Longmont territory over an area of 161,280 acres and in the Sterling territory, which is in the northeast corner of the state on the South Platte River. This latter territory covers an area of 38,400 acres. It is hoped that when the results of this study are worked up some valuable information will be secured.

THE PINK BOLLWORM (GELECHIA GOSSYPIELLA) IN EGYPT

By H. A. Ballou, M. Sc., *Entomologist* on the Staff of the Imperial Department of Agriculture for the West Indies

Seconded for temporary service in Egypt by permission of the Colonial Office

Native Home and Distribution

The pink bollworm appears to be a native of India and the southern Asiatic region. It was introduced into Egypt in badly ginned cotton lint. The importation of cotton from India into Egypt occurred between the years 1903 and 1913. The following table shows the amount of cotton so imported:—

Year	*Quantity in Kilograms*	*Year*	*Quantity in Kilograms*
1903	20,510	1909	31,206
1904	25,827	1910	13,353
1905	9,150	1911	.....*
1906	81,240	1912	10,998
1907	162,000	1913	89,995
1908	21,460		

* No importations.

It was found in 1913 that a very considerable number of cotton seeds occurred in this cotton and that in these seeds considerable numbers of pink bollworms were found.

Since that time cotton seed from Egypt has been imported into Brazil and Mexico and as a result pink bollworm is now established in those countries.

At the present time the pink bollworm is known to occur in: Asia—India, Ceylon, Burmah, Straits Settlements, The Pacific Islands—The Philippines and Hawaiian Islands. Africa—Egypt, Sudan, East and West Africa, Nigeria and Zanzibar. In the Western Hemisphere the pink bollworm now occurs in Mexico and Brazil where it has recently become established as a result of the introduction of Egyptian cotton seed for planting.

Food Plants

In Egypt the pink bollworm is known to attack cotton of all varieties, teel or Indian hemp (*Hibiscus cannabinus*), bahmia or okra (*Hibiscus*

esculentus) and holly-hock (*Althea rosea*). The record of pink bollworm in Egypt being bred from pomegranate is evidently an error and probably resulted from the use of a breeding cage which had formerly been used in connection with gelechia-infested cotton seed for containing a diseased pomegranate.

In India, the pink bollworm is stated to feed upon the oily seeds of several trees, not being confined to the same natural order as the cotton plant. In Hawaii, the pink bollworm is said to feed upon the seeds of a Malvaceous tree, the Milo (*Thespesia populnea*).

The egg of the pink bollworm is very small and inconspicuous. The eggs are deposited singly or in groups not often exceeding four or five together. They are laid on the food plant of the larva, the preferred situation on the cotton plant being on the boll.

Life-History and Habits

The duration of the egg stage is some four to ten days, after which the eggs hatch and the young larvæ issue.

The larva at first is yellowish-white in color with brown head and brown thoracic shield. Later, the body of the larva becomes tinged with pink, this pink color being deposited principally in broad bands across the back and extending down upon the sides. In well colored specimens the whole body appears pinkish.

When first hatched the larva proceeds to tunnel into the boll and to penetrate into the interior of the seed. The duration of the larval stage occupies, in summer, about 20 to 30 days. During its life, the larva probably consumes more than the contents of one seed, but usually its feeding is all done within one boll. When very young bolls or flower buds are attacked they are entirely destroyed; very young seeds are also completely destroyed, while the seeds which are attacked at a later stage of their growth may be only partly consumed.

The full-grown larva spins its cocoon and enters the pupal stage either in the boll or at the base of the boll protected by the bract, or, most often, they descend to the ground and pupate amongst the particles of soil, bits of leaf, fallen flowers or other loose material on the surface. The pupal stage occupies about 10 to 12 days, after which the moth emerges.

Two or three days after the emergence of the moth, egg laying begins. It is probable that this extends over only a few days more, the whole life of the moth not exceeding two or three weeks under ordinary conditions.

The whole life-cycle occupies some four to five weeks at that period when the temperature and the condition of the plant is most suitable for the development of the insect. Later in the season when the

weather is getting cooler and the cotton plants are ripening, this time is somewhat extended.

The moths are very rarely to be seen in the fields, although they may be there in enormous numbers. They hide during the day and it is practically impossible to disturb them into flight. At night, probably in the two or three hours immediately following sunset, they are active. It is at this time that feeding, pairing of the sexes and egg laying take place.

