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TEXAS AGRICULTURAL EXPERIMENT STATION

BULLETIN NO. 231 JUNE, 1918

DIVISION OF ENTOMOLOGY

THE BEEMOTH OR WAXWORM

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COLLEGE STATION, BRAZOS COUNTY, TEXAS.

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

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*As of July 1, 1918.
**In cooperation with A. & M. College of Texas.
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BULLETIN NO. 231 JUNE, 1918

THE BEEMOTH OR WAXWORM

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STATE ENTOMOLOGIST, ENTOMOLOGIST IN CHARGE

INTRODUCTION

This paper is a revision of Bulletin 158 of this Station, now out of print. The continued interest manifested in the beemoth makes this revision and reprint necessary. Additional information has been derived from experiments in the practical control of this pest since the first treatise appeared in the aforementioned bulletin in 1913.

In modern works on apiculture the opinion is expressed that in the present age of modern beekeeping the beemoth cannot be judged a pest of the apiary. It is not only true that box hives favor this insect in its work of destruction, but that warm climates also favor it, even where movable frame hives are used. The long open winters in the southern states allows this insect to feed freely on stored combs. No doubt as the practice of producing extracted honey grows in the northern states, that section will experience more trouble with the work of this insect in the stored combs.

At the present time the beemoth or waxworm is a serious hindrance to the beekeeping industry in Texas, as well as in all of the southern states. Many beekeepers no longer dread the beemoth but keep every colony provided with a vigorous queen. Under such conditions it is difficult for the beemoth to enter the hive to deposit its eggs. The waxworm has become very largely an enemy of the box hive and a destroyer of stored combs and honey and is found usually around the bee hive and in piles of used comb. In large apiaries, the wax and comb that is carelessly left lying around affords ample food for the insect to breed in. In this way the pest is maintained in a yard, ready to infect any weak colony. With many beekeepers the beemoth is a source of constant trouble, for if the bees are not closely watched and become queenless the colony is certain to become infested in a short time. If the beemoth once becomes established, it is hard to exterminate. At present the beekeepers are not able more than to keep this pest in check. It is hoped that a more thorough knowledge of the habits and life history of the insect will result in a better control of this enemy and a reduction of the loss now suffered from its ravages.

Almost every beekeeper is acquainted with the work of the insect, generally known as the "web worm" or "miller," but it is not commonly known that the worm, following maturity, develops into a moth or miller. The worms or larvae feed in protected places, within the comb, which makes them difficult to fight successfully.

HISTORY

This species was known to observers and beekeepers in very early times. Perhaps the first mention was that made by Aristotle, who lived in 384-322 B. C. Later Virgil (70-19 B. C.) made mention of the beemoth in his writings. In the first century, A. D. Columella, a Roman writer on agricultural subjects, mentioned the beemoth as an enemy to the honey bee. Reamur (1685-1757) in France told of the damage done by the beemoth. In Holland, Swammerdam (1637-1680) refers to species of the beemoth, commonly called at that time the "bee wolf." Linnaeus (1707-1778) in Sweden tells of the presence of this pest among the beekeepers of that country. The introduction of the beemoth into America occurred about the beginning of the nineteenth century. It is said that the pest was found in Australia prior to 1878 and in New Zealand it was not noticed until 1904. When this pest was introduced into Texas is not known.

DISPERSION

It has been said that man is the spreading agency of this pest. It is undoubtedly true in the larger sense, for it is very doubtful if the pest spreads fast through its own flight. The carelessness of the beekeeper is almost wholly responsible for the maintenance and spread of the waxworm. As beekeeping has progressed from Asia through Europe and Northern Africa to the North American continent and to the islands of the Pacific, so has been the spread of the beemoth. Wherever beekeeping has been introduced, a few years later the presence of the pest is recorded. Within small areas the spread of the pest is largely through the exchange of infested combs. In Texas it has not been traced, nor is the first location known. The dispersion seems to be restricted by the climatic conditions of Colorado and other western states. In these localities it has been introduced often but had failed to establish itself.

DISTRIBUTION

The beemoth is now found in much of northern Asia and Africa north of the desert, throughout Europe, Great Britain, North America, Australia, New Zealand, Ceylon and India. The distribution of this pest in Texas includes the following counties: Anderson, Atascosa, Bandera, Bastrop, Bee, Bell, Bexar, Blanco, Bosque, Bowie, Brazoria, Brazos, Brooks, Brown, Burleson, Burnet, Caldwell, Callahan, Cass, Cherokee, Coleman, Collin, Colorado, Comanche, Concho, Cook, Coryell, Crockett, Dallas, Delta, Ellis, Erath, Falls, Fannin, Fayette, Franklin, Freestone, Gonzales, Gregg, Grimes, Guadalupe, Hamilton, Harrison, Hays, Henderson, Hill, Houston, Hunt, Jasper, Jefferson, Karnes, Kaufman, Kendall, Kerr, Kimball, Lamar, Lampasas, Lavaca, Lee, Leon, Liberty, Limestone, Llano, Madison, McCullough, McLennan, Mason, McMullen, Medina, Milam, Mills, Morris, Navarro, Nolan, Nueces, Panola, Parker, Polk, Rains, Red River, Robertson, Rockwall, Runnels, Rusk, Sabine, San Jacinto, Schleicher, Shackelford, Smith, Stephens, Taylor, Travis, Trinity, Tyler, Uvalde, Val Verde, Waller, Ward, Washington, Wood, Wilson, and Williamson.

The dissemination of the beemoth in Texas has been very complete, for there are few counties in the State where bees are kept that are free from the pest today. The counties shown to be infested as reported by beekeepers include all of the important beekeeping counties of the State. There is no doubt that further inquiry will show the presence of this pest in still other counties.

SYSTEMATIC POSITION

The very early writers refer to the beemoth as *Tinea mellonella.* Later it was known as *Galleria cereana* Fabr, which genus was erected by Fabricius. A more careful search of the early records revealed that Linnaeus described two species of beemoths known as *Tinea mellonella* and *T. cereana.* Writers were then very confused and we find the beemoth called *G. cereana; G. alveria, T. cerella.* In early American literature this species is referred to as *G. obliquella* Walker. All recent publications on this insect refer to the species as *G. mellonella L.*

The name early applied to this species would indicate that it was placed in the family *Tineidae*, which contains many small fringe-winged moths, the larvae of which are often case-bearing. It can easily be seen how this might have been done, as the waxworms construct very substantial tunnels that might have been classed as cases. Today the beemoth is placed in the family *Galleriidae,* which is now included with the *Tineidae* as the micro-lepidoptera.

The lesser beemoth, a closely associated species, is now known as *Achroia grisella* Fabr. The two species of moths have often been confused by writers on beekeeping subjects. This species is not so widely distributed as the larger beemoth.

ECONOMIC IMPORTANCE

What this pest is costing the beekeepers of the State is hard to determine. The price of bees, honey and wax varies in the different sections of the State. Often the loss of colonies is attributed to other causes and frequently the presence of the beemoth is not detected. In the reports which have been received from beekeepers, no mention has been made of the loss of stored comb, but this must certainly be considerable.

The loss in some cases is very heavy. In the year 1911, 136 beekeepers reported losses varying from five per cent. to their colonies to as high as ninety-five per cent. Many more beekeepers reported the presence of the beemoth as "general," indicating that they suffered no small loss. In one very well kept apiary that has come under the observation of the writer, there has been an annual loss of three per cent. due to the beemoth. It is safe to say that in many of the larger apiaries throughout the State this loss is not uncommon, while in the smaller apiaries and in boxhive apiaries the loss is much greater, as was indicated by the reports referred to above. The census of 1910 shows approximately 295,000 colonies of bees in the State, and it is generally conceded that these figures are below the actual number. Assuming that five per cent. is the average annual loss of colonies due to the waxworm, including the large losses in the poorly kept apiaries, it is seen that the annual loss amounts to at least 14,000 colonies. At an average valuation of $4.00 per colony, this amounts to $56,000 a year, a very considerable annual tax on the beekeeping industry of the State. There is no way to arrive at the loss of combs and honey.

HOSTS

In India, according to T. B. Fletcher, the beemoth attacks wild bees, as well as domesticated. He says, "In India, in districts where bees are not domesticated, it attacks the combs of the wild honey bees to such an extent that the bees often desert their nests in disgust and swarm off and found a new one, while it is very rare to find a deserted comb which does not bear traces of the ravages of this pest." This is the only reference to the attacks of the beemoth on wild bees. Observations of the writer have never disclosed the presence of the beemoth in the domiciles of wild bees.

In the hives of domesticated bees, the midrib of the comb seems to be the preferred food. The old brood-rearing combs are preferred to the new combs. This is probably due to the taste of the beemoth for the cast skins of the bee larvae. The larvae, however, are never eaten by the waxworm, although the bee larvae may die in a badly infested comb. This may be due to a lack of nourishment, as the waxworm will devour pollen wherever it is found, stored in cells or as food for the bee larvae. Small quantities of honey are consumed by the waxworms. Propolis is eaten in small quantities. Although the frames and hive are eaten out for pupation it is doubtful if the wood is a food, but probably it is used slightly in the construction of the cocoon.

In stored empty combs the waxworm shows a decided preference to the combs in which brood has been reared. Of course, any comb is readily attacked and destroyed. In the case of stored honey, the comb is preferred as food and the honey is only eaten in small quantities. Honey cappings are readily devoured whenever found and often serve as the only food of the waxworm. It has been said that if fed on pure wax the worms will die. The writer observed one instance in which two full sheets of medium brood foundation were riddled by the waxworm.

METHODS OF STUDY

For the purpose of observing the details of oviposition, small pieces of old brood comb were used. For the observations on the larvae larger pieces of old brood comb were used, the small pieces of comb being placed in lantern globes having cheese cloth over the top. The habits of the moth were observed in the large rearing cages. Sometimes fresh cappings were supplied the moths for oviposition and for food for the larvae. There was no apparent difference in the activity of the adults with these two foods.

LIFE HISTORY

The larva ("webworm") upon reaching maturity, constructs a cocoon by means of silken threads which it is able to spin. After the cocoon is completed, the larva changes to the pupal stage. This is the stage in which the form of the larva is reconstructed to make the moth which will emerge later from the cocoon. The moths mate and the females deposit the eggs which hatch into the larva. This is called the "life cycle."

The life history of the moth has been assumed by almost every writer on the subject of beekeeping. No definite experiments, however, have been recorded of observations on the details of the life cycle of this insect in this country. The paper by Fletcher in 1911 gave data collected in India. In the United States it is certain that the details of the life cycle will vary much for there is evidence that even in this State there is a variation within the broods as well as a seasonal variation.

THE EGG

The egg is elliptical and pearly white in color. The shell is slightly roughened by wavy lines running across it diagonally at regular intervals. If the egg is not deposited on dark comb, it is very difficult to see and even then experience is necessary to detect all eggs present. There is a slight variation in the size of the egg, as is shown by the measurements given in the following table:

Table 1.—Measurements of eggs.

Date.	Number.	Length.	Width.
Jan. 15, 1913	9 eggs.......	.485 mm.	.440 mm.
Mar. 14, 1913	3 eggs.......	.473 mm.	.360 mm.
Mar. 25, 1913	9 eggs.......	.520 mm.	.400 mm.
April 2, 1913	10 eggs.......	.433 mm.	.378 mm

From the foregoing table the average length was .478 mm. and the average width was .394 mm. for the thirty-one eggs taken in the laboratory over a period of three months.

