Wax Moth IPM

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There are many options available to beekeepers to practice integrated management of wax moths which are troublesome pests, especially in the southern US when conditions are favorable for their rapid reproduction. We will cover first the non-chemical tools that are available and end with chemical control.Wax moths were the leading beekeeping pests in some regions of the US until the mid- 1980s when parasitic mites were discovered and quickly spread to all regions of the country. But wax moths are still a problem and damage from these pests can be significant if certain rules of control are not followed carefully and timely. There are two wax moth species, the greater wax moth, *Galleria mellonella*, and the lesser wax moth, *Achroia grisella*, which occur in all regions of the US. The lesser wax moth is much less a problem than the greater wax moth. Control recommendations discussed in this article are specific to greater wax moths, however I suspect that the same recommendations will control lesser wax moths, as well.

Acceptable Pest Levels

This is another beekeeping pest that a treatment threshold system has not been developed. However, beekeepers have many IPM tools available to control this pest. The beekeeper must resist the temptation of chemical control when there are many safe alternatives to control wax moths. Some beekeepers have a zero tolerance for wax moth damage, but slight damage in stored comb can be tolerated easily because bees are excellent home repairers. But, major damage by wax moths in stored comb is not acceptable by most beekeepers who discard damaged frames or strip frames and insert new foundation. This can be a major expense to the beekeeper in the form of labor and equipment. In addition, bees have to expend valuable resources to produce the wax needed to build new comb when those resources and energy could be used to produce more surplus honey. So, beekeepers should strive to minimize wax moth damage by timely use of good beekeeping pest management practices. When beekeepers become

careless and overlook some well recognized wax moth control recommendations, this pest can become a major problem, especially in stored comb. They can also become a problem in comb or chunk honey that is produced for human consumption.

Preventive Cultural Practices

Beekeepers should maintain strong and healthy colonies by practicing good colony management to help the bees defend against wax moths. Good colony management starts with a good laying queen that can regulate the colony population to maximize the chance of survival. Her genetic makeup is paramount in that her progeny must be able to sustain the colony in the presence of various disease and pests, including wax moths. A young laying queen will help prevent swarming and hopefully prevent supercedure which may lead to stress on a colony.

In general, a high bee-to-comb ratio is recommended for effective wax moth control. Swarming, supercedure, starvation, robbing, small hive beetles, or varroa mites can weaken a bee colony and lead to wax moth problems. Wax moths are opportunists or secondary invaders just waiting for a chance to become established and gain the upper hand. Once the colony's health balance tilts in favor of wax moths, the colony is normally doomed. Attention to detail in good beekeeping management will go a long way toward wax moth control. Even skunks, bears, or human intervention such as over-manipulation by the beekeeper or vandalism can stress a colony and lead to wax moth problems. Beekeepers should be careful with varroa mite detector boards and hive bottom beetle traps because they provide harborage for wax moths.

When honey-filed supers are removed from colonies, the beekeeper should make a habit of protecting hive products from pests. If the beekeeper operates in an area where wax moths or small hive beetles are problematic, the honey should be extracted within about two days. If plans call for holding the honey prior to extraction more than two days, the beekeeper is highly advised to take appropriate action in protecting the honey supers from these pests.

One preventive measure a beekeeper can take to reduce wax moth problems in stored comb is to make every effort to prevent brood production in honey supers. Brood production leaves behind small amounts of pollen and cast larval skins which are a more attractive food source than cells that have a history of just honey storage. Newly drawn wax comb where only honey was stored offers a high level of resistance to wax moths.

Beekeepers should resist the temptation of adding more honey supers than there are bees to cover and defend against pests such as wax moths, especially in late summer or fall. Placing too many wet supers on colonies for cleanup can also be a problem during times of the year when wax moths are most active. Wet supers should be placed only on strong colonies for cleanup.