In Egypt, experiments have shown that the moth is attracted to light. In Hawaii, Mr. August Busck found that the moth was not attracted to light.

The following tables give the figures showing the number of moths captured by single light traps in two different situations. Light traps in the field, however, have not given any results in the control of attacks by this insect.

TABLE GIVING NUMBERS OF GELECHIA MOTHS CAPTURED IN LIGHT TRAP IN INSECTARY AT MINISTRY OF AGRICULTURE, FROM COTTON BOLLS, IN HEAP ON THE GROUND AND IN TRAYS, FROM APRIL 2 ONWARD. THE TRAYS AND BOLLS CONTAINED IN THEM WERE REMOVED MAY 3 TO ANOTHER ROOM. FROM MAY 4 THE TRAP WAS ALTERNATED IN FOUR-DAY PERIODS BETWEEN NO. 1 ROOM CONTAINING HEAP ON THE GROUND AND NO. 2 ROOM CONTAINING BOLLS IN TRAYS.

Day of Month	April	May		June		July		August	
		1	2	1	2	1	2	1	2
1	No light	No light experiments with baits		..	3	2	..	26	..
2	68			..	1	2	..	15	..
3	33			..	1	..	0	13	..
4	41	41	..	..	1	..	2	..	0
5	20	58	..	28	..	..	1	..	1
6	90	69	..	9	..	..	1	..	1
7		60	..	9	..	2	..	..	4
8	54	..	9	11	..	3	..	..	0
9	42	..	3	..	1	1	..	54	..
10	45	..	3	..	1	6	..	35	..
11	73	..	4	..	1	..	0	34	..
12	50	120	..	..	0	..	0	37	..
13	88	45	..	0	..	..	1	..	1
14		46	..	13	..	..	1	..	2
15		60	..	7	..	9	..	..	3
16	250	..	2	..	..	4	..	..	0
17		..	2	..	0	4	..	81	..
18	150	..	2	..	2	7	..	30	..
19	103	..	3	..	0	..	1	38	..
20	93	84	..	..	0	..	2	29	..
21		27	..	13	..	..	1	..	0
22	167	19	..	5	..	..	1	..	2
23	254	53	..		..	8	..	..	1
24	331	..	0	3	..	11	..	..	1
25	300	..	1	..	0	15	..	97	..
26	168	..	0	..	3	13	..	35	..
27	10	..	0	..	0	..	1	40	..
28	50	79	..	..	0	..	0	32	..
29	72	18	..	5	..	..	0	..	0
30	50	19	..	2	..	..	1	..	0
31	..	19	..	..	..	51	..	..	1
									1
Total	2,602	827	29	105	14	138	13	596	18

The light trap used in obtaining the catches recorded in both these tables consisted of an electric light bulb suspended above a pan of

water with a film of kerosene on it. The surface of the water was about 3 feet above the floor level.

TABLE GIVING NUMBERS OF MOTHS CAUGHT IN LIGHT TRAP IN LARGE COTTON SEED STORE AT ALEXANDRIA IN 1917

Date	Moths	Date	Moths
June 21	26	July 13	97
June 22	20	July 14	107
June 23	15	July 15	236
June 25	57	July 16	
June 26	32	July 17	137
June 27	26	July 18	180
June 28	20	July 19	180
June 29	18	July 20	800
June 30	38	July 21	
July 1	65	July 22	
July 2		July 23	
July 3	20	July 24	80
July 4	26	July 25	60
July 5	28	July 26	40
July 6	28	July 27	40
July 8	52	July 28	27
July 9		July 29	20
July 10	68	July 30	
July 11	72	July 31	12
July 12	80	August 1	5

The seed store at Alexandria in which the light trap catches were made, as recorded in the preceding table, was emptied of seed on August 4. New seed from Upper Egypt and the Fayoum began to arrive in this store on August 15. This seed represents the first picking, in 1917, in certain districts.

The numbers of moths caught by the traps each night remained at about the same figures, that is, from 2 or 3 to 15 or 20 until September 1, when the numbers showed a distinct use. In the interval from August 15 to September 1, the emerging moths were probably from scattered seed and pupæ which had been formed between planks in the floor and in crevices in the walls and these represented the resting-stage larvæ from the previous season.

The great increase in numbers, after September 1, was due to the emergence of moths from the short cycle larvæ of the 1917 crop.