The embryonic development of the egg has not been studied, but a few observations have been made upon the incubation period. Throughout this period the egg gradually changes from a white to a yellow color. About four days before hatching, the developing larva becomes visible as a dark ring inside the shell. The perfectly formed larva can be distinctly seen for at least twelve hours before the shell bursts. During this time the larva is engaged in cutting an opening in the shell and its final emergence from the egg is made through a ragged hole in the top. After the larva is out of the shell it appears white and clear.

INCUBATION PERIOD

The period of incubation varies greatly with the brood and in the cooler portions of the year this period is irregular within the brood. The low temperature at which the vitality of the eggs is destroyed has not been determined.

In table 2 the eggs were from moths placed in an unheated room and during this period the temperature averaged 65° F.

Table 2.—Duration of egg stage, spring 1912.

Laid.	Hatched.	Period.
Mar. 8, 1912	April 4, 1912	27 days
Mar. 9, 1912	April 4, 1912	26 days
Mar. 10, 1912	April 4, 1912	25 days
Mar. 13, 1912	April 4, 1912	23 days
Mar. 13, 1912	April 4, 1912	23 days
Mar. 14, 1912	April 4, 1912	22 days
Mar. 21, 1912	April 4, 1912	14 days
Mar. 27, 1912	April 7, 1912	11 days

The average period of incubation of this brood was 21.8 days.

Table 3.—Duration of egg stage, fall 1912.

Laid.	Hatched.	Period.
Aug. 27, 1912	Sept. 3, 1912	7 days
Aug. 27, 1912	Sept. 3, 1912	7 days
Aug. 28, 1912	Sept. 3, 1912	6 days
Aug. 30, 1912	Sept. 5, 1912	6 days
Sept. 1, 1912	Sept. 7, 1912	6 days
Sept. 3, 1912	Sept. 10, 1912	7 days
Sept. 3, 1912	Sept. 11, 1912	8 days
Sept. 4, 1912	Sept. 12, 1912	8 days
Sept. 5, 1912	Sept. 14, 1912	9 days

These eggs were kept in the laboratory and the temperature averaged about 95° F. The average period of incubation of this brood was 7.1 days.

Table 4.—Duration of egg stage, winter 1912.

Laid.	Hatched.	Period.
Dec. 6, 1912	Dec. 11, 1912	5 days
Dec. 6, 1912	Dec. 12, 1912	6 days
Dec. 4, 1912	Dec. 13, 1912	9 days
Dec. 7, 1912	Dec. 14, 1912	7 days
Dec. 7, 1912	Dec. 15, 1912	8 days
Dec. 7, 1912	Dec. 16, 1912	9 days
Dec. 6, 1912	Dec. 18, 1912	12 days
Dec. 7, 1912	Dec. 20, 1912	14 days
Dec. 10, 1912	Dec. 23, 1912	13 days
Dec. 14, 1912	Dec. 26, 1912	12 days

These eggs were kept in the laboratory with artificial heat which averaged 80° F., although it was quite irregular. The average period of incubation of this brood was 9.5 days.

THE LARVA

DESCRIPTION

When first hatched the young larva (worm) is only one to three millimeters (1/25 to 1/8 of an inch) in length. They have a dirty white, waxy color. The head is slightly yellow and smaller than the prothoracic segment, which is decidedly prominent. The true or thoracic legs are especially well developed and the pro-legs or abdominal legs are not apparent when the larva is first hatched, and only appear normal when the larva is about three days old.

FEEDING HABITS

After emerging from the shell through a ragged hole, the larvae are quiet for a short time while they are apparently drying in preparation for their work of destruction. Soon they become active, but only upon close examination is it possible to detect them hurrying over the comb in their attempt to gain an entrance. Within a short time after hatching, the first meal is taken by the larvae. This consists of scales of wax which they can loosen from the comb in their attempts to gain an entrance. The larvae do not enter the comb near the eggs from which they hatched. In fact, several entrances are attempted before one is finished. This may be due to the extra hard comb in such areas or it may be that they are frightened and never return to continue. It was not observed whether entrances started are taken up by other larvae. The entrance is made at the top of the comb between the walls of adjoining cells. It is during this short period of an hour or more that the larvae are at the mercy of the bees but no doubt few if any are killed at this time in the dark hives.

The entrance is extended by the larvae into tunnels directed toward the center of the comb or the bottom of the cells. The presence of the larvae is readily noticeable as soon as the tunnels are well started. In making these tunnels the larvae push back of them and out of the tunnel bits of chewed wax not used for food. This makes the surface of the comb appear rough and poorly kept. These bits of chewed wax contain strands of the web of the larvae. It is evident that the web is secreted continually by the larvae. Some larvae leave their tunnels considerably and may even work two or three tunnels down to the midrib of the comb. During this period of reaching the center of the comb the growth of the larvae is very slow. During this time only a small proportion of the wax is consumed for food. These tunnels extending to the bottom of the cell are increased in size to accommodate the growth of the larvae, in which case only the thinnest wall protects them. The time consumed in extending the tunnels to the center of the comb varies greatly, from four to eight days.

When the center of the empty comb is reached, holes are cut through the bottoms of the cell walls and the larvae leave their tunnels and wander along the mid-rib from cell to cell. At this time the old tunnel serves as a shelter and it is enlarged. The material thrown out falls on the bottom of the cells. This refuse is about four-fifths chewed and webbed wax and one-fifth excrement. When the comb is disturbed, the larvae may run through three or four cells to their tunnels. At first only holes are eaten through the cells, but in a few days lines of web can be seen outlining the passageway from cell to cell. The holes are enlarged to admit free passage of the growing larvae. The silk spun by the larvae is numerous enough in the course of a few days to form a gallery which gives very good protection. If the larvae are shaken from the comb they seem lost for a time but shortly proceed in the direction of the comb. What causes them invariably to seek the comb it is impossible to say. If they encounter refuse before reaching the comb, they will avail themselves of such shelter. At all times the larvae avoid light as much as possible. When disturbed, the larvae will often drop by means of a thread. In this way they return to the exact place of feeding.

From this central gallery the feeding is extended out along the bottoms of the cells or the middle of the comb. The silk is spun wherever the larvae go, so that very soon the bottoms of the cells are replaced by a layer of silk thread covered with excrement of the larvae and particles of chewed wax. The time required for this varies, of course, with the temperature.

After the mid-rib has been eaten, the larvae start on the walls of the cells, the ones farthest away from the light being the first destroyed. As this feeding continues along the cell walls, the threads of silk are extended to cover the new feeding ground, and not only serve to protect the larvae but also act as a scaffold to support the damaged cells. Soon the center of the comb appears as a mass of tangled refuse and discarded wax. The feeding is at times that of a colony all working comparatively close together. At various places through the comb there are constructed false cocoons that serve as a protection to the larvae while they are resting during the day. When small pieces of comb were used, the larvae would leave the comb during the day and remain in well constructed galleries in the refuse under the comb. After the larvae were three-fourths grown, they worked practically none during the day although the cages were darkened. At night the gnawing of the larvae was distinctly audible. Dark comb is preferred for feeding to light comb. When small pieces of comb were used and additional food was necessary, another piece of empty comb was placed under the old comb. The larvae would immediately attack the new comb, going to the bottom of the cells, eating the mid-rib, lower cells, then upper cells, exactly as the first piece of comb was eaten.

The feeding continued until the walls were entirely eaten, but the top of the cells was never eaten, perhaps because this would expose them to outside influences and enemies. The area of feeding was gradually extended from the point of infestation finally to include the entire comb. If the comb does not furnish sufficient food the larvae begin to feed on the refuse under the comb in which there is considerable wax in small pieces. In this they construct such a large amount of web that they are absolutely protected from enemies.

In a few cages, balls of fresh cappings, containing normal amounts of honey, were supplied as food for the larvae. The entrance was usually made on the top side of the cappings. A tunnel was made as in the case of empty comb, directed toward the center of the ball. This tunnel, however, was not extended to the center but was extended around the mass, keeping a uniform distance from the surface. The refuse was thrown back and out of the tunnel as was done when feeding on empty comb. When the tunnel was extended around to a point just above the point of contact with the bottom of the cage, an exit was made. Here much refuse was accumulated and the larvae seemed to prefer to eat here. The growth of larvae feeding on cappings was slower than when feeding on comb and there was a greater variation in the growth.

When feeding on stored combs of honey, the worms apparently fed only on the comb, which allowed the honey to drip. The amount of chewed wax was not so great as when feeding on empty comb, nor were there so many webs visible.

LENGTH OF PERIOD

There was a great variation in the length of the larval period even within the brood when food and climatic conditions were apparently the same in all cages. Throughout the observations made on the feeding habits this fact was readily noticeable. In some cages this variation in the size of the larvae was apparent as early as seven days after hatching. This variation is much more apparent during the later part of the period, and during the colder portion of this year the variation is still more pronounced. As indicated above, the food has an effect upon the length of this period, it being greater when cappings were supplied than when empty comb was used.

Table 5.—Length of larval period, spring 1912.

Hatched.	Matured.	Period.
April 8, 1912	May 25, 1912	47 days
April 4, 1912	May 29, 1912	52 days
April 4, 1912	May 27, 1912	43 days
April 4, 1912	May 29, 1912	55 days
April 3, 1912	May 25, 1912	52 days
April 12, 1912	May 25, 1912	43 days
April 3, 1912	May 21, 1912	48 days
April 5, 1912	May 27, 1912	52 days

These larvae were kept in the laboratory at normal temperature with empty combs for food. The average length of the larval period of this brood was forty-nine days.

Table 6.—Length of larval period, fall 1912.

Hatched.	Matured.	Period.
Aug. 26, 1912	Sept. 25, 1912	30 days
Aug. 25, 1912	Sept. 25, 1912	31 days
Aug. 25, 1912	Sept. 27, 1912	33 days
Aug. 26, 1912	Sept. 28, 1912	33 days
Aug. 26, 1912	Sept. 30, 1912	35 days
Aug. 26, 1912	Oct. 2, 1912	37 days
Aug. 26, 1912	Oct. 4, 1912	39 days
Aug. 24, 1912	Oct. 5, 1912	42 days

These larvae were kept in the laboratory at normal temperature, with empty comb for food. The average length of the larval period of this brood was thirty-five days.

In the fall brood many of the larvae do not mature and pupate until cold weather occurs and a few larvae feed throughout the winter. At any time a comb was inspected there was a vast variation in the size of the larvae from eggs deposited at the same time.

Table 7.—Length of larval period, winter 1912-13.

Hatched.	Matured.	Period.
Sept. 4, 1912	Dec. 10, 1912	97 days
Sept. 9, 1912	Dec. 15, 1912	101 days
Sept. 7, 1912	Dec. 17, 1912	101 days
Sept. 5, 1912	Dec. 17, 1912	103 days
Sept. 3, 1912	Dec. 10, 1912	98 days
Sept. 6, 1912	Dec. 20, 1912	105 days
Sept. 14, 1912	Jan. 27, 1913	135 days
Sept. 13, 1912	Jan. 31, 1913	140 days

These larvae were kept in the laboratory with normal artificial heat, with empty comb as food. The average length of the larval period of these was 110 days.

