March/April 2007

ListProc Newsletter *Food for Thought* *Colony Collapse Disorder*

Newsletter Direct

At the request of many of my newsletter subscribers who do not always remember or prefer not to have to negotiate the links, every two months, to see the most recent issue, I have taken the plunge.

I have established a ListProc mailing list that subscribers can join simply by e-mailing **listproc@ucdavis** and signing up. In the body of your message (not the Subject line) put in the following: sub ucdavisbeenews <your first name (without these "brackets" around it)> <your last name>. If I were subscribing, it would be: **sub ucdavisbeenews Eric Mussen**. If you wish to be removed from the list, then you do the same thing, but instead of sub you use unsub or signoff, then the name of the list and your first and last names.

Then, all I have to do is figure out how to get the newsletter sent to central control, and it will be sent to each of you.

FOOD for Thought

Like other animals, honey bees require adequate shelter and food in order to survive. Food for honey bees is made up of water, nectar, and pollens. Water is as essential to honey bees as it is to us, for the same reasons. Nectar provides a good deal of water and sugar. The sugar can be used immediately by the bees for energy or brood rearing, or stored as honey for later consumption when sugar is needed and nectar is no longer available.

Pollens make up the nutritionally most important food in the hive. They provide the proteins, lipids, vitamins, minerals and micronutrients that support adult bee physiological equilibrium and brood development. Similar to humans, honey bees require the same ten essential amino acids in their food to be healthy. Honey bees cannot synthesize cholesterol, an essential compound for their lives, so they obtain that as 24-methylene cholesterol from the pollens they eat.

From a honey bee nutritional standpoint, not all pollens are the same. Various researchers have determined that pollens can be grouped into categories, based mostly on crude protein content (but also on amino acid composition). Pollens from most deciduous fruit trees are nutritious for honey bees. Lupine pollen is listed as good in Australia, as are almond, clovers, pear, and some of the gum (*Eucalyptus*) trees. Buttercups (some are toxic to bees), *Crocus*, willows, wild radish, prune, apple, mustard, rape (canola), and poppies are supposed to be good.

Pollens that are less nutritious and with which a mix becomes more important are: elm, cottonwood, ash, pussy willow, dandelion, sweet corn, and alfalfa (actually alfalfa pollen is nutritional, but honey bees don't like to eat it).

Air-borne pollens tend to be least nutritious such as alder, hazel nut, ash, birch, poplar, and field corn. Sunflower, eastern buckwheat, fireweed, blueberry, and weeping willow are not adequate nutrient sources. Coniferous tree pollens are especially poor: pine, spruce, fir, and cedars.

Honey bees rear two physiologically distinct types of worker bees. Summer bees, reared from late December through July, progress through the classical textbook series of jobs, beginning with various duties in the hive during the first three weeks. Then, they become foragers for the final three weeks of their lives.

Winter bees, reared from August into October, do not immediately begin hive work, including brood rearing. It might be that brood rearing or beginning to forage may start a six week clock similar to summer bees. During winter, winter bees should do little other than participate in the winter cluster until it is time to begin rearing brood toward spring. Healthy winter bees have a life expectancy of about six months. Winter bees comprise the colony population that survives the winter, when fresh food is not available. Winter bees are still supposed to be in the hive in February and March to be our "almond bees" in California, long after the previous season's summer bees have died off.

As adult bees reach the final days of life, they fly from the hive and die in the field, weather permitting. The few bees that die in or around the hive (five to twenty-five of the daily thousand or so in the summer) are picked up and carried away by undertaker bees to some distance from the hives. Normally, very few bee bodies are found around a hive containing a healthy honey bee colony.

Honey bee longevity also is impacted by a "group effect." Given 100 adult bees of the same age and health, each held in an individual cage with food and water, we would expect the bees to die in a manner that leads to a "bell-shaped curve." A few bees would die quite early, most of the bees would die around the same median time, and a few would persist quite a bit longer. A similar group 100 bees, caged together with the same food and water, would die a bit differently. Again, a few bees would die quite early. The rest of the bees would share food and nutritional body reserves. The intra-group sharing tends to result in a longer average lifespan for the group, and eventually most of the bees will die during a more concentrated period of time at the end.

Honey bee colonies dying of Colony Collapse Disorder (CCD) seem to be following expected behaviors of natural death: 1. flying away and not coming back and 2. maintaining the group as long as possible and then giving out all at once. This may explain the losses in the field, but it does not explain the cause of early death.

When things are going properly, healthy honey bees escape most infections, parasites, and poisonings by resisting them in the first place. The immune system of a honey bee, and its ability to denature toxins, have been found not to be as robust as those of many other insects. Honey bee resistance is at its peak when the colony has been well fed (meaning substantial amounts of quality pollens).

