Educating Veterinarians in Oregon and Surrounding States on the Diagnosis and Treatment of Foulbrood Diseases in Honeybee Hives

by
Samantha Miller

A THESIS
submitted to
Oregon State University
Honors College

in partial fulfillment of
the requirements for the degree of
Honors Baccalaureate of Science in Biology
(Honors Scholar)

Presented August 8, 2022
Commencement June 2023
Abstract

Honeybees are essential for agriculture and to sustain an ecosystem. There are two main types of bacterial diseases that affect honeybee colonies and brood: American Foulbrood and European Foulbrood. Both bacterial diseases can be treated with antibiotics approved for use in honeybees, however American Foulbrood is spore forming and cannot be cured. Use of antibiotics requires a veterinary-client-patient relationship, so veterinarians must write veterinary feed directives (VFDs). Fewer than 1% of veterinarians have received education to diagnose honeybee brood diseases and/or write VFDs. The purpose of this thesis research was: (1) to provide formal training to veterinarians on honeybee brood diseases and how to write VFDs; and then (2) survey veterinarians to determine the efficacy of the training. The survey completion rate was 77.4% (24/31). About 45% of the respondents said they have previously issued a VFD, but only half of those have ever issued a VFD for a beekeeper. Most of the respondents (78%, 18/23) said they would write a VFD for a beekeeper after receiving the training. With the
conclusion of this study, there are now eighteen more veterinarians in Oregon who will assess a honeybee brood and write the appropriate VFD for a beekeeper.

Key Words: American Foulbrood, European Foulbrood, Parasitic Mite Syndrome, Veterinary Feed Directive.

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I understand that my project will become part of the permanent collection of Oregon State University, Honors College. My signature below authorizes release of my project to any reader upon request.

_____________________________________________________________________
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I. Introduction

I.A. Importance of Honeybees

Honeybees are essential for an ecosystem and agricultural success, as they spend most of their adult lives collecting pollen to feed their young, thereby pollinating fruit trees, flowers, and other plants. The species of honeybees that is one of the most common across the world is *Apis mellifera* (*A. mellifera*), which is literally translated as “honey-bearing bee” or “honey-carrying bee.”

Flowers produce pollen that attracts honeybees. Pollen is stored in a reproductive structure within the flower called anthers, which will only release the pollen when jostled. Bees have been observed to grab the flower’s stamen, where the anther is contained, and wrap their bodies around the stamen to flutter their wings to stimulate the release of mature pollen. Once the pollen has shaken out of the anther, it lands on the hairs of the bee’s body. When the bee flies to another flower, the pollen is dislodged and makes its way to the pistil and stigma, where it can fertilize the eggs. Eventually, the pollinated flower will produce fruit or nuts. An absence of honeybees to assist with pollination requires plants to use other sources which are less efficient at pollination (e.g., wind, animals, water). More than 100 crops within the United States are pollinated by predominately bees, which equates to an economic value of more than $15 billion per year in the U.S.

More than 80% of the world’s almonds are grown in California. The U.S. almond industry brings $18 billion in annual economic revenue. For almonds, the only source of pollination is honeybees. It is estimated that 2.5 million commercially managed honeybee colonies are transported to the California’s Central Valley from across the United States.
2006 to 2017, there was a significant decrease (33% annually) in honeybee populations from disease, infection, and other external stressors.  

**I.B. Honeybee Life Cycle**

Efficiency of honeybee pollination can be attributed to the health of a colony, beginning in the early stages of life. The life cycle of honeybees consists of three distinct stages of metamorphosis, putting them in the group called Holometabola. All three of these stages develop within a single cell. The first stage begins with the queen bee laying an egg in a single cell. These cells are in the shape of a hexagon, which line up with one another to form the traditional honeycomb pattern. If the queen has added sperm to an egg, the result will be a female (worker) bee and if she does not add sperm, the result will be a male bee (drone). When these eggs are laid into the cell, the larva inside the egg has enough nutrition to grow until the egg hatches. It only takes three days for the larva to emerge from the egg.