No observations were made on the number of moults of the larvae.

DESCRIPTION

On September 15, 1912, ten specimens of mature larvae were measured and the average length was twenty millimeters. The head is small and pointed, reddish brown in color, with a light v-shaped line on top, this "v" opening towards the front of the head. The body is larger than the head, long, cylindrical, smooth except for a few short hairs. The general color is a dirty gray with the prothoracic shield brown and having a broad band across it.

PUPATION

Having completed its growth, the larva seeks a place in which to pupate, though sometimes the end of the feeding gallery may be enlarged and closed to serve as a cocoon. The cocoon may also be spun in the refuse under the comb and this mass of webs affords an excellent protection to the pupa. The most common places are cracks or corners about the hive, or between the frames and the hive or in the "bee space" at the end of the top bars. The larva prefers to get into a place which it can chew in order that a cavity may be constructed and the cocoon thus be better protected.

Having found the location for the cocoon, the larva begins the spinning of the silk thread about itself, starting just above the head and working backward more than the length of the body. A thin layer of silk is spun in the general shape of the cocoon and this frame work is covered with fine silk from the inside. The larva is able to reverse itself within the cocoon, which it does many times during its construction. The outer layer, upon hardening, becomes very tough, and even like parchment, while the inner layer remains soft and fluffy.

CONSTRUCTION OF COCOON

The time consumed in the spinning varies with the season and varies most in the cooler portions of the year. Within the brood there is some variation.

Table 8.—Period of cocoon construction, summer 1912.

Started.	Completed.	Period.
Aug. 10, 1912	Aug. 11, 1912	1 day
Aug. 10, 1912	Aug. 12, 1912	2 days
Aug. 10, 1912	Aug. 12, 1912	2 days
Aug. 10, 1912	Aug. 13, 1912	3 days
Aug. 10, 1912	Aug. 13, 1912	3 days
Aug. 10, 1912	Aug. 14, 1912	4 days
Aug. 10, 1912	Aug. 11, 1912	1 day
Aug. 11, 1912	Aug. 15, 1912	4 days
Aug. 11, 1912	Aug. 15, 1912	4 days
Aug. 11, 1912	Aug. 16, 1912	5 days
Aug. 11, 1912	Aug. 13, 1912	2 days
Aug. 11, 1912	Aug. 13, 1912	2 days
Aug. 12, 1912	Aug. 14, 1912	2 days
Aug. 12, 1912	Aug. 14, 1912	2 days
Aug. 12, 1912	Aug. 13, 1912	1 day
Aug. 12, 1912	Aug. 13, 1912	1 day
Aug. 12, 1912	Aug. 13, 1912	1 day
Aug. 13, 1912	Aug. 15, 1912	2 days
Aug. 13, 1912	Aug. 15, 1912	2 days
Aug. 13, 1912	Aug. 15, 1912	2 days

The average period of construction of the cocoon of this brood was 2.25 days. The cocoons were spun in cages in the laboratory with normal temperatures.

Table 9.—Period of cocoon construction, fall 1912.

Started.	Completed.	Period.
Oct. 25, 1912	Oct. 30, 1912	5 days
Oct. 24, 1912	Oct. 30, 1912	6 days
Oct. 25, 1912	Oct. 30, 1912	5 days
Oct. 25, 1912	Oct. 30, 1912	5 days
Oct. 27, 1912	Oct. 30, 1912	3 days
Oct. 29, 1912	Oct. 30, 1912	3 days
Oct. 26, 1912	Oct. 31, 1912	5 days
Oct. 26, 1912	Oct. 31, 1912	5 days
Oct. 26, 1912	Oct. 31, 1912	5 days
Oct. 26, 1912	Oct. 31, 1912	5 days

These cocoons were spun in cages in the laboratory with normal artificial heat. The average period of construction of this brood was 4.73 days.

THE PUPA

TRANSFORMATION

As the cocoon nears completion, the larva becomes very sluggish, and the body shortens. The last act of the larva is to make an incision in the cocoon near the head end which provides for the easy emergence of the moth at maturity. The time required in the transformation from the larva to the pupa varies with the broods and somewhat within the broods.

Table 10.—Transformation period, summer 1912.

Larva.	Pupa.	Period.
Aug. 13, 1912	Aug. 15, 1912	2 days
Aug. 7, 1912	Aug. 15, 1912	8 days
Aug. 10, 1912	Aug. 15, 1912	5 days
Aug. 13, 1912	Aug. 15, 1912	2 days
Aug. 14, 1912	Aug. 16, 1912	2 days
Aug. 13, 1912	Aug. 16, 1912	3 days
Aug. 11, 1912	Aug. 20, 1912	9 days
Aug. 17, 1912	Aug. 20, 1912	3 days
Aug. 14, 1912	Aug. 20, 1912	6 days
Aug. 16, 1912	Aug. 21, 1912	5 days
Aug. 19, 1912	Aug. 21, 1912	2 days
Aug. 18, 1912	Aug. 21, 1912	3 days
Aug. 18, 1912	Aug. 22, 1912	4 days
Aug. 19, 1912	Aug. 22, 1912	3 days
Aug. 19, 1912	Aug. 22, 1912	3 days
Aug. 19, 1912	Aug. 22, 1912	3 days
Aug. 19, 1912	Aug. 23, 1912	4 days
Aug. 19, 1912	Aug. 23, 1912	4 days
Aug. 21, 1912	Aug. 23, 1912	2 days
Aug. 21, 1912	Aug. 23, 1912	2 days

This transformation took place in the cages in the laboratory at normal temperature. The average period of transformation of this brood was 3.75 days.

Table 11.—Transformation period, fall 1912.

Larva.	Pupa.	Period.
Oct. 23, 1912	Oct. 29, 1912	6 days
Oct. 23, 1912	Nov. 3, 1912	11 days
Oct. 23, 1912	Oct. 29, 1912	6 days
Oct. 22, 1912	Oct. 28, 1912	6 days
Oct. 22, 1912	Oct. 27, 1912	5 days
Oct. 21, 1912	Oct. 27, 1912	6 days
Oct. 24, 1912	Nov. 3, 1912	10 days
Oct. 20, 1912	Oct. 25, 1912	5 days
Oct. 20, 1912	Oct. 25, 1912	5 days
Oct. 23, 1912	Oct. 27, 1912	4 days

This transformation took place in the laboratory with normal artificial heat. The average period was 6.40 days.

DESCRIPTION

The newly formed pupa is white. At the end of the first twenty-four hours it turns to a straw color, very light at first, deepening slowly. By the end of the fourth day the pupa is light brown and this color gradually deepens, so that by the end of the pupal period the insect is dark brown. The male pupae average fourteen millimeters (about two-thirds of an inch) in length and the female pupae are fully sixteen millimeters in length. A row of spines arises just back of the head and extends to the fifth abdominal segment; the body line is somewhat curved downward.

DURATION OF PUPAL STAGE

The pupal stage varies greatly with the seasons, being especially long during the fall and winter.

Table 12.—Duration of pupal stage, 1912.

Pupated.	Emerged.	Period.
Jan. 17, 1912	Mar. 9, 1912	52 days
Jan. 18, 1912	Mar. 3, 1912	45 days
Jan. 18, 1912	Mar. 7, 1912	49 days
Jan. 21, 1912	Mar. 11, 1912	51 days
Jan. 20, 1912	Mar. 9, 1912	49 days
Jan. 20, 1912	Mar. 15, 1912	55 days

These pupae were in cages in the laboratory with no artificial heat. The average length of the period was fifty days.

Table 13.—Duration of pupal stage, 1912.

Pupated.	Emerged.	Period.
Aug. 12, 1912	Aug. 20, 1912	8 days
Aug. 13, 1912	Aug 19, 1912	6 days
Aug. 12, 1912	Aug. 19, 1912	7 days
Aug. 12, 1912	Aug. 18, 1912	6 days
Aug. 11, 1912	Aug. 20, 1912	9 days
Aug. 14, 1912	Aug. 21, 1912	7 days
Aug. 13, 1912	Aug. 21, 1912	8 days
Aug. 13, 1912	Aug. 24, 1912	9 days
Aug. 14, 1912	Aug. 23, 1912	8 days
Aug. 15, 1912	Aug. 23, 1912	9 days
Aug. 16, 1912	Aug. 24, 1912	8 days
Aug. 16, 1912	Aug. 24, 1912	8 days
Aug. 17, 1912	Aug 25, 1912	8 days
Aug. 17, 1912	Aug. 25, 1912	8 days
Aug. 18, 1912	Aug. 24, 1912	6 days
Aug. 18, 1912	Aug. 26, 1912	8 days
Aug. 19, 1912	Aug. 29, 1912	10 days
Aug. 18, 1912	Aug. 26, 1912	8 days
Aug. 20, 1912	Aug. 27, 1912	7 days
Aug. 20, 1912	Aug. 27, 1912	7 days

These pupae were in cages in the laboratory with normal temperature. The average length of the period was 7.85 days.

Table 14.—Duration of pupal stage, 1912.

Pupated.	Emerged.	Period.
Oct. 31, 1912	Nov. 20, 1912	21 days
Nov. 1, 1912	Nov. 20, 1912	19 days
Nov. 2, 1912	Nov. 22, 1912	19 days
Nov. 3, 1912	Nov. 24, 1912	21 days
Nov. 1, 1912	Nov. 22, 1912	21 days
Nov. 6, 1912	Nov. 24, 1912	18 days
Nov. 6, 1912	Nov. 21, 1912	18 days
Nov. 1, 1912	Nov. 15, 1912	15 days
Nov. 7, 1912	Nov. 25, 1912	18 days
Nov. 7, 1912	Nov. 25, 1912	19 days

These pupae were in cages in the laboratory with normal artificial heat. The average length of the pupal period was 18.9 days.

Table 15.—Duration of pupal stage, 1912.

Pupated.	Emerged.	Period.
Nov. 3, 1912	Nov. 30, 1912	27 days
Nov. 1, 1912	Nov. 30, 1912	30 days
Oct. 26, 1912	Dec. 1, 1912	35 days
Oct. 28, 1912	Dec. 5, 1912	38 days
Nov. 10, 1912	Dec. 20, 1912	40 days
Nov. 1, 1912	Dec. 15, 1912	45 days
Nov. 1, 1912	Dec. 15, 1912	45 days

These pupae were kept under the same conditions as those recorded in table 14. From this it is obvious that a portion of the pupae have a prolonged period. For those recorded in table 15 the average length of the period was 35.5 days.

ADULTS

DESCRIPTION

Although very familiar to many beekeepers, the beemoth is yet not definitely known to many who should be acquainted with it in order that they might more readily combat it. Having been a pest for such a long time, it is remarkable that more beekeepers are not acquainted with this pest of the apiary. Perhaps the reason that these moths are not more commonly known is due to the fact that they are seldom to be seen on the wing, except at dusk, unless frightened from their hiding places.

