Honey Bee Pests, Predators, and Diseases

Second Edition

Edited by

Roger A. Morse and
Richard Nowogrodzki

HONEY BEE PESTS, PREDATORS, AND DISEASES, *Second Edition*

Edited by ROGER A. MORSE
and RICHARD NOWOGRODZKI

COMSTOCK PUBLISHING ASSOCIATES a division of
CORNELL UNIVERSITY PRESS Ithaca and London

Insects: Diptera (Flies)

Lloyd V. Knutson and William L. Murphy

Flies are known to be associated with honey bees as predators, ectoparasites, endoparasites, saprophages, and mimics. Adults of many species of robber flies (family Asilidae) prey on adult honey bees. All known species of bee-lice (family Braulidae) live in association with bees in the genus *Apis,* and five of the seven known species are restricted to *Apis mellifera* L. Adult bee-lice are ectoparasites of adult honey bees, and their larvae live in the combs. Endoparasites of adult honey bees include larvae of certain species of thick-headed flies (family Conopidae), tachinid flies (Tachinidae), flesh flies (Sarcophagidae), and blow flies (Calliphoridae). Larvae of some humpbacked flies (Phoridae) feed on honey bee larvae and prepupae. Each of the families Drosophilidae, Phoridae, and Sarcophagidae includes a few species whose larvae consume dead honey bees as well as other dead organisms; although they are saprophagous, some of these species have been incorrectly implicated as parasites of honey bees. Several dipterous pests of bees appear to be of only minor importance in their normal geographic ranges but could become major pests where their natural enemies and other population-limiting factors are inoperative. Many species of bee flies (Bombyliidae), flower flies (Syrphidae), and soldier flies (Stratiomyiidae) are bee mimics, but none is an enemy of honey bees.

Predators

Asilidae (Robber Flies)

Distribution. About 5,000 species of asilids (robber flies), all predaceous, are known worldwide, with about 850 species in North America. Adults are relatively large (0.6-4.0 cm long) and feed on a variety of insects, including flies, wasps, dragonflies, grasshoppers, butterflies, and moths. Many species prey on honey bees. Asilid predators of honey bees have been reported widely (Robineau-Desvoidy 1836, Grassi and Parona 1881, Poulton 1906, Séguy 1927, Bromley 1930, 1945, Schmidt 1933, Briigger 1935, Zivojinović 1936, Örösi-Pal 1939c, Adamović 1949, 1950, 1963a, b, Linsley 1960, Bullington 1978) and are well known on all continents except Australia and Antarctica.

Because certain species of robber flies are locally abundant, they may have an impact on bee populations. Fattig (1945) recorded some 30 species of asilids captured with honey bees as prey in Georgia, U.S.A. The tendency for certain asilid species to prey on honey bees is reflected in the vernacular names applied to some members of the family. In North America, *Promachus fitchii* Osten Sacken is known as the Nebraska bee-killer; *Proctacanthus milbertii* Macquart as the Missouri bee-killer; *Saropogon dispar* Coquillett, *Diogmites angustipennis* Loew, and *D. symmachus* Loew as the Texas bee-killers; *Mallophora orcina* (Wiedemann) and *M. bomboides* (Wiedemann) as the southern bee-killers; and *M. nigra* Williston as the black bee-killer.

Adamović (1972) reported that the asilids *Dasypogon diadema* (F.) and *Molobratia teutonus* (L.) appear to prefer honey bees as prey over other available potential prey. In the area of Ulcinj, Yugoslavia, honey bees represented 78.4% (342 individuals) of the examined prey of *D. diadema* and 66% (148 individuals) of the examined prey of *M. teutonus.*

Biology. Although many species of asilids prey on honey bees and certain species show a marked predilection for them, none restricts its prey exclusively to honey bees. Many asilid flies mimic honey bees in color pattern, size, and shape. Linsley (1960) concluded that the sting of the honey bee does not prevent asilid attacks but that bee mimicry affords asilids some protection from their own predators and may also allow them to approach bees more easily.

Some of the most detailed observations concerning asilid predation on honey bees have been conducted by Adamović (1963a, b) in Yugoslavia. Described are hunting and feeding habits, mating behavior, egg laying, diel periodicity, populations, territories, and natural enemies of 14 species of honey bee-killing asilids. Powell and Stage (1962) and Linsley (1960) studied prey selection and other behavioral aspects of bee-killing asilids in relatively natural areas, i.e., areas without extensive beekeeping activity. Linsley (1960) found that several asilid species showed distinct prey preferences when they hunted together where many kinds of potential prey were available, whereas Powell and Stage (1962) reported that the *Stenopogon engelhardti* Bromley populations that they studied had a broad hunting range and preyed opportunistically.

