CHAPTER 7

Insects: Lepidoptera (Moths)

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Introduction

A number of moth species attack the products of honey bees—honey, pollen, and wax. Included are the greater and lesser wax moths (*Galleria mellonella* [L.] and *Achroia grisella* [Fabricius], respectively); several species that are primarily pests of stored products, the Indian meal moth (*Plodia interpunctella* [Hubner]), the Mediterranean flour moth (*Anagasta kuehniella* [Zeller]), and the driedfruit moth (*Vitula edmandsae serratilineella* Ragonot) (Milum 1940a, Singh 1962, Smith 1960). Death's head moths (*Acherontia* species) occasionally feed on honey and nectar (Brugger 1946, Raw 1954, Smith 1960). The bumble bee wax moth, *Aphomia sociella* (L.), is a rare pest of honey bee colonies (Toumanoff 1939).

In the developing countries of the world, additional undescribed moth species probably exist and will become pests of honey bee products, perhaps serious ones, as beekeeping in those areas intensifies.

Greater Wax Moth

Many people outside the beekeeping arena consider the greater wax moth, *Galleria mellonella* (L.), to be a useful insect. Larvae are raised commercially in the northern United States and Europe for sale as fish bait. They are also used for studies of physiology, toxicology, and pathology, and as an artificial host for the mass propagation of dipteran and hymenopteran parasites (DeBach 1964, Marston, Campbell, and Boldt 1975). However, the greater wax moth is by far the most important moth pest of honey bee products. It causes serious losses to commercial beekeepers every year (Eckert 1951, Singh 1962, Smith 1960). Whenever honey bee colonies become weakened or die during warm weather, *Galleria* larvae may quickly reduce the combs to a mass of webbing and debris. Conditions that render colonies susceptible to wax moth depre-

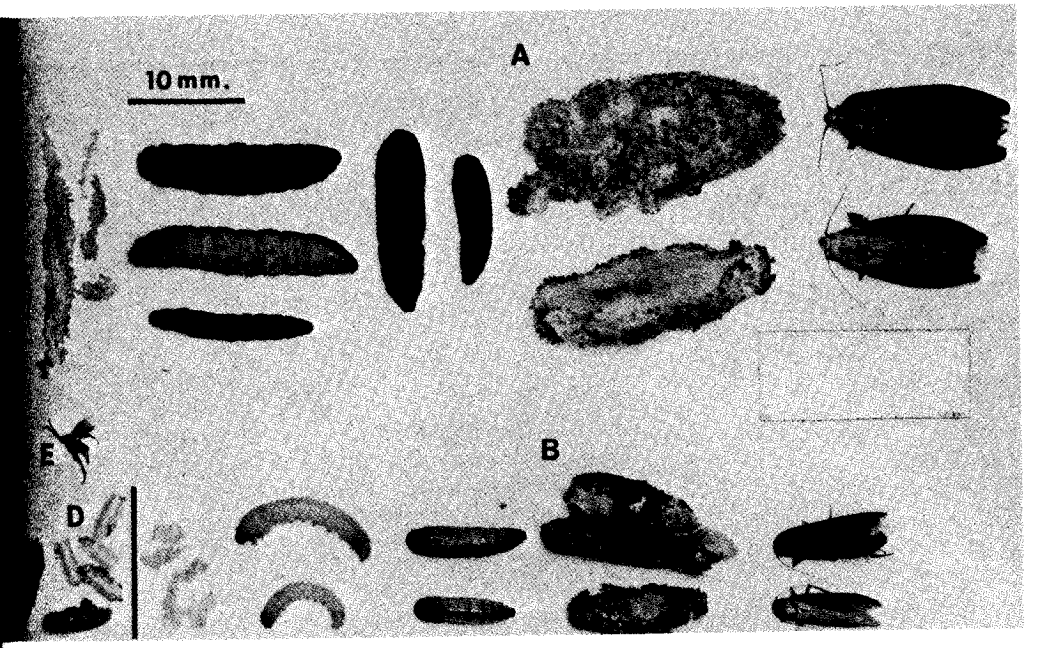

Figure 7.1. Stages of the greater wax moth, the lesser wax moth, and a parasitic wasp, *Apanteles galleriae*, which attacks young larvae of both moths. Eggs, larvae, pupae, cocoons, and adults of the greater wax moth (A) and the lesser wax moth (B). (C) Cocoons spun prematurely by young greater wax moth larvae that have been parasitized by *Apanteles galleriae*. White cocoons (D) and adult (E) of *Apanteles galleriae*. (Photo by M. Burks)

dation include lack of food, disease (especially American foulbrood), failing queens, queenlessness, and marked reduction of the worker bee population as a result of pesticide poisoning. In warm climates, the beekeeper must prevent colonies that dwindle during periods of dearth from being destroyed by *Galleria* (Sechrist 1944). The destructive activities of the greater wax moth are most severe in the tropics and subtropics, presumably because the species evolved in similar habitats in southern Asia along with honey bees (Morse 1975b).

