

The Greater Wax Moth:¹ Adult Behavior²

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ABSTRACT

The behavior of adult *Galleria mellonella* (L.) (Lepidoptera: Pyralidae) was observed throughout the year in apiaries of *Apis mellifera* L. Generally, eclosion occurred in the evening, and moths left the hive to expand their wings even if bees were not present. Soon after dark, the moths flew into trees, and the males were seldom observed again. Females that tried to enter a hive in the early evening were chased by the bees, but ca. 2 h after dark, the bees were no longer aggressive. Ovi-

position in hives started ca. 24 h after eclosion and continued for 4 nights. Each morning the moths left the hives shortly before daylight and flew into trees. Females generally visited strong bee colonies and not decoy hives containing comb or weak colonies. Mated female moths seemed to be attracted to some hives and completely avoided others. In winter when the temperature was 21°C or lower, adults stayed in the hives that contained brood.

The adult greater wax moth, *Galleria mellonella* (L.), emerges in apiaries of the honey bee, *Apis mellifera* L., but leaves them to mate (Langstroth 1853). Bevan (1843) reported that they then re-enter the hives in the evening and deposit their eggs on the sides of combs. However, Oertel (1962) noted that it had not been established by observation or test that the moths fly into the colony at night, lay their eggs, and then leave the hive. He felt it was more likely that the females laid eggs outside the colony, in crevices between supers or under hive covers and that the tiny larvae crawled into the hive to find food. Paddock (1918) theorized that if wax moths were driven from the hives by strong colonies they would infest comb left unprotected by bees and thus maintain their population, but when he put comb in decoy boxes in an apiary for 3 mo, larvae did not infest it. However, some decoy hives that Oertel (1962) set out did become infested within a short time. As we examined our honey bee colonies at Baton Rouge, La., we found that most colonies were infested with wax moth larvae. Thus, the moth is maintained in the apiary by larval development in active hives as well as on comb removed from bees. However, this still disclosed little about where the eggs are deposited or about moth behavior in the apiary.

This paper reports observations of wax moth behavior in the apiary made over a period of 5 yr at Baton Rouge.

MATERIALS AND METHODS

Behavior of resident population moths was studied in 3 apiaries, each containing ca. 50 colonies. From March to October, moths were observed at night by flashlight. During 5 yr, moth activity was monitored all night (4:30 PM to 7:00 AM) ca. 30 times, and for shorter periods (3–8 h/night) more than 100 times. A resident population of moths that emerged from dead bee colonies at the apiary was used to observe behavior of the moth from eclosion to death as far as we were able. As soon as the wings from newly emerged moths were expanded and folded normally,

each moth was placed in a vial, marked, and then returned to its resting place. Moths were marked by 2 methods: (1) A mixture of 3 ml food coloring, 3 ml water, and one drop of a wetting agent (Triton X-100®) was applied to the wing with a brush; or (2) fluorescence dust was applied with a brush or by placing the moth in a jar with a small amount of dust. During a period of 30 days, 2000 ♀ and more than 20,000 ♂ were marked and allowed to fly normally. Different colors were used each day so that any marked moth would have died before its color was used again.

To determine the effects of bees on mortality of moths that emerge in active colonies, we selected 3 very strong bee colonies and removed a comb of brood from each. Then 200 wax moth pupae (100 ♂ and 100 ♀) that were within a few hours of eclosion were placed in the cells that contained bee eggs. At 4:30 PM, the combs with pupae were each placed in a brood nest, and the colonies were observed for newly emerged moths.

RESULTS

Since most moth activity occurred at night, some artificial light was necessary to make observations. We found that the subdued light of a flashlight did not change behavior, but a sudden exposure to the more intense center beam generally stopped activity for several minutes. When the light was gradually increased over a period of several minutes, the center beam did not alter behavior. Also, the intense light of an electronic flash used to photograph the moths did not change behavior.

The moths were not normally attracted to lights at night, but they would fly to the light if they were bumped as we attempted to catch them. Oertel (1962) reported that some released moths flew to the windows or to electric light and that others flew to the wall or ceiling. We found this true of moths conditioned to light of the intensity found in a lighted office; moths previously conditioned to more intense light flew to the windows or to electric lights. Moths conditioned to darkness flew to the dark areas of the room, under desks, or to a black-lined box, but if they were bumped as they were released, they flew to the windows or to electric lights.

¹ Lepidoptera: Pyralidae.