Control. According to Powell and Stage (1962), biased sampling by researchers as well as opportunistic predation by asilids near apiaries are the major reasons for the large number of records of honey bees as prey of asilids. Linsley (1960) obtained no numerical data on the role of asilids in honey bee population control during his studies in relatively natural areas, but he noted that indirect evidence suggested that asilids, when abundant, may serve as a general depressant on flower-visiting populations of bee and wasp species. Analysis of prey records indicates that even some of the notorious "bee-killers" feed to a much greater extent, particularly as larvae, on pest insects than on honey bees and thus should be considered beneficial.

Control of asilids would be difficult because their eggs are minute and are dispersed widely, the larvae and pupae are inaccessible (in soil or rotting wood), and the fast-flying adults are particularly mobile and wide-ranging.

Phoridae (Humpbacked Flies)

Distribution. About 2,500 species of phorids (humpbacked flies) are known worldwide, with about 230 species in North America. Most species are small (2-4 mm long). Although the family includes a number of parasitic forms that attack honey bees as well as other insects, arachnids, and molluscs (Perez 1975), the best known phorid pest of honey bees, *Pseudohypocera kerteszi* Malloch, is a predator that has been found in Mexico (Reyes O. 1983), Colombia (G. Robinson 1981), and Brazil (Pérez 1975).

Biology. Pseudohypocera kerteszi (= *P. nigrofascipes* Borgmeier and Schmitz) is a tiny (2.3-3.0 mm long) fly that attacks the nests of social bees, including the honey bee (Borgmeier 1924). The larvae of *P. kerteszi* feed first on pollen stocked by bees in cells, and later, as the population density of the fly increases or as the bee colony weakens as a result of inclement weather, they feed on bee larvae and prepupae. In one report from Colombia, infestation by *P. kerteszi* of honey bee hives was thought to have been responsible for the death of brood and the absconding of as many as 180 colonies and nuclei (Robinson 1982).

Control. Problems involved in artificially rearing phorids previously hindered the development of control methods for use with hives. Chaud-Netto (1980a) developed an artificial rearing technique in Brazil that enabled researchers to study the biology of *P. kerteszi.* Continued research may allow the development of control methods for this potentially dangerous pest.

Ectoparasites

Braulidae (Bee-lice)

The insects called bee-lice are not true lice (orders Anoplura and Mallophaga) but are actually minute (1.2-1.5 mm long), highly modified, wingless flies. The relationship of the Braulidae to other dipterans has always been and continues to be enigmatic (see Grimaldi and Underwood 1986 for a history of the placement of the Braulidae). Adult braulids lack halteres and wings, the antennae and eyes are reduced, the thorax is concentrated, and the claws are especially adapted for ectoparasitism on bees. One species, *Braula coeca* Nitzsch, has been an immigrant to the United States several times but has rarely become established in apiaries here, except in Maryland, where it is known to be widespread (Morse 1981, Smith and Caron 1984b).

Distribution. Bee-lice are found on every major continent (Nixon 1982, Smith and Caron 1984b, Bradbear 1988). They were probably introduced into the United States along with the first shipments of honey bees in colonial times and have been observed sporadically in 14 states (Smith and Caron 1984a) (Figure 1).

Örösi-Pal (1966) published a comprehensive study of the classification of the Braulidae, based in part on the structure of the male and female genitalia and the eggs. He recognized five species and two subspecies in one genus: *Braula coeca coeca* Nitzsch in Europe, Africa, Australia (Tasmania), and the United States; *B. coeca angulata* Örösi, widespread in Asia, southern Europe, and South America; B. *orientalis* Örösi in the U.S.S.R. (Vladivostok), Turkey, Egypt, and Israel; *B. pretoriensis* Örösi in South Africa, Tanzania, and Zaire; and B. *kohli* Schmitz, known only from a male specimen from Zaire. A taxon reported as *B. coeca* Nitzsch is found also in Argentina (Bregante 1972), Trinidad and Tobago (Laurence and Mohammed 1974), and Venezuela (Stejskal 1967). Several braulid species may live within a single honey bee colony.

