COOPERATIVE EXTENSION UNIVERSITY OF CALIFORNIA

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Honey Bees and DPR

When I began my career at UC Davis, the registration and enforcement activities for pesticides were combined within the California Department of Food and Agriculture (CDFA). I soon became acquainted with the regulatory side, as I met various county agricultural commissioners throughout the state. But I did not have much reason to interact with the pesticide registration folks.

Apparently, some environmentalists and legislators felt that the relationship between agriculture and pesticide registration was a bit too cozy. So, the group was split up and the California Department of Pesticide Regulation (DPR) was formed. In some cases, that department is also referred to as Cal/EPA.

At first, the DPR personnel were the former CDFA employees. But over time, with natural attrition and replacement, the two groups became totally divorced from one another.

The beekeepers did not pay much attention to DPR, except to complain occasionally that their bees were not being protected from pesticide exposure as well as they might be. But, that changed with the appearance of tracheal and varroa mites. If beekeepers were going to use acaricides, legally, in their hives for mite control, then the products had to be registered at both the federal and state levels.

Many of the products came to the market, temporarily, as Section 18 registrations. That meant that a beekeeper had to pass a pesticide safety examination and acquire a permit from the local agricultural commissioner in order to use them. It also meant that some sponsoring individual or organization had to prepare and submit the applications for the Section 18s, since in California, unlike a number of other states, CDFA will not apply for Section 18s in their name. Therefore, I began preparing the Section 18 applications and we submitted them through the California State Beekeepers' Association. The forms require the signature of the president of the state beekeepers' association and the signature of one sympathetic agricultural commissioner.

As time went on, we moved from paper information to electronic information, and I was added to the list of individuals who receives a brief statement, weekly, concerning all the companies that submit requests for new or revised pesticide registration in California. This system is designed to allow interested persons to submit comments on the registrations, if they think there is something important to say. If the information in the comments is quite substantial, DPR is required to look into the question and return a prompt written response.

Have I submitted such letters? Yes. Many of them were quite simple, such as a reminder to be sure that the label for a bee-toxic material contained warnings or prohibitions about using the product around bees. Over the last decade or so, I have become very well acquainted with the individuals in DPR who help us with obtaining Section 18s, renewing Section 18s, and responding to my statements in my letters. Those individuals are now looking out for the concerns of the beekeeping industry and contact me if they wish to know things, such as "Do you wish to have us extend the Section 18 for a certain product another year? If so, we'll take care of it." I am seriously indebted to Rich Bireley, Margaret Reiff, John Inouye, and Tulio Macedo for all they have done for our beekeepers.

Recently one of the weekly notices contained three entries that caught my attention. So far, that is a record. The first item was a registration request for a no-pest strip with DDVP as the active ingredient. DDVP (2,2-dichlorovinyl dimethyl phosphate) used to be called Vapona®. The first strips on the market, decades ago, used an impregnated beeswax strip as the formulation for slow-release of insect-toxic levels of DDVP fumes. The strips were used mostly for fly control in confined areas, but I used a portion of a strip in a shoe box to knock mites off a potted cyclamen.

Way back then, there were stories of beekeepers who had killed colonies by introducing either foundation or drawn combs that had been placed, accidentally or ignorantly, in an area being fumigated by no-pest strips. That prompted me to submit a question about the intended label. Did it carry some sort of information dealing with that problem?

The answer came back to me over the phone, way ahead of a written response. No, there was nothing on the label! Without hesitation, our DPR cooperator contacted EPA, directly, and asked about this. EPA said that it knew nothing about that potential problem, but it would try to determine how best get that information on the label.

The second suggestion I had was to ensure that a product containing Cygon® have a warning on the label about the possible short-term, toxic, systemic effects of the product (dimethoate – O,O-dimethyl S-(N-methylcarbamoylmethyl phosphorodithioate) on bees. I guess that I may have been asking the wrong question, but our DPR contact started by searching the dimethoate labels. He found no cautions or prohibitions on use around bees on about half the products, even though dimethoate is highly toxic to bees. He checked with other knowledgeable folks about the possibility of systemic effects, but I guess I was off on that one.