Presently, in different parts of the world, many millions of combs are fumigated at the close of each beekeeping season as protection against wax moth damage. A typical thousand-colony beekeeping operation in the United States averages about 57,000 drawn combs (Anderson 1969), half or more of which are in storage for about six months out of each year. In the warmer sections of the country, protection of these combs against moth pests and other elements is a vitally necessary part of the beekeeper's management program.

In addition to *Apis* colonies, the greater wax moth infests the

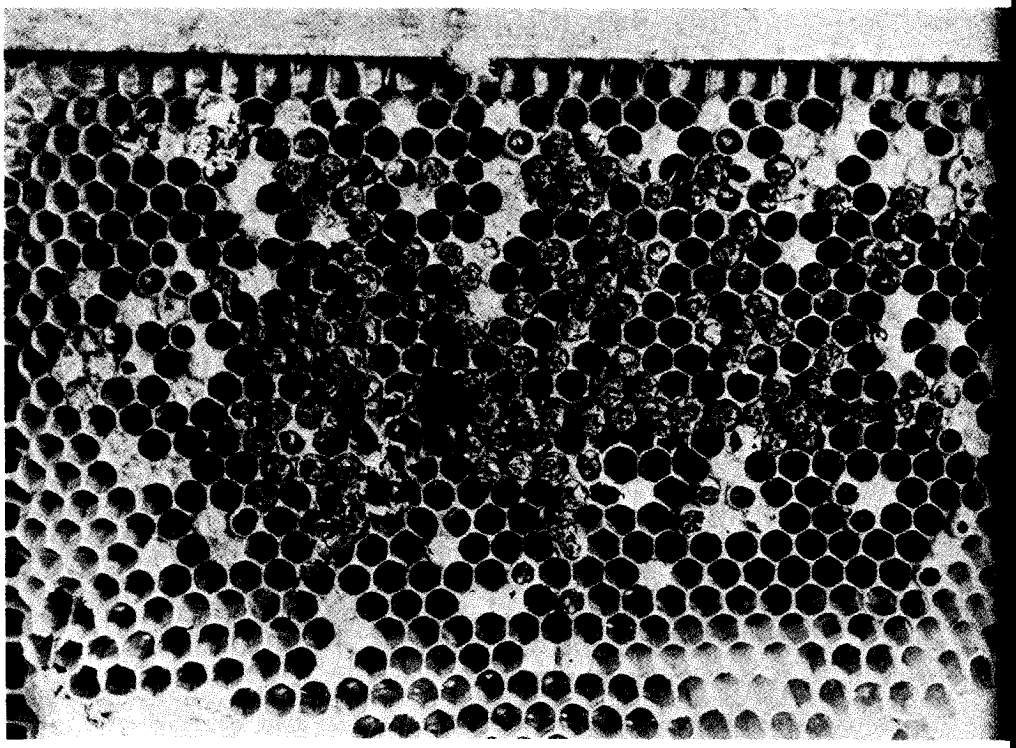

Figure 7.2. Emerging worker honey bees (*Apis mellifera*) afflicted with galleriasis. The adult bees were unable to leave the brood cells, being tethered by their abdomens to the comb with silken threads spun by small *Galleria* larvae. The comb was taken from a nucleus hive at Baton Rouge, Louisiana, during July. (Photo by M. Burks)

nests of the so-called stingless bees and bumble bees (Noguiero-Neto 1953, Oertel 1963).

Distribution

The greater wax moth occurs throughout the world almost everywhere honey bees are kept. Its distribution is limited mainly by an inability of the species to tolerate prolonged subfreezing temperatures. Little or no damage occurs from *Galleria mellonella* (L.) at high elevations (Paddock 1926). For example, natural infestations of beekeeping equipment have not occurred for over 40 years at Laramie, Wyoming.

