Report of the Proceedings

of the

Third Entomological Meeting

Held at Pusa, 3rd to 15th February 1919

REPORT

OF THE

Proceedings of the Third Entomological Meeting

Held at Pusa on the 3rd to 15th February 1919

In Three Volumes

Edited by

T. BAINBRIGGE FLETCHER, R.N., F.L.S., F.E.S., F.Z.S.,
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Proceedings of the Third Entomological Meeting

VOLUME II

15.—SOME INDIAN ECONOMIC ALEYRODIDÆ.

By C. S. Misra, B.A., *First Assistant to the Imperial Entomologist.*

Aleurolobus barodensis, Maskell. (Plate 70).

Aleurodes barodensis, Mask.—Trans. New Zealand Inst., Vol. 28, p. 242, 1895.

Aleurodes barodensis, Mask.—W. M. Maskell, Ind. Mus. Notes, Vol. IV, Pt. 3, pp. 143-144 and 213, Plate XXII, fig. I, 1900.

Aleurodes barodensis, Mask.—H. W. Peal, Jour. Asiatic Soc., Vol. LXXII, Pt. II, No. 3, 1903, pp 90, 92-93.

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Aleurodes barodensis, Mask.—G. W. Kirkaldy, Cat. of Hemipterous family Aleurodidæ, p. 47, 1907.

Aleyrodes barodensis, Mask.—A. L. Quaintance, Genera Insectorum, p. 5, 1908.

Aleurodes barodensis, Mask.—Lefroy, Ind. Ins. Life, p. 751, 1909.

Aleurolobus barodensis, Mask.—A. L. Quaintance and A. C. Baker, Classification of the Aleyrodidæ, Pt. II, 1914, p. 109. U. S. Dept. Agric., Technical Series, No. 27, Part II.

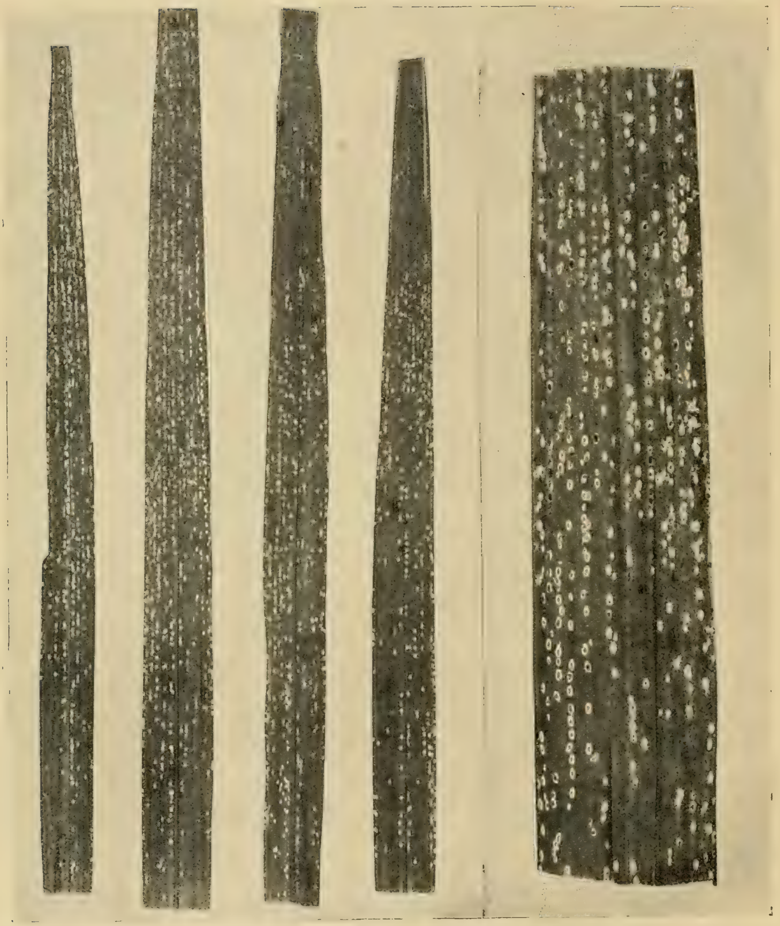
Aleurolobus barodensis, Maskell, popularly known as cane mealy-wing or sugarcane white-fly, is in particular places and in some years very destructive to sugarcane, especially the broad leaved varieties. During the past fourteen years that I have been observing the pest at Pusa, I have found it bad in some years and lightly so in other years. It is bad from July to November when it is more or less parasitized. In years when ratoon cane was allowed to remain on the ground, the subsequent new plantations were more affected than when no such crop was allowed to remain on the ground. With the ratoon crop the pest continued to breed and quickly transferred itself to the new crop. Besides, I have seen the pest bad at Nagpur, Baroda, Tharsa (Central Provinces), and present on the cane at Cawnpore and Sindewahi (District Chanda, Central Provinces). In February 1908, when I examined the sugarcane on the Sewage Farm, Nagpur, the pest was so bad on the leaves that with the whitish puparia on the leaves, especially the lower side, they looked white from a distance. The lower leaves were encrusted thickly with the black fungus, *Capnodium* sp., and on the whole the fields looked pale and sickly. The cultivators though thorough agriculturists ascribed the stunted growth of the plants to the scarcity of irrigation water. In a case like this it was no wonder that, the plants being deficient in sucrose contents, they were not much appreciated by the local people in the city *peths* where they were put up for retail sale.

EXPLANATION OF PLATE 70.

Aleurolobus barodensis.

Fig. 1. Sugarcane plant infested with mealy-wings.
Fig. 2. Eggs on a portion of a leaf; magnified ($\times 20$).
Fig. 3. Nymph, first instar, magnified ($\times 48$).
Fig. 4. Nymph, third instar, magnified ($\times 13$).
Fig. 5. Nymph, fourth instar, magnified ($\times 13$).
Fig. 6. Puparium, female; magnified ($\times 13$).
Fig. 7. Female, as seen on plant; magnified ($\times 13$).
Fig. 8. Female, with wings expanded; magnified ($\times 13$).

ALEUROLOBUS BARODENSIS.



A. barodensis **on sugarcane leaves ; Pusa, 18th December 1915.**

Leaves of *Sannaballi* sugarcane infested with *A. barodensis* and the fungus parasitic on it. Tharsa Farm, C. P., December 1915.

The pest has also been reported from Bassein Fort (7th April 1902) Baroda (*Ind. Mus. Notes*, Vol. IV, Part 3, p. 143, 1899) and Ankleshwar (District Broach, Gujarat, 29th August 1906) from the Bombay Presidency. The Agricultural Inspector, South Arcot, Madras Presidency, (*Ind. Mus. Notes*, Vol. V, Part 2, p. 44, 1900) reported that in consequence of the presence of the pest the crop looked pale and stunted in growth and that the cultivators were aware of the damage done by the pest since the last ten years. The editor of a local paper in Baroda wrote in 1906 that the pest had damaged nearly 50 per cent. of the crop that year in the Baroda territory. Early in September 1914 specimens of the mealy-wing in almost all the instars were collected by the Imperial Entomologist at Pyinmana, Tatkon and Myitkyina, Burma, and an examination of the infested leaves showed that the nymphs of the third and the fourth instars as well as puparia were especially abundant on the lower surface of leaves collected at Pyinmana and Tatkon, and that some of the leaves were heavily encrusted with the black fungoid growth following the honey-dew exuded by the mealy-wings. On most of the leaves the nymphs of the fourth instar as well as the puparia had collected together towards the apices in very large number and it was no wonder that the plants under such heavy infestation should have been pale and sickly in appearance.

In the beginning of December 1915, I examined the sugarcane growing on the Tharsa Farm, Central Provinces, and found some of the varieties of sugarcane infested heavily. Nymphs of the second and the third instars together with the puparia were present in numbers on the lower surface of leaves, and the lower leaves were thick with the black fungus. The variety of cane most affected was *Sennabelli* of Madras. (Plate 72.) On the leaves of this variety the puparia were found affected with a fungus and the specimens were sent for examination to Dr. E. J. Butler, the Imperial Mycologist, who wrote :—

> "Mr. Misra collected on 2nd December 1915 at Tharsa Farm, Central Provinces, a fungus parasitic on the sugarcane mealy-wing, *Aleyrodes barodensis*, Mask., which he asked me to identify. It was an *Aschersonia*, which I submitted to Mr. Petch, Government Mycologist, Ceylon, who has been engaged on a special study of the genus and had seen all the Indian materials available. Mr. Petch now identifies the fungus as *Aschersonia placenta*, B. and Br. This species has not been previously recorded on a sugarcane pest but is relatively common in India on species of Aleyrodidæ on *Citrus*, *Morus* and other plants. An ally has been extensively used in Florida and elsewhere against the white-fly of *Citrus*."

The fungus covered the puparia completely and destroyed them. At least from a number of puparia covered over by the fungus not a single adult emerged. On some leaves the parasitic fungus had formed round yellow hemispherical globules, very much like those of *Ceroplastes*, and these were tilted off the leaves easily as soon as they were either jerked or twisted round leaving whitish round patches which became conspicuous against the black back-ground on the leaves produced by the black fungus.

The insects are known as *Mashi*, *Bamni* or *Popti* in Gujarat and *Lahi* in the United Provinces and some parts of Bihar and Orissa. The adults are tiny, fragile insects with a pale body, prominent black eyes and a pair of mealy-wings. The adults are active and may be seen in numbers on the apices of unopened cane leaves or on the lower surface of leaves. They have not been seen to fly long distances but when disturbed they fly actively from plant to plant. They seem to prefer the broad-leaved sugarcane varieties to those with short, thin leaves. They seem to be active from August to the end of March and appear to be affected prejudicially with hot winds which blow during May and June in Northern India. Eggs are laid during the winter, and nymphs, puparia and adults may be seen during December, January and February. The pest seems to be active from August onwards, and a large number of adults may be seen on the apical unopened leaves early in the mornings from 7 to 9 A.M. After that they disperse and may then be seen on almost all the parts of the plant. The female is distinguished readily from the male in being more robust and less active than the male. Copulation takes place end to end. The male on approaching the female shakes its wings rapidly whilst the female remains stationary with her legs stretched out. In one instance they were observed to remain in copulation for three and a half minutes, when the male flew away.

The eggs are laid in a line near the midrib or in any part of the lower surface of the leaf. In exceptional cases the eggs have been seen laid on the upper surface of the leaves. Otherwise they are laid invariably on the lower surface of leaves. The eggs are either continuous or broken. They are deep castaneous or dark black and as such appear prominently against the greenish background of the leaves. If the female is disturbed at the time of egg-laying the eggs are laid in small clusters on various parts of the leaf. At times, when a large number of adults emerge, as is generally the case from August to December, the undersides of leaves contain a large number of eggs. The eggs are laid mostly on the apices of unopened leaves, but they are also laid in numbers on the old leaves full of nymphs and puparia. The number of eggs laid varies greatly. In one instance a female began laying eggs at

7 A.M. and by 8-45 A.M. in the same day she had laid 27 eggs when she flew away and was seen no more. The least number in a cluster may be as low as 3 or as high as 51. It is difficult to find the exact number of eggs laid by a female in the fields as she never lays them at one sitting. In captivity the number of eggs laid by individual females varied from 27 to 47 and I think it would not be wide of the mark if the average number of eggs laid by a female be taken as 40. Subsequent to the observation noted above a female was observed to have laid on the 18th September 1909, 27 eggs in one place, 11 a little to the south of the former cluster and 10 a little to the side of the first cluster. In all she laid 48 eggs on the same leaf, though in three separate masses. On the 8th November 1911, a count was made of the number of eggs in different clusters and the result was as follows :—

Cluster—	Number of eggs	
1st	17	
2nd	19	
3rd	18	
4th	28	
5th	22	
6th	14	
7th	25	
8th	10	
9th	27	
10th	14	
11th	51	
12th	46	
13th	38	Of these 14 were laid at a distance of not more than 2 mm. from the main cluster and so were taken to form one cluster.
14th	21	
15th	19	

In some years these eggs were laid close to the eggs of *Neomaskellia bergii*, Sign. on the lower surface of the same leaf, but could be distinguished readily from the latter as they are laid in straight lines though broken. The females of *Neomaskellia bergii*, Sign., lay eggs either in a circle or in two crescents very nearly touching each other to form a circle.

The eggs when laid freshly are dull pale brown. They change colour 48 hours after they are laid. They are broad at the base, pointed at the other end. It is pedunculated* at the broad end with a short, thick smoky-brown peduncle with which it is attached to the leaf. Each

* A number of females were treated with cool K O H 10 per cent. from 24 to 48 hours and the chitin had become so transparent that the eggs within could be seen distinctly under the microscope. They were then seen with peduncles attached to their broad ends.

egg touches the other at the sides and may be upright against the plane of the leaf or a little bent on either side. It is ellipsoid in shape, sometimes covered over with a thin bloom which is hardly perceptible to the naked eye. The eggs ultimately became deep black and as such may be seen as thin, black lines on the leaves.

When fully matured, a slit opens longitudinally and the head is thrown out. Slowly the slit widens and nearly half of the nymph is out of the eggshell. After 17 to 28 minutes the nymph is completely out of the eggshell. It then remains stationary for a few minutes when it begins to wander about. It is then a tiny pale yellow insect which wanders up and down the leaf until it settles down to feed. Its colour becomes smoky yellow, then deep grey, light black, and ultimately shiny black.

Larva—1st Instar. Length 0·36 mm. including the whitish fringe; shape elliptical, colour fuscous grey with two dark spots representing the eyes; a whitish waxy fringe on the margin which consists of fine, white thin waxy threads intimately touching each other. The waxy threads rise a little above the margin. Dorsum longitudinally, medianally raised with a pair of whitish elongate ovoid flocculent globules touching each other laterally. The two pairs of flocculent globules are situated on the dorsum between the eyes and the vasiform orifice. Vasiform orifice conical, broad at base, apex pointing caudad, rounded apically, apex not touching the margin. Edge of the orifice black, operculum fitting nearly the anterior, basal flat portion of the orifice which is posteriorly dark fuscous, anteriorly fuscous yellow. Lingula long, cylindrical, pointed apically, dark fuscous towards the apex, not touching the apex of the orifice. It lies centrally in the space between the apex of the operculum and the apex of the vasiform orifice. Two long, greyish setæ caudad, with a pair of smaller setæ at the side on the margin with another pair of long dark grey setæ a little above the smaller setæ. The space on the dorsum between the posterior median pair of flocculent globules and the base of the vasiform orifice is finely, transversely striated.

Larva—2nd Instar. Length 0·46 mm., breadth 0·26 mm.; elongate elliptical, slightly convex. The newly moulted larva is greyish-brown with a dark spot on each side of a median, longitudinal ridge from the cephalo-thorax to the base of the vasiform orifice dorsally; a thin, whitish, waxy fringe on the margin composed of shiny rods touching each other; abdomen dorsally, distinctly segmented, the transverse carinations being especially prominent on the median longitudinal dorsal ridge, the carinations not reaching the marginal fringe. The first transverse carination is the longest, nearly reaching the end of the central longitudinal dorsal convexity, the second is curved more inwardly in the middle, third and fourth nearly equal ; fifth, sixth and seventh nearly equal to each other, eighth slightly smaller than the seventh, ninth nearly equal to the third. Two dark fuscous spots on either side of the base of the vasiform orifice ; the space between the longitudinal dorsal ridge and the lateral margin inwardly is sparsely covered with a thin whitish meal. Margin finely crenulated, the crenulations consisting of outwardly pointed translucent teeth (as seen in specimens treated with K O H 10 per cent., dehydrated, passed through clove oil and finally mounted in Xylol × Balsam), the apex of the teeth not reaching the outer margin ; two translucent white setæ cephalad, the length of each being 0·01 mm. ; two pointed setæ caudad posteriorly laterally, the length of each seta being 0·02 mm. ; vasiform orifice subconical, posteriorly slightly produced and not reaching the margin. Length of vasiform orifice 0·03 mm. ; operculum broad, flat, nearly covering loosely the basal broad half of the orifice ; lingula 0·03 mm. long, 0·01 mm. broad, broad at base, slightly constricted in the middle and broad at tip with two fine hairs on either side of the apex, not reaching the apex of the vasiform orifice though projecting prominently beyond the operculum ; two transparent tubercles ending in hairs below the transparent pointed teeth of the crenulations ; two transparent spots on either side of the base of the vasiform orifice, a series of single pores on the margin all round below the pointed crenulations.

Nymph—3rd Instar. Length 1·2 mm., breadth 0·45 mm., shiny black in colour with a prominent cretaceous fringe in the margin ; shape elongate elliptical with distinct transverse striations on the dorsum which is slightly longitudinally raised from the anterior part of the cephalo-thorax to the base of the vasiform orifice. The cretaceous marginal fringe consists of thin whitish threads closely touching each other, the length of each thread being 0·24 mm. The dorsum is covered sparsely with white mealy granules which in some places by coalescing or touching each other closely form small lines. The coalescence of the granules is greater near the margin thus forming an indistinct fringe all round the margin inwardly. A little away from this fringe inwardly is another coalescence of granules forming another fringe. There are ten deeply indented transverse lines on the dorsum. Of these the first, second and the third are subequal, fifth longer than fourth and the following sixth, seventh, eighth and ninth subequal and approximate 1st, 2nd and 3rd in length, tenth small in the form of an inverted crescent a little above the vasiform orifice.

Vasiform orifice subconical, broad at base, apex somewhat not reaching the margin ; operculum broad heart-shaped fitting loosely into the basal broad half of the vasiform orifice. The apex of the lingula projects beyond the operculum and not reaching the apex of the vasiform orifice, unicolorous with the operculum.

Nymph—4th Instar. (Nymph as seen on the leaf, not treated with K O H.) In the 4th instar the distinction between the male and the female nymphs becomes very distinct. Female nymphs are longer and broader than male nymphs. The nymph immediately after moulting is dull brown, quickly turning dark grey and ultimately shiny black with two translucent spots on either side of the longitudinal median ridge on the cephalo-thorax. A deep excavated line runs interiorly round the margin. The exuvium remained attached to the nymph for some time.

The full-grown larva is 2·25 mm. long, 1·05 mm. broad exclusive of the waxy fringe. Dorsum covered thickly with cretaceous white meal. Between the whitish dorsal meal and the marginal cretaceous white fringe a deep black excavated line runs internally round the periphery of the margin. A dorso-median longitudinal cretaceous white line on the cephalo-thorax and the abdomen extending to the base of the vasiform orifice, somewhat broken on the cephalo-thorax anteriorly, prominent on the cephalo-thorax prominently and the abdomen basally.

Vasiform orifice long, in the shape of an elongate cone, apex pointing caudad, basally and laterally bounded by cretaceous white lines, the lateral ones meeting below apex of the vasiform orifice forming a thick white line which touches the marginal fringe.

In the untreated specimens the operculum and the lingula are indistinct on account of the black colour of the chitin.

Life-cycle and Hibernation.

During August 1913, a complete life-cycle was seen to occupy 24 to 25 days, thus :—

Eggs laid	9th August 1913.	
Eggs hatched	16th August 1913.	
Adults emerged . . .	3rd September 1913 . .	25 days.

In the winter the cycle must be still longer. There is practically no hibernation in this species during the winter. The adults are found from November until the end of January and the beginning of February. They seem to be very susceptible to hot winds during April-June. On the 14th April 1908, I made a note to this effect in my note-book thus :—

> *14th April 1908.*—Egg-laying sparse, not many imagines are to be seen on the leaves. The past hot days seem to have had a deterrent effect on egglaying. Yesterday the temperature was 109·7 with strong, hot winds and a large number of nymphs were seen shrivelled up on the leaves......

Again on the 12th May 1908, I noted :—

> ......Eggs freshly laid with nymphs of II, III and IV instars on the leaves. The number of eggs on the leaves extremely small. The past hot days seem to have had a deterrent effect on the growth of the nymphs, and a number of them are to be seen shrivelled up or looking unhealthy......

Last year I tried to work out the life-history of the species to find out the time taken for a complete cycle during the winter and with this object found adults in the fields which when confined laid eggs. These hatched and the nymphs were progressing healthily when the plant on which they were breeding was found to have been affected with borers and withered prematurely. In the fields adults are plentiful in the beginning of December when eggs are laid. They, however, become scarce during January, again appearing by the beginning of February at Pusa.

Parasites and Predators.

I have not hitherto found any parasites on the eggs or on the adults. The nymphs and the puparia are parasitized heavily by three species of Chalcididæ noted up to this time. It is possible there are many more which have not been noted as yet. The puparia seem to be affected more than the nymphs, and the parasitization seems to reach its maximum by the middle of December. Last year we have had a few countings made with the following results :—

No. of nymphs and puparia on leaves	No. parasitized	Percentage
3rd December 1918, 397 (one leaf)	322	81·10
5th December 1918, 146 (one leaf)	134	91·70
12th December 1918, 465 (one leaf)	418	92·04
14th December 1918, 228 (one leaf)	199	87·51

From the beginning until the third week of December 1918, the parasites were so numerous that large numbers of them were to be seen on the infested leaves close to the nymphs and puparia. Their colour is black and as such they are seen distinctly against the greenish or pale-green background of the leaves. Of the three parasites observed to be plentiful during December 1918, the one figured below was the most prominent. It is a shiny black Chalcidid with antennæ and legs pale stramineous. The wings have no veins ; instead there is a slight thickening of the costal margin at base. The tibial spur on anterior leg is very prominent. The third antennal joint is the shortest and the apical joint is transversely, obliquely though very faintly divided in some specimens. In others the divisions are not prominent. In some specimens the apical joint of the left antenna is broader and flatter than the apical joint of the right antenna which is thin and pointed as shown in the figures below. This shows the variation taking place in individual specimens of the same species. In future generations these variations may become fixed and lead to the growth of new species. There were as many as 3 to 6 clean circular holes on some puparia and this shows that a puparium could harbour as many as six parasites within it. (Plate 73.)

The fact that at times and in particular localities the pest is very bad will be clear to any one who has opportunities of observing it on its favourite foodplant, the sugarcane, in various localities in the sugarcane-growing tracts in Northern India. At Pusa the pest is bad in some years. A single affected leaf has been counted to contain from 146 to as many as 517 nymphs and puparia, and one can easily form an idea of the sap drained off by such a large horde of insects which exude honey-dew so copiously that it lies thickly on the leaves and gives rise to the black fungus. In 1907 we tried to remove the affected leaves in the worst infested plots and much good was done. But this measure though effective is very drastic in its application and I am chary how far it will commend itself to the cultivators. Besides this, no other easy and equally effective measure seems to be practicable. Some such measure was also adopted by the Superintendent of Entomology, Baroda, in 1911 or thereabout and he remarked :—

> " The result of operations was that all the canes became leafless. A few weeks after the aspect changed and the plants put forth healthy and vigorous leaves and the whole crop was thus relieved of the pest."

The area treated was one acre and 3 gunthas and four cuttings were made on the Model Farm, Baroda.

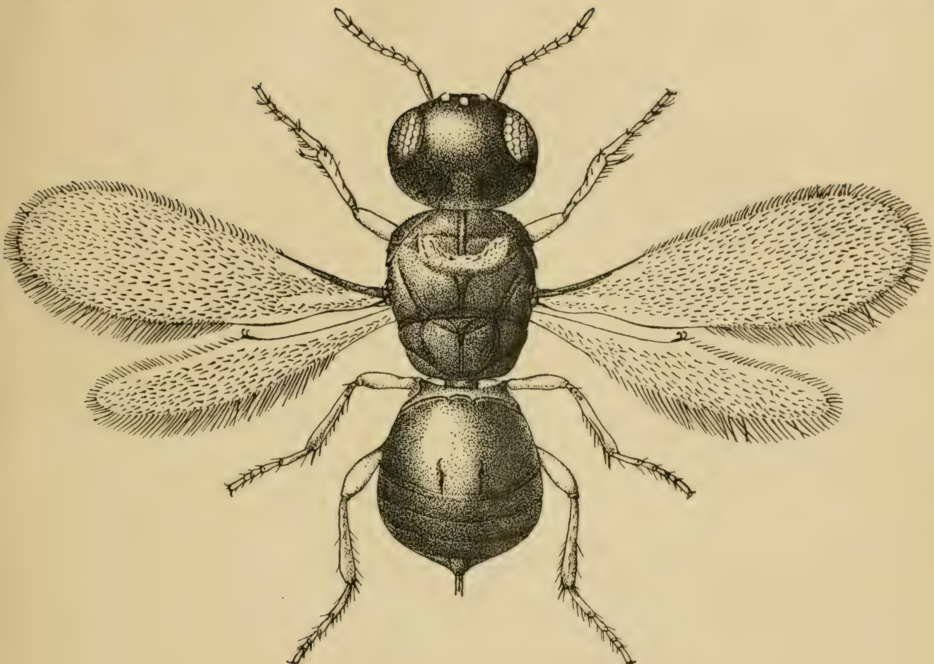
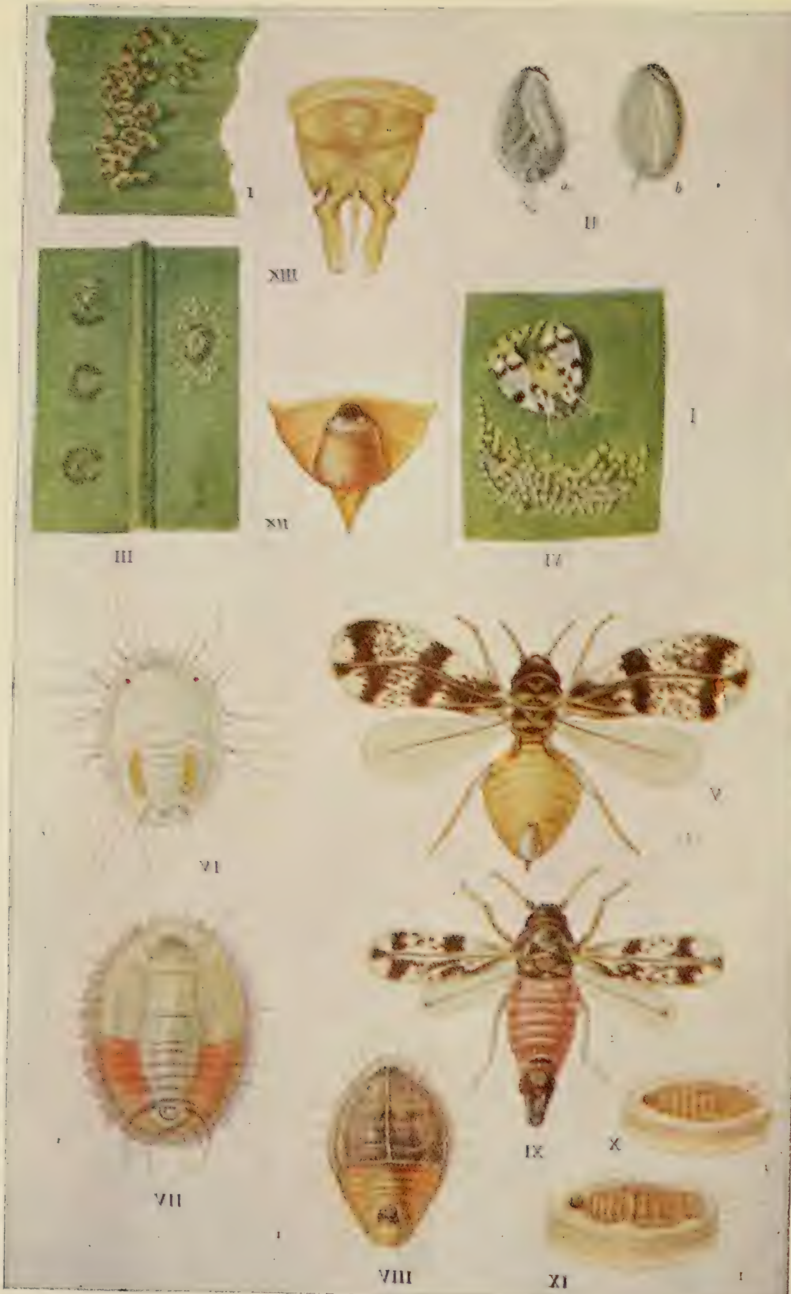


Fig. 1.—Chalcidid parasite on *A. barodensis* ; Pusa, December 1918 ; $\times 45$.

Fig. 2.—Apical joints of (*a*) left and (*b*) right antennæ of Chalcidid parasitic on *A. barodensis*, $\times 400$.



NEOMASKELLIA BERGII.

EXPLANATION OF PLATE 74.

Neomaskellia bergii.

Fig. 1. Eggs on lower surface of sugarcane leaf, magnified ($\times 12$).
Fig. 2. (*a*) An egg (somewhat shrivelled); magnified ($\times 67$).
(*b*) A healthy egg, showing peduncle; magnified ($\times 67$).
Fig. 3. Female laying eggs on a leaf, natural size.
Fig. 4. Female laying eggs, magnified ($\times 5$).
Freshly laid eggs, yellow.
Eggs more than 12 hours old. Dark grey.
Fig. 5. Female with wings expanded; magnified ($\times 16$).
Figs. 6—8. Larvæ (dorsal view).
Fig. 9. Male, dorsal view; magnified ($\times 27$).
Fig. 10. Male puparium, lateral view; magnified ($\times 20$).
Fig. 11. Female puparium, lateral view; magnified ($\times 20$).
Fig. 12. Female vasiform orifice, viewed from behind, much enlarged.
Fig. 13. Male vasiform orifice and genitalia; magnified ($\times 67$).

Date of operation	No. of leaves cut	Labour
7th June	...	1
18th June	165	1
16th–18th July	2,333	2
28th July	2,663	2
29th „	7,073	2
30th „	17,235	3½
31st „	7,442	2
1st August	5,151	1
2nd „	11,419	2
3rd „	17,810	4

Neomaskellia bergii, Signoret. (Plate 74.)

Aleurodes bergii, Sign.—Signoret, Annales Soc. Ento. France (4), Vol. VIII, p. 395 (1868).

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Aleurodes bergii, Sign.—H. M. Lefroy, Ind. Ins. Life, p. 752 (1909).

Aleurodes bergii, Sign.—Fletcher, South Ind. Ins., p. 507, f. 394 (1914).

Aleurodes bergii, Sign.—Maskell, Trans. New Zealand Institute, XXII, p. 172 (1890).

Aleyrodes bergii, Sign.—Cockerell, Proc. Acad. Sc. Philadelphia, p. 281 (1902).

Aleyrodes bergii, Sign.—A. L. Quaintance, Genera Insectorum, Aleyrodidæ, p. 5 (1908).

Aleurodes bergii, Sign.—S. Matsumura, Die Schädlichen und Nützlichen, p. 12, Plate XI, figs. 1-4.

Aleurodes bergii, Sign.—L. Zehntner, Mededeelengen van Het Proef Station Oost Java, Nieuw Series, No. 29, pp. 3-4, Plate, figs. 1-16.

Neomaskellia bergii, Sign.—Quaintance and Baker, U. S. Dept. Agri., Tech. Series, No. 27, Pt. I, Plate XXXIV, figs. 1-8 (1912).

Neomaskellia bergii, Sign.—Quaintance and Baker, U. S. Dept. Agri., Tech. Series, No. 27, Pt. II, p. 104.

The adults, eggs and nymphs were first found by me on sugarcane at Pusa on the 5th July 1907 along with the nymphs and puparia of

Aleurolobus barodensis, Maskell. These, along with those of *A. barodensis*, are found in the majority of cases almost wholly on the lower surface of sugarcane leaves, but the eggs with the female laying them are very conspicuous objects on the leaves and once seen cannot be forgotten soon. Besides, the presence of eggs and the females laying them are betrayed by the presence of the ants which attend upon them for the sake of the honey-dew. The ants may be seen standing behind the females and tapping them gently with their antennæ and these are seen to exude the honey-dew in droplets which are licked up greedily by the ants. The eggmasses are fairly large, either wholly circular or consisting of two crescents meeting each other towards their sharp ends in the centre, thus forming a circular spot. The eggs when laid freshly are shiny pale yellow and 48 hours after being laid they turn dusky yellow, the apices turning dark fuscous brown, ultimately turning deep chocolate brown. They are attached to the surface of leaves by peduncles. In a mass of eggs, some are pale yellow whilst others are dark castaneous. The former are freshly laid eggs whilst the latter are at least 48 hours old. The position of the female while laying eggs is very characteristic. She stations herself mostly on the lower surface of a cane leaf, the abdomen is slightly raised and the legs stretched out; the eggs are then laid close to each other on one side—completing either the right or the left side of the circle; she then wheels round and begins laying eggs on the other side. In this posture she becomes a very conspicuous object on the leaves. The eggs, with the female laying them, and stationed in the centre, become very prominent. The female is so slow in her movements that, even if disturbed whilst laying eggs, she stops for a few minutes and then again begins laying eggs. While doing so, she is attended by the ants, *Camponotus compressus*, which wait upon her for the sake of the honey-dew. Thus she performs two functions simultaneously. She lays eggs and then has to respond to the gentle taps of her ant-attendants for the honey-dew. When, however, the female refuses to exude the honey-dew, the ants get annoyed and remove her to another place to feed. On the 18th July 1907 I watched the ants attending upon females while laying eggs. An ant which repeatedly tapped the female on the dorsum failed to obtain the required supply of honey-dew. It became irritated, caught hold of the female gently in its mandibles and transported her bodily to another suitable succulent spot in the same leaf. On the 21st July 1907, I found the same female (the female under observation was marked with red on the abdomen to facilitate distinction from other females) resting 7 inches down from the spot I had seen her on the previous day, with a number of ants attending upon her.

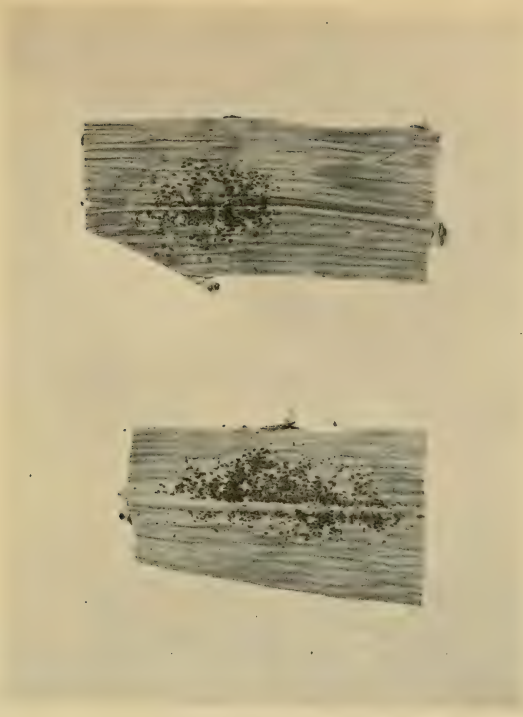


Fig. 2.—*Neomaskellia bergii* on *Andropogon Sorghum*; Nagpur.

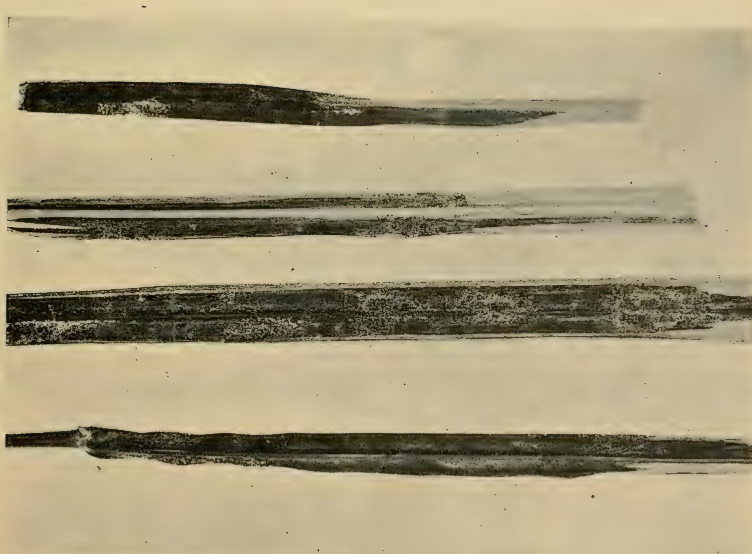


Fig. 1.—*Neomaskellia bergii* on sugarcane; Pusa, 20th January 1914.

The female lays eggs very slowly. Sometimes she has been seen to continue laying eggs for more than three days. In one case a female began laying eggs at 11 A.M. on the 16th July 1907 and had not completed laying eggs till 12 noon on the 20th July 1907. From 11 A.M., 16th July, until 4 P.M., 19th July, she had finished only one side of the circle. In another case a female was seen to have started laying eggs at 5-37 P.M. and by 5-52 P.M. of the same day, 17th July, she had laid only 4 eggs.

The number of eggs in a cluster varies greatly. It may be from 100 to 150 or more. In a count of eggs in different clusters made on the 20th July 1907 it was found that the number was :—

Eggmass—	
1st	109
2nd	187
3rd	154
4th	129
5th	137
6th	138
7th	141
8th	126

Average 140 per cluster and this number corresponds to the number of eggs found laid by two females under observation—one of them laid 138 and the other 141 (clusters 6th and 7th above). In cases where two or more females have oviposited close to each other the eggmasses appear like small black patches on the leaves. But this is rather the exception than the rule.

Each egg is elliptical in shape, 0·25 mm. long, 0·05 mm. broad. It is attached to the leaf with a pale brown peduncle. It is broad at base, and tapers towards the apex with a slight swelling in the middle. When fully matured it turns shiny black and remains either upright or inclines slightly towards one side. When the nymph is about to emerge a slit opens longitudinally laterally and the head with the antenna is thrust out. The slit then widens and a pale brown nymph comes out. It then rests near the empty egg-shell or moves about slowly amidst empty egg-shells. Having selected a suitable succulent spot, it settles down and begins to feed. If touched or pricked shortly after emergence it exudes a drop of clear liquid. The nymphs moult and their exuvia remain attached to them until they are blown away.

A life-cycle takes 20 to 22 days to complete. Thus :—

Eggs laid	18th June 1914.	
Adults emerged	6th July 1914	19 days.

In another case, a cycle was found to last for 22 days in June 1914. The adults on emergence move about slowly on the leaves, at times flapping their wings. They couple end to end and the copulation was noticed to last for four or five minutes only. The female after laying eggs becomes sluggish and in a case under observation was found to rest at the base of a leaf on which she had laid eggs.

The grubs and adults of *Scymnus* sp. devour the eggs, nymphs and adults of the mealy-wing. The eggs of the beetle were seen laid in the midst of eggmasses of the mealy-wing. Each egg is elongate, elliptical, pointed at one end and broad at the other. The tiny grub that hatches out is pale-yellow, distinctly segmented with hairs laterally. It moves under the eggs feeling the peduncles which may be seen to shake when an affected egg-cluster is seen under the microscope. The grub stations itself below the egg and gnaws its base with its strong mandibles. Having eaten one it moves on to another. It also devours the nymphs as well as the adults. In confinement they showed carnivorous tendencies as the stronger ones killed and devoured the weaker ones. In several cases the grubs were seen to kill more adult mealy-wings than they ate actually. The grubs when about to pupate become stationary and pupate on the leaf with the exuvium attached to their hind ends. A grub pupated on 13th September 1913 and the adult emerged on the 19th September 1913. Besides *Scymnus* sp., the puparia were found parasitized by a pale yellow Chalcidid, although the number was not very large.

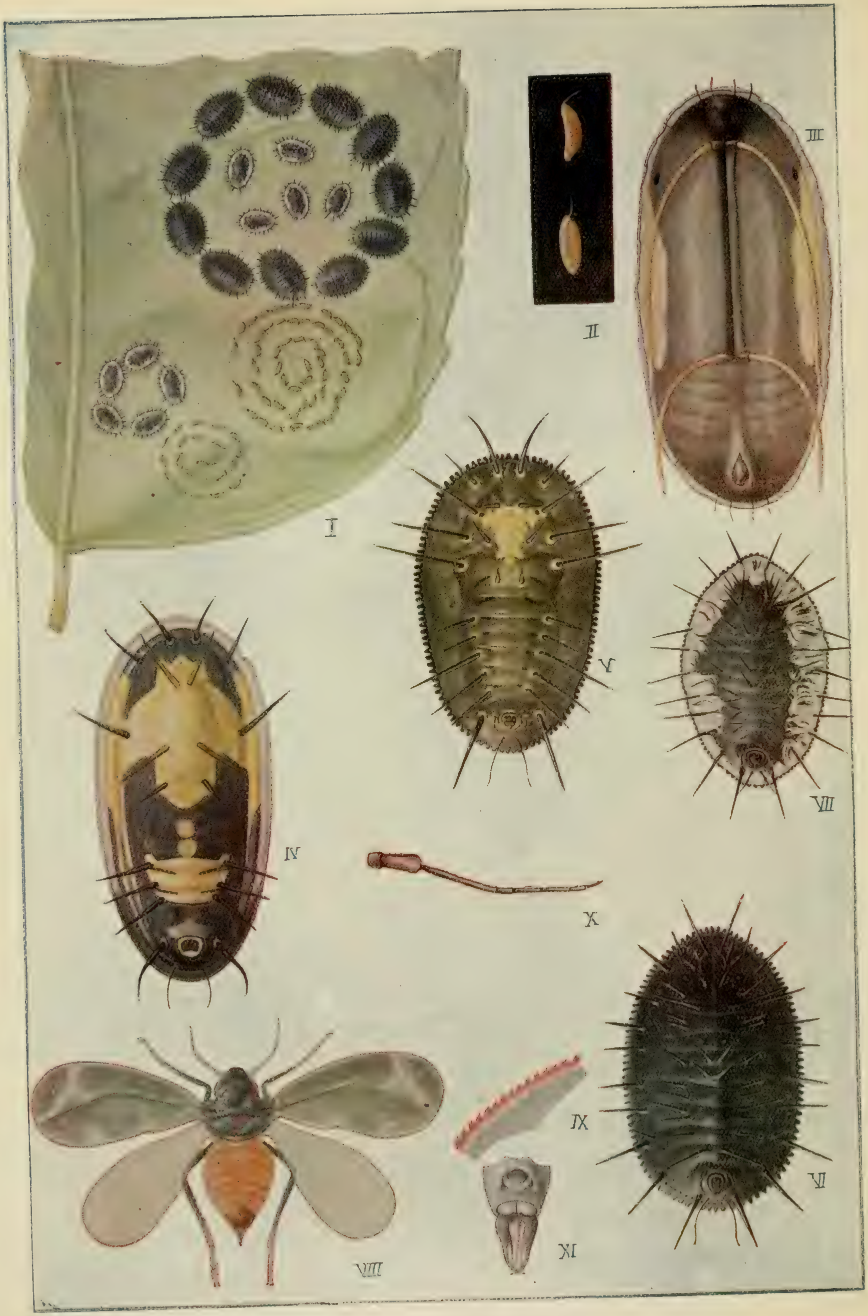
The adults are abundant in some years though not so in others. During the past thirteen years I have come across large numbers of them during 1907, 1911, 1913, 1914, and 1915. During January 1914 the adults were so numerous on the leaves that they appeared black from a distance.

This mealy-wing is not a serious pest of sugarcane, but appears sporadically and may then be seen on the leaves along with *A. barodensis*. In Java it is found along with *A. lactinea*, which I have not hitherto found in this country.

No measure need be taken against this mealy-wing. If at all numerous, the collection and destruction of eggmasses could be easily effected as they are very prominent on the leaves.

Besides Pusa, specimens have also been received from Nagpur in the Central Provinces. It also occurs on cane in South India. In the Central Provinces the species has been found to occur on *juar* both at Nagpur and Tharsa. (Plates 75, 76.)

Neomaskellia bergii on *Andropogon sorghum*, Telinkhedi Farm, Nagpur, 1913.



ALEUROCANTHUS SPINIFERUS.

EXPLANATION OF PLATE 77.

Aleurocanthus spiniferus.

Fig. 1. Eggs on a portion of leaf.
Fig. 2. Single egg; magnified ($\times 33$).
Figs. 3—6. Nymphs.
Fig. 7. Male puparium; magnified ($\times 40$).
Fig. 8. Female with wings expanded; magnified ($\times 54$).
Fig. 9. Portion of margin of forewing of female, much enlarged.
Fig. 10. Antenna, female, much enlarged.
Fig. 11. Genitalia, male; magnified ($\times 20$).

Aleurocanthus spiniferus, Quaint. (Plate 77.)

Aleurodes spinifera, Quaint.—Quaintance, Canadian Entomologist, Vol. XXXIV, p. 63 (1902).

Aleyrodes spinifera, Quaint.—Quaintance, Genera Insectorum, Fasc. 87, p. 10 (1908).

Aleurocanthus spiniferus, Quaint.—U. S. Dept. Agri., Tech. Series, No. 27, Pt. II, p. 102 (1904).

Distribution.—Java, India.

