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Pesticides and Honey Bee Death and Decline

By William Quarles

A large number of overwintering honey bees are dying in the U.S. For the last five years, winter losses of managed honey bee colonies have been around 30% each year (van Engelsdorp et al. 2012). Overwintering honey bees are being killed by pathogens, pests, poor nutrition, and pesticides. Honey bee problems are part of the overall pollinator decline in the U.S. (Spivak et al. 2011; NAS 2007).

Managed honey bees are trucked from state to state and forage over large areas. Most of the crops they encounter have been treated with pesticides, and chemical analysis of overwintering honey bee hives shows extensive pesticide contamination (Mullin et al. 2010).

Pesticides are accumulating in hives, and bees are also being killed while foraging in fields (Krupke et al. 2012). Part of the problem is exposure to systemic insecticides called neonicotinoids. Insecticides are normally applied in ways to mitigate their impact on bees. Mitigation strategies are not possible with systemics because they are always present in the plant. Over 59 million ha (146 million acres) of crops in the U.S. have been treated with systemics. This represents about 45% of the total cropland, and acreage is increasing each year (Mullin et al. 2010; Stokstad 2012; Spivak et al. 2011).

Pesticides can impact bee populations through direct mortality and through sublethal effects on behavior, such as impaired memory, learning and foraging. Impaired foraging can lead to poor nutrition, and pesticides may directly impact bee immune systems, making them more susceptible to disease. In addition, sublethal pesticides interfere with brood development and shorten lifespans of adults (Henry et al. 2012; Pettis et al. 2012; Wu et al. 2012; Desneux et al. 2007).

Pesticides may also contribute to Colony Collapse Disorder (CCD). This phenomenon was first observed in the U.S. in 2006. Bees disappear from the hive, leaving food, brood, and even a queen (USHR 2007; Quarles 2008a). Despite intensive research, an exact cause of CCD has not been identified. There may be a number of causes working synergistically. But it has been established that overwintering bee colonies are under stress, and one of those stresses is pesticides (Spivak et al. 2011; USHR 2008; Quarles 2008a). One observation that seems to implicate pesticides is that organic beekeepers do not seem to have CCD (Schacker 2008).

Photo courtesy of Kathy Keatley Garvey

A honey bee, *Apis mellifera*, is headed toward an almond blossom. Massive losses of these managed honey bees are occurring each year, and pesticide poisoning is part of the problem.

In This Issue

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Update

Helga Martin Williamson Olkowski
1931-2012
Co-Founder of the Bio-Integral Resource Center

Helga Olkowski passed away peacefully at home on April 27, 2012 from complications from a stroke. Helga was active in many environmental organizations, and she was co-founder of the Farallones Institute, the John Muir Institute, and others. Helga actively promoted organic agriculture, writing for *Organic Gardening* and other magazines. She was coauthor of several influential books, including *The City People's Book of Raising Food*, *The Integral Urban House* and *Common Sense Pest Control*. She was co-founder of the Bio-Integral Resource Center (BIRC) and worked for years as an editor for BIRC, writing articles for the *IPM Practitioner* and *Common Sense Pest Control Quarterly*.

Helga retired from BIRC in 1999, and spent many enjoyable years traveling with her husband, William Olkowski. She suffered a stroke about three years ago from which she never completely recovered. We will miss her.

A more complete biography can be found at her website www.who1615.com

Are Pesticides found in Bee Hives?

Bees can come into contact with pesticides when foraging or when the hive is treated with pesticides to kill mites. Foragers can collect contaminated pollen and nectar and bring it back to the hive. Some of the nectar and pollen is mixed together with enzymes to form bee bread. In the hive bees evaporate water from nectar to produce honey. Any pesticide in the nectar is concentrated at least 4x in the honey, which is stored for later use. So bees can be exposed both in the field and in the hive (Bonmatin et al. 2005; Kievits 2007).

Bee exposure to pesticides is widespread. Mullin et al. (2010) checked a large number of commercial bee hives for pesticides. Hives from 23 states including Florida, California, Pennsylvania and migratory bees from East Coast colonies were analyzed. Wax, pollen, and bees were highly contaminated with pesticides. There were 121 different pesticides and metabolites in 887 wax, bee, and pollen samples, averaging about 6 pesticides per sample.

This diverse contamination opens the question of synergism. Mixtures of pesticides are known to be more toxic to bees than individual products. Some fungicides, for instance, are known to increase the toxic effects of insecticides (Johansen 1977; Atkins 1992; USHR 2008; Pilling and Jepson 1993; Schmuck et al. 2003; Isawa et al. 2004).

The 350 pollen samples contained about 98 different pesticides and metabolites in concentrations up to 214 ppm. Each pollen sample averaged about 7 different pesticides, up to a maximum of 31.

Pollen was contaminated from miticides and fungicides applied in the hive, and insecticides, herbicides, and fungicides applied in the field. Pyrethroids were the most frequently detected insecticide, and were sometimes found at levels known to disorient foraging bees. Fungicides were the predominant pesticide type found in pollen (Mullin et al. 2010).

Contamination similar to this can lead to delayed development of bees and can shorten life span of adult workers. Premature death of foragers forces nurse bees to forage, with further consequences on colony health (Wu et al. 2011).

Neonicotinoids

Among the pesticides found in bee hives by Mullin et al. (2010) were neonicotinoids. These pesticides are analogs of the neurotoxin nicotine and have similar actions. Neonicotinoids include imidacloprid, clothianidin, thiamethoxam and others. They are applied as seed treatments to a number of crops, including corn, sunflower, cotton, and canola. Foliar sprays, soil drenches, and seed treatments are used. Both crop plants and ornamentals are treated (Elbert et al. 2008; Stokstad 2012; Hopwood et al. 2012).

Mullin et al. (2010) found bee pollen in hives contained imidacloprid at a median concentration of 20 ppb and a maximum concentration of 206 ppb. These levels are known to impact the health of bees. A total of 43 pollen samples (12%) out of 350 contained neonicotinoids or their metabolites. Mullin et al. were analyzing hives foraging on specialty crops such as citrus, apples and others that do not use seed treatments. Where bees forage on crops such as corn, canola, or sunflowers that use neonicotinoid seed treatments, 50% of pollen samples carried by honey bees can be contaminated with these pesticides (Krupke et al. 2012; Lu et al. 2012; Blacquiere et al. 2012).

There is no doubt that these potent new pesticides can kill bees if bees are exposed. Just 3.7 billionths of a gram of imidacloprid will likely kill a bee (oral LD50= 3.7 to 81 ng/bee). The oral LD50 of clothianidin is 2.8 to 3.7 ng/bee,

Photo courtesy of Kathy Keatley Garvey

Commercial hives can be heavily contaminated with pesticides.

and contact toxicity is 22-44 ng/bee. For comparison, the oral LD50 of cypermethrin is 160 ng/bee and for the organophosphate dimethoate 152 ng/bee (Colin et al. 2004; Schmuck et al. 2001; Suchail et al. 2001ab; Krupke et al. 2012).