The adult beemoth is about five-eighths of an inch (fifteen millimeters) in length, with a wing expanse of about one and one-quarter inches (thirty to thirty-two millimeters). The moth with its wings folded appears ashy gray in color but the back third of each front wing is bronze colored. This wing is thickly covered with fine scales which rub off easily when the moth is touched. On the outer and rear margins of the forewing is a scanty row of short hairs. The hind wings are uniform in color, usually gray, with traces of a few black lines extending from the outer margin inward toward the base; on the outer and rear margins is a thick fringe of hairs on which is a dark line running parallel with the border of the wing. The body is brown, the shade varying with a covering of scales. These scales rub off easily and are not always present on the older moths. The male is slightly smaller than the female. A difference between the sexes is noticed in the fore-wing, which in the case of the male is deeply scalloped on the outer margin. This scallop carrier a heavy fringe of hairs, almost black in color. Another difference is in the mouth parts, the palpi of the male being rudimentary.

EMERGENCE

The moths emerge during the first part of the evening. In the cages emergence started just before sundown (6:30 p. m.) and no moths emerged after 9 p. m. They at once sought some protected place in which to expand their wings and dry, and by the next morning they were able to fly.

The first and last emerging individuals of the brood are smaller in size than the average, regardless of sex. The quantity of the food has a great deal to do with the size of the adults. The last larvae of the brood are always undersized, but are almost always able to pupate and reach maturity.

DURATION OF LIFE

In no instance were the moths of either sex seen to feed during their existence. In many cages fresh cappings were supplied for oviposition but the honey in those cappings did not serve as food for the moths. No other attempts were made to supply food to the moths. The duration of the life of the adults varies greatly, apparently depending upon several conditions, retarded fertilization and oviposition, brood and temperature conditions. The males usually live longer than the females, as shown in table 16. The average length of the life of a female was twelve days and the average length of the life of the male was twenty-one days. The average time that the male lived longer than the female was nine days.

Table 16.—Length of adult life.

Date.	Female lived.	Male. lived.
Jan. 5, 1912	21 days	30 days
Sept. 5, 1912	6 days	18 days
Sept. 9, 1912	11 days	21 days
Sept. 9, 1912	12 days	18 days
Sept. 10, 1912	12 days	21 days
Sept. 19, 1912	21 days	21 days

PROPORTION OF SEX

On October 25, 1912, 182 larvae were placed in separate vials to determine sex and rate of emergence. The results are shown in table 17.

Table 17.—Proportion of sex.

Date.	Males.	Females.
Nov. 20, 1912	3	0
Nov. 21, 1912	5	4
Nov. 22, 1912	5	5
Nov. 23, 1912	4	4
Nov. 24, 1912	3	3
Nov. 25, 1912	1	1
Nov. 26, 1912	2	3
Nov. 27, 1912	2	5
Nov. 29, 1912	1	1
Nov. 30, 1912	5	6
Dec. 1, 1912	0	2
Dec. 2, 1912	13	14
Dec. 3, 1912	3	9
Dec. 4, 1912	0	4
Dec. 5, 1912	1	2
Dec. 6, 1912	2	3
Dec. 7, 1912	4	6
Dec. 8, 1912	3	9
Dec. 9, 1912	2	0
Dec. 10, 1912	1	0
Dec. 11, 1912	7	6
Dec. 12, 1912	11	16
	78	104

The results that are given would seem to indicate a preponderance of females and a tendency of the males to emerge somewhat ahead of the females.

Another collection of eighty-five larvae was made on November 29, 1912, and each larva was placed in a separate vial. The emergence record of this collection is shown in table 18.

Table 18.—Proportion of sex.

Date.	Males.	Females.
Dec. 1, 1912	2	0
Dec. 11, 1912	7	6
Dec. 12, 1912	14	13
Dec. 19, 1912	3	19
Dec. 26, 1912	3	3
Jan. 18, 1913	0	2
Jan. 19, 1913	2	1
	31	44

In this case there were more females than males and the early emergence of the males is more pronounced than in table 16.

On November 30, 1912, another collection of sixty-one larvae was made. These larvae were placed in separate vials to observe the emergence of the adults. The results are shown in table 19.

Table 19.—Proportion of sex.

Date.	Males.	Females.
Dec. 26, 1912	7	6
Dec. 30, 1912	6	7
Jan. 3, 1913	10	10
Jan. 6, 1913	2	12
Jan. 18, 1913	0	1
	25	36

The females predominate in this collection, as in those of the first two shown in tables 16 and 17. Of the 318 larvae observed 184 developed into females and 134 into males.

HABITS

During the day the moths seek a sheltered place away from light and enemies, where they apparently settle down and draw their wings around them, remaining very quiet. Usually they are well protected by their color, which resembles weatherbeaten wood. If disturbed during the day, the moths will make a dart or short flight, acting as though blinded by light. When an object is met, the moth quickly settles down and seems very anxious to avoid flight. That the moths are hard to disturb in the daytime is shown by the fact that in several of the cages used in the experiments small ants attacked the moths and killed them without any apparent struggle on the part of the latter. Only by close examination could it be detected that the moths were dead and not resting in the usual manner. It is only during the later part of the oviposition period that the females are active during the daytime. The male moths are very active throughout their existence.

PERIOD BETWEEN EMERGENCE AND COPULATION

The moths under normal conditions probably mate soon after emergence. No cage observations were recorded but a series of unmated females were killed and examined to determine the condition of the eggs. The first moth was killed one hour after emergence. Many of the eggs were full size but were not close to the ovipositor. The second moth was killed fourteen hours after emergence. In this moth fully one-third of the eggs were fully developed and a very few were close to the ovipositor. The third moth was thirty-eight hours old when killed. Four eggs were extruded before death. The eggs were crowded close to the oviduct and were well rounded, the immature eggs being somewhat flattened on the ends. A count was made of 1128 eggs, 700 of which were full sized. The fourth moth was sixty-two hours old when killed. Fully two-thirds of the eggs were full sized, the remainder varying in size. The fifth moth was eighty-six hours old when killed. In this moth fully three-fourths of the eggs were full sized and they were closely packed in the lower portion of the reproductive organ. The next female was 110 hours old when killed. The eggs were of the same comparative size and condition as in the previous moth. Those eggs nearest the ovipositor, however, assumed a yellowish color. The next moth killed was 134 hours old. The proportion of full sized eggs was the same as in the two previous cases noted but the smaller eggs were increased in size.

LIFE OF UNMATED FEMALES

Several observations were made on the length of life of the unmated females, which period is very irregular. The results of these observations are shown in table 20.

Table 20.—Life of unmated females.

Emerged.	Died.	Period.
Mar. 19, 1912	Mar. 27, 1912	8 days
Mar. 18, 1912	Mar. 26, 1912	8 days
Aug. 14, 1912	Aug. 22, 1912	8 days
Aug. 25, 1912	Aug. 31, 1912	6 days
Aug. 20, 1912	Sept. 9, 1912	19 days
Aug. 30, 1912	Sept. 9, 1912	10 days
Aug. 30, 1912	Sept. 9, 1912	10 days
Aug. 30, 1912	Sept. 9, 1912	10 days
Sept. 1, 1912	Sept. 16, 1912	15 days
Aug. 31, 1912	Sept. 19, 1912	19 days
Nov. 20, 1912	Dec. 11, 1912	20 days

MATING

During the mating period the males are more active than the females, and at this time can be noticed "drumming" with their wings, the vibrations of which are at times sufficient to produce a low hum.

Mating takes place at night, as would naturally be expected from the nocturnal habits of the species. In one case a pair of moths were observed *in coitu* early in the morning, but this was no doubt an abnormal condition and the female died in a short time. Another case was observed when the moths were *in coitu* from 7 p. m. till 10:30 p. m. The next morning no eggs were deposited, but the following night the female began ovipositing. This was an exceptional case, as the female had been confined for a week after emergence before having the opportunity to mate.

AGE AT BEGINNING OF OVIPOSITION

The females begin to oviposit in a comparatively short time after emergence. This period, of course, varies with the brood and within the brood. The comparative age of the male and of the female undoubtedly has an influence on the length of this period. The results of the observations on the age of the female when the first eggs are deposited are shown in table 21.

Table 21.—Age of female.

Emerged.	First eggs.	Age.
Mar. 8, 1912	Mar. 14, 1912	6 days
Mar. 6, 1912	Mar. 21, 1912	15 days
Aug. 29, 1912	Sept. 1, 1912	3 days
Aug. 26, 1912	Sept. 2, 1912	7 days
Aug. 31, 1912	Sept. 2, 1912	7 days
Aug. 29, 1912	Sept. 3, 1912	3 days
Aug. 29, 1912	Sept. 3, 1912	5 days
Aug. 28, 1912	Sept. 3, 1912	5 days
Aug. 30, 1912	Sept. 3, 1912	6 days
Aug. 28, 1912	Sept. 5, 1912	6 days
Sept 7, 1912	Sept. 6, 1912	9 days
Sept. 4, 1912	Sept. 10, 1912	3 days
Sept. 3, 1912	Sept. 11, 1912	7 days
Sept. 3, 1912	Sept. 11, 1912	8 days
Nov. 23, 1912	Dec. 1, 1912	8 days
Nov. 26, 1912	Dec. 1, 1912	8 days
Nov. 24, 1912	Dec. 4, 1912	8 days
Dec. 2, 1912	Dec. 4, 1912	10 days
Dec. 2, 1912	Dec. 5, 1912	3 days
Dec. 2, 1912	Dec. 5, 1912	3 days
Nov. 27, 1912	Dec. 5, 1912	8 days
Nov. 25, 1912	Dec. 5, 1912	10 days
Nov. 22, 1912	Dec. 5, 1912	13 days
Dec. 3, 1912	Dec. 7, 1912	4 days
Nov. 30, 1912	Dec. 7, 1912	7 days
Nov. 30, 1912	Dec. 9, 1912	9 days
Dec. 7, 1912	Dec. 11, 1912	4 days
Dec. 10, 1912	Dec. 14, 1912	4 days
Dec. 9, 1912	Dec. 14, 1912	5 days

PROCESS OF OVIPOSITION

While depositing eggs the female seems mindful only of the task she is performing and is not easily disturbed. Some of the females appear nervous while ovipositing but work steadily. In the cages relatively small pieces of comb were supplied for oviposition. The female usually went over the top and down the sides of the comb, repeating this course continuously. In going over the top of the comb the ovipositor is extended and appears to be dragged along. Apparently the interior of every cell was inspected by the ovipositor but never were any eggs deposited in these empty cells. From the top of the comb the female went to the sides, where suitable places for oviposition were readily found. A very thorough inspection was made of the crevice before the eggs were deposited, sometimes a situation would not be accepted one time but an egg would later be placed there. When a suitable location was found, the moth exerted a tremendous force backward, such as to bend the abdomen, perhaps to force the ovipositor into the crevice as far as possible. Then there was a moment of quiet when the body was rigid, then a quick jerk and the female was on her journey again. During the inspection work the antennae were vibrating continuously but they were motionless while the egg was passing down the oviduct.

The eggs are always securely fastened to whatever object they are laid upon. The eggs are always laid in cavities. In the cage experiments these were on the side of the comb, often where the walls of cells had been turned in. Only one egg is deposited at a time, although in working over the comb, the female often places the eggs close together. On the smaller pieces of comb, furnished to moths confined in cages, as many as seven eggs were found in a single cavity. The number of eggs actually deposited by one female has not been determined. In the cages, under artificial conditions, if the comb was not supplied for the female she would deposit her eggs in any rough place detected by her ovipositor. In many instances the female would refuse to oviposit on cappings which were furnished in some of the cages, but would go around the base of the lamp globe in which they were confined and fill every crevice with eggs. Sometimes these eggs would be fastened on the outside of the glass, and in such cases the globe would be fastened to its resting place.