Honey bees reared when a good mix of pollens are not available are stressed. In some cases, the stress is visibly apparent. Examining colonies in alfalfa seed pollination in California shows that newly emerged bees are much smaller than normal, looking more like flies than honey bees. Usually, however, malnourished bees do not look different from normal bees.

Previous studies on honey bee nutrition and those being conducted currently by USDA/ARS researchers demonstrate that undernourished colonies produce worker bees that are lighter in weight and have significantly reduced life expectancies. It appears as though supportive feeding of the colonies, with pollen substitutes or supplements (substitute with added pollen), helps the bees to a certain extent. Up to this time, we do not have an available pollen substitute or supplement that can replace a mix of pollens, nutritionally, and sustain robust brood rearing. In most cases, honey bees will not consume the supportive feeds, unless some fresh, natural pollen is being collected and brought into the hive.

That was a concern of some beekeepers whose bees were collapsing this winter – "They won't touch the feed." This past winter in California was different in that we basically had no rain in January. Normally, winter weeds grow and bloom in January. We also had serious, unanticipated frosts that set back or killed winter annual plants. Our normal early pollens were not there to stimulate consumption of beekeeper supplied feed.

One other observation that beekeepers made was "How can my colonies be nutritionally deprived when I see combs of multi-colored pollens (bee bread) inside as the colonies collapse?" That is a question that directs further attention to pollen production and local weather conditions. There are references in the literature that report that too much chilling interferes with meiosis in forming pollen and the grains are "sterile." Other reports suggest that too dry and too hot conditions lead to the production of "non-viable" pollen. But, those reports relate to germination and fertilization studies. What has happened to the living protoplasm that normally occurs inside the pollen grains? That protoplasm contains the protein and carbohydrate used by the pollen grain to grow a pollen tube into the female part of the flower and fertilize the potential seed. Is the protoplasm still there, or are the pollen grains empty? Bee bread would look the same whether the pollen grains were intact or empty. Perhaps the weather changed the vitamin content or amino acid ratio of otherwise nutritious pollen.

When I arrived in California in 1976, many western beekeepers already were providing supplemental feed to their colonies. Sugar syrups were being used to stimulate egg laying, and protein patties were being fed to help build brood. Dr. Christine Peng conducted research that determined brewers yeast was well digested by bees and helped support brood rearing. Her studies showed that late summer/fall feeding returned the best results for the dollars invested. While not much more brood was reared than in the unfed colonies, examined workers contained more stored protein and glycogen (fat bees), survived the winter better, and produced more brood through the spring into May. Colonies fed only in the early spring did not benefit nearly as much from the feeding. Colonies fed in the fall and spring benefited the most in colony size, but the gain was not as cost effective as feeding only in the fall. Fortunately, during the field study, natural pollens were abundant enough to stimulate use of the substitute feed.

What about Australian packages? Since the seasons are reversed from ours in the southern hemisphere, their summer bees are reared from late June through January, and their winter bees in February and March. Their winter bees would be expected to live through August or September. Thus, Australian packages purchased in October through January would be populated with summer bees having a six week life expectancy. So, it would be unrealistic to expect the Australian bees to "make it through the winter" in our hives, unless they had access to substantial food and reared considerable brood during August and September or during our winter months.

All this information suggests that despite our efforts, honey bee colonies can be impacted severely by the vagaries of local weather conditions, especially as they affect quantities and quality of pollens. Honey bees are one of the few agriculture related animals for which a complete, sustaining, artificial diet has not been developed. It appears that research in that area has to be accelerated as changing land use and the vagaries of weather continually reduce the forage available to honey bee colonies.

For more targeted information, try to borrow a copy of the 307 page textbook "Pollen: Biology, Biochemistry, Management" by R.G. Stanley and H.F. Linskens. Springer-Verlag, New Yourk 1974. Also, there is the down-loadable "Fat Bees, Skinny Bees" at a url that I have suggested in previous newsletters: www.rirdc.gov.au/reports/HBE/05-054.pdf. There is a review table of values of Australian pollens to honey bees at: www.rirdc.gov.au/reports/HBE/01-047sum.html.

Colony Collapse Disorder

This year the attention of most of the world has been focused on the population crashes of honey bee colonies in northern temperate climates, beginning in fall and continuing into spring. Honey bee populations that appeared to be normal would simply dwindle down to empty or nearly empty boxes in days or weeks. This is really peculiar, since a honey bee population tends to decrease going into and during winter, but is supposed to survive until well into the next spring.