As we see in Table 1, clothianidin, thiamethoxam, dinotefuran, and imidacloprid are extremely toxic to bees, acetamiprid and thiacloprid less so. We can also see that there can be a wide range of toxicity. Effects can vary depending on genetic variation in bees and other factors (Hopwood et al. 2012; Quarles 2008).

Complicating Factors in the Field

Neonicotinoids are causing concern due to widespread bee exposure, their potency to bees, and their persistence in the field (see Table 1). Sublethal doses can cause impaired learning and foraging. These effects have been measured at very low concentrations in the laboratory, but critics point out that there are mitigating effects in the field. Bees can collect pollen from untreated plants, and dilute pesticide effects. So experiments with neonicotinoids and bees often become a numbers game. If an effect is detected, the first criticism is that doses used were not representative of concentrations found in the field (Stokstad 2012; Hopwood et al. 2012).

It is true that dilution from untreated plants can occur in the field. Nguyen et al. (2009) found that imidacloprid treated corn fields in Belgium had no effect on mortality of honey bee hives found within 3 km (1.8 mi) of the fields. However, only 13.2% of the corn acreage within foraging range had been treated, and these treated fields represented a maximum 2.48% of the foraging area. So effects on bees from treated acreage can be diluted in the field by access to other food sources. But as more and more acreage is planted with systemics, then bees will have problems finding untreated plants (Hopwood et al. 2012).

Experiments have been conducted where hives are placed near treated fields and monitored for effects. Unfortunately, these colonies are often monitored over a relatively short period of time. Honey bee colonies have at least two generations a year. So it is not enough to measure the effects on one generation. Chronic sublethal doses in one generation can reduce the number

Table 1.
Toxicity of Neonicotinoids to the Honey Bee, *Apis mellifera**

Neonicotinoid	Oral LD50 (ng/bee)	Contact LD50 (ng/bee)	Soil Half Life (days)
Clothianidin	2.8-3.79	22-44	148-1,155
Imidacloprid	3.7-81	17.9-243	40-997
Thiamethoxam	5	24-29	25-100
Dinotefuran	7.6-23	24-61	138
Thiacloprid	8,510-17,300	14,600-38,830	1-27
Acetamiprid	8,850-14,520	7,100-8,091	1-8

*from Hopwood et al. 2012, Laurino et al. 2011. One nanogram (ng) is one-billionth of a gram.

Photo courtesy of Kathy Keatley Garvey

Honey bees can be killed by acute exposure to aerially dispersed seed coatings containing neonicotinoids. Chronic exposure can cause foragers to lose their way home.

of bees in the next generation (Lu et al. 2012).

Sublethal Doses in Hives

Krupke et al. (2012) found sick hives had pollen concentrations up to 10.7 ppb clothianidin or 20.4 ppb of thiamethoxam. Pollen is fed to larvae by nurse bees. A nurse bee will consume 65 mg of pollen in 10 days. If the pollen contains 20 ppb clothianidin, 65 mg will contain 1.3 ng, about 50% of the LD50 of 2.8 ng/bee. Sublethal doses of 1.3 ng are high enough to disorient foragers and cause field losses of bees (Henry et al. 2012).

Sublethal concentrations of neonicotinoids and other pesticides in brood comb can delay development of adult bees. Delayed development can make the bees more susceptible to mites. Pesticides in the brood comb also shorten life span of adult bees (Wu et al. 2011).

Bee colonies have even been killed by feeding them neonicotinoids at chronic sublethal concentrations of 20 ppb, which is close to what they could encounter in the field. Lethal effects were not seen for months (Lu et al. 2012).

Can Field Concentrations of Neonicotinoids Kill Bees?

Neonicotinoids can kill bees foraging in fields. Most of the 35.7 million ha (88.2 million acres) of corn in the U.S. are treated. Application rates are 0.25 to 1.25 mg/kernel, and the pesticide on one seed is enough to kill 80,000 bees. Fortunately, most of the pesticide is buried with the seed (Hopwood et al. 2012; Krupke et al. 2012).

But flying bees can be directly exposed to aerially dispersed seed coatings and talc from planting machines. Talc can contain 3,400 to 15,043 ppb clothianidin, which is many times the lethal dose for a bee. Exposures of this kind have led to honey bee deaths in the field. Mortality increases with humidity (Krupke et al. 2012; Marzaro et al. 2011; Tapparo et al. 2012; Girolami et al. 2012).

In May of 2008, about 50% of honey bees in the German state of Baden-Wurttemberg were killed. The problem was traced to the application of the systemic pesticides clothianidin and imidacloprid to seeds. According to the manufacturer, farmers applied these pesticides without using the adhesives recommended to keep the pesticides localized to seeds. Germany banned the use of these pesticides for seed treatment after this incident (ENS 2008; EPA 2008). Bee deaths during planting season have been seen in other European countries (Mazaro et al. 2011).

Even if adhesives have been properly applied, bees can still be killed by careless operation of planting machines. Krupke et al. (2012) investigated the cause of dead bees in apiaries in Indiana. They found that dead bees and pollen from their hives contained the neonicotinoids thiamethoxam and clothianidin. Some of the pollen samples had clothianidin levels higher than the LD50. Returning foragers from hives near fields had pollen concentrations up to 88 ppb of clothianidin.

Aerial seed waste also contaminates soil, surface water, and wild plants found near field margins. Some of these, such as dandelions, are attractive to bees. Concentrations of 6 ppb clothianidin were found in soil after treated seeds were planted. Dandelion plants near corn fields had residues of up to 9.4 ppb. The neonicotinoids are persistent, and some have soil half lives of more than a year. This means that material from one year can appear in the next year's planting. Soil contamination can also put soil nesting bees at risk (Hopwood et al. 2012).

According to the California EPA, where imidacloprid is being used, models suggest expected concentrations in surface water of 17 ppb, and 2 ppb is expected in groundwater. Residues on plants near a crop site can be 14-54 ppb (Fossen 2006).

Some of these problems can be mitigated by filtering air from planting machines to prevent dispersal of contaminated talc and seed coatings (Mazaro et al. 2011). Other researchers question the need for seed treatments in corn, citing effective IPM practices, and the problem of insect resistance with systemic pesticides (Maini et al. 2010).

Neonicotinoids in Guttation Drops

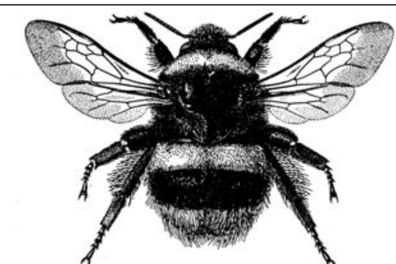
Bees can also be exposed through guttation water from plants. Corn excretes droplets of water along leaf margins called guttation drops. For about 3 weeks after emergence, droplets from treated corn contain large concentrations of neonicotinoids: 47 to 83 mg/liter imidacloprid, 23 mg/liter clothianidin, about 12 mg/liter for thiamethoxam (Girolami et al. 2009). Therefore, the levels in guttation fluid can be 254 times the LD50 for imidacloprid, 280 times the LD50 for clothianidin and 48 times the LD50 for thiamethoxam. Guttation droplets fed to bees in the laboratory will kill them (Thompson 2010). Lethal guttation drops can also be produced by melon crops with neonicotinoid soil treatments (Hoffman and Castle 2012).