However, that prompted another call to EPA. Our DPR contact asked, “Why are some of the dimethoate products carrying bee prohibitions while others are not?” Apparently, at one point in time, all the products carried the restrictions. Then, someone made the sage decision to relax the regulations and those prohibitions no longer would be necessary. The companies that left the restrictions on their labels should be com-mended. After that discussion, ALL the products will be required to carry the prohibitions, once again.

Finally, there was a request to use dinotefuran on field crops. I had a real concern about that. The reason is that many growers have switched to soil-penetrating drip line irrigation. That should deliver the water and whatever else is added to the water down around the roots of the crop. This significantly saves on water expenses and is supposed to keep the chemicals away from the soil surface.

However, in the drip fields that I have visited, it is practically impossible to hook up all the equipment without a little leakage. In our hot, dry summer environment, honey bees will be on the leaky water as soon as the equipment starts pumping. Many times the bees will be standing on the irrigation lines licking up the seepage, but if a leak is large enough to cause a small puddle to form on the ground, bees can be found all around the puddle.

My concern is that drinking chemigation water that contains a neonicotinoid at “field dose” allows the bees to bring back much more residue than they would acquire later when the neonic moved into the nectar and pollen.

Our contact was told by EPA that there was no reason to put a warning about chemigation on the label, because the equipment is not supposed to leak. He was sent back to our DPR "pesticide enforcement" group who told him that a leak like that, and especially a puddle formation, violates state regulations and the growers could be fined.

Whoa! I had no intentions of fingering growers and applicators. I wished only that they be made aware of potential problems when using bee-toxic pesticides in chemigation systems. Anyway, I guess I stirred the pot pretty vigorously this time.

Is Tobacco Ringspot the Only One?

Nearly every time a new piece of information about honey bees is released, people are sure that the real reason for colony collapse disorder has been discovered. This time it is the paper that demonstrated that tobacco ringspot virus can replicate in honey bee tissues. (See J.L. Li, *et al*., doi:10.1128/mBio.00898-13.) This does not seem too extraordinary to me for two reasons: First, we know that quite a few plant diseases are vectored by sucking insects, so it is clear that plant viruses can reproduce in insects (or is it actually an insect virus that can cause damage to plants, once it "changed hosts" in the other direction?).

Second, honey bees and plant viruses must have been together for tens of millions of years. That would be a long time, compared to the rapid rate of mutation for RNA plant viruses, to "just-now" be the first time that a plant virus could infect a bee.

So, now we have added another RNA virus to the previous list of viruses that are putting our honey bees under stress. It will be interesting to see if researchers can find tobacco ringspot virus in bumble bees or solitary bees, since it seems that honey bees are good at spreading their viruses around to other species of bees in the area.

I haven't heard much recently from Dr. Joe DeRisi, who is employed at the UC San Francisco Mission Bay campus. So, I looked him up. The last thing I remember, he had begun a project designed to develop a microarray chip that could be used to identify every known virus on the planet (there are 22,000 of them). That is a tall order, but the ViroChip is well on its way. Joe is quoted as saying. "Are they (the viruses) causal, or do they just coexist (with certain diseases)? We can't say yet, but it is a question worth asking." Honey bee researchers can say the same thing about the viruses we are identifying from honey bees.

But he did tell me previously, that he had branched out from honey bees to look at some other insects, like wasps, ants and solitary bees. They seemed to share a lot of RNA viruses beyond the named ones we already can detect. Perhaps his new list will include more viruses that are infectious to both bees and plants.

Joe did become involved in a study of Inclusion Body Disease (IBD) of boa constrictors and pythons. He and his coworkers found a novel snake arenavirus that is closely related to the disease.

HopGuard II on the California Market

California beekeepers (and those in five other states where the product is registered) who are interested in trying the newly formulated HopGuard II® strips of beta acid extract of hop may do so with a Section 18 permit obtainable from your county agricultural commissioner. There still is a written examination that has to be passed to obtain the permit. If you wish to study for the test, you can obtain a public-cation covering the information from a cooperative extension office which usually is next door.

The new strips are every bit as gooey as the older formulation. Don't wipe the goo off, since it is the active ingredient for the treatment. The new strips have more active ingredient on each of them. They are stiffer and go down between the frames more easily. If they still dry out rather quickly, the distributors suggest that they be "refreshed" (new strips to replace the old) at the appropriate interval. Since newly released mites hang around on nurse bees for 6-9 days after the bee exits the cell, a weekly changing of strips, for three sets, might be effective.