The nymphs and adults of *A. spiniferus* were first observed by me early in September 1908 in the Botanic gardens at Pusa on orange, lemon and pomelo leaves. It, however, appeared on a number of trees in the same area in the following year when 23 out of 51 trees were full of the black mealy-wings in all stages. The nymphs and the adults exude honey-dew so copiously that it lies thickly on the leaves, giving rise to a black fungus. I have observed these for a number of years but have not found them to be in any way injurious to the plants, which however, look unhealthy with a thick deposit of a black fungus which interferes with the proper function of the leaves and causes them thereby to become prematurely seared. Such leaves drop off with the nymphs and puparia on them and when blown away by the wind establish the mealy-wings on hitherto unaffected plants. Besides this, there is a peculiar aroma or smell wafted from the infested trees and it is probably due to this that a number of Syrphidæ were seen to be hovering about them. An unusually large number of Vespidæ were also to be seen visiting the infested plants, probably for the sake of the honey-dew. I did not notice ants attending either the nymphs or the adults on the trees. The eggs, the nymphs and puparia are to be seen on the lower surface of the leaves invariably. In no case were these seen on the upper surface of leaves. During 1910 the mealy-wing was very abundant on a large number of *Citrus* spp. plants in the Botanical area at Pusa. On the 28th July 1910, a large number of Sylhet orange plants were swarming with the Aleyrodid in every stage of development and so profuse was the exudation of the honey-dew and the subsequent development of *Capnodium* sp. on the leaves, that they looked black from a distance. But for this, the plants did not seem to be any way the worse. They seemed to be flowering and fruiting like others which were not so badly affected and which were situated at a distance from the former.

Copulation takes place from side to side and the male may be seen shaking its anal end briskly from side to side and flapping its wings which are thinly covered with a white meal. Copulation lasts for from four or five minutes when the male flies off. The female lays eggs in spirals on the lower surface of leaves. The eggs when laid freshly are pale yellow but when they are matured they turn orange-brown. They are elongate oval, somewhat concave in the middle. They are attached to the leaf surface by means of short, thick, slaty-grey peduncles. If examined under the microscope the chorion seems to be tessellated finely with hexagonal patterns. The number of eggs laid by a female has not been determined. In a number of eggmasses examined the number was found to be :—

Eggmass—	
1st	46
2nd	37
3rd	19
4th	37
5th	39
6th	47
7th	34
8th	62
9th	41
10th	52

In some cases the spirals forming eggmasses crossed each other and in others, when a number of females had oviposited close to each other, they formed broad spots on the lower surfaces of leaves.

The nymphs on hatching fix themselves near the empty eggshells and move but little. When the adult emerges, a longitudinal slit opens on the cephalo-thorax dorsally and the head is thrust out. A few minutes later nearly half the body is out of the puparium. It then struggles from side to side and stands bolt upright within the slit on the puparium. The lateral motions are continued until it is clear out of the puparium. It is then bright yellow with eyes deep maroon. The wings are crumpled and remain pressed against the abdomen laterally. As they get aërated they continue to expand. Twelve to fifteen minutes after coming out of the puparium the adult begins to move about. The male puparia may be distinguished easily from the female puparia on account of their size ; they are much smaller than the latter. The honey-dew exuded by the adults is so profuse that it lies thickly on the leaves and gives rise to a fungus, *Clasdosporium* sp., along with the sooty-mould found so profusely on the leaves.

During August 1909 a number of grubs of *Chrysopa fulvolineata* was seen actively running about the infested leaves with the remains of their victims on their backs. On the 18th August 1909 three grubs were found on a leaf and from 19th–27th August 1909 they were fed exclusively with the nymphs and puparia of the Aleyrodid. On the 28th August one of these pupated and emerged as an imago on the 6th September 1909.

Besides these, the nymphs and puparia are parasitized by a small, pale yellow Chalcidid. From 20-35 adult Chalcidids were seen on a very badly infested leaf either resting or in cop. The parasitized puparia may be distinguished readily from healthy ones or those from which the adults had emerged by the presence of clean circular holes on the dorsum. On the 7th January 1911 the parasitization was as under :—

—	No. of nymphs and puparia on a leaf	Number parasitized
Leaf—		
1st	60	28
2nd	54	2
3rd	55	1
4th	36	6
5th	24	3
6th	13	4
7th	45	13
	287	57—19·86 per cent.

In this species, too, there is no hibernation. The adults continue to emerge during December and January and lay eggs. Like *A. barodensis* and *N. bergii*, this species too seems to be rather prejudicially affected with hot winds, which blow in North India from the beginning of May to the end of June. The adults as well as the nymphs are met with in numbers on the leaves during the winter.

16.—THE RICE LEAF-HOPPERS.

By C. S. Misra, B.A., *First Assistant to the Imperial Entomologist.*

(*Nephotettix bipunctatus*, Fabr. and *N. apicalis*, Motsch.)

The rice leaf-hoppers were reported for the first time damaging rice in the Sambhalpur District, Bihar and Orissa, in 1910. But the hoppers appeared late in the season and consequently slight or no damage was done. They again appeared in 1913 though late in the season and did some damage to the standing crop of rice. The same year they were also reported from Champhai in the Lushai Hills. Mr. J. Hezlett, I.C.S., Superintendent, Lushai Hills, Aijal, wrote on the 4th December 1913 :—

" The flat areas under wet rice cultivation are small and are surrounded by miles of jungle. The insect is well known to the Lushais and frequently does some damage, but for the first time this year the damage done by it has become serious."

In the Chhattisgarh Division of the Central Provinces the pests were noticed for the first time in 1913 when they appeared late in the season and did some damage to the standing crop of rice. The following year, *i.e.*, 1914, they appeared early and over a much larger area. They did considerable damage to the paddy crop in the Bilaspur and the Raipur Districts of the Central Provinces. The damage done by the hoppers was so serious that the Commissioner of the Division, Mr. H. M. Laurie, I.C.S., wrote :—

" I have been touring in the Mungali Tahsil of the Bilaspur District and I find much complaint of havoc caused in respect to the heavier kinds of rice by the insect '*Maho*' or '*Mahor*' concerning which you have already made some inquiries. The Deputy Commissioner does not think that the damage in the Mungali Tahsil has in any village exceeded four annas, but I am not quite sure about this. I am inclined to think that in some villages in which '*Mai*' or '*Garhuna*' *Dhan* constituted the bulk of the rice sown the damage may have arisen to eight annas, or in some cases even more. A loss of four or six annas in these kinds of *Dhan* will, according to my belief, be found to be a matter of fairly common occurrence even in the Mungali *Tahsil*. The damage done in the Janjgir *Tahsil* is said to be greater than in Mungali. There is complete unanimity of opinion that this pest is absolutely new in the experience of the Chhattisgarhi cultivators. Not even the oldest inhabitant has seen anything like it before....."

In order to get an idea of the damage done by the hoppers in one single year one had to visit the localities and he would have been struck with the havoc caused by the leaf-hoppers. Not only was there no grain, but the fields were left unharvested, as they were not worth doing so. By the attack of the hoppers the straw had become insipid and rancid and as such was not eaten by the cattle which were in bad condition. It was fortunate that the pests broke out in a mild form during the following year (1915) otherwise the condition of the people as well as the cattle would have been very miserable. In this connection Mr. D. Clouston, Deputy Director of Agriculture, Southern and Eastern Circle, Central Provinces, wrote on the 16th June 1915 :—

"..........it appears to me, however, that in the event of the pest doing as much damage as it did last year, it would be highly advisable to consider whether it is not necessary to appoint a larger entomological staff for the pioneer work. Even if the pest should fail to spread beyond the confines of Chhattisgarh, we still have in that Division alone nearly three million acres of rice. If we allow only 10 per cent. of the area being affected, we would still have 300,000 acres to deal with."

The total area under rice in the Chhattisgarh Division of the Central Provinces is 3,315,484 acres. Calculating a loss of six annas in the rupee for the badly infested sub-divisions during 1914, the total loss comes to 14 and a half million rupees on the basis of 548 lb. cleaned rice per acre at Rs. 3-1-0, the wholesale price. This enormous loss represents the destructiveness of the hoppers for one season only, and it is unthinkable what the loss would have been, had the pests overrun the paddy crop for a series of years. This also brings into prominence the case of an insect which is not heard of as a pest in the beginning, suddenly it springs into prominence, does considerable damage for a series of years and again sinks into insignificance. The causes which operated specifically in this instance are not well understood up to the present, and the details incorporated regarding the life-history, destructiveness, alternative foodplants, parasites, predators, and preventive and remedial measures elsewhere represent two years' work against the hoppers. But as far as is known the parasites and predators were not so abundant during the seasons when the hoppers were specially abundant, as to warrant the conclusion that they were materially effectual in the destruction and subsequent disappearance of the pests. It may be possible that in subsequent years 1916-18 they have appeared in numbers just at the time when the hoppers were developing and thus circumvented their increase. But in the absence of definite observations or data to substantiate the above conclusion, nothing definite could be put forward to explain satisfactorily the non-appearance of the pests during the years 1916-17 and 1918. That the climatic conditions play no mean part in circumventing or diminishing the numbers of pests requires no explanation, but a critical study of the meteorological data for the years during which the pests overran the paddy crop and damaged it considerably and the subsequent years when they did not appear in numbers does not yield sufficiently convincing facts to explain the abnormal appearance of the pests.

In 1915 the hoppers appeared late and in small numbers and in consequence no serious damage was done. These were preceded by an unexpected outbreak of *Hieroglyphus banian*, and the three Delphacid leaf-hoppers, *Sogata pusana*, Dist., *Sogata distincta*, Dist., and *Sogata pallescens*, Dist. These latter were mistaken for the leaf-hoppers and the measures recommended in the previous year against *N. bipunctatus* and *N. apicalis* were promptly put in operation, with the result that no tangible results were achieved. It was no wonder that the recommendations should have borne no fruit as the two pests differ profoundly in habits. The rice leaf-hoppers are attracted to light whilst the Delphacid leaf-hoppers are not. The Delphacid leaf-hoppers develop fast in a damp and moist atmosphere whilst the rice leaf-hoppers require hot sunny days to reach their maximum development. The Delphacid leaf-hoppers, like the rice leaf-hoppers, lay their eggs in the issues of leaves. The nymphs on hatching out remain on the leaves sucking the juice and exuding the honey-dew which accumulates on the lower leaves. The nymphs as well as the adults are extremely agile and with the least disturbance jump off from plant to plant. With the break in the rains in the middle of September 1915, the Delphacid leaf-hoppers perished in hordes and were largely parasitized by a Dryinid. Innumerable nymphs of the Delphacid leaf-hoppers could be seen with dark-castaneous to blackish ovoid sacs either on the meso and meta-pleural regions or on the penultimate segment laterally. When parasitized by the Dryinid, the nymphs became sluggish in their movements. They were then to be seen either moving about awkwardly on the leaves or jumping off short distances only. When the parasitic grub becomes full-fed, the sac containing it dehisces longitudinally and a whitish legless Dryinid grub comes out. It moves about a little or rests on the spot it came out of the sac and begins spinning a thin hammock-shaped cocoon within which it spins another, ovoid in shape and consisting of firmer texture than the outer one. From such a cocoon the adult Dryinid comes out by biting a circular hole with its strong mandibles. On emergence the adult is very active and flits about the fields infested by the Delphacid leaf-hoppers. In fact the Dryinid was responsible for the destruction of a large number of Delphacid leaf-hopper nymphs. The nymphs seemed to be the special victims as in no case could I see a parasitized adult. An examination of a large number of paddy fields in the infested area in the Bilaspur District of the Chhattisgarh Division, Central Provinces, showed that a large number of pupæ of the parasite were to be seen on the infested plants. With the disappearance of the Delphacid leaf-hoppers the Dryinid parasite also disappeared. The two pests preceding the leaf-hoppers were destroyed to a large extent by the use of field bags, by squirting kerosine in the infested fields and drawing a rope across the fields so as to get the nymphs as well as adults in contact with kerosine on the water. The cultivators also bagged their fields with *dhoties* turned into temporary bags, previously moistened with a little kerosine.

The appearance of the infested fields.

The infested fields appeared blighted. In the year when the leaf-hoppers appeared early, when the paddy plants were hardly above the ground, considerable damage was done. The hoppers, both the nymphs and the adult, sucked the juice, in consequence of which the affected plants turned pale brown, then brown and ultimately withered away. If, however, the hoppers appeared at a time when the plants were about to put forth ears, so much sap was drained off that these plants were lowered in vitality and so failed to put forth ears. In places it was also found that if the appearance of the hoppers synchronized with the appearance of the ears on the plants, there was no grain in them and they appeared puckered or prematurely blasted. It was found that in localities where the crop had attained sufficient maturity little or no damage was done. It was also noticed that the early ripening varieties of paddy either entirely escaped damage or were damaged to a very small extent. Late ripening and transplanted varieties as well as those in *Gehunras* lands [lands adjoining villages and enriched from the village washings and the particular habits of the local inhabitants] were the worst sufferers. The reason for this is not far to seek. The varieties of paddy usually grown in *Gehunras* lands are usually late varieties and as such remain green and succulent at the time of the appearance of the hoppers. It was also noticed that the leaf-hoppers preferred to feed on these than the *Harhum* [early ripening] varieties growing on *Bhata* lands [undulating lands with laterite nodules in process of disintegration]. In some places the visitation of the leaf-hoppers on rice plants was associated with the reddening of the water of the infested fields, and it was explained that when the honey-dew exuded by the hoppers—both nymphs and adults—came in contact with the water in the fields, it turned red. I made a search for such fields during September-October 1915, but could in no way associate the discolouration of the infested fields with the honey-dew exuded by the insects. In fact I could then hardly find a field which had turned red markedly. All that I could see, and that too in two or three instances only, was that the water in the infested fields had turned slightly red. This was close to the *Bhata* lands and I could not associate the discolouration with the honey-dew exuded by the hoppers. In fields adjoining fields containing discoloured water the damage was just the same although the water in them had not become discoloured. I did not, in fact, come across a field wherein the damage was more than others containing normal rainwater. No doubt in two or three villages in the Bilaspur District I came across fields where *Sclerotium oryzœ* was bad, especially in *Gurmatia* variety of paddy. If, however, the redness of the infested fields is associated with a fungoid growth, my experience in the worst infested areas deters me from vouchsafing for the correctness or otherwise of the plausible explanation offered for the peculiar phenomenon observed in the hopper-infested areas.

Life-history. (Plate 78.)

On the ninth to tenth day after maturity, the female begins to lay eggs in the tissues of the sheathing leaves. At times, when the hoppers are at their worst, eggs may be seen laid in the tissues of midribs of leaves as well as in the edges. But such cases were rather the exception than the rule. In working out the life-history of the pests at Pusa, I found the eggs laid invariably in the edges of the sheathing leaves to stems. There is nothing to show externally the place or places where the eggs have been laid. If, however, a close examination is made of the spots where eggs have been laid with a hand lens, a slight swelling will be apparent. There is no whitish froth or any whitish cretaceous hairs deposited on the eggs to make them conspicuous objects, especially against the greenish background of the leaves. The female when about to lay eggs approaches the edge of a sheathing leaf, makes a longitudinal slit with her strong ovipositor and deposits the eggs in quick succession. The eggs when laid freshly are pale-yellow with two dull red spots. The number of eggs laid varies from 22 to as high as 37. In a specific instance under observation, a female was found to deposit 34 eggs in a slit 9 mm. long.

When the nymph emerges a slit opens at the apex represented by two deep maroon-coloured specks and the head is thrust out. The nymph then squirms from side to side until it is clear out of the egg-shell. It then presents a shiny appearance and is enveloped in a thin membrane which on exposure ruptures allowing the nymph to move about, leaving the amnion attached to the apex of the empty egg-shell as a thin crumpled pellicle. The eggs were found parasitized by a small, pale yellow Chalcidid. The parasitized eggs turn black and the adult Chalcidid emerges after making a clean, circular hole in the egg-shell. After the emergence of the parasites, the empty parasitized egg-shells appear deep, fuscous brown with their apices black. The number of parasitized eggs was not large, and the parasite could in no sense be reckoned as an effective check to the development of the hoppers.

The nymph on coming out of the egg-shell is active and after only a few seconds begins to move about on the leaf. After moving up and down the leaf for a few minutes it soon selects a spot where it fixes itself, and begins to suck the juice. It then exudes the honey-dew which falls on the lower leaves and accumulates there. The nymphs are very active and jump off with the least disturbance. During the hottest part of the day they may be seen clustered together in enormous numbers below leaves. If, therefore, an infested leaf be held up to the light, it will be found to contain a number of punctures representing the spots where the nymphs and the adults had thrust their rostra to suck the sap which

EXPLANATION OF PLATE 78.

Fig. 1. Rice plant with young and adult hoppers on it.
Fig. 2. Eggs in a sheathing-leaf of a plant $\times 14$.
Fig. 3. An egg (much enlarged).
Fig. 4. Nymph, 1st instar $\times 72$
Fig. 5. Male hopper $\times 15$.
Fig. 6. Female hopper $\times 15$.

NEPHOTETTIX BIPUNCTATUS.

should have gone ordinarily to the maturing of the plant. In the case of the worst infested fields as many as 167 adults and nymphs were found to feed on a single leaf. Unlike the adults, the nymphs are not attracted to the light.

The nymphs before maturing into adults pass through five moults. At the time of moulting the rostrum is so firmly embedded in the tissues of the leaves or the stems, that if the exuvia are lifted with a teaser, the rostral setæ break off and remain embedded in the tissues. After passing through five moults the adults appear on the leaves and are then represented by two species. The characteristic differences between the two species are :—

Nephotettix bipunctatus, Fabr. (*Fauna of British India, Rhynchota*, Vol. IV, p. 359, fig. 228). Yellowish brown, shining, smooth, face (except the lateral margins) and a spot on each side of clypeus black ; tegmina with a spot before the middle and the apical two-fifths black ; lateral spots to sternum and abdomen black. The female is usually without the discal black spot to the tegmina and with the face as described for the varietal male.

Nephotettix apicalis, Motsch. (*Fauna of British India, Rhynchota*, Vol. IV, pp. 360-361, fig. 229). Yellowish virescent, smooth, shining ; face, anterior subimpressed transverse line on vertex between anterior margins of eyes, anterior margin of pronotum, scutellar and commissural margins of clavus, a spot before the middle extending to the claval suture and there acutely produced hindward, apical third of tegmina, sternum, abdomen, greater part of the femora, anterior tibiæ and the tarsi black ; the posterior tibiæ at the bases of the spinules spotted with black ; ventral incisures flavescent.

N. apicalis is closely allied to *N. bipunctatus*, but differs in having the head shorter and more obtuse, anteriorly obtusely rounded and by the marking of same. Head as broad as pronotum, but somewhat shorter, vertex a little longer in the middle than at the eyes, scarcely twice as broad between eyes as long, anteriorly within the margin transversely impressed.

In plain language, the females in both the species are unspotted. They are pale green in colour, with a strong, brownish ovipositor with which they laterate the tissues of the leaves and deposit the eggs. The males in both the species are black, one has two black prominent spots on the wings, in the other there are two oblique black lines. There is very little difference between the females of both the species. The adults, both males and females, remain on the lower surface of leaves mostly near the midribs sucking the juice during the hottest part of the day. At dusk they become active and fly from plant to plant. While feeding they exude a clear, thin liquid—the honey-dew—which, falling on the leaves below, makes them very sticky. The adults of both the species exhibit a strong predilection for light.

Of the two species, *Nephotettix bipunctatus* was the most predominant, and the observations regarding life-history, etc., recorded herein relate mostly to *N. bipunctatus.*

Life-cycle.

During September and October 1916, a life-cycle was found to occupy from 17 to 25 days. The egg stage lasts from 4 to 6 days, and the nymphal stages were found to last for 13, 17, 19 and 21 days. In a specific case under observation it was found that a female which matured on the 12th October 1916, began laying eggs on the 21st of the same month.

Hibernation.

From a record extending over sixteen months at Pusa, it was found that the hoppers hibernated during the winter in the adult stage. This was found to be case at Pusa, where the climatic and other conditions are so dissimilar to those prevailing in the rice tract of the Chhattisgarh Division of the Central Provinces, that some time was devoted to finding out the stage in which the adults of the two species hibernated during the winter. The observations made there corroborated the observations made at Pusa and it was found that the adults hibernated in a number of green succulent grasses in dry pond or river beds or in such other places where moisture was available for the grasses to exist. A few adults were also found in long grasses on field embankments and road sides. But the number of adults collected was not very large.

Distribution.

The two species of hoppers have been recorded by Mr. Distant in the *Fauna of British India*, Vol. IV, pp. 359-362 from Calcutta, Pusa, Ranchi, Saraghat, Dacca, Ceylon, Borneo, Sumatra, Philippines, East Africa, Natal and Durban. Dr. Matsumura has recorded *N. apicalis* to occur in China, Japan, Malaya, and Europe. In the Pusa collection there are specimens from Balasore, Chapra, Pusa, Kankey Farm (Ranchi), Sambhalpur, Raipur, Sakti, Janjgir, Drug, Sindewahi, Coimbatore, and Chanphai in the Lushai Hills.

Though the above record is fairly extensive, the hoppers have been reported as serious pests to rice plants from Chanphai in the Lushai Hills and a tract of country which may be said roughly to extend from Balasore in the East to the borders of the Raipur District in the Central

Provinces in the West. Elsewhere the hoppers are found more or less but not in such large numbers as to be considered as pests. In towns such as Calcutta, the hoppers are known as green-flies which swarm in millions around arc lamps in the streets and in private residences. But they have not been reported as yet as serious pests to rice. The question is well worth studying and I am sure further study of such abstruse and obscure points connected with the life-history, habits and seasonal variations of the pests will afford material which will lead to the adoption of such measures, both preventive and remedial, as would prevent them effectively from laying a heavy toll on the country's produce and these-by denying the patient and sturdy cultivator the fruits of his labour.

Alternative food-plants.

Hitherto the hoppers have been found exclusively on green succulent grasses growing in damp places in pond and river beds as well as on grasses growing on field embankments in suitable localities. They have also been found to some extent on millets, especially Kodon (*Setaria italica*). Besides these, I am unacquainted with any other foodplant on which the hoppers are found to live and to breed.

Local names of the pests.

In the Chhattisgarh Division of the Central Provinces the hoppers are known under the common name of "*Maho*" or "*Mahor*" but preferably the former. The local word conveys an idea of the blight caused by the insects. Some cultivators nicknamed the hoppers as "*Maho*" on account of the honey-dew exuded by them, which made the leaves of the infested plants sticky. In the adjoining Oriya district of Sambhalpur in Bihar and Orissa the pests are known as '*Daoni*,' '*Ghunghutti*' or '*Dhana*.' In the Balasore District they are known as '*Jhatkas*.' The Lushais call them the '*Kumthu*.' Besides these, other minor local names for the hoppers were a legion in the Chhatisgarh Division but that most in common and familiar use was "*Maho*."

Other insects associated with the leaf-hoppers.

During 1915, prior to the appearance of the leaf-hoppers, *Hieroglyphus banian* and *Sogata* spp. appeared in enormous swarms in the Central Provinces and damaged the paddy crop considerably. Later on when the hoppers appeared the following insects were also found in numbers in the infested fields :—

(1) *Athysanus indicus*, Dist.
(2) *Athysanus fusconervosus*, Motsch.

(3) *Thomsoniella albomaculata*, Dist.
(4) *Tettigoniella spectra*, Dist.
(5) *Kolla* sp. near *mimica.*
(6) *Selenocephalus virescens*, Dist.
(7) *Paramesus lineaticollis*, Dist.
(8) *Clovia puncta*, Walk.

In Cuttack and Balasore Districts in Bihar and Orissa, *Pachydiplosis oryzæ* occurred simultaneously with the hoppers and did considerable damage.

Besides these, *Schœnobius bipunctifer*, *Cnaphalocrocis medinalis* and *Chapra mathias* were also found more or less in the fields infested by the hoppers.

Preventive and remedial measures.

A number of measures were tried during 1914 and 1915 and of these the following appear worth adopting in cases of future outbreaks of the pests. It was also found that the measures adopted met with varying success depending very much upon the particular proclivities of the people and the local conditions prevailing in a particular tract in the infested area. In some places, oil for the lamps was available and people were willing to set up lantern traps, in others people readily took to bagging the hoppers. In some places the local cultivators, profiting by their previous experience, had put down a greater portion of the area cultivated by them under early maturing varieties, thereby getting a crop whereby to maintain themselves as well as their cattle. In fact, some such innovation in local methods of cultivation was seriously mooted by us in case the pests ran their course for a series of years. But fortunately for the *raiyats* the pests appeared for two years only and have not been reported as yet from any rice-growing tract in the Central Provinces since 1916.

1. As far as possible the cultivators should be impressed with the necessity of ploughing up their fields after the crop has been harvested and thereafter to allow the cattle to graze freely in the cultivated areas.

2. If there have been good rains during March-April, and the rainfall is not heavy during July-August, with a considerable break in the rains in the latter part of August and early September with a spell of hot sunny days, the nurseries as well as places containing green grasses should be bagged either with hand-nets or *dhoties* turned into bags and lightly sprinkled with kerosine oil.

3. Considerable pioneer work remains yet to be done, but if from data collected in the areas affected last it is found that the number of hoppers is larger than in normal years, systematic bagging is to be

started. No doubt, the measure is not much appreciated by the local people who are either loath to buy the cloth required for the bags or are unable to contribute labour necessary to work the bags. But in the long run, if the unexpected happens, it is possible that they will take to the measure to escape the loss caused by the hoppers.

4. To set up light-traps during July-August when there are only a few hoppers and again at the end of September when they reach their maximum developments. The local people do not like the idea of going to their fields at night and putting up the lanterns. They are mortally afraid of vermin which in some parts are very common. But the appointment of a few specially trained men to take charge of two or three villages at a time was found to work well, and the local cultivators were willing to pay for the extra cost of maintaining a *Kamdar*.

17.—COTTON BOLLWORMS IN INDIA.

By T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., *Imperial Entomologist*, and C. S. Misra, B.A., *First Assistant to the Imperial Entomologist.*

The name "Bollworm" is applied in India to two distinct groups of moths whose larvæ bore into cotton-bolls. Firstly it covers two Noctuid moths of the genus *Earias*, *E. fabia* and *E. insulana*, and secondly it includes the Gelechiad, *Platyedra* (*Gelechia*) *gossypiella*, commonly called the "Pink Bollworm" on account of the salmon-pink colour of the larva in its later stages. These Bollworms, and especially the two species of *Earias*, have been under close observation at Pusa for many years past and in this paper we propose to record a few of the conclusions at which we have arrived, without going into full details on every point.

Prior to 1903, Bollworms were known to affect cotton, but they were not considered so serious as is now realized to be the case. It was in 1905, with the failure of the cotton crop in the Punjab and in 1906 in Sind, that they (and *E. insulana* in particular) came into prominence. In 1905, a very serious cold snap occurred during the winter in the Punjab, and it was presumed that the parasites which normally kept the bollworms in check had been affected adversely, the result being a failure of the crop over a greater part of the Province. In 1911 also the loss to cotton in the Punjab was much greater than in normal years. Since 1911 there has been no serious outbreak but it is certain that the total loss brought about by these insects annually is very great. The

Punjab is of course by no means the only, or even the largest, cotton-growing Province within the Indian Empire, the total area under cotton in the various provinces of India in 1917-18* being :—

Province	Area (acres)	Yield (bales of 400 lb. each)
Bombay	8,227,000	1,571,000
Central Provinces and Berar	4,582,000	591,000
Hyderabad State	3,451,000	450,000
Madras	2,592,000	569,000
Punjab	1,799,000	271,000
United Provinces	1,316,000	198,000
Central India States	1,454,000	116,000
Rajputana	435,000	54,000
Sind	245,000	67,000
Burma	246,000	54,000
Mysore	154,000	22,000
Bihar and Orissa	69,000	17,000
North-West Frontier Province	38,000	10,000
Bengal	71,000	19,000
Ajmer-Merwara	70,000	14,000
Assam	32,000	12,000
TOTAL .	24,781,000	4,035,000

In all these areas Bollworms (usually all the three species) occur and levy an annual toll on the cotton-crop which in normal years may be estimated at anything between twenty and fifty millions of rupees. The damage done by the Bollworms is very insidious and the ordinary cultivator, although he is aware that damage is being done, is unable to calculate the loss, and this accounts for the way he puts up with the loss patiently from year to year. In the case of a leaf-eating insect he sees the leaves and shoots of the plants being devoured and he at once

* *Estimates of Area and Yield of Principal Crops in India, 1917-18* (Department of Statistics, No. 766; 1918).

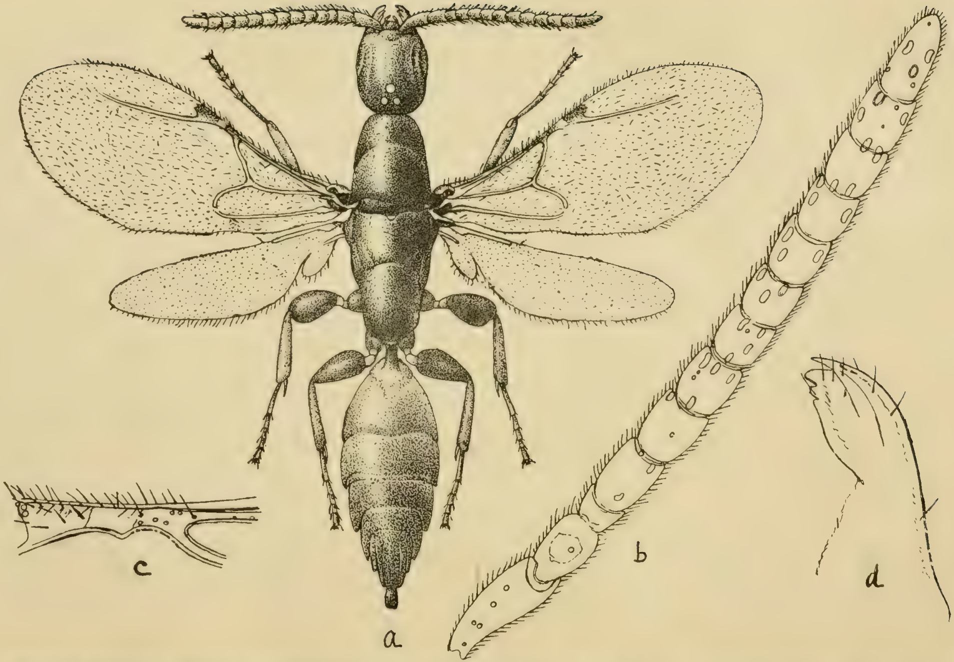
adopts such measures as lessen the incidence of the pest or reports the matter to a Revenue authority or a member of the Agricultural Department to secure some relief. In the case of Bollworms, the damage done by them is felt either at the time of picking cotton or after the crop has been picked. It is then that the shortage of outturn is ascribed to the Bollworms.

The distribution in India of the two species of *Earias* is very characteristic. In the Punjab and Bombay *Earias insulana* preponderates over *Earias fabia,* which outnumbers the former in Bihar and Orissa, Bengal, Madras and the Central Provinces. This statement is made under reserve and is liable to change with a fuller inquiry into the status of the pests in all the important cotton-growing tracts in India. At Pusa, *Earias fabia* is by far the commoner species, *Earias insulana* being found more in *Abutilon indicum* than in cotton. In the United Provinces *E. fabia* is found in greater numbers than *E. insulana* although the real pest to cotton in these Provinces is *Platyedra* (*Gelechia*) *gossypiella.* In the North-West Frontier Province it is the Pink bollworm which does more damage to cotton than *Earias insulana.* In April 1913, Mr. Robertson-Brown, Agricultural Officer, North-West Frontier Province, wrote as follows :—

> "In the North-West Frontier Province we find that the Pink Bollworm (*Gelechia gossypiella*) is very much more common than *Earias insulana.* In fact we rarely find the larvæ of the latter in cotton-bolls. On the other hand, I have caught quite twenty green moths of *Earias insulana* flitting around my dining-room lamp during winter. We also find that the larvæ of Pink Bollworm are found in greater numbers in *kapas* when hand-ginning is being done in the villages. We were of opinion that the Pink Bollworm was not so common as *Earias insulana.* Will you very kindly say if *Gelechia* is more common than *Earias* in any other part of India? Mr. Lefroy records that the Pink Bollworm hibernates chiefly as a larva and that *Earias* hibernates more commonly as a pupa and moth. That being so, it appears to us that the Pink Bollworm would be more easily checked than *Earias.* In 1910 we had a quarter of an acre of very perfect and heavily fruited *bhindi* as a trap-crop for bollworm, but we did not trap very many larvæ. Now that we have found that the Pink Bollworm is our commonest pest, it is understood why the *bhindi* was not much affected, as Mr. Lefroy says Pink Bollworm does not affect the crops allied to cotton ....." (*vide* letter No. 665, dated the 22nd April 1913).

Subsequent to this, Mr. Safdar Shah, L.Ag., Entomological Assistant, North-West Frontier Province, wrote :—" In either case *Rhogas lefroyi* has been found to parasitize *Gelechia* as well as *Earias*. It appears that in the early part of the cotton season *Earias* is common with us, whilst in the latter part *Gelechia*....." This experience accords with ours at Pusa, where the bollworms *E. fabia* and *E. insulana* are present in larger numbers than *Platyedra gossypiella* in the beginning of the cotton season from July to November, after which the Pink worm is more in evidence and does most damage. Besides, in India, in places where cotton is introduced for the first time, it becomes heavily infested by the bollworms. In May 1909, Mr. E. E. Green, Government Entomologist, Ceylon, wrote :—" We have recently, for the first time, grown some plants of cotton, on our Peradeniya experimental station. No other cotton is or has been cultivated in the place, yet the very first crop has been completely ruined by the Pink bollworm (*Gelechia gossypiella*).... I have examined allied malvaceous plants (*e.g.*, *H. abelmoschus*) but have found no trace of infestation....." A similar stage of affairs arose in Burma when cotton was grown there for the first time, as Mr. F. G. Sly, Officiating Inspector-General of Agriculture, wrote from Burma on the 22nd February 1905 :—" The cotton had grown fairly well—a good show of plant, but nearly all the bolls were destroyed. It flowered freely, formed many bolls, but quite 75 per cent. of the bolls were destroyed. I presume that this is bollworm ?"

In the United Provinces *P. gossypiella* has come to be recognized as the most serious pest to cotton and the Pusa experience warrants the same conclusion. In the beginning *Earias fabia* was thought to be responsible primarily for the loss to cotton suffered every year. But subsequent work in connection with Bollworms has brought out the fact prominently that it is the Pink Bollworm which does the greatest amount of damage. One fact that has been brought out very prominently by the investigations for the past seven years is, that the Pink Bollworm is not so susceptible to the attack of parasites as are *E. fabia* and *E. insulana*, although a *Microbracon* (*? M. lefroyi*) has been found parasitizing Pink Bollworms both in cotton and in its alternative food-plant *Hibiscus abelmoschus*, which has proved with us a very useful trap-crop for *Earias*, but we have never found any *Chalcididæ* parasitic on the eggs, worms or cocoons of *P. gossypiella*, and this experience is corroborated by that Mr. E. E. Green in Ceylon, who wrote—".....I have been keeping this insect under observation for many months, and have not yet raised a single parasite from it....." (*in litt.*, 4th November 1909). Last year (1918), however, Bethylid parasites (Plate 79) were



Bethylid parasite of *Platyedra gossypiella*. *a*, adult, dorsal view $\times 38$; *b*, antenna, highly magnified, showing sensery pits ; *c*, junction of marginal and submarginal veins of forewing, magnified ; *d*, right mandible, magnified.

obtained from Pink Bollworms in cotton-seed obtained from the cotton seed stores at Nawabganj (Cawnpur) in July 1918. The seed was kept for observation in a dish and was frequently examined. Between July and October only three Bethylid parasites were obtained and no other parasites. The seed was then cut up and examined and was found to contain no other insect excepting the Pink Bollworms. On a former occasion in 1915 a parasite was sent by the Entomological Assistant, United Provinces, Cawnpur (*vide* I. R. No. 893 ; 4th January 1915) and this was similar to the three parasites bred last year from cotton-seed obtained from the same locality. This lends colour to the supposition that the Bethylid parasite bred last year was actually parasitic on the Pink Bollworm. But as far as Pusa is concerned, we have not been able to obtain any Bethylid or Chalcidid parasite either on the eggs, worms or the pupæ of the Pink Bollworms. [Since this paper was read, one of us (T. B. F.) has obtained at Coimbatore a Braconid which is apparently parasitic on *P. gossypiella.*]

With the failure of the cotton crop in the Punjab, cotton was grown at Pusa to make observations on the cotton pests, especially for the use of the post-graduate students under training. From 1906 until 1911, the varieties of cotton were mostly utilized for the despatch of parasites to the Punjab whenever required. It was in the year 1912 that regular sowings of cotton were made and detailed observations started regarding the bollworms *E. fabia* and *E. insulana*, as well as *Platyedra gossypiella*. Since then, attempts have been made to gather information to elucidate the following points :—

(*a*) The life-history of the Bollworms.

(*b*) Alternative food plants.

(*c*) Distribution of the Bollworms throughout the year.

(*d*) Parasites, the extent to which these are effectual in keeping the bollworms in check, and the life-history of *Microbracon lefroyi*.

(*e*) To find the alternative hosts of *Microbracon lefroyi* so as to breed them when they were not found on *Earias*, and to facilitate collection and despatch of them whenever they are required in any Province to restore or preserve the balance between the Bollworms and this parasite.

(*f*) The effect of mixed cropping on the incidence of Bollworms.

(*g*) The effect of cultural methods, *i.e.*, thick and thin sowing, on the presence of the Bollworms.

(h) Besides the trap-crops and the introduction of parasites, trial of mechanical measures which may be effective in reducing the affection of cotton by Bollworms.

(k) The relative immunity of varieties of cotton recommended for adoption in the Provinces.

(a) *The Life-history of the Bollworms.*

The two species of *Earias*, *E. fabia* and *E. insulana*, occur at Pusa along with *Platyedra gossypiella* and *Earias cupreoviridis* (*chromataria*), which last has not hitherto been found in cotton, although it is found in *Hibiscus abelmoschus* along with the two other species of *Earias*. In Pusa the number of *Earias fabia* is much larger than *Earias insulana*, which is found more in *Hibiscus abelmoschus* and *Abutilon indicum*. The adults are active at dusk and night and have been especially noticed to flit in numbers about the fields at dusk. During the daytime they remain in hiding below plants, under fallen leaves or other weeds in the fields. The adults are attracted to strong light and are occasionally found to come to light within houses. But the number so attracted is not large and experiments made to attract them to light have not been successful. It is possible that the light put up was not sufficiently strong to attract them. What we used was the ordinary hurricane lamp (Junior Dietz) hung over a pan containing water with a film of kerosine. Occasionally an acetylene (Meduse) lamp-trap has also been used, but no moths were trapped in it.

The adult female becomes active after dusk and lays eggs on the flowers and leaf-buds, tender top-leaves, capsules and flowers and their bracts. The eggs have not been seen laid on old toughened or seared leaves. At times the eggs are seen laid in the axils of leaves but this is rare. The larva on hatching moves about and bores into the buds, bolls or the top-shoots. At Pusa the larvæ as well as the adults are present throughout the year and, practically speaking, there is no hibernation, although activity is considerably restricted during the winter months—December, January and the first half of February. When the temperature rises the moths begin laying eggs either on cotton, if any is available, or on other malvaceous food-plants available in the locality. The larva bores into the shoots, flowers and buds and the characteristic appearance of the withered shoots is very prominent. In Bihar as well as in the United Provinces, the winter vegetables are off the ground and are generally replaced with *Hibiscus esculentus*, gourds, etc. The bollworm moths have, therefore, no difficulty in finding their alternative food-plant, *bhindi*, and breeding in this. In Sind they have been found breeding in ratoon plants which were growing individually on the outskirts of villages or in quite out-of-the-way places. If food-plants are available the bollworms develop in these in sufficient numbers and attack the crop when the plants are grown up in the fields. During July and August a large number of plants are affected and these have their tops blanched or withered. The tops of affected plants, if allowed to remain on the plants, soon tiller into fresh shoots which in turn are again affected by the bollworms. In such cases the growth of the plant is retarded considerably and it fails to put forth the normal number of bolls. Such plants present quite a characteristic appearance in the fields and can soon be spotted. If, however, at this stage such plants be pulled out and, instead of being thrown away on the field embankment to allow the worms to breed and thereafter to emerge as adult moths to lay eggs again, they be burned, considerable good will be done. In all the important cotton-growing tracts in India where the cultivation is done intelligently, every cultivator after sowing the seed in lines, thins out the plants a foot to a foot and a half apart when they are from a foot to a foot and a half high. In such tracts this practice forms a regular part of the cultivation. If, however, the cultivator could be induced, or rather educated, to the extreme necessity of pulling out such plants first as show signs of withering, considerable good would be done. After the withered plants have been removed, he could then space out the rest to a distance of a foot or a foot and a half, as the practice may be locally. To do this still more effectively and without detriment to his interests, it would be advisable to use a larger seed-rate than is in use at present and, as the cost of seed is not much, it is expected that the cultivator will not be a loser by a small initial extra outlay in the seed. This extra cost will however be recouped later on by the extra produce obtained from the fields. If this practice can be brought home to the cultivators much good is likely to accrue and the baneful effects of the attacks of the Bollworms, if not totally reduced, will be greatly minimized. This measure has appealed to us most after seven years' work with the Cotton Bollworms at Pusa, and we think it is a measure fraught with much good if adopted efficiently. Since the Bollworms are already present in the land, it is not possible that, with the adoption of this measure only, miraculous effects will follow. It all depends upon the way the question is tackled. Patient and continuous work for years together is required to produce any appreciable result. The cultivator, as a rule, is very conservative and as such is loath to take to novelties unless he is convinced that they are effective and thus likely to compensate him for his extra expense and labour. Once he is convinced of this, he is quick to adopt the measure and to practise it regularly. No doubt along with this simple measure, other measures will have to be adopted concurrently to produce the desired result. The introduction of parasites will still require to be done. But much reliance cannot be placed on this parasite work, unless it is done by specially trained men. This work is rather technical and as such cannot be trusted to an agency, such as the cultivators, to adopt and carry it through. The parasites, though effective as checks to Bollworms to some extent, cannot be expected to bring about the desired change soon, unless a parasite is found which breeds fast and lays a large number of eggs. None of the Bollworm parasites known up to this time fulfils these conditions. *Microbracon lefroyi* no doubt parasitizes *Earias* as well as the Pink Bollworm (*Platyedra gossypiella*) to some extent, but does not seem to be the ideal parasite so far as our investigations at Pusa appear to indicate. Being a Braconid it lays only 11 to 13 eggs on its host—the maximum number of eggs found laid by *M. lefroyi* in the Punjab is said to be 21—and, as these grubs develop a tendency to cannibalism in confinement, it is possible that even this small number of grubs does not develop on the host. Thus it is not able to keep pace with the development of its host and as such is not very effective in circumventing its further increase. We have worked at the question of parasitization for some years past, and have come to the conclusion that Chalcidid parasites are more effective than either Braconids or Ichneumonids. Hitherto we have not found any Chalcidid parasite which can be said to be effective against the Bollworms. The one Chalcidid parasite that has been found is on the pupæ and is not very effective. Hitherto we have not found any parasite on the eggs and none such has been recorded from other cotton-growing countries where *Earias* occurs, and this is because of the way the eggs are laid on the host-plants. The eggs are laid singly and are coloured cryptically. It is perhaps due to some such cause that the eggs enjoy complete immunity against parasites.

Earias fabia and *E. insulana* are found at Pusa in cotton, *Hibiscus esculentus*, *H. abelmoschus*, *H. Sabdariffa*, *H. panduriformis*, *H. rosa-sinensis*, *H. cannabinus*, *Abutilon indicum*, and *Althæa rosea*. They have not yet been found in *Hibiscus vitifolius*, *H. mutabilis*, *H. tricuspis* or *Malachra capitata*, although these plants have been examined from time to time. It is only in *Hibiscus abelmoschus* that we have been able to find all the three species of *Earias*, *E. fabia*, *E. insulana* and *cupreoviridis*, feeding on the same plant. *E. cupreoviridis* attacks jute capsules also and has not been found in cotton. *Earias insulana* is found more frequently in *Abutilon indicum* than in either cotton or *H. esculentus* at Pusa. The larvæ of all the three species of Bollworms have been found parasitized by *Microbracon lefroyi* whilst feeding on seeds within the capsules of *Hibiscus abelmoschus*.

At Pusa the life-history of *E. fabia* has been found to last from 21 to 32 days according to the time of the year.

(1)	Eggs laid	8th April 1916.
	Eggs hatched	11th April 1916.
	Larvæ pupated	20th, 21st and 22nd April 1916.
	Adult emerged	27th April 1916.
	Total	19 to 21 days.
(2)	Eggs laid	14th September 1915.
	Eggs hatched	17th September 1915.
	Pupated	7th October 1915.
	Adult emerged	15th, 16th October 1915
	Total	31 to 32 days.