The following figures give the catches for each night. It will be noted that on the night of September 11–12 there was no light, and the trap caught only 8 moths, the windows of the seed store being closed. Closing the windows or leaving them open during the night does not seem definitely to affect the catch in the trap.

THE RESTING STAGE

The most important feature in the life-history of this insect is what is called the resting stage of the larva. This resting stage appears to be an adaptation of the insect to its environment. For some reason or in response to some stimulus which is not at present understood, certain of the larvæ, after becoming full grown, spin a special kind of cocoon

TABLE SHOWING CATCHES IN LIGHT TRAP IN SEED STORE* AT ALEXANDRIA, SEPTEMBER 1-17. NEW SEED OF 1917 CROP BEGAN TO ARRIVE IN THIS STORE AUGUST 15

Date, 1917, Morning of	Number of Moths	Windows Open or Closed at Night
September 1	32	.....
September 2	265	.....
September 3	.....	.....
September 4	191	Open
September 5	184	Open
September 6	318	Open
September 7	943	Closed
September 8	2,470	Closed
September 9	4,500	Closed
September 10	7,960	Closed
September 11	5,500	Closed
September 12	8	Closed
September 13	6,060	Closed
September 14	5,760	Open
September 15	2,800	Closed
September 16	5,500	Open
September 17		

* The windows in this seed store were open all day and every day for ventilation. They were closed at night, all through the summer, until September 4.

in which they pass a period of time, varying greatly in length, after which they come out and spin the ordinary cocoon in which the pupa is formed.

In the early part of the season nearly all the larvæ proceed at once to pupate and complete their development. As the season advances an increasing number of them enters the resting stage until, at the end of the season, nearly all follow this course.

It is in the resting stage that the insect passes through the winter or through the period between one crop of cotton and the next, and it is consequently in this condition that it offers the best opportunity for methods of control to be applied.

The eggs are very small and inconspicuous, and the egg stage is short, the larvæ spend all their existence within the tissues of the plant, the pupa is small, well hidden, and occupies a short period of time and the moths are very difficult to find even when they are very abundant. None of these stages offer any satisfactory opportunity for control methods except during that part of the larval life which is called the resting stage.

Resting-stage larvæ are mostly to be found within the cotton seeds. These seeds may be in the seed cotton which is removed from the field as the crop, or they may be in the seeds in bolls which are left attached to the plants or scattered on the ground after the crop is removed. Often two or more seeds are fastened together by the larva in such a way as to allow of its passage from one to another. The presence of "double" seeds is a sure indication of attack by the pink bollworm, but many resting larvæ occur in single seeds. Double seeds are found in the seed cotton, in cotton seed, and in the bolls left in the field after the crop is harvested.

For the control of this insect it is necessary to destroy the resting-stage larvæ at the end of the cotton season. This work falls naturally under two headings—the destruction of all bolls left in the field after the crop is harvested and the destruction of the larvæ in the cotton seed after the cotton is ginned.

Control Measures

In Egypt a law has been passed requiring the destruction of the bolls on the plants and of all that may have fallen to the ground immediately after the crop is finished. A law has also been passed requiring that every ginnery shall be provided with a suitable machine for the treatment of cotton seed as it leaves the gins, for the destruction of the pink bollworm larvæ in the seed.

On account of the difficulties which arise from the war, in obtaining the necessary machinery, this law has not yet been put into force. Experiments have been made, however, with machinery for the treatment of seed by means of heat and there appears to be no difficulty in killing all the worms in the seed without affecting the quality of the seed either for the purposes of planting or for the production of oil.

The use of hydrocyanic-acid gas and carbon bisulphide does not seem to be practicable under the existing conditions in Egypt. The highly poisonous nature of hydrocyanic-acid gas requires the employment of careful and responsible labor in its application and this is not to be had in the ordinary way in the cotton ginneries in Egypt. Further, it is objected that in such a densely populated country the liberation of large quantities of poisonous waste gases would be likely to be injurious to public health. Carbon bisulphide, on account of its highly inflammable and almost explosive character, is not suitable for use in close proximity to cotton ginneries where the atmosphere is laden with the fine particles of cotton which, in the event of fire, are also highly inflammable.

As far as Egypt is concerned, hot air seems to be the most suitable agent for the destruction of the pink bollworm in cotton seed at the ginneries.