Grimaldi and Underwood (1986) recently proposed a new genus for two new braulid species from Nepal. The two species co-inhabit nests of *Apis laboriosa* Smith.

Biology. Phillips (1925), Örösi-Pal (1966), and Cantwell et al. (1975) discussed the biology of bee-lice. Braulids attach themselves firmly to bees by drawing their comblike claws through the branched hairs of the host. They apparently eat nectar and pollen at the bee's mouth and feed on material secreted by the host. The female lays her eggs on the inner and outer surfaces of the cappings of honey cells, not on brood cells. The larvae consume wax, honey, and pollen, tunneling through the wax combs. They pupate near the ends of the tunnels. After emergence, adults make their way to the surface of the comb. Dukov (1964) noted that *B. orientalis* requires 63-67 days to develop. Several generations are produced each season, with the largest populations being produced in late summer. Hassanein and Abd El-Salaam (1962) state that *B. coeca coeca* requires 16-23 days to develop.

In field and laboratory tests in Maryland, U.S.A., Smith and Caron (1984b) found that *B. coeca* prefer younger worker bees to older ones, queens to workers or drones, and mated queens to virgin queens. Among 638 infested worker bees, 98.6% carried a single braulid, 1.2% harbored two each, and one (0.2%) had three. In the 18-colony study apiary, levels of infestation increased from April to May, decreased in May and June as the overwintered braulids died following oviposition, then increased through October, except for an unexplained decline during August.

Control. Bee-lice are usually considered to be harmless inquilines in honey bee colonies, but they may become pests in some areas because their larvae tunnel and despoil comb, and both larvae and adults steal food from bees. European researchers have reported finding large numbers of bee-lice, even several hundred, on a single queen (Morse 1981); such

numbers may reduce the fecundity of the queen and weaken the hive. Brief exposure to tobacco smoke will cause adult braulids to leave a queen honey bee (Bertrand, cited in Phillips 1925). Dukov (1964) noted that in the U.S.S.R. several periodic treatments of phenothiazine killed *B. orientalis* adults but not immatures. Atakishiev (1971b) recommended cutting the cappings off honeycombs to control immature stages of Braula while controlling adults by smoking infested colonies with tedion, Folbex, or phenothiazine.

Endoparasites

Each of the fly families Conopidae, Tachinidae, and Sarcophagidae includes species whose larvae are internal parasites and cause apimyiasis (*myiasis* is the infestation of any part of an animal by fly larvae).

Conopidae (Thick-headed Flies)

Conopid larvae (thick-headed flies) are medium-sized (0.3-1.5 cm long), solitary internal parasites of other insects, particularly bees and wasps. Conopids usually oviposit on their hosts during flight. Many species closely mimic wasps in appearance.

Distribution. About 500 species of conopids are known worldwide, with nine genera and about 70 species in North America. Hüttinger (1974) listed six species of conopids as reared from honey bees, although he noted that they parasitize other species of bees as well.

Three of the species he listed were from North America: *Physocephala marginata* (Say), *P. sagittaria* (Say), *Zodion fulvifrons* Say; and three were from Europe and the U.S.S.R.: *Thecophora apivora* Zimina, *T. longirostris* Lyneborg, *Z. notatum* Meigen. The bee-parasitizing behavior of *P. marginata* and *P. sagittaria* was described by Van Duzee (1934), that of *T. apivora* and *T. longirostris* by Zimina (1968), and that of *Z. fulvifrons* and *Z. notatum* by Severin (1937).

Biology. Smith (1966) reviewed the biology of the Conopidae and provided an extensive bibliography and list of host-parasite relationships. Hüttinger (1974) reported that the life histories and bee-parasitizing activities of conopids are very seldom observed, but provided an account on which the following description is based. The female deposits a first-instar larva on the abdomen of a host. The larva penetrates the host between the abdominal segments and feeds on haemolymph and muscle tissue. Later, after it has grown to fill the abdominal cavity completely, it forces its head into the thorax and begins to consume the flight muscles. The host at this point is no longer capable of flight and drags itself by means of its forelegs. Most often the conopid larva kills the host, but a few hosts may overwinter with the parasitic pupa remaining in the abdomen. If a honey bee hive is heavily parasitized by conopids, the dried, shriveled appearance of the dead bees is usually noticed by the beekeeper.

