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An Introduction to Integrated Pest Management for Honey Bee Pests

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'IPM enables us to accomplish by finesse, that which we cannot achieve by brute strength alone.'

'To survive, beekeepers must learn to manage pest populations in a manner that is not only effective and affordable in the short run, but also safe and sustainable in the long run.'

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This article is the first in what I hope will be a useful series on the management of honey bee pests, parasites, pathogens and predators, or, more simply, pests. My goal is to encourage beekeepers to approach pest management in a systematic manner using methods based on the principles of IPM – that's Integrated Pest Management. IPM, as I hope to convince you, provides the best long-term solution to the problems that challenge beekeeping today. Make no mistake, the problems we face are industry-threatening and difficult to solve. To survive, beekeepers must learn to manage pest populations in a manner that is not only effective and affordable in the short run, but also safe and sustainable in the long run. Without an underlying philosophy to guide our pest management decisions, we will fall short of those goals, and major sectors of the beekeeping industry may become little more than a historical curiosity.

A LITTLE BACKGROUND

Back in 1977, I had the good fortune to find work at one of the world's premiere honey bee research labs - the lab of Professor Walter C. Rothenbuhler at The Ohio State University in Columbus, Ohio. It was not by accident that I ended up working for Doc, as we all called him. Several years earlier, I had taken a class in apiculture taught by Dr. Tom Rinderer, then, one of Doc's Ph.D. students and now the head of the USDA-ARS bee research lab in Baton Rouge. Tom was an engaging teacher who stimulated my interest in bees so much that I decided to become a beekeeper and to return to school to pursue a degree in apiculture – Doc was my advisor. When I completed my degree, I leapt at the chance to work as his beekeeping technician.

I worked closely with Vic Thompson, Doc's colleague of nearly 25 years. Vic managed the bees, but after a couple of years of apprenticeship, he gradually turned that job over to me. I ran between 150 and 250 hives to support the lab's research programs. I remember Vic telling me one day that he had never used antibiotics for control or treatment of AFB or EFB. Vic kept the incidence of AFB below ½ % by using careful management techniques, and he was proud of

that accomplishment. It was not that Vic was a purist who didn't believe in using chemicals. Far from it. We routinely used ethylene dibromide (EDB) for controlling wax moths, much to my dismay. No, Vic had figured out that he was best off managing diseases without chemicals.

Back then, AFB was the only big problem. Today, we have tracheal mites, varroa mites and the small hive beetle, and chemicals play an essential role in the management of those problems. When you add it all up, we use chemicals for just about everything, including nosema, AFB, EFB, the tracheal and varroa mites, the small hive beetle, and the wax moth. Problems have simply come upon us faster than we have been able to solve them, and we have become chemically dependent.

As I look at beekeeping today, I think back to my days with Vic and Doc at Ohio State. They were good beekeepers who limited their use of chemicals whenever possible. I think their success holds lessons for beekeepers today, even as we struggle to survive in a very different and more complicated world. So, let us get started by looking at how IPM can help beekeeping remain a viable and competitive enterprise in the coming century.

JARGON

Every field of study comes complete with its own jargon, and IPM is no different. Therefore, if we are going to talk about developing and implementing IPM strategies for honey bee pests, we need to be familiar with a few basic terms. The key words for today are: integrated pest management, pest population density, economic injury level, LD50, chemical resistance, pest resistance, quality assurance, and sustainable:

integrated pest management: an approach to managing pests that is based on the coordinated use of one or more methods and that seeks to minimize chemical inputs

pest population density: a measure of the size of the pest population relative to the size of the crop, in our case, bees; population density may be measured in terms of the number of mites per 300 adult bees, or the number of cells of chalkbrood per 100 cells of brood

economic injury level - EIL: the lowest pest population density that causes economic damage

LD50: the dose of a chemical that causes the death of 50% of a test population. LD50's are specific to the formulation being tested (pure chemical, dust, emulsifiable concentrate) and the route of entry (dermal, oral, inhalation). We can measure LD50's in terms of milligrams of chemical per kilogram of test organism, or mg/kg. A milligram is 1/1,000 of a gram. A kilogram is 1,000 grams. LD50's for highly toxic chemicals are measured in terms of micrograms of chemical per kilogram of test organism, or ug/kg. A ug is equal to 1/1,000,000 of a gram. LD50's can be measured in terms of ug/bee, although this is less precise. Toxicity is also measured in terms of LC50's and LT50's, reflecting the concentration of a chemical or the time of exposure to a specific dose or concentration of a chemical

chemical resistance: the ability of a strain of a species to tolerate or avoid factors that would prove fatal to or reduce the productivity of the majority of strains of that species. More narrowly, a condition in which a population of a pest species that has been exposed to a chemical has an LD50 for that chemical that is significantly higher than the corresponding LD50 in an unexposed population – the chemicals involved can be pesticides or antibiotics

pest resistance: the ability of a strain of a species to maintain productivity, relative to the majority of strains of that species, when infested with a pest

quality assurance: a systematic program for ensuring that all products conform to a well-defined set of quality standards

sustainable: a process that can be conducted indefinitely

WHAT IS IPM?

