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Greater Wax Moth *Galleria mellonella* (Linnaeus 1758) (Insecta: Lepidoptera: Pyralidae)

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Introduction

Figure 1. Greater Wax Moth Larvae Instars and Adult
Credits: LandLearn NSW http://www.landlearnnsw.org.au/

The greater wax moth, *Galleria mellonella* is a significant pest to honey bees worldwide. Regionally known as the bee moth, wax miller, or webworm, wax moths are also used as fish bait and animal food, as well as in scientific research (Caron 1992).

Although two species of wax moths exist, the greater wax moth, *Galleria mellonella* and the lesser wax moth, *Achroia grisella,* the greater wax moth causes more damage in apiaries. However, larvae of both species are equally able to cause destruction of comb and often coexist in colonies (Charriere and Imdorf 1999; Somerville 2007). Infestation results in spoiling of beehive products and damage to honeycomb (particularly stored honeycomb) and beehive material (Somerville 2007). In addition, the wax moth can cause indirect damage to apiaries by transfer of serious bee diseases such as American Foulbrood (Ben Hamida 1997; Charriere and Imdorf 1999).

History and Distribution

According to Paddock (1918), the greater wax moth was likely introduced into the U.S. from Europe in the mid-nineteenth century (Smith 1937). Occurring in all regions of the U.S., *Galleria mellonela* is prolific in the southwest. Warmer climates favor increased reproduction rates and allow populations to thrive year-round. Distribution is limited in colder climates and at higher altitudes, with infestations reduced or not found (Charriere and Imdorf 1999).

Description/Life Cycle

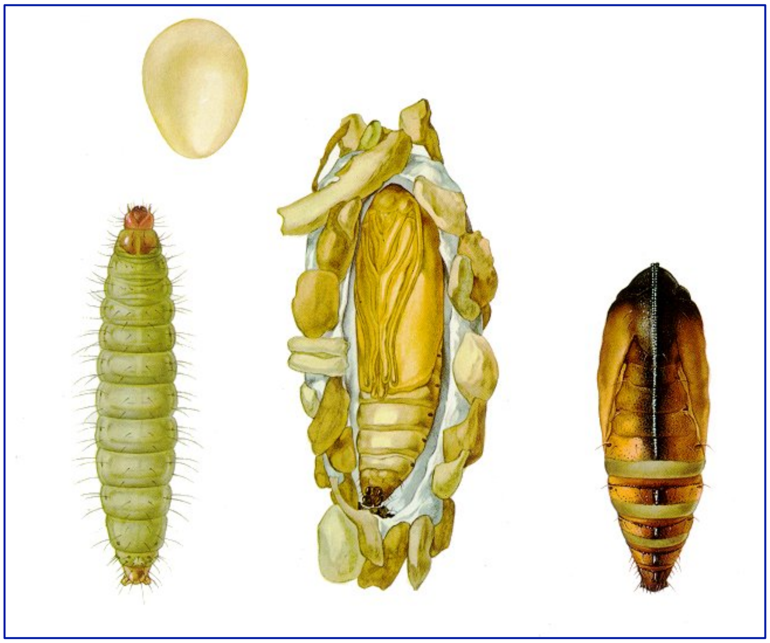

Figure 2. Developmental Stages of the Greater Wax Moth
Credits: Degesch Inc.

The wax moth life cycle is completed in four stages made up of egg, larva, pupa and adult. Adult female moths gain entry to the hive at night and lay eggs in tiny cracks and crevices where these cryptically placed eggs often go unnoticed during inspection (Jafari et al. 2010).

Adult

The adult wax moth is about 20mm in length (with females larger in size than males) and colored pale brown to gray with wings that form a "roof" or "boat" shape when folded over the body (Gulati and Kaushik 2004). Female wings have a smooth outer margin of the forewing while males have a semi-lunar notch on the forewing. Labial palps in females extend forward with head presenting a beak-like appearance (Gulati and Kaushik 2004), while males possess reduced labial palps hidden in scaling (Powell and Opler 2009).