Limited graphical data from the manufacturer can be reviewed at its website [BETA_5830_HopGuard_SS_HiRes(3).pdf] and testimonials from satisfied customers seem to suggest that this product is considerably improved over its predecessor. A list of states with Section 18 registrations can be seen at: http://www.mannlakeltd.com/hopguard/availability/. However, more states may be added to the list, so you should check, locally or with Mann Lake, if your state is not on the current list.

Cost of Bee Feed

For years we have made plans to generate a cost of production data package for maintaining a colony of honey bees for 12 months in California. Requests for voluntary completion of survey forms have never generated enough responses to complete the task. However, best-guess estimates by a number of commercial beekeepers in 2012 pegged the costs to at least $220 to have colony populations of eight frames or better to meet almond pollination demands.

At the January 2014 meeting of the California Bee Breeders' Association, Inc., I had a captive audience of nearly 20 commercial operators. I sent around a data sheet asking all beekeepers to anonymously fill in the number of colonies they operated in 2013 and the total costs for sugar syrup and protein feed, fed only to their full-sized colonies but not including the feed that was fed to their queen mating nucs. With total anonymity, the response was pretty good.

Fifteen beekeepers supplied data that can be reviewed in the table on the next page. The substantial variations in the per-colony costs of purchasing feed exemplify the difficulty we have had in trying to generate an average cost of production for California beekeeping operations. Very few of them are "average." Keep in mind that the listed feed costs represent the costs of only the raw ingredients, not the labor and travel expenses involved with placing the feed in the hives. Prices for raw ingredients vary according to feed type (*i.e.*, sucrose or high fructose corn syrup blends) and whether the feeds are pre-mixed or self-formulated.

The 15 bee breeders reported operating a total of 83,550 colonies. They spent more than $42.8 million on sugar syrups and $506,500 on protein substances. They averaged feeding $32 in syrup and a little over $6 per colony on protein, for a total of nearly $39 for bee feed. However, the range in the per-colony expenses varied from a high of $45.00 for syrup to a low of

Annual Cost of Feed – CBBA, January 2013

Beekeeper	Col. Nos. in Thousands	Annual Syrup Cost in Thousands of Dollars	Syrup Cost/Col. In Dollars	Annual Protein Cost in Thousands of Dollars	Protein Cost/Col. In Dollars	Total Feed Costs in Thousands of Dollars	Total Feed Costs/Col. In Dollars
1	6.00	252	42.00	90.0	15.00	342.0	67.00
2	2.00	62	31.00	11.0	5.50	73.0	36.50
3	15.00	675	45.00	60.0	4.00	735.0	49.00
4	11.00	430	39.09	48.0	4.36	478.0	43.45
5	6.00	250	41.67	25.0	4.17	275.0	45.84
6	12.00	300	25.00	60.0	5.00	360.0	30.00
7	14.00	400	28.57	100.0	7.14	500.0	35.71
8	2.00	65	32.50	16.0	8.00	81.0	40.50
9	5.00	100	20.00	25.0	5.00	125.0	25.00
10	2.00	60	30.00	12.0.0	6.00	72.0	36.00
11	1.15	30	26.09	4.5.0	3.91	343.5	29.99
12	2.00	60	30.00	6.0	3.00	66.0	33.00
13	1.00	30	30.00	5.0	5.00	35.0	35.00
14	3.30	65	19.70	36.0	10.91	101.0	30.61
15	1.10	45	40.91	8.0	7.27	53.0	48.18
Totals	83.55	2,824	481.53	506.5	94.26	3,330.5	585.78
Averages	5.57	188.27	32.10	33.77	6.28	222.0	39.05

Figures may not match exactly due to rounding errors.

$19.70, and for protein feed, a high of $8 to a low of $3. Most of the variation is related to the amount of natural nectar and pollen resources the bees were able to find during the year.

The bee breeders are located in the Sacramento Valley in northern California. Beekeepers based in the San Joaquin Valley, in southern California, or in other states are likely to have very different requirements for bee feed.