Hargreaves (1934) stated that in Uganda two parasitic flies, one an unidentified conopid and the other the tachinid *Rondanioestrus apivorus* Villeneuve, killed many hybrid worker bees that had been obtained by crossing local wild honey bees with Italian queens. Lundie (1965) recorded an unidentified conopid reared from honey bees in South Africa. Riedel and Shimanuki (1965) reported that during August and September 1965, some dead worker honey bees collected at Laramie, Wyoming, U.S.A., had been parasitized by the conopid *Physocephala texana* (Williston). The bees died before the parasite reached the second larval instar. Dissections showed that only workers were parasitized, probably while foraging (no adult Conopidae were seen in or around the hives). The incidence of parasitism (500 bees examined over a 2-week period) was 7.8%.

Baker and Delfinado-Baker (1983) reported on honey bees parasitized by a conopid of the genus *Physocephala* in Guatemala. The parasite, locally known as the "bee botfly," infested the abdomens of honey bees.

Control. Conopidae are such infrequent parasites of honey bees that no control measures have been developed or seem necessary.

Tachinidae

The family Tachinidae is the second largest family in the order Diptera, with about 8,000 species known throughout the world, about 1,300 of which are known from North America. The larvae are endoparasites of many kinds of insects, especially larval butterflies and moths, sawflies, and beetles, as well as of a few other classes of arthropods. Because some species of tachinids help control populations of major pest insects, the family as a whole is considered to be highly beneficial. Despite the family's wide range of hosts, the unusual species *Rondanioestrus apivorus* is the only tachinid known to be associated with honey bees. This species also is notable as the first fly to have been reported to cause apimyiasis (Villeneuve 1916).

Distribution. Rondanioestrus apivorus, the sole species in its genus, is known from South Africa and Uganda.

Biology. Skaife (1921) reported that the female tachinid hovers in front of the hive and deposits a newly hatched larva on a honey bee as the bee enters the hive. The larva penetrates into the abdomen of the bee through one of the intersegmental membranes, and within 4 weeks it occupies the entire abdomen. After the bee dies, the mature larva exits and pupates in the ground. The adult fly emerges after about 10 days. Hargreaves (1934) stated that this species of tachinid attacks both wild honey bees and hybrids of the latter with Italian honey bee queens. Van Emden (1944:417) noted that a specimen from Durban, South Africa "was bred on 1.VI.03 from a larva, found crawling on the glass of a solar wax-extractor; the pupal stage

lasted six weeks. There is also a worker of the Italian variety of Apis *mellifica* [= *Apis mellifera*] with a larva squeezed out of its abdomen by the same collector [A. C. Sewell] at Durban."

Control. Tachinids range so widely and are such infrequent parasites of honey bees that no control measures have been developed or seem necessary.

Sarcophagidae (Flesh Flies)

The family Sarcophagidae contains about 2,500 species worldwide and about 330 in North America. The food and feeding habits of the larvae are exceedingly diverse; most species are saprophagous, while a few are parasitic, particularly on beetles and grasshoppers. Most sarcophagids in the subfamily Miltogramminae lay their eggs in the nests of bees and wasps, where the larvae feed on materials with which the nests are provisioned. *Senotainia tricuspis* Meigen is a well-known endoparasite of honey bees, and two species in the genus *Sarcophaga* Meigen are saprophages in honey bee hives.

Distribution. Senotainia tricuspis is common and widespread throughout central and southern Europe and the Ukraine and has also been recorded from Algeria, Tunisia, and Australia *(Myiapis angellozi* Séguy, which was described from the larval stage, is a junior synonym of *S. tricuspis).*

Biology. Simintzis (1949) and Giordani (1956) described the biology of *S. tricuspis.* Females attack bees—usually the honey bee but occasionally *Bombus* species and other wild bees—as they leave the nest. The female deposits one or two tiny larvae on the intersegmental membranes between the head and thorax of the host. Boiko (1958) noted that attacks may be repeated every 6-10 seconds during the sunny parts of the day; one female fly may produce 700-800 larvae. The larva penetrates into the thoracic muscles and immediately develops to the second instar. It remains in this stage, feeding on haemolymph, as long as its host lives. When the bee dies (2-4 days after the infestation), the larva begins to feed on the solid tissues and molts to the third instar. It consumes the thoracic muscle and then either moves directly into the abdomen or breaks out of the thorax and re-enters through the abdominal wall. After consuming the contents of the abdomen, the larva leaves the bee, usually through one of the ventral intersegmental membranes. Larval development requires 6-11 days. If provided with another dead bee, the larva will enter and consume it, grow to a maximum length of 8-9 mm, then pupate in the ground. Giordani (1956) established that pupation could be completed successfully within a single bee host. Adults emerge in 7-12 days (Boiko 1958) or 16 days (Giordani 1956), or they overwinter in diapause. Simintzis and Fiasson (1951) stated that in France, August is the peak month of infestation and that only hives exposed to full sunlight are affected.