The AFB management program I had learned at OSU was an example of a pest management concept called IPM, short for Integrated Pest Management. IPM is a philosophy for managing, not necessarily eliminating, agricultural pests so that the pest population density does not exceed the economic injury level. IPM programs originated in the 1950's in response to growing problems with environmental contamination, residues on crops, and an increasing number of cases of chemical resistance in pest populations. IPM programs grew steadily during the 1960's and 1970's, and the IPM concept serves as a model for pest management programs throughout agriculture.

IPM is not organic farming. Unlike organic farming, IPM incorporates synthetic chemical inputs for pest management when needed. However, IPM programs do seek to minimize chemical inputs. There are four very sound reasons for this. First, chemicals often have a negative impact on the environment. DDT is the classic example. Although not particularly toxic to humans, DDT proved to be environmentally persistent and highly toxic to many other species. Second, chemicals are expensive, and producers often realize a significant reduction in production costs by limiting their use. Third, chemical residues compromise the purity of the products produced, possibly rendering them unhealthy or undesirable in the market place. Fourth, chemical resistance develops at a slower rate when the pest population is exposed to pesticides or antibiotics less frequently, and that extends the useful life span of existing chemical controls.

IPM TREATMENT OPTIONS

IPM programs are able to reduce the use of chemicals because they employ a variety of other methods, depending on the crop. Below, I group these methods into several broad categories (after Luckmann and Metcalf 1982) and give a few examples of each. Some methods may fit into more than one group, but the categories serve to demonstrate the variety of methods available for pest management.

1. **CHEMICAL** inputs include, among others, antibiotics, pesticides, pheromones, attractants, repellants, sterilants, and growth inhibitors. Most of us are familiar with this group, especially the pesticides and antibiotics. Chemicals used in the bee industry include Apistan, Coumaphos, PDB, terramycin, grease patties, menthol, and Fumidil-B. Essential oils are a diverse group of natural plant chemicals that hold great promise for pest control.

Some chemicals are less well known. These are the pheromones and the allelochemicals. Insects use pheromones to communicate with other member of the same species. For example, bees use an alarm pheromone to recruit defenders. Pheromones are especially important in the mating process, and researchers have learned to use them in the management of agriculturally important pests. Pheromones may eventually play a role in the management of the small hive beetle and the wax moth. Allelochemicals are involved in communication between members of different species. One group of allelochemicals consists of compounds produced by bee larvae. These chemicals may be used by varroa as cues for host location. Allelochemicals may someday play a role in a varroa trap.

2. **CULTURAL** methods include the use of crop rotation, pesticide rotation, variation in the timing of planting, fertilization, sanitation, and the planting of trap crops. Several studies have documented that the timing of an application of pesticide can have a major impact on mite populations (Delaplane and Hood 1997). Management techniques that reduce stress make up another large group of cultural methods that can provide a solid foundation for healthy colonies.

3. **PHYSICAL** methods include the use of heat, cold, humidity, light, and sound. Beekeepers have tried heat for mite control, but without much success. Beekeepers routinely use cold temperatures to kill wax moth eggs in section honey.

4. **MECHANICAL** methods include hand destruction, barriers, and traps. Beekeepers use many types of barriers for control of skunks, ants, bears and wax moths.

5. **BIOLOGICAL** methods include beneficial insects and various pathogens. Everybody is familiar with ladybugs, one of 'the other beneficial insects' used for control of many pest species. Many farmers also use small wasps called parasitoids for fly control and these creatures might also be developed to control wax moths and the small hive beetle.

6. **GENETIC** methods include the release of sterile or incompatible individuals and the development of pest resistant stocks. The genetic solution is most desired; yet, it remains the most elusive. Rothenbuhler (1964) demonstrated that AFB resistance was a selectable trait. Recently, Prof. Marla Spivak, at the University of Minnesota, has selected for hygienic bees and improved the technique for identifying hygienic bees (Spivak and Downey 1998). The USDA-ARS lab in Baton Rouge is conducting promising work on mite resistance (Harbo and Hoopingarner 1997). Pest resistant stocks will play a major role in the future of beekeeping. On the horizon are modern molecular techniques that may help to identify desirable genotypes in the laboratory.