Critics say that bee behavior must be taken into account. Droplets may appear in the morning before bees start foraging. Bees use water to cool their hives. Hives may not need cooling in the morning. Guttation water may not be a common source of water, since bees need large amounts of water and are fond of irrigation water and large sources (Hopwood et al. 2012; Girolami et al. 2009).

Neonicotinoids in Pollen and Nectar

Bees can also be exposed to contaminated nectar and pollen produced by treated plants. Though concentration in nectar and pollen may be low, chronic doses can accumulate because bee metabolism and elimination of neonicotinoids such as imidacloprid (IMD) are slow. Metabolism is complex and thiamethoxam is actually converted by metabolism into clothianidin (Hopwood et al. 2012; Krupke et al. 2012; Suchail et al. 2001ab).

Imidacloprid (IMD) is often applied as a seed treatment. Sunflower seed treatments can lead to concentrations of 13 ppb in sunflower pollen (Laurent and Rathahao 2003). Other experiments show 3.9 ppb in sunflower pollen, 8 ppb in flowers, and 1.9 ppb in nectar. Rape has 4.4 to 7.6 ppb in pollen. Corn can have average concentrations of 2.1 ppb in pollen and 6.6 ppb in flowers. Some corn plants show concentrations of 18 ppb in pollen (Fossen 2006; Bonmatin et al. 2005). Bees could ingest IMD in pollen, nectar, and water. They could be exposed by contact on flowers and leaves of treated plants (Blacquiere et al. 2012).



Soil contamination puts groundnesting bumble bees, *Bombus* spp., at risk.

From Nixon 1954

Treated plants metabolize IMD to toxic metabolites, and one of them is twice as toxic to bees as IMD. Chauzat et al. (2006) found IMD metabolites in 44% of pollen samples collected in France. Bayer researchers found that about 15% of IMD in sunflower pollen had metabolized (Sur and Stork 2003).

Neonicotinoids are also used as foliar sprays, as soil drenches, and for treating landscape ornamentals as well as crop plants. Amounts used on ornamentals lead to residues 12-16x greater than found on crop plants (Hopwood et al. 2012).

Cresswell (2011) combined a number of studies on imidacloprid into a meta-analysis and concluded that "trace dietary imidacloprid at field realistic levels in nectar will have no lethal effects, but will reduce expected performance in honey bees by between 6 and 20%."

Cresswell, however, included no studies on ornamentals and tossed out studies (Suchail et al. 2001ab) showing mortality from small chronic doses. Also excluded were studies showing lethal field levels of imidacloprid due to guttation droplets and airborne seed residues (Krupke et al. 2012; Girolami et al. 2009).

Can Field Concentrations of Pesticides Lead to Impaired Foraging?

Yang et al. (2008) found that concentrations of imidacloprid of 40-50 ppb in sugar water were enough to cause impaired foraging of honey bees in the field. Nectar concentrations from seed treatments are lower than this, but even if nectar concentrations are low, fairly large chronic doses can be delivered. A bee ingests 20-30 µl of nectar each time, and the half life of IMD is about 4.5 hrs, making chronic accumulation possible. Imidacloprid is also metabolized by bees into toxic metabolites that can also accumulate (Suchail et al. 2003; 2004).

Although nectar from seed treatments do not regularly reach 40-50 ppb in the field, these concentrations occur with some other crops. Thiamethoxam soil drenches to pumpkins at label rates with half applied to transplants and half applied during flowering led to nectar concentrations of 54.8-90.4 ppb (Hopwood et al. 2012). Bees exposed to this concentration could receive the doses used by Yang et al. (2008).

Cresswell (2011) estimates that a honeybee ingests an average nectar load of 40 mg. If nectar contained 50 ppb (ng/gram), then 2.0 ng of toxin would be ingested with each load. Faucon et al. (2005) estimate that foraging bees have an 11.5 mg/hour nutrient need from pollen and nectar. If the pollen or nectar contained 50 ppb, about 1.8 ng of toxin would be accumulated in 3 hours.

Neonicotinoids are known to impair bee foraging efficiency in the laboratory. An experimental challenge is measuring these effects in a field situation. One way is to identify treated bees with a microchip. Henry et al. (2012) equipped 653 honey bees with a 3 mg microchip. An individual adult bee weighs 80-100 mg, so this roughly represents a weight handicap of about 3%. Bees were treated with a sublethal dose of 1.34 ng of thiamethoxam, which is about 27% of the LD50 of 5 ng/bee. It was administered in a sugar solution containing thiamethoxam (1.34 ng in 20 µl).

Losses Higher in Unfamiliar Terrain

Henry et al. (2012) released treated bees, along with equal numbers of untreated bees up to 1 km (0.6 mi) away from the hive. Hives were equipped with microchip (RFID) monitoring equipment. Some of the treated foragers were released in a familiar field of *Phacelia*, others were released in unfamiliar surroundings. About 10% of treated bees released in familiar surroundings failed to make it back to the hive. About 32% of treated bees released in unfamiliar surroundings failed to return. Most commercial honey bee hives are trucked from place to place and released in an unfamiliar environment, maximizing pesticide effects on foraging.

Foraging of bumble bees, *Bombus* spp., can be impaired by neonicotinoids.

Photo courtesy of Gary McDonald

Schneider et al. (2012) found similar results with microchip experiments. When bees were treated with 1 ng of orally ingested clothianidin, about 26% did not return to hive. With 2 ng, 79% did not return. Impairment was noticed at 1.5 ng imidacloprid or 0.5 ng clothianidin.

Calculations by Henry et al. (2012) showed that if 90% of a colony was exposed to nectar of a treated oilseed crop each day, and these levels of foraging mortality occurred, "populations would follow a marked decline during the blooming period, and would hardly recover afterwards."

Releasing treated bees in a familiar area only 70 meters (230 ft) from the hive still led to excess forager mortality—about 6% of them did not return. Field impact studies often put hives immediately adjacent to treated fields to assess effects. This study shows that this method would tend to underestimate pesticide induced foraging impairment (Henry et al. 2012).

Bumble Bees also Affected

Although the latest research does not definitely establish a unique link between neonicotinoids and colony collapse disorder, it does show that neonicotinoids can have detrimental effects on bees at realistic field concentrations. Bumble bees, native bees, and honey bees are all at risk (Hopwood et al. 2012; Quarles 2008b). Several studies have shown that field concentrations in pollen and nectar from seed treatments on average are in the range 0.7-10 ppb. Concentrations as high as 88 ppb have been found in corn pollen (Krupke et al. 2012).

Sublethal doses of IMD have been shown to affect bumble bee foraging. After 9 days of foraging in sunflowers treated with IMD, about 10% more bumble bees were lost in the field compared to bumble bee foragers in untreated fields (Taséi et al. 2001).