TIME OF OVIPOSITION

Oviposition usually takes place at night, beginning at early dusk. In every cage the most of the ovipositing was completed by 9:30 p. m. On the last day the female may oviposit during the afternoon, especially if the day is cloudy or the cage is not directly exposed to light.

HABITS DURING OVIPOSITION

Whenever freed from the cages, the females always started immediately for the windows of the laboratory, but the males, when turned out, sought protection in darkened places. The female was active as soon as darkness started, but upon turning on the electric lights in the room, sought the darker places. If a bright light, such as a candle or reading lamp was placed close to the cage, however, the female at once attempted to reach the light. The male was not so readily affected by light, seeming to prefer quiet and protection.

During the cool evenings of early fall, the moths are active only on those nights when no breeze is blowing. At this latitude the usual breeze stops during the later part of the evening, and the moths may become active for a short period.

The male is never found on the food during the oviposition period, and rarely is the male found on food preceding the period. The female is not found around the food before the oviposition period, but may often be found in the better protected places during the period.

PERIOD OF OVIPOSITION

The period of oviposition of the beemoth varies considerably within the brood as well as with broods. During the last part of the egg laying period the female appears to be in a great hurry, and during the last few days she deposits during the day, as well as during the night, at times stopping to rest. If disturbed during the resting period, she vigorously resumes her egg laying. The females usually die while ovipositing and the last three or four eggs are barely extruded from the ovipositor. If a female is being killed or injured, she will attempt to oviposit even after she is unable to walk.

The cage records on the period of oviposition are shown in table 22.

Table 22.—Period of oviposition.

First eggs.	Last eggs.	Period.
Mar. 9, 1912	Mar. 13, 1912	4 days
Mar. 12, 1912	Mar. 17, 1912	5 days
Mar. 20, 1912	Mar. 26, 1912	6 days
Mar. 21, 1912	Mar. 28, 1912	8 days
Mar. 27, 1912	April 7, 1912	13 days
Sept. 3, 1912	Sept. 6, 1912	3 days
Sept. 5, 1912	Sept. 8, 1912	3 days
Sept. 5, 1912	Sept. 8, 1912	3 days
Sept. 5, 1912	Sept. 9, 1912	4 days
Sept. 6, 1912	Sept. 9, 1912	3 days
Sept. 9, 1912	Sept. 18, 1912	9 days
Sept. 12, 1912	Sept. 20, 1912	8 days
Dec. 11, 1912	Dec. 19, 1912	8 days
Dec. 14, 1912	Dec. 17, 1912	3 days
Dec. 14, 1912	Dec. 18, 1912	4 days
Dec. 14, 1912	Dec. 20, 1912	6 days
Dec. 16, 1912	Dec. 23, 1912	7 days

EFFECT OF AGE OF SEX

The age of the sex apparently does not have any constant effect on the fertility of the eggs. Females of excessive age were mated with freshly emerged males. Eggs were deposited which hatched. Females that had just emerged were mated with males of excessive age and the eggs that were deposited hatched. In one cage a female was mated with a male that had mated in another cage the previous night. Mating took place and all eggs deposited hatched.

The females will deposit their eggs even when they have not had the opportunity to mate. In all cases when the sexes were not properly paired the females would finally oviposit, the period of oviposition being, however, much shorter than the natural one. Although many females which did not mate were confined in cages, and although they deposited eggs, none of these unfertilized eggs ever hatched. It seems a fairly safe conclusion that parthenogensis does not occur with this species.

RATE OF OVIPOSITION

In many instances females have been observed depositing their eggs at the rate of one every minute for a period of thirty minutes, and then after a short rest have continued again at the same rate.

EFFECT OF HUMIDITY ON DEVELOPMENT

Experiments were planned to determine the effect of a low humidity on the hatching of the eggs and development of the larvae and pupae. For this purpose a large egg incubator of the hot water type was secured. The temperature of ninety degrees F. was decided upon and a humidity of approximately thirty-five per cent. A recording hygrothermograph was placed inside the incubator and the records of the temperature and the humidity maintained in the experiments are shown in table 24.

The eggs were deposited by the moths in cages in the laboratory and the following morning they were placed in the incubator. The larvae were supplied with ample food in the form of fresh cappings. The larvae that hatched in a twenty-four hour period were kept together.

The results of this experiment are shown in table 23. The eggs of one batch were placed in the incubator over a period of one day. After the first twenty-four hour period, the hatching was very slow, only four to six larvae from a batch. The prolonged exposure in the incubator dried the eggs badly and after a short time the eggs would not hatch. The larvae started their work in the normal manner but this condition was soon changed.

Table 23—Effect of humidity on development.

Eggs deposited.	Eggs hatched.	Larvae died.	Remarks.
Dec. 3, 1912	Dec. 13, 1912	Mar. 24, 1913	Work very unnatural.
Dec. 3, 1912	Dec. 15, 1912	April 12, 1913	Variation in size.
Dec. 3, 1912	Dec. 16, 1912	Mar. 5, 1913	Very little growth.
Dec. 3, 1912	....	....	No eggs hatched.
Dec. 3, 1912	Dec. 16, 1912	April 5, 1913	Larva died.
Dec. 3, 1912	Dec. 16, 1912	Mar. 24, 1913	Larva one-third grown.
Dec. 3, 1912	Dec. 17, 1912	April 12, 1913	Larva one-fourth grown.
Dec. 3, 1912	Dec. 18, 1912	Mar. 24, 1913	Larva one-fourth grown.
Dec. 3, 1912	Dec. 19, 1912	April 5, 1913	Larva one-half grown.
Dec. 3, 1912	Dec. 20, 1912	Mar. 24, 1913	Very little work.
Dec. 3, 1912	Dec. 22, 1912	April 12, 1913	Larva one-fourth grown.
Dec. 3, 1912	Dec. 23, 1912	Mar. 15, 1913	Very little work.
Dec. 3, 1912	....	....	No eggs hatched.
Dec. 9, 1912	Dec. 17, 1912	Mar. 24, 1913	Larva one-third grown.
Dec. 9, 1912	Dec. 16, 1912	April 12, 1913	Very little growth.
Dec. 9, 1912	Dec. 17, 1912	Mar. 24, 1913	Larva one-half grown.
Dec. 9, 1912	Dec. 18, 1912	Mar. 24, 1913	Very little growth.
Dec. 9, 1912	....	....	No eggs hatched.
Dec. 9, 1912	Dec. 26, 1912	Mar. 24, 1913	Larva one-half grown.
Dec. 9, 1912	Dec. 24, 1912	Mar. 24, 1913	Very little growth.
Dec. 9, 1912	Dec. 24, 1912	April 5, 1913	Larva two-thirds grown.
Dec. 9, 1912	Dec. 26, 1912	April 5, 1913	Larva two-thirds grown.
Dec. 4, 1912	Dec. 12, 1912	April 12, 1913	Larva one-third grown.
Dec. 4, 1912	Dec. 16, 1912	Dec. 31, 1912	Very little work.
Dec. 4, 1912	Dec. 17, 1912	Mar. 24, 1913	Larva one-third grown.
Dec. 4, 1912	Dec. 18, 1912	April 12, 1913	Larva one-half grown.
Dec. 4, 1912	....	....	No eggs hatched.
Dec. 5, 1912	Dec. 17, 1912	Mar. 24, 1913	Larva one-third grown.
Dec. 5, 1912	Dec. 18, 1912	Mar. 12, 1913	Larva one-third grown.
Dec. 5, 1912	Dec. 20, 1912	April 12, 1913	Larva one-third grown.
Dec. 5, 1912	Dec. 24, 1912	Mar. 5, 1913	Larva one-third grown.
Dec. 5, 1912	....	....	No eggs hatched.
Dec. 5, 1912	Dec. 20, 1912	Mar. 24, 1913	Very little work.
Dec. 5, 1912	Dec. 21, 1912	Feb. 26, 1913	Very little work.
Dec. 5, 1912	Dec. 22, 1912	April 5, 1913	Larva one-fourth grown.
Dec. 5, 1912	Dec. 23, 1912	April 5, 1912	Larva one-fourth grown.
Dec. 5, 1912	....	....	No eggs hatched.
Dec. 5, 1912	Dec. 20, 1912	April 5, 1913	Very little work.
Dec. 5, 1912	Dec. 21, 1912	April 5, 1913	Larva dried.
Dec. 5, 1912	Dec. 27, 1912	April 5, 1913	Larva one-third grown.
Dec. 5, 1912	Jan. 2, 1913	Feb. 21, 1913	Very little work.
Dec. 5, 1912	....	....	No eggs hatched.
Dec. 5, 1912	Dec. 22, 1912	Mar. 12, 1913	Larva one-fourth grown.
Dec. 9, 1912	Dec. 23, 1912	April 5, 1913	Larva one-fourth grown.
Dec. 9, 1912	Dec. 26, 1912	Mar. 12, 1913	Very little work.
Dec. 9, 1912	Dec. 28, 1912	April 5, 1913	Very little work.
Dec. 9, 1912	Jan. 1, 1913	Mar. 24, 1913	Larva two-thirds grown.
Dec. 9, 1912	....	....	No eggs hatched.
Dec. 11, 1912	Dec. 23, 1912	Feb. 21, 1913	Larva one-third grown.
Dec. 11, 1912	Dec. 24, 1912	Feb. 26, 1913	Very little work.
Dec. 11, 1912	Dec. 25, 1912	Mar. 24, 1913	Very little work.
Dec. 11, 1912	Dec. 26, 1912	Mar. 24, 1913	Very little work.
Dec. 11, 1912	Dec. 28, 1912	Mar. 24, 1913	Very little work.

Table 23.— Effect of humidity on development—continued.

