A Visit with Tucson Bee Lab Leader Gloria DeGrandi-Hoffman

Dr. Gloria DeGrandi-Hoffman

by JERRY HAYES

I was in a meeting several months ago with Dr. Gloria DeGrandi-Hoffman, the Lab Leader of the USDA-ARS Carl Hayden Bee Research Center in Tucson, Az. I have known Gloria for many years but not really. She has been in our industry for years and it struck me at that time that I wanted others to know about her work and the work of her Lab that benefits honey bees and beekeepers. But we really never pay as close attention to the USDA Labs as we could or should, so I decided to visit with Gloria .

JERRY
What is your exact title and what does the Tucson Bee lab do? Would you share some brief history of the Center?

GLORIA
Research Leader and Location Coordinator, Carl Hayden Bee Research Center (CHBRC), USDA-ARS. I wrote a brief history of the CHBRC for the 2014 Visioning Conference. Below is a modified version:

The history of the Carl Hayden Bee Research Center begins in 1949. The USDA sent apiculturists Frank Todd and Sam McGregor to Tucson to set up a federal research laboratory on the University of Arizona campus. The research emphasis was on crop pollination, and the effects of agricultural pesticides on honey bees. In those early years, the honey bee research program was moved from one building on campus to another, eventually ending up in three buildings near the campus farm. As the research program expanded, there was a need for a permanent facility. The Bee Laboratory building as it stands today was constructed in 1966 and was named after Arizona Senator Carl Hayden in 1978.

Carl Hayden was Arizona's first congressman after the territory became a state in 1912. He served 7 terms as a congressman and in 1926, was elected to the U.S. Senate. He remained Arizona's Senator until 1969. Carl Hayden became associated with Arizona beekeeping through a close friend, Clarence Benson. Mr. Benson was concerned about pesticides killing bees in the cotton fields in Arizona, and approached Carl Hayden for help. Senator Hayden was a strong proponent of several public projects, including the honey bee research facility that now bears his name. He championed the efforts to fund a Honey Bee Research Center to conduct studies on pesticides and honey bees.

In the 1970s, Dr. Lonnie Standifer became the Research Director of the Bee Center and added studies on nutrition to the research program. The Center produced such noteworthy publications as: "Supplemental Feeding of Honey Bee Colonies", "Pesticides and Honey Bees", "Using Honey Bees to Pollinate Crops", and S.E. McGregor's "The Handbook of Crop Pollination". McGregor's book is still the industry standard for comprehensive information on bee-pollinated crops. The research program on nutrition included studies on supplemental diets and the role of microorganisms in pollen storage and digestion. After Dr. Standifer retired, Dr. Marshall Levin became Research Leader and studies on pollination and nutrition continued.

In the 1990's, African bees and Varroa mites entered Arizona. The research program, under the direction of Dr. Eric Erickson, expanded to include the population dynamics and behavior of African bees so that the Africanization of European colonies might be prevented or reversed. During this time, researchers at the Bee Center also began investigating new methods to control Varroa mites.

In 2002, Dr. Gloria DeGrandi-Hoffman became Research Leader and refocused the research program on nutrition in addition to controlling Varroa. The Bee Center became the Africanized Honey Bee Identification Laboratory for the U.S. The nutrition research

The Carl Hayden Bee Research Center

Queens emerging to test the effect of fungicides on queen rearing.

program resulted in the development of a commercially available protein supplement diet (MegaBee®). A new product called HopGuard® to control Varroa mites also was developed. Recently, the research program was broadened to include the fundamental role of microorganisms and honey bee physiology on colony health. Sublethal effects of fungicides and pesticides on honey bee physiology, especially in relation to metabolism and immunity, also are part of the current research program. The research program at the CHBRC has come full circle, returning to the original vision of Senator Hayden to prevent bee losses from pesticides and poor nutrition and insure that healthy colonies are available for the pollination needs of U.S. agriculture.

JERRY
How many scientists, who are they and how many Labs does the Tucson Bee Research Center support?

GLORIA
Our staff scientists are: Dr. Kirk Anderson, Dr. Vanessa Corby-Harris, Dr. Mark Carroll, and Dr. William Meikle. Dr. Stephanie Gage and Dr. Vincent Ricigliano are post-doctoral Research Entomologists. There is an open position with the retirement of Dr. Frank Eischen. When we fill Frank's position, we will have six scientists. The Laboratory supports six scientists.