Whitehorn et al. (2012) fed 25 bumble bee colonies in the laboratory for 14 days on pollen containing 6 ppb imidacloprid and sugar water containing 0.7 ppb. Exposures of this sort would be obtained if bees foraged mostly on treated fields, and rarely sought alternate food sources. Another 25 colonies received food containing twice this concentration and another 25 were fed untreated food. Colonies were then left to forage in the field for six weeks.

After six weeks, treated colonies weighed 8-12% less than untreated controls. This amount represents a combined drop in weight of food stores, wax, immature and adult bees. The weight drop was likely due to pesticide induced impairment of food gathering efficiency.

Treated colonies also had on average about 85% fewer queens (13.72 vs 1.7), probably because bumble bee queen production is dependent on colony size. According to Whitehorn et al. "our results suggest that trace levels of neonicotinoid pesticides can have strong negative consequence for queen production by bumble bee colonies under realistic field conditions, and this is likely to have a substantial population level impact."

Summer Bees, Winter Bees

There are two kinds of adult honey bees—summer bees that have a relatively short lifetime (40 days), and adult winter bees that live for 6 months or more. Summer bees gather food and feed the larvae that will develop into adult winter bees. Winter bees emerge September through November, and are responsible for colony overwintering, sometimes in very cold situations (see Quarles 2008a).

Most of the massive bee kills in the U.S. are occurring during overwintering. Large numbers of foragers collect nectar and pollen during the summer. Foraging kills a lot of them, and colony numbers drop in the fall. A smaller colony overwinters, then queens start laying eggs in late December, and the colony starts to expand in January (Winston 1987; Langstroth 1923; Morse 1975).

Adult winter bees are old bees, and are physiologically different from summer bees. Because of their relatively long lifetime, winter bees have had more time to be exposed to pesticides and pathogens. Winter bees are often more susceptible to pesticides. This may be because they have greater fat deposits, allowing pesticides to accumulate. For instance, winter bees are 4x

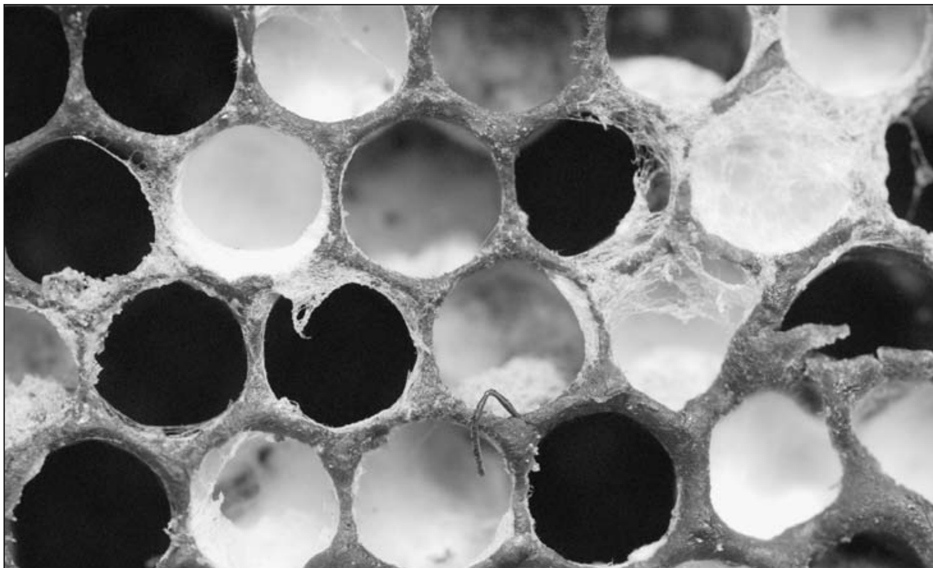


Photo courtesy of Kathy Keatley Garvey

Closeup of a hive killed by Colony Collapse Disorder. Note that brood is present, but all adult bees have disappeared.

more sensitive to the chronic lethal effects of imidacloprid than are summer bees. Cold temperatures also make pesticides more toxic to bees (Decourtye et al. 2003; Johansen 1975; Belzunces et al. 2001b).

Summer Bees Poisoned, Winter Bees Die

Most of the bee toxicity experiments are done either on individual bees or on hives monitored for a limited amount of time. Lu et al. (2012) chronically dosed summer bees with imidacloprid, then stopped. Mortality was delayed for several months. Bees were fed imidacloprid in high fructose corn syrup for about three months (13 weeks), starting July 1. Very low concentrations were used for one month, then amounts likely to cause damage were fed for two months. High fructose corn syrup containing 20, 40, 200, and 400 ppb imidacloprid were fed to the bees. Treatment was applied from July 1 to September 30.

After treatment, bees were allowed unhindered foraging until mid December, when overwintering colonies were given supplemental food. All colonies were still alive 12 weeks after the last dose was given (December 22), but hives receiving the largest dose were showing some toxic effects. However, 23 weeks (March 10, 2011) after the last dose of imidacloprid, 15 of 16 of the treated hives were dead.

Dead hives had no bees, but still had food. Summer bees were fed imidacloprid, and the winter bees died. This kind of delayed mortality mimics some of the manifestations of Colony Collapse Disorder. The lowest feeding dose was 20 ppb. Earlier experiments had shown no effect on overwintering bees when summer bees were fed 5 ppb of imidacloprid in sugar syrup. There were four untreated control hives, and three of four survived (Faucon et al. 2005; Lu et al. 2012).

Since this experiment mimics some of the manifestations of Colony Collapse Disorder, Lu et al. (2012) hypothesize that bee keepers may have produced CCD by feeding overwintering bees with corn syrup laced with imidacloprid. Imidacloprid is used extensively on corn, and relatively high tolerances (50 ppm) are permitted. However, the researchers provide no evidence that high fructose corn syrup is contaminated with IMD. Further research is needed to confirm these results and to check field samples of corn syrup for pesticide contamination.

Conclusion

Honey bees receive widespread exposure to pesticides. Large numbers of different pesticides accumulate in stored pollen and in wax combs. Large numbers increase the likelihood of synergism. Sublethal concentrations known to affect bee health and behavior have been found in many bee hives.

Pesticide exposure is a likely contributing factor to colony collapse disorder. Pesticides can depress the bees' immune system, interfere with normal brood development, and lead to poor nutrition through impaired foraging. Sublethal doses can shorten lifespan, and make bees more susceptible to mites and pathogens. Effects can be subtle, as bees poisoned in one generation may not show effects until the next generation appears.

Though bees are being impacted by a large number of pesticides, neonicotinoids are receiving increased attention. Widespread use of seed treatments, foliar sprays, and soil drenches are exposing bees to these potent pesticides over a large area. Careless use of planting machines is contaminating water, soil, and wild plants near treated fields, and exposing bees to lethal airborne seed waste and talc.

William Quarles, Ph.D., is an IPM Specialist, Executive Director of the Bio-Integral Resource Center (BIRC), and Managing Editor of the IPM Practitioner. He can be reached by email, birc@igc.org.