Monitoring practices

Adult wax moths are normally present in most apiaries during warmer months. They are nocturnal and spend their daytime hidden in bushes, trees or other sheltered places. In early evening, the adult female moths fly and often sneak by guard bees which have relaxed their protection duties. Weak colonies are not capable of protecting their colony entrance from intrusion by this pest, but even strong colonies are often vulnerable to passage of wax moth adults. Once inside the hive, adult female moths lay eggs in protected cracks and crevices and exit the colony in the early morning hours undetected by the bees. If adult wax moths are found in the hive during daytime hours, the colony is weak and is likely highly infested and demoralized.

If wax moths are becoming a problem in a bee colony, their presence is normally obvious when the beekeeper opens the hive and identifies larvae found inside. The larvae are most often found tunneling inside frames leaving behind damage and webbing. Careful identification of larvae is necessary because wax moth and small hive beetle larvae are very similar in appearance to the untrained eye. Wax moth larvae have 3 pairs of thoracic legs on the anterior end of the body and have other uniform pairs of prolegs along the rest of the body. Small hive beetle larvae have only 3 pairs of thoracic legs on the anterior end of the body and no prolegs are present. The wax moth larval body is soft and fleshy, whereas the small hive beetle larval body is rigid and hard. Many times both pests can be found active in the same bee colony. Wax moth larvae leave behind a mess of webbing in comb, but small hive beetles do not. Sometimes the wax moth webbing in brood frames result in trapping bee pupae in their cells and prevents the young adult bees from emerging. This problem is called galleriasis. Mature wax moth larvae excavate the inside of wooden super boxes or hive frames for their pupation sites leaving behind scooped out areas in the wood that can harbor or provide hiding places for hive pests.

Genetic control

Wax moth control can be enhanced indirectly by the use of bees that have been selected for resistance to disease and other pests. These resistant strains of bees should be more tolerant of some of the primary problems that affect bee colonies which often create stress conditions that “open the door” to secondary invaders like wax moths. Bees that have been selected for hygienic behavior are normally better housekeepers which remove colony debris that creates conditions favorable for increased wax moth reproduction.

Mechanical control

Traps can play an important role in a wax moth integrated management plan because of their safety in providing control without fear of hive product contamination. No wax moth traps are marketed in the US, but a homemade trap can be easily constructed that may be used in the apiary as well as in the honey house or comb storage room to attract and kill wax moth adults (see photo). These traps can be constructed from readily available, low cost materials. I have seen several versions of these traps, but most use a 2 liter clear soda bottle with lid secured. A 1.25 inch (3.2 cm) diameter hole should be cut in the side of the bottle just below the shoulder

of the neck. The ingredients for the bottle trap include one cup white vinegar, one cup granulated sugar, one cup water, and one banana peel. The bottle should be set aside a few days until the contents begin to ferment after which the bottle should be suspended a few feet off the ground using wire or string making a noose opposite the side of the entrance hole. Wax moths adults will be attracted by the trap contents and will enter the bottle entrance and die because they are unable to escape.

Physical control

Wax moth damage is expected when honey-extracted comb is stored in dark, warm, or poorly ventilated places. Unprotected, wet supers are highly attractive to wax moths. From experience, I have learned to never store freshly honey-extracted supers in tightly sealed trash bags, thinking that you have excluded all life stages of wax moths. Invariably, wax moth eggs or larvae show up unexpectedly in the equipment and the comb can be destroyed in a few weeks in a warm storage area. One exception is to freeze the comb, allow the comb to thaw in a wax moth free room till dry, then store the frames in tightly sealed bags.

On the other hand, maximum use of light and ventilation is recommended to control wax moths. Beekeepers who have only a few colonies can easily take advantage of these two physical factors. A very effective and economical method of moth control can be achieved by storing supers of comb or individual frames of comb by wire from the roof or rafters of a room or attic which has good light and ventilation (see photo). If wax moths have already become established and webbing is present in the comb, the use of light and ventilation option of wax moth control is not recommended.