JERRY
You are the Lab Leader of this early iconic lab that has lots of history. Do you feel any pressure because of that history and expectations?

GLORIA
It is special being the current Research Leader of a Laboratory with a history of excellence in research. We have come full circle in that we began as a nutrition Laboratory, then got away from that for a while and now have become a nutrition Laboratory again. The nutrition work is comprehensive in that we examine the effects at the level of microbes, physiology and whole colony. We also conduct research on Varroa, and that is a huge challenge. The problems facing beekeeping in the past seem small compared with the challenges facing beekeepers today. The only pressure I feel is that we need to get solutions to current problems to beekeepers ASAP.

Colonies used to measure mite migration

JERRY
I think you and I started down the honey bee /beekeeping path about the same time in the early 80's. Can you tell me how your journey started? (I remember reading about you and your early apple pollination modeling when you were with Dr. Roger Hoopingarner at Michigan State University (MSU). Then, one of my first stints was the Dadant Branch Mgr. in Michigan)

GLORIA
I started working with honey bees during my MS research at Penn State when Dr. Clarence Collison was my Advisor. I did research on the pollination of birdsfoot trefoil. During my MS research I became interested in mathematical modelling. Modelling was being used in pest management, but not in honey bee research. I thought that I could take modelling concepts and tools and apply them to pollination to predict fruit and seed set. Michigan State University was a terrific place to learn mathematical modelling, so that is where I wanted to do my Ph.D. For my dissertation research, I wanted to construct a computer model that would predict fruit or seed set based on weather and field conditions and the foraging behaviors of honey bees. I was lucky enough to get accepted by the MSU Entomology Department, and have Dr. Roger Hoopingarner as my advisor. Together we built the first mathematical model of pollination that predicted cross-pollination and fruit set in apple orchards. After graduation and a post-doc at MSU, I was offered a position at the Carl Hayden Bee Research Center to build a similar model to predict cross-pollination and nut set in almonds. Since then, I have conducted research in sunflower pollination, African honey bees, Varroa mites and nutrition. Building models and using a systems approach to research has been a mainstay for me in all these projects.

JERRY
Why did you stick with honey bees?

GLORIA
I think all insects are incredibly fascinating. I started watching and collecting insects when I was about 8 years old, and am still fascinated by them. Honey bees are particularly interesting because of their social organization. The importance of honey bees to agriculture also motivated me continue to do research on them particularly concerning pollination and crop production and issues of maintaining colony health and survival.

JERRY
Tell me how you have seen the beekeeping industry change over time to what it is now.

GLORIA
Probably the biggest change is the transport of colonies to California for almond pollination. That has changed commercial beekeeping because almonds bloom so early, overwintering schemes have had to change to accommodate almond pollination. Also, overwintering losses have greater impact because there is not time to recover (because the almond trees bloom so early). The other factor is the Varroa mite. Varroa started as a pest that could be controlled with well-timed miticides (and we had effective miticides) or with the selection of resistant lines. Now the mite is extremely difficult to control because colonies become reinfested, I think, with mites that migrate into hives on foragers. There also was a time when there was adequate forage to support colonies in the summer and fall, and protein supplements were needed only for brief periods of pollen dearths. Now it is difficult to find forage areas and protein supplements are being used for longer periods of time. The supplements were never meant to be used as substitutes for pollen, and colonies experience nutritional deficiencies even though there are adequate

amounts of supplement patties available. Together, these challenges have made it more difficult for beekeepers to reduce colony losses, and that is the biggest change I have seen. That has caused a sense of urgency in bee research, because we must find solutions that beekeepers can implement to save their colonies. I think those solutions will come from balanced research programs that have elements of basic science to uncover underlying factors that can cause stress on colonies and determine how the colony responds, and applied science that uses the findings from basic science to develop creative and sustainable solutions to beekeepers' problems.