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Chickens are Back in the Backyard

By William Quarles

There has been a significant resurgence of urban farming in the U.S. A number of books have been written on the subject, and it is becoming a favorite topic of newspaper journalists. Urban farmers produce fresh food free of pesticide residues and pathogens that sometimes occur with industrial food production. Backyard food gardeners have learned that raising their own vegetables can be fun, and can provide a way to interact and share with neighbors.

Photo by Helga Olkowski

Backyard chickens reestablish the bond with nature that was broken with factory farming.

Backyard Chickens

Animals have always been an integral part of organic farming operations. And urban gardeners are now taking the next step by raising chickens. There are a number of good reasons to raise backyard chickens. Chickens in your yard represent a small but significant step away from factory farming. You can control what your chickens eat, producing eggs that are more nutricious than store-bought eggs. The eggs you harvest are fresher, you can eat them the same day they are laid. Backyard chickens help reestablish the bond with nature that was broken with industrial food production.

Backyard chickens can be pets and can be nurtured just like a dog or a cat. Your children will not have to go to a petting zoo. Chicken manure can be composted to produce a rich nutritional input for garden soil. Once gardeners get the idea, they do not have to be egged on, very little money has to be shelled out, and they very rarely have to endure a bad yoke.

Getting Started

Where do you get your startup chickens? You can buy them at feedstores or you can order them from hatcheries (see Resources). Hatcheries sometimes have minimum orders, so you might have to form a coalition and divide up the order.

There are a few possible drawbacks. Although they can be mostly troublefree, raising chickens requires some effort. You have to like eggs, as each hen tends to produce one egg a day. And there are some upfront costs in building a chicken coop and the chicken run. There are some ongoing costs with purchase of organic chicken feed. You must also protect your birds from predators, including the family dog.

Chickens? In Berkeley?

Backyard chickens are legal now in many cities. Municipal ordinances usually require that chickens be enclosed in a coop, and that the coop be maintained in sanitary conditions. Some cities specify a minimum distance from neighbors. Others ban roosters due to the noise, yet others limit the number of chickens that can be maintained. Sometimes, chicken enthusiasts start their projects before they are protected by an ordinance. This option is outlined in the movie, *Mad City Chickens* (see Resources).

Protection

The chicken coop must be constructed to exclude raccoons and predators. Wooden frame construction with chicken wire is sufficient. Foundations should be constructed so that critters cannot dig their way into your flock (see Resources). Most backyard fowl are healthy because they are not raised in crowded conditions that depress their immune system. Urban veterinarians are now adapting to the new reality, and can provide needed vaccinations.

Endgame

Before you start something involving living beings, it is a good idea to have an exit strategy. What if you decide that chickens are not for you? What if you have to move? Fortunately, with the upsurge in backyard operations, many people are raising chickens. As chickens get older and die, they have to be replaced. Typical lifespan is 5-10 years. Hens lay for about 3-5 years. Networking with chicken owners can keep you in touch with humane ways of dechickening yourself.

Resources

A Chicken in Every Yard. 2011. Robert and Hannah Litt, Ten Speed Press, 208 pp.
Art of the Chicken Coop. 2011. Chris Gleason, Fox Chapel Publishing, 161 pp.
Chickens in your Backyard. 1976. Rick and Gail Luttman, Rodale Press, 157 pp.
Mad City Chickens. 2008. Tarazod Films, films.contact@tarazod.com
Murray McMurray Hatchery, Webster City, IA 50595; 515-832-3280; www.mcmurray-hatchery.com
Storey's Guide to Raising Chickens, 3rd ed. 2010. Gail Demerow, Storey Publishing, 448 pp.

Conference Notes

ESA 2011 Annual Meeting Highlights

By Joel Grossman

These Conference Highlights are from the Nov. 13-16, 2011, Entomological Society of America (ESA) annual meeting in Reno, Nevada. ESA's next annual meeting is November 11-14, 2012, in Knoxville, Tennessee. For more information contact the ESA (10001 Derekwood Lane, Suite 100, Lanham, MD 20706; 301/731-4535;http://www.entsoc.org

Attractants formulated into baits can aid in surveillance and management of ticks and other blood-sucking arthropods. "Tick surveillance provides information about population densities, geographic spread, and risk of pathogen transmission," said Ann Carr (North Carolina State Univ, W.M. Keck Center, Raleigh, NC 27695; alcarr2@ncsu.edu). Carr et al. tested responses of the lone star tick, *Amblyomma americanum*, and the American dog tick, *Dermacentor variabilis,* to six semiochemicals attractive to other blood-sucking arthropod species. Possible attractants tested in the laboratory were carbon dioxide, L-lactic acid, acetone, carboxylic acids, nitrogenous wastes, sulphides and 1-octen-3-ol.

"Carbon dioxide, 1-octen-3-ol, acetone and ammonium hydroxide were attractive to *A. americanum,* but only carbon dioxide was attractive to *D. variabilis*," said Carr. Carbon dioxide (dry ice) consistently attracted the highest number of host-seeking *A. americanum* nymphs and adults. However, for the first time, acetone and ammonium hydroxide were shown to attract high numbers of *A. americanum* ticks. Acetone and carbon dioxide attracted similar numbers of ticks.

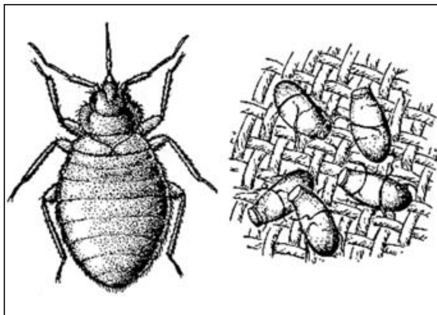
Designing Bed Bug Detection Devices

"Bed bugs, *Cimex lectularius*, are temporary ectoparasites that feed on the blood of warm-blooded animals, including humans, poultry, rabbits, and rodents," said Philip Koehler (Univ of Florida, 970 Natural Area Dr, Gainesville, FL 32611; pgk@ifas.ufl.edu). They are usually found in aggregations, hiding in cracks and crevices. To obtain a blood meal, bed bugs emerge from their harborages, orient to the host, crawl next to skin, insert their mouthparts, and take 3-12 minutes for full blood engorgement. (See *Don't let the bed bugs bite*, *IPMP* 32(3/4):1-7)

"After engorgement, bed bugs leave the vicinity of the host, and return to their harborages," said Koehler. Their cryptic behavior along with long periods of hiding in refuges between blood meals makes them difficult to detect.

At different stages in the feeding cycle, bed bugs are either attracted by host cues or harborage and aggregation cues. The design of detection devices must avoid giving the bed bugs conflicting cues. Conflicting signals may deter bed bugs from entering detectors.

"Carbon dioxide has been shown by several researchers to be the most effective attractant for bed bugs," said Koehler. Though stationary sources may be best, CO_2 flushes from CO_2 cartridges produce an immediate response, flushing bed bugs from their harborages. For example, a CO_2 flush gets bed bugs running from harborages to the top of a bed.