Control. Legislation has been passed and is enforced in some European countries to control the shipment of bees infested with *S. tricuspis.* Boiko (1949,1959) considered the parasite to be a serious pest in the U.S.S.R. He stated that hives of some apiaries in the Ukraine lost 73-78% of their bees, apparently as a result of infestation with *S. tricuspis.* He recommended controlling the parasite by painting the outer hive covers with a 1-2% DDT solution or capitalizing on the fly's attraction to white, glistening surfaces by capturing adults in white dishes of water and drowning them. Meged (1960), however, considered the latter technique to be ineffective.

Simintzis and Fiasson (1951) stated that colonies heavily infested with *S. tricuspis* show no sign of abnormality, even under close observation, but that perhaps a late depopulation occurs. Giordani (1956) noted no abnormal symptoms in colonies in which 80% of the bees were parasitized and reported that host bees fly and perform their work without any apparent hindrance. Simintzis (1958) determined that the mean lifespan of caged honey bees naturally parasitized with larvae of S. *tricuspis* was no shorter than that of unparasitized caged bees. Bees were also artificially infested by removing larvae from the fly uterus and placing them by means of a micropipette on the dorsal side of the membranes between the head and thorax of the bees. With this treatment, 3-22% of the artificially infested bees were successfully parasitized, but their hives were apparently unaffected. According to Simintzis (1958), no pathogenic effect was detected as a result of this parasitic infection.

Calliphoridae (Blow Flies)

Distribution. The family Calliphoridae (blow flies) includes 1,000 species worldwide, with about 80 species in North America. Most species are about the size of the house fly and are green, blue, or gray. Most are scavengers; the larvae live in carrion, excrement, and similar materials. A few species, such as the screwworm fly, *Cochliomyia hominivorax* Coquerel, are parasitic, but only one species, in the genus *Pollenia,* has been found to parasitize honey bees.

Biology. In 1981, larvae of a species of the calliphorid genus *Pollenia* were discovered in crawling honey bees from apiaries in Egypt, and their development was described by Ibrahim (1984). Larvae of this species feed on the soft tissues of the thorax for about 2 days, after which the honey bee dies. The larvae continue to feed on the contents of the thorax, then enter the abdomen, either from inside the infested individual or through one of the first abdominal intersegmental membranes. The larvae feed on the abdominal contents until they mature, at which time they gnaw through the integument of the tip of the bee abdomen and emerge to pupate. Adults kept in jars and supplied with live honey bees and offered diluted honey did not parasitize the bees, an indication that natural parasitization occurs outside honey bee hives.

Control. Calliphorids are such infrequent parasites of honey bees that no control measures have been developed.

Phoridae (Humpbacked Flies)

At least eight species of humpbacked flies (family Phoridae) in the genus *Melaloncha* are common parasites of *A. mellifera* in the New World tropics (Ramirez 1984). Ronna (1936) reported high mortality of European honey bees near Rio de Janeiro, Brazil, as a result of parasitism by *Melaloncha ronnai* Borgmeier. More recently, Van de Sande et al. (in press) documented parasitism of Africanized honey bees in Brazil by this species: mortality was reported in six apiaries in Minas Gerais in 1985 and seven in Santa Catarina in 1986. Apiaries that were near native vegetation suffered the heaviest losses. Parasitized bees moved or flew with difficulty, had tremors, and finally died. Dissected thoraxes contained one or sometimes two larvae or pupae, from which adult phorids emerged in about 20 days.

Female *Melaloncha* apparently oviposit through the intersegmental membranes of the abdomen of a bee host, where the first larval stages develop (Ramirez 1984). After the bee dies, the larva migrates to the thorax, where it completes its development and pupates. The genus *Melaloncha* is restricted to the Neotropics, where most species parasitize meliponid bees (Borgmeier 1935). The parasitized condition of the bees has been referred to as *autumn disease.*

Saprophages

Sarcophagidae (Flesh Flies)

Endoparasitic members of the family Sarcophagidae are discussed above. In addition, Séguy (1965) recorded *Sarcophaga nigriventris* Meigen, and Ronna (1936) recorded *S. surrubea* Van der Wulp (= *Helicobia morionella* [Aldrich]), as parasites of honey bees, but the larvae of these species are primarily saprophagous and also feed on many other arthropods, primarily sick individuals. These two species should probably be considered as saprophagous in regard to honey bees.