The larvae are small, white, and curled up on the bottom of the cell. The larvae are supplied with nutrients from worker bees. The nutrients are a mixture of glandular secretions (“jelly”) and honey. The transition from larvae to pupae takes around six days, which can vary depending on the sex of the bee. At the beginning of the pupal phase, worker bees cover the larva inside the cell with wax to protect it during their metamorphosis.

During the pupal phase, the larvae will metamorphose into pupae. Initially, the larva within the capped cell spins a cocoon around itself. The cocoon is made out of a thin silk glandular secretion. During this metamorphosis, the pupae develop distinctive features that are characteristic of an adult bee. This can take anywhere from seven to fourteen days before the bee fully matures and is able to leave the cell. A fully grown, adult bee, will first chew away the silk
cocoon and once freed, this bee will start to eat through the wax that has kept the cell capped.\(^10\) Once the adult bee has fully exited the cell, it can now contribute to the maintenance of the hive and pollination. Collectively, the eggs, larvae, and pupae of honeybees are referred to as “brood.”\(^11\)

**I.C. Parasitic Mite Syndrome**

There are many factors that can affect honeybee health including, but not limited to, pesticides, sudden environmental changes, lack of adequate resources, and long-distance transportation for the purposes of pollination services. Honeybees are also susceptible to and targeted by mites, namely the Varroa mite.

**I.C.1. What is Parasitic Mite Syndrome?**

Parasitic mite syndrome (PMS) is caused by the *Varroa destructor*, also known as the Varroa mite. The Varroa mite feeds off the hemolymph and fat cells of pupae and adult bees.\(^12\) The life cycle of Varroa mite has two distinct phases: the phoretic and reproductive phase. During the phoretic phase, female mites will attach themselves between the abdominal segments of adult honeybees and feed off their hemolymph until they are taken to pupae. In pupae, the mite will enter the reproductive phase and feed off the prepupae. The mite will lay several eggs in the cell that hatch during the capped stage.\(^12\) The new mites will leave the capped cell when the pupa emerges, or the cap of the cell is opened by the bees in an effort to kill the mites.\(^13\) The young mites will attach to the abdominal segments of adult bees and the cycle will repeat.\(^13\)

**I.C.2. How is Parasitic Mite Syndrome Diagnosed?**
Suspecting the presence of PMS in a colony begins with seeing a decrease in the adult bee population and a spotty brood pattern. It is also likely that the hive will have a foul smell, due to dying or decaying brood. Varroa mites are large enough to be seen on adult bees, but a better way to observe them and the severity of infestation is by looking at the brood and individual cells. Parasite mite syndrome may also show up as signs of broken/chewed caps and guanine crystals on the cell walls.

**I.C.3. How is Parasitic Mite Syndrome Treated?**

Treatment of PMS is centered on reducing the mite population as eradication is nearly impossible. This includes the use of miticides, organic acids, and products derived from plant volatiles. These treatments are not always effective because many of the mites exist in capped cells, where treatments cannot reach, and with repeated efforts, mites may become resistant to the treatment. Bees may also groom the mites off one another; a term called “mite biting,” which may be used with a sticky board to catch any dislodged mites to prevent them from adhering to another bee. Mites can be left behind on flowers if one falls off a bee, and that same mite can be picked up by a bee from another colony.