Bed bug, *Cimex lectularius*, and eggs

Bed bugs follow CO_2 gradients to find live hosts. Humans produce about 700 mg (0.02 oz) of CO_2 per minute. "Thus, detectors with very slow CO_2 releases cannot compete with human hosts," said Koehler. A rapid release is a better mimic to human breathing pattern. Detectors with fast release capture about 4x more bed bugs than detectors with slow release.

A commercial product, the Verifi™ trap, is a dual-action detector, combining fast CO_2 generation with liquid kairomone and pheromone lures. The CO_2 and liquid kairomone lures attract host seeking bed bugs to the pitfall trap, and the liquid pheromone lure encourages aggregation seeking bed bugs to settle in the harborage in the back of the detector. The signals are separated, so bed bugs are not confused.

Early Detection of Bed Bugs

"Early detection of bed bugs is critical in order to quickly and effectively eliminate these pests," said Susan Jones (Ohio State Univ, 2501 W. Carmack Rd, Columbus, OH 43210; jones.1800@osu.edu).

"An inexpensive detector that can be left in place and routinely serviced is needed to aid pest management professionals in effective IPM of bed bugs," said Jones. "Rutger's do-it-yourself dry ice traps are a cheap and effective method for overnight surveys of potentially infested habitations." (See *Bed bug pheromones and traps IPMP* 31(5/6):1-8)

"Launched by FMC in October 2011, the Verifi™ bed bug detector provides a multiple attractor mechanism combining carbon dioxide and pheromone plus kairomone lures to bring bed bugs into an easily accessible receptacle that can be quickly monitored for activity," said Jones. A field trial in a 13-story high-rise apartment building in Columbus, Ohio compared: 20 rooms with 3 Verifi™ bed bug detectors per room; 20 rooms with one dry ice trap per room; and 20 rooms with canine detection teams.

During the study, 17 of 20 rooms had dry ice trap or Verifi™ confirmation of a bed bug infestation. The Verifi™ detector found bed bugs in 11 of the 17 infested rooms in the first 24 hours; and in 14 of 17 infested rooms within 7 days. The dry ice traps also detected 14 of 17 infested rooms. The canine teams reported infestations in 19 of the rooms; each dog alerted for bed bugs in 3 rooms where neither visual inspections, dry ice traps, nor Verifi™ detected bed bugs. Each dog also missed one room rated positive for bed bugs. In the rooms that were bed bug positive, one dog was rated 94% accurate (16/17) and the other dog was rated 82% (14/17).

Inverted Dog Bowl Bed Bug Pitfall Trap

Affordable, accurate traps are needed for monitoring and detection of low levels of bed bugs, as human labor for visual inspections is costly, said Narinderpal Singh (Rutgers Univ, 93 Lipman Dr, New Brunswick, NJ 08901; nsingh@aesop.rutgers.edu). [*Ed. Note: Some inexpensive traps such as Climbup® are already commercially available*.]

An inverted dog bowl painted black on the outside makes a good inexpensive pitfall trap, and can be combined with attractants or lures. The inverted dog bowl pitfall trap was tested in laboratory arena tests. Attractants tested were carbon dioxide, heat, and chemical lures. Carbon dioxide attracted at all concentrations tested; and was more important than heat as an attractant.

Materials tested as bed bug lures included nonanol, octanol, 1-octen-3-ol, coriander, and spearmint. In general, lures with a mixture of chemical components

Photo courtesy Susan McKnight

The Climbup™ bed bug trap

worked better than lures with one component. A combination of CO_2, heat, and a lure was similar in effectiveness to CO_2 plus a lure. Carbon dioxide and lures had an additive effect.

Carbon Dioxide Fumigation for Bed Bugs

Carbon dioxide is used by libraries, museums, and others as an insect-killing fumigant, said Changlu Wang (Rutgers Univ, Blake Hall Rm 215, New Brunswick, NJ 08901; cwang@AESOP.rutgers.edu). It can also be an attractant and alter insect behavior. One fumigation methodology is CO_2 release from dry ice. Variables governing efficacy include the concentration, ambient temperature, and insect developmental stage sensitivity.

In lab experiments, 10 nymphs, 10 adult males, and bed bug eggs were placed in petri dishes at 25°C (77°F) in incubators with 20% and 30% CO_2 for 24 hours. Both 20% and 30% concentrations reduced bed bug egg hatch; but statistical significance was not seen until 30%, which was deemed the minimum concentration for bed bug fumigations to kill the tough egg stage.

A second set of experiments utilized 100% CO_2 for 2-24 hours at 20°C (68°F), 25°C (77°F), and 30°C (86°F). Placing dry ice in the bottom of a flask allowed the evaporating carbon dioxide to push out the air; and the flask at 100% concentration was sealed with a stopper as ambient temperature was reached. Bed bug mortality at 100% CO_2 was faster at higher temperatures, at 30°C (86°F) all bed bug eggs were killed in 3 hours, though it took 8 hours to kill the nymphs and adults.

A practical fumigation test involved filling plastic garbage bags 90% full with mattress covers and fabrics, leaving little room for air; and then sealing the bags with dry ice inside. Bed bugs in petri dishes were placed at the top, bottom, and

EcoWise News

EcoWise is now in the midst of renewing the IPM Service Provider certification of our first companies. Hearts Pest Management, an innovative company from San Diego owned and operated by Gerry Weitz, was the first to renew. His EcoWise service accounts have increased by 30% since the beginning of the year. We are also pleased to announce the renewal of Pestec IPM Providers of San Francisco, and Applied Pest Management of Vallejo. These companies were doing good work before they were certified, and we are happy that we can provide a framework to recognize their achievements.

The EcoWise Certified Online Course at www.birc.org continues to train and certify Pest Management Professionals (PMPs) in IPM methods. PMPs recently certified online include Jeff Baerwald, John Chi, David Cole, Scott Conner, Greg Dorman, Nick Fowler, Gregory Fox, Keenan Gibson, Dave Howard, Scott McDonough, Richard Mercado, Shaun Miller, Arym Nicado, Justin Quiroz, William Seniff, David Shouger, Joseph Spencer, and Ryan Wheeler.

Companies wanting to start an EcoWise Certified service should contact BIRC, PO Box 7414, Berkeley, CA 94707 or call us at 510-524-2567 or email us at birc@igc.org_. Part C of the EcoWise Certified Online Course at our website www.birc.org also has information on company certification.