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Eclosion occurred at 2 periods of the day. Ca. 1–2 moths/1000 pupae emerged between 6 and 11 AM, and the rest between 5 and 10 PM. However, the evening eclosion sometimes started at 5 PM and did not finish until 10 PM, though on other evenings all moths emerged within 1 h.

Moths that emerged in the evening ran rapidly out of the hive entrance whether the bees were in the hive or not. They generally ran until they found a place where their legs could be above the body; then they expanded their wings downward perpendicular to the body. However, some moths stopped on vertical or flat surfaces and expanded their wings. About 20–30 min after eclosion, the moths folded the expanded wings in the normal position over the body and remained in this position for ca. 10–20 min if it was dark. If they emerged before dark, they stayed in that position until it was nearly dark. When the moths moved, they flew into trees and disappeared in the foliage at a height in excess of 12 m; if no trees were near, they flew so high that we could not follow them.

Moths that emerged in the morning stayed in the hive while they expanded their wings, and if both males and females were present, they mated without leaving the hive. When it was nearly dark, the males and any virgin females flew out into trees as described. The mated females stayed in the hive and started to oviposit ca. 24 h after they mated.

We found that within 3 h after 200 pupae were placed into each of 3 strong hives, 100 ♂ and 100 ♀ emerged and left each hive. As they came out, they ran among and over the large number of bees at the hive entrance, but several stopped and expanded their wings within 15 cm of the entrance. However, 2 moths that were expanding their wings 15 and 18 cm from the entrance moved to a greater distance when bees approached. Plainly moths can emerge in active bee colonies without being destroyed by the bees.

To locate moths that developed in active hives, we observed many bee colonies during the evening when moths should be emerging. Although 19 moths were found expanding their wings near colonies from which they had evidently just emerged, this is a small number in view of the many colonies observed; however, moths expanding their wings in the grass or under a colony are very hard to find. When we examined the colonies near the 19 moths, we found only 5 empty exuvia.

Many active colonies were examined for live wax moth pupae or for evidence that moths had emerged. Most pupae were found in cocoons, but a few cocoonless pupae were found on bottom boards. A large number of cocoons were empty except for an exuvium. Most pupae and empty cocoons were found in enlarged holes in the wood frames, the most common place being the holes for wire in end bars. The larva enlarges this hole and spins a cocoon. If a larva is present in a hole, the bees generally place a patch of propolis over the hole. Then when the moth emerges, it pushes the patch outward, but generally leaves it

hinged on 1 side so that it moves back over the empty hole. If the patch of propolis is removed from an empty hole, the bees do not replace it until another larva moves into the hole.

The male moths that emerged and flew into trees or into the air were seldom observed again. Two found on leaves of a tree at a height of 13 m were fanning their wings in much the same way that males do just before mating in the laboratory. One male was observed running on an empty super in the apiary at 2 AM. Also, 3 ♂ were found on a tree trunk during the day. However, of the more than 20,000 marked males released, only one was observed after it flew into trees. It was found on a tree trunk at a height of 11 m 5.5 days after it was marked and released.

Many females were observed flying out of trees back to colonies. We determined that all these females had mated by the presence of one or more spermatophore in each of more than 300 ♀ examined. If the day had been unusually warm, the flight back to the colonies sometimes started when it was just about dark. However, most of the time, and even sometimes after a hot day, the flight started 1–3 h after dark. On 3 different occasions, there was no moth activity during the night though we could not detect any difference in conditions from the previous night or during the following night when flight was normal.

Some bee colonies seemed to attract more moths than other colonies did. Although it has generally been thought that strong bee colonies prevented moths from infesting a hive (Paddock 1918, Milum 1940, Whitcomb 1965), this was not generally the case. During 5 yr of study, only 5 weak colonies were observed that seemed to attract moths. Moths started going to these weak hives when they contained fewer than 300 bees and continued to go to them until ca. 10 days after all bees were dead. However, when we made colonies weak, no moths were observed going to any of these weak colonies or to decoy boxes of comb. Instead, they usually went to strong active hives and often to the larger colonies in the apiary. As many as 7–12 moths went to a few strong colonies nearly every night, but many other colonies seemed never to be visited. Even when the attractive hives were moved as far as 300 m from the apiary, the moths continued to go to them.