Other wax moth safe storage options are available to beekeepers who have lots of equipment to store. At Clemson University, we have a storage building which is used mainly for equipment storage, especially supers of drawn comb. The building has large open air windows and ceiling that are covered with hardwire cloth to exclude bees and wax moth adults. Supers of drawn comb are stacked in a manner that allows minimum of one inch distance between supers. We have had supers of comb stored in this building year-round with minimum wax moth damage mainly due to good light and ventilation.

A similar approach but practiced normally on a larger scale is the use of “wax moth –safe” storage rooms with single frames resting on frame holders or hanging from a ceiling of an open air building having no sides. This storage room was photographed in Argentina. Frames were stored about 1 inch apart in a well ventilated room which provided circulating air that prevented heat from rising to the point necessary for wax moth development (Popolizio and Pailhe 1973). According to the authors of this report, the storage room was 3.2 x 3.2 meters and was 2.5 meters high on the highest side which faced north and 2.0 meters high on the lowest side which faced south. The storage room had four floors and had a total holding capacity of 1,440 frames.

Temperature manipulation and carbon dioxide fumigation are other forms of physical control that are recommended for rapid, safe, and effective wax moth protection. These control measures can be used for stored extracted comb or hive products intended for human consumption, such as comb honey or pollen.

Cold Treatment: minimum cold temperature storage time required to kill all life stages of wax moths in honey-extracted comb include: 20ºF (-7ºC) for 4.5 hours, 10ºF (-12ºC) for three hours, or 5ºF (-15ºC) for two hours. Additional time should be given for equipment to reach required minimum temperatures, especially in hot weather or large capacity freezers. These temperature exposure periods will have to be increased to kill wax moth larvae in comb honey. Wax moth development is accelerated at higher temperatures, so comb honey should be protected from this pest beginning immediately after harvest.

Freezing individual frames containing wax moth larvae from live bee colonies is recommended to control this pest, but this will rarely result in successfully salvaging a colony that also shows signs of weakness and low morale. Some other more serious primary problem such as queen failure, mites, or disease is responsible for the poor condition of the colony.

Heat Treatment: heat can be used to kill all life stages of wax moths by using the following exposure periods: 115ºF (46ºC) for 80 minutes or 120ºF (49ºC) for 40 minutes. Treatment exposure periods should not begin till specified temperatures are reached. Combs should not be heated above 120ºF (49ºC) because combs will sag above this temperature and beeswax melts at about 148ºF (64ºC). Frames of comb should be heat-treated only in the upright position and should not be handled until allowed to cool. Heat treatment should be used only for comb containing little or no honey (Shimanuki and Knox 1997).

Carbon Dioxide Treatment: carbon dioxide can be used as a fumigant to control wax moths in stored comb or comb honey. Air-tight treatment rooms or fumigation chambers are required to hold 80-98% carbon dioxide levels which have to be maintained continuously for up to 5 days at the lower levels to kill all life stages of wax moths. At the highest level (98% carbon dioxide) with a temperature of 100°F and relative humidity of 50%, only 4 hours are required to kill all life stages of the wax moth. ***Precaution*: although no harmful carbon dioxide residues are left behind on treated comb or inside the fumigation chamber following use, a fully charged carbon dioxide room is hazardous to humans and can result in death.**

Other physical control recommendations for reducing wax moth problems include cleaning equipment like bottom boards in live bee colonies at least annually to remove debris where wax moth larvae can escape detection by bees. Cleaning up old empty boxes with a hive tool to remove any overwintering wax moth cocoons is recommended, also. Another good idea is to freeze or burn damaged comb which could possibly harbor wax moths.

Biological Control

B401, a microorganism, is a product manufactured by Vita-Europe Ltd. for the biological control of wax moths, but it is not currently registered for use in the US. The product is a bacterium, Bacillus thuringiensis subspecies aizawai that is manufactured specifically for wax moth control in stored comb. The material is formulated to kill young wax moth larvae as they attempt to feed on comb and must be used as a preventive before combs are infested. B401 leaves no residue on comb and it is harmless to bees and humans. Some other strains of Bacillus thuringiensis are toxic to bees and humans, so beekeepers must resist the temptation of using other BT products. B401was marketed in the US several years ago by the trade name Certan®. The product directions called for a mixture of one part Certan® to 19 parts water to be sprayed on both sides of every frame for effective wax moth control. Once mixed the solution must be used the same day. One application of the product gives wax moth protection in stored comb until the next season. B401 is currently available in Canada and some European countries. There have been some indications that this product may be re-registered in the US, but currently it is illegal to purchase or use this material in this country.