Calendar

February 23-25, 2012. 23rd Annual Moses Organic Farm Conference. La Crosse, WI. Contact: Moses, PO Box 339, Spring Valley, WI 54767; 715/778-5775; www.mosesorganic.org

March 4-6, 2012. California Small Farm Conference. Valencia, CA. Contact: www.californiafarmconference.com

March 27-29, 2012. 7th Intl. IPM Symposium. Memphis, TN. Contact: E. Wolff, Univ. IL, Urbana. 217/233-2880; email ipmsymposium@ad.uiuc.edu

March 30-31, 2012. Beyond Pesticides 30th Anniversary Meeting. Yale, New Haven, CT. Contact: Beyond Pesticides, 701 E Street, SE, Washington, DC 20003; 202-543-5450; www.beyondpesticides.org

June 21-23, 2012. 69th Annual Convention, Pest Control Operators of CA. Catamaran Resort, San Diego, CA. Contact: www.pcoc.org

July 5, 2012. Intl. Symp. Nematodes Environmental Indicators. Ghent, Belgium. Contact: russell@aab.org.uk

August 4-8, 2012. Annual Conference American Phytopathological Society (APS). Providence, RI. Contact: www.apsnet.org

August 5-10, 2012. 97th Annual Conference Ecological Society of America. Portland, OR. Contact: www.esa.org

October 17-20, 2012. Pestworld, Annual Meeting National Pest Management Association (NPMA), Boston, MA. Contact: NPMA, 10460 North St., Fairfax, VA 22031; 800/678-6722; 703/352-6762www.npmapestworld.org

November 4-10, 2012. Biocontrol of Bacterial Plant Diseases. Agadir, Morocco. Contact: www.lavcha.ac.ma/biocontrol2012

November 11-14, 2012. ESA Annual Meeting Knoxville, TN. Contact: ESA, 10001 Derekwood Lane, Suite 100, Lanham, MD 20706; 301/731-4535; http://www.entsoc.org

February 4-7, 2013. Annual Meeting Weed Science Society of America. Baltimore, MD. Contact: www.wssa.net

February 21-23, 2013. 24th Annual Moses Organic Farm Conference. La Crosse, WI. Contact: Moses, PO Box 339, Spring Valley, WI 54767; 715/778-5775; www.mosesorganic.org

November 17-20, 2013. Annual ESA Meeting. Austin, TX. Contact: ESA, 10001 Derekwood Lane, Suite 100, Lanham, MD 20706; 301/731-4535; http://www.entsoc.org

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center of the sealed bags. Dry ice at 2-3 lbs (0.9-1.4 kg) per garbage bag provided 100% bed bug mortality in 24 hours.

Dry ice fumigation is cheaper than washing and drying fabrics; and can be used with or without heat, depending on the materials being fumigated. Carbon dioxide alone might be useful for books, electronics, toys, and other items where heat might cause damage. However, temperatures can drop quickly as the dry ice sublimates; so several hours in sealed bags (100% CO_2) is recommended rather than very quick fumigations. Wang recommends turning on fans for ventilation when opening many bags filled with CO_2 fumigant. It is also advisable to wear gloves when handling material for fumigations.

Diatomaceous Earth Bed Bug Alternative

A combination of a chemical treatment and two non-chemical alternatives such as freezing or steam can cost $500 per apartment, and require three treatments for bed bug control, said Molly Stedfast (Virginia Tech, Old Glade Rd, Blacksburg, VA 24061; msted14@vt.edu). It can cost $1,200 per apartment to treat for bed bugs without having any chemical residues, which is beyond the means of low-income people who cannot afford even one $500 treatment. Language and literacy barriers make bed bug treatments an even harder sell. Instead residents resort to dangerous and often ineffective home remedies for bed bugs such as bleach, rubbing alcohol, boric acid dust, and total release aerosols.

Diatomaceous earth (DE), a silica product mined from fossilized diatom deposits and pulverized into a fine powder for animal feed, filtering, and other uses, is relatively safe and easy to apply compared to many of the home remedies being used. DE is porous, absorbing water; and is also abrasive and a desiccant. Food grade DE is made from freshwater diatoms, and is considered nontoxic. Filtering grade DE (used for swimming pool filters) is a crystalline form with inhalation toxicity. (See *Diatomaceous earth alternative to stored product fumigants IPMP* 28(1/2):1-10)

Food grade DE, which is labeled for pest control, costs about $8 for 8 oz (227 grams), which can treat 500 ft² (46 m²). Thus, a 1,000 ft² (93 m²) apartment can be treated with DE for $32. In lab tests, Safer® and Harris® DEs provided 100% bed bug mortality in 5-6 days. MotherEarth® D Pest Control Dust and PermaGuard provided faster bed bug control.

MotherEarth® D Pest Control Dust was tested further to develop an application protocol for beds, box springs, under carpets, and room perimeters where bed bugs crawl and can contact the DE. On contact, DE becomes embedded in the bed bug cuticle and causes death. A scanning electron microscope confirmed that DE becomes embedded in and abrades the insect cuticle. The idea is to use food grade DE on places such as mattress covers as part of an IPM program that includes monitoring and other control methods.

Steam Heating Bed Bugs & Dust Mites

The Jiffy Steamer J-4000, which sells for about $200 and gives digital temperature readings, showed good potential against bed bugs, *Cimex lectularius*, and house dust mites, *Dermataphagoides farinae*, said Roger Gold (Texas A&M Univ, 2475 TAMU, College Station, TX 77843; r-gold@tamu.edu). The J-4000's 74°C (165°F) heat provided 89% bed bug mortality, with a few bed bugs escaping the 15 cm (6 inch) metal steam head. The treatment did not leave any stains or cause bacterial or fungal growth.

Similar good results were reported against house dust mites inoculated into a mattress; a Traceable™ infrared thermometer provided temperature readings. Steam head contact caused 100% dust mite mortality within 10 seconds; and there were no problems with stains, molds or fungi. It would take an

Conference Notes

hour or more to disinfest a king-size mattress with a small steamer. However, steamers could be adapted from other commercial uses; though the economics and treatment speeds need to be worked out.

Liquid Nitrogen Spray Freezes Italian Bed Bugs

Besides conventional chemicals, Italy uses liquid nitrogen sprays to freeze pests, the Criopest™ method developed by Ecotrade (Via Salaria, 1428D - 00138 Roma, Italy; www.ecotrade-disinfestazioni.it). Liquid nitrogen sprays for bed bugs works well where textiles are treated with heat (dry air) and pyrethrin gels are also used. Pyrethrin gels in bags take 210 minutes for 100% bed bug mortality. Conventional chemicals are used where residues are wanted, in locations such as electric sockets where bed bugs might hide; but chemicals are only 75% effective (in 5 days) against bed bugs and cockroaches. Hence, the need for an IPM approach. (See *Bed bugs bounce back IPMP* 29(3/4):1-8)

Ecotrade's Criopest method sprays liquid nitrogen at -196°C (-320°F) to freeze bed bugs and other pests. Liquid nitrogen has percolation effects, penetrating pillows and carpets to kill bed bugs. The method is ecologically sound because 78% of the atmosphere is nitrogen. The cost is $1.26 euros per liter (0.94 qt). Hotels like the system, because they can rent the room again immediately. Room treatments cost $400-600 euros, and are also guaranteed 100%; 1-2 treatments, much less than conventional approaches, works well; and 80% of clients choose the liquid nitrogen option.