Eggs deposited.	Eggs Hatched.	Larvae died.	Remarks.
Dec. 11, 1912	Dec. 29, 1912	Mar. 24, 1913	Larva two-thirds grown.
Dec. 11, 1912	Jan. 2, 1913	Mar. 24, 1913	Larva two-thirds grown.
Dec. 11, 1912	Jan. 9, 1913	Feb. 21, 1913	Very little growth.
Dec. 11, 1912	....	....	No eggs hatched.
Dec. 11, 1912	Dec. 23, 1912	April 12, 1913	Larva two-thirds grown.
Dec. 11, 1912	Dec. 24, 1912	Mar. 24, 1913	Very little work.
Dec. 11, 1912	Dec. 25, 1912	Mar. 24, 1913	Very little work.
Dec. 11, 1912	Dec. 26, 1912	April 12, 1913	Larva one-half grown.
Dec. 11, 1912	....	....	No eggs hatched.
Dec. 3, 1912	Dec. 15, 1912	Mar. 31, 1912	Larva two-thirds grown.
Dec. 3, 1912	Dec. 17, 1912	Mar. 31, 1913	Very little work.
Dec. 3, 1912	Dec. 19, 1912	Mar. 31, 1913	Very little work.
Dec. 3, 1912	Dec. 22, 1912	Mar. 31, 1913	Very little work.
Dec. 3, 1912	Dec. 26, 1912	Mar. 31, 1913	Very little work.
Dec. 3, 1912	Dec. 31, 1912	Mar. 31, 1913	Very little work.
Dec. 3, 1912	Jan. 2, 1913	Mar. 31, 1913	Very little work.
Dec. 3, 1912	....	....	No eggs hatched.
Dec. 5, 1912	Dec. 21, 1912	Mar. 31, 1913	Very little work.
Dec. 5, 1912	Dec. 22, 1912	Mar. 31, 1913	Very little work.
Dec. 5, 1912	Dec. 26, 1912	Mar. 31, 1913	Very little work.
Dec. 5, 1912	....	....	No eggs hatched.
Dec. 14, 1912	Dec. 30, 1912	Mar. 31, 1913	Very little work.
Dec. 14, 1912	Dec. 31, 1912	Mar. 31, 1913	Very little work.
Dec. 14, 1912	Jan. 1, 1913	Mar. 31, 1913	Very little work.
Dec. 14, 1912	Jan. 2, 1913	Mar. 31, 1913	Very little work.
Dec. 14, 1912	Jan. 3, 1913	Mar. 31, 1913	Very little work.
Dec. 14, 1912	Jan. 4, 1913	Mar. 31, 1913	Very little work.
Dec. 14, 1912	Jan. 5, 1913	Mar. 31, 1913	Very little work.
Dec. 14, 1912	Jan. 7, 1913	Mar. 31, 1913	Very little work.
Dec. 14, 1912	....	....	No eggs hatched.

For the temperature maintained, the work of the larvae was much prolonged. The table shows that in no case did a larva ever reach more than two-thirds normal size when it died. Very quickly after death the larva would become dry and hard. Usually the larva grew but little in the long period of exposure and a point was reached where growth was not possible and death ensued.

In table 24 is shown the mean atmospheric humidity prevailing at College Station over the period of months when the experiment was conducted. Compared with this is the mean humidity of the incubator where the experiments were conducted.

Table 24.—Mean atmospheric humidity prevailing at time of experiment.

Date.	Incubator.						Room.		
	Humidity.			Temperature.			Temperature.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Dec. 1, 1912	43	37	40.0	92	90	91.0	......	......	......
Dec. 2, 1912	41	38	39.5	92	91	91.5	......	......	......
Dec. 3, 1912	41	40	40.5	92	91	91.5	......	......	......
Dec. 4, 1912	45	44	44.5	93	92	92.5	......	......	......
Dec. 5, 1912	44	37	40.5	93	91	92.0	......	......	......
Dec. 6, 1912	37	36	36.5	91	89	90.0	......	......	......
Dec. 7, 1912	38	35	36.5	93	91	92.0	......	......	......
Dec. 8, 1912	38	35	36.5	91	90	90.5	......	......	......
Dec. 9, 1912	35	31	33.0	93	90	91.5	......	......	......
Dec. 10, 1912	39	35	37.0	92	90	91.0	......	......	......
Dec. 11, 1912	39	33	36.0	92	88	90.0	......	......	......
Dec. 12, 1912	36	31	33.5	92	89	90.5	......	......	......
Dec. 13, 1912	32	30	31.0	92	90	91.0	......	......	......
Dec. 14, 1912	34	32	33.0	93	90	91.5	......	......	......

Table 24.—Mean atmospheric humidity prevailing at time of experiment—continued.

Date.	Incubator.						Room.		
	Humidity.			Temperature.			Temperature.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Dec. 15, 1912	34	33	33.5	91	89	90.0	......	......	......
Dec. 16, 1912	47	42	44.5	93	89	91.0	......	......	......
Dec. 17, 1912	41	36	38.5	91	90	90.5	......	......	......
Dec. 18, 1912	43	35	39.0	90	88	89.0	......	......	......
Dec. 19, 1912	42	38	40.0	91	90	90.5	......	......	......
Dec. 20, 1912	43	42	42.5	91	89	90.0	......	......	......
Dec. 21, 1912	42	41	41.5	90	89	89.5	......	......	......
Dec. 22, 1912	40	38	39.0	89	88	88.5	......	......	......
Dec. 23, 1912	35	33	34.0	91	89	90.0	73	58	65.0
Dec. 24, 1912	34	32	33.0	92	90	91.0	72	60	66.0
Dec. 25, 1912	35	33	34.0	92	90	91.0	69	62	65.5
Dec. 26, 1912	35	30	32.5	94	91	92.5	73	59	66.0
Dec. 27, 1912	33	31	32.0	93	90	91.5	77	60	68.5
Dec. 28, 1912	36	32	34.0	93	91	92.0	68	62	65.0
Dec. 29, 1912	37	34	35.2	93	90	91.5	72	60	66.0
Dec. 30, 1912	34	33	33.5	90	86	88.0	75	56	70.5
Dec. 31, 1912	35	33	34.0	90	89	89.5	73	61	67.0
Jan. 1, 1913	37	31	34.0	94	89	91.5	78	64	71.0
Jan. 2, 1913	34	31	32.5	92	89	90.5	74	59	66.5
Jan. 3, 1913	33	30	31.5	92	89	90.5	74	60	67.0
Jan. 4, 1913	39	32	35.5	93	90	91.5	72	71	71.5
Jan. 5, 1913	41	33	37.0	92	85	88.5	75	55	65.0
Jan. 6, 1912	33	30	31.5	93	89	91.0	80	62	71.0
Jan. 7, 1913	32	30	31.0	92	89	90.5	73	60	66.5
Jan. 8, 1913	31	30	30.5	92	88	90.0	75	59	67.0
Jan. 9, 1913	31	29	30.0	93	89	91.0	80	64	72.0
Jan. 10, 1913	41	31	36.0	92	90	91.0	75	67	71.0
Jan. 11, 1912	38	32	35.0	93	89	91.0	80	62	71.0
Jan. 12, 1913	33	32	32.0	90	88	89.0	69	60	64.5
Jan. 13, 1913	34	33	38.5	91	88	89.5	80	66	73.0
Jan. 14, 1913	37	33	35.0	92	90	91.0	80	69	64.5
Jan. 15, 1913	42	37	39.5	92	90	91.0	79	72	75.5
Jan. 16, 1913	44	42	43.0	93	90	91.5	80	74	77.0
Jan. 17, 1913	45	42	43.5	92	90	91.0	80	73	76.5
Jan. 18, 1913	45	42	43.5	92	90	91.0	83	73	78.0
Jan. 19, 1913	45	44	44.5	90	89	89.5	77	73	75.0
Jan. 20, 1913	42	33	37.5	93	89	91.0	82	67	74.5
Jan. 21, 1913	33	33	33.0	92	89	90.5	81	67	74.5
Jan. 22, 1913	35	34	34.5	92	89	90.5	80	67	73.5
Jan. 23, 1913	35	33	34.0	91	90	90.5	78	69	73.5
Jan. 24, 1913	34	32	33.0	93	90	91.5	79	69	74.0
Jan. 25, 1913	34	32	33.0	92	90	91.0	79	69	74.0
Jan. 26, 1913	33	31	32.0	91	89	90.0	73	65	69.0
Jan. 27, 1913	30	28	39.0	91	87	89.0	77	61	69.0
Dec. 28, 1913	30	28	29.0	91	89	90.0	73	67	70.0
Jan. 29, 1913	31	27	29.0	91	89	90.0	75	66	70.5
Jan. 30, 1913	31	26	28.5	91	89	90.0	73	66	69.5
Jan. 31, 1913	26	24	25.0	92	89	90.5	80	65	72.5
Feb. 1, 1913	27	23	25.0	90	87	89.5	75	65	70.0
Feb. 2, 1913	27	26	26.5	92	88	90.0	75	60	67.5
Feb. 3, 1913	33	32	32.5	92	90	91.0	72	62	67.0
Feb. 4, 1913	39	33	36.0	91	89	90.0	74	66	70.0
Feb. 5, 1913	39	38	38.5	91	90	90.5	74	68	71.0
Feb. 6, 1913	39	36	37.5	92	89	90.5	78	65	71.5
Feb. 7, 1913	37	33	35.0	90	88	89.5	71	59	65.0
Feb. 8, 1913	35	33	34.0	90	87	88.5	74	68	71.0
Feb. 9, 1913	37	33	35.0	89	88	88.5	67	60	63.5
Feb. 10, 1913	41	38	39.5	92	91	91.5	73	66	69.5
Feb. 11, 1913	41	36	38.5	92	91	91.5	77	63	70.0
Feb. 12, 1913	37	35	36.0	93	90	91.0	74	63	68.5
Feb. 13, 1913	36	35	35.5	91	89	90.0	70	61	65.5
Feb. 14, 1913	35	35	35.0	90	89	89.5	67	60	63.5
Feb. 15, 1913	35	34	34.5	91	88	89.5	72	63	68.5
Feb. 16, 1913	37	35	36.0	91	89	90.0	71	64	67.5
Feb. 17, 1913	41	38	39.5	92	90	91.0	76	68	72.0
Feb. 18, 1913	47	41	44.0	92	90	91.0	75	68	71.5
Feb. 19, 1913	47	45	46.0	92	90	91.0	73	70	71.5
Feb. 20, 1913	45	42	43.5	91	90	90.5	71	70	70.5
Feb. 21, 1913	43	36	39.5	91	89	90.0	75	65	70.0
Feb. 22, 1913	38	35	36.5	92	89	90.5	85	65	75.0
Feb. 23, 1913	37	32	34.5	91	89	90.0	70	62	66.0
Feb. 24, 1913	32	28	30.0	92	88	90.0	83	64	73.5
Feb. 25, 1913	38	30	34.0	92	92	92.0	83	70	76.5
Feb. 26, 1913	40	31	35.5	92	89	90.5	74	67	70.5

Table 24.—Mean atmospheric humidity prevailing at time of experiment—continued.