To mark the moults, etc., the larvæ after hatching were fed on the petals in glass dishes so as to enable one to make observations on their habits, time of moulting, etc. In the fields the larvæ prefer to burrow into the bolls or buds (both leaf and flower) and, if these are not available then, they go into the top-shoots, which wither soon after affectation. These become very withered and thereby become conspicuous in the fields. Such tops are especially abundant in the beginning of the cotton season when no bolls are present on the plants and when the moths after hibernation have started to breed. The larvæ pierce more bolls than they actually feed on. A larva may enter a capsule and, after boring into it and nibbling the seeds, leave it and move about in search of another. This happens when the Bollworms are most active and this period corresponds with the rainy months, when the rain water lodges in the bolls and sets up decomposition. Such bolls soon rot and drop down on to the ground. In some cases the larvæ simply scratch the outside rind of the capsule and thus facilitate penetration of other bacterial and fungal diseases, of which the internal boll-disease so much complained of in the West Indies is one. We have found a very large number of bolls falling down prematurely, and suspect these to be attacked with the internal boll-disease or some such cause. The bolls get shrivelled and soon become discoloured. If such are cut open they are found to be flaccid with the immature seeds within much shrivelled and discoloured. The fall of an unusually large number of bolls makes this aspect of the question worth further investigation. The worms not only bore into the bolls, shoots and buds, but destroy the vitality of seeds of a large number of bolls. The loss thus caused is far greater than the actual destruction of the bolls. When the bolls are only partially affected they open badly and the lint within loses its uniformity and strength.

The strength of the individual fibres is much reduced and they lose much of their glossiness.

Bollworm Parasites.

Of the five parasites (two Braconids, two Ichneumonids and one Chalcidid) *Microbracon lefroyi* is the most active, next to it the yellow Braconid and then the others. That there is great variability of colour in *Microbracon lefroyi* has been stated in a separate paper* by Mr. C. T. Brues, to whom all the *Microbracon* material was sent for examination. The adults are very active in the fields during the day and may be seen flitting briskly about the plants or resting in places advantageous for oviposition. The female *Microbracon lefroyi* is more robust than the male and has a prominent ovipositor. In several instances *Microbracon lefroyi* females have been seen entering the affected shoots and exserting their ovipositor to reach their victims. The eggs are laid either on the anterior or the posterior part of the Bollworm larva but in a large number of cases examined during the past seven years a greatest proportion of parasitized worms was found with the eggs of the parasite on their posterior ends. This was only to be expected since the larva normally remains with its anal externity near the hole used for extrusion of frass. The parasitized larva becomes restive and changes colour. If touched, it squirms from side to side and is not able to move about, as in the majority of cases the posterior end becomes rigid and shrunk. The eggs are laid either singly or in groups of three or four or six or even more. The largest number of eggs found laid on a parasitized worm was 13, although in the Punjab as many as 21 have been found on a single parasitized Bollworm. The eggs are shiny to dirty white in colour, elongate, cylindrical, somewhat curved in the middle ; in some one end is broader than the other. The grub on hatching remains on the body of the host and feeds by imbibition. The chitin of the grub is so thin and transparent that the inner pulsations are quite visible under a high-power objective. The grub is of the usual hymenopterous type, plump and fat, broad posteriorly, somewhat narrowed towards the head, with strong mandibles. The tracheæ are prominent and visible beneath the cuticle under the microscope or even when examined with a hand-lens magnifying at least ten diameters. When full-fed it leaves the host, which lies dead and shrivelled up within the boll or the shoot or on the spot where it was parasitized. Pupation takes place on a leaf, within the shoot or the boll where the host was feeding prior to parasitization. The cocoon is cylindrical, flattened towards both ends. It is dirty white in colour and rather firm in texture. When the adult emerges

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* See paper No. 80 in these Proceedings.

it bites a hole at one end with its strong mandibles and comes out. In several instances, adults were found to bite through two or three layers of green voile cloth tied over rearing dishes and to escape. Shortly after emergence the adult becomes active and begins flying about briskly. The female may be distinguished easily from the male on account of its size and the presence of a strong, black ovipositor. In confinement the grubs have been found to develop cannibalistic tendencies, and on several occasions the stronger ones have been found making a meal off their weaker brethren. In several instances the grubs have been found to be suffering from flaccidity, and there is reason to believe that the disease, though not exactly Flacherie, is very much akin to it. At times a large number of grubs has been observed to suffer from this disease. This disease has also been found common in the Bollworms and it is possible that the parasitic grubs, feeding by imbibition, become infected themselves and die of the disease. A complete life-cycle has been found to last from 9 to 13 days according to the time of the year.

Alternative hosts of Microbracon lefroyi.

Besides the Bollworms, attention has also been directed towards finding the alternative hosts of *Microbracon lefroyi*. A large number of caterpillars with Braconid grubs on them has been reared, and these reared specimens were sent to Mr. C. T. Brues for identification. But the whole consignment of these very valuable specimens was lost through submarine piracy during the war. Specimens of *Microbracon* were reared from *Platyedra gossypiella*, *Epicephala chalybacma*, *Eublemma quadrilineata*, *Adisura atkinsoni*, *Alcides leopardus*, *Carpomyia vesuviana*, *Sylepta derogata*, *Phycita infusella*, *Anarsia melanoplecta*, *Chlumetia transversa* and *Eublemma amabilis*. This investigation was intended to give a clue to the alternative hosts which might be utilized for breeding or collecting the parasite when it was required for introduction in a new locality or in an old one where the proportion between the host and its parasite was found to be lower than the normal.

Trapping of Bollworm Moths.

Along with the study of the parasites, attention has also been paid to the trapping of the adults by mechanical methods. But these have not as yet yielded any tangible results. No Bollworm moths have as yet been trapped in the Andres-Maire traps or in the Meduse lamp-traps set up right in the middle of or in close proximity to the cotton fields, although *Earias insulana* and *E. fabia* do frequently come in to light and *P. gossypiella* occasionally.

The effect of cultural methods.

The effect of thick and thin sowing has not been very pronounced, although the effect of sowing cotton as a mixed crop has given good results. *Tur* (*Cajanus indicus*) was sown alternatively with cotton, but it was found that the *tur* plants become so bushy that they interfered seriously with the growth and subsequent bolling of the cotton.

The following Table shows the result of examination of various cottons grown (*a*) by themselves ("pure") and (*b*) inter-sown with *tur* ("intermixed").

Variety	Date of examination	Grown "pure"			Grown "intermixed"		
		Total Bolls examined	Total affected bolls	Percentage	Total Bolls examined	Total affected bolls	Percentage
Cawnpur American	5th October 1917	399	18		69	5	
	14th January 1918	397	8		45	0	
	8th September 1918	11	6		..	..	
	4th October 1918	270	41		..	..	
		1,077	73	6·7	114	5	4·38
White-flower	6th October 1917	304	32		98	5	
	8th October 1917	353	33		118	16	
	26th November 1917	217	8		23	3	
	15th January 1918	118	1		9	0	
	17th January 1918	78	3		2	2	
	2nd March 1918	0	0		0	0	
	10th April 1918	1	0		..	..	
	15th April 1918	7	1		..	..	
	31st May 1918	40	10		..	..	
	29th September 1918	0	0		..	..	
	4th October 1918	8	2		..	..	
	4th October 1918	13	2		..	..	
		1,139	92	8·07	250	26	10·4
K. 22	6th October 1917	282	18		143	4	
	11th October 1917	555	33		143	13	
	16th January 1918	172	3		15	0	
	21st January 1918	271	5		5	0	
	11th April 1918	1	1		..		
	23rd April 1918	11	4		..	..	
	4th October 1918	15	4		..	..	
	4th October 1918	16	10		..	..	
		1,323	78	5·8	306	17	5·5

Variety	Date of examination	Grown "pure"			Grown "intermixed"		
		Total Bolls examined	Total affected bolls	Percentage	Total Bolls examined	Total affected bolls	Percentage
Yellow flower	9th October 1917	747	31		113	8	
	1st November 1917	219	9		45	1	
	30th November 1917	348	9		18	0	
	18th January 1918	125	3		4	0	
	23rd January 1918	224	4		2	0	
	4th March 1918	0	0		0	0	
	16th April 1918	7	1		..	..	
	25th April 1918	5	0		..	..	
	10th June 1918	134	17		..	..	
	21st September 1918	28	4		..	..	
	4th October 1918	5	3		..	..	
	5th October 1918	0	0		..	..	
		1,842	81	4·39	182	9	4·9
Buri	12th October 1917	617	73		58	7	
	3rd November 1917	170	16		31	3	
	22nd January 1918	1,344	20		18	0	
	24th January 1918	855	15		8	0	
	24th April 1918	40	26		..	..	
	2nd May 1918	34	15		..	..	
	5th October 1918	607	152		..	..	
	5th October 1918	163	56		..	..	
		3,830	373	9·7	115	10	8·69
4 F. American	3rd November 1917	165	28		18	1	
	25th January 1918	601	8		4	0	
	3rd May 1918	10	4		..	..	
	5th October 1918	211	49		..	..	
		987	89	9·01	22	1	4·5
Selected broad-leaf (*Sanguineum*).	9th November 1917	79	1		4	0	
	29th January 1918	259	1		0	0	
	11th May 1918	70	34		..	..	
	5th October 1918	8	0		..	..	
		416	36	8·6	4	0	..
Fine Broach	9th November 1917	0	0		0	0	
	30th January 1918	22	0		0	0	
	17th May 1918	46	6		..	..	
	5th October 1918	0	0		..	..	
		68	6	8·8	0	0	..

Variety	Date of examination	Grown "pure"			Grown "intermixed"		
		Total Bolls examined	Total affected bolls	Percentage	Total Bolls examined	Total affected bolls	Percentage
Selection I. A.	9th November 1917	0	0		0	0	
	4th February 1918	11	0		0	0	
	18th May 1918	52	11		..	..	
	5th October 1918	0	0		..	..	
		63	11	17·4	0	0	..
N. R.	17th November 1917	225	2		11	0	
	14th December 1917	390	10		15	0	
	6th February 1918	90	0		0	0	
	26th March 1918	0	0		0	0	
	20th May 1918	167	24		..	..	
	16th July 1918	100	14		..	..	
	25th September 1918	7	0		..	..	
	5th October 1918	16	0		..	..	
		995	50	5·02	26	0	..
Dharwar I. Kumpta	19th November 1917	54	0		4	0	
	7th February 1918	125	1		0	0	
	21st May 1918	12	3		..	..	
	5th October 1918	0	0		..	..	
		191	4	2·09	4	0	..
Dharwar-Kumpta Cross.	19th November 1917	22	0		6	0	
	23rd February 1918	38	0		2	0	
	22nd May 1918	33	5		..	..	
	5th October 1918	0	0		..	..	
		93	5	5·37	8	0	..
Wagad	22nd November 1917	0	0		0	0	
	25th February 1918	37	0		0	0	
	23rd May 1918	29	7		..	..	
	5th October 1918	0	0		..	..	
		66	7	10·6	0	0	..
Lalio	22nd November 1917	0	0		0	0	
	26th February 1918	2	0		0	0	
	25th May 1918	17	3		..	..	
	5th October 1918	0	0		..	..	
		19	3	15·7	0	0	..

Variety	Date of examination	GROWN "PURE" Total Bolls examined	GROWN "PURE" Total affected bolls	GROWN "PURE" Percentage	GROWN "INTERMIXED" Total Bolls examined	GROWN "INTERMIXED" Total affected bolls	GROWN "INTERMIXED" Percentage
Kumpta ordinary	24th November 1917	20	0		4	0	
	27th February 1918	1	0		2	0	
	28th May 1918	10	2		..	..	
	21st September 1918	56	10		..	..	
		87	12	13·79	6	0	..
Cambodia	26th November 1917	90	1		9	1	
	28th February 1918	85	4		10	0	
	30th May 1918	109	9		..	..	
	21st September 1918	0	0		..	..	
		284	14	4·9	19	1	5·2
Roseum	3rd December 1917	258	2		23	0	
	5th December 1917	224	2		20	0	
	6th March 1918	0	0		0	0	
	12th March 1918	0	0		0	0	
	12th June 1918	103	19		..	..	
	3rd July 1918	175	20		..	..	
	21st September 1918	11	0		..	..	
	23rd September 1918	9	3		..	..	
		780	46	5·89	43	0	..
Sindewahi cross	4th December 1917	137	2		9	0	
	6th March 1918	0	0		0	0	
	13th June 1918	174	20		..	..	
	21st September 1918	0			..	..	
		311	22	7·07	9	0	..
Tinteria	6th December 1917	200	5		16	0	
	14th March 1918	0	0		0	0	
	9th July 1918	48	6		..	..	
	23rd September 1918	7	1		..	..	
		255	12	4·7	16	0	..
Garo No. II	7th December 1917	106	5		15	0	
	23rd March 1918	0	0		0	0	
	12th July 1918	49	14		..	..	
	23rd September 1918	70	5		..	..	
		225	24	10·6	15	0	..

Variety	Date of examination	Grown "pure"			Grown "intermixed"		
		Total Bolls examined	Total affected bolls	Percentage	Total Bolls examined	Total affected bolls	Percentage
Chittagong No. I	13th December 1917	86	8		16	0	
	23rd March 1918	0	0		0	0	
	13th July 1918	29	4		..	..	
	24th September 1918	56	6		..	..	
		171	18	10·5	16	0	..
Jhata	13th December 1917	51	3		11	0	
	23rd March 1918	0	0		0	0	
	13th July 1918	17	1		..	..	
	24th September 1918	64	8		..	..	
		132	12	9·09	11	0	..
Garo	13th December 1917	70	1		8	0	
	23rd March 1918	0	0		0	0	
	15th July 1918	50	4		..	..	
	24th September 1918	9	0		..	..	
		129	5	3·8	8	0	..
Triumph	14th December 1917	23	0		8	0	
	26th March 1918	0	0		0	0	
	16th July 1918	45	13		..	..	
	25th September 1918	57	14		..	..	
		125	27	21·6	8	0	..
Company No. II	17th December 1917	173	0		9	0	
	26th March 1918	0	0		0	0	
	17th July 1918	4	0		..	..	
	27th September 1918	0	0		..	..	
		177	0	..	9	0	..
Company No. III	19th December 1917	48	0		4	0	
	26th March 1918	0	0		0	0	
	17th July 1918	2	0		..	..	
	27th September 1918	0	0		..	..	
		50	0	..	4	0	..
Company No. III-A	19th December 1917	42	0		0	0	
	26th March 1918	0	0		0	0	
	17th July 1918	3	0		..	..	
	27th September 1918	0	0		..	..	
		45	0	..	..	..	

Variety	Date of examination	GROWN "PURE"			GROWN "INTERMIXED"		
		Total Bolls examined	Total affected bolls	Percentage	Total Bolls examined	Total affected bolls	Percentage
Hagari No. I	19th December 1917	0	6		0	0	
	26th March 1918	0	0		0	0	
	17th July 1918	0	0		..	..	
	27th September 1918	0	0		..	..	
		0	0	..	0	0	..

NOTE.—In the foregoing table the figure 0 in the columns for "Total Bolls examined" indicates that no bolls were present on the plants; where no figure is given, these plants had been removed.

The following Table shows the relative infestation of Bollworms in some other malvaceous plants.

Plant	Date of examination	Total pods examined	Total affected pods	Percentage of infestation
Hollyhock	17th December 1917	184	0	
	13th March 1918	656	11	
		840	11	1·3
Abutilon	17th December 1917	1,596	6	
	4th April 1918	684	32	
		2,280	38	1·6
Hibiscus esculentus	5th October 1917	48	21	
	10th October 1917	26	13	
	18th December 1917	274	111	
		348	145	41·6
Hibiscus abelmoschus	7th November 1917	1,734	52	
	25th January 1918	428	3	
		2,162	55	2·5

The relative immunity of varieties of cotton.

Along with mixed cropping, we have endeavoured to find out the relative immunity of various varieties of cotton recommended for general sowing from time to time. The figures for all such varieties have not been tabulated as yet, but we quote from one year's figures to show that there are varieties which show a tendency to resist the Bollworms' attacks, whilst there are others which seem to be more liable to attack. The following Table indicates these differences. It must be admitted, however, that the figures shown here are too small to allow of much in the way

Table showing relative infestation by Bollworms of different varieties of Cotton and allied malvaceous plants grown at Pusa.

Variety	Date of examination	Bolls: Total	Bolls: Affected	Bolls: Percentage infestation	Shoots: Total	Shoots: Affected	Shoots: Percentage infestation	Flower-buds: Total	Flower-buds: Affected	Flower-buds: Percentage infestation
Bellary, Type 5	26th October 1915	0	0		527	0		166	0	
	7th January 1916	29	0		539	2		513	1	
	26th January 1916	2	0		512	0		502	1	
	15th February 1916	6	0		537	2		531	0	
	8th March 1916	2	0		522	0		589	52	
	28th March 1916	0	0		544	0		557	44	
	19th April 1916	12	0		537	0		626	60	
	9th May 1916	53	2		531	0		548	24	
		104	2	1·9	4,219	4	·09	4,032	182	4·5
Bellary, Type 44	26th October 1915	4	0		530	7		288	0	
	7th January 1916	56	0		524	1		551	2	
	26th January 1916	18	0		526	2		506	0	
	15th February 1916	11	1		512	0		513	0	
	8th March 1916	8	0		515	0		550	29	
	28th March 1916	9	3		500	0		533	33	
	19th April 1916	23	2		518	0		578	47	
	9th May 1916	62	1		506	0		531	15	
		191	7	3·6	4,131	10	·26	4,050	126	3·1

Bellary, Type 3	28th October 1915	0	0		543	0		175	0	
	10th January 1916	58	1		513	3		530	2	
	27th January 1916	22	0		532	2		506	0	
	21st February 1916	9	0		500	0		524	2	
	9th March 1916	4	0		528	0		577	41	
	29th March 1916	4	1		510	0		580	33	
	20th April 1916	18	1		517	0		595	70	
	11th May 1916	44	3		520	0		512	12	
		159	6	3·7	4,163	5	·1	3,999	160	4·001
Bellary, Type 9	28th October 1915	19	0		538	4		300	0	
	10th January 1916	50	1		538	2		507	1	
	27th January 1916	18	0		576	0		515	2	
	21st February 1916	5	0		509	1		507	2	
	9th March 1916	8	0		544	0		539	23	
	29th March 1916	5	1		516	0		564	21	
	20th April 1916	17	2		543	0		619	83	
	11th May 1916	55	5		509	0		515	15	
		177	9	5·08	4,273	7	·16	4,066	147	3·6
Bellary, Type 21	1st November 1915	5	0		615	1		184	0	
	11th January 1916	15	0		532	2		416	6	
	28th January 1916	4	0		529	1		52	3	
	22nd February 1916	4	0		505	0		567	6	
	10th March 1916	3	0		528	0		585	50	
	30th March 1916	0	0		507	1		457	35	
	25th April 1916	10	1		502	0		555	40	
	12th May 1916	33	3		530	0		537	21	
		74	4	5·4	4,218	5	·1	3,353	161	4·2

Table showing relative infestation by Bollworms of different varieties of Cotton and allied malvaceous plants grown at Pusa—contd.

Variety	Date of examination	Bolls			Shoots			Flower-buds		
		Total	Affected	Percentage infestation	Total	Affected	Percentage infestation	Total	Affected	Percentage infestation
Bellary, Type 10	11th January 1916	23	1		521	2		532	3	
	28th January 1916	18	0		548	7		506	1	
	22nd February 1916	14	0		568	1		505	5	
	10th March 1916	10	0		594	0		589	39	
	30th March 1916	3	0		520	0		533	22	
	25th April 1916	16	5		533	0		557	41	
	12th May 1916	35	2		533	0		533	13	
		119	8	6·7	3,817	10	·2	3,755	124	3·3
Bellary, Type 11	12th January 1916	32	0		533	0		518	4	
	31st January 1916	18	0		522	1		525	0	
	23rd February 1916	10	0		515	1		537	10	
	13th March 1916	7	0		543	0		553	34	
	3rd April 1916	4	0		541	1		550	48	
	26th April 1916	16	1		515	0		567	58	
	16th May 1916	50	1		555	0		538	13	
		137	2	1·4	3,724	3	·08	3,788	167	4·4

Bellary, Type 23	12th January 1916	56	0		511	0		523	0	
	31st January 1916	17	0		538	2		528	0	
	23rd February 1916	9	0		520	0		524	8	
	13th March 1916	8	0		526	0		557	23	
	3rd April 1916	6	0		506	0		564	43	
	26th April 1916	15	3		523	0		552	52	
	16th May 1916	34	2		525	0		513	11	
		145	5	3·4	3,649	2	·05	3,761	137	3·6
Hagari, Type 25	31st January 1916	63	0		536	0		514	2	
	1st February 1916	17	0		549	0		513	4	
	24th February 1916	11	0		510	0		553	14	
	14th March 1916	4	0		528	0		552	32	
	4th April 1916	4	0		528	0		538	29	
	27th April 1916	7	0		523	0		587	45	
	18th May 1916	52	2		523	0		528	10	
		158	2	1·2	3,697	0	..	3,785	136	3·5
Hagari, Type 1	14th January 1916	10	0		533	0		524	2	
	2nd February 1916	2	0		532	0		526	0	
	24th February 1916	6	0		514	0		529	13	
	15th March 1916	2	0		504	0		558	40	
	5th April 1916	0	0		529	0		576	37	
	28th April 1916	2	0		517	1		590	65	
	24th May 1916	102	8		506	0		564	27	
		124	8	6·4	3,635	1	·027	3,867	184	4·7

Table showing relative infestation by Bollworms of different varieties of Cotton and allied malvaceous plants grown at Pusa—contd.

Variety	Date of examination	Bolls			Shoots			Flower-buds		
		Total	Affected	Percentage infestation	Total	Affected	Percentage infestation	Total	Affected	Percentage infestation
Hagari, Type 61	14th January 1916	33	0		514	0		534	1	
	2nd February 1916	6	0		542	0		508	0	
	24th February 1916	9	0		561	0		577	24	
	15th March 1916	10	0		535	0		562	53	
	5th April 1916	4	1		516	0		543	37	
	28th April 1916	6	2		543	0		548	41	
	24th May 1916	73	8		554	0		523	12	
		141	11	7·8	3,765	0	..	3,795	168	4·4
Hagari, Type 21	17th January 1916	30	0		550	0		505	2	
	3rd February 1916	31	1		510	0		536	2	
	28th February 1916	9	0		523	0		521	16	
	16th March 1916	7	0		503	0		578	73	
	6th April 1916	2	0		536	0		536	34	
	1st May 1916	57	4		503	0		519	18	
	25th May 1916	157	10		512	0		543	9	
		293	15	5·1	3,637	0	..	3,738	154	4·1

Hagari, Type 43 .	19th January 1916 .	22	0		504	0		528	0	
	4th February 1916 .	12	0		502	2		530	1	
	29th February 1916 .	4	0		533	0		536	8	
	17th March 1916 . .	10	0		547	0		600	54	
	7th April 1916 . .	7	0		502	0		557	29	
	2nd May 1916 . .	57	6		506	0		548	7	
	26th May 1916 . .	104	7		511	0		570	28	
		216	13	6·01	3,605	2	·05	3,869	127	3·2
Black cotton seed .	19th January 1916 .	19	0		500	0		508	0	
	4th February 1916 .	13	0		535	0		513	1	
	29th February 1916 .	2	0		513	0		532	6	
	17th March 1916 . .	6	0		502	0		547	43	
	7th April 1916 . .	2	0		541	0		526	19	
	2nd May 1916 . .	48	4		532	0		434	13	
	26th May 1916 . .	80	4		505	0		572	17	
		170	8	4·7	3,628	0	..	3,632	99	2·7
Allan's Long-staple (Central Provinces).	20th January 1916 .	543	20		526	0		515	5	
	7th February 1916 .	504	13		533	1		541	0	
	1st March 1916 . .	305	3		522	0		548	13	
	22nd March 1916 . .	21	5		500	0		553	38	
	10th April 1916 . .	15	5		520	0		566	65	
	3rd May 1916 . .	140	22		519	0		575	58	
	27th May 1916 . .	561	43		525	0		555	31	
	30th September 1916 .	668	39		0	0		0	0	
		2,757	150	5·4	3,645	1	·02	3,853	210	5·4

Table showing relative infestation by Bollworms of different varieties of Cotton and allied malvaceous plants grown at Pusa—contd.

Variety	Date of examination	Bolls			Shoots			Flower-buds		
		Total	Affected	Percentage infestation	Total	Affected	Percentage infestation	Total	Affected	Percentage infestation
Buri (Central Provinces)	20th January 1916	535	13		504	0		504	0	
	7th February 1916	509	6		507	0		505	0	
	1st March 1916	243	4		513	0		530	9	
	22nd March 1916	4	1		521	0		537	29	
	10th April 1916	15	3		512	0		500	48	
	3rd May 1916	108	17		512	0		566	63	
	27th May 1916	537	22		532	0		563	27	
	14th September 1916	331	23		0	0		0	0	
		2,282	89	3·8	3,601	0	..	3,795	176	4·6
Cambodia (Central Provinces).	1st January 1916	532	2		529	2		537	2	
	10th February 1916	513	3		550	1		504	0	
	3rd March 1916	291	6		514	1		570	46	
	23rd March 1916	3	0		513	0		573	64	
	11th April 1916	15	3		541	0		548	25	
	4th May 1916	118	13		517	0		592	72	
	29th May 1916	539	23		507	0		535	8	
	14th September 1916	235	14		0	0		0	0	
		2,246	64	2·8	3,671	4	·1	3,859	217	5·6

Sangarjari, White-flower	24th January 1916	4	0		167	0		58	0	
	11th February 1916	0	0		163	0		86	0	
	6th March 1916	0	0		144	0		86	9	
	24th March 1916	0	0		213	0		109	9	
	14th April 1916	0	0		142	0		303	33	
	5th May 1916	3	1		215	0		197	24	
	30th May 1916	17	1		229	0		284	10	
		24	2	4·1	1,273	0	..	1,123	85	7·5
Cawnpur, American	24th January 1916	513	8		539	1		534	1	
	11th February 1916	402	3		509	0		513	1	
	6th March 1916	115	1		533	0		599	63	
	24th March 1916	7	1		534	2		594	74	
	14th April 1916	23	0		528	0		586	54	
	5th May 1916	117	18		502	0		564	63	
	30th May 1916	556	37		525	0		565	32	
	14th September 1916	285	26		0	0		0	0	
		2,018	94	4·6	3,670	3	·08	3,955	288	7·2

Table showing relative infestation by Bollworms of different varieties of Cotton and allied malvaceous plants grown at Pusa—concld.

Variety	Date of examination	Bolls			Shoots			Flower-buds		
		Total	Affected	Percentage infestation	Total	Affected	Percentage infestation	Total	Affected	Percentage infestation
Hibiscus abelmoschus	17th January 1916	536	20		541	4		508	0	
	25th January 1916	541	17		542	3		536	1	
	3rd February 1916	524	11		517	2		517	0	
	14th February 1916	525	14		512	2		513	0	
	28th February 1916	574	27		536	0		521	7	
	7th March 1916	205	3		525	0		569	36	
	16th March 1916	290	68		515	3		585	59	
	27th March 1916	62	12		531	15		577	60	
	5th April 1916	63	6		553	10		49	4	
	17th April 1916	17	3		556	14		7	0	
	1st May 1916	7	0		519	13		2	0	
	8th May 1916	3	1		577	63		0	0	
	25th May 1916	1	0		515	8		0	0	
	31st May 1916	0	0		519	9		0	0	
		3,348	182	5·4	7,458	146	1·9	4,384	167	3·8
Hibiscus esculentus	1st November 1915	530	22		550	0		519	10	
	4th January 1916	861	623		0	0		0	0	
	6th January 1916	510	385		0	0		0	0	
		1,901	1,030	54·1	550	0	..	519	10	1·9

Hollyhock	13th January 1916	0	0		541	15		506	4	
	1st February 1916	37	0		508	0		510	2	
	24th February 1916	193	0		519	0		556	0	
	14th March 1916	523	7		515	6		539	3	
	4th April 1916	572	22		500	0		543	7	
	27th April 1916	482	20		329	6		119	8	
	18th May 1916	35	1		113	1		136	0	
		1,842	50	2·7	3,025	28	·9	2,909	24	·8
Abutilon indicum	21st January 1916	500	0		519	0		543	0	
	10th February 1916	533	0		544	0		521	0	
	3rd March 1916	517	0		533	0		506	0	
	23rd March 1916	539	18		524	0		538	7	
	11th April 1916	555	15		549	0		521	0	
	4th May 1916	540	15		502	0		502	0	
	29th May 1916	512	0		532	0		505	0	
		3,696	48	1·2	3,703	0	..	3,636	7	·1

of comparison and, furthermore, they are mostly taken in the months January-May, when Bollworm activity is comparatively low, so that the percentage of infestation is relatively small. It must also be remembered that these plots of cotton were being grown in connection with the rearing of *Microbracon* parasites of *Earias* and that these parasites were therefore present in probably abnormally large numbers.

Mr. Fletcher. We will discuss *Earias* first and then *Platyedra* (*Gelechia*).

Mr. Ramakrishna Ayyar. Have any trap-crops been tried ?

Mr. Misra. We have tried *bhindi* and *Hibiscus abelmoschus* and we find that the latter attracts *Earias* more than cotton.

Mr. Ramakrishna Ayyar. Then a trap-crop is the best remedy.

Mr. Fletcher. We put down *Hibiscus abelmoschus* expressly to breed *Earias*. Our endeavour has been to breed these bollworms and to keep them going in as large numbers as possible in order to get parasites. These parasites have been sent to the Punjab and used there but we do not exactly know with what results beyond what was said at the last Meeting.

Mr. Ramrao. We tried *bhindi* as a trap-crop in our Presidency [Bombay] but we found that we required to use an early-maturing variety. Otherwise, there is more damage than good done.

Mr. Fletcher. Can you make your cultivators pull up the trap-crops at the proper time ?

Mr. Ramakrishna Ayyar. That is the main trouble.

Mr. Jhaveri. If the top-shoots of the cotton-plants are cut off in the early stage of attack, it is useful.

Mr. Misra. We also recommended that the top-shoots should be cut.

Mr. Fletcher. In the Punjab it was suggested that cattle might be turned into the fields to eat the top-shoots.

Mr. G. R. Dutt. Grazing cattle in such a field is of no use. The attacked shoots wither and cattle will not eat them ; in fact, the green shoots would be eaten and more damage done.

Mr. Ramrao. At Poona, in the case of certain varieties, the cutting of the top-shoots is harmful.

Mr. Fletcher. Dr. Gough, will you tell us something about *Earias* in Egypt ?

Dr. Gough. In 1912, when I first came to India, my mission was to obtain parasites of *Earias* and to introduce them into Egypt. *Gelechia* was not a pest of cotton in Egypt at that time. We had legislation against *Earias* and the result is that what was a bad pest in 1912 is only a quite minor pest now. In 1910-12 at the electric light on our verandah we used to attract twenty or thirty *Earias insulana* moths every evening, but now-a-days this species is comparatively a rarity, and the percentage of cotton bolls attacked by *Earias* at its worst is well below ten per cent. The legislation laid down demands that all the bolls be destroyed at the end of the year and that all cotton-sticks be pulled out and burnt; and this applies also to *Hibiscus esculentus* and *H. cannabinus*. Thus for five months there is no food available for *Earias*, as we do not leave any cotton or *Hibiscus* or any other food-plant. Legislation on such lines forms the best means of control.

The conditions differ in India. *Hibiscus esculentus* is a very useful vegetable and it would be difficult to legislate against it. But our greatest difficulty is the removal of the trap-crop. **Mr. Misra.**

I am perfectly convinced that in the United Provinces *bhindi* as a trap-crop will not be useful. *Bhindi* is a very valuable vegetable and is grown over a very extended area. I do not think that any cultivator would pull out *bhindi*, which is sometimes even more valuable than cotton. **Mr. Burt.**

To destroy the early shoots of cotton is also of doubtful value as this causes a severe check to the growth of the plant and the remedy is worse than the disease, as you make your crop late. Topping is out of the question. But when we get a vigorous crop, then topping is useful.

Do you think that any legislation for the destruction of *bhindi* plants by a particular date would be useful? **Mr. Fletcher.**

Bhindi is grown in the United Provinces as a hot-weather and rainy-season crop and bollworms and their parasites are found earlier in the season on *bhindi* than on cotton. **Mr. Burt.**

Legislation for *bhindi* alone, without taking account of other wild food-plants, would do comparatively little good. Have you any wild food-plants in Egypt? **Mr. Fletcher.**

In Egypt we have not got any wild plants that are fed on by *Earias*. Wild *Hibiscus* does not harbour it. **Dr. Gough.**

In my judgment fumigation or hot-air treatment of the seeds would be the best remedy. **Mr. Burt.**

The difficulty probably is that the cotton area is so extensive that, where one cotton plot ends, another begins. **Mr. Robertson-Brown.**

That is not quite so. One tract is separated from another. **Mr. Burt.**

As regards topping of the plants, there seems to be some difference of opinion. In the Central Provinces the crop is sown thick and is then thinned out and in such cases we can pull out whole affected plants. This work is rendered easier when the plants are sown in rows. But the worst of it is that the plants which are pulled out are generally thrown down on one side of the field. If the cultivators could be persuaded to destroy these plants, it would be useful. **Mr. Misra.**

Ramakrishna ...ar. If the top-shoot is attacked, the tip is destroyed in any case and it may as well be clipped off.

Fletcher. If the top-shoot is cut off there is a danger of its falling down, but if it is simply squeezed and the contained larva squashed, this danger is obviated.

18.—THE PINK BOLLWORM IN EGYPT.

By Lewis H. Gough, Ph.D., F.E.S., *Director of the Entomological Service, Ministry of Agriculture, Egypt.*

There can be no doubt whatever that the Pink Bollworm is a recent introduction into Egypt, and there is very little doubt that it found its way there from India. The date of its introduction lies between the years 1903 and 1910. The first specimens of the insect were seen by Mr. Willcocks, Entomologist to the Khedivial Agricultural Society, in 1910. Mr. Adolf Andres, who later on was Mr. Willcocks' Assistant, also claims to have had specimens in the same year. Our records date back to 1911, the year when we started work in Egypt.

The first records available are all grouped around Alexandria, and in the north of the Delta. The first really severe outbreak was on the Abukir Estate, near Alexandria, in 1912.

The reason why all the earlier records are grouped in this way is without doubt connected with the first importations. Table I shows the quantities of Indian cotton imported from 1903 to 1913. This cotton was required for spinning by the spinning mills at Alexandria, being somewhat cheaper than the Egyptian, and being required for the manufacture of yarns for muslin weaving in Turkey.

Incidentally, the importation of the rather badly ginned Indian cotton could have been prevented under a law passed in 1907, prohibiting the importation of cotton seed. But the law was not considered by those concerned to be applicable to the few seeds found in bales of cotton. One of the first difficulties which arose in connection with the Plant Importation Law of 1913 was in connection with the same point, and as the legal authorities could not see their way to prohibit the importation of, or to condemn, faulty bales, the law had to be withdrawn and replaced by Law I of 1916, which prohibits the importation of ginned cotton altogether. It appears that it was not considered possible to consider whole bales as contraband on account of their containing contraband in the form of seeds.

It was during the exercise of supervision under the law of 1913 that the method of introduction was actually discovered. The Filature

National Mills at Alexandria had imported a number of bales of Indian cotton, which were found on examination at the Customs to be badly ginned. They were allowed to go forward only on the condition that they should be kept in a moth-proof store, and that the cotton should be re-ginned in the presence of a delegate from the Ministry of Agriculture. During the re-ginning several "double" seeds containing living Pink Bollworms were found.

From Egypt the Pink Bollworm is known to have spread to other countries, to which Egyptian seed had been sent. The outbreak in Tokar (Sudan) is probably due to the traffic in Egyptian seed, which prior to 1913 was not restricted in any way by the Sudan Government. The discovery that the Pink Bollworm occurred in the Sudan was made in the Laboratory of the Entomological Section in Cairo, when examining some seed sent from the Sudan to the Ministry for experimental purposes.

Brazil received the Pink Bollworm also from Egypt. The Brazilian Government imported seed in 1913 and 1914 for distribution, without consulting the Egyptian Ministry of Agriculture. This seed cannot be traced in our Customs returns, and may have been exported first to England and transhipped from there. The result appears to have been a very violent outbreak.

Mexico is another of Egypt's unfortunate customers. We can trace from the Customs returns that a consignment of 115 ardebs* went to Monterey, Mexico, in 1911; it has spread across the United States borders into Texas, where the United States Government is now taking active measures to prevent the spread of the pest.

We have unpublished records of this pest from Mesopotamia and from Palestine.

Thus the present known distribution includes (1) in Asia : Palestine, Mesopotamia, India, Ceylon, Burma, Straits Settlements, China, Japan, the Philippine Islands.

(2) in Africa : Egypt (not yet in Algiers or further West), Sudan, (German) East Africa, Zanzibar, Southern Nigeria, Sierra Leone, Lagos. (It apparently does not occur in Central nor in South Africa.)

(3) in America : Brazil, Mexico, United States, and Hawaii. There is little doubt that it will spread in time to wherever cotton is grown, unless cotton-growing countries which are still free take most stringent precautions against the introduction of cotton seed, seed-cotton and badly ginned cotton. This last commodity is frequently used as packing material for leather goods manufactured in the East, and might get overlooked by Customs Officials.

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* One Ardeb=121·5 Kg. or 270 lbs. wt.

The original home of the Pink Bollworm appears to be most probably Asia. The insect was probably introduced from India into (German) East Africa before the German occupation; according to the accounts by various German authors, the insect is thoroughly established there. Trade with East Africa before the advent of the Germans was practically all with India. Its spread to Zanzibar is understandable in view of the trade connections with India.

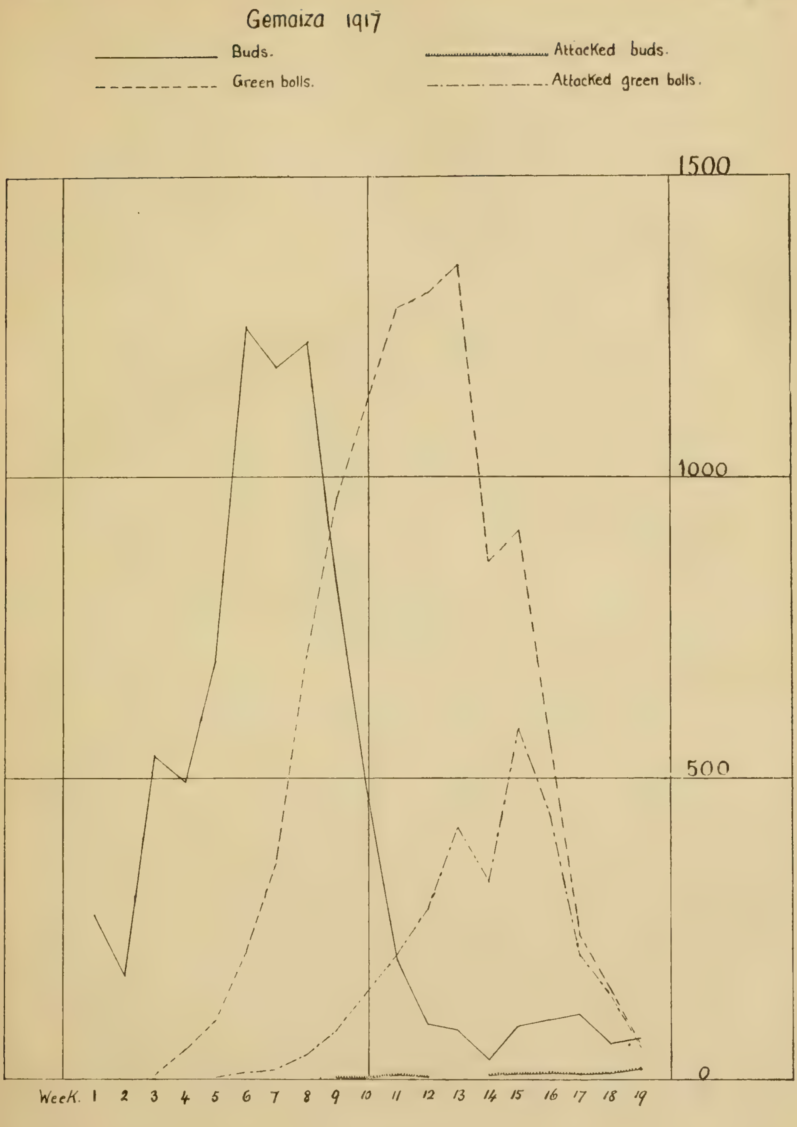
Although the introduction of the Pink Bollworm took place so recently, very little is really known about its rate of spread in Egypt. A few records are given by Willcocks, for the localities in which it was noted before 1913, but these records are defective in many ways, especially as they are the result of stray notes and not of an organized search for the insect. Although first recorded in Egypt in 1910 from around Alexandria we have distinct evidence in the shape of hollowed-out seeds, ginned at Maghagha in Upper Egypt in 1911, that it had already reached so far in the first year after its discovery.

Food-Plants. The principal food-plant is without doubt cotton; it feeds on various other malvaceous plants contrary to the assertion of Busck which has apparently been accepted by the American authorities.

On cotton the larva feeds in the seeds, bolls, flower-buds, flowers and in the stem, in which last it bores in the cambium; the order of preference being as stated.

It was found in an experiment made at the Government farm at Gemmeiza in 1917, that during the 19 weeks from June 9th to October 20th, of 44,013 buds only 165, of 5,792 flowers only 13 and of 48,395 green bolls 16,831 contained worms or showed signs of previous attack or both (Plate 80). Of the green bolls very many certainly contained more than one larva. This represents the total number of buds, flowers and green bolls found on 9,300 plants; 100 plants being daily pulled up and examined until the 15th September, after which only 50 plants were utilized for the daily counts. Recalculated in such a way that each week is made to weigh in its proper proportion and calculating all the buds, flowers and bolls each as 10,000, the proportion of attacked flowers is found as 42 in 10,000, buds 67 in 10,000 and bolls (green) 4,346 out of 10,000. (See Table II.) We will have to come back to this subject later on.

After cotton the chief host plant in Egypt is the *Okroe* (*Hibiscus esculentus*). (See Table III.) And here it may be mentioned that we totally disagree on this subject with the views of Busck, who denies that the Pink Bollworm feeds, or develops through, on any other plant than cotton. Our experience has shown us that at certain seasons, it can infest *okroe* pods to a serious extent (16 per cent.). (See Table IV.)


Gemaiza 1917
Buds.
Attacked buds.
Green bolls.
Attacked green bolls.
1500
1000
500
0
Week. 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19

In all we have examined 6,060 *okroe* pods this year, and have found 319 larvæ in them. From an inquiry received from America we judge that Busck is willing to admit that the Pink Bollworm may feed for a certain time on food other than cotton, but that such larvæ will not mature and emerge. Against this we can set the fact that we have had 191 emergences from *okroe* pods this year (up to 23rd December 1918).

The pods and seeds of *Hibiscus cannabinus* also serve as food to the insect. Examination of 1,000 pods collected last October gave 45 larvæ. That larvæ feeding on this plant can develop and emerge as moths can be seen from the fact that we have bred through 131 moths from *cannabinus* pods (23rd December 1918). (See Table V.)

It was necessary to elaborate the possibility of other food-plants than cotton being utilized on account of the attitude adopted by Busck.

Other recorded food-plants are hollyhock (*Althœa*) on which plant it has been found in Egypt by Willcocks, (and possibly in India), and *Abutilon* sp., recorded by King in the Sudan, and Fletcher in India. The fact that these two pairs of records were made in different countries by different observers would seem to exclude the possibility of a mere chance straying of a worm on to a pod of an unsuitable plant, and pupating there, which is the explanation advanced by Busck to disprove records which he does not agree with, as for instance, the records for *Thespesia populnea* by Fullaway. This last record has, however, not yet been confirmed by observations by other workers. *Hibiscus abelmoschus* was recorded as a host at the Second Indian Entomological Meeting by Fletcher.

We further consider it extremely probable that the Pink Bollworm feeds on *Malva sylvestris*, but the observation is not sufficiently established for certainty.

After this list one would not be surprised to obtain records from other malvaceous plants. We have however searched for it in vain in the pods of *melochia* or Jew Mallow (*Corchorus olitorius*).

The record formerly given for pomegranates must be withdrawn and was undoubtedly based on error.

The eggs are minute and are laid singly, or in small groups of up to ten. They are to be found on the bolls, involucres, leaves and axils of leaves. The egg-stage in Egypt is known to last from 3-7 days. Busck gives the period as 4-12 days. Owing to the small size of the eggs, the insect cannot be controlled at this stage.

