native bees and growers need to be aware of these practices. Some specific recommendations include:

Pesticide usage:

- Minimize pesticide usage whenever possible. Besides insecticides, other pesticides such as fungicides may harm bees.
- Check relative toxicities of materials to be used in the Virginia Pest Management Guide.
- Time pesticide use to avoid periods when bees are active. Many native bees are active earlier and later than honey bees. Late afternoon or early evening pesticide application is recommended. Pollinators are generally less active late in the day.

Habitat protection and enhancement:

- Help support healthy bee populations by ensuring that nectar, pollen, and fresh water are available when the target crop(s) is(are) not in flower.
  - Let fallow areas flower (weedy plants can be cut prior to going to seed).
  - Plant nectar and pollen producing forage with a variety of plants, providing blooms throughout the growing season.
  - Enhance habitat around stream corridors by increasing buffer zones or planting flowering shrubs.
- Protect nesting areas. Most native bees are ground nesting, while others use reeds and woody plant cavities.
  - Shallow tilling is less likely to kill overwintering ground-nesting species (most nests are more than 6" below ground level.
  - Leave undisturbed areas in proximity to target crops. Ground-nesting bees tend to use exposed and sandier soil. Bumble bees prefer old mouse nests, often found in grassy areas.
  - Feral honey bees and cavity nesting native bees use large trees for nesting. Other native bees use the stems of caneberries (blackberries, etc.) and large grasses for nesting. Therefore, protecting forests and other natural areas,

particularly brushy habitat and large trees in proximity to cropland can support bee populations.

- Provide nesting sites by bundling cane or grass stems, drilling holes in large pieces of wood, or buying commercially available nesting material can greatly increase bee populations, particularly in large orchards or in large acreage farmland where little natural habitat is found.

Promotion of Beekeeping to Increase Hive Numbers in Virginia

Beekeeping activities were extensively promoted throughout the past two years to increase educational opportunities for beginning beekeepers. Classes and workshops were sponsored by local beekeeping groups, private entities, and public agencies. The promotion efforts resulted in a 3-fold increase in the number of beekeeping classes (22 total) offered in the spring of 2008 with a total audience of more than 600 people. Similar numbers of beekeeping classes were offered in 2009. VDACS staff and the VT Extension specialist participated in many of the beekeeping classes and workshops as instructors. In addition 8 one-day workshop programs were offered during 2008 and 2009 through Cooperative Extension to provide training to existing beekeepers. These programs were directed primarily at sustainable hive management and the problems associated with parasitic mites and diseases.

A total of 250 basic hive units were purchased for distribution to participants in beekeeping training programs across the state. The hive units were offered to participants in the beginner beekeeping classes. Equipment provided in this program is a cost sharing incentive to increase the number of beekeepers and beehives in the State. Recipients are anticipated to invest a minimum of $200 in the purchase of additional beekeeping equipment, honey bees, and supplies for the maintenance of each of these hive units.

In 2008-09 a total of 500 copies of a manual entitled “Beekeeping Basics” were purchased for distribution to participants in beekeeping training programs. The manual was prepared by the Mid-Atlantic Apiculture Research and Extension Consortium, a regional group focused on addressing the pest management crisis facing the beekeeping industry. The group is composed of representatives from the departments of agriculture, state beekeeping organizations, and land-grant universities from six Mid-Atlantic States, including Virginia. “Beekeeping Basics” provides an overview of honey bee biology and behavior, as well as, beekeeping management practices in the region. The manual is a standard text used in most of the beekeeping training courses around the Commonwealth of Virginia.

The information in this report was provided through Virginia Cooperative Extension in collaboration with the Virginia Department of Agriculture and Consumer Services.