JERRY
Can you expand on the Almond Pollination model? In my mind commercial beekeeping is production agriculture. And in production agriculture and in support of production agriculture the model certainly is a hybrid model that has little parallel to the 10's of thousands of backyard beekeepers…me included. What is the management and production model for providing colonies for almond pollination because it requires almost 2 million colonies, transported at 460-480 colonies per semi load, wrong time of the year and bunched up together on 4- or 6-way pallets with other colonies from across the U.S. It is an amazing process. How are colonies prepared?

GLORIA
Historically, colonies have been moved to open ranches in southern California in November and kept there until bloom. The colonies are fed protein and carbohydrate supplements because there is not much forage available especially in dry years. Mite treatments also are applied if needed. Many colonies are lost or weakened after they are moved to California. It is difficult to maintain strong colonies for 3 months on supplements alone. More beekeepers are putting colonies in cold storage now and taking them out in January to move to almonds. Cold storage can reduce the number of mite applications and the amount of supplements that are needed over the winter.

Colonies need at least 4 frames of bees to be acceptable for almond pollination, but 6-12 frames are preferred and will bring higher rental prices. The model predicts almond yield (lbs of nuts per acre) based on orchard design (cultivars and the arrangement in rows), weather conditions, bloom density on trees, and numbers and strengths of colonies introduced per acre. The model predicts yields that can be obtained by introducing stronger colonies under good or poor (i.e., limiting to bee flight) bloom period weather conditions. Changes in yields and crop value by adding colonies or introducing stronger colonies can provide useful estimates of the return on investing in stronger or additional colonies.

JERRY
And to get to what you said there is no one place that there is enough natural pollen forage to support colony health and growth for this mass of honey bees. What do beekeepers do before, during and after to support nutrition which, in turn, is a honey bee health driver?

GLORIA
As I mentioned above, beekeepers need to feed protein supplements and sugar syrup. Many beekeepers have their own formulations for protein supplements, but some purchase commercial supplements. Planting forage for bees (such as rapini) in California has been suggested to provide some pollen before almond bloom. However, in dry years, this is not possible because water shortages are a serious issue. Similarly, after bloom colonies will consume the almond pollen they stored. If there isn't another crop in bloom or areas with blooming plants, colonies will need supplemental feed. This can be a serious issue because the colonies will have built their populations during almond bloom, and will need substantial amounts of protein to maintain or continue to grow those populations.

JERRY
How has your Lab addressed this nutritional deficiency? And can it get better?

Examining colonies in nutrition experiment

GLORIA
Several years ago beekeepers asked me to direct a research project to develop a protein supplement diet that could be fed to colonies in either liquid or patty form. The beekeepers wanted to efficiently feed large numbers of colonies before almond pollination. The term they used was 'stockyard feeding of bees'. At that time I knew nothing about bee nutrition. However, I needed to start learning about it. I set up a Cooperative Research and Development Agreement with S.A.F.E Research and Development (Gordon Wardell's company), and we began working on the diet. Several years later, the MegaBee diet was in commercial production. The diet can be used in liquid and patty form and also added to candy boards. However, it is not a replacement for pollen.

The CHBRC has now developed a comprehensive honey bee nutrition program that evaluates the effects of nutrition on honey bee physiology, immunity, and colony growth and survival. We also investigate the role of microbes on nutrient acquisition and preservation of stored pollen and nectar. Included in the research program are the effects of environmental factors including colony management on microbial communities in the bees and their food stores. Our Laboratory also is investigating the nutritional needs of colonies throughout the year. An unconscious assumption of past nutrition research and the development of protein supplements is that nutritional needs of colonies are constant. Anyone who has seen a colony go through its yearly cycle knows that the colony population, especially in terms of brood rearing and age structure, is very different in the spring than in the fall. Because the composition of the colony population changes, it is not unreasonable to assume that there are differences in nutritional needs. There are numerous papers in the literature comparing the 'nutritional value' of pollen from different species and classifying some as 'highly nutritious' and others 'less nutritious' without any consideration of the time of year when the pollen was collected and the nutritional needs of

Rapini field for bee forage

colonies at that time. Before we can improve colony nutrition, I think we need first to understand its dynamic nature.

JERRY
The growth in pollinator dependent agriculture and the need being filled by this relatively new super hybrid Commercial Beekeeping business model has changed honey bee health inputs. With Varroa, beekeepers putting pesticides in a colony to kill, hurt or damage Varroa, poor natural nutrition access and environmental toxins what can be done Gloria?