Beauveria bassiana Beats Bed Bugs

"Over the past decade, bed bug infestations have grown almost exponentially in North America and Europe," said Alexis Barbarin (Pennsylvania State Univ, 525 ASI Bldg, University Park, PA 16802; amb1113@psu.edu). "Current bed bug control measures rely heavily on the use of pyrethroid insecticides," but "the threat of resistance is stimulating the search for alternative methods. "

"*Beauveria bassiana* shows great potential for development as a microbial control agent for bed bugs, exhibiting a very fast (4 day) speed of kill," and "spray residue can remain potent for up to 3 months," said Barbarin. "Conidia are acquired via brief contact with sprayed surfaces. Additionally, *B. bassiana* is equally effective on both fed and unfed bed bugs, male and female bed bugs, and first instar and adult bed bugs."

Aged Versus Fresh Termite Baits

Aged versus fresh baits, and effects of irrigation versus non-irrigation on baits, are factors to consider with subterranean termite baiting systems such as Sentricon®, said Ronda Hamm (Dow AgroSci, 9330 Zionsville Rd, Indianapolis, IN 46268; rlhamm@dow.com). The Sentricon system, which dates to 1990, was most recently optimized with Recruit™ HD termite bait. The system is noted for its durability and a high density bait matrix that termites readily consume. (see *Baits or barriers? Field efficacy of IPM termite treatments IPMP* 32(9/10):1-9)

A 4-year field study (2007-2011) looked at the baits under conditions of irrigation and natural rainfall. Laboratory bioassays compared fresh versus aged field baits.

The trend was a subterranean termite preference for aged baits over fresh baits. However, termite population variability was noted "here and there." Overall, termites preferred the bait over real world food choices. Over the course of 5 years, even brown rot and white rot fungal bait degradation did not stop termite bait consumption or reduce bait acceptance or efficacy.

In the field, subterranean termites feed on bait fed on by other species or other termite colonies, said Joe Eger (Dow AgroSci, 2606 S. Dundee St, Tampa, FL 33629; jeeger@dow.com). In lab trials with

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Recruit HD bait, previous bait consumption by other termites did not affect palatability. In field trials in Delaware, Florida, and Louisiana, termite bait consumption was higher on baits previously fed upon by other termites; and a preference for aged over fresh bait was also noted.

These lab and field studies were further validated in field testing at the African American Museum in New Orleans: Bait fed on by other species or other termite colonies did not deter new subterranean termite feeding. Cracks, which are good termite entry sites, may be a factor distinguishing aged baits from uncracked fresh baits, said Eger.

New Orleans Areawide Termite IPM

Very high densities of Formosan subterranean termite (FST), *Coptotermes formosanus*, have caused about $300 million in damage in New Orleans and $500 million in damage in Louisiana, prompting a multi-agency areawide IPM program. The program started in 1998 in New Orleans and is still ongoing, albeit with fewer private participants since outside funding was cut in early 2011, said Dennis Ring (Louisiana State Univ, 404 Life Sci Bldg, Baton Rouge, LA 70803; dring@agctr.lsu.edu). “Structures have collapsed and others have been demolished because of damage caused by this termite. The centers of live trees are eaten by the FST, and trees serve as reservoirs of termites.”

“Initially, commercially available baits or termiticides were used to treat properties in a contiguous 15 block area (Area I) in the French Quarter,” said Ring. “Densities of alates (winged termites) were sampled using glue boards hung on street lamp poles near lights,” said Ring. “Alates were sampled once a week in April and 2-3 times weekly during the flight season (May through July 15) in 1998 through 2011. Alate numbers were reduced by 50-75% following treatment, and the lowest numbers of alates were captured in 2011. Funding for the program ended in early 2011. Some property owners are choosing not to renew their termite contracts. Therefore, some treatments are being discontinued.” Alate trapping numbers, a measure of treatment success (fewer flying FST indicate lower FST populations overall in the area), are expected to increase in coming years with lower program participation.

Borate Fire Ant Baits

Niban™ Granular Baits have the advantage of being among the most resistant to water, weather, and molds, said Janet Kintz-Early (Nisus Corp, 100 Nisus Dr, Rockford, TN 37853; janete@nisuscorp.com). Granular bait formulations were compared with and without active ingredients (including borates) and with different attractants in an effort to overcome borate repellency.

Granular bait field tests in Georgia and Texas to gather data for EPA submission were conducted for 90 days on 1/4-acre (0.1 ha) plots with 10 red imported fire ant, *Solenopsis invicta*, mounds per plot. Treatments included: AMDRO (hydramethylnon and methoprene); Niban A (5% boric acid); Niban B (methoprene); and untreated control.

AMDRO peaked at week 13 with 81% control. Niban A boric acid bait provided 39% control at week 8 when rain washed off the borates (which have a little fertilizer value for the soil). Niban B methoprene bait provided 74.4% control at 13 weeks.

Argentine Ant Trail Pheromone Disruption

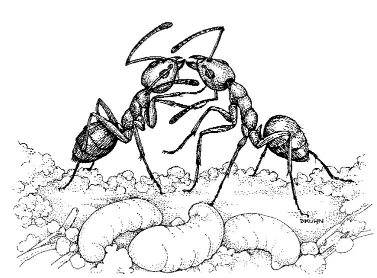
Argentine ant, *Linepithema humile*, trail pheromone, (Z)-9-hexadecenal, is a commercial chemical that is also a moth pheromone, which means it is readily available for IPM programs, said Max Suckling (New Zealand Instit of Plant and Food Res Ltd, PB 4704, Christchurch, New Zealand; Max.Suckling@plantandfood.co.nz). Argentine ant trail pheromone disruption work began in Hawaii’s ecologically-sensitive Volcano National Park, spurred in part by Tatsuki et al.’s (2005) demonstration that Argentine ant trails in orchards could be partially disrupted by release of (Z)-9-hexadecenal from polyethylene tubing dispensers.

At Japan’s Port of Yokohama, an IPM approach combining pesticides and Shinetsu twist-ties to disrupt ant trails is said to be successful; though the mechanism is unknown. Another strategy is using trail pheromone to paint a trail leading somewhere else; for example, an artificial trail leading off the main trail towards baits. These potential IPM strategies using trail pheromones need more testing.

Bullet Ant, World’s Most Painful Sting

The world’s most painful stinging insect, *Paraponera clavata*, the bullet ant, gets its common name because its sting feels like a bullet ripping through you, said Justin Schmidt (Southwestern Biological Instit, Tucson, AZ 85720; jschmidt@ag.arizona.edu). On a 1-4 pain scale, bullet ants rate a 4 because of the 12-24 hours of intense pain from stings. Harvester ant stings rate a 3, as they can hurt for 4-8 hours. A honey bee sting rates a 2. One fire ant sting rates a 1.

One of the world’s largest ants at 18-24 mm (0.7-0.9 in), the bullet ant lives in colonies of about 3,000 and is native to the tropical Atlantic coast of the Americas from Nicaragua to the Amazon basin. Bullet ants are predators and nectar feeders in the rainforest canopy. Mass spectroscopy of bullet ant venom indicates two peptide peaks very similar chemically to poneratoxin.



Argentine ant, *L. humile*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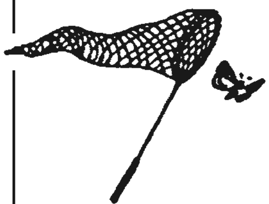

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