In early evening, bees chased moths that tried to enter hives. The moth generally ran up the front of the hive in a half circle so that it came back to the entrance and sometimes into the hive without stopping. On several occasions, a bee caught the leg of the moth with its mandibles, but the moth always escaped and generally flew to another colony. Sometimes when bees were aggressive, moths oviposited outside the hive between supers or under the lid of the hive without entering the colony. About 2 h after dark, the bees became less aggressive, and the moths often landed among the guard bees at the hive entrance, remained there motionless for 1–5 min, and then ran into the hive.

A total of 2000 wax moth ♀ were marked and allowed to fly normally as they emerged over a period of several nights. None was observed going to a colony the night they emerged. However, the 2nd night after they emerged, as few as 12% (6 moths) and as many as 62% (31 moths) were observed entering colonies. On the 3rd night as few as 9% (7 moths) to as many as 41% (21 moths) were observed going to colonies. On the 4th night none that developed on one night was observed and as many as 19% (17 moths) that developed on other nights were observed. On the 5th night, only one moth was observed.

Also, on each of 2 nights, 25 marked virgin ♀ that had emerged 24 h earlier were released. They flew into trees in the same way as just emerged. However, 1 h after release, one attempted to enter a colony, and most went to colonies ca. 3 h after they flew into trees. During one night, 9 of the 25 ♀ were captured as they went to the colonies, and on the other night, 13 of the 25 ♀ were captured. All those females going to bee colonies the night of release had mated.

The behavior of 2 moth ♀ on a decoy brood comb at the hive entrance was observed. Bees from the hive entrance generally covered the decoy combs, especially when the comb contained brood, and moths usually entered the hive without stopping on the decoy combs. However, one night ca. 3 h after dark, 7 moths entered the hive, and 2 stayed for nearly 1 h on a decoy comb of brood from that particular colony. Although the comb was nearly covered with bees, the moths searched the comb for suitable places to oviposit. Their antennae were positioned slightly forward as they moved about, and when they were over areas containing fresh pollen, the antennae vibrated wildly; over other areas of the comb, they vibrated gently. Each moth dragged its abdomen over the comb as its ovipositor moved from side to side feeling for a place to deposit eggs. Sometimes the moths backed into cells containing fresh pollen and stayed in the cell for as long as 2 min. In one of these cells, 54 eggs were deposited between the cell wall and fresh pollen that was packed loosely in the cell. Eggs were also deposited on the wall of open cells ca. 1 mm from the entrance next to the thick outer edge of the cell. Several eggs were deposited under the cap of a partially capped honey cell, and a few eggs were laid in the corner where the end bar joined to the top bar. The moths tended to stay in areas of the comb where few bees were located, but they often touched the bees as they moved over the comb, and several times they ran over the top of groups of bees. They stayed on the comb for nearly 1 h and then went into the hive.

When bee colonies containing moths were disturbed by a tap on the hive, the bees quickly killed the moths. Five colonies each containing 9 moths or more were disturbed, and none of the moths survived.

The moths usually left the hives during a 1-h period beginning nearly 1 h before daylight. About the same number of moths were observed leaving the undisturbed colonies as were observed entering them during the evening. As the moths left, they often stopped at the entrance among the bees for as long as 1 min and then flew high into trees or into low bushes near the apiary.

Some moths that left the hives when it was nearly light were located in trees. They generally stayed motionless all day though some moved slightly, and 3 moved as much as 40 cm as they oviposited in crevices of the bark at a height of 9–12 m. One moth that was ovipositing had been marked the night it emerged 4.5 days earlier. It continued to deposit eggs until early afternoon and then died. One moth oviposited until late afternoon and died before 6 p.m. One moth was still ovipositing at noon but disappeared before 1 p.m.

During the daytime in the winter, many bee colonies were examined for moths under the hive lids. Moths were only found in colonies that contained brood and only when the temperature was 21°C or lower. One day 3 ♀ were observed leaving the hives and flying to a tree when the temperature reached 22°C. Later in the afternoon when the temperature dropped to 17°C, two flew to hives that contained brood and ran into the hives after stopping at the entrance for almost 1 min. The 3rd moth disappeared while we were following the flight of the other 2 moths to the hives.

DISCUSSION

Obviously the behavior of the greater wax moth and the honey bee allows the moth to survive. Most moths emerge when bees aggressively chase any moths that try to enter the hive. However, the young moth runs out of the hive so rapidly that the bees could probably not catch it even if they tried. Only a few moths arrive at the hive to oviposit early in the evening when the bees are aggressive; the others fly to the hive when they can enter without difficulty. We conclude that few adult moths are destroyed by bees in a natural undisturbed environment.

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