The pink bollworm campaign which is carried out under the direction of the Ministry of Agriculture has for its object the destruction of the bolls left in the fields after the crop is harvested. The season of 1916–1917 was the first one in which this campaign was well organized and thoroughly carried out. The results obtained from this campaign although not altogether satisfactory have been very useful. A very large proportion of the bolls were destroyed.

The law required that the bolls should be cleaned from the standing

plants and burnt and that all fallen bolls should be collected from the ground and burnt before the cotton plants were cut or pulled.

In cases where this was not done before the prescribed time the cotton sticks were seized and destroyed by the officers of the Ministry of Agriculture. The value of the sticks destroyed in this manner is estimated at L. E. 87,000.[1] In Egypt, the scarcity of fuel gives to the cotton plants a value which they probably possess in no other cotton growing country and it is because of this that attempts are made to have the bolls cleaned from the plants instead of having them uprooted and burnt.

The prospects for the control of the pink bollworm in the future are distinctly hopeful. During the past season much opposition was met with on the part of the ignorant and superstitious peasantry while the village officials failed to give that assistance which might reasonably be expected of them, and in some instances even directly opposed the efforts of the Ministry of Agriculture.

In succeeding years, however, it is to be expected that the peasants will realize more and more the usefulness of this campaign and that the village officials will render valuable assistance. In the past season also, as a result of the war, there was a shortage of English officials and the native subordinate officials were all new to the work and had to be trained in their duties.

When the working of the field campaign has been improved and the ginneries are equipped with suitable machines for the treatment of seed, there is every reason to hope that the pink bollworm will be controlled to such an extent as to impose only normal losses on the cotton industry of Egypt.

There is no hope that the pink bollworm will ever be exterminated and so far as at present known there seems no likelihood of its ever being controlled to a satisfactory extent by its natural enemies.

The Nature and Amount of Loss Caused by the Pink Bollworm

The pink bollworm causes injury and loss to the cotton by injuring the seed and by reducing the amount of lint produced. The quality of the lint is also seriously affected. Young bolls are attacked and completely destroyed, while, when flower buds are attacked, these are destroyed and no flowers produced.

When a seed is attacked at an early stage of its growth not only is the seed completely destroyed, but no lint is produced by it. Later on, seeds may be attacked when they have formed all or part of their lint. In such cases, it is easily seen that a considerable amount of damage

[1] The L. E. = about $5.00.

may be done to the seed without causing very much loss in the amount of lint produced, although its quality may be affected.[1] A certain amount of damage is also caused by the tunnels of the larvæ through the boll. The lint is stained either by the larva or by fungi or bacteria which attack the injured tissues. Another and important injury is that which results in producing a dead or unopened boll or sections of boll. In these, the cotton remains matted, failing to open properly and is often discolored.

The amount of loss resulting from the attacks of the pink bollworm is very difficult to estimate. In Egypt, for something like twenty years past the average yield of cotton per feddan has been steadily decreasing but there has not been, since the advent of the pink bollworm, any acceleration in the rate of this decrease. The crops of the past three or four years have been slightly smaller than those of the previous few years. The following figures show the yield per feddan for the period 1894–1916 and the means of average yields for the last four five-year periods.

TABLE SHOWING AVERAGE YIELD OF COTTON IN EGYPT FOR THE YEARS 1894–1916

Year	Yield in Qantars* per Feddan	Year	Yield in Qantars per Feddan
1894	4.78	1906	4.61
1895	5.27	1907	4.51
1896	5.60	1908	4.12
1897	5.80	1909	3.13
1898	4.98	1910	4.57
1899	5.64	1911	4.31
1900	4.42	1912	4.35
1901	5.10	1913	4.45
1902	4.58	1914	3.67
1903	4.88	1915	4.05
1904	4.39	1916	3.64
1905	3.80		

* The qantar = 99.05 lbs.; the feddan = 1.038 acres.

The means of the average yields for 5-year periods are:

1897–1901	5.09 qantars
1902–1906	4.45 qantars
1907–1911	4.12 qantars
1912–1916	4.03 qantars

There has been a great fluctuation in the price of cotton owing to the war which makes it extremely difficult to place a money value on the losses caused by the pink bollworm. It would appear, however, from

[1] Attacked seeds lose in weight: They may be entirely destroyed, or may be injured in varying amounts, some, although attacked, being nearly of full weight and producing almost a normal amount of lint.