Adults are nocturnal, hidden in sheltered areas in daytime (Hood 2010). The life span of adults averages up to three weeks with females able to begin ovipositing four to five days after emerging from the pupal stage (Somerville 2007). Female moths actively seek entry into hives to oviposit at dusk when guard bees are most likely to have relaxed their protective behavior (Hood 2010).

Irregular to many other moth and butterfly species, the male wax moths emit the mating pheromone attracting females (Greenfield 1981; Somerville 2007). Typically, the process is reversed and this has generated interest in control of populations by Sterile Insect Technique (SIT) methods (Jafari et al. 2010).

Eggs

Eggs are laid in batches with a single female capable of producing up to 1800 eggs (Warren and Huddleston 1962). Almost spherical, the eggs are pinkish-white and measure about 0.5 mm in diameter (Goodman 2006).

Hatching occurs in approximately 5-8 days (Caron 1992), although significant variability can exist dependent on brood and time of year (Warren and Huddleston 1962), with hatching delayed up to 30 days in cool conditions (Somerville 2007).

Larvae

Fully developed larvae transition through eight instars (Smith 1937) and reach 28 mm in length after approximately 1-5 months (Goodman 2006). Initially white in color, they gradually become dark gray with age. Larvae have a dark head capsule, 3 pairs of segmented legs, and several body segments with some bearing caterpillar prolegs (Caron 1992).

Figure 3. Ventral view of wax moth larva
Credits: The Home BeeKeeping Guide
http://www.homebeekeeping.com/wax-moth-infestation-revealed-in-bee-video/

Pupae

Changing from brownish-white to dark brown in color with age, the pupae average 14 to 16 mm in size. Development is correlated to temperature with adult emergence occurring in as quickly as eight days (warm conditions) or taking up to two months (Caron 1992; Somerville 2007).

Damage

Damage to apiaries by wax moths is from larval feeding and development as adults' mouthparts are atrophied (Charriere and Imdorf 1999). The hive, developing brood, and stored comb can be seriously affected if populations are left unchecked. In optimal temperature conditions, newly hatched larvae may even be able to infest nearby colonies as research indicates they have the capacity to travel in excess of 50 meters (Goodman 2006).

After hatching, the larvae cause damage as they burrow through the wax comb feeding preferentially on cocoons, cast skins, and pollen left behind from reared brood (Jafari et al. 2010). Honey bee pupae may be exposed when feeding wax moth larvae partly remove cell caps, a condition known as bald brood, and sometimes honey bee pupae in their final moult are affected by wax moth excreta which causes deformity of the bee legs or wings prior to emergence from the cell (Goodman 2003).

As they feed, they leave behind webbing, a classic symptom of wax moth presence known as Gallariasis, and Toumanoff (1939) found larval fecal debris could harbor spores of Paenibacillus larvae, transmitting American foulbrood (Ben Hamida 1997).

The webbing spun by fully-grown larvae is typically attached to the frame or hive body and the subsequent cocoon will be cemented in a cavity excavated by the larvae chewing into the wood (Caron 1992). It is this dense webbing that entraps the emerging adult bees, leaving them unable to exit their cells (Caron 1992).

Larval tunneling and excavated wood parts render frames and hive components unusable (Ben Hamida 1997; Goodman 2003). Damage is far greater in stored comb and weakened colonies lacking a defense mechanism. In warmer months of the year, moth numbers quickly explode and entire devastation of comb and equipment can occur in as little as one week (Goodman 2003).

Figure 4. Wax moth damage to comb
Credits: The Home BeeKeeping Guide
http://www.homebeekeeping.com/wax-moth-infestation-revealed-in-bee-video/

Control

While infestation may begin in the hive, wax moth populations are generally tolerated in strong and healthy colonies when worker bees are able to remove eggs and larvae from the nest (Warren and Huddleston 1962; Sanford 2009). Preventative measures include regular hive inspections with attention to colony health and protection of stored equipment. Problems requiring intervention typically arise at the close of the honey flow season in conjunction with the subsequent storage of supers. Management efforts should emphasize stored comb protection, particularly in conjunction with warmer temperatures when wax moth populations explode. If left unchecked, rapid destruction of comb can occur, resulting in serious economic loss for beekeepers (Caron 1992; Donahaye et al. 1998).