Varroa mite reproduction can be hindered by bees that have a genetic trait the suppresses mite reproduction. This can be achieved through a selective breeding process that bee breeders have adopted to reduce mites in a way that does not use chemicals. Bee breeders are looking for heritable Varroa sensitive hygiene (VSH) behavior to be passed onto future generations of bees. This behavior is exhibited by a worker bee using its antennae to open the cap of a cell that is infested with Varroa mites. Once the cell is open, several other worker bees will clean the cell by removing the affected larva, thus halting the reproduction of that mite. If a queen bee in
a colony has the VSH trait, then that colony has a much better chance of decreasing the mite count until there are more bees with the VSH trait to offset those that do not have the trait.\textsuperscript{17} This mitigation strategy of selective breeding is not guaranteed to work for every colony because of the difficulty with keeping the trait consistently in the queen’s offspring. There is ongoing research looking into artificial insemination of queen bees, but researchers predict colonies in the future will have more bees with the VSH trait and there will be a decline in Varroa infestations.\textsuperscript{17}

\textbf{I.D. Bacterial Brood Diseases}

Beyond mites, bees are also susceptible to contracting bacterial diseases. There are two bacterial diseases that affect bee brood: American Foulbrood and European Foulbrood. Both of these bacterial diseases have drastic effects on entire bee colonies as they both target the various stages of the honeybee brood, affecting reproduction rates and the health of a colony.

\textbf{I.D.1. What is American Foulbrood?}

American Foulbrood (\textbf{AFB}) is a highly contagious bacterial disease caused by the spore forming bacterium called \textit{Paenibacillus larvae}, which targets the larvae and pupae stage of the brood.\textsuperscript{18} Although not as prevalent as the other bacterial brood disease, AFB is regarded as the most destructive because without treatment, it will kill affected bees within a three-week period.\textsuperscript{18} For this reason, AFB is a reportable disease in many states.

Transmission of AFB can begin with a single spore that is introduced to a hive through a beekeeper, other colonies robbing a hive of their resources, drifting bees, and purchasing used hives or colonies from other farms.\textsuperscript{19} The AFB spores can remain dormant for up to 70 years in the environment until they are ingested by a bee larva, where the bacterium reaches the intestines
and become active.\textsuperscript{19} Once the affected cell in the honeycomb is capped by the worker bees, the larva will die.\textsuperscript{18} This act dries out the \textit{Paenibacillus larvae} spores and creates a tough scale within the cell. Scales are stuck inside the cell and incredibly hard to remove. Though uncommon, if the larva progressed to the pupal stage before death, it forms a pupal tongue that extends from the deceased pupae to the top of the cell.\textsuperscript{18} American Foulbrood infections leave a spotty brood pattern, concave cell caps, a wet appearance to the capped cells, and the deceased larvae are yellow in color.\textsuperscript{19} A hive that has been infected with AFB spores will also present a substantial increase in the number of dead adult bees at the entrance of the hive.\textsuperscript{19}

A diagnosis of AFB is made through a series of confirmatory tests after it is initially suspected based on the brood appearance. The most common test done once AFB is suspected is the “ropiness test” where a toothpick or similarly shaped object is poked through a capped cell that is suspected to be diseased with AFB. Then, the object is swirled around in the cell and slowly pulled out. If the contents of the cell adhere to the object with a viscous consistency stretching out half an inch or more, then the test is positive for AFB.\textsuperscript{20} The ropiness test can be performed on site and does not require any specific equipment. Another diagnostic tool that can be used in conjunction with the ropiness test is shining a light into the uncapped cells looking for the presence of scales.\textsuperscript{20} Confirmatory testing can be accomplished with a lateral flow enzyme-linked immunosorbent assay for an on-site diagnosis. With the lateral flow test, after several minutes, if a line appears below the “T” in the well, it is indicative of a positive result. Samples of the affected comb can be submitted to the United States Department of Agriculture (USDA) or to state apiculture testing facilities (e.g., Oregon State University Honeybee Laboratory) for enzyme-linked immunosorbent testing as well.\textsuperscript{21}
Once AFB is confirmed in a hive, there is no cure but there are ways to prevent further spread. Antibiotics labeled for the management of AFB are: oxytetracycline, lincomycin, and tylosin. These antibiotics are available in different forms for ease of application, including as a patty for the bees to eat, a syrup for them to drink, or a powder to be dusted over the surface of the honeycomb.