Research investigations have been conducted to find other effective forms of biological control for wax moths. Red imported fire ants (*Solenopsis invicta*) which are found throughout the southern US feed on other insects and can play an important role in wax moth IPM. Fire ants establish a network of underground tunnels that radiate from the mound and have been reported to cover a foraging range of several meters. The red imported fire ant now infests over 275 million acres of land, primarily in nine southeastern states in the US and Puerto Rico, with small infestations in Oklahoma and Tennessee. The overlapping generations of wax moths and fire ants offer the potential for beekeepers to take advantage of this natural predator-prey relationship.

Some beekeepers in the southern US store their supers of drawn comb on wooden pallets stacked cross-frame to allow light and ventilation along with fire ants to also contribute to wax moth control. The fire ant intervention form of wax moth control was brought to my attention some years ago when the only available product PCB (Paradichlorobenzene) was temporarily unavailable for purchase in the US. Two innovative beekeepers, Bert Kelley (Lakeland, Florida) and L.C. Reynolds (Saluda, South Carolina), shared with me their ideas and experiences with this form of wax moth biocontrol. Their reports of wax moth control intrigued me enough to conduct research investigations to either prove or disprove this theory of possible wax moth biocontrol.

Dr. Mac Horton, a fire ant extension specialist at Clemson University, and myself confirmed that fire ants along with light and ventilation offer the beekeeper an excellent IPM option (Hood et al. 2003). In our research that was conducted at Clemson University, South Carolina, we found that a high degree of wax moth control (practically 100%) in stored equipment can only be achieved

in areas of extreme fire ant activity that would make the average beekeeper uncomfortable. However, storing comb on a site or out-yard where a few fire ant mounds are present should offer the beekeeper an acceptable level of wax moth control.

> **A warning is advised here: beekeepers, who are allergic to fire ant venom, are not advised to practice this form of wax moth biocontrol, because there is always a chance of being stung by the ants. However, if a few guidelines are followed carefully, the chance of being stung is minimal.**

Following honey extraction, beekeepers should store wet combs away from the apiary for a few hours to allow bees to clean up the residual honey. If wet combs are stored in the presence of fire ants, the fire ants will feed on the honey and may damage the comb. Check out my super storing arrangement in the photos. You will notice that the supers can be stacked vertically and cross-framed on a wooden pallet five supers high with a piece of plywood on top to prevent rain from reaching the stored comb or sunlight from melting the wax. The equipment can be stacked for wax moth protection in mid-summer then moved into cold storage in winter, if preferred when fire ants are less active.

In our research, we also found that an alternate form of super storage on a wooden pallet provided wax moth control. Five supers with frames can be stacked horizontally and secured with a ratchet band to hold supers together. This stacking arrangement allows for additional ventilation and light to enter the combs. In some areas, it may be necessary to place a queen excluder on each end of the stacked supers to avoid damage by mice or birds.

One super stacking option that we found totally unacceptable was stacking supers of comb in a beehive arrangement that provided minimum light and poor ventilation. Total destruction of the comb occurred even at the highest level of fire ant activity. However, some beekeepers report good cleanup of dead-out colonies that are riddled with wax moths when stacked in this manner and placed directly on top of a fire ant mound.