<u>Sublethal Effects</u>

It should be apparent by now that honey bees seem to be having problems when too many pesticide residues accumulate in the hives. Since the bees are not dying of acute poisoning, researchers are focusing their attention on so called "sub-lethal effects," as if this were a novel idea. However, in 1988, Kenneth Haynes from the University of Kentucky published a paper titled, "Sublethal Effects of Neurotoxic Insecticides on Insect Behavior." He felt that this sort of information was important for a number of reasons: 1) it might better explain the modes of actions of various insecticides; 2) and it might elicit behavior changes that might be disruptive to target pest insect physiology; however he stated that this otherwise beneficial effect might be deleterious to beneficial insects; and 3) it might shed light on how insects develop avoidance reactions to some insecticides. Haynes referred to a paper by H. Levinson who coined the word "insectistatics" to describe interfered-with normal processes of growth and reproduction that do not necessarily lead to death.

The article goes on to explain in detail various categories of behavior that are influenced by sublethal exposures to various insecticides. Since this is an earlier publication, the examples are mostly from exposures to organophosphates, carbamates and pyrethroids. The discussion of reproductive behavior states that exposures usually result in production of reduced numbers of viable offspring. This can be the result of failure to find mates, failure to mate, and detrimental physiological changes in the reproducing female. Occasionally, more viable offspring resulted.

The next category, host-finding and feeding behavior, includes references to honey bees. Haynes states that we should not assume that a honey bee colony is not affected by an insecticide exposure simply because there is no immediate bee kill. When fed sublethal doses of parathion, honey bee foragers lost their ability to correctly relate the direction to the food source with their waggle tail dance. They were off by 7.5 to 29 degrees when they danced on vertical combs in the hive. When placed on horizontal combs in sunlight, they danced directly to the source. "So, it appears that the exposure to parathion interfered with the translation between photomenotaxis (directed movement at an angle to light) and geomenotaxis (directed movement in relation to gravity). During the first 5.5 hours following exposure to the parathion, flying foragers would stop short before they reached the food source at which they had been trained. The exposed bees normally recovered their normal dance patterns by the next day. However, the parathion exposure also interfered with their ability to remember the time of day when the food was provided in the feeder. That effect lasted for more than a day. That suggested that various alterations in behavior do not all commence and dissipate at the same rate.

The parathion-exposed bees also took longer to learn the proboscis-extension behavior, and spent more time cleaning them-selves and doing trembling dances than tending to their routine house bee tasks.

The section on dispersal and locomotory behavior did not refer to bees. The following section on perception of pesticides did refer to honey bee behavior. Both E. L. Atkins at UC Riverside and K.S. Pike, *et al.*, at Oregon State University felt that insects, including honey bees, were repelled by permethrin applications in the field. The observations showed that treated fields were not visited as often by honey bees and the bees in the field avoided contact with the treated foliage. They called this repellency. However, Dr. Christine Peng (now retired from UC Davis) and I ran experiments with permethrin in laboratory studies, and found that honey bees were not averse to walking across heavily dosed filter paper to get to their food. I presumed that the lack of foragers in the field was due to the failure of the early "leader bees" that return from the field with rewards that start the entire field population on their way for the day, were killed and never set off the foraging behavior for that crop. Haynes recognized that possibility. However, now I wonder. Is it not permethrin that is impregnated into military and high end recreational sports clothing to repel biting arthropods?

Haynes' article wraps up with a review of the modes of action of the chemicals that had been discussed and the following sentiment: Looking for changes in behavior should be the best way to determine sublethal effects. Even though such studies are more laborious than dose mortality studies, they would elicit insectistatic effects. Those are the types of effects that we are seeing in our honey bee colonies but are not receiving the attention they deserve during our pesticide registration evaluations.

The complete citation for this article is: Haynes, Kenneth F., 1988. “Sublethal effects of neurotoxic insecticides on insect behavior.” *Annual Review of Entomology* 33:149-68.

Sincerely,

Eric Mussen
Entomology Extension
University of California
Davis, CA 95616
Phone: (530) 752-0472
FAX: (530) 752-1537
E-mail: ecmussen@ucdavis.edu
URL: **entomology.ucdavis.edu/faculty/mussen.cfm**

Eric Mussen
Entomology/UC Davis
Davis, CA 95616