Another form of injury by the pink bollworm is the loss in weight of seed, in weight of lint, in germination of seed and in quality of lint in the case of unattacked seeds in locules in which other seeds have been attacked.

figures already at hand that the losses resulting from the attacks of this insect may be taken at 10 per cent of the total crop of cotton in Egypt during the past two or three seasons. If this is calculated on the amount and value of last season's crop (1916) we get the following figures:

The total crop of cotton was about 6,000,000 qantars, 10 per cent of which would amount to 600,000 qantars. The average price per qantar for the season may be taken as between 30–40 dollars.[1] At the former price this would mean a loss of L. E. 3,600,000 and at the latter a loss of L. E. 4,800,000. These figures are probably under rather than over the amount of this loss, but, whether they are accurate or not they indicate, strikingly, the very large toll which this insect takes from the cotton industry of the country, and they should serve as a warning to any country in which the pink bollworm does not occur to take every precaution against its introduction.

Natural Enemies

The natural enemies of the pink bollworm do not occur in sufficient numbers or at the right time of the year to exercise any great degree of control over this pest in Egypt.

The insects known to be parasitic or predaceous on the pink bollworm are:

Pimpla roborator, *Chelonella sulcata*, *Rhogas kitcheneri*, a Pteromalid and *Pediculoides ventricosus*.

Pimpla roborator is a general parasite in Egypt. It appears to attack the pink bollworm only late in the season, too late in fact to exercise any control over the amount of damage to the cotton in that season. The practice of burning the bolls left after the cotton is harvested destroys large numbers of this parasite. This is the only parasitic insect which has been bred in large numbers from the pink bollworm.

Chelonella sulcata at present is known in Egypt only as a parasite of *Gelechia gossypiella* and has been known in this country only since the advent of this pest. Up to the present time, it has not been recorded in large numbers.

Rhogas kitcheneri and the small Pteromalid—*Pteromalus* sp., are general parasites which are known at times to attack the pink bollworm.

Pediculoides ventricosus sometimes occurs in great abundance in cotton seed stores and causes the death of large numbers of Gelechia larvæ. There is no certainty that this mite is capable of penetrating into infested single or double seeds containing resting-stage larvæ if nothing has happened to render the union between the double seeds

[1] The dollar = 20 piastres tarif = 1/6 of the Egyptian pound (L. E.).

or the covering over the entrance to the infested single seed less impenetrable than they were made by the larvæ. The action of the cotton gins may result in loosening the silk spun by the larvæ sufficiently to allow for the entrance of the mites.

Any larvæ that come out of the seed in a mass of seed where Pediculoides occurs abundantly are almost certain to be attacked and killed by this mite, especially late in the season.

The two principal natural enemies are then Pimpla and Pediculoides. Pimpla occurs in some numbers but the bollworm campaign in Egypt should result in all the bolls remaining in the field after the crop being destroyed before the time of the greatest emergence of the parasite, and Pediculoides occurs in numbers only in the storehouses later in the season. When the ginneries are equipped with machines for treating the seed as it leaves the gins, the predaceous mite will cease to be of any importance in connection with the control of pink bollworm in cotton seed.

NOTES ON THE WOOLLY APHIS

By Geo. G. Becker, *Fayetteville, Ark.*

Owing to the war and to the uncertainty of concluding investigations as planned, the writer is submitting in this paper the results of investigations with the woolly aphis, *Eriosoma lanigera* Haus., which had as their aim (1) the working out of the life-history of the insect in the Ozarks, (2) studying the relative immunity of various hosts of this insect and of the relationship of these hosts to the species, (3) studying the immunity of Northern Spy stock to the attacks of this species, and (4) determining whether *Eriosoma cratægi* Oestlund is a synonym of *Eriosoma lanigera* Hausmann.

In the Ozarks the species winters on elm in the egg stage and on the roots of apple and in wounds, knots and rough places on the trunk above the ground, of apple and Cratægus as apterous viviparіæ. The occurrence of overwintering apterous viviparіæ above ground on apple or Cratægus is uncommon in this latitude as the aphids seem unable to withstand the low temperatures.

The overwintering eggs on elm probably hatch sometime between the first and the middle of March. In 1916 we found stem-mothers in about the third instar by the 30th of March. At this time the buds, with the exception of the infested ones, had not pushed through.

The second generation begins to make its appearance by the first of April. In 1915 a stem-mother was found on April 20 with about 20 or more young, in 1916 we found a stem-mother on April 6 with