Drosophilidae (Pomace Flies)

The Drosophilidae is a large family of small flies (3-4 mm long) known as pomace flies, many of which are very common. About 180 species are known from North America. Larvae of most species are found in decaying fruit and fungi. Larvae of a few species are ectoparasitic on caterpillars, and others prey on mealybugs and other small Homoptera. The cosmopolitan *Drosophila busckii* Coquillett has been reported as a parasite of honey bees (Mages 1956), but it is almost certainly saprophagous, feeding on dead organic material of many kinds. *Cacoxenus indagator* Loew lives as a "social parasite," a scavenger, in the nests of various carpenter bees and mason wasps.

Phoridae (Humpbacked Flies)

The humpbacked flies (family Phoridae) include the species *Megaselia* (= *Aphiochaeta) rufipes* (Meigen), whose larvae feed on a great variety of dead or decaying plants and animals, including dead bees, in Europe (Clout 1956). This phorid has apparently been misidentified as *Phora incrassata* (Meigen) (also known as *Hypocera incrassata* [Meigen] and *Borophaga incrassata* [Meigen]), and listed as a parasite of honey bees (Packard 1869).

Bee Mimics

Flies that show the most extensive and striking superficial similarities to bees have only limited relationships with honey bees. Many bee flies (Bombyliidae) are obvious mimics of bees and associate with them in exploiting the nectar of flowers. The larvae of many species of Bombyliidae are parasites, predators, or scavengers in the nests of solitary bees, but none is known to be a honey bee enemy. Included among the species of flower flies (Syrphidae) and soldier flies (Stratiomyiidae) are many bee mimics that feed in the same flowers as their bee models, but none is a pest of honey bees.

Acknowledgments

We thank Aubrey G. Scarbrough, Department of Biology, Towson State University, Towson, Maryland, U.S.A.; F. Christian Thompson, Systematic Entomology Laboratory, USDA-ARS; and H. Shimanuki, Beneficial Insects Laboratory, USDA-ARS, for their thorough reviews of this manuscript. We thank Norman E. Woodley for supplying information on the number of species of calliphorid and sarcophagid flies. Special thanks are due to Dewey M. Caron for granting us permission to use his illustration.

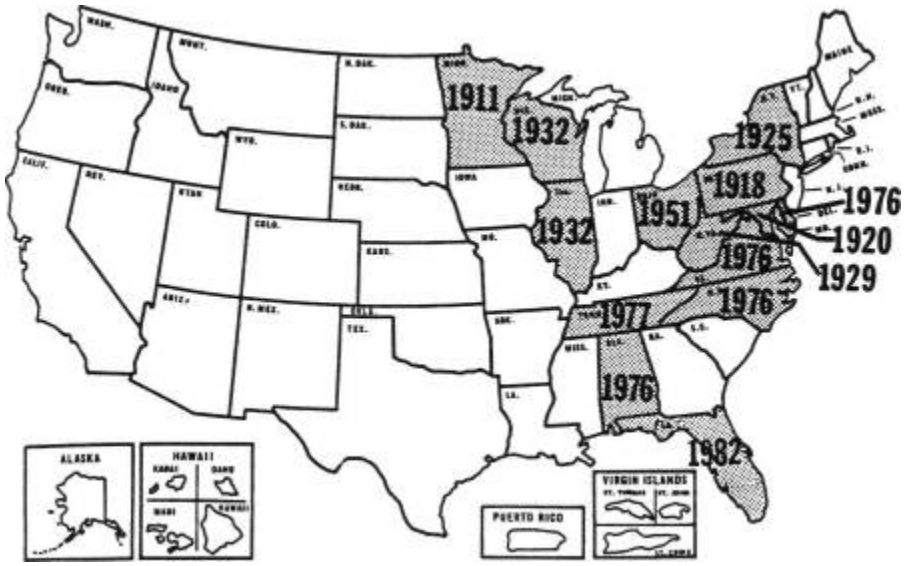

Figure 8.1. Known distribution of the bee-louse, *Braula coeca,* in the United States. The shaded areas indicate states in which bee-lice have been recorded, and dates indicate the year they were first observed. (Courtesy of D. M. Caron and *American Bee Journal.)*

Figure 8.2. Braula coeca adult. (Photo by G. L. Williams, Maryland Dept. of Agriculture.)