The phenomenon is not new to US beekeeping. It was observed in the late 1800's and has occurred periodically for a century. Now called Colony Collapse Disorder (CCD), this disorder has been called "spring dwindling," "autumn collapse," or disappearing disease" in past years. The hives end up with plenty of stored honey, stored pollens, usually some amount of brood, and often the queen bee with a tiny number of young workers bees with her. In California or other "warm" climates, that little group of bees may survive but the exposed brood dies. In colder regions, those remaining adult bees will die off.

Many suggested reasons for such losses have been made. However, one has to consider that the phenomenon seems to be very widespread, but did not affect all beekeeping operations equally. While one beekeeper could be losing nearly every colony of bees, the next beekeeper may have seen nothing irregular. So, the idea of the problem being a simultaneous worldwide outbreak of a previously unknown infectious disease; contact with a new, globally distributed toxic agent; or complications involving an increase of electromagnetic waves does not seem to fit the patchiness of the occurrences.

Analyses of samples of bees and stored food for disease-producing pathogens have demonstrated all the viruses of which we are aware. The concentrations of the viruses in the bodies of the bees ranged from slight to very heavy, with some of the apparently healthy bees being most heavily infected. We now know that RNA viruses seem to be constant companions of honey bees. They can be found in all the life stages of the bees and in their stored food. At this point in time, they do not seem to be the primary cause of CCD losses.

Adult worker bees were found to be infected by microbes that would not normally infect honey bees. Those microbes were extracted from the bees and cultured. They were determined to be soil and air-borne inhabitants that had previously been found in beehives, but they are not considered pathogenic to honey bees. So, why were they infecting the bees? Most likely, the innate resistance of the bees to becoming infected was lowered, allowing what we call "opportunistic" infections to develop. Such infections are common in many animals when their protective tissues (especially skin) and immune systems are physiologically impaired.

The two possible toxic agents that are drawing the most attention are a systemic insecticide and proteins from genetically modified (GM) plants. The suspected insecticide is imidacloprid. There are certain facts about imidacloprid that cannot be disputed. Every year there are more uses for the chemical. It is quite safe to use around mammals and birds, but it is highly toxic to invertebrates. It usually penetrates the treated plant or animal and becomes systemic. While this is good for presenting the pesticide to chewing and sucking insects, it causes many to be suspicious of the chemical occurring in the nectar and pollen of treated plants at levels that may be toxic to honey bees and other non-target animals. Studies conducted on the nectar and pollens normally demonstrate no residue or less than would be toxic to adult honey bees. But, other laboratory conducted studies show that sub-lethal doses of imidacloprid do change behaviors of honey bees. Those changes are thought by some to interfere with the navigation or memory systems of the bees and they fly off and never get back to the hive.

While the concentrations of the parent chemical and its breakdown products in the nectar and pollen probably don't have this immediate effect, we do not know what effect small concentrations over a period of time have on honey bees. Do the residues continue to build up in the bee body until reaching a specific dose that leads to the loss of the bee? Or, do the chemicals inside the bee body contact enzymes that denature the toxins? A tobacco hornworm can eat tobacco and not have a problem with the nicotine. Can the honey bee do the same with neonicotinoids? There never has been a time when we needed the assistance of an insect toxicologist (honey bee toxicologist) more than we do today with these questions.

Genetically modified plants usually have genes added that instruct the plant to produce novel proteins that benefit the plant. In order to keep lepidopterous insects from consuming corn plants, the plants are stimulated to produce a toxin that occurs naturally when the bacterium, *Bacillus thuringiensis* (B.t.), sporulates in culture. The extra-sporal crystalline body in the bacterial cell paralyses the intestinal tract of the caterpillar which eventually starves to death. B.t. has been used for decades as a bio-control agent on field and orchard crops. *Bacillus thuringiensis* and its toxin are not toxic to any stage of honey bees at concentrations that would be encountered in the field. Apparently, a study was conducted over four years where the toxin was fed to honey bee colonies at ten times the dose they would encounter in pollen from GM corn. Nothing negative happened until a "honey bee parasite" worked its way into the experiment. Then the bees fed the 10X dose of toxin were more susceptible to the parasite.

Another modification of plants is to include instructions for producing an enzyme that breaks down an herbicide, glysophate. Enzymes are proteins. If this protein is present in the pollen of the GM plant, then one would suspect that it would be digested with the rest of the proteins in pollens as they passed through the bee's digestive tract. The novel protein would be problematic only if it interfered with food digestion or turned into a toxicant as the protein broke down. Neither of those is likely to be the case.

Recently, a third approach to pest insect control consisted of having the plant produce an enzyme (protease) that does attack the digestive proteins of the target insects. Extensive studies were conducted and the induced protease does not interfere with honey bee digestion.