Because the disease cannot be cured, many beekeepers burn the hive (including all the frames, honey, pollen, and bees) and start over. The American Veterinary Medical Association recommends sealing the entrances with tape, digging a deep hole to place the hive in, and igniting the hive far enough away from any trees and other structures to prevent a larger than necessary fire. Burning all the hives on one property decreases the likelihood of bees from other properties from contracting the disease.

**I.D.2. What is European Foulbrood?**

European Foulbrood (EFB) is caused by the *Melissococcus plutonius* bacterium and affects the larval stage of the brood. European Foulbrood is more prevalent in hives compared to AFB. European Foulbrood infections appear during the colder and rainier spring months due to stress from lack of food. Transmission of the disease is through larvae consuming the bacterium after it is mixed with bee bread, nectar, honey, or directly from the nurse bees. The disease cycle of the bacterium consists of its growth and multiplication within the intestines of the larvae after ingestion, introducing competition for food. The larvae cannot outcompete the bacteria and will die in as little as four days after the bacterium has been introduced. Within this period before death, the larvae will change from looking plump and white to desiccated and yellow appearance.
The first indicator of EFB in a hive is the observation of many dead bees near the entrance of the hive, a spotty brood pattern in the honeycomb, deformed and discolored larvae, and a sour odor to the entire hive.\textsuperscript{23} The foul smell of a hive is not always conclusive of the presence of the disease because EFB can exist without an odor. Rapid lateral flow enzyme-linked immunosorbent assays can be used to diagnose EFB or sending samples of the infected comb to the USDA or to state apiculture testing facilities (e.g., Oregon State University Honeybee Laboratory) for confirmation before treatment.\textsuperscript{21}

European Foulbrood is not spread through the formation of spores, allowing the infection to be cured through antibiotic treatment. Oxytetracycline is labeled for the treatment of EFB.\textsuperscript{22} In addition, some beekeepers have reported a spontaneous resolution of EFB without antibiotic treatment.\textsuperscript{23} Unlike AFB, there is no need to burn the hive because there is no formation of spores. Good management practices (e.g., thoroughly cleaning equipment, quarantining any new bees and hives) can prevent introduction of EFB.\textsuperscript{18}

\textbf{I.E. The Veterinary Feed Directive}

Prior to January 1, 2017, beekeepers were able to purchase antibiotics over-the-counter through online apiculture supply sites and gardening stores to treat foulbrood diseases in their hives. However, on January 1, 2017, the Food and Drug Administration (FDA) revised Rule 21 of the Code of Federal Regulations to include bees in the food-producing animal category under the same oversight as cattle, sheep, goats, and pigs.\textsuperscript{24} Honeybee producers with AFB or EFB in their hives could no longer go to the local grocery store or online beehive supply company and purchase the antibiotics needed for the treatment and management of these diseases.
From January 1, 2017, onward, animal feeds that contain antibiotics require a veterinary feed directive (VFD). A VFD has many similarities to a prescription in that it is a written statement issued by licensed veterinarians so owners of food-producing animals can purchase feed containing antibiotics. However, unlike a prescription, VFDs are only valid for six months (whereas prescriptions can be valid for up to twelve months) and they must be in writing (whereas prescriptions can be called into pharmacies). It is important to note that honeybee producers that had antibiotics left over from prior to January 1, 2017, could not legally use these antibiotics without a VFD.

The majority of veterinarians in the United States have not received formal training on honeybee foulbrood diseases and as a result, few veterinarians would write VFDs for beekeepers fearing possible legal repercussions. According to the Honeybee Veterinary Consortium and Oregon State Beekeepers Association, in January 2019, there were fewer than ten veterinarians in Oregon willing to write a VFD for beekeepers. This lack of willingness may be due to a lack of curriculum or continuing education opportunities regarding bee health and treatments in veterinary school.