Chemical control

The use of chemicals in an integrated pest management program is recommended as a last resort when other options have failed or are not possible. There are two chemicals available in the US to control wax moths, paradichlorobenzene (PDB) and aluminum phosphide (Phostoxin). PDB is registered for wax moth control for use in protecting stored comb. PDB cannot be used for wax moth control in live bee colonies, nor is it approved for protection of comb honey. PDB is available in crystalline form which vaporizes when temperatures are higher than 70ºF (21ºC). Honey readily absorbs PCB fumes resulting in honey being unfit for human consumption. Therefore, comb should be free of honey prior to treatment with PCB. Five full-depth supers or 10 half-depth supers can be stacked vertically in beehive fashion making sure to secure any cracks or openings with tape to provide a good seal. The product label calls for 3 oz or 4

tablespoons (85 g) to be placed on a piece of paper or cardboard on frame top bars of the top super with lid to cover the stack. Some beekeeping equipment suppliers sell a hive shim that contains a sliding drawer which crystals can be conveniently placed and inspected. As the crystals vaporize, the vapors are heavier than air causing the vapors to move downward through the stacked supers killing wax moth adults, larvae, and pupae. PDB vapors also repel wax moths from entering exposed equipment. However, the vapors will not kill wax moth eggs. Crystals vaporize quickly at warm temperatures and have to be replenished periodically. Beekeepers are strongly advised to air out stored chemically exposed supers for a day or two away from PCB prior to placement on colonies because it is toxic to bees at high concentrations. Mothballs which contain naphthalene are not registered for wax moth control and are illegal for use in protecting beekeeping equipment.

Aluminum phosphide is sold under various trade names and comes in tablet or pellet form and turns to a gas state as a fumigant for control of wax moth in stored drawn comb. The material is highly effective for killing wax moths, but it is flammable and can be extremely hazardous to humans. Therefore, it is classified as a "restricted use chemical" that only licensed pesticide applicators can legally purchase and use.

> **NOTE. Beekeepers should resist the temptation of using off-brand or unregistered chemicals for wax moth control. There are great risks involved when a beekeeper breaks the law (federal and state) when using a product or chemical that in not registered for a specific pest. We have found that beeswax readily absorbs chemicals and may harbor toxic materials for long periods of time. Using illegal chemicals for wax moth control may lead to contaminated hive products and can result in injury to the consumer as well as the beekeeper. Our beekeeping industry can ill afford the public outcry over the news of contaminated honey.**

Summary

Wax moths are found almost anywhere honey bees are kept, but they can be a major problem for beekeepers in warmer climates, particularly in the tropics and the subtropics. I agree with Gillard (2009) who noted that "wax moths keep us from becoming lazy. Conversely, they make us pay dearly for our procrastination, they wake us up from lethargy and reinforce our resolve how we have to be better beekeepers and more efficient managers of our resources."

Keeping strong and healthy colonies reduces the chance of wax moth problems in live bee colonies. The use of wax moth traps in the apiary may reduce the number of adult female moths that are available to enter bee colonies.

Wax moths are best known for their total destruction of stored beeswax comb which according to the late George Imirie is "the beekeepers most precious asset." I have seen various sources that make the statement that bees have to consume 8 lbs of honey for each 1 lb of beeswax they

produce. Therefore, comb protection should be a major goal for all beekeepers and further that goal should be met without the use of chemicals.

In most cases, the integrated management of wax moths will serve you well because we have so many options available to control this beekeeping pest. Maybe it is time for you to try a new option that we have discussed in these two articles. Good luck in your wax moth management for this season.

As a senior aged beekeeper friend of mine once shared with me, "when wax moths take over, maybe it is time to go fishing because wax moth larvae make great fish bait." Good luck with your fishing this year, but I hope that you have to use bait other than wax moths.

For a quick review, here are 10 recommendations on how to control wax moths:

- maintain healthy, strong colonies to promote high bee-to-comb ratio
- clean varroa mite detector boards and beetle traps on a regular basis
- trap adult wax moths in the apiary as well as in the honey house
- do not leave supers of drawn comb in unoccupied beehives
- extract honey from supers within 2 days of hive removal
- freeze lightly damaged wax moth infested equipment
- burn badly damaged wax moth infested equipment
- replace old comb especially brood comb with new foundation
- maintain good sanitary conditions inside and outside the honey house
- use chemicals as a last resort

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