The suggestion that electromagnetic fields are interfering with navigational systems in the honey bee do not seem to be tenable. Studies on honey bee navigation decades ago determined that the bees rely very heavily on learning landmarks for returning to their hives. During the time that adult honey bees are transforming from in-hive to foraging bees, they can be seen in large numbers flying around directly in front of the hive, back and forth and in ever increasing circles. This flight is called "play flight" or "orientation flight." With time, the distance from the hive becomes greater, and a bee eventually learns the hive location in the "neighborhood." As the bee goes off to forage, it learns the landmarks to and from the water, nectar, or pollen source. It cannot recognize landmarks in areas where it has never been and honey bees are not like homing pigeons – they will not return to their hive from places they have never been before, unless they are close enough to catch a "whiff" of the hive odor.

Honey bees also use polarized light as a navigational aid. Investigators looking at the dance language of bees noted that the dancing bees use gravity as an indicator of where to fly in relation to the position of the sun. A waggle dance, straight up, means fly toward the sun. A straight down dance means fly directly away from the sun. If you have polarized sun glasses and hold them at arms length, while looking just above the horizon, you will see that the sky is brightest when the sun is straight ahead or directly behind you. It is darkest 90 degrees to the right or left of the sun. The bee's eyes can see this, too. Experiments with polarized filters placed above the entrances of hives and rotated in various directions caused the bees to fly off in different directions, and then correct themselves when they reached un-modified sunlight. Neither the landmark nor polarized light navigation would be influenced by communication electromagnetic waves.

The cell phone studies are not persuasive. An earlier paper, by the authors of the paper that caused the recent stir, determined that having a functioning cell phone relay, accepting in-coming and sending out-going calls, inside a beehive for a year did not affect the bees' performance. The paper that created the stir suggested that the frequencies used by cell phones appeared to be of wave lengths that might cause resonance in bee brains or portions of bee brains that were the correct size. A good way to measure that would be to put electrodes into the brain tissues and see if "spikes" could be generated on an oscilloscope. Instead, the researchers collected bees from entrance tubes of colonies, with and without cell phones in them. They marked the bees and took them away from the apiary and let them go. In these trials, the bees from the hives without cell phones returned in greater numbers and more quickly than did the ones from hives with a cell phone in them. In fact no bees returned to one of the hives containing a cell phone. Referring back to earlier comments on honey bee navigation, if the bees taken from this last hive were bees taking orientation flights or they were transported to a place they had never been before, it is not surprising that they did not get back.

A possible cause of CCD that is not getting much attention is the nutritional status of the bees. Research decades ago determined that honey bees, like humans, require certain amino acids, lipids (especially a precursor for cholesterol), vitamins and minerals to survive. It has been known for a long time, also, that no one pollen contains all the nutrients required by honey bees for brood rearing and survival. So, a good mix of nutritionally adequate pollens will lead to the production of strong, healthy, "fat" (stored nutrient reserves) bees. Such bees are resistant to many of the potential causes of CCD mentioned previously, such as infections by naturally occurring soil and air-borne microbes.

Malnourished bees, in addition to being more susceptible to infections and toxins, are expected to be lighter in weight and to have reduced life expectancies. However, we are lacking the specific information on exactly how much a bee's life can be shortened by malnutrition. If foragers are not bringing in pollens, the bees tend not to rear brood. If only a little pollen is being brought in, what is the condition of the few bees being reared? It will matter greatly if the bees being reared are winter bees! How much can a normal six month life expectancy be shortened before the bees simply stop rearing brood?

Although state administrators in California do not want to call 2007 a drought year (because there is adequate stored water in the reservoirs from last year's rains), beekeepers already can see problems in their bees. In January, there was just a tiny fraction of an inch of rain. The normal mustard, filaree, wild radish, red maids and shepherd's purse were not there. In almonds, most of the colonies responded to the wealth of food by rearing good amounts of brood and populations were on the incline.

As soon as the almond flow ended, many of the colonies tapered off brood rearing, even with (possibly problematic) pollens stored from the previous late summer and fall in the hives. Natural pollens are still not available. Sage plants, that usually provide a reasonable honey crop, are not providing anything in most places.

Commercial beekeepers already are feeding pollen substitutes to their colonies. As the season progresses, naturally occurring forage plants appear to be few and far between. Plants that provide the late summer and fall food for bees likely will produce nearly nothing, as the soil moisture will be long gone before August and September.

Unfortunately, beekeepers cannot control the weather. Weather impacts the availability and, probably, the quality of the pollens crucial for honey bee health.

Weather allows or prevents the bees from flying when the food could be available (rain and high winds keep bees in the hive). Currently, we do not have a man-made diet for bees that even comes close to providing the nutrients needed to sustain honey bee populations and support brood rearing adequately. Unless I miss my guess, we are going to see significant losses of honey bee colonies, again, this winter in California simply because of the weather and its effects on the bees' food supply.

Sincerely,

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