I.F. Thesis Objective and Hypothesis

The objective of this project was to provide veterinarians in Oregon with the formal education for diagnosing and treating bacterial diseases in honeybee broods, so that they (as trained veterinarians) will be confident and willing to work with beekeepers who have AFB or EFB in their hives. The hypothesis is that the provision of formal continuing education for practicing veterinarians on bacterial foulbrood and other bee diseases will increase the number of veterinarians willing to treat honeybees in all Oregon counties.
II. Methods

II.A. Selecting Participants

The target group of participants was veterinarians who were actively licensed and practicing in Oregon and surrounding states. The Oregon Veterinary Medical Association (OVMA) (https://www.oregonvma.org/vetdirectory) and the Oregon Veterinary Medical Examining Board (OVMEB) (https://ovmeb.onlineservice.oregon.gov/webs/ovmeb/register/#) websites contain the necessary information to identify veterinary practices and individuals who renewed their licenses in 2020. These websites provided the names of the veterinary clinics, a physical address, email address, and phone number. If an email address was missing, then it was necessary to obtain one with a Google search. All information that was collected was organized alphabetically by county and included all relevant clinic contact information. This information was listed in a Microsoft Excel spreadsheet. This Excel spreadsheet contained 630 veterinary clinics that represented 35 of the 36 counties in the state of Oregon and a few within surrounding states.

II.B. Pre-Training Survey Development and Distribution

A survey was created in Qualtrics to gauge general interest and allow veterinarians to decide which was their preferred method to receive the training on diagnosing and treating foulbrood and other diseases in hives. The questionnaire provided veterinarians the option to choose from: an in-person lecture, a live zoom lecture, or watching a recording of a zoom lecture at their convenience. The survey consisted of twenty questions in total, though some of the questions were only presented to individuals who selected the in-person option to determine an ideal day to present the lecture. For those who selected the real-time zoom or recorded lecture
option, a question regarding a day and time to set up an in-person frame exam was presented. Using the email addresses provided by OVMA, OVMEB, and Google searches, a mass email request to fill out the survey was sent in groups of 100 clinics with each email address listed in the blind carbon copy section. The initial emails with the survey linked were sent on June 23, 2020, from the osuhoneybees@gmail.com email account.

II.C. Scheduling the Lectures

After receiving a substantial amount of completed surveys that chose the same dates for their availability for an in-person lecture, clinics were prioritized on a first-come-first-served basis. Any clinic that only selected one date they were available for that overlapped with another clinic or did not specify a one-hour time frame for the lecture was contacted directly through email to inquire about other availability. Taking into consideration various research team members’ personal and academic schedules, a master schedule was constructed of each clinic’s address, telephone number, names of the three or less predetermined attendees. Any veterinarian who needed to reschedule was asked to provide several alternate dates and times so that the researchers could select the date/time that best worked for their schedule.

II.D. Delivering the Lectures

The lecture was prepared and presented by Dr. Michel Kutzler, and she was assisted by undergraduate researchers Samantha Miller and Shea Fleetwood. The lecture covered the following three learning outcomes that centered on foulbrood diseases that affect immature bees. The first learning outcome was to understand what the setup for a standard beehive was. This lecture highlighted what a normal, healthy beehive looks like. Also described was the
life cycle of a bee in ideal conditions beginning with the egg phase, then moving onto the larval stage, then the pupae stage, and finally the adult stage, where the bees can venture out of the hive to obtain resources. This learning outcome also contained detailed instructions on how to examine a hive.

The second learning outcome introduced the possible stressors that affect the health of a hive including pesticides, long-haul transportation, parasites, pests, pathogens, and poor nutrition. The parasitic and bacterial brood diseases described were PMS, EFB, and AFB. Each disease was covered in detail with images and videos showing the obvious differences between the three diseases and characteristics unique to each disease for diagnostic purposes.