GLORIA
I think there are 4 major challenges to commercial beekeepers. The first is Varroa followed by poor nutrition from lack of forage and then pesticides, whether self-inflicted from Varroa applications or from the environment. The fourth challenge that is not being included is climate change. An example of how climate change might be affecting colony growth and survival is that fall flowers are blooming earlier and colonies are foraging longer in the fall. This combination is causing bees to gather overwintering resources earlier and consuming them before they cease to forage for the winter. Foraging in the fall also physiologically ages the bees that will comprise the winter cluster. The bees that forage in the fall will have fewer days to forage before expiring in the spring. Under the best of situations (i.e., no Varroa, viruses or sub-lethal pesticide exposure), short-lived foragers will make the low point for the population in the spring (due to spring dwindling) more severe, and might cause colonies to be too weak to build into substantial populations. If the longevity of winter bees is further reduced by other stress factors (i.e., Varroa, viruses, pesticides, poor nutrition), the colony can crash in the spring even when the population going into winter was large. This is because the population was comprised of a majority of physiologically 'older bees'.

I learned a lot about the population dynamics of colonies while building the BEEPOP and VARROAPOP models and running hundreds if not thousands of simulations with them. There is a critical number of bees that are needed in the spring to build large colony populations because adult bees are needed to rear brood (the adult bee to brood ratio). If there are not enough adult bees, brood rearing will slow down or stop, even if the queen is strong and there are sufficient food resources available. Another problem with late fall foraging is that Varroa is moving between colonies whenever foragers are flying. If bees are foraging into November or even December, as occurred this year in the northeast, single fall miticide applications might not be effective because colonies are becoming reinfested after the last miticide application.

JERRY
And yes there is urgency, but 'we' have been talking about Varroa for 30 years and nutrition even longer. What do the next 5 to 10 years look like to you for if not solving some of these challenges at least minimizing them?

GLORIA
I think the beekeepers who will be successful in the future will be those who rethink their management practices. Rethinking Varroa management has to come first. Beekeepers must rotate Varroa treatments to avoid resistance. The days of having a single treatment in the summer and another in the fall might be gone at least for now. There are numerous miticides available that can be used under different conditions.

A major area that needs to be changed is overwintering. The problems I discussed above in Question 3 can be solved by overwintering colonies indoors. Colonies could be put into overwintering facilities in October and kept there until late January when they are moved to almond orchards. Research needs to be conducted to determine if overwintering in cold storage facilities significantly reduces winter losses, and is an economically feasible tradeoff to feeding protein supplements and treating for Varroa in colonies that are active all winter.

Expanding areas for bee forage are needed to give beekeepers a chance for maintaining healthy colonies. This is underway now, but the plantings will take several years to establish. As we move forward, I think that colony rental fees will continue to rise because of increasing demand for high density acreages of bee-pollinated crops. Beekeepers who can adopt strategies that reduce colony losses with economically feasible practices will be the winners in the future. One thing for certain, the strategies we are applying now do not reduce colony losses in the end, so things need to change.

JERRY
Would you like to expand on the climate-controlled/controlled atmosphere (CA) storage overwintering? Everything old is new again and this technique using old potato cellars and basements etc. was used for a very long time here and in Canada, even back in the late 1800's I think.

GLORIA
I think that putting bees in climate-controlled shelters in the winter may become an increasingly important management strategy for reducing overwintering losses for several reasons. Our studies on Varroa are showing that mites are moving among colonies on foragers with the greatest frequency in the fall. The longer that bees fly in the fall, the greater the chances of having colonies that were treated in September or October becoming reinfested with mites. Last year, temperatures were warm enough in parts of the Midwest and Northeast for bee flight throughout October until December (it was in the 60's on Christmas day in central PA). Bees are flying, but brood isn't being reared. There are no flowering plants, so the bees are burning up their winter stores. The result is that colonies coming out of the winter are populated with bees that flew too long the previous fall so they are physiologically older than if they had not flown) and colony stores could be depleted if the beekeeper did not continue to feed in the fall. Putting bees in storage in October might alleviate mite migration problems and prevent late season bee flights so that the overwintering population has an age structure that is more conducive to colony growth in the spring.