Date.	Incubator.						Room.		
	Humidity.			Temperature.			Temperature.		
	Max.	Min.	Mean.	Max.	Min.	Mean.	Max.	Min.	Mean.
Feb. 27, 1913	33	30	31.5	90	90	90.0	72	66	69.0
Feb. 28, 1913	32	27	29.5	91	88	89.5	69	59	64.0
Mar. 1, 1913	30	23	26.5	91	90	90.5	82	61	71.5
Mar. 2, 1913	26	23	24.5	92	90	91.0	69	60	64.5
Mar. 3, 1913	32	29	30.5	91	90	90.5	80	72	76.0
Mar. 4, 1913	32	28	30.0	93	91	92.0	78	65	71.5
Mar. 5, 1913	30	25	27.5	92	91	91.5	71	66	68.5
Mar. 6, 1913	32	25	28.5	94	85	89.5	80	67	73.5
Mar. 7, 1913	28	24	26.0	93	91	92.0	83	74	78.5
Mar. 8, 1913	28	25	26.5	91	91	91.0	79	73	76.0
Mar. 9, 1913	30	28	29.0	91	91	91.0	77	65	71.0
Mar. 10, 1913	33	30	31.5	92	91	91.5	82	67	74.5
Mar. 11, 1913	36	31	33.5	92	91	91.5	85	68	76.5
Mar. 12, 1913	39	32	35.5	92	91	91.5	80	70	75.0
Mar. 13, 1913	32	22	27.0	93	91	92.0	90	66	78.0
Mar. 14, 1913	24	21	22.5	92	89	90.5	90	60	75.0
Mar. 15, 1913	21	19	20.0	93	90	92.0	80	60	70.0
Mar. 16, 1913	19	19	19.0	91	90	90.5	76	58	67.0
Mar. 17, 1913	24	20	22.0	92	88	90.5	74	62	68.0
Mar. 18, 1913	28	24	26.0	93	89	91.0	70	64	67.0
Mar. 19, 1913	33	28	30.5	94	92	93.0	69	68	68.5
Mar. 20, 1913	33	25	29.0	94	89	91.5	80	63	71.5
Mar. 21, 1913	25	25	25.0	92	89	90.5	80	63	71.5
Mar. 22, 1913	30	26	28.0	90	90	90.0	71	63	67.0
Mar. 23, 1913	33	30	31.5	92	90	91.0	74	71	72.5
Mar. 24, 1913	46	44	45.0	93	90	91.5	77	73	75.0
Mar. 25, 1913	46	40	43.0	92	91	91.5	......	......	......
Mar. 26, 1913	40	32	36.0	92	90	91.0	......	......	......
Mar. 27, 1913	36	28	32.0	92	88	90.0	......	......	......
Mar. 28, 1913	34	30	32.0	93	90	91.5	75	65	70.0
Mar. 29, 1913	39	33	36.0	91	89	90.0	74	68	71.0
Mar. 30, 1913	38	37	37.5	91	90	90.5	70	64	67.0
Mar. 31, 1913	40	38	39.0	93	90	91.5	82	71	76.5
April 1, 1913	48	38	43.0	93	91	92.0	78	72	75.0
April 2, 1913	50	45	47.5	95	86	90.5	76	74	75.0
April 3, 1913	47	38	42.5	91	86	88.5	74	69	71.5
April 4, 1913	40	34	37.0	92	88	90.0	72	65	68.5
April 5, 1913	34	30	32.0	92	90	91.0	75	68	71.5
April 6, 1913	38	32	35.0	90	88	89.0	74	70	72.0
April 7, 1913	42	38	40.0	92	90	91.0	77	70	73.5
April 8, 1913	45	42	43.5	92	91	91.5	74	70	72.0
April 9, 1913	43	39	41.0	91	88	89.5	72	65	68.5
April 10, 1913	41	31	36.0	91	89	90.0	67	63	65.0
April 11, 1913	33	30	31.5	92	90	91.0	67	62	64.5
April 12, 1913	32	22	27.0	93	90	91.5	67	61	64.0
April 13, 1913	22	18	20.0	91	89	90.0	68	62	65.0

Table 25.—Comparison of humidity.

Year.	Atmosphere.			
	December.	January.	February.	March.
1914	78.1	64.6	72.0	70.5
1915	74.2	72.8	69.6	72.6
1916	64.5	78.9	66.7	61.8
1917	62.8	70.8	58.7	63.0
Average	69.9	71.8	66.8	66.7

Year.	Incubator.			
	December.	January.	February.	March.
1912	36.7	......	......	......
1913	......	34.2	35.7	30.0

SEASONAL HISTORY

From the work which was done in trying to identify the different broods or generations of this insect, it appears that there are three broods in the extreme southern part of the United States. The third brood is not nearly so large as the first two, due to the fact that some of the second brood of larvae do not pupate until late fall. There is a decided overlapping of the generations, which makes it difficult to determine the exact number of broods a year. At almost any time, from early spring until December, examination of a colony of bees is likely to reveal this insect in all stages. It is often assumed from this that the life history is short and there are several generations each year.

In well protected hives the development may continue throughout the year without interruption. Usually the winter is passed with about one-third of the insects in the pupal stage and the remainder in the larval stage. Warm spells during the winter cause some of the moths to emerge from their cocoons; in the laboratory many moths emerged when the temperature was maintained constantly at sixty degrees F. It is not unusual to see moths on the windows of the honey house, trying to escape during the warm spells in December and January. Their presence may be accounted for on the supposition that they have just emerged from their cocoons or that they may have been in hibernation as adults and become active with the rise in temperature. Such moths do not reproduce in localities where freezing temperatures are frequent. Even the most vigorous moths cannot withstand a freezing temperature for more than three days. Moths in well protected places can survive an outside temperature as low as twenty-six degrees F. for as long as five days. The moths are never active during the day when the temperature is below fifty degrees F., so at such times reproduction does not take place.

For College Station, Texas, the following life history and duration of broods has been carefully determined:

The maximum number of moths which mature from the over-wintering larvae and pupae appear about the first of April. These moths are active for some time before any eggs are deposited and it is the middle of April before the eggs are laid for the first brood of larvae. Usually twelve days are required for the eggs of this brood to hatch, so that by the first of May most of the first brood of larvae are out. The larval period of this brood is quite long, most of the larvae feeding at least forty-five days before completing their growth. A majority of the larvae of the generation are ready to pupate by the middle of June, but there is a considerable variation in the rate of growth, for some of these larvae feed for six weeks longer before attaining full size. The pupation of the first brood takes place during the last two weeks in June, and by July 1 some of the moths of the second generation are to be seen.

The moths of this generation emerge at about the same time and give the impression of constituting a very large brood. Most of the eggs are laid very soon after emergence of the moths and by the middle of July all of the eggs of the second generation are deposited. The high temperature at this time of the year shortens the egg period, only ten days being required for these eggs to hatch. There is a considerable variation in the maturing of this brood of larvae. Normally the larval period is shorter than for the first brood and by the first of September many of the larvae are full grown. Some of the larvae may continue to feed for four weeks longer and then pupate.

Some of the larvae which mature early in September may pass through a short pupal stage and soon emerge as moths. This accounts for the appearance of the number of moths about the first of October. This brood is usually small and scattered and few of the larvae which result from the eggs of these moths reach full size. Some of the larvae of the second generation do not pupate during the fall, but live over the winter in the larval stage and pupate the following spring.

The following summary shows the stages which normally occur during each month of the year at College Station, Texas:

April: Moths reach maturity from the over-wintering larvae and pupae.
Eggs are deposited.
May: Eggs hatch.
Larvae are about three-fourths grown.
June: Larvae reach maturity.
Some pupae.
July: Pupae.
Adults of the second generation.
Eggs deposited by the second generation of moths.
August: Larvae of the first generation.
Pupae of the first generation.
Moths of the second generation.
Eggs of the second generation.
Larvae of the second generation.
September: Pupae of the first generation.
Moths of the second generation.
Eggs of the second generation.
Larvae of the second generation.
Moths of the third generation.
Eggs of the third generation.
October: Larvae of the second generation.
Pupae of the second generation.
Moths of the third generation.
Eggs of the third generation.
November: Larvae of the second generation.
Pupae of the second generation.
Larvae of the third generation.
December: Same stages as during November.
January: Same stages as during November.
February: Same stages as during November.
March: Pupae.

NATURAL CONTROL

PREDACEOUS ENEMIES

Of the natural enemies of the beemoth, the most important is the honey bee itself. It is a well established fact that if the colony be kept strong, healthy, and with a vigorous queen, it will defend itself against the beemoth. This is particularly true in the case of "Italian" bees. In the *Ohio Cultivator* for 1849, page 185, Micajah T. Johnson says, "One thing is certain: if the bees, from any cause, should lose their queen and not have the means in their power of raising another, the miller and the worms soon take possession. I believe no hive is destroyed by worms while an efficient queen remains in it." This seems to be the earliest published notice of this important fact by an American observer.

This fact is of vital importance in the fight against the beemoth, for if the pest can be kept from its favorite food control measures are made much easier. The fact that the bees under natural conditions are able to defend themselves should leave the problem of control to such means as will destroy the pest in places other than the hives. Recently it has been found advantageous to introduce Italian blood into the colony, as the workers of this race seem to be more efficient fighters of the beemoth. In most cases this is sufficient for the control of the pest in the colonies, but it must be remembered that the colony cannot be kept under close observation and maintained at full strength unless domiciled in a frame hive.

A small red ant, *Solenopsis geminata* Fab. was found to be an enemy of the beemoth, as many of the cage experiments were destroyed by these ants killing the moths and larvae. The attack is made on the moths during the day or when they are at rest. Usually the ant crawls under the wings of the moth, and begin the attack on the abdomen. There is no apparent struggle on the part of the moth, for close examination was necessary to determine that the moth was dead and not resting. The abdomen seems to be all that is desired, and this is carried away in small pieces to the nest of the ants. The same species of ant also destroyed moths which had recently been prepared for exhibits. At such times only the abdomen was taken by the ants. In their attacks on the larvae the ants entered the cages and crawled over the comb and wax in search of their prey and if any larvae were exposed, they were attacked. The larger larvae are more frequently attacked, as they are less active and usually feed in more exposed places than do the smaller ones. Unless the larvae were well protected by webs in the refuse, they were destroyed by the ants. Apparently there are days and even parts of days when the ants are most active in their destruction. Never were the ants present in sufficient numbers to attempt tracing them to their nests. No observations have been made upon this ant in or about the apiary and while it proved very destructive under artificial conditions, the moths and larvae might be better able to protect themselves under natural conditions.

PARASITES

Three hymenopterous parasites have been recorded from the beemoth. One is chalcid, *Eupelmus cereanus,* found by Roudani in Italy; another is *Bracon bravicornis,* which was found by Marshall in France, and a third species, *Apenteles lateralis,* was recently found by A. Conté in France. The last species was found near Lyons, where it spread very rapidly. It is apparently of considerable importance since it has also been reported to attack the larvae of several other moths in England and Germany. The adult parasite is about one-sixth of an inch (4 millimeters) in length, very lively, and avoids light. The body is black and the wings are transparent, with black specks. The larvae of the beemoth are attacked while quite young and never attain a large size. A single parasite develops in each larva. The bees are said to pay no attention to the presence of the parasite, so that it can easily enter the hive in search of the beemoth larvae. It was artificially introduced into hives by Conté with very satisfactory results.

CLIMATE

Cold is perhaps the greatest climatic factor in the control of the beemoth. Young and vigorous moths when exposed were able to withstand a temperature of a few degrees below freezing. When a temperature of twenty-eight degrees F. occurred, all exposed moths were killed. Even with some protection all moths did not survive this temperature. The young moths may withstand this temperature for one night, but not for a longer period of time.

The larvae are greatly susceptible to cold. Larvae of all ages even up to two-thirds grown, were placed out-of-doors, and with only the meager protection of light tunnels and small pieces of comb. Whenever a temperature of thirty-two degrees F. was reached, all larvae were killed. Under natural conditions the larvae are better protected to pass through the winter by better built feeding galleries. The natural mortality was observed in an infested hive that was allowed to remain untouched throughout the winter. The results are shown in table 26. It will be seen that the high mortality was among the larvae. Of the 208 larvae examined, 146 or seventy per cent. were dead, and of the 158 pupae examined, eight or five per cent. were dead.

Table 26.—Mortality of waxworms.