The third learning outcome marked the transition from diagnosing the foulbrood diseases to the treatment or management of the hive. Medical treatments for hives with bacterial infections utilize antibiotics that only veterinarians can prescribe. Antibiotic dosages and explicit instructions on how to fill out a VFD were provided. Veterinarians who had no previous experience filling out VFDs for food-producing animals were emailed a .pdf from the osuhoneybees@gmail.com email account. In her lecture, Dr. Kutzler emphasized the importance of utilizing established Veterinarian-Client-Patient-Relationship and Veterinary Telemedicine guidelines for Oregon-based veterinarians. Telemedicine allows veterinarians to write a VFD without traveling on farm calls or having any direct contact with live bees.

Veterinarians who chose the pre-recorded version of the lecture were emailed a private link to the pre-recorded lecture video presented by Dr. Kutzler, which presented material identical to that covered in the in-person and real-time zoom lectures. This lecture video was posted to osuhoneybees@gmail.com’s YouTube channel (https://youtu.be/Tt7tCe4c_CA).
II.E. Frame Examinations

From September 2020 to April 2022, in-person frame exams were performed immediately after an in-person lecture was delivered or at a later date following the veterinarian’s attendance of the real-time zoom lecture or viewing of the recorded lecture on YouTube. This demonstration was led by both Dr. Kutzler and Samantha Miller. It covered the proper technique of examining a frame from a honeybee hive and the diagnostic techniques covered in the lecture. This allowed the researcher to demonstrate the technique on one frame and have the veterinarian practice on another frame: specifically, the roping technique with a toothpick for AFB, easily removable EFB scales, and observation of mite frass on the cells.

From July 2021 to February 2022, veterinarians were given the option of a live Zoom lecture or watching the pre-recorded YouTube lecture. This was done as an accommodation to the constant changing of COVID-19 protocols due to new variants within each county and individual clinic requirement. This change was offered in tandem with a frame exam to be given over Zoom or the option of Samantha Miller recording a frame exam and subsequently posting it on the osuhoneybees@gmail.com YouTube channel. The in-person frame exam was typically the time to provide the veterinarians with the “Honeybee Disease Diagnostic Kits,” but because there was no in-person contact, the veterinarians were mailed to the clinic’s address on record through FedEx.

II.F. Follow-up Surveys After the Training

Participants would receive an email with a follow-up Qualtrics survey. (https://oregonstate.qualtrics.com/jfe/form/SV_51fYwGgjlcZiFZI). These survey questions were approved by the Oregon State University Institutional Review Board and were intended to be
completely anonymous with the only demographic questions referencing graduation year from veterinary school and the types of bee species that were predominately treated by each veterinarian (Appendix A). The questions were designed to gauge whether or not the material covered in the lecture was sufficient to provide veterinarians with the confidence to diagnose and treat foulbrood diseases in honeybee hives.

II.G. Distribution of Follow-up Surveys After the Training

Thirty-one veterinarians confirmed their participation in the online or in person training. This did not include the veterinarians who watched the YouTube video but did not send a confirmation email after watching the video. The total views on YouTube were over 50.
III. Results

The survey completion rate was 77.4% (24/31), but not all the respondents answered every question. The majority of respondents (59%, 13/22) graduated from veterinary school from 1986-2000 (Figure 1). Of the responding veterinarians, dogs and cats were the most treated species, while reptiles were the least commonly treated species (Figure 2). Only a quarter of respondents commonly treated food animals (dairy cattle, beef cattle, sheep, swine, and poultry). About 45% of the respondents said they have previously issued a VFD, but only half of those have ever issued a VFD for a beekeeper (Figure 3). Most of the respondents (78%, 18/23) said they would write a VFD for a beekeeper after receiving the training (Figure 4). Of those respondents who said they would not write a VFD for a beekeeper after receiving the training, several different answers were returned. They were: one respondent said he or she would first need to review the material from the presentation, one respondent said he or she would need more training, and one respondent said he or she was too busy to take on more clients. The majority of respondents (60%, 3/5) said they would charge less than $100 for issuing a VFD (Figure 5). Respondents were asked what additional information they would like about caring for honeybees. The responses included: more information on management of hives for new beekeepers; more holistic approaches to treating honeybee diseases, more hands-on training with active hives, and more information about Varroa mites.
Figure 1. Graduation year of the survey respondents.
Figure 2. Most commonly treated species by survey respondents.
Figure 3. Survey respondent's experience in writing veterinary feed directive (VFD).
Figure 4. Survey respondents that will write a veterinary feed directive for beekeepers if requested.
Figure 5. Estimated cost of issuing a veterinary feed directive for a beekeeper.
IV. Discussion