Beehive Management

Crucial to maintaining the health of a colony is keeping it strong. Apiary hygiene is an essential mechanism in defending the colony from wax moth populations. Italian honey bees possess better housekeeping abilities, so re-queening with an Italian strain can provide added defense against wax moth invaders (Somerville 2007). Weaker colonies may be integrated with healthier ones to maximize protection (Goodman 2003).

Regular inspections and the ability to identify the pest are critical elements in preventing loss (Somerville 2007). Larvae of *Galleria mellonella* resemble small hive beetle larvae and without close inspection may be misidentified (Hood 2010). In the wax moth, larvae are soft-bodied with 3 pairs of thoracic legs on the anterior end of the body and uniform prolegs on the rest of the body, while small hive beetle larvae are hard-bodied and possess only 3 pairs of thoracic legs on the anterior end with prolegs absent (Hood 2010).

Stored Comb Management

Implementing preventative measures to keep stored comb and hive components safe from infestation of *Galleria mellonella* is critical in preventing economic loss to apiaries. Conventional control of wax moths in stored supers has been achieved by chemical fumigants. However, safety concerns, application procedures, and expense of products are limiting factors for the apiarist.

Currently, the only chemical for wax moth control on the market is paradichlorabenzene (PDB) or the moth crystal (Tew 1997). As directives for use can change, adhering to label instructions is imperative to safeguard honey products that may be made available for sale. Use is recommended only for fumigation of stored comb and should not be confused or substituted with another common moth fumigant, naphathlene (Caron 1992). Additionally, treating with PDB has no effect on moth eggs (Ben Hamida 1997), so further treatment strategies may need to be implemented in conjunction with PDB fumigation.

Non-chemical control methods offer alternative protective measures that can be effective in small-scale apiaries. These include temperature extremes and fumigation with carbon dioxide (Sanford 2009), also known as modified atmospheres (MAs) (Donahaye et al. 1998). Other methods researched for control of wax moth infestation include biological measures (Ben Hamida 1997), including use of the Red Imported Fire Ant (Hymenoptera: Formicidae) (Hood et al. 2004) and the male sterile technique (Jafari et al. 2010).

Temperature extremes:

Heat Treatment

Heat is effective at killing all stages of the wax moth at a temperature of 46 degrees Celsius for 80 minutes or at 49 degrees Celsius for 40 minutes. Combs should be allowed to reach the temperature requirements before measurements of exposure are calculated (Tew 1997). Combs should not overheat at temperatures exceeding 49 degrees Celsius as sagging may occur, and melting of wax is initiated at 64 degrees Celsius. Heat treatment should be applied only to upright combs that contain little to no honey (Hood 2010), and carefully circulated to avoid hot spots melting the wax (Sanford 2009).

Cold Treatment

Cold storage of equipment should be at a minimum of 7 degrees Celsius for 4.5 hours,

-12 degrees Celsius for 3 hours, or -15 degrees Celsius for 2 hours to exterminate all life stages of wax moth (Hood 2010). When implementing cold treatment, equipment exposure should be calculated from the time the minimum cold storage temperatures are reached. Additionally, extra care is advised as beeswax may become brittle and easily break when exposed to cold temperatures (Sanford 2009).

Carbon Dioxide Fumigation (Modified Atmosphere):

Fumigation of stored comb and comb honey with carbon dioxide may be utilized to control wax moths. In an airtight environment with 98% carbon dioxide-levels continuously maintained for 4 hours at a temperature of 37.8 degrees Celsius and relative humidity of 50%, it is possible to kill wax moths in all life stages (Sanford 2009; Hood 2010). Fumigation with carbon dioxide poses a suffocation risk to humans, although no residues are left behind on treated comb or comb honey (Sanford 2009; Hood 2010).

Maintenance and Physical Control/Preventative Measures:

As some of the worst infestations of wax moths occur in stacked, stored supers in areas of warmer weather, apiarists may be able to reduce buildup of wax moth populations by implementing new storage habits (Sanford 2009). Providing ventilation in storage areas where equipment is exposed to light will make the hive components less attractive to wax moths. Since wax moths are attracted to old comb, regular replacement or renovation of comb is another essential preventative measure to implement for overall hive health (Sanford 2009).

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