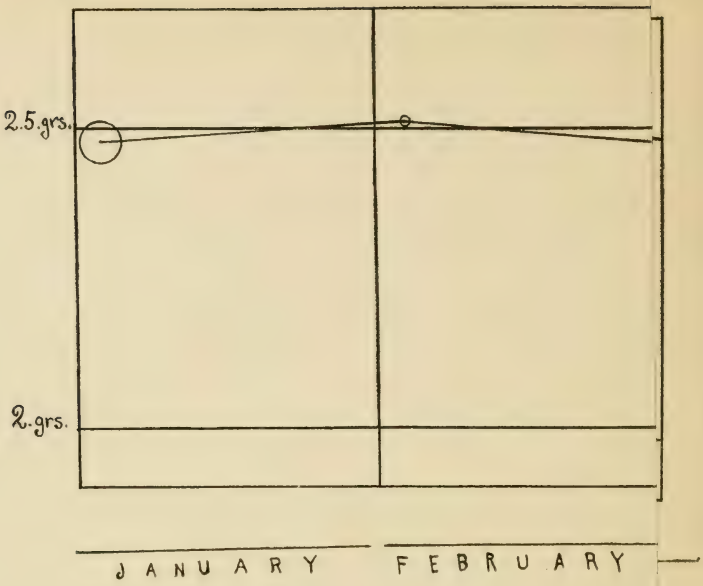
The larval stage is passed, almost entirely, inside the part of the plant attacked. The time required for this stage as given by Willcocks is 9—19 days. Busck found 20—30 days. The feeding period is usually immediately followed in summer by spinning up and pupation, but in the case of some larvæ, especially those whose feeding period closes in the late autumn or winter, it is followed by a resting period which can last as long as two and a half years, perhaps longer. We apply the terms "short cycle" larvæ to those worms which pupate immediately after feeding and "long cycle" or "resting" larvæ to such as intercalate a long period of rest between feeding and pupating. Resting larvæ are usually found spun up inside hollow seeds, or "double" seeds. A "double" seed is produced in the following manner: the larva having hollowed out a seed, attaches another seed to the hollow one, uniting the edges of the opening of the hollow seed to the new seed by silk threads. The attachment of the two seeds to each other is very firm and resists the action of the gins. The second seed is usually eaten into. When no second seed is used, resting larvæ spin up the opening of the seed they inhabit; double seeds often contain two worms. It is not an infrequent occurrence for the larvæ to use more than two seeds for their resting shelter; as many as six seeds have been found utilized in this way. The seeds composing "double" seeds usually vary in their state of maturity. The original hollow one is usually in the red unripe stage of development, the next seed or seeds being black or ripe.

The presence of *Gelechia* larvæ in attacked green bolls cannot be noticed without cutting open the boll, as the entrance hole made by the larva is very minute and the larva does not keep it open nor enlarge it in order to void the frass as *Earias* larvæ do. For this reason it is not possible to control the Pink Bollworm by collecting attacked green bolls. When full fed, short cycle larvæ leave the bolls by a hole they make. This hole might be mistaken for the work of an *Earias* larva, but that the frass left by such larvæ is wanting.

The winter is passed in the larval stage, mostly by "resting" larvæ. However in the months January to March 1916 we were able to prove the existence of a very slow-feeding brood, which was found in bolls collected off the ground in fields previously under cotton, but cultivated with bersîm, beans, wheat or barley. (*Bulletin No. 4, Technical and Scientific Service.*)

The resting stage larvæ are to be found in seeds of cotton, *okroe* and *H. cannabinus* during the winter. First picking seed by March contains only very few larvæ as compared to the number of seeds attacked, second picking seed contains a greater proportion of larvæ. From this it is concluded that the worms infesting the bolls at the time of the first picking are mostly short-cycle larvæ, and that the proportion of long-cycle larvæ increases considerably during the 4 to 6 weeks which

Page 477.



separate the first from the second picking. This is confirmed by breeding results. The emergence from green bolls collected between 1st September and 10th October 1917 gave 5 per cent., from 11th October to end of November 23 per cent. long cycle moths. The resting period can last up to two and a half years.

Unfortunately it is not possible to make direct observations, by taking out and isolating larvæ, as they appear to react immediately to the stimulus of the interference, and thence-forward to behave in a manner which would not be the normal one if no interference had taken place.

As already stated, it is not safe to base any conclusions on the behaviour of larvæ put into unnatural surroundings. In our work we have always recognized this as a fact, and in our endeavours to obtain information have frequently had recourse to indirect methods, utilizing statistics based on sufficiently large masses of figures. Thus the problem, does the resting stage larva feed, has been tackled by the weighing of hundreds of larvæ at intervals during several months. Needless to say the larvæ were extracted from the seeds they inhabited immediately before weighing, and the same individuals were never used twice. They were weighed in groups of one hundred together, several groups being handled each time.

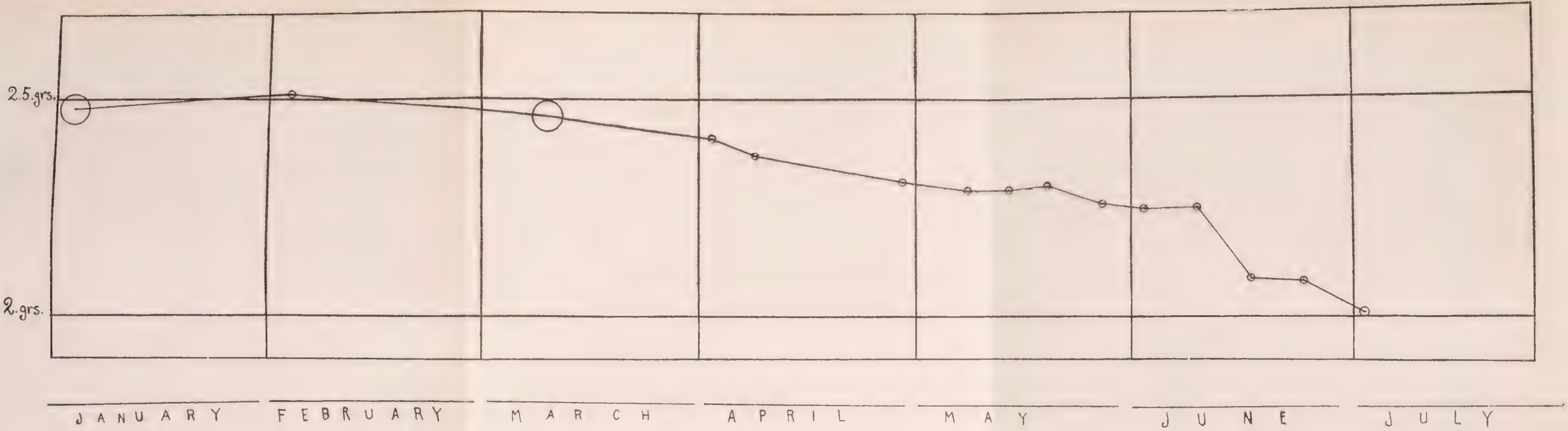
The result obtained shows that during the period from February to June there is a continuous and significant fall in weight (see Plate 81). This does not necessarily prove that the larvæ were fasting, but it certainly shows that they were not actually making good their losses in substance.

It is mainly the resting stage larvæ which (in Egypt) serve to carry the species over from one year to the other. They are found almost exclusively in seed, whether in seed cotton, ginned seed or in abandoned bolls in the field.

The resting stage is the only period of the life-cycle of the Pink Bollworm during which it can be controlled, and, acting on the advice of the Entomological Section of the Ministry of Agriculture, the Egyptian legislator has seized the opportunity given by the insects to ensure its destruction, (*a*) in the cotton field by ordering the pulling up of the cotton sticks and the destruction of the remaining bolls after the last picking, and consequently ensuring the destruction of the larvæ left in the field, (*b*) by the treatment by heat or fumigation of the seed in the ginneries, and (*c*) by compulsory screening of all stores where seed cotton or cotton-seed is kept during the period from May to August.

Larvæ inhabiting green bolls almost invariably leave the bolls before pupating. During the examination of three-quarters of a million bolls

Fluctuations in weight of resting larvæ.
Average weight in grammes of 100 larvæ.



in 1916, 1917 and 1918, only two or three pupæ have been found. Traces of previous occupation were very frequent, as the larvæ when full grown desert the boll to pupate elsewhere. We have observed and recorded in 1917 and 1918 about 50,000 such traces of previous occupation (1917—35,495; 1918,—14,301). We cannot therefore give unqualified assent to Busck's statements.—" The larva normally makes its cocoon and pupates within the boll, partly within the last seed attacked " (*Journal Agriculture Research*, IX, No. 10, p. 353, line 5) and " under normal conditions in the field, however, the pupation nearly always takes place within the boll " (*ibid*. line 19). Larvæ arrived in a seed-store with seed almost invariably leave the seed and pupate in the angle between the line of contact of two sacks or in crevices of the masonry of the walls, or between the floor-boards. The pupal period has been observed to vary from 10 days to 2 weeks. Busck gives it as 10—20 days. Control of the insect at this stage is not feasible as pupæ are not easily found in seed stores, even when abundant, and are practically unfindable outside. Before pupating, the caterpillar spins a cocoon, and requires a few days for its transformation.

The pupa is enclosed in a silken cocoon, and is found sometimes in the lint of an open boll, on the soil, under refuse in the fields between the bract and the boll, or between dead leaves. Willcocks remarks on their frequence in fallen flowers on the ground, and in fallen bolls.

Short-cycle larvæ spin only one cocoon, that in which the pupation takes place, whilst long-cycle larvæ spin up inside hollow seeds for their resting period and leave their resting place to spin their pupal cocoon, which is more elongate and loosely woven than the resting shelter. Whilst resting they are doubled up, head to tail.

The moth is crepuscular or nocturnal in its habits. During the day it is very difficult to find in fields, or in seed-stores, where one knows it to be present ; if disturbed, it escapes by running swiftly and hiding under any shelter it can find.

During the day-time the moth very rarely takes to wing, but at night it can fly long distances when circumstances are favourable. At night it is readily attracted to artificial light. Unfortunately light-traps do not form a reliable method of control. No method of control during the adult stage seems possible.

Emergence of moths from the long-cycle brood appears to depend very considerably upon the conditions under which they wintered. Thus it is now no longer possible to make any absolute statement of the period at which the maximum of emergence may be expected. It has been found that the larvæ living in bolls lying on the ground, which consequently are kept slightly moist, are earlier to emerge, and give

Page 479(1).

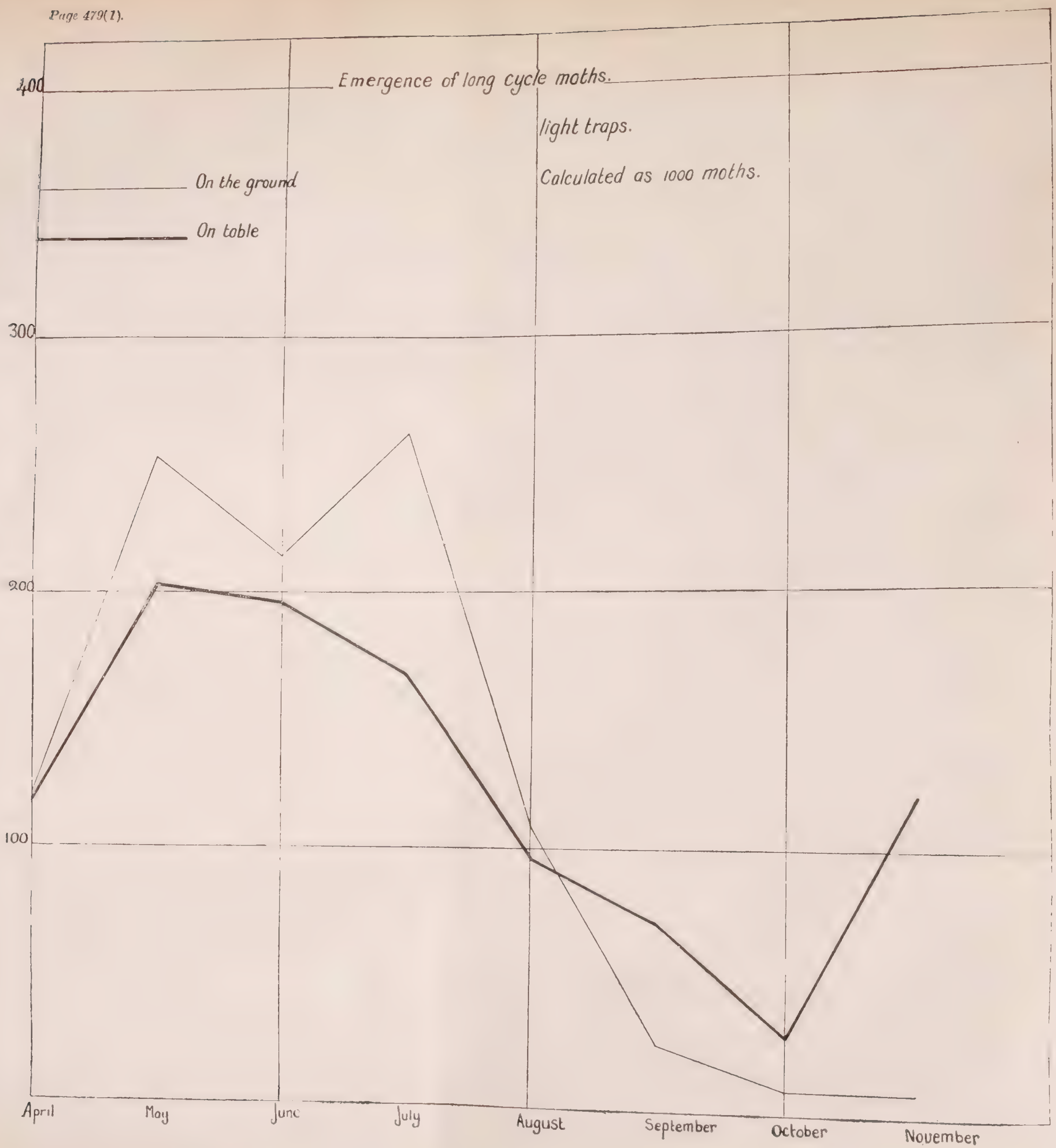
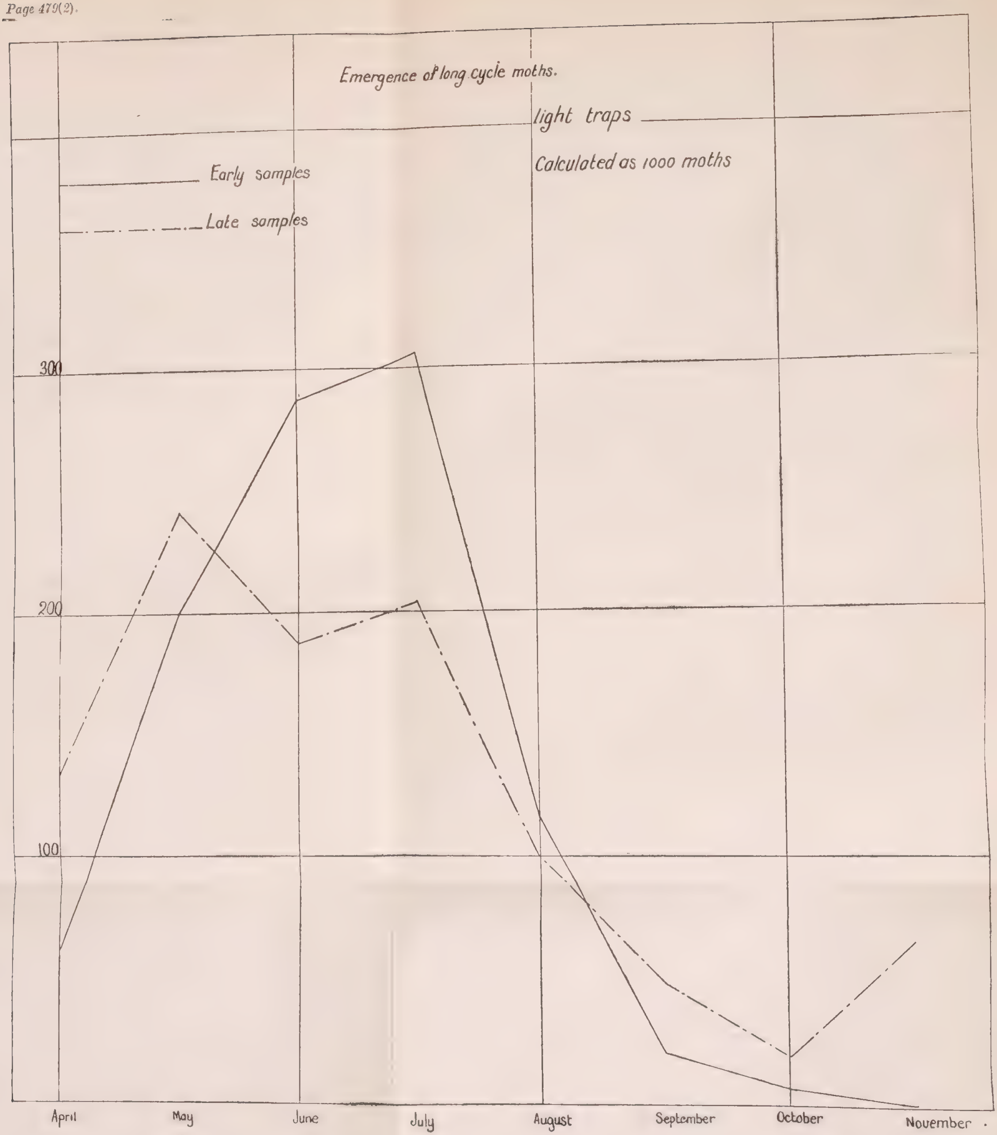

Emergence of long cycle moths.
light traps.
Calculated as 1000 moths.
On the ground
On table
400
300
200
100
April
May
June
July
August
September
October
November

PLATE 83.

Page 479(2).


Emergence of long cycle moths.
light traps
Calculated as 1000 moths
Early samples
Late samples
300
200
100
April
May
June
July
August
September
October
November

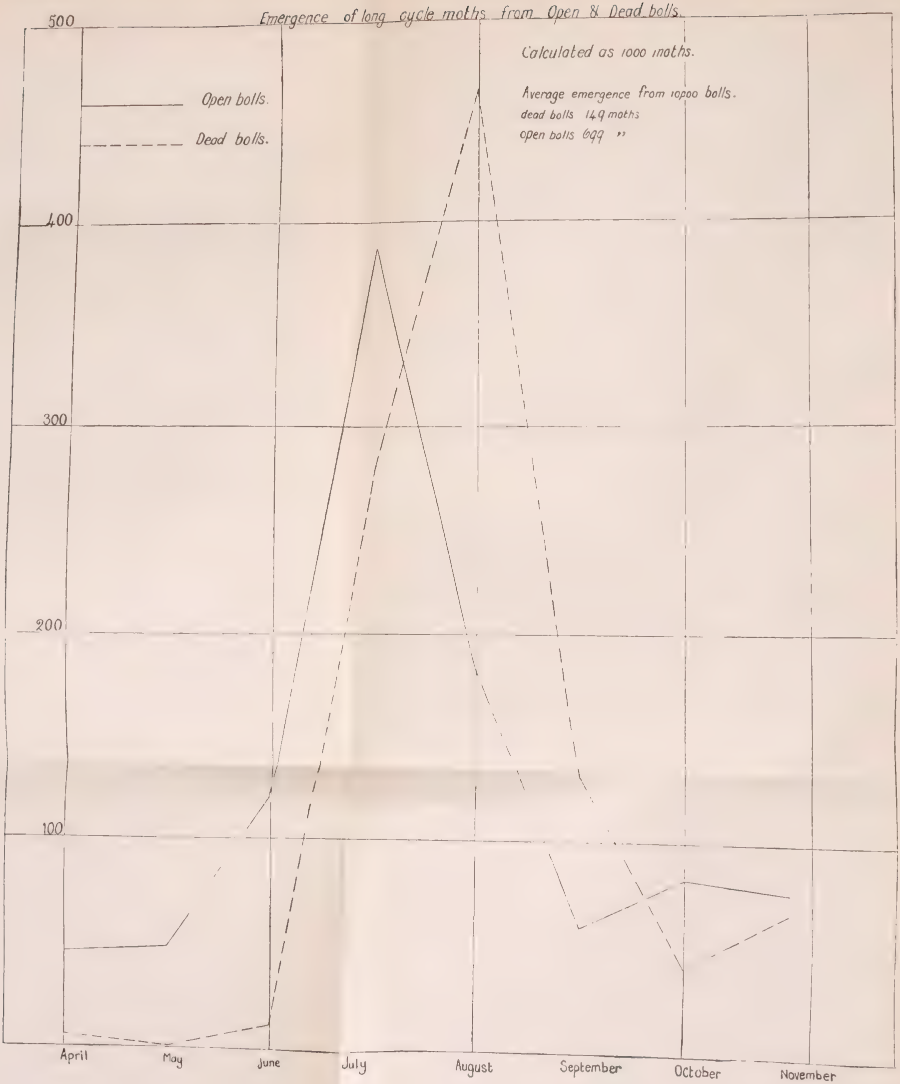

Emergence of long cycle moths from Open & Dead bolls.
Calculated as 1000 moths.
Average emergence from 10,000 bolls.
dead bolls 149 moths
open bolls 699 "
Open bolls.
Dead bolls.
500
400
300
200
100
April
May
June
July
August
September
October
November

PLATE 84.

greater quantities of moths than if wintering in bolls raised up on a table or otherwise sheltered from the moisture of the soil. (See Table VI and Plate 82). These results are only just beginning to come forward, and will require checking by a few more seasons' work before generalization will be safe.

From breeding results obtained in the course of 1917-1918, the following conclusions appear to be justifiable.

The position in which material containing Pink Bollworms is kept has a distinct influence on emergence of moths, both as to the period of the year in which the main emergence may take place, and more especially as to the total number of emergences. Bolls lying on the ground appear to give a greater total emergence for a given quantity, than bolls raised off the ground. A further difference is found between material collected early and late.

A series of breeding experiments made by Mr. Adair is now beginning to give information. In this work samples of fixed numbers of green bolls, of open bolls, and of dead bolls were collected in various parts of the country at ten-day intervals from 1st September 1917 finishing on 30th November 1917.

It has been found that there is a difference in the emergence curves for early and late samples, 11th October being very close to the turning date. In very many cases emergence from early samples was more numerous than from late samples. Here parasites may have had some influence. (See Table VII and Plate 83).

A very puzzling feature is the diversity in emergence from green, open and dead bolls. (Green bolls were bolls which were unripe at the time of picking. Open bolls were recently opened bolls which would not be rejected by cultivators taking their harvest; and dead bolls were bolls stopped in their development before ripening and which had dried up prematurely.) (Plate 84).

Ignoring all emergences which took place before 1st April 1918, as being of little economic importance, we find that of the emergence from the three classes that from the "dead" bolls is possibly most readily understood. Picked early or late, we find practically no emergence of moths before July. Two-thirds of all the moths left these bolls in July and August, but emergence was continuous to the end of November. (See Table VIII).

Very similar results were obtained from the early green bolls, no emergence before July, maximum in July and August, and steady numbers till the end of our observations (30th November 1918).

Both of these sets, *i.e.*, the complete "dead" boll and the early part of the "green boll" gave comparatively few emergences. They are comparable *inter se* in other ways. The "dead" bolls were killed before maturing (by the Pink Bollworm) the early green bolls were killed before maturity (by picking) or ripened prematurely. Their curves, as has been stated, are very similar, and are composed entirely of "long-cycle" moths. (Plate 85.)

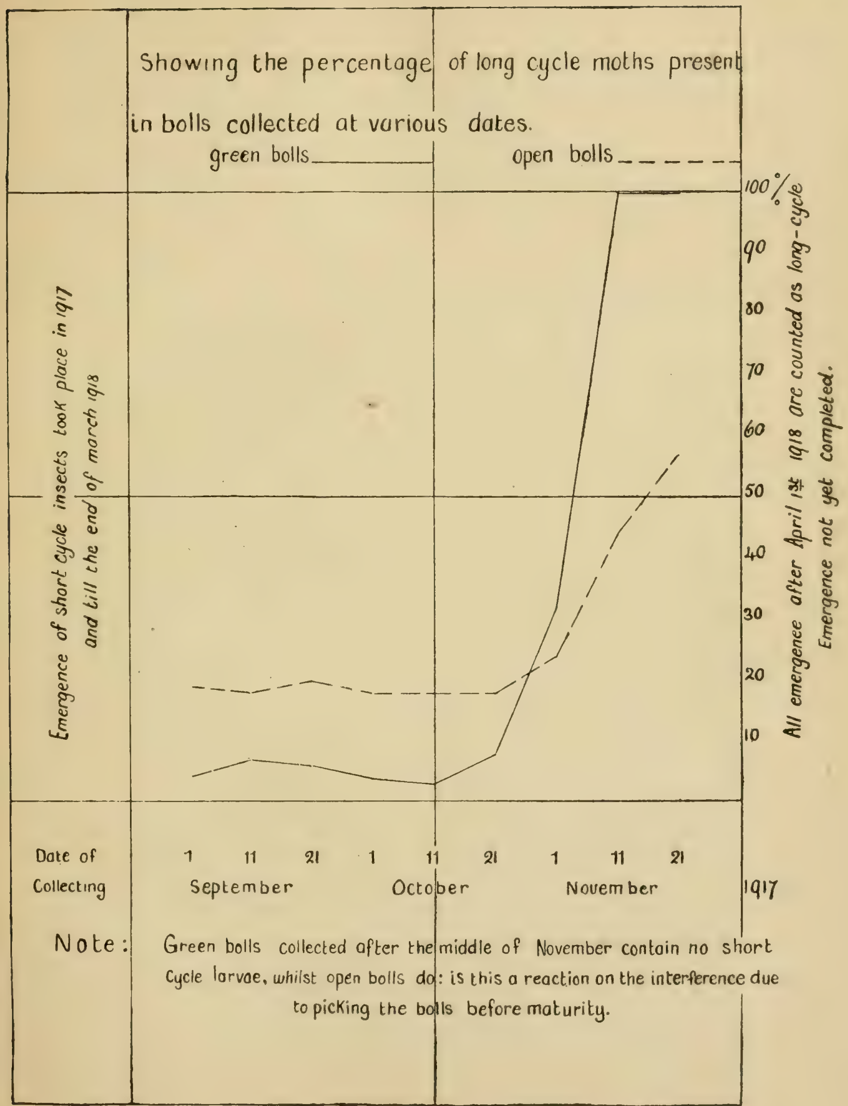
The late green bolls are at first sight very puzzling. Sixty-five per cent. of the emergences from this lot were in April and May, followed by none at all in June. The remaining emergences were observed in July, August, October and November.

This very great rush of emerging moths in April and May is characteristic of the late green bolls only. The "open" bolls have no parallel to show. In their case the emergence curve is a continuous one over the whole period, a little steeper in the case of moths bred from early collected material than from that collected later.

There is only one explanation possible by which the late "green" boll curve can be understood, and that is that the rush of moths emerging in April and May did not belong to the long-cycle generation at all. It seems much more probable that they belong to the winter generation, which I mentioned earlier. All that we know of this winter generation has been found out by the statistical method. In 1916 I drew attention to the fact that in bolls collected in the field in the first three months of the year there were varying numbers of *Gelechia* larvæ of small and medium size. The number of small and medium larvæ found in January was approximately in agreement with the number of medium-sized ones found in February, whilst in March small and medium larvæ were almost absent. Nothing further was known of this winter-generation until these breeding results came forward. It was considered not possible to verify the existence of the winter generation by direct breeding methods, owing to the intolerance of Pink Bollworms to interference.

It may now be assumed as nearly certain, that the winter-generation is produced by eggs laid before the end of November on the late green bolls, that, owing to cold conditions, these eggs and the resultant larvæ mature very slowly—for which many parallels could be brought—and that the winter-generation mainly belongs to the short-cycle.

As to the relative economic value of worms harbouring in green bolls, open bolls and dry bolls, it may be stated that very probably the dead bolls are the least and the open bolls the most dangerous. However, the worms in the open bolls will all find their way to the ginneries, where a warm reception is provided for them in the seed-treating machines. Of the bolls remaining in the field the green ones are by far the most important, as they harbour more worms per unit


Showing the percentage of long cycle moths present in bolls collected at various dates.
green bolls
open bolls
Emergence of short cycle insects took place in 1917 and till the end of march 1918
100%
90
80
70
60
50
40
30
20
10
All emergence after April 1st 1918 are counted as long-cycle
Emergence not yet completed.
Date of Collecting
1 11 21 1 11 21 1 11 21
September
October
November
1917
Note: Green bolls collected after the middle of November contain no short Cycle larvae, whilst open bolls do: is this a reaction on the interference due to picking the bolls before maturity.

than the dead bolls; both of these two classes of bolls are emitting their maximum numbers of long-cycle moths in July and August, that is, at the very time when the cotton plant is most ready to receive them. What happens to the moths of the winter generation emerging in April and May is yet unknown. Unless they can manage to survive into June it would seem probable that they must die without giving rise to new descendants, unless they utilize *okroe*. Investigations are planned by which it is hoped to acquire information on these points. (See Table IX).

The moths hide away in dark places during the day-time, and are then very difficult to find. In seed stores where one knows that immense quantities of living moths must be present, it is very difficult to find them. However, by turning over boards, raking in the seed, and examining between sacks, it is usually possible to find specimens. Dead moths are most abundant on the sills of moth-screened windows and under the skylights in seed stores. In the fields they are equally well hidden, and more difficult to find as there are more hiding places for them. When disturbed in the day-time they very rarely fly, but scurry away and hide as soon as any dark cover or crack presents itself. At night they are attracted to artificial light, but according to Willcocks' experiments not sufficiently so to allow light-traps to be of practical use as a remedy. The attraction to light is however quite marked, and is utilized by us in Cairo in obtaining our emergence results. In our large breeding sheds, and also in one of the largest seed stores at Alexandria, we trap the moths, which would otherwise be almost impossible to find, in this way. An electric light of 20 candle-power is suspended about 15 cm. above a basin of water, on whose surface there is a thin film of petroleum. We also employ a similar trap in the open in our garden to inform us of the frequence of the insects outside our experiments. Our recorded catches by this method run to 71,372 Pink Bollworm moths (see Table X). The series of records from the Alexandria seed store are particularly interesting. Here, during a period when the insects were being caught by the thousand, the light failed on two occasions. The moths also failed to get caught on those same occasions (see Table XI). This proves that it was not the petroleum, nor the water which was the principal attraction, but the light itself. Against this I must again quote Busck (*loc. cit.*, p. 355) "From very many varied and repeated observations under different conditions it may be definitely stated, notwithstanding the many other statements to the contrary, that *Pectinophora gossypiella* is not attracted to light, but is, on the contrary, shy of all light, natural and artificial."

The following data were collected by Ballou when working at Cairo, relative to the time of flight of moth, as evidenced by traplight captures.

The number of moths caught were counted at half-hourly intervals on eight different nights.

On two occasions the light was turned on one hour before sun-set. Nothing was caught on either of these occasions.

The total number of moths caught during the eight nights was 4,278 ; of these 3,321 were taken during the first hour after dark during which the light was burning. In this respect it made little difference whether the light began shining before sun-set or up to two hours after. A later time was not tested ; in every case the bulk of the catch came during the first hour after sun-set during which the light was on.

The Pink Bollworm breeds continuously from April onwards, as long as there are cotton-plants and especially cotton-bolls for it to feed on. The generations overlap each other, so that one cannot separate the broods. In this respect it resembles *Earias*. A possible cause for this is the straggling way in which the long-cycle larvæ complete their resting stage. At Cairo the emergence of moths from the resting larvæ never absolutely ceases, and begins to rise in April, reaching its maximum intensity between May and August. The maximum emergence of moths belonging to short-cycle larvæ takes place in the autumn.

It has already been stated that flowers and buds are attacked to a much less extent than bolls. A glance at Table II will show that the absolute maximum of infestation of buds and flowers does not coincide with the period of maximum presence of those organs. On the contrary, the Pink Bollworm more readily selects flowers and buds at the end of the season long after their maximum has been passed. The reason for this lies in the fact that at this time the absolute Pink Bollworm population is greatest, and the supply of green bolls is falling. What green bolls exist are frequently multiply infested. Apparently the stress of over-population drives the insects into attacking buds and flowers which might be considered to be unsuitable.

Here it may also be remarked that in summer, when cotton bolls are plentiful and not overpopulated, *okroe* and *H. cannabinus* pods are usually not attacked. In September and October when the cotton boll production is falling off, *okroe* and *cannabinus* pods are increasingly attacked. The apparent immunity of these two species of *Hibiscus* in summer is due to the cotton acting as a trap-crop and protecting them, and not to direct immunity (see Table IV).

Since 1916 the Entomological Laboratory has every summer made an examination into the intensity of infestation of green bolls by the

Pink Bollworm. Briefly described, the material for investigation consists of fixed numbers of green bolls taken weekly in all the provinces and sent in for examination. It is desired that the bolls from any province shall not all come from one field nor from a single village. This scattering of the samples is intended to improve the sampling for each province. No fear need be entertained of individual bias being introduced by the collectors, as it is impossible to judge whether green bolls are sound or attacked, without cutting them open.

In the Laboratory these bolls are sliced through, each in at least three places, and examined for larvæ. All bolls received from any province between Friday and Thursday are reckoned together as belonging to the week commencing on the Friday. The samples (about 1,000 bolls for each province) are worked up in batches of 100 bolls for convenience in finding percentages and for probable-error calculations should such be required. Each operator examines his 100 bolls; when finished the supervisor checks the work; thus not much error creeps through.

As a result of these examinations we can now give certain general results, and indicate anticipated ones which will probably be gained when we have a sufficient number of years' work behind us to allow average figures to be made.

The seasonal distribution is very marked. Every year we commence in the Delta in July with only a few per cent. of the bolls infested. The degree of infestation progresses slowly but steadily until about one quarter of the green bolls are attacked. Then the position changes rapidly; for any small locality about three weeks suffice, for any province or for the Delta four or five weeks will find 75 per cent. and more of the bolls attacked. The end is always the same, provided the bolls are collected late enough in the season, namely 90 to 100 per cent. infestation.

What the crop will be depends on the period when the 25 per cent. infestation average is reached. If this point is reached early, as compared to the maturity of the crop, the result will be a disaster; if late, it will mean a good crop.

Now, 100 per cent. infestation at the end of the season sounds serious, but the gravity is more apparent than real. The green bolls at the end of the season will not ripen in any case, and are consequently of no importance except as preparing the next year's crop of worms. And this leads to the next consideration, the greatest crop of worms in green bolls is not at the period when the percentage of attack is highest, but at an earlier period when the green boll population is greater. The sudden rise in the percentage of attack from 25 per cent.

to 75 per cent. is partly due to decrease in number of green bolls available accompanied by an increase in the actual Pink Bollworm population.

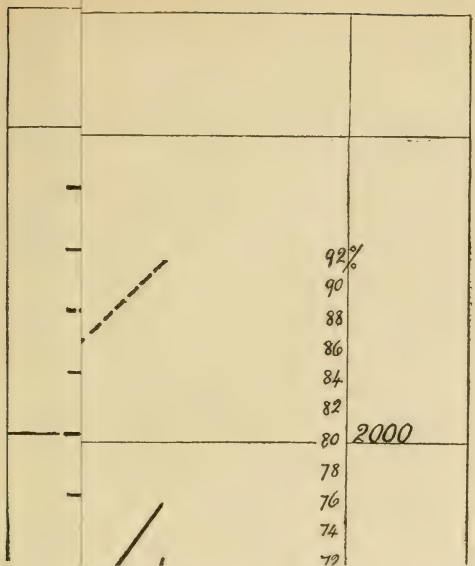
As an illustration of the fact that the greatest Pink Bollworm population does not exist at the time of the highest percentage of infestation some figures obtained in 1917 may be quoted. In this experiment the average green boll population for 100 cotton-trees has been recorded for each week from that commencing on 9th June onwards until that starting on 13th October. In this case the greatest number of attacked bolls observed in any week was found in the week commencing 15th September when 580 out of a total 908 bolls or 61 per cent. were attacked. In the last week, when 92 per cent. of the bolls were infested, there were only 59 bolls to be attacked. (Plate 86.)

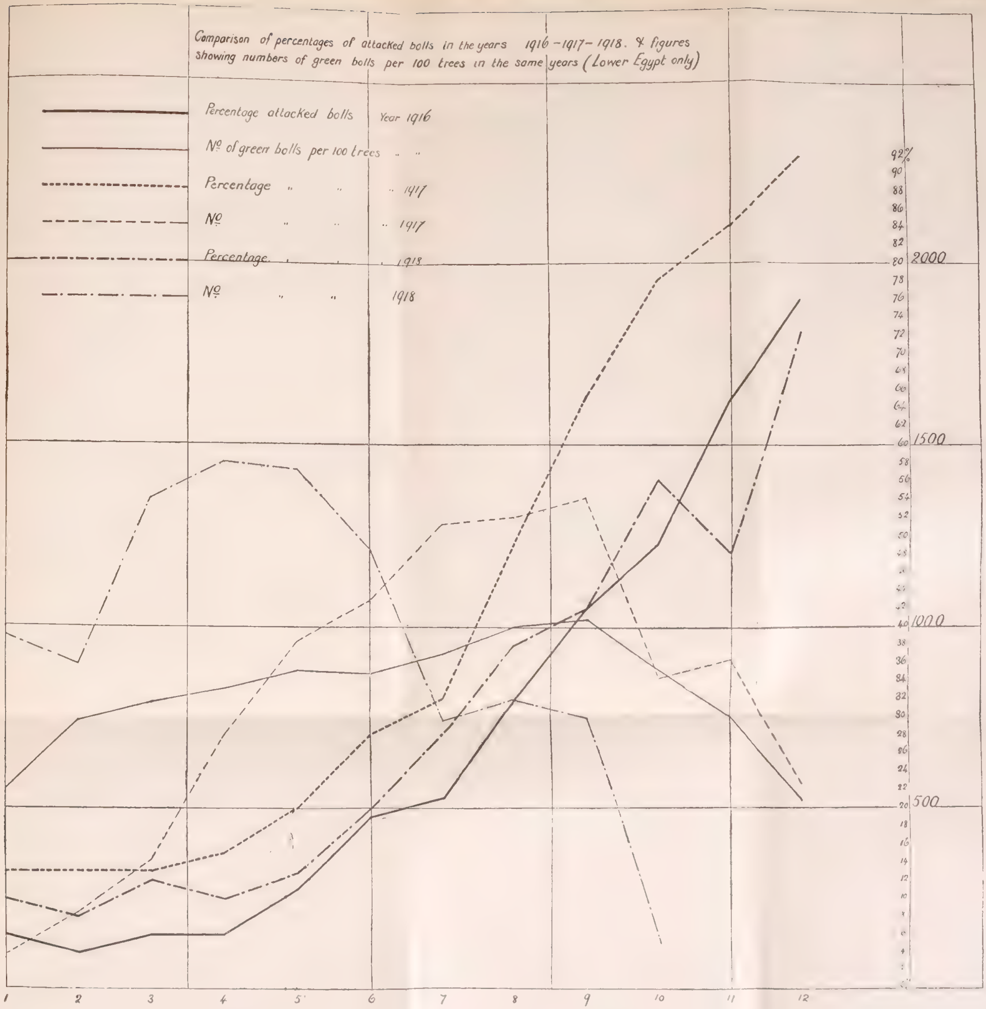
According to the percentage infestation figures, 1918 was better than 1917, by at least one week. Whether this would correspond to a real improvement in the crop or not depends on the comparative dates of ripening of the crops for the two years. (See Plate 86).

One point comes out quite clearly to my mind. Any method by which the cotton crop can be rendered more early will infallibly place the maximum of green bolls in a more secure position, in other words will reduce attack. Two ways present themselves as leading to this result, either the production by selection of an earlier-maturing variety of cotton, or making existing varieties mature earlier by cultural means. The new cotton is still wanting, but the cultural method has been devised and experimented during three seasons by Mr. Cartwright, Inspector of Agriculture in Gharbia Province. The method consists mainly in judicious withholding of water at a time when normal practice is giving the plants more than they need. The result is a gain of two or three weeks on the surrounding crops, with a considerable gain in the harvest. Incidentally it may be mentioned that a gain of about 3 weeks would eliminate loss of at least 10 per cent. of the crop.

In 1918 an attempt was made to obtain some information, whilst examining bolls for percentages of infestation, to obtain evidence as to the age of bolls when attacked. For this purpose all the bolls were, before examination, graded in a boll-grading machine which automatically sorts them out according to their sizes into three groups. Grade A, bolls less than $1\frac{1}{2}$ cm. in diameter; Grade B, bolls over $1\frac{1}{2}$ cm. and less than 2 cm.; Grade C, all larger bolls. At the same time the worms were recorded as small (*i.e.*, less than 5 mm. long), medium (5 to 10 mm.) or large (over 10 mm.). There appears to have been no difficulty in the great majority of cases in apportioning the worms to their proper class. The method is admittedly crude, but there was no alternative

PLATE 86.




Comparison of percentages of attacked bolls in the years 1916 – 1917 – 1918. & figures showing numbers of green bolls per 100 trees in the same years (Lower Egypt only)
Percentage attacked bolls Year 1916
Nº of green bolls per 100 trees " "
Percentage " " " 1917
Nº " " " 1917
Percentage " " " 1918
Nº " " 1918
92%
2000
1500
1000
500
Weeks 1 2 3 4 5 6 7 8 9 10 11 12
July
August
September

except to leave the whole examination alone; it must be remembered that nearly a quarter of a million bolls are dealt with annually, the busiest weeks averaging 23-24,000 bolls examined. The results may be summarized briefly as follows (see Table XII) :—

Grouping together all the bolls examined throughout the season, we find that group A was attacked only to the extent of 4 per cent., group B to 20 per cent., group C 33 per cent. (This includes a few per cent. *Earias*).

Given equal numbers of bolls of all three groups—which does not occur in nature, as the large bolls predominate—we find that small worms are three times less abundant in bolls of grade A than in either of the two larger grades. Medium-sized worms are seven times more abundant in bolls of grade B and ten times more abundant in grade C than in grade A. Large worms are eight times more frequent in grade B and twenty times in grade C than in A.

Supposing our samples to have been approximately representative in the proportions contained of the three grades (probably grade A is however under-represented), then small worms are three times more abundant in grade B and twenty-five times in grade C than in grade A. Medium-sized worms are eight and eighty-six times more abundant in B and C than in A, and large-sized worms nine and one hundred and seventy-one times more abundant in grades B and C than in A.

All this probably only proves that the older grades have been longer exposed than the younger ones. But it is conceivable that an insect might prefer young bolls to old ones; this is not the case with the Pink Bollworm.

From an investigation made in 1917 in which the entire spoils of at first 100 and later 50 cotton-plants were examined daily, the results of which it is hoped will be published more *in extenso* elsewhere, the following observations have a bearing on the same problem of the age of bolls when attacked. In this case no attempt had been made to grade the bolls or larvæ, but attention was given to recording the traces of previous occupation of a boll by worms which had left the boll, and in many cases it was found that a boll containing larvæ had previously been attacked by others. Traces of previous occupation begin to be recorded about one week after the first worms had been seen, and there is a very strong correlation ($0{\cdot}968 \pm 0{\cdot}015$) between the attack of one week and the "traces" of the next week, especially for the period of eight weeks commencing 7th July and ending 31st August and commencing 14th July and ending 7th September. This period is selected for remark, as after that date part of the bolls showing "traces" would have ripened and no longer be recorded.

An examination made at Tel el Kebir this year has brought out that after the last picking there are approximately 4 times as many bolls on the trees, as on the ground and about 1 boll per tree; as each boll may contain up to six or seven worms, it is obvious that any work done in destroying bolls must be of use.

The damage done by the Pink Bollworm has been studied very carefully during the last three years. A preliminary paper on this subject was published early in 1916, since when an enormous mass of *data* has been obtained. It is intended to publish these *data* elsewhere, *in extenso*, but the main results may be summarized here.

It was already indicated in 1916 that the average weight of sound seeds that develop in attacked bolls is lowered on account of the attack. It has now been shown that the average weight decreases in proportion as the average intensity of the attack increases. The correlation between the percentage of sound seed in a sample and the average weight of a sound seed in that sample is as high as $0{\cdot}976 \pm 0{\cdot}008$. Higher correlation could not be expected. (Plate 87.)

This falling in weight of sound seeds developing in attacked bolls has further been shown to be due not to a general reduction in weight of all the seeds but to an increase in the percentage of the smaller weight seeds at the cost of the heavier grades. This has been worked out by weighing the seeds from a long series of bolls, each seed separately

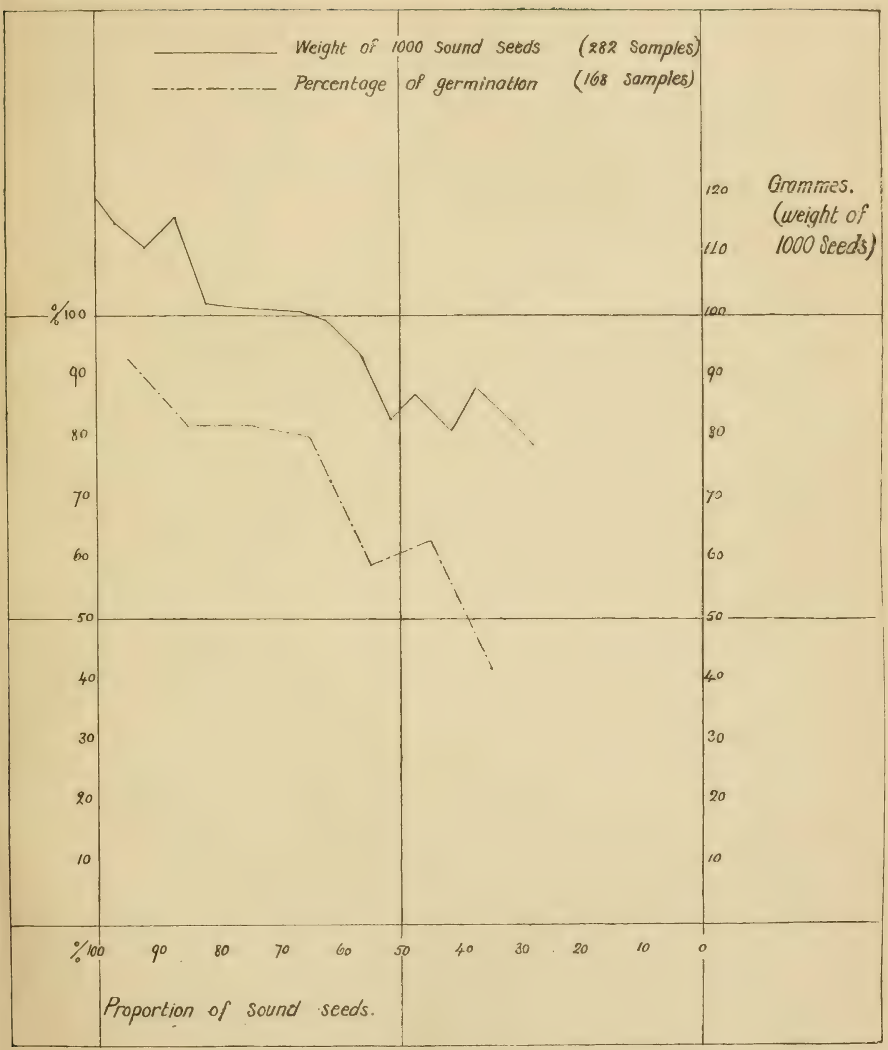
This year we have obtained the further indication that the sound seeds developed in sound locks of attacked bolls are inferior in weight to sound seeds developed in perfectly sound bolls.