7. **REGULATORY** efforts include import restrictions, quarantines, eradication and suppression. Regulatory efforts have played an important, if often controversial role, in reducing the rate at which pests have spread between countries and throughout countries. Currently, Canada has restricted the

import of US bees to prevent varroa mites, Apistan resistant varroa mites and the small hive beetle from entering the country. Some states in the US have restricted the importation of bees to control the small hive beetle.

IPM - WHY NOW?

Historically, beekeepers have not had to deal with many of the realities of modern agricultural life. Before 1984, AFB was the only serious threat to bees, and it was largely controlled by the use of terramycin, rigorous inspection programs, and hygienic management practices. The years 1984 and 1987 were watershed years in beekeeping. They marked a loss of innocence. The arrival of the parasitic mites accompanied by the emergence of a suite of disease causing pathogens propelled beekeeping into the world of modern agriculture. The recent arrival of the small hive beetle, the development of chemically resistant mites and pathogens, and the globalization of the honey market completed this transition. Like it or not, we can not go home again.

A discussion of IPM is important at anytime because it always represents the best long-term approach to the problem of pest management. It is especially important today because of the crisis in mite control, a crisis that was completely predictable from an examination of the history of chemical control of pests in other crop systems. There are five stages common to most crop systems (after Smith 1969):

1. The subsistence phase is characterized by low yields, a poor understanding of the crop system, and limited efforts in pest management. This phase characterizes beekeeping before the discovery of the bee space and the introduction of the Langstroth hive in 1851.
2. The exploitation phase is characterized by an increasing understanding of the crop system, better management, success with chemical controls, increased yields and the development of new markets. This phase corresponds to beekeeping between 1851 and 1997.
3. The crisis phase occurs after many years of chemical dependency. Resistance develops in the pest populations, growers substitute new chemicals for old ones, and the process is repeated. This is where we find ourselves today.
4. The disaster phase is characterized by the need for repeated applications of chemicals for pest control. Two or more chemicals may be required for control. The cost of pesticides increases production costs to a point where the crop can not be profitably grown. Pesticide residues increase to unacceptable levels, and eventually, the pest control program collapses with accompanying bankruptcies and social displacement. This seems to be where we are headed.
5. The integrated pest management phase is characterized by the coordination of multiple tactics that keep the pest population below the economic injury level. The IPM phase can only be achieved after research has first, produced a thorough understanding of the pest's biology and second, developed multiple techniques for effectively and reliably manipulating the pest population. This is where we need to be.

Sound familiar? Whether we can get to the integrated pest management phase without going through the disaster phase is uncertain. However, beekeepers should not fool themselves into believing that 'if we just had one more chemical, everything would be alright.' Pesticides in the absence of a rational pattern of pesticide use cannot and will not provide a sustainable solution to any pest problem.

PROSPECTIVE

As you will see in the articles to follow, many of the practices you are using right now qualify as IPM practices. As I wrote this article, I asked myself how beekeepers would benefit by attaching a name to their pest management program. I believe that there is a lot to gain. IPM provides an important theme to pest management. Viewing your pest management from an IPM perspective enables you to move from a series of often disconnected acts, to an organized system of pest management that is always in search of new ways to reduce the use of chemicals. IPM requires you to evaluate each management decision in terms of its impact on the health of your bees and your use of chemicals. IPM can help you to achieve your pest management goals, minimizing the use of chemicals in the short run and maximizing the useful life span of those chemicals in the long run. Finally, by de-emphasizing the use of chemicals, IPM minimizes residues and ensures that your hive products continue to be of the highest quality possible.

IPM will not mean the same thing for all beekeepers. Some beekeepers run a few colonies, others a few hundred colonies, and others many thousands. Some techniques are compatible with small to mid-sized operations, but not with larger operations. Consequently, different beekeepers will need to adopt different IPM programs. For the hobbyist who does not want to use chemicals, drone trapping may suffice as a mite management tool. For the commercial beekeeper, IPM for varroa may be as simple as using available chemicals only when needed and only according to label instructions. Tomorrow, new techniques will allow you to reduce the number of chemical treatments, in some cases allowing you to eliminate them altogether.

I hope the articles that follow will help you to manage better the pests that attack your bees. In the next article, I start with the basics, based on the adage that 'an ounce of prevention is worth a pound of cure'. Honey bee colonies are living, breathing creatures. They thrive in some environments and become sick in others. Never forget that your management system, from top to bottom, IS the bee's environment. You can help your bees by making sure that you do everything possible to provide them with an environment that promotes their health and well being. IPM does not yet have all of the answers, but it does provide an important conceptual foundation upon which to build our pest management programs.

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