Date.	Alive.	Larvae.	Pupae.
April 9, 1913	216	66	150
	Dead.	Larvae.	Pupae.
	150	142	8

ARTIFICIAL CONTROL

Unfortunately, the only natural enemy of the beemoth that is present to any great extent in Texas is the honey bee itself. In the absence of any natural enemies of importance, the measure of artificial control must be made all the more effective if the beekeeper is to free his apiary of the pest. If the moths are driven from the hives by strong colonies of Italianized bees, they will surely seek scraps of comb and wax about the ground and stored comb and honey in the honey house. It seems quite likely that in such cases the eggs are deposited as near to the comb as possible, as along the cracks between the supers, and the larvae, after hatching, find their way to the comb through crevices much smaller than the moth can enter.

TRAP LIGHTS

Trap lights were employed to learn if the moths were attracted to them. On September 10, 1913, a large lantern and an acetylene lamp were placed in an apiary where the beemoth had been present constantly. The lights were so placed as to throw the rays across the apiary over a great number of hives. The night was warm, clear, and still. The lights were run from 7:30 to 10 p. m. Not a single beemoth was ever present at either light.

Again on September 27, 1913, the trap lights were put in operation in the same apiary. The day had been rainy and it was still misty in the evening, which was also very dark. No moths were ever at the lights.

DECOY BOXES

Decoy boxes containing pieces of comb were placed in and around the apiary. These were put out during September, 1913, and remained under observation until December. None of the twelve boxes was ever infested during this period.

FUMIGATION

One of the methods of artificial control, and one upon which many beekeepers depend, is fumigation of combs and honey. Gas is able to penetrate material that it is not possible to treat in any other manner. The fumigation process is not difficult, for when once started no further attention is necessary until the treatment is complete. It is not necessary to watch the entire process. Stored material, such as comb honey and empty combs, should be examined from time to time and at the first evidence of the waxworm they should be fumigated. Stored material of this kind should be examined at least once every week during the summer and once every month during the winter season, so as to detect the infestation at the start.

In the present investigation two materials have been used in the fumigating experiments. These were selected because almost every beekeeper is acquainted with them and they can be obtained in practically every locality at a reasonable price. They are sulphur and carbon bisulphide, or "high-life."

Sulphur

Dry powdered sulphur, or "flowers of sulphur," is a light yellowish powder with which everyone is familiar. When sulphur is burned, it unites with the oxygen of the air and forms a poisonous gas known as "sulphur dioxide." This gas is effective in killing some kinds of insects, including the waxworm. A common method of burning the sulphur is to place it on a pan of red hot coals and immediately tier up the infested supers over the burning sulphur. The bottom super should not contain any infested material and the pile should be covered as quickly as possible. A number of experiments were made with sulpher fumigating combs containing waxworms. The result of these experiments are given in table 26.

Table 26.—Results of fumigating infested combs with sulphur dioxide.

Stage of beemoth.	Amount of sulphur used per cubic foot.	Time the combs were confined to fumes.	Effect.
Larvae	One-fourth ounce	One hour	Killed
Larvae	One-half ounce	One hour	Killed
Larvae	Two-thirds ounce	One hour	Killed

The larvae which were used for these experiments were from ten to twenty days old and in every case they were well protected by the webs and refuse. The larvae which were used in the experiments were of different ages and some better protected than others. When the larvae are not very well protected, they are quite susceptible to the gas, but the larger larvae, which are often enclosed in a mass of webs, were not killed except when extremely large doses of sulphur were used.

From the experiment with sulphur dioxide, it is evident that only extremely large doses will effect the eggs of the beemoth; so large, in fact, that such fumigation would not be practical.

These results seem to indicate that the sulphur fumes are not ordinarily penetrating enough to effect the eggs, and only when the larvae are young and not well protected will the gas effect them. While the method is simple, there are minor details upon which the success of the operation depends. The sulphur must be burned at a high temperature in order to generate the most effective gas. While the method is generally effective under proper conditions, it cannot be recommended in preference to fumigation with carbon bisulphide.

Carbon Bisulphide ("High Life")

The commercial bisulphide is an oily liquid, very volatile and exceedingly foul smelling. It is cold to the touch and because of its rapid evaporation it produces a freezing sensation when dropped on the skin. When exposed to air at ordinary temperatures the bisulphide rapidly changes to a gas or vapor which is a little more than two and one-half times as heavy as air. This is a point to be remembered in its use, since it goes first to the bottom of whatever it is confined in. When mixed with air, it becomes highly inflammable and sometimes explosive. Such a mixture of air and bisulphide gas may be exploded by even a spark such as might be made by hitting a nail with a hammer. The liquid, upon evaporation, leaves a residue of impurities. Its rate of evaporation is in proportion to the temperature and the area of the exposed surface. Its efficiency is the greatest with the rapid evaporation, and this is secured in relatively warm weather, but artificial heat must *never* be used to hasten its changes into gas. Carbon bisulphide is obtainable from practically every druggist.

When carbon bisulphide is to be used for fumigation of infested material, the greatest precaution should be used to keep all fire, such as lights, cigarettes, etc., away from the liquid and where it is being used. For this reason it is well to take the material that is to be fumigated out-of-doors and at least 100 feet away from any building. The infested material should be placed in supers or hive bodies if possible. These are piled as high as is convenient and all cracks between the containers made as nearly gas-proof as possible. Especially should the bottom be tight. A good plan is to place an inverted hive cover on the ground, lay a piece of canvas over it and then tier up the supers on this. After the pile has been completed, an empty super should be put on top, in which should be placed a large shallow pan. Into the latter the bisulphide is to be poured. When all is in readiness, pour the bisulphide into the pan, and immediately put a hive cover on the top of the tier to confine the gas. This operation is best performed in the evening, and the pile of supers should be left intact the following morning. When the supers are taken down the confined gas will escape immediately, even before they can be carried separately into a building.

The results of fumigating infested material with carbon bisulphide is shown in table 27.

Table 27.—Results of fumigating infested combs with carbon bisulphide.

Stage of beemoth.	Amount of liquid carbon bisulphide used per cu. ft.	Time of confinement.	Effect	Remarks.
Moth	One-half ounce	15 minutes	Killed	
Moth	Two-thirds ounce	20 minutes	Killed	The moth was unable to walk within 10 minutes after being confined.
Moth	Three-eighths ounce	20 minutes	Killed	The moth was unable to walk within 10 minutes. Not all the bisulphide evaporated.
Moth	One-fourth ounce	20 minutes	Killed	The moth was dead before all the bisulphide evaporated.
Pupae	One-sixth ounce	24 hours	Killed	Several larvae in cocoons were also killed.
Pupae	One-fourth ounce	24 hours	Killed	Several larvae in cocoons were also killed.
Pupae	Three-eighths ounce	24 hours	Killed	Several larvae in cocoons were also killed.
Pupae	One-half ounce	24 hours	Killed	Several larvae in cocoons were also killed.
Larvae (in cocoons)	One-eighth ounce	24 hours	Killed	Some died in one hour in cocoon.
Larvae (in cocoons)	One-fourth ounce	24 hours	Killed	Some died in one and one-half hours in cocoon.
Larvae (in cocoons)	Five-eighths ounce	24 hours	Killed	
Larvae (exposed)*	One-sixth ounce	24 hours	Killed	Larvae 10 days old and well protected.
Larvae (exposed)*	One-eighth ounce	24 hours	Killed	These larvae were five days old and well protected in webs.
Larvae (exposed)*	One-eighth ounce	24 hours	Killed	Larvae were 25 days old, and protected.
Larvae (exposed)*	One-fourth ounce	24 hours	Killed	These were 20 days old and fairly well protected.
Larvae (exposed)*	One-fourth ounce	24 hours	Killed	These were 20 days old and exposed.
Larvae (exposed)*	One-fourth ounce	24 hours	Killed	These were 12 days old and exposed.
Larvae (exposed)*	One-half ounce	24 hours	Killed	These were 15 days old and fairly well protected.
Larvae (exposed)*	Three-fourths ounce	24 hours	Killed	Eggs were present which hatched afterward.
Larvae (exposed)*	Three-fourths ounce	24 hours	Killed	Eggs were present; hatched afterward.
Larvae (exposed)*	One ounce	24 hours	Killed	Eggs were present, hatched afterward.
Larvae	One ounce	24 hours	Killed	Eggs were present; hatched afterward.
Larvae (exposed)*	One ounce	24 hours	Killed	

*These larvae were feeding in empty combs.

In all the experiments conducted, the eggs of the beemoth were uninjured by the fumes of carbon bisulphide. It is possible that in cases of extremely large doses the eggs may be injured.

A number of experiments were conducted to determine the effect of the fumes of carbon bisulphide upon the larvae. Comb containing larvae of various ages and different degrees of protection was fumigated. Many experiments were made with the larvae in cocoons, and these showed that the carbon bisulphide was very effective. The larvae which are hardest to kill are those about three-fourths grown and well protected in a mass of webs and refuse. Ordinarily the larvae succumb to the average dose of carbon bisulphide in a comparatively short time. The outcome of the experiments demonstrated the effectiveness of carbon bisulphide for the destruction of the larvae.

Several experiments were conducted to determine the effect of carbon bisulphide upon the pupae. It was found that they are quite susceptible, but a long exposure to the fumes is necessary as the pupae do not consume air very fast.

From the experiments conducted with the moths, it was found that they are very susceptible to the fumes of carbon bisulphide. With the average dose the moths are overcome in from ten to fifteen minutes and are killed in from fifteen to twenty minutes after being confined.

All fumigation should be allowed to continue for at least twelve hours, for those larvae which are best protected by webs and refuse will not be killed unless plenty of time is given for the gas to penetrate the material. The liquid will evaporate in a few hours, but the resulting gas will be effective for several hours.

The following table has been prepared to show at a glance how much liquid carbon bisulphide is required for effective fumigation of ten frame supers and hive bodies containing infested material.

Table 28.—Amount of carbon bisulphide to use in fumigating ten frame supers for the waxworm.

Number of supers in the tier.	Cu. ft. contained in tier.	Amount of liquid bisulphide required.
2...............	1.74	⅓ ounce
3...............	2.61	½ ounce
4...............	3.48	¾ ounce
5...............	4.35	1 ounce
6...............	5.22	1¼ ounce
7...............	6.09	1½ ounce
8...............	6.96	1¾ ounce
9...............	7.83	2 ounces
10...............	8.70	2¼ ounces
11...............	9.57	2½ ounces
12...............	10.44	2¾ ounces

Table 29.—Amount of carbon bisulphide to use in fumigating ten frame hive bodies for the waxworm.

Number of bodies in the tier.	Cu. ft. contained in tier.	Amount of liquid bisulphide required.
2...............	2.90	⅔ ounce
3...............	4.35	1 ounce
4...............	5.80	1⅓ ounce
5...............	7.25	1⅔ ounce
6...............	8.70	2 ounces
7...............	10.15	2⅓ ounces
8...............	11.60	2⅔ ounces

For eight-frame supers and hive bodies, use eighty per cent. as much bisulphide as is given in the foregoing table for the corresponding number of supers or bodies.

Example: Suppose that the beekeeper has six ten-frame shallow extracting supers containing combs which he wishes to fumigate. All are tiered up as previously directed and an empty super is placed on top. This makes seven supers in all. Reference to the preceding table shows that this tier of seven supers contains 6.09 cubic feet of space and that for the destruction of all of the waxworms in it one and one-half ounces of the liquid bisulphide are required.