As in 1916 we had stated that there were strong indications that seed developing in attacked bolls loses some of its power of germination, this problem was followed up to see how far the loss of germination is proportional to intensity of attack. (Plate 88.)

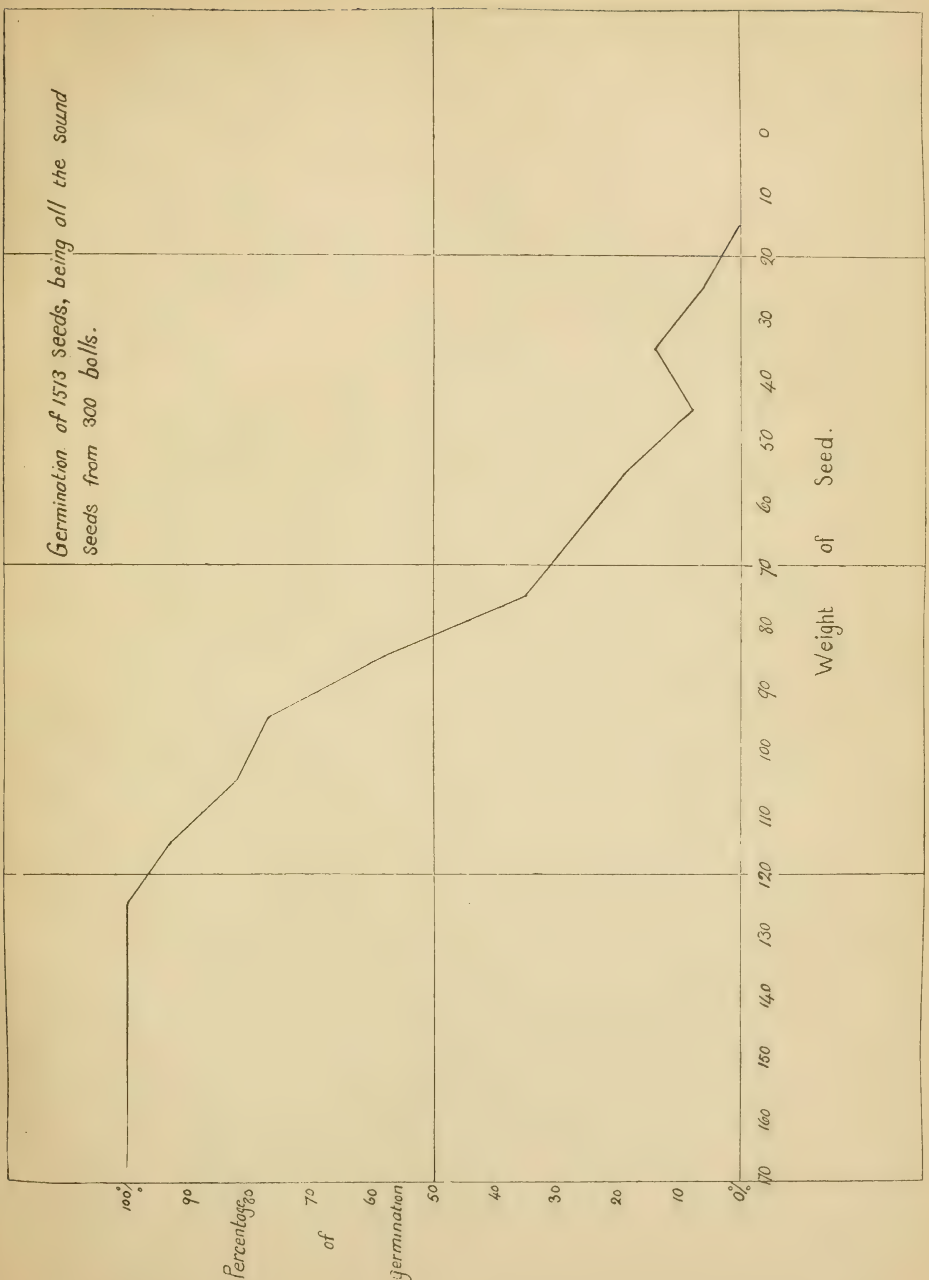
The correlation between the proportion of sound seed in a sample and the germination of that sound seed has been found to be $0{\cdot}925 \pm 0{\cdot}017$, which again is very high.

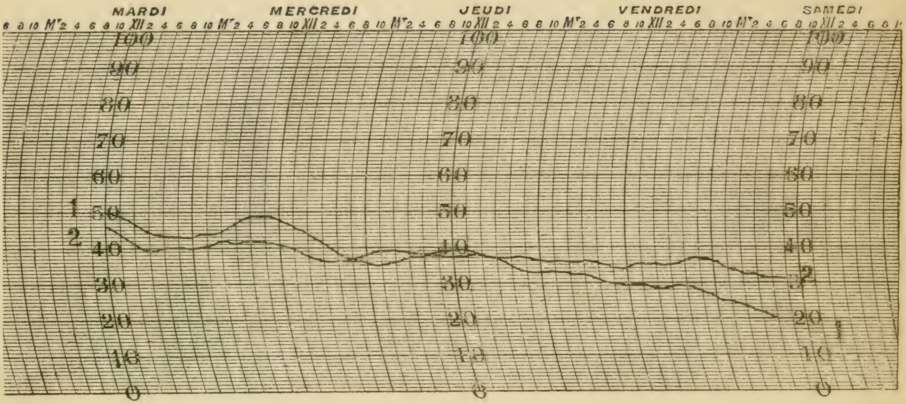
This problem has been pursued further, and by germination of seeds carefully weighed singly and grouped in weight groups at 10 milligram intervals, a correlation of $0{\cdot}958 \pm 0{\cdot}014$ has been found between weight of seed and intensity of germination.

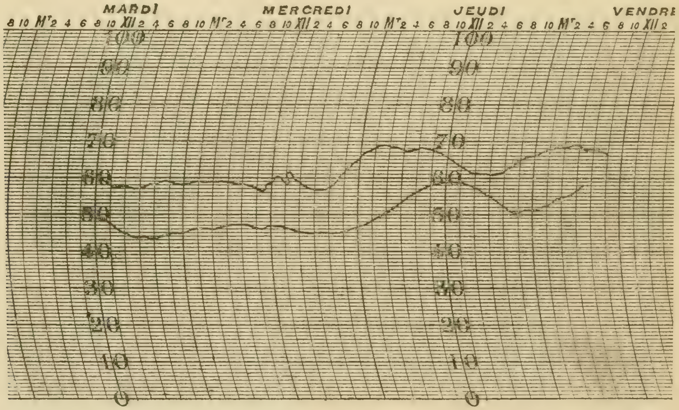
It has further been found that attacked bolls do not form so many seeds (sound *plus* attacked) as sound bolls. The reason for this is that, where the attack takes place early in the life of a boll, entire seeds are liable to be totally destroyed without leaving traces. The correlation between intensity of attack and reduction in number of seeds was found to be $0{\cdot}889 \pm 0{\cdot}063$.



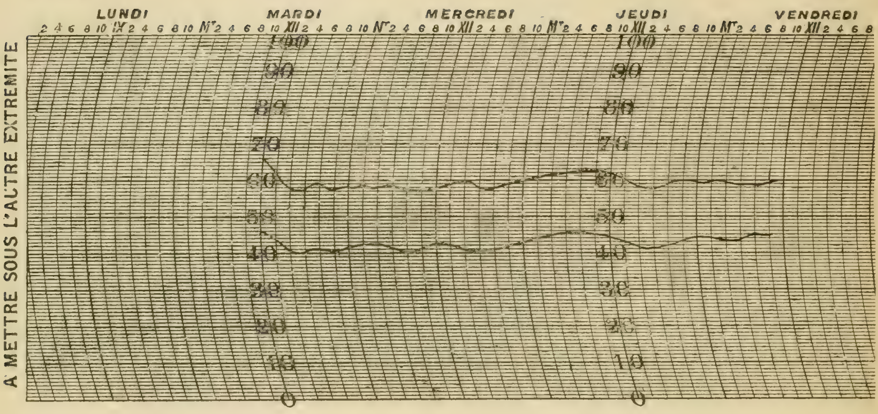
Weight of 1000 Sound Seeds (282 Samples)
Percentage of germination (168 Samples)
Grammes. (weight of 1000 Seeds)
%100
90
80
70
60
50
40
30
20
10
120
110
100
90
80
70
60
50
40
30
20
10
%100 90 80 70 60 50 40 30 20 10 0
Proportion of sound seeds.

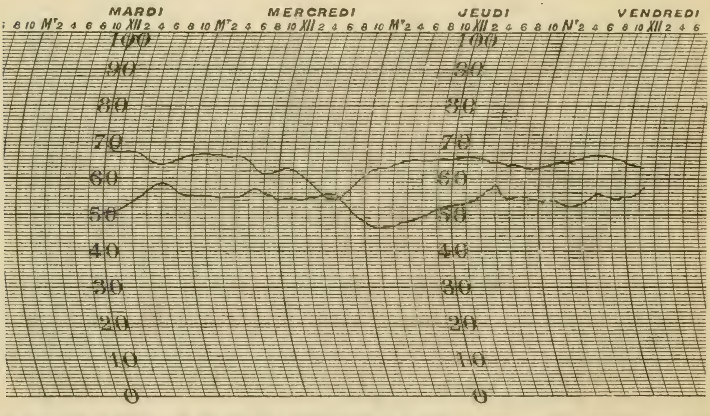

Germination of 1513 seeds, being all the sound
Seeds from 300 bolls.
Weight of Seed.
Percentage of germination
100% 90 80 70 60 50 40 30 20 10 0%
0 10 20 30 40 50 60 70 80 90 100 110 120 130 140 150 160 170





Relationship between seed-weight and atmospheric humidity. Upper curve (1), humidity; lower curve (2), seed-weight.





Relationship between lint-weight and atmospheric humidity. Upper curve, humidity ; lower curve, lint-weight.

Intensity of attack is always calculated above by the proportion of sound to damaged seed. Calculating the number of damaged seed in a sample is always a difficult and tedious task, but can be done if trouble is taken. None of the samples used for the correlations above mentioned were made for that purpose, and using the data obtained from them for correlations was not considered until a whole year after the records had been made. They were originally intended for use for a totally different purpose.

That seed samples which have been damaged will be deficient in oil is evident, but has not been investigated by us.

The effect of Pink Bollworm attack on the lint has also been studied, but from the quantitative side only. We know that the quality suffers, but have not yet examined this aspect of the question.

Ginned lint can only be studied in bulk, and can only be understood in connection with the seed from which it was derived.

The first question to examine was the effect of Pink Bollworm attack on the percentage lint.

The percentage lint is obtained by dividing the weight of lint, after multiplying the lint-weight by one hundred, by the total weight of seed cotton.

Before we could attempt any examination along these lines, we found it necessary to study the percentage lint in normal samples in order to understand to some extent the problems involved. Very little literature was available beyond the writings of Balls, which did not throw much light on this subject.

The percentage lint of any lot of cotton can only be known by examining the whole lot. The errors of sampling are great. They consist of two different kinds, (*a*) an error due to the portion of the sample examined not being truly representative of the whole lot, and (*b*) an error introduced by the atmospheric humidity at the time of weighing.

To make this clear, eighty samples of about 100 bolls each, together forming the whole lot of cotton collected in an uniform field, varied in the percentage lint from 29·5 per cent. to 32·2 per cent.; the whole lot gave 31·1 per cent. $\pm$ 0·04, and the standard deviation was 0·6 per cent.

The error introduced by the atmospheric humidity can be quite great. Lintweight rises and falls *pari passu* with the atmospheric humidity, as can be seen from Plates 89, 90. In this case the weight was recorded by a spot of light thrown on a mirror fixed close to the knife-edge of a chemical balance and reflected from thence on to a sheet of gas-light paper revolving on the drum of the hygrometer giving the humidity record. The curve obtained has been re-drawn on the humidity chart. One gramme of lint was used.

Seed-weight is also a variable factor, but apparently changes with a lag of a few hours, as can be seen from the second graph made in the same way but with seed instead of lint. The third graph made with two grammes of seed on one pan and one gramme of lint × a one gramme weight shows how humidity is constantly modifying the percentage lint.

There is no correlation between seed-weight and percentage lint; on the other hand, the correlation between the lint produced per seed and percentage lint is very high, as was to be expected. (We found it to be $0{\cdot}905 \pm 0{\cdot}013$). The correlation between lint produced per boll and percentage lint is lower, being calculated from the same samples at $0.367 \pm 0{\cdot}064$.

These being the limitations of the percentage lint as a means to gain evidence as to the damage done by the Pink Bollworm, we can proceed to apply the method. And it may in advance be stated that there is a loss of lint directly proportionate to the loss of seed substance, involving practically no fluctuation of the percentage lint.

The effect of *Gelechia* attack on seed cotton is to decrease the production of seed and lint. For the seed we have already shown a decrease (1) in numbers matured, (2) in weight of the sound seed matured, (3) actual loss of substance produced in attacked seeds. The effect on the quantities of lint produced has been studied indirectly by examination of the percentages of lint.

Obviously the suppressed seeds mature no lint, and are pure loss.

It has not been possible to find any evidence that the reduction in weight of sound seeds from attacked bolls is accompanied by any change in the percentage of lint produced by such seeds. The loss of lint in such sound seeds may be considered proportionate to their loss of weight.

The changes in the percentage of lint produced by damaged seeds are more difficult to summarize, and depend to some extent on the age of the seed at the time of the attack.

(1) If the seed is attacked at a very early stage, it disappears entirely, thus causing the reduction observed in the average number of seeds set remarked on above.

(2) Attacked slightly later, part of the seed remains but sets no lint, thus causing the percentage to fall to 0 per cent.

(3) Attacked when nearing complete maturity, no damage is caused to the lint, but the seed loses substance, thus causing a rise in the percentage of lint observed.

Gelechia attack can produce results ranging from total suppression of the production of lint to an apparent rise in the percentage of lint produced.

Table XIII has been prepared to show the limits within which fluctuations may under the present conditions (crop 1917) be most frequently expected to lie. All the samples came from the same crop, being Sakellaridis grown on one *feddan* of land at Gemmaiza in 1917. For the purposes of this examination 30 sets of 100 sound seeds were selected as control, with 30 sets of 100 damaged seeds and 30 sets of 50 " double " seeds (=100 seeds per set) for comparison. As additional control 30 random samples each of about 150 grammes weight were taken from the same material.

It may be stated at once, that all of these samples with the exception of the random ones may be seriously biassed on account of sampling. In picking out the sound seeds, the operator may have unintentionally selected the largest, and, in selecting the damaged seeds, a rather more than the average damage may be expected as the standard. The " double " seeds are on the other hand probably quite representative; as being rare every one found would be retained, and as they are fairly easy to recognise by feeling before ginning, all those encountered would be kept. The only test we can apply for unbiassed sampling is by comparing the total weight of the 3,000 seeds in question, with the average weight of 3,000 seeds as calculated from the " Gemmaiza crop " figures, which may be accepted as being quite free from bias, as will be seen later. The " Gemmaiza crop " samples came from the same field as the others, but do not include them.

From the comparison it would appear that the sound seeds selected were below the average for " Gemmaiza crop " sound bolls. This was to be expected, if the sampling was unbiassed, as in the seed cotton from which the seeds were selected sound and attacked bolls were inextricably mixed together. In any case it may be maintained, that the good seeds selected were not above the average in weight. Similarly it will be seen that the random samples varied very little (about 1·5 per cent. only) in weight from corresponding quantities of " Gemmaiza crop," of the same quality. This was expected in this case, as there was no reason for any bias to be introduced.

The " Gemmaiza crop " figures have a greater claim to be accepted as accurate. There is no possibility of errors in sampling; the entire yield has been taken under circumstances which exclude error as far as is possible; the sound and the damaged bolls were separated from each other carefully, and although a small percentage of attacked bolls was included under the sound ones, the proportion of attacked seeds wrongly included is less than 2 per cent. The damaged bolls and the sound bolls together make up the entire yield of all the plants from which they were taken.

It will be seen that the only set of samples needing control and for whose sampling no check can be found consists of the damaged seeds other than double ones.

The following conclusions appear to be justifiable on comparing the percentages of lint of all the samples together before removal of the worms.

The 30 sets of sound seeds approach very closely in their percentage lint to that found for the entire crop, the difference being only 0·2 per cent.; the closeness of results, in view of the small size of the sample, may in part be due to chance.

The 30 sets of random samples are also not very far out in percentage lint, being 0·7 per cent. in excess.

The "damaged" seeds and the "double" seeds vary most from the normal, as was to be expected, but it is almost surprising that they varied so little. The "damaged" seeds are only 1·5 per cent. above the normal. Remembering that the sound seeds varied to half this extent from the normal and the entire bulk of the 30 samples was in itself small, it is questionable how much significance should be attributed to the figures. On the other hand the "double" seeds are 3·75 per cent. below the normal. In their case part at least of the difference may be real, especially as a certain amount of the lint on both components is probably destroyed by the worm when attacking the seeds together. Hitherto, we have been reckoning the weight of the worms in with the seed weight, as would happen at a ginnery when calculating ginning outturn. Obviously the weight of the worm compensates to a large extent for the lost seed weight in the percentage lint calculations. However, on comparing the total weights produced by damaged seeds and double seeds with that of the sound seeds, it is very obvious that a considerable loss of substance has occurred, which strangely enough is distributed in such a manner that lint and seed *plus* worm are in very nearly the same proportions as lint and seed in normal seeds. Removing the larvæ from these samples, the percentage lint rises two to three per cent.

The "Gemmaiza crop" samples are much bigger individually and together than the sets just under consideration. Here, as was normal, the component samples varied in percentage lint, the standard deviation being approximately 0·5 per cent. The entire samples on the other hand all worked out to 34·0 per cent. lint (seed weighed including worms).

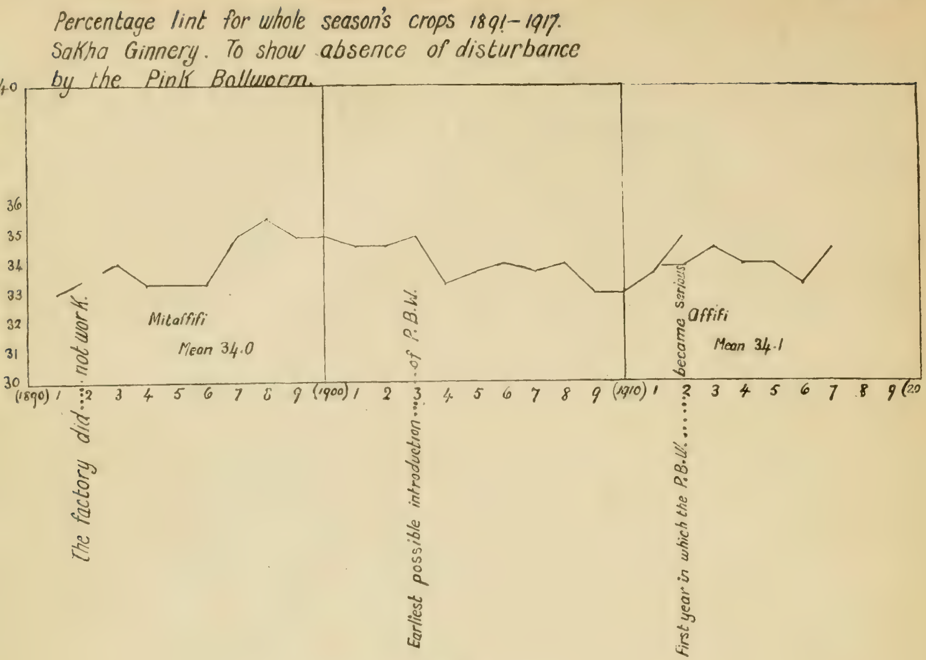

Percentage lint for whole season's crops 1891–1917.
SaKha Ginnery. To show absence of disturbance
by the Pink Bollworm.
40
36
35
34
33
32
31
30
(1890) 1 2 3 4 5 6 7 8 9 (1900) 1 2 3 4 5 6 7 8 9 (1910) 1 2 3 4 5 6 7 8 9 (20
The factory did not work.
Mitaffifi
Mean 34.0
Earliest possible introduction of P.B.W.
First year in which the P.B.W. became serious
Affifi
Mean 34.1

Fig. 1.

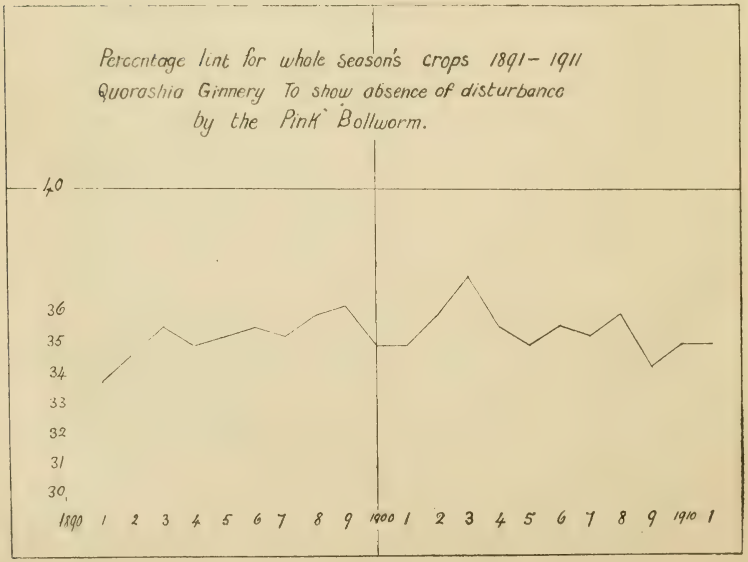

Percentage lint for whole season's crops 1891–1911
Quorashia Ginnery To show absence of disturbance
by the Pink Bollworm.
40
36
35
34
33
32
31
30
1890 1 2 3 4 5 6 7 8 9 1900 1 2 3 4 5 6 7 8 9 1910 1

Fig. 2.

Even supposing the sets of 30 samples of " damaged " and " double " seeds to be absolutely representative of the change produced in the percentage lint of such seed, it may be remembered that changes of such magnitude would not occur in ordinary samples, as 100 per cent. infestation of seed is very exceptional. 100 per cent. infestation of bolls does not necessarily mean more than 6·6 per cent. infestation of the seed, and rarely more than about 20 per cent. (Crop conditions 1917). The alteration to the ultimate percentage lint would also not be in the ratio percentage infestation × abnormal percentage lint : percentage sound seeds × normal percentage lint, but would be altered in the direction of the normal percentage lint by the less weight produced by the damaged seeds.

The differences in direction of variation of percentage lint of double and ordinary damaged seeds would also tend to eliminate each other. All these factors together help to keep the percentage lint close to what would have been the normal, if the Pink Bollworm had been absent.

In passing it may be remarked that the ginning outturns published for the last few years have not shown any fluctuations which can be traced to damage done by *Gelechia*. (Plate 91).

Tables XIV and XV have been compiled (from figures supplied by the State Domains Administration, to whom our thanks are due) to show how far the percentage lint in Mitaffifi and Affifi has varied during the period 1891-1917 and in Affifi, Assili and Sakellaridis in the period 1911-1917.

The figures for Mitaffifi and Affifi can be considered comparable to a great extent. The mean percentage lint for Mitaffifi is 34·0, for Affifi 34·1 ; the two series are consequently extremely suitable for comparison and can be considered as forming an unbroken series.

The first point that calls for remark is that for every year during the whole period Qorashia ginnery has never given a lower percentage lint than Sakha ginnery, and in all but two years it has given a higher percentage.

The second point is that the simultaneous difference between the percentages obtained by the two ginneries is often quite as large or larger than the yearly fluctuations from the mean percentage.

The third point is that the standard deviation for Mitaffifi (period 1891-1912) is twice as great as that for Affifi (period 1911-1917). As Mitaffifi was grown previous to the introduction of *Gelechia*, and Affifi is contemporaneous with that pest, it is evident that the percentage lint has not been greatly influenced, if at all, by the Pink Bollworm. The reduction of the magnitude of the standard deviation however, may be considered to be connected with the greater purity of Affifi as compared to Mitaffifi.

Finally, the deviations observed nowhere reach three times the standard deviation and may not have any real significance.

In the next Table are recorded the percentages of lint for various varieties for the period 1911-1917 which just covers the period during which *Gelechia* has risen from insignificance to importance. It can here again be pointed out that none of the fluctuations shown is sufficiently large to be significant.

Finally, comparing the standard deviations for the annual variations in the percentage lint with the standard deviation found for the samples composing the crop of a single field shown on Table XIII (comparison of sound and attacked samples) it will be found that the standard deviation of the annual variation is nearly the same as the standard deviation of the variation of the percentage lint of various parts of a single crop.

The damage done to the crop can be calculated consequently from the seed alone, or from seed cotton, or from the lint alone. Provided that the sampling in the field is properly done, and this has throughout been found to be the most difficult part of the work to get done correctly, the rest is simple. It is necessary that a really representative sample be taken, boll by boll, each boll being wrapped separately in paper. For this purpose all the ripe bolls of a large number of trees are required. In the laboratory the bolls are picked apart and examined for damaged seeds. The sound bolls are counted and then ginned together, the damaged ones likewise. Before ginning, if the two piles of seed cotton are weighed, we already obtain material for the estimation of the damage. The loss can be calculated by finding the total weight of all the seed cotton, and subtracting this from the weight found by multiplying the average weight of one sound boll by the total number of bolls used, sound or attacked.

The loss itself is however composed of various items, which are briefly :—

(1) Reduced weight of sound seeds developed in attacked bolls and consequent proportionate loss of seed and lint weight.

(2) Lost substance of attacked seeds, and proportionate loss of lint.

(3) Total loss of some of the seeds in attacked bolls, and total loss of the lint they ought to produce. Material in which the bolls have been carefully separated as above described, from which all the seed has been carefuly counted and weighed, can be tested for the proportion of loss due to each

of the three modes of loss, and gives quite close results, whether dealt with as seed cotton, or whether each item is separately estimated and the totals added together.

The total damage to the crop week for week in one field in 1917 was thus estimated as being about 11 per cent. at the end of August increasing to about 19 per cent. by the end of the season. The average damage for that field in 1917 was probably near 17 per cent., a figure Ballou and I reached by a totally different method of calculation for the year 1916 as an average for the Delta. The work on the 1918 crop is now being carried out, but from figures received at the time of writing (25th December 1918) the first picking in four fields calculated for was only damaged to about 4 per cent. ; the second pickings varied more than the first in respect of damage, the lowest of these giving 8 per cent. and the highest 29 per cent. The actual damage would be somewhere between 6 per cent. in the least damaged field and 17 per cent. in the worst. All these figures are, however, still provisional, and subject to checking.

Work on the Pink Bollworm has in Egypt been done practically in ignorance of what has been done elsewhere, especially as concerns all work prior to 1916. Our Department of Agriculture was only recently started and has not yet been developed. For this reason we have not frequently quoted previous authors' results in our earlier papers, and for the same reason all our statements have been made entirely on our own observations.

Such a condition has its good and its bad sides. We have perhaps started on lines of investigation leading nowhere, which a little reading would have helped us to avoid. It has on the other hand prevented us taking anybody's results for granted, and has made us much more sure on points where we claim knowledge.

In 1911 the Pink Bollworm was considered to be a rare cotton insect and rather a curiosity. There was then no old-established, sufficiently complete collection of insects in Cairo, from which one could have gathered the information that the rare insect was a probably new importation. Such a collection now exists and is the creation and property of the Entomological Section. Newly-introduced pests will in future be liable to be recognized as such, at an earlier date, should the misfortune happen that they evade our importation restrictions.

In the autumn of 1912 it was first recognized that the Pink Bollworm was probably a recent introduction, on account of a severe outbreak at Abukir near Alexandria.

In the early months of 1913 our first Plant Protection Law (*Loi No. 5 du 11 Mars 1913, sur la Protection des Plantes contre les Maladies* *provenant de l'Etranger*) was passed. It had been asked for before the Pink Bollworm had been recognised to be an imported pest, and was intended to act as a safeguard against similar occurrences. The Law prohibited the importation of unginned cotton, cotton-seed, cotton-sticks and living cotton-plants. It further subjected all living plants introduced into Egypt, apart from a few exceptions, to be fumigated at the port of entry. This law was replaced three years later by a new law (*Loi No. 1 de 1916 sur la Protection des Plantes contre les Maladies provenant de l'Etranger*) which prohibits the traffic in ginned cotton as well as cotton-seed and gives improved facilities in a few other weak points which had been found out in the course of time. Our work on the methods of control was begun in 1912 when treatment by fumigating seed in sacks was tried. At that time the insect was a very minor pest, and treatment of the seed in bulk could not be thought of on account of the opposition expectable from the ginneries.

It was then already recognized that treatment of the seed alone would lead nowhere, unless treatment of the rejected bolls in the field was insisted on.

In 1913 we concluded that whatever steps were taken to free the seed from worms, the seed would have to be treated in bulk. Further, that it would be as absolutely necessary to treat all the seed produced as it was necessary to insist on the destruction of all the bolls left on the trees after the last picking throughout the whole country. In dealing with an insect like the Pink Bollworm one must insist on the widest and simultaneous application of the measures decided on, if any relief is to be expected.

The methods tested in 1913 were mechanical and chemical. Of the mechanical methods treatment by hot water, by hot-air, by cold and by vacuum were tested. It was found possible to kill the worms by immersion in hot water, without injuring the germination of the seeds. To quote from a paper by Gough and Storey, "The fatal temperature for Gelechia *larvæ* must lie very close to 50° C., as 50° applied for five minutes kills ninety-seven per cent. of the worms. One minute at 54° was not sufficient to kill all the worms, but two minutes at 55° were absolutely fatal to them. Temperatures of 55° and over were invariably fatal."

The temperature limits of the seed were also given :—"Immersion in hot water at temperatures of 50° to 55° appears to have no bad influence on the germination. However, five minutes at 55° appear to have stimulated the germination. Stimulation of the germination certainly appears to take place after immersion for one minute at 60°, 65°, and 70°, though longer exposures at these temperatures still appear to have little or no effect on the seed. At 75° the fatal temperature for cotton-seed is already being approached, the germination after five minutes exposure to 75° falling."

As will be seen later, these temperature limits have been found to apply to seed treated by heat by other methods, now being applied commercially.

Dry heat was in 1913 also experimented with and was found to kill the worms sufficiently (100 per cent.) without injuring the germination of the seed. We gave a table showing temperature of the air, time required and results to worms and germination confirming our statements. However, we failed at the time to examine the extreme temperature reached by the seed, and thus missed obtaining confirmation of the immersion temperatures.

Cold temperatures to —6° C. were tested, but found ineffective.

Worms subjected to a partial vacuum were not affected.

Fumigation with hydrocyanic acid gas, carbon bisulphide, and sulphur dioxide were tested. The first two gave good, the last only partial results (carbon tetra-chloride was tested at a later date, but gave negative results). Ammonia and motor-spirit were tested, giving very poor results, and tobacco smoke, giving negative results.

Immersion of the seed in Cyllin solution 1 : 1000 for 24 hours was found satisfactory, and in a proprietory insecticide called Salvatorine 18 : 1000 which killed both worms and seed.

About the time when these experiments were being made, we were informed that it was possible to electrocute the worms, and that this method led to satisfactory results. On testing, it was found to have practically no effect on the worms.

Of the methods just mentioned the heat treatment has finally been adopted as the standard, not however without the fumigation method by carbon bisulphide and by hydrocyanic acid gas both having been tested on a commercial scale.

The carbon bisulphide method was tested on a large scale in a machine built entirely in Egypt by Messrs. T. Cook & Sons to the order of the Ministry of Agriculture. This machine was originally erected at the Domains ginnery at Sakha, and has since been re-erected in the grounds of the Ministry of Agriculture at Cairo.

The machine consists of six vats, connected to each other and to an air-pump by a series of pipes. The vats can be hermetically closed. They are intended to be filled with cotton-seed, and are each of two cubic metres capacity. An opening at the top allows for filling with seed, another at the bottom for discharging the seed into sacks. In the system of pipes is inserted an evaporating apparatus, and a series of taps. It is possible to connect any one, two or more vats with the air-pump and with the evaporator. In practice it was intended to fill one vat and charge it with carbon bisulphide gas. Whilst the gas is acting the other vats would be filling. Allowing 10 minutes for filling and discharging each vat, the turn of each for action would come round in one hour's time, during which its contents would be exposed to the gas. After this time the gas would be pumped over into the vat whose turn for gassing had come, and a fresh dose of bisulphide added. The action of the machine was perfect, and not over expensive, but objections were raised to it on account of the smell created, and more particularly on account of the danger of explosions. The Entomological Section, considering that hydrocyanic acid gas was too dangerous to be used for this purpose, consequently turned its attention to heat treatment.

In the meanwhile the possibility of hydrocyanic acid gas treatment as a method of killing worms in seed was advocated by a member of the public and a machine was constructed at Government expense by Messrs. Sulzer, of Winterthur, Switzerland. It consisted of a gas generator and dryer, an air-pump, and six vats which, in contrast to ours, were intended to withstand a partial vacuum. The seed was likewise fed in at the top and withdrawn at the bottom.

Experimental work with this machine in 1916 revealed an unexpected weakness. At temperatures under 27°C. the gas condensed on the seed, and action was imperfect. To obtain reasonable results it was consequently necessary to heat the seed previous to treatment, if its initial temperature was too low—a condition normal in winter. The use of the machine has never advanced beyond the experimental stage. Its initial cost will prevent its adoption by ginneries, as the standard heat-treating machines are much cheaper both in initial cost and in running expenses.

Prior to the erection of this machine an experimental hot-air machine had in 1914 been erected by Mr. Crovisier of the State Domains Administration, and demonstrated in June 1914 simultaneously with our carbon bisulphide machine. Although successful, it was rejected on account of its great bulk and small output. It consisted of a large double-walled box four metres long and sixty centimetres high and sixty centimetres broad and was heated by a number of steam pipes running from one end to the other. An endless canvas band, kept in position by means of a leather belt at either side, ran into the box at one end and out at the other, passing along a short distance above

the steam pipes. After leaving the hot-air chamber the band was carried back on rollers underneath the box. The temperature of the hot-air chamber was regulated by means of a steam-tap and a lever which opened two ventilators situated under the box. A thermometer was passed through a hole in the roof until its bulb was situated a few centimetres above the cloth band. The seed was fed on to the band by an automatic feeder consisting of a grooved roller revolving under a hopper with an adjustable outlet. The rollers carrying the canvas band were connected with a variable gearing apparatus by means of which the speed at which the band travelled could be regulated.

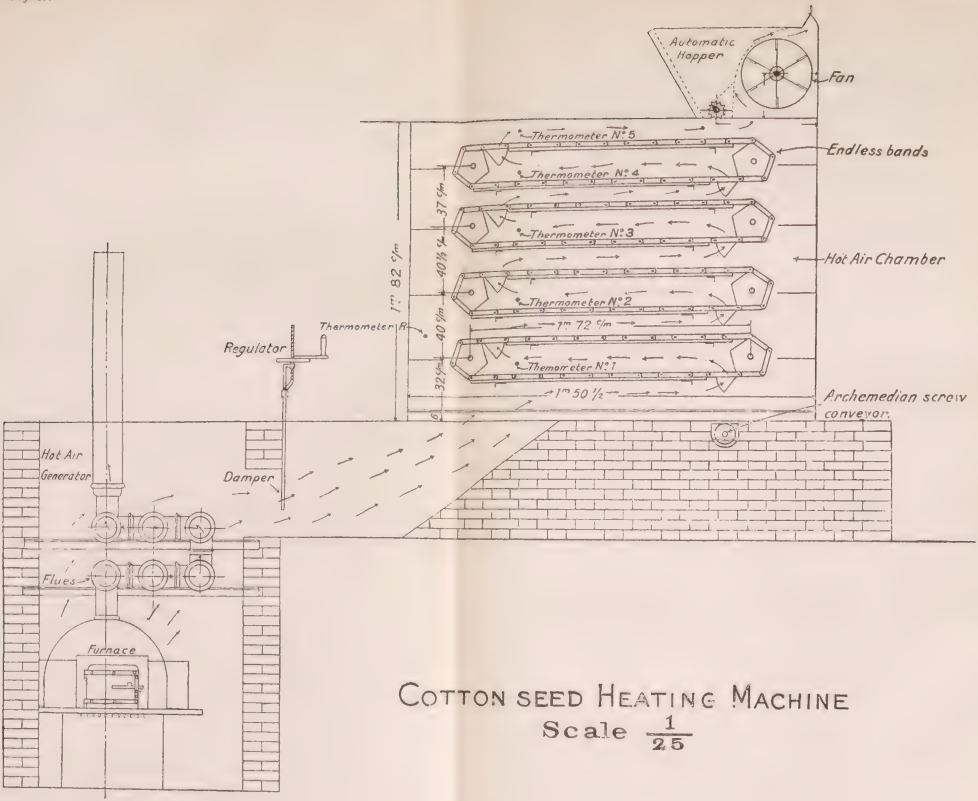
The machine was tested by Mr. Storey in June 1914. It was found to kill the worms satisfactorily without affecting the germination of the seed, but was only able to treat one *ardeb* of seed in five hours. This machine was only a working model.

Our carbon bisulphide machine and Crovisier's machine were demonstrated in June 1914 to a meeting of ginners and other persons interested in the problem. The results of the meeting showed that ginners would object more to any machine employing a poisonous or explosive gas than to a machine whose action was based on the application of heat. The Ministry of Agriculture consequently decided to devote special attention to the elaboration of a machine on the latter lines and to have a working model erected.

The contract was given to Messrs. T. Cook & Sons, Bulaq, in January 1915, and the machine was expected to be delivered by the end of February. Owing to the war, delivery was not actually made until November 1915.

The machine is really a very simple one. In its main lines it consists of a furnace for the generation of the hot air, a hot air chamber through which the seed passes, and a motor (Plate 92). The hot air machine is a rectangular box of iron, insulated on the outside by asbestos to avoid loss of heat. Internally there are four endless bands made of iron chains, with trays on which the seed is carried. By a contrivance the seed, after having been carried nearly the whole journey on the upper surface of the upper part of a band, is discharged on to the upper surface of the lower part of the same band, and from here, after travelling nearly the whole journey, it is again discharged on to the upper surface of the upper part of the next band, and so on, until finally it is discharged into an Archimedean screw conveyor which carries it into the sacking exit.

The seed is fed in at the top of the machine by an automatic hopper, which drops in exactly the quantity of seed required to make a layer one seed deep on the endless bands.



COTTON SEED HEATING MACHINE

Scale $\frac{1}{25}$

A fan situated near the feed-in causes a continuous draft of air to circulate through the machine. The air is exhausted from the hot air generator, a brick chamber surrounding the furnace.

The temperature is regulated by a damper which opens or closes by means of screw. This damper is interposed between the hot air generator and the hot air chamber. A thermometer passing into the body of the hot air chamber indicates the heat of the air at that part of the machine, and is used in regulating the temperatures. By opening the damper as soon as any indication of a fall is evident, and by closing it as soon as a rise commences, it is easily possible to keep the machine regulated to *plus* or *minus* half a degree of the desired temperature. This regulation could, of course, be made automatic if necessary. We did not fit an automatic control on account of the extra expense.

In working the machine the following factors have to be considered :—

(1) The outside temperature=the temperature of the seed.
(2) The time required to pass through the machine.
(3) The temperature the machine is regulated to give.
(4) The temperature of the seed at the exit.

Of these four factors the last is the most important, and the other three factors must be regulated so as to keep the temperature of the seed at the exit between 48° C. and 55° C. The best temperature to regulate for is 50°C.

When working the machine, the time required for the seed to pass through is not interfered with ; the temperature required in practice is actually obtained by observation of the thermometer situated near the regulating damper, these readings being supplemented and corrected by observations of the temperature of the seed at the exit.

The temperature regulated for is not so important as the temperature of the seed at exit.

This machine, which was quite successful in killing all the worms in the seed without injuring germination, was used for the treatment of several hundred *ardebs* of seed, much of which was intended for exportation. Much of the work done with it was of great importance, in that it familiarized us with the problems of seed treatment by heat before the introduction of other, more perfect machines ; and also that the results obtained in the growing of treated seed enabled us to counter many, one might almost say frivolous, objections which were urged by interested parties when opposing legislation compelling seed-treatment in the ginneries.

The small output of the machine, about 4 *ardebs* an hour, prevented its adoption on a commercial scale. It had, however, excited sufficient notice to the problem, and as a consequence other machines were offered to the Ministry of Agriculture for testing, in which seed treatment by heat is applied. The first of these other machines offered us was Messrs. Simon's machine for drying malt.

This machine consists of a horizontal cylinder in which revolves a skeleton comprising five longitudinal steam pipes and an equal number of bars carrying flanges which serve to mix up the seed. The seed is fed at the top at one end of the cylinder and makes its way out through a hole in the side near the other end.

The machine was remarkably successful, especially after a regular automatic feed was fitted. If worked properly, it kills all the worms in the seed without affecting the germination in the least. It had long been desired to force the ginners to kill all the worms in the seed. Until this machine was tested it had not been possible to ask for legislation in this direction, but after the possibilities of this apparatus had been demonstrated there was no longer any obstacle to legislation.

As a consequence, Law No. 29 of 1916 was passed, which orders that every ginnery must be fitted with an approved machine for the destruction of the worms in the seed, and that the machines must be worked to the satisfaction of the Ministry of Agriculture. The Ministry was given the power to enter any ginnery, inspect, take samples and, in case the worms are not being killed, to stop the ginnery and to destroy all seed containing living worms. This could all be done before obtaining a judgment. If found guilty of contravening, the offender gets off with a fine of up to one pound and, or, one week's imprisonment. The judge must, however, order the destruction of seed containing living worms if asked to do so by the public prosecutor. This power to stop a ginnery from working and to destroy seed is relied on as a preventive, the legal penalty being inadequate.

The passing of this law caused still more interest to be taken by engineers in the seed treatment problem, and many more machines were presented for trial or in plans. An account of all of these is given by Storey in Bulletin No. 14, "*Machines for the Treatment of Cotton Seed against Pink Bollworm* (*1918*)," from which paper I am quoting freely. In this place I intend only to refer to the two most successful of them, one of which has been approved by the Ministry of Agriculture for erection and as fulfilling all legal requirements.

The simpler of the two is Lenzi's machine. It consists of a long narrow cylinder, steam-jacketed all round, in which revolves an axle bearing a number of broad propeller blades which force the seed from one end to the other.

A sample of seed treated at 55°C. showed complete mortality of the worms, but about 5 per cent. of the seed is damaged in the process. This damage must certainly be due to the overheating of a number of seeds that have remained too long in direct contact with the heating surface. It was observable that masses of seed in front of the propeller blades traversed the lower part of each revolution *en masse* with very little movement *inter se*. The outermost seeds of such masses would consequently remain in contact with the surface of the steam-jacket for a considerable period, as the rate of revolution was very slow. Obviously, it should be possible to overcome this defect by keeping the seed in more rapid motion during its passage through the machine.

Apart from this one remediable defect the machine was very satisfactory. In a trial the first seed that came through had a temperature of 50° C. which rose very gradually and regularly to 55° C. where it remained constant.

The other machine, known as the Delta, has been approved as complying with the requirements of the law, and has been adopted by some of the ginneries. One has been working with very satisfactory results for two seasons at Beni-Suef. It is practically identical in principle with Lenzi's machine, but instead of consisting of a single long cylinder, steam-jacketed all round, it consists of three shorter cylinders, placed one above the other, and steam-jacketed on the lower half only, the upper half being a lid which can be removed so as to facilitate the cleaning of the cylinders. In each cylinder there is a revolving framework which carries on its circumference a spiral band which propels the seed along the cylinder, and a number of longitudinal bars which keep the seed in constant motion, the whole framework revolving quite rapidly. The seed enters through an automatic feeder at one end of the uppermost cylinder and, after passing through the three cylinders, is delivered at the other end of the bottom cylinder.