Economic Importance

Apparently there are no data concerning monetary losses caused by the greater wax moth in major honey-producing countries other

than the United States. Even in the United States few attempts have been made to assess the economic significance of this important pest of the beekeeping industry. Paddock (1918) assumed the number of hives of comb destroyed in Texas by *Galleria* to be approximately 5 per cent annually (14,000 units), and Oertel (1969) estimated annual losses in Louisiana to be approximately 31,000 dollars. In the United States *Galleria mellonella* (L.) presently causes extensive losses in the areas that produce the most queens and package bees (Gulf Coast states, Georgia, and California), where the climate is warm. Based on a survey of 114 southern commercial and semicommercial beekeepers who operated over 180,000 Langstroth colonies and over 250,000 queen-mating nuclei, *Galleria*-caused losses in the United States were estimated to be about three million dollars or more during 1973 and about four million in 1976 (Williams 1976). Losses in the three main beekeeping states in the south averaged nearly $1.00 per colony in California, $1.50 per colony in Texas, and $3.00 per colony in Florida.

Annual losses from American foulbrood in the United States, including operational costs for state apiary inspection programs, probably reach five million dollars or more. Wax moth losses may approach those caused by American foulbrood nationally and equal or exceed them in the states covered by the survey.

Morphology

Newly hatched *Galleria* larvae have a creamy-white body color that becomes gray to dark gray on the dorsal and lateral surfaces in older larvae; strains of larvae that are white-bodied at maturity have been bred commercially in the United States. *Galleria mellonella* (L.) larvae are the largest of the comb-infesting Lepidoptera, reaching as much as 28 millimeters in length and 240 milligrams in weight (Hase 1926).

Greater wax moth cocoons are usually bare and white, but some are almost completely covered with dark fecal pellets and frass; they usually are 12 to 20 millimeters long and about five to seven millimeters in diameter. Often the last-instar larvae migrate from the feeding site and spin cocoons on hive bodies or the inner cover. Large sheets of several thousand cocoons or more are a distressingly familiar sight to beekeepers in warm climates, including those in the southeastern United States. As many as 10,000 cocoons may be found in a two-story, 10-frame Langstroth hive, but normally only about 250 normal-sized larvae are able to develop on

a dark brood comb (frame size: 447.7 × 231.8 millimeters) (Nielsen, personal communication, 1975).

Adult *Galleria mellonella* (L.) are heavy-bodied, fairly small moths. The females range in length up to about 20 millimeters and average as much as 169 milligrams in weight (Marston and Campbell 1973); the males average considerably less. In addition to usually being smaller, male moths may be distinguished from females by their lighter color and the distinctly scalloped apical margins of the forewings. Also, the female's labial palps extend forward giving the head a beaklike appearance. The anterior two-thirds of the forewing of normal adults of both sexes is rather uniformly dark, but the posterior one-third has irregular light and dark areas interspersed with darker streaks and uneven spots. Dorsally the thorax and head are light-colored. Both sexes vary considerably in size and color according to larval diet. Silver-white adults have been reared from wax foundation, whereas those reared on a diet of brood comb are colored predominantly brown to dark gray to almost black (Whitcomb 1936, Milum 1940a). *Galleria mellonella* (L.) adults may be smaller than some adult lesser wax moths if the larvae have developed slowly as a result of poor diet and low temperatures.

Adult Biology

The life cycle time for wax moths varies from four weeks to six months; in the case of the longer time, dormancy occurs in the prepupal stage (Marston, Campbell, and Boldt 1975). The adults require neither food nor water. The female begins laying eggs within about four to ten days after emergence and she produces about 300 to 600 eggs, though individual moths may lay up to 1,800 eggs (El-Sawaf 1950).

Adult *Galleria* live from three to over 30 days, but most mated females die within seven days when held at 30° to 32° Celsius (El-Sawaf 1950, Nielsen 1971). The lifespan of the wax moth is greatly increased at lower temperatures. The female lifespan averages 3.8 days at 40° Celsius and 19.6 days at 20° Celsius (Marston, Campbell, and Boldt 1975).

Galleria Eggs

The eggs of the greater wax moth vary in color from pinkish to cream to whitish. They are quite difficult to detect with the naked eye even though most are glued together in sheets of 50 to 150 eggs each. Undoubtedly the female moths' habit of depositing eggs