Study participants are increasingly resistant to responding to surveys for a variety of reasons. The concern about surveys with low response rates is that the results might not represent the intended population. For this reason, the reported standard for federally funded research is to achieve an 80% survey response rate. The survey response rate in the current study was 77.4% (24/31), which is higher than the online survey response rate reported for veterinarians (54-67%). It is important to mention that only veterinarians that were enthusiastic about receiving training in honeybee medicine received the training and those were the study participants who received the online survey.

The average age of veterinarians currently practicing in the United States is 44.3 years old. Assuming that these veterinarians were on average 24 years old at graduation, the average year of graduation for veterinarians currently practicing in the United States was 2000. In the current study, the majority of respondents graduated between 1986 and 2000, which would suggest that the respondents of the current survey are older than the average veterinarian in practice. It is not known what influence the age of veterinarian/year of graduation had on the survey response rate and/or survey answers.

On January 1, 2017, stricter federal rules went into effect regulating veterinary oversight of antibiotics administered to food animal species via feed. As a result of this, food animal veterinarians are generally familiar with the VFD requirements. However, most today’s veterinarians work primarily with companion animals (dogs, cats, birds, and small mammals) and have not written VFDs before. In the current study, less than half (45%) of respondents had written a VFD at the time of the presentation and hands-on training. However, after receiving the training, most respondents (78%) answered that they would write a VFD for a beekeeper if
requested. It is important to note that there is no guarantee that these veterinarians will ever have honeybees as patients.
V. Conclusion

The objective of this research was to provide practicing veterinarians in Oregon with formal education on diagnosing and treating bacterial diseases of honeybee larvae. With the conclusion of this study, there are now eighteen more veterinarians in Oregon who will assess a honeybee brood and write the appropriate VFD for a beekeeper. To further increase the number of veterinarians that will treat honeybees, a short section should be added to the standard curriculum in veterinary schools within the United States. For those who have already graduated from veterinary school and are actively practicing, more continuing education courses need to be made available to veterinarians that want to improve their education and understanding of honeybee medicine.
VI. References


2. U.S. Forest Service. What is pollination?

3. USDA releases results of New Survey on honeybee colony health. USDA.

4. Weisbrod K. California's almond trees rely on honeybees and wild pollinators, but a lack of good habitat is making their job harder. Inside Climate News.


VII. Appendix: Questionnaire to Oregon State Practicing Veterinarians

Q1 What year did you graduate from veterinary school
   o 1981-1985           o 2001-2005

Q2 Which species do you predominately work with? (Select all that apply)
   o Dogs                  o Sheep                o Swine
   o Cats                  o Goats                o Poultry
   o Pet birds            o Camelids            o Other
   o Small mammals        o Beef cattle
   o Horses               o Dairy cattle

Q3 Have you ever issued a VFD?
   o Yes
   o No

Q4 Have you issued a VFD for a beekeeper?
   o Yes
   o No

Q5 How much would you charge for a VFD? (Including travel charges)
   o Less than $100       o $100 - $300        o Over $300

Q6 After the honeybee hive exam and training, would you now issue a VFD for a beekeeper?
   o Yes
   o No
Q7 Why would you not issue a VFD for a beekeeper?

- I need more training before I would write a VFD
- I am allergic to bees so I would not work with a beekeeper
- I am not allergic to bees, but I would not work with a beekeeper
- I don’t have time to take on any more clients/patients
- Other

Q8 What additional information would you like to learn about honeybees (free response)?