In more recent models the machine has been made to consist of a single cylinder equal in length to the three component ones of the earlier pattern. This modification was introduced in order to let the machine fit into the available space in a factory with less alteration to building.

Although the legislation enforcing seed-treatment was passed in 1916, and although ginners were given a clear year in which to supply themselves with the necessary machinery, the law could not be enforced until 1918, because of the difficulties in obtaining machinery in war time. This difficulty was increased by the want of interest on the part of some of the ginners, who postponed ordering their seed-treating machines until too late. However, as a sufficient number of machines was ultimately obtained to supply the needs of Upper Egypt, the law has been applied to that part of the country alone. Lower Egypt will have to follow suit next ginning season.

The enforcement of this law has hitherto not presented any special difficulties. Some of the factories in Upper Egypt, which had received their machinery in 1917, treated a large quantity of seed in that season. Although the law was not operative we were given the opportunity to study the methods of control, and thus to be able to start with a definite routine at the beginning of this season.

The working of the machines is controlled by germination tests and worm tests. For this purpose we rely on two sets of samples; a voluntary set of five samples of about 500 grammes each, sent on each working day by the ginner, and occasional surprise samples taken by our own agents.

On the arrival of samples at the Laboratory they are registered. Then 50 grammes (or about 500 seeds) from each sample are germinated, the remainder of the material received being searched through for living worms. If any unsatisfactory result is obtained in germination, a further 50 grammes from the same sample is immediately germinated. Ginners are notified immediately of spoilt seed and of living worms found. So far only one has had to have further proceedings taken against him, for continuous and habitual disregard of warnings.

Economic entomology is hopelessly mixed up with botany, in fact cannot be separated from it. Thus we have evolved quite a technique for our germination routine, which as it may be of use to others dealing with the same problem is here shortly described.

Our germination is all done at a uniform temperature of 30°C. to 27° C. As we have to deal with very large numbers of samples, we have converted a room measuring 3·5 metres by 3·5 metres into an incubator. The windows and door are double, having an air-lock of about 50 cm. width. The ceiling has been lowered, a straw matting forming a false ceiling at 3 metres from the ground. The heat is supplied by a hot water radiator, heated by gas. A regulator made in Cairo to our own design, actuated by a Hearson's capsule, admits only the quantity of gas necessary to give the heat required.

Shelving all round the room gives space for 4000 germinating dishes at a time. Our dishes are native made, glazed earthenware, about 20 cm. wide by 5 cm. deep. The seed is placed on a sheet of felt and covered by another sheet of felt. One hundred cc. of warm water is given to each sample to start germination; the water is drained off and replaced by fresh water after 24 hours. Germination is complete in 48 hours. The dishes, when in use are piled one on top of the other, so as to act as lids. On the top of a stack comes an empty dish.

After each germination the felt discs are washed in copper sulphate solution (1 : 1000).

Before using this method we used to employ Petri dishes and blotting paper, each dish taking at the most 100 seeds. The dishes were in those days placed in an ordinary Hearson's incubator. It was of course not possible to work on a large scale in this way, especially as rotting of samples used to be very frequent. We have not had a single rotted sample since using our newer method, and have germinated without difficulty over two million three hundred thousand seeds.

After germination is complete, the seeds are sorted and counted. Forty-eight hours under the conditions described produces rootlets of three and more centimetres in length greatly facilitating discrimination. The non-germinated seed is previous to counting resorted into whole and attacked seed. For the purposes of the tests the attacked seed is not recorded for germination ; its numbers are however recorded for the purpose of estimating extent of attack.

Samples of 500 seeds give a probable error of about 2 per cent. for germination. The average germination of sound Upper Egypt seed is near 90 per cent., Lower Egypt seed near 82 per cent. It is suspected that the non-viable seeds have very probably lost their vitality owing to puncture by *Oxycarenus*.

The following statistics relating to the first three months' working of the law may be of interest.

There are 24 factories working under the law, each one of which was inspected before ginning commenced in order to verify the existence and proper fitting of the machinery.

Our inspector, sub-inspector and *moawens* [assistants] have made 310 visits and taken 1,063 samples and ginners have forwarded 3,650 samples and these 4,713 samples have been examined for worms or germinated. In these 239 samples were found to contain living worms ; 18,273 larvæ were found of which 17,734 dead, or 97 per cent. mortality ; and 37 samples were found to have been burnt. 2,313,834 seeds have been germinated of which 281,257 failed, giving 88 per cent. germination.

Considering that this is the first year that the majority of the factories have worked the seed-treating machines, this is a very creditable result for them.

It may be mentioned here that the percentage of germination fluctuates from district to district, but appears to be very constant within each district. This is one of the reasons why we suspect a seed-sucking insect of damaging the germination.

Law No. 29 of 1916, in addition to ordering the treatment of all seed in the ginneries, regulated the storage of cotton-seed and seed-cotton during the months May to August. During this period all cotton-seed and seed-cotton must be kept in licensed stores. Licenses for stores are only granted, after inspection, if the stores are properly moth-proof. All windows must be screened with wire-gauze or cloth, and the doors must be kept shut at night. This part of the law was enforced only in 1916; it was found impossible to enforce it in 1917-1918, on account of the shipping difficulty which it was anticipated would enormously increase the quantities of cotton-seed kept in Egypt during the summer.

Prior to its application the cotton merchants feared that the screens would interfere unduly with ventilation, and that they would soon get clogged with particles of fibre. Some of the stores were consequently fitted with closable screens, which were left open all day and shut at night. Other stores were fitted with permanent screens: from inspection of such screens after the end of the season the fear that the ventilation would be seriously interfered with appears to have been unnecessary.

Owing to the habits of the moth, as already mentioned earlier, there is no fear whatever that they may escape through open doors or windows during the day.

In 1909, before the Pink Bollworm had become known as a pest on cotton in Egypt, a law was passed prescribing the measures to be taken against the Bollworm (*Earias insulana*). This law (No. 7 of 1909) prescribed the pulling up of all *okroe* and *Hibiscus cannabinus* plants by the roots, and the pulling up of cotton or the cutting of its roots in such a manner that it could not sprout again. If the existence of non-uprooted plants of these three species between the 1st of January and the end of March on lands where they had previously been grown was noticed, the local authorities were to have them pulled up, the cost of the procedure being recovered from the owner of the land by the administrative channel. Exceptions were made for certain districts in the North of Behera, Gharbia and Sharkia provinces, where ratoon cotton was customarily grown.

It was hoped by this law to restrict the damage done by *Earias* by making a period of three months during which it could not find any food-supply; speaking from knowledge acquired later from experience, the last date for pulling up the plants was much too late to be of much use, without simultaneous destruction of the bolls, which was not ordered.

In 1912, after the formation of the Department of Agriculture, this law was revised and replaced by Law 19 of 1912. It was now provided that in all the provinces south of Gizeh (Upper Egypt) the last date for pulling up the cotton-sticks and the *okroe* and *H. cannabinus* should be 15th December of each year. The other, more northern, provinces were given until 31st December. Exceptions were made for the most northern sub-districts in which 15th January was the final date. Owing to intense opposition encountered when preparing the law, ratoon cotton had to be permitted. The growing of ratoon cotton was however regulated; the ratooning plants had to be cut down to 15 cm. above the ground, sheep had to be pastured in the cotton fields before this cutting down of the plants in order to eat the leaves and bolls, and any leaves or bolls left after their passage were to be swept up and burnt before the cotton-sticks might be cut or heaped up. If all this treatment were not applied before 15th January then the exception granted for the ratoon fields was annulled, and the land was to be treated as if no exemption had been granted.

As in the previous law, all cotton, *okroe* or *H. cannabinus* found growing after the prescribed date was to be pulled up and destroyed by the local authorities, costs being recovered by the administrative channel.

A weak point in both these laws was the inadequate penalties. The Capitulations limit the penalties to one pound or one week's imprisonment or both.

In 1912 the first serious outbreak of the Pink Bollworm occurred at Abukir near Alexandria. In the next year it became more or less general throughout the Delta, and was noticed in Upper Egypt (where we know of its occurrence, however, since 1911).

This outbreak of the Pink Bollworm, whose very serious nature was recognized in the autumn of 1913—in the summer of 1912 one still was of the opinion that it was a native insect—led during the summer of 1914 to the issuing of Law No. 4 of 1914, which ordered that each year after the cotton harvest, all bolls adhering to the plants were to be removed and burnt. This operation was to be executed 15 days before the date fixed as the last one before which all plants must be pulled up. In case of non-execution of the boll-picking the plants were to be seized and burnt.

In the light of after-events it did not go far enough. The dates fixed were much too late to do any good and the law made no mention of the fallen bolls. The burning of the sticks was, however, a penalty which would induce most landowners to comply after a fashion.

The question of removal of bolls from the cotton-sticks before or after pulling the sticks was not an important one from the theoretic side. It was however considered important by the inspectors who had to administer the law.

This law was operative for two years and the organization used was similar to that then recently introduced for the Cotton worm campaigns. The Mudir [Provincial Governor] was in supreme command in his province, and was assisted by the Inspector of Agriculture. Each province was divided into zones, the charge of which was entrusted to the Mamurs [District Officers] and these had the help of the *Moawens* [Assistants] of Agriculture. In the villages the *Omdehs* [headmen] were responsible for the whole village lands, but deputed the control of portions of their command to the *Sheikhs* of the village.

A campaign of publicity was organized before the commencement of the work, in which the villagers were told what was wanted of them, and why.

It was ordered that a special spot be set aside in each field, marked with a red flag, for the burning of the bolls. The *Sheikhs* were instructed to supervise the burning personally, and the *Moawens* of Agriculture and administrative staff were specially asked to give this work personal attention as far as possible.

Cotton-sticks were to be burnt if found standing with the bolls after the date fixed, or if found cut or pulled without the bolls having been removed. Any expenses connected with the burning were charged to the owner of the sticks.

No sticks were allowed to be pulled before the bolls were removed. A written permission had to be obtained from the *Sheikh* for this purpose, the *Sheikh* verifying the facts before giving the permit. The necessary routine for reporting to the Head Office was also worked out in advance.

The campaign of 1915 was very vigorously carried out, but it soon became evident that the final dates allowed were much too late to be of practical use ; and what is worse, the law taking no notice of fallen bolls, many cultivators simplified matters for themselves by merely beating the bolls off the trees instead of picking and burning them. A modification of the law consequently became necessary. Our previous experience was consequently again embodied in legislation, the result being Law No. 17 of 1916.

This law is the first one which was drafted specially against the Pink Bollworm. The previous ones had been based on *Earias* legislation, and were patchwork, having the defects of patchwork.

The new law runs much on the same lines as the previous ones, but introduced several new points.

The last dates on which cotton, *okroe*, and *H. cannabinus* had to be pulled up, or have their roots cut in such a way that they could not grow again, were not altered. No exceptions could be granted for ratoon cotton.

Every year, immediately after the harvest, and in every case before the dates fixed annually for each district or zone by the Ministry of Agriculture after consultation with the Provincial Councils, all the bolls remaining on the cotton plants or lying on the ground must be collected and destroyed by one of the means prescribed by the Ministry of Agriculture. The removal and destruction of the bolls must be accomplished before pulling up the sticks. Independently of the trivial punishments which it was possible to inflict on account of the Capitulations, the local authorities or the agents authorized by the Ministry of Agriculture were empowered, in the case of plants left standing beyond the final date, to have the plants pulled up by the owner under their supervision, or, if necessary, to have the work done by labour supplied by themselves.

Secondly, in case the bolls had not been removed by the date fixed, to supervise the removal and destruction by the owner of all bolls left on the trees, or, if necessary, to have the work done by labour supplied by themselves.

Thirdly, to seize and destroy bolls which had been collected, but which the cultivator had not destroyed.

Fourthly, to seize and destroy cotton-plants which had been pulled up before being cleaned.

The cost of all these operations would be charged to the owner of the plants, and could be recovered administratively.

The transport of uncleaned or insufficiently cleaned sticks was prohibited ; such sticks if found could be seized and destroyed by the local authorities or by authorized agents of the Ministry of Agriculture.

It will be seen that this law gives sufficient power to the administration to ensure the proper cleaning up to the cotton-fields after the harvest, and, taken in conjunction with the law enforcing the treatment of seed in the ginneries and screening of seed-stores, theoretically gets at all the possible lurking places of the Pink Bollworm.

Some criticism of the law may however be permitted. The clause compelling pulling of bolls previous to uprooting the cotton-sticks was not asked for for entomological but administrative reasons. As already stated, the penalties were inadequate, the maximum one being one pound or one week's imprisonment, or both. In almost every case it would pay to suffer the maximum penalty rather than to do the work. It was for this reason that the law had to allow the Ministry of Agriculture to intervene and do the work at the owner's expense. The judges, too, instead of imposing the full possible penalty, usually inflicted fines of one or two shillings only. Burning cotton-sticks is not a desirable punishment in a country destitute of other sources of fuel supply, but was the only thing that really moved the people to action.

In an educated community, where everyone realizes the necessity and the reasons for action, one might hope for the maximum possible results from a law like this. In Egypt, however, almost every one was out to dodge the inspector, and to do just so little as to avoid getting his sticks burnt. The desire to protect the next year's crop seems to be missing. If it could be done without work, everybody would praise the Government, but measures which involve any display of energy are not popular.

As already stated, the law appears to cover all the lurking places for the Pink Bollworm, but it is of course recognised that the strictest application possible will never eradicate the insect. A large percentage of the bolls, which have fallen to the ground, will always escape destruction. All that can be hoped for consequently is to check the increase of the pest and to keep it within reasonable limits, perhaps even, with very good work, to reduce the infestation to some extent.

A good deal of the usefulness of the law turns on the last date for the destruction of the bolls. And here it may be remarked that entomological *desiderata* and agricultural possibility clash. We demand, with reasons which can almost be demonstrated by simple arithmetic, that the last date be placed early in the autumn, much earlier than the agriculturist was willing to give in 1916, or for that matter in 1918. But unless the claim for earliness is seriously taken, we can see but little hope for the future. In this respect it may be mentioned that the law of 1912, ordering the pulling up of cotton-sticks by 15th December in Upper Egypt, 31st in Middle Egypt and the southern half of the Delta and by 15th January in the northern Delta, was opposed on the plea that the dates were impossibly early. The dates for the removal of the bolls are now much earlier, being 10th November for Upper and Middle Egypt, and part of the Delta, 20th November for the middle and 30th November for the north of the Delta and these dates might stand being advanced still more without affecting more than a small fraction of cultivators whose crop is backward. In other words, the date appears to be fixed not for the average requirement of the agriculturists, but distinctly later than average requirements. Our firm conviction is that every day after 1st October matters very considerably, and that it is false economy to balance possible present loss to the few against the certain increased loss to the entire community in the next season.

The campaign of 1916 was carried out much more thoroughly and vigorously than that of 1915. But it is humanly impossible to get perfect work. It is also to be remembered that the war seriously interfered with the organization. A very large percentage of our British Inspectors were fighting. The few left were overworked. The native staff, especially in the lowest, badly paid grades, was unreliable and corrupt. Many were only taken on temporarily and made the most of their opportunities.

In August 1916, Mr. Ballou, Entomologist to the West Indies, was lent to the Egyptian Government by the Colonial Office to examine and report on the Pink Bollworm situation, and on the measures adopted for its control. Mr. Ballou arrived in time to see the campaign of 1916, and remained long enough to see that of 1917. He presented a long report of what he had seen, in which he endorsed the action taken up to the present as being satisfactory, making however, the suggestion that the plants should be pulled up immediately after the harvest, and stripped of bolls later on. This suggestion was arrived at in conference with Mr. Willcocks, Entomologist of the Sultania Agricultural Society, Mr. Storey, Mr. Adair and myself, all being in agreement. The reason underlying the change is that plants left standing will, by producing new buds, flowers, or bolls, be constantly producing new sources of food-supply for the Pink Bollworm and keeping old ones in a suitable condition. It is thought that, by uprooting the plants as soon as possible, the buds and young bolls will almost immediately, and the older bolls very soon, become totally unsuitable as food-supply for young worms.

Plants pulled up before October would, without removal of their bolls, be less dangerous than plants left till November before boll removal and December before pulling. Ballou's report, which endorses the action taken by the Ministry of Agriculture, has hitherto had to remain unpublished on account of the paper famine in Egypt, which was at a time really very acute.

In 1916 burning sticks was really carried out, and produced a very salutary effect on the cultivators, but in 1917 and 1918 it was no longer possible to insist on the burning of the sticks on account of the fuel famine. The absence of any serious penalty instantly showed itself, as was to be expected, in increased indifference on the part of the cultivators, so much so that the 1918 campaign may be said to have been very imperfect.

In August 1917, the law was modified in order to permit the pulling up of sticks before removal of bolls in all cases in which it appeared advisable to the Ministry to permit this course of action. This was because it had been demonstrated by various Inspectors of the Ministry, and by members of the public, that it was possible to do the work of boll-pulling more efficiently, at less cost and with less spilling of bolls, if the trees could be pulled up and combed through rakes or put through a specially designed machine. This modifying law (No. 12 of 1917) marks a real advance in the development of the campaign.

On account of the fuel shortage a modifying law (No. 11 of 1918) has had to be passed permitting the Government to seize and confiscate cotton-sticks instead of seizing and burning.

Having detailed the progress of legislation and outlined the lines of growth of the Pink Bollworm campaign, a few remarks on the theories underlying them may yet be made.

The Campaign in all its aspects, fieldwork, seed treatment in the ginneries, and screening of seed-stores, aims only at the elimination of the long-cycle larvæ or of the moths belonging to the long-cycle generation. Short-cycle moths emerging at the end of the season are comparatively innocuous as compared to their long-cycle progeny. Now it has long been known to us that the proportion of long-cycle larvæ in the Pink Bollworm population is constantly increasing as the season progresses. Recent work has shown that even in the summer months there are amongst the short-cycle larvæ a few per mille of long-cycle worms. From breeding results of 1917-1918, we find that green bolls collected before 10th October contained 5 per cent. long-cycle larvæ and 95 per cent. short-cycle. After this date the proportion changed rapidly. For the whole period 11th October to the end of November there were 23 per cent. long-cycle larvæ. But for the last three weeks of November all the worms give rise to long-cycle moths.

It will be seen that, supposing it were possible to take the crop early enough every year, there would be very few long-cycle larvæ to carry over to the next year, and consequently the subsequent years would know less and less of the pest. The longer the delay the more serious the menace for the future. Every week thousands of attacked bolls fall off the trees and escape from later control by being trampled into the ground, by falling down cracks in the earth, or by being silted over when the land is watered. The later in the season the more certain it is that such bolls must contain resting larvæ. Without doubt many of these larvæ are destroyed by ants, by disease or parasites, by being buried too deeply or by exposure to the sun. But immense numbers manage to survive through to the next season and even to the season after that. Of the bolls left on the sticks also, it is certain that, the later they are left, the more resting larvæ they contain. Heaps of sticks are a very good surrounding for the further development of the insects, though perhaps the best environment is on the ground in sufficient shade to prevent the temperature rising above 50° C. It has been stated earlier, that the rise in percentage attack of green bolls from 25 per cent. to 75 per cent. passes through in three or four weeks. This takes place roughly at the time of the first picking.

The whole question of Pink Bollworm control centres in the possibility of early removal of growing cotton plants from the fields. A very imperfectly conducted campaign in September would give better results than an obtainably perfect one at the end of October, but unfortunately this is not yet agriculturally a possibility.

The treatment of the seed is without doubt also of importance, but cannot compare in this respect with the fieldwork. Excellent work done on a small area is useless, unless the surroundings are far and wide equally well cleaned. And imperfect work of one year is certain to make itself felt for two following years, even if the first of those two following years should be conspicuous by good work. This is due to the fact that a comparatively large proportion of resting worms can and do survive to the second following summer before pupating and emerging as moths.

Two experiments have been made in 1917, to test the plan of the campaign, one at Tel el Kebir, where in a large area isolated to a great extent by desert on both sides, the land was swept after the last crop was taken, and where the bolls were very thoroughly destroyed and this year was planted with treated seed. The area was looked after by several *moawens*. One part of it showed exceptionally high infection this year as compared to the others, and it was afterwards found by inquiry, that the *moawen* at first in charge of that part had had to be disciplined for neglect of duty and corruption.

For the first part of the season the whole area however was considerably better judging by percentages of green bolls attacked than in the corresponding part of the previous year. Towards the end of the season it deteriorated, but was even so better than at the corresponding period of the previous season. Part of the deterioration may be due to larvæ of two seasons earlier.

The other experiment was made at Armant in Upper Egypt. This place was left alone. The cultivators know the law, and its objects, but without driving by the agents of the Government may be relied on doing nothing towards destroying the bolls at the end of the season. There has been a high rise of infection percentage of green bolls recorded from there this year, but as all Upper Egypt shows an increase, judgment must be reserved for a fw more seasons.

The problems presented by the Pink Bollworm are not yet all solved, and the problem of its control has still much to be developed. Theoretically I am sure we are on the right track, but the administrative problem in transmuting theory into practice appears to me to be a most difficult one, and far from finally solved. It is rendered all the more difficult by the passive resistance and indifference of cultivators, and the disorganization due to the war.

A scientific Cotton Research Board is now being formed by the Government. This board will consist mainly of Government officials of scientific standing and will also have one or more representatives from outside. Its duties will be to promote research on all problems affecting cotton in Egypt, and without doubt this question of the control of the Pink Bollworm will be one of the most serious it will have to deal with for a long time to come. The setback in control due to the war is not likely to have improved conditions. But the Board will be in a position to represent to Government whatever it considers urgent, necessary or serious in a more forcible manner than any individual or department could do.

Dr. Gough has informed me that *P. gossypiella* rings the stem and branches of the cotton-plant. But in my experience I have never seen that. **Mr. Misra.**

It is very rare with us too. We have only recorded four or five cases and Willcocks has recorded two or three, but of course we have examined an enormous number of plants. The ringing goes into the cambium and the plant withers. **Dr. Gough.**

Dr. Gough has given us a very complete account regarding the work being done on this insect in Egypt and we shall be glad if he can tell us something about the Staff which carries out this work and how it is organized. **Mr. Fletcher.**

We have a well organized campaign. The organization of the pest campaigns is as follows :— **Dr. Gough.**

In each province the *Mudir* (or Governor) is in supreme command. He is assisted by the Inspector of Agriculture who generally supervises the working of the campaign, and reports on the work.

Each province is divided into zones under sub-inspectors ; these zones are again sub-divided, the divisions being under *moawnin* (or fieldmen). In each village the *Omdeh* (or headman) is responsible for the work ; his area is however further sub-divided and *sheikhs el balad* are in charge of the final sub-division of the control of the campaign.

Where the work of destruction of bolls is not thoroughly done, the cotton sticks may be seized and confiscated, or burnt. Bolls removed from the sticks are invariably burnt.

As a general rule the bolls are to be removed before the sticks are pulled up, but authority can be given by the Inspector of Agriculture for the sticks to be pulled up first and cleaned afterwards. This is to enable boll stripping apparatus to be used.

Mr. Fletcher. What Entomological Staff is employed ?

Dr. Gough. Our Work and Staff are distributed as follows :—

1. *Direction.*
   Director, Entomological Section.
2. *Collections.*
   1 Entomologist.
   2 *Moawnin.*
3. *Insect Breeding.*
   1 Entomologist.
   2 *Moawnin.*
   2 *Mulahzin.*
   12 Operators (daily labour).
4. *Research* (under Director).
   1 Technical Assistant.
   1 *Moawen.*
   20 Operators (daily labour).
5. *Control of Ginneries for the Treatment of Cotton Seed* (under Director and Sub-Director).
   2 Sub-Inspectors.
   4 *Moawnin.*
   20 Operators (daily labour).
6. *Inspection of Imported Plants and seeds* (under Director).
   1 Assistant Entomologist.
   4 *Moawnin.*
7. *Insecticides* (under Director).
   1 Assistant Entomologist.
   Daily labour.
8. *Bee-Keeping* (under Director).
   1 *Moawen.*
   1 Operator (Apiarist).
   Daily labour.
9. *Various Regulations concerning pests of trees* (under Director).
   1 *Moawen* for inspection of shrubs and plants transported from the clean to the infected area.
   1 *Moawen* for the examination of gardens.

10. *Fumigation of Citrus trees with Hydrocyanic gas* (under Sub-Director).

5 Brigades, each brigade composed of :—

1 *Moawen* as Head.
2 *Mulahzin*.
2 Operators (daily labour).
12 Labourers (daily labour).
1 Tent-maker (daily labour).
1 Guard.

11. *Clerical Staff*.

1 Head Clerk.
4 Clerks.
1 Store-keeper.
1 Assistant Store-keeper.

12. *Hors-Cadre Staff*.

Shawish.
Messengers.
Sweepers.
Gardeners.

NOTE.—*Moawen* is a graduate of a High School of Agriculture.
NOTE.—*Molahiz* is a graduate of an Intermediate School of Agriculture.

The Entomological Service comes directly under the Secretary of State.

What is the extent of your cultivated area ? **Mr. Fletcher.**

One and a half million acres under cotton. **Dr. Gough.**

In India we have about twenty million acres under cotton alone. **Mr. Fletcher.**

Has the Pink Bollworm any foodplants other than cotton in Egypt ? **Mr. Ramakrishna Ayyar.**

We have found it on *Hibiscus cannabinus* and *H. esculentus*. These must be pulled out of the ground at the same time as the cotton-plants. **Dr. Gough.**

In Bombay we do not find it on anything else except cotton. **Mr. Ramrao.**

You are sure to find it if you look before or after the cotton crop. **Dr. Gough.**

Both these insects [*Earias* spp. and *Platyedra gossypiella*] are serious pests in the United Provinces and, unless we can adopt measures such as in Egypt, there is no chance of checking them. In irrigated parts of our Province the cotton can easily be removed by the end of December because the cultivators are anxious to get in a catch-crop of peas. The sticks are burnt probably by the end of March in making *gur*. But in irrigated lands we still get the pest and therefore there seems to be some factor which we do not know yet. Before introducing any legislation, we must know this factor. In some districts cotton-sticks remain standing in the fields until June or July ; that happens **Mr. Burt.**

in the unirrigated area. In our Province we get the attack equally badly in the unirrigated and in the irrigated lands. What is the result of ploughing the bolls in ?

Dr. Gough. Bolls ploughed underground are as dangerous as those left on the field and burning is necessary. As a matter of fact, bolls on the ground are more dangerous. In our experiments those placed on the ground produced more adults than those raised off the ground on tables. *Bersîm* follows cotton in Egypt and it is irrigated, but the irrigation has no effect on the bolls in the ground. Sometimes *bersîm* is sown before the cotton is removed and the cotton-sticks are pulled out later ; we have examined bolls that were lying underground under these conditions and found that a large number of them contained living larvæ.

Mr. Burt. How deep can you bury the larvæ without killing them ?

Dr. Gough. I cannot say, but a few inches do not do them any harm. The cotton-field must be swept up before it is ploughed.

Mr. Fletcher. The point raised by Mr. Burt is dealt with in Mr. Willcocks' paper which will be taken next.

Mr. Burt. The difficulty about legislation is that cotton is not our best crop.

Mr. Robertson-Brown. I have seen that sheep are very fond of cotton-bolls and if they are turned into the cotton-field at the end of the cotton season, they will eat all the bolls.

Dr. Gough. They are useful and will take the last boll and also pick up bolls lying on the ground, but we have not got sufficient sheep in Egypt to go around.

Mr. Burt. Has any work been done in Egypt on parasites as controls for *P. gossypiella* ?

Dr. Gough. We are only just touching the fringe of this work. We have not yet done any work on the utilization of parasites, but certainly some parasite is controlling it.

Mr. Burt. We have a parasite on *Earias.*

Dr. Gough. *Earias* is a rarity with us now and the *Earias* problem has ceased to be a practical problem for Egypt.

Mr. Robertson-Brown. Is there any variety of cotton in Egypt that is free from *Gelechia ?*

Dr. Gough. There is no variety that is free from it.

Mr. Robertson-Brown. I found at Peshawar that Texas Big-boll was comparatively more immune.

Dr. Gough. I may mention that a long-cycle generation of *P. gossypiella* occurs in India. We have received double seeds from India from which a moth emerged after two and a half years.

Mr. Senior-White. In 1917 I grew a small experimental plot of Cambodia cotton in my own compound in the Matale District, Ceylon. Cotton is not a commercial crop in Ceylon, and I doubt if in Matale district any cotton at all had been grown before, at any rate since the British Cotton-Growing Association campaign a good many years ago. On this crop *G. gossypiella* was found in fair numbers. I have always growing in my compound *H. rosa-sinensis*, *H. esculentus* and usually *H. Sabdariffa*, *Althœa rosea* frequently also, but neither before I grew this cotton nor subsequently have I seen *G. gossypiella*.

My compound is ringed in with a pure crop of *Hevea* trees for a distance of quite half a mile in all directions and the land falls steeply in all directions from it. The rainfall is sixty to ninety inches and the elevation 1386 feet.

Table I.—showing the Quantities of Indian Cotton Imported into Egypt.

Year	Quantity in Kilograms
Prior to 1903	None.
1903	20,510
1904	25,827
1905	9,150
1906	81,240
1907	1,62,000
1908	21,460
1909	31,206
1910	13,353
1911	None
1912	10,998
1913	90,012

Table II.—Showing the Distribution of Gelechia attack in Buds, Flowers and Green Bolls.

Week commencing on	Actual number observed per 100 plants: Buds: Total	Buds: Attacked	Flowers: Total	Flowers: Attacked	Green Bolls: Total	Green Bolls: Attacked (worms present or absent)	Percentage attacked: Buds	Percentage attacked: Flowers	Green boll attacked (worms present)	Green bolls showing traces of previous attack (worms absent)	Multiple infestation	Recombined as though 10,000 buds, flowers or bolls had been produced during the season: Buds: Weekly Total	Buds: Attacked	Flowers: Weekly Total	Flowers: Attacked	Green Bolls: Weekly Total	Sound	Worms present	Trace (worms absent)	Multiple infestation
June—																				
9th	271	0	0	0	0	0	0	0	0	0	0	342	0	0	0	0	0	0	0	0
16th	171	0	0	0	0	0	0	0	0	0	0	216	0	0	0	0	0	0	0	0
23rd	532	1	4	0	6	0	0	0	0	0	0	672	1	43	0	6	6	0	0	0
30th	491	0	24	0	47	0	0	0	0	0	0	621	0	242	0	46	46	0·25	0	0
July—																				
7th	690	0	21	0	95	3	0	0	3	0	0	872	0	212	0	93	90	3	0	0
14th	1,245	0(·3)	58	0	209	3	0	0	5	0	0	1,573	0	585	0	206	195	11	1	1
21st	1,178	0	68	0	355	15	0	0	4	2	0	1,489	0	695	0	350	327	15	0	0
28th	1,221	0	219	0	697	37	0	0	5	2	0	1,543	0	2,208	0	686	631	36	17	2
August—																				
4th	818	1	236	0	96	80	0	0	8	5	0	1,033	1	2,379	2	946	821	79	46	0
11th	475	1	152	0	1,071	97	0	0	9	5	0	600	1	1,532	0	1,054	901	96	58	1
18th	195	2	144	0	1,279	206	1	0	16	12	0	249	2	1,452	3	1,260	915	203	146	4
25th	89	1	31	0	1,303	·279	1	0	21	17	2	113	1	313	0	1,283	813	275	218	23
September—																				
1st	82	0(·3)	8	1	1,351	416	0	8	31	21	4	104	0	81	7	1,330	681	410	287	48
8th	33	2	5	0(·3)	857	325	3	7	38	24	6	42	3	50	3	844	365	320	206	47
	First picking took place.																			
15th	88	8	7	0	908	580	9	0	64	33	19	111	10	71	0	894	200	571	294	171
22nd	98	9	3	0	564	437	9	0	77	25	17	124	11	33	0	555	80	430	142	97
29th	107	7	4	1	241	204	7	15	85	18	11	135	9	43	7	237	21	201	41	26
October—																				
6th	59	8	5	1	152	142	14	19	94	16	13	75	10	53	10	149	4	140	24	19
13th	68	14	3	1	59	55	21	40	75	39	12	86	18	25	10	58	4	44	23	7
												10,000	67	10,013	42	9,997	6,100	2,834	1,512	446

Table III.—Emergences of Gelechia Moths from Hibiscus esculentus pods and seeds.

EMERGENCE OF GELECHIA MOTHS FROM HIBISCUS ESCULENTUS PODS AND SEEDS.						EMERGENCE OF GELECHIA MOTHS FROM HIBISCUS CANNABINUS.	
750 green pods collected 5th October 1918. 1,000 green pods collected 14th October 1918. 750 green pods collected 6th November 1918. 750 green pods collected 13th November 1918. (The figures have been combined for the purposes of this table).		*500 Dry pods collected 15th October 1918.*		*Seeds received 19th February 1918.*		*8,000 green pods collected 13th October 1918.*	
Date	Number of Moths emerged	Date	Number of Moths emerged	Date	Number of Moths emerged	Date	Number of Moths emerged
October—		October—		April—		October—	
25th } 26th }	2	20th	1	28th	1	27th	7
		21st	2			28th	18
27th	7	25th } 26th }	2	May—		29th	30
28th	9			20th	1	30th	40
29th	14	27th	0	23rd	1	31st	14
30th	21	28th	1	27th	1		
31st	8	29th	3			November—	
		30th	2	June—		1st } 2nd }	17
November—		31st	0	12th	3		
1st } 2nd }	18					3rd	3
		November—				4th	1
3rd	4	1st } 2nd }	3			5th	1
4th	6						
5th	9	3rd	1				
6th	6						
7th	10						
8th } 9th }	10						
10th	3						
11th	1						
12th	5						
13th	4						
14th	2						
15th } 16th }	4						
17th	4						
18th	1						
19th	1						
20th	1						
21st	3						
22nd } 23rd }	2						
24th	0						
25th	1						
26th	0						
27th	0						
28th	0						
29th } 30th }	0						
December—							
1st	0						
2nd	0						
3rd	2						
4th	1						
5th	0						
6th & 7th	1						
8th	1						
9th	0						
10th	0						
11th	1						
12th	0						

Table III.—Emergences of Gelechia Moths from Hibiscus esculentus pods and seeds—concld.

Emergence of Gelenchia Moths from Hibiscus esculentus pods and seeds.						Emergence of Gelechia Moths from Hibiscus cannabinus.	
750 green pods collected 5th October 1918. 1,000 green pods collected 14th October 1918. 750 green pods collected 6th November 1918. 750 green pods collected 13th November 1918. (The figures have been combined for the purposes of this table).		*500 Dry pods collected 15th October 1918.*		*Seeds received 19th February 1918.*		*8,000 green pods collected 13th Octobber 1918.*	
Date	Number of Moths emerged	Date	Number of Moths emerged	Date	Number of Moths emerged	Date	Number of Moths emerged.
13th & 14th	3						
15th .	0						
16th—18th	0						
19th .	3						
20th & 21st	3						
22nd .	4						
23rd .	0						
24th .	2						
25th .	1						
26th .	0						
27th & 28th	0						
29th	0						
30th .	0						
31st .	1						
January—							
1st . .	1						
2nd . .	1						
3rd & 4th	0						
5th . .	2						

Table IV.—Showing Result of Examination of Green Bamia [Hibiscus esculentus] *Pods, in July-November 1918.*

Sample No.	Locality	Date of collection	Actual Numbers for: No. of Bolls examined	No. of Sound Bolls	No. of Bolls damaged by Gelechia	No. of Bolls damaged by Earias	No. of Bolls with traces of B. W.	Per cent. Sound	Gelechia	Earias	Traces of B.W.
1	Giza	30th July	1,000	999	0	1	0	100	0	..	0
2	Giza	10th August	800	799	0	1	0	100	0	..	0
3	Giza	27th August	1,000	998	0	2	0	100	0	..	0
4	Abul Numrus	4th October	1,000	938	27	22	13	94	3	2	1
5	Minia	8th October	950	846	85	8	13	89	9	1	1
6	Beni Suef	10th October	1,200	937	192	82	8	78	16	7	1
7	Helwan	5th November	110	85	15	7	3	77	14	6	3

Table V.—Result of Examination of a sample of Til [Hibiscus cannabinus] *Pods.*

Sample No.	Locality	Date of collection	Actual Numbers for: No. of Bolls examined	No. of Sound Bolls	No. of Bolls damaged by Gelechia	No. of Bolls damaged by Earias	No. of Bolls with traces of B. W.	Per cent. Sound	Gelechia	Earias	Traces of B.W.
1	Gemmeiza	14th October	1,000	929	45	18	9	93	5	2	1

Table VI.—Influence of position in which is kept material containing Pink Bollworms.

	January	February	March	April	May	June	July	August	September	October	November	December	TOTAL
On ground—													
1821 . . .				26	319	1,176	1,656	524	67	49	38		
1737 . . .	1			28	50	43	177	121	46	25	13	2	
1838 . . .		2	1	35	107	87	52	6		2	14		
	1	2	1	89	476	1,306	1,885	651	113	76	65		
On table—													
1822 . . .	6			24	67	107	119	41	10	12	102		
1839 . . .	5	3	3	19	7			2	4	18	30		
	11	3	3	43	74	107	119	43	14	30	132		
Light trap in the open.		1				4	6	7	36	37	27		
Gemmeiza Samples—													
1855 . . .				45	145	208	222	84	15	5	1	Ground Table.	
1856 . . .				174	220	89	107	74	20	5	3	Ground.	
1857 . . .				364	657	56	39	57	40	5	14		
				747	1,305	562	496	333	196	20	23		
TOTALS	1	2	1	89	476	1,306	1,885	651	113	76	65		4,665
	11	3	3	43	74	107	119	43	14	30	132		579
		1				4	6	7	36	37	27		118
				747	1,305	562	496	333	196	20	23		3,682
	12	6	4	879	1,855	1,979	2,506	1,034	359	163	247		9,044
Calculated to facilitate comparison as 10,000 emergences—													
Ground . . .	2	4	2	191	1,021	2,799	4,041	1,395	242	163	139		9,999
Table . . .	190	52	52	743	1,277	1,848	2,055	743	242	518	2,280		10,000
Gemmeiza . . .				2,029	3,544	1,526	1,348	904	532	54	62		9,999
Average .	64	19	18	988	1,947	2,058	2,481	1,014	339	245	827		10,000

Table VII.—Summary of all emergences of long cycle moths : by months.

1917	Equal numbers of bolls.												Short cycle previous year	Remarks
	January	February	March	April	May	June	July	August	September	October	November	December		
Bolls collected—														
1st September–10th October.				1	0	0	243	273	13	12	16		9,559	(Calculated as 32 cages.)
11th October–30th November.				132	15	0	20	18	0	30	13		734	(Calculated as 32 cages.)
Total				133	15	0	265	275	13	42	29		10,293	
Bolls on the ground				89	476	1,306	1,885	651	113	76	65	Not recorded.		
Bolls on table				43	74	107	119	43	14	30	132			
Light trap in the open.						4	6	7	36	37	27			Light trap in open probably collected many short cycles.
Gemmeiza				747	1,305	562	496	333	196	20	23			
Totals of above				879	1,845	1,979	2,506	1,034	359	163	247			
Total of both totals.				1,012	1,870	1,979	2,771	1,309	372	205	276			

Table VII.—Summary of all emergences of long cycle moths : by months—contd.

—	Fall. 1917	January	February	March	April	May	June	July	August	September	October	November	December
		Green Bolls 1918											
Upper Egypt.													
Calculated as 8 Cages.													
September—													
1st–10th	789							16	12			1	
11th–20th	1,677				1			51	67	4		3	
21st-end	1,120	1		1				52	60	1	2	4	
October—													
1st–10th	809	7	1					16	8		3	5	
11th–20th	756				10	4		4	2		4	2	
21st-end	308				11	6					2	1	
November—													
1st–10th	108				17	1							
11th–20th	0				20						4	8	
21st-end	0				16								
Lower Egypt.													
September—													
1st–10th	1,103	1						24	28	4			
11th–20th	1,549							51	69	3	1	1	
21st-end	1,446	1						14	19	1			

October—												
1st–10th	1,066		2					19	10		6	2
11th–20th	755				6	3		1			5	2
21st-end	291	1			21	5		2				3
November—												
1st–10th	59	5			8			21	35		11	
11th–20th	0				48				8		16	
21st-end	0				8							
UPPER AND LOWER EGYPT COMBINED.												
September—												
1st–10th	1,892	1						40	40	4		1
11th–20th	3,226				1			102	136	7	1	4
21st-end	2,566	2		1				66	79	2	2	4
October—												
1st–10th	1,875	7	3					35	18		9	7
11th–20th	1,511				16	7		5	2		9	4
21st-end	599	1			32	11		2			2	4
November—												
1st–10th	167	5			25	1		21			11	
11th—20th	0				68						16	8
21st-end	0				24							
1st September–10th October	9,559	10	3	1	1			243	273	13	12	16
11th October–November	917	6			165	19		28	2		38	16

Bolls collected 1st September to 10th October contained 9573 short and 557 long cycle, bolls collected after 11th October contained 917 short and 268 long-cycle larvæ.

First period 6 per cent. long-cycle, second period 23 per cent. long-cycle.

For the total period, first half contained 5 per cent. second half 2 per cent. long cycle larvæ.

Remarks.—The first period bolls would all mature and form part of the second picking.

Table VII.—Summary of all emergences of long cycle moths : by months—concld.

	1918						1917					
	Open bolls						Green bolls					
—	Short		Long		Short		Long		Short		Long	
September—												
1st . . .	208		70		828	592	42	22				
11th . . .	8	84	8	78	1,187	1,258	94	94				
21st . . .	17	47	7	109	1.267	1,261	30	132				
October—												
1st . . .	0	10	0	21	935	910	33	36				
11th . . .	27	1	1	45	755	850	17	28	19	9	6	95
21st . . .	2	6	4	41	291	347	1	21	17	4	50	95
November—												
1st . . .	2		10		22	82	34	14	8		59	
11th . . .					0	0	9	8	7		111	
21st . . .					0	0	1	2				
September—												
1st . . .	208		70		1,420		64					
11th . . .	72		86		2,445		188					
21st . . .	64		116		2,528		162					
October—												
1st . . .	10		21		1,845		69					
11th . . .	28		46		1,605		45			28		101
21st . . .	8		81		638		52			21		145

November—						
1st . . .	2	1[illegible]	104	48	8	59
11th . . .			0	17	7	111
21st . . .			0	3		
	Per cent.	Per cent.	Per cent.	Per cent.		
September—						
1st . . .	75	25	95	5		
11th . . .	46	54	93	7		
21st . . .	29	71	94	6		
October—						
1st . . .	32	68	96	4		
11th . . .	38	62	97	3	22	78
21st . . .	8	81	92	8	13	87
November—						
1st . . .	7	83	68	32	12	88
11th . . .			0	100	6	94
21st . . .			0	100		

	1917.		1916.					
September								
1st . . .	829+497=1,326	194+121=315						
11th . . .	497+488=985	124+ 98=222		48	48		32	32
21st . . .	603+594=1,397	105+259=364						
October—								
1st . . .	861+594=1,455	116+199=315		7	7		41	41
11th . . .	920+589=1,409	149+167=316	113	17	130	4	77	81
21st . . .	792+542=1,334	158+144=302	235	35	270	112	108	[illegible]20
October—								
1st . . .	40+303=343	54+52=106	35	2	37	88	38	126
11th . . .	28+35=63	4+45=49						
21st . . .	14+2=16	9+12=21	35		35	47		47

Table VIII.—Emergence record for 1918. Moths bred from material collected in 1917.

Date of Collection and Description.	Number of Moths emerging in								Total
	April	May	June	July	August	September	October	November	
Stated as from 10,000 bolls.									
Green Bolls.									
1st September–10th October	1	0	0	151	171	8	7	10	348
11th October–30th November	82	8	0	14	22	0	28	8	162
Open Bolls.									
1st September–10th October	10	31	143	381	148	51	50	44	858
11th October–30th November	41	36	40	178	105	26	58	104	588
Dead Bolls.									
1st September–10th October	0	0	0	23	56	7	2	6	94
11th October–30th November	2	0	5	74	73	37	10	14	215
Stated as 10,000 emergences.									
Green Bolls.									
1st September–10th October	24	0	0	4,334	4,911	229	207	296	10,000
11th October–30th November	4,983	619	0	856	1,345	0	1,722	474	9,999
Open Bolls.									
1st September–10th October	122	362	1,669	4,430	1,725	597	582	513	10,000
11th October–30th November	703	615	674	3,036	1,785	437	981	1,768	9,999
Dead Bolls.									
1st September–10th October	0	0	0	2,455	5,878	735	259	672	9,999
11th October–30th November.	88	0	222	3,463	3,379	1,740	461	647	10,000

Table IX.—Emergence record for 1918. Moths bred from material collected in 1917 stated as 1000 emergences.