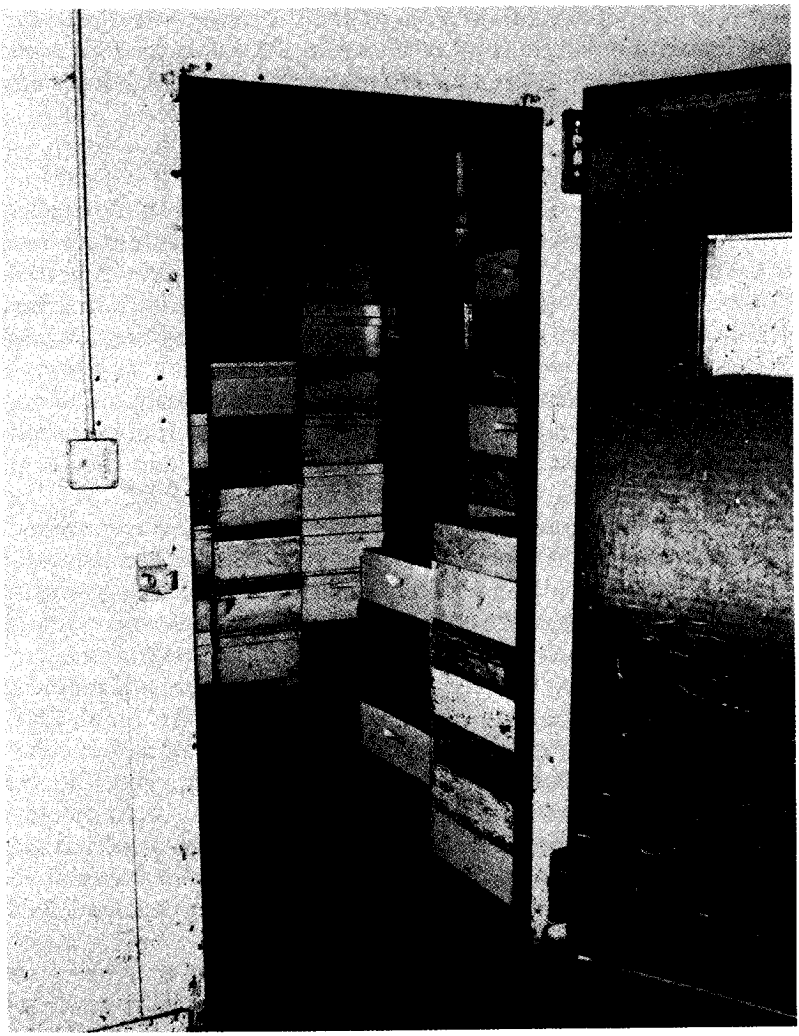

Figure 7.3. Air tight chamber used at the University of California, Davis, for the fumigation and storage of combs between seasons. (Photo by K. Lorenzen)

in small cracks and crevices that barely admit their ovipositors affords considerable protection against removal by worker bees and predation by other insects (Makings 1958, Milum and Geuther 1935).

Eggs develop rapidly when held at warm temperatures (29° to 35° Celsius) and begin to hatch within three to five days of oviposition (Dutky, Thompson, and Cantwell 1962, Nielsen 1971). Egg

hatch is extended to about 30 days at 18° Celsius. Short exposure to temperature extremes (at or above 46.1° Celsius for 70 minutes and at or below 0° Celsius for 270 minutes) will cause 100 per cent mortality of eggs (Cantwell and Smith 1970).

Galleria Larvae

Upon hatching, *Galleria* larvae feed on honey, nectar, or pollen, if available, for their first meal. Typically, the larvae then burrow into the outer edge of cell walls or into pollen contained in cells. Developing larvae extend their tunnels to the midrib of the comb where they continue to feed and grow, protected from worker bees.

Larvae of the greater wax moth grow at an unusually rapid rate. If diet and temperature are favorable, they can double in body weight daily for the first ten days after hatching, and they begin to spin cocoons as early as day 18 or 19 (Beck 1960). This fast rate of growth accounts for the fact that all of the combs in a honey bee colony are often destroyed within 10 to 15 days after the adult bee population has been severely depleted by poisoning or other causes. As a consequence of this rapid growth, *Galleria* larvae produce substantial quantities of metabolic heat; temperatures as high as 25° Celsius above the environmental temperature are produced in the center of aggregations of larvae (Roubaud 1954, Smith 1941).

In spite of their extremely rapid growth under optimum conditions, *Galleria* larvae are also capable of surviving even if food is available intermittently or if they feed continuously on a marginal diet. Under such conditions, the total developmental period (egg to adult) is greatly extended—up to six months or so—and the adults are progressively smaller (Marston, Campbell, and Boldt 1975, Milum and Geuther 1935).

Developing larvae feed upon practically all of the honey bee products in the colony. Dark combs are especially preferred whether they contain honey, pollen, or both. Bee brood (larvae and pupae) also will be attacked if *Galleria* larvae are short of food (Milum 1935, Paddock 1918, Whitcomb 1936). In warm climates, many larvae often develop in the pillars of wax and in the pollen and debris on the bottom board of the hive.

Comb honey and freshly extracted combs may be quickly destroyed or heavily damaged if not properly handled when removed from the hive. In subtropical and tropical climates, *Galleria* larvae often infest impure cakes of beeswax, slumgum, and wax cappings. In addition, honey bee breeders operating in warm