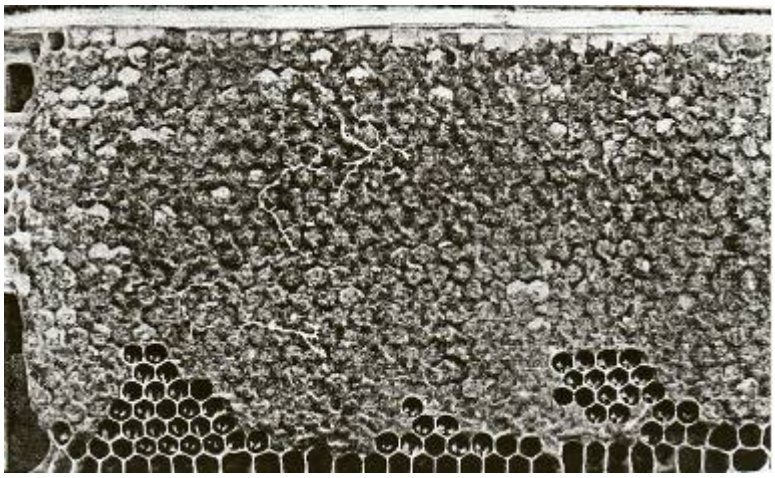

Figure 8.3. Tunnels made by *Braula coeca* larvae in cappings of honey comb. (Photo by I. B. Smith, Jr., Maryland Dept. of Agriculture.

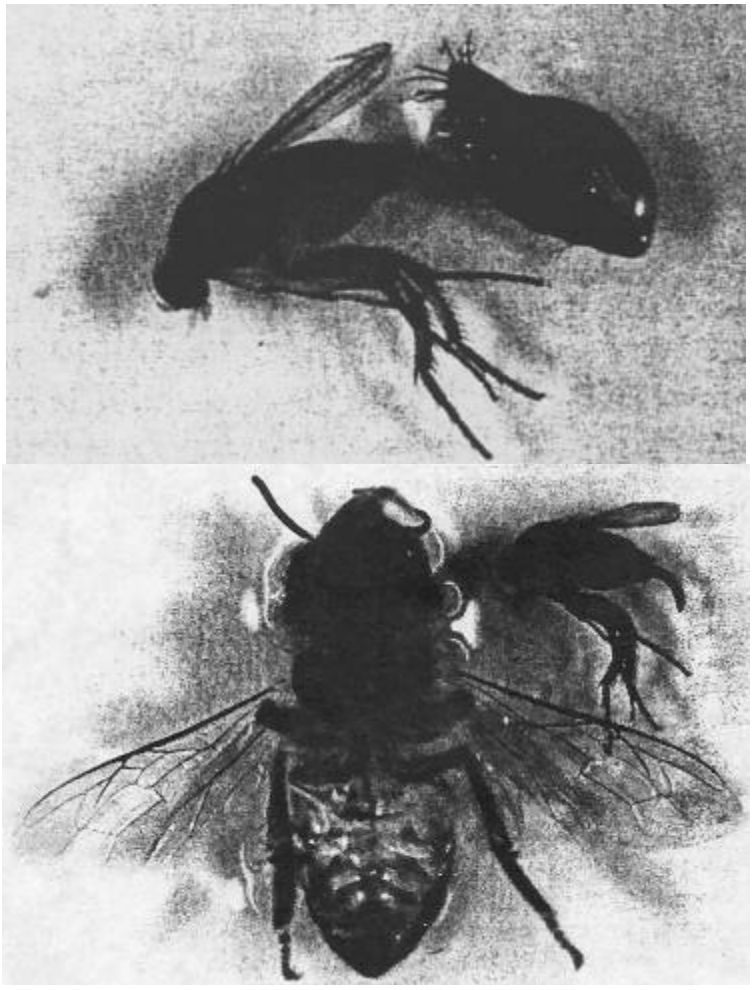

Figure 8.4. Top: Adult and pupa of the phorid fly *Melaloncha ronnai*, which parasitizes honey bees in Brazil. *Bottom*: An adult fly next to a worker bee, for size comparison. (Photos by M. W. C. M. Van de Sande.)