Bolls collected	Moths Emerged in								Total
	April	May	June	July	August	September	October	November	
Green Bolls.									
1st September–10th October.	2	0	0	436	489	23	22	29	1,001
11th October–30th November.	579	66	0	87	79	0	132	57	1,000
Open Bolls.									
1st September–10th October.	12	29	166	441	172	70	58	51	999
11th October–30th November.	77	67	74	332	193	48	107	102	1,000
Dead Bolls.									
1st September–10th October.	0	0	0	246	588	74	26	67	1,001
11th October–30th November.	9	0	21	314	342	188	56	69	999
Average for whole Season.									
Green bolls . .	291	33	0	262	284	12	77	43	1,002
Open bolls . .	45	48	120	387	183	59	83	77	1,002
Dead bolls . .	5	0	11	280	465	131	41	68	1,001
STATED AS FROM 10,000 BOLLS.									
Green Bolls.									
1st September–10th October.	1	0	0	151	170	9	7	10	348
11th October–30th November.	74	8	0	14	22	0	28	8	154
Open Bolls.									
1st September–10th October.	10	25	143	381	148	60	0	44	861
11th October–30th November.	41	36	40	178	103	26	58	55	537
Dead Bolls.									
1st September–10th October.	0	0	0	23	56	7	2	6	94
11th October–30th November.	2	0	4	63	69	38	11	14	201
Average for the whole Season.									
Green bolls . .	38	4	0	83	96	5	18	9	253
Open bolls . .	26	32	92	280	126	43	54	50	99
Dead bolls . .	1	0	2	43	63	23	7	10	149

Table X.—Showing the number of Gelechia moths caught in a cotton-seed store by traplight, weekly.

Week commencing	Number caught	Week commencing	Number caught	Week commencing	Number caught
1917.		December—		May—	
June—		6th . . .	14	23rd . . .	40
21st . . .	176	13th . . .	5	30th . . .	56
28th . . .	187	20th . . .	12	June—	
July—		27th . . .	0	6th . . .	81
5th . . .	248	*1918.*		13th . . .	17
12th . . .	837	January—		20th . . .	4
19th . . .	1,120	3rd . . .	1	27th . . .	26
26th . . .	144	10th . . .	2	July—	
August—		17th . . .	3	4th . . .	8
2nd . . .	41	24th . . .	0	11th . . .	0
9th . . .	123	31st . . .	4	18th . . .	29
16th . . .	69	February—		25th . . .	40
23rd . . .	19	7th . . .	6	August—	
30th . . .	691	14th . . .	7	1st . .	35
September—		21st . . .	4	8th . .	51
6th . . .	21,699	28th . . .	2	15th . . .	33
13th . . .	16,843	March—		22nd . . .	13
20th . . .	7,340	7th . . .	5	29th . . .	72
27th . . .	232	14th . . .	2	September—	
October—		21st . . .	5	5th . . .	39
4th . . .	194	28th . . .	10	12th . . .	11
11th . . .	416	April—		19th . . .	27
18th . . .	235	4th . . .	20	26th . . .	20
25th . . .	737	11th . . .	38	October—	
November—		18th . . .	39	3rd . . .	8
1st . .	212	25th . . .	20	10th . . .	315
8th . . .	1,128	May—		17th . . .	949
15th . . .	1,166	2nd . . .	29	24th . . .	3,965
22nd . . .	26	9th . . .	45	31st	..
29th . .	25	16th . . .	58		

TOTAL — 58,050 moths.

Table XI.—Showing the daily numbers of Gelechia Moths caught during the period 6th September to 26th September 1917:

	Moths caught.	
September—		
6th	318	
7th	943	
8th	2,470	
9th	4,500	
10th	7,960	
11th	5,500	
12th	8	Light not burning.
13th	6,060	
14th	5,670	
15th	2,800	
September—		
16th & 17th	5,500	
18th	2,222	
19th	1	Light not burning.
20th	821	
21st	1,403	
22nd	1,524	
23rd	1,610	
24th	985	
25th	710	
26th	227	

Table XII.—Showing the Infestation of green Cotton bolls by Pink Boll-worm, data arranged according to sizes of bolls and of worms.

Grade of bolls	Total number of Bolls.		Total number of worms.			
	Examined	Found sound	Small	Medium	Large	Whose traces only were found
A	18,913	18,084	357	132	171	127
B	22,737	18,281	1,112	1,094	1,580	1,107
C	1,66,997	1,11,499	8,800	11,380	29,328	13,067
		Calculated to facilitate comparison.				
A	10,000	95,618	188	70	90	67
B	10,000	80,402	489	481	695	487
C	10,000	66,765	527	681	1,766	782

Table XIII.—Showing comparison of sound and attacked samples (weights in grammes.)

Description of sample	Total weight with worms	Total weight without worms	Percentage Lint with worms	M	Percentage Lint without worms	M
30 sets of 100 sound seeds	..	449·69	..	..	34·2+0·08	0·65
30 random samples of about 150 grs. each.	4,319·4*	4,287·6	34·7+0·09	0·7	34·9+0·09	0·7
30 sets of 100 damaged seeds other than "double" ones.	2,82·93	2,69·93	35·6+0·19	1·5	37·3+0·18	1·5
30 sets of 50 double seeds (=100 seeds per cent.)	3,13·79	2,84·66	30·3+0·28	2·3	33·3+0·26	2·15
Gemmaiza Crop. Sound bolls.	4,777·4†	..	34·0+0·02	0·529		
Gemmaiza crop. Damaged bolls.	15,226·0	..	34·0+0·01	0·492		
Gemmaiza crop. Entire yield.	20,003·4‡	..	34·0+0·01	0·478		

* The total weight of 3,000 seeds with their lint would average 438·37.
† The total weight of 3,000 seeds with their lint would average 496·28.
‡ The total weight of 3,000 seeds with their lint would average 439·49.

Table XIV.—Variations of the Percentages of Lint in Mitaffifi and Affifi Cottons ginned by the State Domains during the years 1891-1917, calculated from figures supplied by the State Domains Administration.

Year	Mitaffifi Sakha Ginnery	Qorashia Ginnery	Remarks
	Percentage Lint	Percentage Lint	
1891	33·0	33·7	
1892	...	...	
1893	34·0	35·5	
1894	33·3	34·9	
1895	33·3	35·2	
1896	33·3	35·5	
1897	34·9	35·2	
1898	35·5	35·9	
1899	34·9	36·2	
1900	34·9	34·9	
1901	34·6	34·9	
1902	34·6	35·9	

Table XIV.—Variations of the Percentage of Lint in Mitaffifi and Affifi Cottons ginned by the State Domains during the years 1891-1917, calculated from figures supplied by the State Domains Administration—concld.

Year	Mitaffifi Sakha Ginnery	Qorashia Ginnery	Remarks
	Percentage Lint	Percentage Lint	
1903	34·9	37·1	
1904	33·3	35·5	
1905	33·7	34·9	
1906	34·0	35·5	
1907	33·7	35·2	
1908	34·0	35·9	
1909	33·0	34·2	
1910	33·0	34·9	
1911	33·7	34·9	
1912	34·9	...	
Mean	34·0	35·3	
Affifi. Σ=	0·74		
1911	33·9	34·1	
1912	33·9	...	
1913	34·5	34·5	
1914	34·0	...	
1915	34·0	...	
1916	33·3	...	
1917	34·5	...	
1917*.	33·7	...	
Mean	34·1	34·3	
Σ=	0·36		

* Special experimental cotton.

Table XV.—Variation in the Percentage of Lint of Sakellaridis, Assili and Affifi Cottons ginned by the State Domains during the years 1911-1917, calculated from figures supplied by the State Domains Administration.

Year	Sakellaridis Percentage Lint	Assili Sakha Percentage Lint	Assili Qorashia Percentage Lint	Affifi Percentage Lint
1911	33·8	35·6	35·6	33·9
1912	32·7	35·4	35·7	33·9
1913	33·5	36·4	36·2	34·5
1914	33·8	36·2	36·2	34·0
1915	32·8	35·7	35·5	34·0
1916	31·5	36·0	34·7	33·0
1917	34·1	36·4	36·7	34·5
Mean	33·2	36·0	35·8	34·0

Sakel $\Sigma = 0{\cdot}8$ Assili $\Sigma = 0{\cdot}5$ Affifi $\Sigma = 0{\cdot}5$

For all varieties combined $\Sigma = 0{\cdot}6$

19.—EXPERIMENTS IN EGYPT ON THE SURVIVAL OF THE PINK BOLLWORMS (RESTING STAGE LARVÆ) IN RIPE DAMAGED COTTON BOLLS BURIED AT DIFFERENT DEPTHS.

By F. C. Willcocks, *Entomologist to the Sultanic Agricultural Society Cairo, Egypt.*

Locality.—Ghezireh—an island in the Nile, opposite Cairo.

Soil.—A sandy loam.

The ground had been flooded September-November 1916 by infiltration from high Nile.

Pits were made 5 cm., 10 cm., 15 cm., and 20 cm. in depth.

The bolls were "planted," *i.e.*, there was a space between each boll and its neighbours. The soil was then put back into the pits and trodden down. Not all the soil which had been taken out was got back into the pits.

Bolls were buried about the second week in January 1917—much later than had been planned, but owing to infiltration the soil was not in a fit state before this date.

There were three series of four pits.

Plot I had *bersîm* sown on it.
Plot II was left bare—' bare-fallow.'
Plot III had wheat sown on it.

One thousand bolls were removed from each pit on 30th April 1917; 31st May 1917; 30th June 1917, and 31st July 1917, and examined. These dates are approximate—it was not possible always to remove bolls on the exact date, but there was only a difference of a day or two.

A sample of 200 of the bolls (used for this experiment), examined at the end of May, gave the following result:—

First 100.	Second 100.
82 Pink Bollworms alive.	89 Pink Bollworms alive.
2 „ „ dead.	2 „ „ dead.
1 „ „ dead (*Pediculoides.*)	8 „ „ dead (*Pediculoides.*)
5 Empty pupæ (moth emerged)	3 empty pupæ (moth emerged).

These bolls had been kept in the Laboratory.

NOTE.—The second 100 bolls were from a sample used in the 5 cm. and 10 cm. pit in Plot II. The original sample gave out, Plot II being sown with bolls last. It is possible that bolls in 5 and 10 cm. pit of Plot II were rather more heavily infested than the bolls in the other pits which were from same field. The other lot came from another locality.

RESULTS.

Plot I. Bersîm. (*Trifolium alexandrinum.*)

Bolls buried 13th January 1917.
Plot irrigated and *bersîm* sown 28th January 1917.
12th March 1917.—Irrigated.
10th April 1917.—First cutting *bersîm* and irrigated.
10th May 1917.—Last watering.
1st July.—Cut the *bersîm*; it was dry.
30th April 1917.—Removed 1,000 bolls from each pit.

5 cm. Pit.—1,000 bolls. They had not broken up and had not rotted. In these were—
Found 34 live Pink Bollworm larvæ.
9 „ pupæ Pink Bollworm.
22 empty pupa cases.

10 cm. Pit.—1,000 bolls; mostly not broken up—slightly decayed. In these were-
Found 18 live Pink Bollworm larvæ.
5 live pupæ.
7 empty pupa cases.

15 cm. Pit.—1,000 bolls; a good deal decayed and broken up. In these were—
Found 5 live Pink Bollworm larvæ.
1 live pupa.
8 empty pupa cases.

20 cm. Pit.—1,000 bolls ; much decayed, mostly broken up. In these were—

Found 3 live Pink Bollworm larvæ.
1 live pupa.
14 empty pupa cases.

Plot II. Bare fallow.

Bolls buried 18th January 1917. Removed first lot of bolls, 30th April 1917.

5 cm.—1,000 bolls ; majority of bolls whole—not broken up. Least decayed of this series.

Found 124 Pink Bollworm larvæ alive.
6 pupæ alive.
19 empty pupa cases.

N.B.—Most of the larvæ in unusually thickly woven and tough cocoons.

10 cm.—1,000 bolls—condition good, many broken, but not in such good condition as 5 cm.

Found 10 Pink Bollworm larvæ alive.
0 live pupæ.
36 empty pupa cases.

15 cm.—1,000 bolls ; very much decayed, nearly all broken up—

Found 1 live Pink Bollworm larva.
5 live pupæ.
10 empty pupa cases.

20 cm.—1,000 bolls. Very much decayed, broken up mostly—in fact, nearly all—

Found 1 live Pink Bollworm larva.
1 live pupa.
13 empty pupa cases.

Plot III. Under Wheat.

Bolls buried 16th January 1917.
Wheat sown 25th January 1917 ; no watering given.
28th January 1917 ; a light watering.
26th March 1917 ; watered.
16th April 1917 ; Cut wheat—ripe.
Bolls removed 29th April 1917.

5 cm. Pit—1,000 bolls in good condition—only a few broken up—

Found 114 live Pink Bollworm larvæ.
16 live pupæ.
18 empty pupa cases.

(*N.B.*—Many larvæ in unusually thickly woven cocoons—the latter in the bolls or seeds.)

10 cm, Pit.—1,000 bolls ; majority unbroken, condition good—

Found 36 live Pink Bollworm larvæ.
3 live pupæ.
10 empty pupa cases.

15 cm. Pit.—1,000 bolls. Not in bad condition at all. Many unbroken. Better than in 15 cm. pits of Plots 1 and *ii*—

Found 54 live Pink Bollworm larvæ.
20 live pupæ.
14 empty pupa cases,

(*N.B.*—State of bolls in 15 cm. and 20 cm. pits much about the same.)

20 cm. Pit.—1,000 bolls—not in bad condition—slightly decayed—many unbroken.

Found 46 live Pink Bollworm larvæ
8 live pupæ.
22 empty pupa cases.

Bolls Removed 31st May.

Plot I. Bersîm.

5 cm. Pit.—Bolls much decayed and broken up—
Found 10 live Pink Bollworm larvæ.
2 live pupæ.
9 empty pupa cases.

10 cm. Pit.—Bolls very much decayed—not all broken up—not so bad as 15 or 20 cm. bolls.
Found 4 live Pink Bollworm larvæ.
0 live pupæ.
8 empty pupa cases.

15 cm. Pit.—Bolls very much decayed and broken up. Same as 20 cm. pit.—
Found 1 live Pink Bollworm larva.
0 live pupæ.
1 empty pupa case.

20 cm. Pit.—Bolls very much decayed and broken up—
Found 0 live Pink Bollworm larvæ.
0 live pupæ.
0 empty pupæ.

N.B.—The 1,000 bolls removed is the theoretical number. The space occupied by each 1,000 bolls was marked, but when bolls were much decayed one could not be certain of course of recovering all the pieces.

Plot II. Bare Fallow.

NOTE.—Bolls in 5 and 10 cm. pits were from a different sample to that used for the other pits in all three plots.

5 cm. Pit.—1,000 bolls. Condition good; a few only broken up—
Found 214 live Pink Bollworm larvæ. } majority in the tough cocoons
0 live pupæ. }
2 empty pupa cases. } in fibre of boll or seeds.

10 cm. Pit.—1,000 bolls—about two-thirds of bolls broken up—
Found 2 live Pink Bollworm larvæ.
0 live pupæ.
4 empty pupa cases.

15 cm. Pit.—1,000 bolls—majority broken up and decayed—
Found 0 live Pink Bollworm larvæ.
0 live pupæ.
2 empty pupa cases.

20 cm. Pit. 1,000 bolls; much decayed and broken up—
Found 0 live Pink Bollworm larvæ.
1 live pupa.
7 empty pupa cases

Plot III. Wheat.

5 cm. Pit.—1,000 bolls; very few broken up; condition good.

Found 123 live Pink Bollworm larvæ.
2 live pupæ.
14 empty pupa cases.
} many larvæ in the tough cocoons.

10 cm. Pit—1,000 bolls; not much decayed and a few only broken up.

Found 21 live Pink Bollworm larvæ.
5 live pupæ.
10 empty pupa cases.

15 cm. Pit.—1,000 bolls—very roughly about 40 per cent. not broken up; decayed on the outside.

Found 0 live Pink Bollworm larvæ.
1 live pupa.
8 empty pupa cases.

20 cm. Pit.—1,000 bolls; not badly decayed, but many broken up—

Found 1 live Pink Bollworm larva.
1 live pupa.
4 empty pupa cases.

Bolls Removed 30th June 1917.

Plot I. Bersîm.

Note.—The *bersîm* was not cut until 1st July so soil still had shade of crop up to 30th June.

5 cm. Pit.—1,000 bolls; very much decayed and mostly broken up.

Found 0 live Pink Bollworm larvæ.
0 pupæ alive.
1 empty pupa case.

10 cm. Pit.—No time to examine bolls. Had to be put in cages. Results calculated from moths which emerged.

Found 1 live Pink Bollworm larva.
0 pupæ.
0 empty pupa cases?

15 cm. Pit.—Bolls not removed until 31st July. Other work interfered with this experiment. Nothing emerged from these bolls which were kept in cages.

20 cm. Pit.—Same as 15 cms. plot.

Plot II. Bare Fallow.

5 cm. Pit.—1,000 bolls; condition of bolls good.

Found 13 live Pink Bollworm larvæ.
10 live pupæ.
1 empty pupa case.
12 dead larvæ found—dried up.
2 dead larvæ still soft.

10 cm. Pit.—Bolls kept in cages. From dates moths emerged 3 Pink Bollworm larvæ must have been alive on 30th June.

15 cm. Pit.
20 cm. Pit.
} 1,000 bolls removed on 31st July and kept in cages. No moths emerged.

But this does not indicate for certain that no living Pink Bollworms were present on 30th June.

Plot III. Wheat.

5 cm. Pit.—1,000 bolls; condition not bad—many bolls broken up and many have retained their form.

NOTE.—The bolls which have decayed to a considerable extent get broken up during the removal. Naturally, *in situ* they retain their form more or less, owing to the support of the surrounding soil.

Found 0 live Pink Bollworm larvæ.
0 live pupa.
1 empty pupa case.

10 cm. Pit.—1,000 bolls removed and put into cages. No moths were obtained.

15 cm. Pit }
20 cm. Pit } The bolls not removed until 31st July, put into cages. No moths obtained.

Bolls Removed 31st July 1917.

Plot I. Bersîm.

The *bersîm* was cut 1st June so during July there had been no shading of the last section of the pits.

5 cm. Pit.—1,000 bolls removed 31st July 1917. Bolls very much decayed and broken up.

Found 0 live Pink Bollworm larvæ.
0 live pupa.
0 empty pupa case.

10 cm. Pit.—1,000 bolls removed 31st July 1917 and put in cage. No moths were obtained.

15 cm. }
20 cm. } Same as 10 cms. pit.

Plot II. Bare Fallow.

5 cm. Pit.—1,000 bolls removed 31st July 1917. Bolls in good condition.

Found 6 live Pink Bollworm larvæ.
6 live pupæ.
2 empty pupa cases.
13 Pink Bollworm larvæ dead and dried up.
1 Pink Bollworm larva dead—still soft.

10 cm. Pit.—1,000 bolls removed 31st June 1917 and caged. Obtained 3 moths, showing that 3 live Pink Bollworm larvæ were present when bolls were removed.

15 cm. Pit. }
20 cm. Pit. } 2,000 bolls removed 31st July 1917 and caged. No moths were obtained.

Plot III. Wheat.

5 cm. Pit.—1,000 bolls removed 31st July 1917. Many of these were broken up.

Found 1 live Pink Bollworm larva.
1 pupa alive.
3 empty pupa cases.

10 cm. Pit. }
15 cm. Pit. }
20 cm. Pit. } 1,000 bolls removed 31st July 1917 and caged. No moths were obtained.

The foregoing results are summarized in the following table :—

Survival of Pink Bollworms in Buried Bolls according to Depth, Culture and Dates.

Dates on which Bolls were removed	5 cm. Pit			10 cm. Pit			15 cm. Pit			20 cm. Pit		
	Live P.B.	Live Pupæ	Empty pupæ	Live P.B.	Live Pupæ	Empty pupæ	Live P.B	Live Pupæ	Empty Pupæ	Live P.B.	Live Pupæ	Empty Pupæ
PLOT I UNDER BERSIM												
30th April	34	9	22	18	5	7	5	1	8	3	1	14
31st May	10	2	9	4	0	8	1	0	1	0	0	0
30th June	0	0	1	1	0	0	0	0	0	0	0	0
31st July	0	0	0	0	0	0	0	0	0	0	0	0
Totals	44	11	32	23	5	15	6	1	9	3	1	14
PLOT II UNDER BARE-FALLOW												
30th April	124	6	19	10	0	36	1	5	10	1	1	13
31st May	214	0	2	2	0	4	0	0	2	0	1	7
30th June	13	10	1	3	0	0	0	0	0	0	0	0
31st July	6	6	2	3	0	0	0	0	0	0	0	0
Totals	357	22	24	18	0	40	1	5	12	1	2	20
PLOT III UNDER WHEAT												
30th April	114	16	18	36	3	10	54	20	14	46	8	22
31st May	123	2	14	21	5	10	0	1	8	1	1	4
30th June	0	0	1	0	0	0	0	0	0	0	0	0
31st July	1	1	3	0	0	0	0	0	0	0	0	0
Totals	238	19	36	57	8	20	54	21	22	47	9	26

Total Pink Bollworms which Survived in Buried Bolls.

Plot and culture	Live P. Bs.	Live pupæ	Empty pupa cases	TOTAL
Plot I. Bersim	76	18	69	163
,, II Bare fallow	377	29	96	502
,, III Wheat	396	57	104	557
TOTAL .	849	104	269	

NOTE.—One is not certain if all empty pupa cases found in the bolls were left by moths which emerge after or before bolls were buried. I think most larvæ pupated after bolls were buried.

Total Pupations according to culture.

Plot and culture	Live Pupæ and Empty Pupæ
Plot I Bersîm	87
,, II Bare fallow	125
,, III Wheat	161

NOTE.—In all there were 12 pits containing a total of 48,000 bolls. I judge that when buried these bolls contained a total population of at least 40,000 live Pink Bollworms.

Total Pink Bollworms, etc., which Survived in Bolls buried at Different Depths.

Plot and culture	PIT 5 CM. DEEP			PIT 10 CM. DEEP			PIT 15 CM. DEEP			PIT 20 CM. DEEP		
	Live P. Bs.	Live Pupæ	Empty pupa cases	Live P. Bs.	Live Pupæ	Empty pupa cases	Live P. Bs.	Live Pupæ	Empty pupa cases	Live P. Bs.	Live Pupæ	Empty pupa cases
Plot I Bersîm	44	11	32	23	5	15	6	1	9	3	1	14
Plot II Bare fallow . . .	357	22	24	18	0	40	1	5	12	1	2	20
Plot III Wheat	238	19	36	58	8	20	54	21	22	47	9	26
TOTALS .	639	52	92	99	13	75	61	27	43	51	12	60
TOTAL PUPATION ACCORDING TO DEPTH.	144			88			70			72		

At our Second Meeting I called your attention to the interesting results obtained by Mr. Willcocks in his experiments on the emergence of long-cycle larvæ of *Platyedra gossypiella* and pointed out that similar conditions probably exist in India. In gathering material for the present Meeting, I wrote to Mr. Willcocks and asked him if he could contribute a note on any further work he may have done on this insect and he has very kindly forwarded this most suggestive paper. In a letter forwarding his paper, he also writes as follows :—

"As regards the Pink Bollworm : since 1915 I have done very little work on it as I was put on to other investigations and so I am not in a position to communicate any very interesting matter to the Meeting at Pusa, but please accept my sincere thanks for the opportunity to do so, you so kindly offered to me.

"*G. gossypiella* is still a very serious pest in Egypt, but it is hoped that the good work which is being done by the Entomological and Administrative branches of the Ministry of Agriculture will soon bear fruit—in the form of lighter loss from Pink Bollworm attack. I have not statistics at all as regards the loss caused by this insect in Egypt as a whole. The only figures available refer to conditions on our own farm at Bahtim, near Cairo. Here, on calculations based on the examination of the bolls from 200 plants from 100 "holes" or "nogras" we estimate that in 1915, 1916, 1917 and 1918 the loss was approximately between 30 and 40 per cent. of the crop.

I have obtained no new information about the parasites of *Gelechia*. It is strange that you have not been able to breed any in India. If you wished to, I think it would be a fairly easy matter for you to introduce living *Gelechia*-parasites from Egypt. There should be no great difficulty in getting *Pimpla roborator* across in consignments of Pink Bollworm infested bolls (ripe) picked—say from September to October. You would probably get *Chelonella sulcata* too in this way. Whether or not the latter is of any importance I really cannot say. From an interesting communication received recently from Mr. Dwight Pierce in America I gather that *Chelonella* probably lays its eggs in the eggs of the Pink Bollworm moth. This, to me, was news indeed and quite an undreamed of habit—it seems so strange for such a comparatively large insect to oviposit in the minute *Gelechia* eggs.

"In Egypt we (I think I can say we) are still very much in the dark as to the relative importance of the various natural agencies which check the Pink Bollworm, but as will be perfectly clear to you, the proper investigation of this question would employ the time of several men for some considerable time.

"As regards attempts at artificial control of the pest in the field you may perhaps be interested in an experiment I made with light traps in 1916.

"At Ghezireh (an island in the Nile opposite Cairo) on part of our grounds which are some distance from the nearest cotton, I had sown three plots of cotton each being ½ *feddan* (acre) in area. The plots were separated from each other but only by quite a small distance. On one plot I had 12 light traps, on another 6, and the third plot was kept as a sort of control, no traps being employed on it.

"The traps—small paraffin lamps in glass lanterns standing in trays containing water with a film of paraffin on the surface, the whole supported on a wooden stand about level with the tops of the cotton plants, each lamp being visible from any part of the plot—were started on 20th June and were run continuously until 28th September on the 12-lamp plot, and to 21st November on the 6-lamp plot. Heavy flooding by infiltration from a high Nile caused operations to be suspended so early on the 12-lamp plot. The 6-lamp plot was finally flooded too but not quite so badly and we were able to get to the traps by building raised causeways. Here operations were continued until no more moths were caught. The flooding had, I think, a decidedy adverse effect on *Gelechia* and so rather interfered with our experiment. The control plot was also flooded—it was the first to suffer.

"During the whole period we caught a total of roughly 16,000 *Gelechia gossypiella.* Of these we examined some 13,000 for sex, finding 9,000 females and 5,000 males. These figures are given under reserve as I have not yet worked up in detail all the *data* available.*

"Although the females greatly outnumber the males there were periods when the reverse was the case. The question of the fluctuation in the proportion of the sexes of moths captured in the traps is an interesting one and needs investigating. I have no explanation of it sufficiently definite to offer at present.

"Examination of the ovaries of the female *Gelechia* moths showed that a very large number of them contained large numbers of eggs and quite a number appeared to me to have been captured before oviposition had commenced.

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* In a later communication Mr. Willcocks gives the following figures :—

Females	10,141
Males	5,959
Not examined	2,853
TOTAL	18,952

" Now as to the results of catching this number of moths as shown by the yield from the different plots—they are not encouraging !

" The following Table shows the amount of cotton picked and the loss we estimated to have taken place on each plot :

Plot	First Picking			Second Picking		Both Pickings	
	Seed-cotton picked		Estimated loss on first picking	Seed-cotton picked	Estimated loss on second picking	Total seed-cotton picked	Estimate of Total loss on both pickings
	K.	Rs.	Per cent.	*K.*	Per cent.	*K.*	Per cent.
12 Lamps . . .	1	7	17	0·23	63	1·25	33
6 Lamps	1	74	19	0·41	74	1·64	44
Control	1	1	25	0·32	76	1·31	46

K=*Kantar*, Rs.=*Rottle*.*

N.B.—The crop was rather late and flooding interfered with the second picking. Part of the 12-lamp plot was very poor ; hence there occurred the lowest yield on the plot which showed the lowest loss.

" From these figures it would appear that the intensity of the attack was rather less on the 12-lamp plot than on the others, but I hesitate to attribute it to the influence of the 12 traps. The following figures obtained from an examination of green bolls picked from the three plots on 25th September are of some interest since they also show that the intensity of the attack was less on the 12-lamp plot.

Plot	Number of bolls (green) picked	Sound	Attacked by Pink Boll-worm	Average Number of		Average Number of		Total Number of *Earias* in all the bolls
				Injured " locks" per boll	Injured " Divisions " per boll	Pink boll-worms found per boll	Pink boll-worms found per boll if exit holes are counted as Pink Boll-worms	
12 Lamps .	125	23	102	1·5	2·8	0·82	1·36	20
6 Lamps .	117	0	117	2·63	5·128	1·7	2·6	16
Control . .	142	1[illegible]	132	2·5	5	1·3	2·9	20

N.B.—I reckon 6 divisions to the boll of 3 locks—each boll of unripe fibre being easily divided into two pieces.

" My preliminary conclusions—so far as I have any—on this experiment are that the 6 traps on ½ *feddan* gave no protection of practical use to the crop ; the 12 lamps per ½ *feddan* may have done something to lessen the attack, but as I do not know that all other conditions were equal on the 3 plots I cannot be certain that this result was entirely due

* *Kantar*=315 *Rottles*. A *rottle* is approximately one pound-weight.

to the traps. From a practical point of view 24 traps per *feddan* are I think out of the question—unless they gave immunity from Pink Bollworm attack.

"It is a pity that this experiment was so interfered with by the flooding and the lack of uniformity in the crop apart from the question of insect pests. I should say that roughly one-third of the 12-lamp plot gave practically no cotton owing to poor soil and to the influence of a row of mulberry trees along one side. As regards growth the 6-lamp and the control plots were most alike, but in each the growth of the plants was rather irregular.

"I wonder why trapping moths does not have more effect, and suppose it is because one does not catch a large enough proportion of the total moth population present. It is a difficult matter to explain why one can catch some individuals and not others. Can the members of a species vary individually as regards their reaction to a light stimulus? Sometimes I begin to think that perhaps it is only the foolish or inquisitive moths which are lured away from their proper occupations to destruction in the traps!

"One point that was rather striking was the number of injured bolls on plants immediately surrounding and actually touching the traps—in this respect there seemed to be no difference in close and remote plants as regards distance from a lamp.

"Some years ago I tried the effect of coloured lights. Blue lanterns appeared to attract *Earias insulana* to a greater extent than white, but I rather think that the position of the blue in relation to the white against which it is being opposed may have a good deal to do with the matter. The Pink Bollworm moth did not appear to exhibit any partiality for blue.

"As to the relative attractiveness of coloured lights—(if there is any such thing—because it may be entirely a question of brilliance, visibility, etc.)—the figures I obtained placed the coloured light traps in the following order.

1	2	3
Blue. White.	Green.	Red. Orange.

"The question of high-power against low-power lights is of interest because possibly one very brilliant incandescent oil gas light might do the work, say, of 24 low-power paraffin lamps. I was only able to carry out a trial of this nature on two occasions. The results obtained showed that although the bright light (500-1000 candle power) caught the most moths it only reduced the catches in the paraffin lamp traps close to or just beneath it.

"I think myself that moths are not attracted to light from any great distance and that they have to come near to a light in the course of natural flight before they see it or come under its influence; then no doubt, the more brilliant the light is, the greater its power over those species which will come to lights.

"Another matter in which I am interested and to which I have been able to give a little time is the question of the survival of resting Pink Bollworms in fallen bolls buried by ploughing the land for the crop following cotton.

"An experiment of a simple nature was carried out in 1917 with a view to giving us more information on this point. I enclose the results in tabular form and other details on separate sheets as perhaps they may be of some interest to you.

"This experiment really requires to be done with more fineness and attention to detail—for instance, it would be desirable to know the temperature of the soil from day to day and the moisture content of the soil and the influence on these factors of the different crops grown. Again, if one could devise some means of keeping track of all—or at any rate most of—those Pink Bollworms which one knows one has buried in the bolls but which one never sees—or rather sees so few—figure in one's records, it would be a great gain. It is not possible to cover in a plot because by so doing one cuts off to a large extent the influence of the sun—a most important factor. No doubt many of the "missing" larvæ have left the bolls, made their way to the surface, and crawled away, but I do not feel by any means confident that this *is* the explanation of the sudden drop in the number of the larvæ surviving in buried bolls during the period end of May to end of June and subsequently. It is possible, and personally I think it quite probable, that at this season many larvæ are killed by the dry soil being heated up to a temperature fatal to the Pink Bollworm by the sun—at any rate to a depth of 5 cm. if not to 10 cm. One might say, as there are no records of dead larvæ being found in the bolls, that therefore it is more probable that they had left the bolls to pupate on the surface than that they had remained to be baked alive. But as a matter of fact one cannot employ this explanation since it is exceedingly difficult to spot remains of dead Pink Bollworms when examining bolls which have been buried and are therefore more or less rotten and much discoloured —the dead Pink Bollworms being in the same state.

"The presentation of records showing the large numbers of live larvæ present in bolls kept in the laboratory on certain dates is also inconclusive as evidence from "the death by heat" explanation rather than the "evacuation of the bolls to pupate" explanation, because the temperature conditions in the soil will be quite different to what they are in the laboratory, and the same applies to the humidity conditions.

"The main object of this experiment was really to give us positive evidence of the survival of the Pink Bollworms in bolls buried to a depth of 5-10 cm. to a date after the restrictions on the irrigation of *shiraki* lands [land which has grown crops of *bersîm,* beans, wheat or barley, and has been left fallow, after the cotton crop] are removed; this happens as a rule about the end of June. We obtained our evidence, since at the end of July there were still live Pink Bollworms present at 5 and 10 cm. depth. Other experiments at this time, and others made in 1916 and 1918, confirmed this.

"I am thus still of the opinion that we have in these Pink Bollworm infested buried bolls a source from which the growing cotton crop might be infested. But as to its relative importance in this connection I do not feel in a position to say anything definite—all I can say at present is that the number of fallen bolls left on the ground after a cotton crop, and which will be turned in by ploughing, etc., may be very large, and furthermore the Pink Bollworm population in these bolls may be very large also—it varies of course, but might be anything from 10,000 to 100,000. Thus, given only a very small percentage of survivals to the end of June, when conditions—owing to the watering of the dry soil—I mean the *shiraki* lands—will be much more favourable to the Pink Bollworm, there might be sufficient moths produced from this source to be of considerable importance, as these would find conditions in the cotton fields very favourable to their rapid multiplication.

"I may point out here that the Ministry of Agriculture do all they can to make farmers collect fallen bolls before ploughing for the following crop.

"You will see by the results given in the Table that the survival of Pink Bollworms was greatest under wheat and bare fallow and least under *bersîm.*

"The bolls buried under wheat crop gave us the highest figure for survival of Pink Bollworms, but I do not know if the difference over the figure in the bare fallow pits is sufficient to signify anything.

"I attach great importance to the influence of moisture, when the temperature is high or fairly so, on the activity of the Pink Bollworm, especially in inducing the larvæ to leave the bolls or seeds and pupate. It is possible that the soil under a crop receiving only a very moderate amount of water would be drier than soil bearing no crop, owing to the large amount of water taken and evaporated from the plants. However, in this case I cannot say that the wheat pit bolls were drier and so larvæ would be less likely to leave the bolls to pupate, because as a matter of fact I rather think the soil under the wheat was moister than it should have been on account of seepage from a near-by canal through which water was run fairly frequently to irrigate other crops. Unfortunately this point was overlooked at the time when the pits were dug, the land then being uncropped.

"I should have expected the smallest number of live larvæ from bolls buried in Plot I under *bersîm* as, owing to the large amount of water necessary for the growth of this crop, the ground is always moist, not to say wet, even at 5 cm. depth during the winter and spring. However, whether the effect of these conditions was to cause the larvæ to leave the bolls in greater numbers in order to pupate or whether they died in larger numbers owing to the damp surroundings rendering them less resistant to diseases, I do not know—the old trouble of the fate of the "missing" larvæ again. I am in favour of the first explanation. It is curious however that the fewest pupæ and empty pupa cases were found in the pits under *bersîm* and most in the wheat-pit bolls—the reverse of what I should have anticipated. But I do not attach much importance to the figures for pupation; to begin with, it is probably only a small minority of larvæ which pupate in the soil, and also the moister the soil is the more difficult it is to see pupæ and especially empty pupa cases when digging into the soil—it would have been better had the soil been sifted.

"The small number of larvæ in the bolls buried at 15 cm. and 20 cm. depth I also account for by the much moister conditions causing the larvæ to leave these bolls more readily than those under the drier surroundings prevailing in the 5 cm. and 10 cm. pits.

"Please make any use of this letter you like—if you think anything in it is of sufficient interest. You will not mind, I am sure, my saying that I must reserve the right to also publish the figures in the Society's publications, should my Chief wish to do so.

"I much regret that I am unable to give you more information on the points you mentioned in your letter, but I have been working on insects feeding on the graminaceous crops during the past two years and have had little time to give to the Pink Bollworm.

"As you know no doubt, we have *Chilo simplex* here and I think Egypt is saved from very serious loss from this insect (which I think may be from 6-8 brooded) by a minute egg parasite. I will send you specimens of the latter and perhaps you would be so kind as to compare it with your *Chilo* egg parasite and see if it is the same."

Mr. Willcocks' paper and letter answer the question asked just now by Mr. Burt regarding the survival of Pink Bollworm larvæ in bolls which drop off and remain in the field. Of course, these results have been obtained in Egypt and require checking in India, but the conditions are very similar and I have little doubt but that the larvæ do survive, probably over more than one year in many cases, in India also. **Mr. Fletcher.**

I should like to say how much we feel indebted to Mr. Willcocks for sending us this very complete information and also to Dr. Gough for coming here from Egypt and telling us all about their cotton pests. It would perhaps be out of place for us to pass a formal vote of thanks to the Ministry of Agriculture of His Majesty the Sultan of Egypt for sending Dr. Gough to India to attend our Meeting, but I propose to ask the Government of India to thank the Egyptian Government for sending an official delegate in the person of Dr. Gough. We hope that this is not the last Meeting at which we shall see a representative from Egypt.

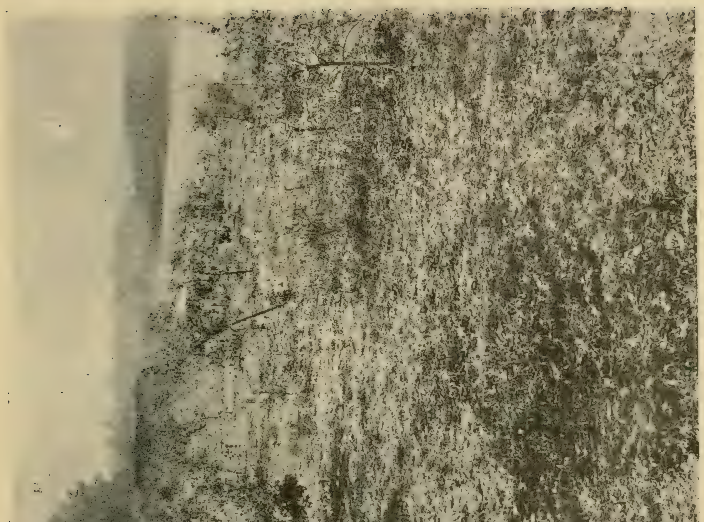
I wish to thank Mr. Fletcher for all that he has said. I have learnt a good deal at this Meeting and the Egyptian Government has got good value for its money. **Dr. Gough.**

20.—SOME PESTS OF COTTON IN NORTH BIHAR.

By C. S. Misra, B.A., *First Assistant to the Imperial Entomologist.*

We first devoted ourselves to the study of the cotton pests in 1906 when a greater portion of the cotton crop was damaged by the bollworms, *Earias fabia* and *E. insulana*, in the Punjab. Subsequently when there was a partial failure of the cotton crop in Sind in 1907 and I was deputed by the Imperial Entomologist to make investigations regarding the incidence of the bollworm attack, the percentage of parasitization, etc., at the instance of the Bombay Government, the importance of a detailed study of the cotton pests was fully brought to the fore. For a few years subsequent to these preliminary investigations we devoted ourselves to the study of the parasites and had some cotton grown at Pusa to allow the parasites to breed and to distribute them to such places, especially the Punjab, when required to do so. Prior to these investigations, some experiments regarding the suitability of cotton as a field crop in North Bihar to make up the loss caused by the low prices of indigo due to the introduction of synthetic colours were carried out by the Imperial Agriculturist, Pusa. In these experiments the varieties of tree cottons, as well as exotics, figured largely and it was found ultimately that cotton as a field crop was not expected to yield financially under the peculiar climatic conditions prevailing in Bihar, where the heavy rains during the growing season were found to retard the growth of the plants so much that they became stunted and sickly in growth. In consequence of this, the flowering as well as the bolling periods were considerably lengthened with the result that the lint in the open bolls was spoiled by the winter rains. It was then found that, along with the climatic conditions, the insect pests damaged the crop considerably and reduced the outturn so much that it was not at all found profitable to grow it. In the beginning, when the plants were hardly six to eight inches high, ground grasshoppers, *Chrotogonus* spp., appeared in enormous numbers and cut away the tops of the tender plants. In one year these were so plentiful that in some plots three to four sowings had to be done before germination could be secured. Later on, when the plants were a foot high, large numbers of *Sylepta derogata* caterpillars appeared in large numbers and damaged the crop considerably. Along with these appeared the shoot-weevil, *Alcides leopardus*, and the stem-weevil, *Pempheres affinis*. The last was so severe, especially in the tree cottons and other broad-leaved exotics, that almost all the plants were affected and showed gall-like swellings on the stems. In some varieties these gall-like swellings weakened the plants so much that they broke in two with the first sharp storm of wind and rain. We tried several measures to circumvent the pest but to no purpose. Removal of the affected plants left very few plants in the plots to make the crop a success. *Broach deshi* was sown as a trap crop between rows of tree cottons and broad-leaved exotics but to no purpose. A series of plants was painted with various deterrent mixtures but all to no purpose. The cost of these was found to outweigh the profits. While these were present, the leaf-hoppers, *Empoasca notata*, appeared in enormous swarms sucking away the sap which would have gone to mature the plants. The leaves curled badly, became pale and seared and dropped off prematurely. The bollworms too did not fail to put in their appearance and completed the cycle by contributing their own share. The Red Cotton Bug, *Dysdercus cingulatus*, and the dusky cotton bug, *Oxycarenus lœtus*, spoiled whatever little lint was left on the cotton plant. (Plate 93.)

Such was the history of the cotton crop in its initial stage of introduction in North Bihar and the consensus of opinion was that the crop could under no circumstances be said to be a profitable one in the particular tract under the peculiar climatic conditions prevailing there. But with us the crop had a different function to perform. We had to grow it for carrying on the bollworms, *Earias fabia*, *E. insulana* and



Midnapur tree-cotton, two years old, affected by stem-weevil (*Pempheres affinis*) and *Machærota planitiæ*; Pusa, 8th February 1918.

Platyedra (*Pectinophora*) *gossypiella*, from generation to generation to allow the parasites to breed and to send these if required either to the Punjab or the North-West Frontier Province as the necessity arose. Now that we have been growing cotton for the last 14 years, we have come to the conclusion that the experiments are considerably hampered by the presence of such insidious pests as :—

Pseudococcus corymbatus, Green.
Phenacoccus hirsutus, Green.
Pseudococcus virgatus, Ckll.
Machærota planitiæ.
Saissetia nigra.
Eriophyes sp. (possibly *gossypii*).

Of these, the mealy-bugs have been especially troublesome, due no doubt to our allowing the cotton crop to remain on the ground uninterruptedly throughout the year. As a part of our investigations regarding the parasitization of the Bollworms, *Earias fabia*, *E. insulana* and *P. gossypiella*, throughout the year, the plants have to remain on the ground and as such the mealy-bugs have run their course uninterruptedly with the result that during the present season the plants became so heavily infested that in some varieties they were denuded of their leaves and appeared white with the cretaceous white flocculent mass of the female ovisacs especially of *Pseudococcus corymbatus* and *Phenacoccus hirsutus*. On some plants the females congregated in such large numbers that their ovisacs coalesced and the shoots, the branches and the stems appeared white at a distance (see photograph). This whiteness was very prominent on the affected plants until a week ago, but now has been washed off by the recent rains. The curled topshoots are still present on the plants (2nd February 1919) and in some varieties there has been so much drain of the plant food that the plants have become gnarled and stunted with hard compact top-shoots and a minimum of leafage on them. Such plants have failed to put forth flowers and bolls and in consequence we got very few bolls this season to continue our weekly cotton countings for the bollworms and their parasites. Of these mealy-bugs *Pseudococcus corymbatus* and *Phenacoccus hirsutus* are the worst. Both appear together on the cotton top-shoots and one who has not worked at them closely will find it difficult, if not impossible, to differentiate the species. But with practice the task becomes fairly easy. The females and eggs of *Pseudococcus corymbatus* are dark castaneous, whilst those of *Phenacoccus hirsutus* are bright pink. The former has been found by me to occur on cotton and soy bean at Pusa, the latter has been found on *Morus* spp. and cotton. *Pseudococcus virgatus* (Plate 94, fig. 1) occurs with these both on *Morus* spp. and cotton and can readily be distinguished from *P. corymbatus* and *Phenacoccus hirsutus* in being pale-white. All the three mealy-bugs appear together on the cotton top-shoots. They can be differentiated easily thus :—

Pseudococcus corymbatus.	*Phenacoccus hirsutus.*	*Pseudococcus virgatus.*
Eggs.—Round, cylindrical, flattened at both ends, dark castaneous, fully covered over with fine cretaceous white flocculent material forming the female ovisac.	*Eggs.*—Round, cylindrical, flattened at both ends, bright pink lying close to each other within the female ovisac made up of thin, cretaceous white cottony threads. The flocculent material is not so sticky as that of *P. corymbatus* and the eggs could be seen distinctly within the ovisac with a hand lens magnifying 10 diameters.	*Eggs.*—Round, cylindrical, flattened at both ends, few, bigger than those of *P. corymbatus* or *P. hirsutus.* Pale yellow. Very thinly covered with a few white cottony threads.
Nymphs.—Deep chocolate, dorsum covered thinly with a whitish meal.	*Nymph.*—Bright pink, dorsum covered with a thin whitish meal.	*Nymph.*—Pale yellow, with two stout, cretaceous threads at pygidial end.
Females.—Dark castaneous, completely covered with sticky cretaceous white ovisac also containing chocolate brown eggs. The female if removed from the ovisac is covered thinly with whitish meal.	*Females.*—Bright pink, to darkpink, cretaceous white cottony ovisac completely covering the female with eggs which too are bright pink. The flocculent whitish material of the ovisac consists of cottony threads which are not so sticky as in *P. corymbatus.*	*Females.*—Pale yellow to dusky yellow at period of gestation, eggs are also pale yellow, fewer in number than those of *P. corymbatus* of *P. hirsutus.* Ovisac does not cover up the female as well as the eggs. The gravid female has two stout caudal threads at anal lobes. The whitish cottony threads forming the ovisac are few and lie loosely below and laterally of the female while laying eggs.

The above description is from specimens not treated with KOH. If these are, however, treated in KOH 10 *per cent.* over a spirit lamp or a laboratory gas-burner, the reactions are very prominent and characteristic.

Pseudococcus corymbatus. Turns deep blackish green or practically black, then deep green, light green, finally clears up after a brisk boil of 7 to 10 minutes. Even then in some cases the visceral contents are not easily ejected. These take a much longer time to clear up.

Fig. 1.—*Pseudococcus virgatus* **on cotton ; Pusa ; 14th April 1918. The same species is also found on mulberry.**

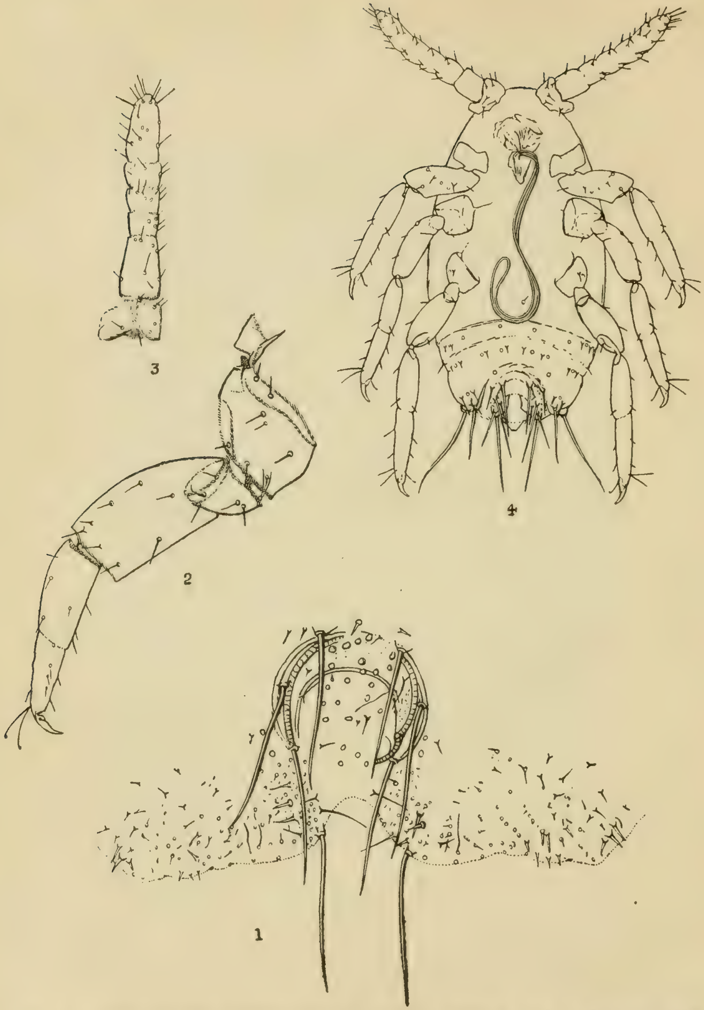


Fig. 2.—*Pseudococcus corymbatus*, Green ; 1, pygidial end of female, much enlarged ; 2, posterior leg of female × 133 ; 3, antenna of newly hatched larva × 67 ; 4, nymph immediately after hatching × 133. (Note presence of lingula.)

Pseudococcus virgatus. The female when treated with KOH 10 *per cent.* turns light brown and begins to clear up 3-4 minutes after boiling.

Phenacoccus hirsutus. When treated with KOH 10 *per cent.* turns bright pink and begins to clear up after 3-4 minutes.

In prepared and mounted specimens the three species may be separated first by their antennæ and then by their pygidial ends. The antennæ in *Pseudococcus corymbatus* are 7-jointed, whilst in *Phenacoccus hirsutus* they are 9-jointed. The anal lobes on the pygidial ends are also important characters to differentiate with.

On the cotton plant the three species of mealy-bugs occur together. But for the last two years we have had much to do with *P. corymbatus* and *P. hirsutus.* Both occur together on the cotton top-shoots and in some cases their ovisacs are so closed together that they form a whitish patch 10 to 15 mm. long. When several hundreds of these are present together on the stems and top-shoots these appear white from a distance as seen in the photographs above. The effect is that the top-shoots become hard and compact and the growth of the plants is retarded considerably, with the result that the flowering as well as the bolling periods are delayed and a minimum number of bolls is put forth. These too are not well developed and a good percentage of them falls off with the least shaking of plants and I think a majority of them become affected with the internal Boll disease so much heard of in the West Indies. No doubt a counting of these windfalls has shown us that a good percentage of them is more or less affected by the bollworms.

Pseudococcus corymbatus (Plate 94, fig. 2, and Plate 95). The eggs lie touching each other within the female ovisac. Each egg is from ·32 to ·36 mm. long and ·15 to ·18 mm. broad, cylindrical, rounded at both ends, somewhat broad in the middle, dark castaneous. The chorion covered with a fine whitish meal. When fully matured, one end becomes translucent under the microscope (aa×b Zeiss) and the fully matured nymph can be seen within. When the nymph hatches a slit opens towards the end suffused with dark chocolate and the nymph comes out, leaving the empty eggshell in the female ovisac. These appear as pale white shrivelled pellicles interspersed freely in the female ovisacs and appear distinctly under the microscope in contrast with the chocolate brown eggs and the whitish threads of the ovisac.

After hatching the nymph moves about in search of food and as soon as it comes upon a succulent place it fixes itself and begins to feed. In the majority of cases observed the nymphs congregated together on the leaf-stalks and the stems of shoots. They are gregarious in habit and a number of them may be seen together on the leaf-stalks and stems—especially the apical ones. In this case I did not find ants attending upon the nymphs to lick the honey-dew as has been seen in the case of *Phenacoccus hirsutus* on cotton. The male nymphs prior to pupation generally remain under a thin whitish floss near the midribs of leaves at the curled lateral portions of leaves. The female nymphs remain feeding and developing near the nymphs, but these are found mostly on the apical shoots. A thin whitish meal covers the dorsum of the female, and appears laterally as well. This is an index that the nymphs have matured into females which are about to lay eggs, which lie close together within the ovisac. In one case a female was observed to lay eggs in a thin line where each egg appeared like a bead. Some time after the same female was observed to have ceased laying eggs. On examination on the 27th January 1919, it was found to have been parasitized by a Chalcidid and on dissection the pupa of the Chalcidid parasite was found near the mentum. This showed that the internal Chalcidid parasite hibernates during the winter within the body of its host, the female.

The nymphs as a rule are dark castaneous and as such may easily be distinguished from those of *P. hirsutus* which are bright pink or from those of *P. virgatus* which are pale-yellow. On some cotton top-shoots the three species of nymphs may be seen feeding together but with the above test they can easily be differentiated. In fact, while I was working out the life-history of *P. hirsutus* causing *Tukra* disease in mulberry, it was a common sight to see the nymphs of *P. hirsutus* and *P. virgatus* feeding together on the same shoots and I used to separate them with the colour test alone and thus could isolate the species for specific observations. Like the females, the nymphs too are parasitized by three species of Chalcididæ. The parasitized nymphs swell up and turn into round cylindrical bodies with both ends flattened. The parasitized nymphs thus become very conspicuous and may then easily be separated under a dissecting microscope from other healthy nymphs. The parasite emerges by pushing out the flattened end at one side, leaving the dead host either on the shoots or near the eggs within the ovisacs. A healthy nymph is dull chocolate brown or dark castaneous, with legs and antennæ stramineous. The dorsum is covered with a thin whitish meal and the abdomen is distinctly segmented dorsally. Setæ to anal lobes concolorous with legs and antennæ, with a pair of stout, whitish threads on the pygidial cleft. This description applies to a nymph just out of the eggshell and not treated with caustic potash. The adult female (not treated with caustic potash) is broad and flat, dark castaneous, with the dorsum covered with a thin whitish meal. Legs and rostral setæ yellow, castaneous.

Fig. 1.—*Pseudococcus corymbatus,* Green, on cotton ; Pusa, January 1919.

Fig. 2.—*Pseudococcus corymbatus,* Green, on cotton ; Pusa, January 1919.

When cleared with KOH and mounted in Balsam, it appears ovoid with the antennæ, legs, mentum, rostral setæ, and the anal lobes distinct.

The male puparium lies on the shoots near the eggmasses of females or away on the curled leaves. It is covered with a thin whitish floss and is very much like the male puparium of *P. hirsutus* excepting that it is dark-brown in colour with the antennæ addressed fronto-laterally. The male is a fragile castaneous brown insect with a pair of broad mealy wings. Its antennæ and legs are light stramineous. They emerge in numbers from August to end of October. The winter is passed in the egg and nymphal stages though females are also to be seen, but the majority of them lie quiescent after having laid the eggs. This year I found a full-developed male lying by the side of empty eggs on the 27th January 1919. The male had fully developed wings and a pair of anal cretaceous white threads and would possibly have emerged had not the temperature gone down. At the time of writing this note (5th February 1919), it is lying by the side of a female ovisac from which the eggs are emerging in large numbers.

The nymphs and the gravid females, as well as those which have laid eggs, are parasitized by three species of Chalcididæ. As already stated above, the parasitized nymph turns deep black-brown in colour and swells up into a miniature cylinder with both the ends flattened. When the adult parasite emerges it pushes out the cap over one end and escapes. A parasitized female ceases to lay eggs and if parasitized when the egg-laying has not been completed the mass of eggs remains uncovered with the whitish cottony threads forming the female ovisace. I have not up till now found any parasites either on the eggs or the adults. Numbers of *Scymnus nubilans* grubs may be seen present in the midst of eggmasses and burrowing below these to reach the female. The grubs have not hitherto been seen devouring the eggs although a few eggs may be seen lying spoiled here and there. The *Scymnus* grubs have been noticed to exhibit an especial liking for the females whom they try to reach by burrowing inside or through the eggmasses even. In one case an eggmass showed no presence of a *Scymnus* grub within, but when it was opened up a *Scymnus* grub was found within burrowing through the eggs to reach the female (13th August 1918). From August to October a number of adult *Scymnus nubilans* was seen on the leaves as well as on affected cotton shoots and this period represents the maximum activity of the cotton mealy-bug *P. corymbatus*. During the last season, 1918-19, it was found that *P. corymbatus* was present in large numbers on the cotton and on soy beans and the number of *P. hirsutus* was less. But by the beginning of November the majority of the nymphs and females of the former were parasitized and an examination of the affected cotton shoots in the middle and end of December showed that *P. hirsutus* was present in larger numbers than *P. corymbatus*. The three species of Chalcididæ found to parasitize *P. hirsutus* are probably the same which parasitize *P. corymbatus*, but in the absence of specific determination I am chary of confirming this view. The identification of Indian Chalcididæ is a tedious business and we have to wait for long months or even years to get the identification of a limited number of specimens even. I hope to send these specimens out for identification soon and on receipt of identifications will communicate them to you if desired.

A Cecidomyiad* has also been found to prey upon the nymphs and adults of this species. The predaceous maggot, which is pale-yellow, pointed at one end and bluntly rounded at the other, may be seen within or near the eggmasses. I have seen these maggots attacking and sucking dry the nymphs and gravid females as well as those that have finished laying eggs. In this case I have not as yet seen the predaceous maggots sucking dry the eggs whose empty eggshells lie stuck upon the ovisac-floss, though I have seen them attacking the eggs of *P. hirsutus*. It is just possible that this observation has escaped me though they might be attacking the eggs as well. The maggot when full-fed pupated *in situ* and the adult fly emerged leaving the empty puparium stuck up in the cottony floss of the female ovisac. An examination of a large number of ovisacs under the microscope revealed the presence of 3 to as many as 7 empty pale-yellow cocoons of the predaceous Cecidomyiad lying bolt upright with prominent frontal sutures on them through which the adult flies had escaped. These cocoons on account of their pale-yellow colour are seen in good contrast against the whitish background formed by the coalescence of two, three or even more ovisacs of the female mealy-bug. This Cecidomyiad fly is the same as the one that preys upon the eggs, nymphs and females of *P. hirsutus* causing *Tukra* disease of mulberry plants and the fact has already been referred to by me under a separate paper on "*Tukra* disease of Mulberry" read at this Meeting.

Besides the Chalcididæ and Cecidomyiad fly parasites and predators on the cotton mealy-bug, *Eublemma quadrilineata* has been also found predacious on the mealy-bug. The caterpillars have been seen to clear off whole colonies of them on the shoots, but their appearance is very spasmodic and cannot be relied upon to be used as agents of destruction of the cotton mealy-bug. The very same

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* Since named by Professor E. P. Felt as *Diadiplosis indica*, n. sp.—*Editor*

species, *Eublemma quadrilineata*, has been seen to clear off colonies of *P. hirsutus* on mulberry shoots, but they appear late when the majority of the damage has been done.

During August-September-October 1912, and again during October last year, a large number of Drosophilids, *Gitonides perspicax*, Knab., was seen on cotton shoots affected by *P. corymbatus* and *P. hirsutus*. Hitherto I have seen only the puparia of the fly lying in large numbers within, near and under the whitish felted material formed by a number of females having congregated together to feed and to lay eggs. The literature so far available for reference shows that Drosophilid flies are not parasitic in habit. They are attracted either by the secretions of insects or by the special aroma wafted from plants infested with plant lice and scale insects.* But in this case I have reasons to believe, though I am not as yet certain, that the flies are predaceous on the female mealy-bugs. I shall avail myself of the next opportunity of confirming the above opinion. In the majority of cases examined the empty puparia of the fly have been seen in large numbers lying close to or below the female mealy-bug in such a position as to show that the fly must have affected the female adversely. In some cases the puparia were found with a portion of the cuticle of the female mealy-bug adhering close to them (Plate 96, fig. 1). However, it is only future observations that will clear up this point. In August 1912 and again late in December 1918, a large number of flies was seen to emerge from cages containing affected cotton shoots. I have hitherto found the fly on affected cotton shoots and in one instance bred it from mulberry shoots affected by *P. hirsutus*. Besides these, a large number of *Anthocorid* nymphs are found on shoots infested by the mealy-bug and it is possible that they are predaceous on both the cotton Aphis and the nymphs of *P. corymbatus*. In one instance a pupa of a Hemerobiid, *Notiobiella* sp., was found on a cotton shoot heavily infested with *P. hirsutus* and *P. corymbatus*, and on the 29th January last, the adult emerged. The pupa was lying embedded in the whitish felted material forming the ovisac of females of the two species of mealy-bugs. As no more nymphs

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* Note.—After this note was read on the 8th February 1919 my attention was drawn to an article in the Bulletin of Entomological Research, Vol. IX, part 2, pp. 157-162, figs. 1-4, September 1918, where Mr. C. G. Lamb had described *Drosophila paradoxa* as being parasitic on a Cercopid of the genus *Clastoptera*. On a further reference to past literature it was found that the late Mr. Frederick Knab had described *Gitonides perspicax* as parasitic on *Pseudococcus* on sugarcane, Honolulu (Hawaii), on *Pseudococcus* common on shrubs and trees, Manila, Philippine Islands, also on a *Pseudococcus*, Philippine Islands. He recorded the distribution for the species from Honolulu (Hawaii), Manila (Philippine Islands) and Pusa (India). The latter specimens were sent to him from a Coccid on cotton shoots.

Drosophilidæ with parasitic larvæ-F. Knab.

Insecutor Inscitiæ Menstruus, Vol. II, No. 11, November 1914, pp. 166-167.

or adults have been found, it cannot be said that the Hemerobiid was truly predaceous. But I mention the case for what it is worth. It is possible that further observations would elucidate the rôle played by the Hemerobiid in a colony of mealy-bugs on cotton shoots.

The next pest to cotton is *Machærota planitiæ*. (Dist., F. I. Rhyn., IV, p. 84). It is recorded from Pusa, Chin Hills, Burma, and Distant records it from Pusa, Muzaffarpur, Igatpuri. It is specially bad on tree cottons and on cotton allowed to remain on the ground for the continuance of experimental work or for rearing parasites on the cotton bollworms, *E. fabia, E. insulana* and *P. gossypiella*. It is specially bad from April to December when a large number of whitish calcareous tubes may be seen attached to the stems and shoots of cotton. In some years when *P. corymbatus* and *P. hirsutus* are present in large numbers, this tube-making Cercopid seems to be specially abundant. The pests combine together to undermine the vitality of the cotton plant to such an extent that it fails to put forth the normal number of flowers and bolls. In particular years, as was the case in 1907, 1912, 1916 and 1917, innumerable tubes were to be seen on the cotton shoots with the effect that these curled up and the leaves were shed. During 1910 it was the case that a few varieties of tree cottons obtained from Bengal were so heavily affected by the Cercopid that the plants had to be removed. From my past experience of the cotton plant at Pusa for the last 14 years, I have found that the Cercopid is at times not to be neglected. In sowings of a great many varieties of cotton for experimental work against the cotton bollworms, it has been found that some varieties are more amenable to attack than the others. Some of the varieties were so heavily infested that they had to be removed from the plots. On such plants the wiry, dirty-white calcareous tubes were found in numbers on the top shoots, stems, axils of stems and even midribs of leaves. Several such tubes were to be seen close together either on the top shoots or the stems. (Plate 96, fig. 2, and Plate 97.)

The pest was observed for the first time during 1907 and it was mentioned by Mr. H. Maxwell-Lefroy in *Indian Insect Life*, p. 733, from unfinished observations made by me. Professor J. O. Westwood had already drawn attention to *Machærota guttigera* from Ceylon, (Notice of a tube-making Homopterous insect from Ceylon, Prof. J. O. Westwood, *Trans. Ent. Soc.* 1886, pp. 329-333, plate VIII, figs. 1—15) and there are two other species of *Machærota* which make calcareous tubes on *Aegle marmelos* and *Phyllanthus emblica*. The one that makes calcareous tubes on *Zizyphus jujuba* is identical with *Machærota planitiæ*, but there seems to be some difference in the colour, shape and size of the tubes on *Z. jujuba*. The genus requires working through when

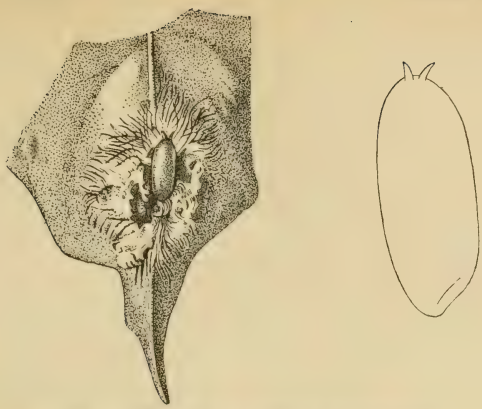

Fig. 1.—Puparium of *Gitonides perspicax.*

Fig. 2.—*Machærota planitiæ* on cotton ; Pusa ; 27th April 1915.

Fig. 1.—Aligarh yellow-flowered cotton badly infested by *Pseudococcus virgatus* and *Machærota planitiæ*; Pusa, 8th February 1918.

Fig. 2.—American upland cotton badly infested by *Pseudococcus virgatus* and *Machærota planitiæ*; Pusa, 8th February 1918.

differences in structure of calcareous tubes, their colour variations, their composition and object in the nymphal stages of the insect, as well as the morphological differences in the shape, colour and size of the pronotal spine can be placed in their proper perspective, and I hope to revert to this subject later on, when I am in a position to draw conclusions from observations made through a series of years.

The adults are very common on the cotton plants from April to October. During the winter I have seen eggs and nymphs within tubes on the plants. Adults are not seen from the middle of December until the middle of February at Pusa. The eggs are laid in the tissues of the plant, on the shoots, soft portions of stems, calyces of flowers, leaf stalks, midribs of leaves and even flower buds. The eggs are either laid singly or in twos or threes but not in masses together. The eggs lie embedded in the tissues of plant. Each egg is about 1 mm. long, dirty-white in colour. The end which lies embedded in the tissues of the plant is pointed, the other is obliquely truncate with a membranous dark-grey cap over it. As the egg matures the membranous cap over the truncate end turns darker and darker in colour until it becomes shiny black prior to the emergence of the nymph. The nymph when about to come out forces out the cap which remains attached to the edge of the eggshell. Towards the pointed end of the egg which lies embedded in the tissues of the plant there is an oblique spine, about as long as the eggshell. The function of the spine is not well understood; it is possibly to secure fixity of the eggs in the plants. The nymph on hatching wanders about for some time, when it fixes itself on a succulent portion of the stem, the leaf-stalk, the shoot and even the midrib of a leaf. Its rostrum is short and pointed. It begins to suck the juice and exude a clear liquid in bubbles which completely surround it. More liquid is exuded until the nymph is covered completely by the froth which on exposure to the air coagulates and the nymph may be seen working it into a thin case round its abdominal segments which are so retractable that they may be seen distinctly expanding and retracting, shaping the semi-plastic material. More liquid is exuded, it is allowed to coagulate and worked up to extend the tube. This goes on until the tube is ready. The abdominal segments of the nymph are so retractable that it is able to exsert them to the entire length of the tube. If however, the nymph is disturbed at the time of making the tube, it leaves its old place, moves about, settles down to feed and to exude a clear liquid in bubbles which coagulates and is worked up into a case to cover the nymph. In some cases the tube just as it was finished by the nymph was removed to see if it would make a fresh one instead. It was found that the nymph again began exuding a clear liquid, which as before was again worked up into a tube. In some cases when the nymphs were removed from their tubal habitations some were observed to re-tenant them whilst others failed to do so and died. In one case a nymph taken out of its tube on 30th May 1912 was able to make another tube 4-5 mm. long by 10·15 a.m. on the 2nd June 1912. The body of the nymph has a shiny coating round it and if exposed for a long time it hardens and the nymph is unable to move about. When the tube is finished, the nymph moves up, fixes itself on the stem within the tube and begins exuding a thin clear liquid which after accumulating at the mouth of the tubes falls on the leaves below in droplets. On hatching, the nymph is 2·5 mm. long with head and legs dark fuscous, abdomen pale yellow to brown, the abdominal segments freely telescopic into each other. As the nymph remains ensconced within the calcareous tube its further developments as well as moults cannot be observed. Nineteen days after hatching, if a nymph be taken out of the tube, its head will be somewhat anteriorly pointed, posteriorly broad, dark fuscous; eyes prominent deep ferruginous; rostrum thick and stout, reaching the anterior legs, dark piceous; the thorax is contracted, with a shiny, black cap over it; the abdomen is pale-brown with the segments telescoping into each other easily; the penultimate as well as the anal segments constructed together forming a tube through which the viscid liquid is exuded. The nymph when about to moult for the last time comes out of the tube and walks up the mouth of the tube for a millimetre or two. It then exudes a clear liquid which settles round the intermediate and the posterior legs. On exposure to the air the liquid thickens and thus holds the legs in position. A longitudinal slit opens dorsally from the vertex of the head to the base of the metathorax and the head comes out. A little jerking sideways brings out the anterior legs and with some further jerking from side to side, the imago comes out clear of the exuvium. It is then grey with light piceous eyes. Fifteen minutes after, the colour changes rapidly and the imago moves about. The exuvium remains attached to the mouth of the tube as seen in figure 6, plate LXXIX, *Indian Insect Life*, facing page 732. The female is more robust than the male and has a strong ovipositor. In the majority of cases the adults were seen to emerge in larger numbers in the mornings than at any other part of the day.

Here I would not go into the morphology of the pronotal spine, as well as the presence of the accessory tube to the main nymphal calcareous tube. These I reserve to speak on some future occasion.

Up to this time I have found neither any parasite on the eggs, nymphs or adults nor any predator which can be said to check the pest from increasing unduly. Besides cotton, I have seen the tubes with adults on *Hibiscus panduriformis* at Pusa when the crop was being tried as a fibre crop. The tubes as well as the habits of the nymphs correspond with those found on *Zizyphus jujuba.* In particular years and on some varieties of cotton this pest is really very serious and does more damage than either *Sylepta derogata* or other leaf-eating caterpillars put together. During 1912, a complete cycle was found to last for 40-41 days thus :—

Eggs laid	21st April 1912.
Eggs hatched	28th April 1912.
Adults emerged . . .	31st May 1912 to 1st June 1912—40-41 days.

Next to the three mealy-bugs, *P. hirsutus*, *P. corymbatus* and *P. virgatus*, and *Machærota planitiæ*, the cotton *Eriophyes* (probably *Eriophyes gossypii ?*) has been found in certain years to retard the growth of the plants considerably. Prior to 1914, stray specimens were found on the leaves of certain varieties of plants. But in 1915 and again in 1916 the pest was found to have extended its range and to be more or less present on all the short-leaved varieties of cotton. At first it appears as a small whitish spot on the leaves, which increases with the subsequent curling of the leaves. It has been found bad on certain varieties of cotton, especially those obtained from the Bombay Presidency. As varieties of cotton from the United Provinces such as Aligarh white and Aligarh yellow were sown close to those of Bombay, these in turn again became heavily infested and in consequence some of the worst infested plants had to be removed from time to time and burned. At first if the tiny silvery or brownish spots are examined under the microscope, the adults will be seen as tiny little whitish mites with body distinctly transversely ringed moving freely about the proliferation of the leaf-tissues caused by them. Soon after the whitish patch extends until a greater portion of the leaf-surface becomes affected. The leaf then becomes hard and crisp and the adult mites move on to fresh leaves leaving behind them a few adults in their old tenements to extend the colonies. The eggs are whitish, ovoid, and very large for the size of the mite. When several leaves are affected, especially the top leaves, they become hard and compact. The plant is considerably thrown back in growth and is not able to recoup its lost vitality. If an infested cotton leaf be examined under a high power under the microscope, innumerable tiny whitish elongate cylindrical bodies will be seen either moving about freely or lying either upright or at an angle against the plane of the leaf. The mites were found to congregate on the leaves on the top shoots which became compact. They were also found on other leaves as well, such leaves either curling over at the sides or crumpling badly. As the plants were not to be treated so as not to disturb the normal conditions prevailing in the cultivators' field, the pest got well established and damaged the crop to a great extent, so much so, that even the bolls became affected, shrivelled up and fell down. The mite in conjunction with the three mealy-bugs referred to above and *Machærota planitiæ*, vitiated some of our experiments a good deal. As spraying either with soap and flowers of sulphur or resin fish-oil soap and sulphur was out of the question, the worst affected plants were pulled out and burned. But this was a very drastic measure, as with its wide and frequent application very few plants were left in the experimental plots to continue the experiments against the Bollworms. This year we have tried the fumigation of cotton seed with CS_2 prior to sowing and there appears to be less whitish mould or cotton *Eriophyes* on the plants. But it is still to be seen later on whether they remain such till the end of the season. The mite has been reported from Bombay as well as Hansi in the Punjab. The disease has also been reported from :—

Surat	1908, 1909, February 1909, October 1906.
Kirkee	January 1909.
Nadiad	December 1907.
Baroda	March 1907.
Sibpur	July 1905.
Cuttack	November 1906.
Pusa	1912, 1915.

In Surat the disease is known as *Chhasio* or *Chasiu* and *Badi Rog* in Dharwar on account of the ash-like appearance of the curled leaves. In occasional years it has been reported to cause as much as 50 per cent. damage. (*Annual Report. Surat Farm*, 1908-1909). The Superintendent of the Surat Farm reported that the disease was especially bad during 1906. Specimens of mites on cotton leaves from Surat were sent to Mr. Nathan Banks and he reported "....the mites agree with my *Eriophyes gossypii* from the West Indies. The leaves do not seem to be as badly affected as those I had from the West Indies."

As an adjunct to fumigation we have also tried on a small scale treating the seed with corrosive sublimate solution 1 in 1000 (*Tropical Agriculturist*, Vol. XXXIII, September 1909, p. 209) and find that the effect has been good.

The Black Scale, *Saissetia nigra*, has also been bad occasionally. Certain varieties of cotton appeared to be more affected than the others. It was bad in patches in the beginning—especially during 1912 and 1914 and even now occasional plants are met with which are very heavily infested by the black scale. The infested plant becomes conspicuous, looks sickly and withers away prematurely. Prompt removal of such plants is necessary to secure safety of the other plants. This has also been reported to occur on cotton at Coimbatore in South India.

In Madras we have four species of Coccids on cotton, but none of them is serious. *Saissetia nigra* attacks isolated plants and every plant thus attacked is killed. Last year (1918) ten plants in a patch were attacked and parasites were found in all the Coccids. *Pseudococcus corymbatus* is found not only on cotton but on jak also. On cotton it occurs late, when the plants are left for another picking. *Œcophylla smaragdina* is found attending this Coccid. A *Pseudococcus* also occurs on cotton. *Pulvinaria maxima* is a bad pest of *nîm* [*Melia azadirachta*] trees in the South. The *nîm* is a valuable tree with us. Of late years we find *P. maxima* occurring on cotton also. **Mr. Ramakrishna Ayyar.**

Cerococcus hibisci also occurs at times on cotton in Madras. **Mr. Fletcher.**

In Mysore we get *Saissetia nigra* and *Pulvinaria maxima.* **Mr. Kunhi Kannan**

In Egypt we have a mealy-bug which has only appeared recently. It attacks by preference *Erythrina*, mulberry, *Hibiscus* and cotton. It has not been identified; it gives a red colour to alcohol. It also attacks many other plants, but it only seems to go through one or two stages on these and does not attain to maturity on them. I want to get parasites for this mealy-bug. **Dr. Gough.**

Is *Oxycarenus* bad on cotton in Egypt? **Mr. Robertson-Brown.**

*Oxycarenus** is a very bad pest with us, and there is going to be a special investigation regarding it. If it attacks garden hollyhock of the European variety, the leaves curl up and budshedding occurs. Forty *per cent.* of the flowers fail to mature on account of the sucking of *Oxycarenus.* I believe that about eighty *per cent.* of the seeds of cotton are rendered useless by this insect. **Dr. Gough.**

I would like to know if anyone has any experience of *Aphis gossypii*?

We have found it very bad on Cambodia cotton. This ought to be grown as an annual plant but it is often grown as a perennial. **Mr. Ramakrishna Ayyar.**

With us it acts in the edges of the fields and along road-sides. **Dr. Gough.**

Smooth-leaved and partially smooth-leaved varieties are attacked more by this *Aphis*. It may be only a secondary agent. **Mr. Burt.**

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* The species referred to is presumably *O. hyalinipennis*.—*Editor.*

21.—LIST OF THE PESTS OF FIBRE-YIELDING PLANTS IN BURMA.

By K. D. Shroff, B. A., *Entomological Assistant, Burma.*

Pest	Part of the plant attacked	Remarks
	1. Cotton.	
Brachytrypes portentosus	Seedlings	Once proved very serious in the Sagaing district.
Epacromia tamulus	Leaves	Not serious.
Cyrtacanthacris ranacea	Do.	Ditto.
Aularches miliaris	Do.	Reported "serious" from Myingyan in 1918.
Diacrisia obliqua	Do.	Not serious.
Tarache crocata	Do.	Ditto.
Sylepta derogata	Do.	Sometimes serious.
Astycus lateralis	Do.	Not serious.
Dereodus sparsus	Do.	Ditto.
Earias fabia	Buds and Bolls	Major pest. Very serious.
Earias insulana	Do.	Major pest. It is less serious than *Earias fabia.*
Earias chromataria	Do.	Only one moth reared from a boll.
Gelechia gossypiella	Buds and Seed	Major pest. Very serious
Dysdercus cingulatus	Seed (Sucking)	Major pest.
Oxycarenus lœtus	Do.	Minor pest.
Dolycoris indicus	Juice (Sucking)	Not serious.
Graptostethus servus	Do.	Occurs in large numbers but rarely injurious.
Jassids	Do.	Not serious.
Aphis gossypii	Do.	Sometimes very serious.
Cerococcus hibisci	Do.	Very serious to exotic cottons.

21.—LIST OF THE PESTS OF FIBRE-YIELDING PLANTS IN BURMA—*contd.*

Pest	Part of the plant attacked	REMARKS
	1. COTTON—*contd.*	
Mealy bugs	Juice (Sucking) (Shoots)	Not very serious
Mealy bugs	Juice (Leaves and small fruits).	Not very serious.
Alcides sp.	Stem, branch	Not very serious.
Zeuzera coffeæ	Do.	Found only once in exotic cotton.
Chafer grubs	Roots	Once proved very serious in the Sagaing district.
	2. SANN HEMP.	
Flea Beetles	Leaves	Minor pest.
Utetheisa pulchella	Leaves and Pods	Serious pest of sann hemp.
Argina cribraria	Do.	Only once noticed during 11 years.
Argina syringa	Do.	Ditto.
Nezara viridula	Plant-juice	Minor pest; scarcely serious.
	3. JUTE.	
Diacrisia obliqua	Leaves	Sometimes serious.
Chrysomelid beetles	Do.	Found attacking full-grown plants before harvest at Tatkon.

22.—INDEX TO INDIAN FRUIT-PESTS.

By C. S. Misra, B.A., First Assistant to the Imperial Entomologist.

Alphabetical List of Fruit-trees quoted.

Almond (Country), (*Terminalia catappa*).
Averrhoa carambola.
Apple (*Pyrus malus*).
Apricot.
Bael (*Ægle marmelos*).
Ber (*Zizyphus jujuba*).
Berberry.
Cashew (*Anacardium occidentale*).
Carissa carandas (*Karonda*).
Cherry.
Cherramoya.
Chestnut.
Citrus spp. (orange, lemon, pomelo, etc.).
Coconut (*Cocos nucifera*).
Custard-apple.
Date Palm(*Phœnix sylvestris*) (*Khajur*).
Fig (*Ficus carica*).
Gooseberry (*Physalis peruviana*).
Greengage.
Guava (*Psidium guyava*).
Grewia asiatica.
Jamun (*Eugenia jambolana*).
Jak (*Artocarpus integrifolia*).
Loquat (*Eriobotrya japonica*).
Litchi (*Nephelium litchi*).
Mango (*Mangifera indica*).
Melon (*Cucumis melo*).
Mulberry (*Morus* spp.).
Nectarine.
Olive.
Papaya (*Carica papaya*).
Peach (*Prunus persica*).
Pear (*Pyrus communis*).
Phyllanthus emblica.
Phoont (*Cucumis trigonus*).
Plantain (*Musa sapientum*).
Plum.
Pomegranate (*Punica granatum*).
Sapatu, or Alligator-pear (*Achras sapota*).
Strawberry.
Tamarind (*Tamarindus indica*).
Vine (*Vitis* spp.).
Walnut.
Water-melon (*Citrullus vulgaris*).
Water-nut (*Trapa bispinosa*).
Wood-apple (*Feronia elephantum*).

Almond (Country) (*Terminalia catappa*).

Leaves .	*Selepa* (*Plotheia*) *celtis* . .	..	Pusa . .	Cage No. 1675, Larva gregarious, nibbling epidermal layers and internal tissue; grown-up caterpillars biting leaves from edge.
	Metanastria hyrtaca . .	S. I. I., pp. 409-10	Coimbatore, Chingleput, Ganjam.	
	Amblyrrhinus poricollis Boh. .	..	Pithapuram (Godavari).	Larva, almond leaves.
	Apoderus tranquebaricus F. .	S. I. I., pp. 335-336, f. 193.	Chepauk (Madras).	Twisting country almond leaves.
	Trabala vishnu, Lef. . .	Hmpsn., F. I. I., 421 422, f. 293; I. M. N. V. 107; I. I. L., p. 498, t. 46.	India, Burma, Pusa.	
	Acrocercops supplex Meyr. .	..	Pusa . .	Larva mining leaves.
	Acrocercops terminaliæ, Stt. .	Stainton. T. E. S. (3)1, 298-299, t. 10, f. 8 (1862).	Calcutta . .	Larva mining in leaves; not a pest.

Averrhoa carambola (Vern., *Kamrak*).

Flowers .	*Diacrotricha fasciola*, Z. . .	..	..	Larva bores into flowers and destroys them.

APPLE (*Pyrus malus*).

Leaves	Chrysomelid (Gen.? sp.?) . .	..	Solan 7th Aug. 1915.	I. R. 568 of 1915.
	Lymantria obfuscata Wlk. .	Hmpsn. F. I. I., 460-461.	Kashmir	Larva damaging leaves; also on apricot, poplar and willow.
	Euproctis scintillans . .	Hmpsn. F. I. I. 485, f. 322; I. I. L., pp. 460-461.	Shillong.	
	Sphingid (Gen.? sp.?) . [Langia zenzeroides.]	..	Shillong; Kulu.	Larva, a serious pest of apple, and to a less extent of pear about the end of June. It does considerable damage. One larva will strip a whole branch of leaves. One brood annually, pupæ hibernating.
	Belippa laleana, Mo. . .	I. I. L., p. 501, t. 28, f. 14.	Coorg; Shillong.	
	Notodontidæ (Gen.? sp.?) . .	..	Shillong . .	Larvæ in small numbers at end of June. Larvæ eat leaves from one side and are very difficult to detect as their coloration is highly cryptic, resembling a withered edge of the leaf.
	Geometridæ (Gen.? sp.?) (near *Hyperythra ?*)	..	Shillong 21st June 1918.	Larva on apple leaf.
	Geometridæ (Gen.? sp.?) (Boarmianæ).	..	Shillong . .	Larvæ in small numbers, but does a good deal of damage, as the larvæ are stick-like and large and not easy to see.
	Limacodidæ (Gen.? sp.?). .	..	Ditto. . .	On apple in some numbers.
	Virachola isocrates, Fb. . .	S. I. I., p. 416, f. 289; Bell. B. J. XXIV, 184.	Plains of India except North-west of United Provinces, not noted in Burma. Coimbatore, Bangalore, Surat, Pusa, Nagpur.	
	Soritia leptalina, Koll. . .	Hmpsn. F. I. I. 252, f. 168.	Shillong . .	In some numbers.

APPLE (*Pyrus malus*)—*contd.*

Leaves—*cont.*	*Gracillaria zachrysa* Meyr.	Proc. 2nd Entl. Meeting, p. 248.	Parachinar, Abbottabad, Peshawar, Shillong.	Larva first mines the leaves afterwards ties up the leaves gnawing the green substance on upper side of leaf; young leaves are destroyed in this way. A decided pest of apple.
	Dasychira horsfieldi, Saund.	B. J. XIII, 414	Pusa, 20th September 1909.	Larva on leaves. (One specimen reared on apple leaves.)
	Brahmina coriacea, Hope	..	Chavai; Kulu, Jeolikote.	Defoliating by night. Also on pear tree.
	Anomala variivestis, Arr.	Arrow, F. I. Rut., p. 156, t. 3, ff. 20-21.	Shillong 23rd-26th June 1918.	Defoliating fruit trees.
	Anomala dimidiata Hope	Arrow F. I. Rut. pp. 232-233.	Chawai Kangra	Adult damaging fruit chiefly.
	Anomala rufiventris, Redt.	Arrow F. I. Rutel. pp. 236-237.	Ditto	Adult defoliating tree coming in swarms at night, no trace during the day. Do a great deal of damage.
	Adoretus duvauceli, Bl.	Arrow F. I. Rut. pp. 343-344; Ento. Note 21.	Jeolikote.	
	Adoretus horticola, Arr.	Arrow F. I. Rut. p. 344; Ento. Note 20.	Ditto	Damage by night.
	Adoretus versutus, Har.	F. I. Rutel. pp. 350-351; Ento. Note 20.	Ditto.	
	Dereodus pollinosus, Redt.	Mshll. F. I., Curc. I., 121.	Kulu	Attacking wild apples defoliating them.
	Emperorrhinus defoliator, Mshll.	Mshll. F. I. Curc. I., 236-287.	Kulu	Alternative food *Alnus nitida*.
	Myllocerus 11-pustulatus, Fst.	Mshll. F. I. Curc. I., 350-352.	Bangalore	On leaves and shoots.
	Deiradolcus sp.	(Unpublished name).	Shillong, June-July 1918.	Nibbling holes on leave, doing considerable damage; collection by hand.
	Haplosonyx trifasciatus	..	Ramgarh United Provinces	Eats tips of fresh apple leaf growth.
	Prodenia litura	..	Jeolikote, United Provinces.	
	Dasychira mendosa	..	Jeolikote.	

APPLE (*Pyrus malus*)—*contd.*

Leaves—*contd.*	*Dasychira* sp.	..	Jeolikote	Reported by Mr. Norman Gill.
	Prodenia litura	..	Ditto.	Mr. N. Gill sent the specimen on Apple. He fed it on castor leaves.
	Euproctis flava	..	Lyallpur, 27th June 1917.	(File; Pusa.)
	Tiracola plagiata Wlk.	Hmpsn. Cat. Lep. Phal V, 258-259, f. 51.	Shillong	One larva found on apple eating leaves, 11th-12th August 1918.
Shoots	*Alcides mali*, Mshll. MS.	..	Ditto.	Larva boring shoots of apple causing a gall-like swelling.
Fruits	*Mimastra cyanea*, Hope	I. M. N. IV, 4, p. 217.	Jeolikote	Adult on fruits.
			Hills near Simla	Defoliating trees including wild *Pyrus Pashia*, recurring annually at end of May. Flying in morning and late afternoon resting at mid-day. (I. H. Burkill, 28th May 1906.)
	Dyscerus fletcheri, Mshll., MS.	..	Shillong, June 1918.	Larva boring in apple fruits. Adults lived in Insectary, Pusa, until October 1918.
	Dyscerus malignus, Mshll., MS. (Black weevil).	..	Ditto	Larva boring into apple fruits, as well as in *Prunus nepalensis*.
	Laspeyresia pomonella, Linn.	..	..	The notorious codling Moth of Europe. Recorded from Dras Ladak (7,000 ft.) in Kashmir. Not recorded hitherto from any other part of India.
Stems	*Linda nigroscutata*, *Fairm*	..	Shillong, June-July 1918.	Girdling apple twigs and ovipositing in them. Larva boring. Adults on trees and girdled twigs.
	Lophosternus hugeli Redt.	Gahan. F. I. Ceram, pp. 11-12; Stebbing. F. Inst. Coleop., pp. 274-275, t. 17.	Chaubatia (Kumaun).	Boring apple trees. Larva attacking root and trunks of trees.
Roots	*Lophosternus hugelii* (Cerambycid).	..	Chaubatia, Kumaun, United Provinces. (I. R. 199; 5th June 1916.)	

APRICOT.

Leaves	*Emperorrhinus defoliator*, Mshll.	Mshll. F. I., Curc. I, 286-287.	Kulu	Alternative food plant *Alnus nitida*.
	Mimastra cyanea, Hope	I. M. N., IV, 4, 217.	Jeolikote; Sambli (Murree Hills).	Defoliating trees.
	Chrysomelid (Gen.? sp.?)	..	Solan, 7th August 1915. (I. R. 568).	Attacks and ruins leaves of large apricot trees.
	Lymantria obfuscata, Wlk.	Hmpsn. F. I. I., 460-461.	Kashmir	Larva on leaves.
Shoots	*Anomala polita*, Blanch	Arrow F. I., Rut., pp. 146-147, t. 2, p. 24.	Jeolikote	Adult on shoots and on tree.

BAEL (*Aegle marmelos*).

Leaves	*Clitea picta*, Baly	Proc. 2nd Ent. Conf., 1917, p. 215.	Pusa	Leaves and shoots.
		Se. Hund. notes	Tharrawady	At Pusa larva bores into leaf petioles and shoots; adult destroys leaves, eating small holes on them.
	Phyllocnistis citrella	S. I. I., p. 465, f. 341.	Sibpur	Larva mines leaves.
		Proc. 2nd Ent. Conf., 1917, p. 215.	Pusa.	
	Papilio demoleus, L.	S. I. I., pp. 412-413, t. 25.	Pusa; S. India.	
		Proc. 2nd Ent. Conf., 1917, p. 215.		
	Myllocerus discolor	Proc. 2nd Ent. Conf., 1917, p. 215.	Pusa	Scarcely a pest Adult on leaves.
	Aspidiotus orientalis	Proc. 2nd Ent. Conf., 1917, p. 216.	Do.	
	Amblyrrhinus poricollis	Proc. 2nd Ent. Conf., 1917, p. 219.	Do.	Not a pest.
Fruits	*Chætodacus zonatus*, Saun., (*persicæ*)	Bezzi. Bull. Ent. Res. VII, 105-106, 1916.	..	Ripe Bael fruit.
		Proc. 2nd Ent. Conf., 1917, p. 216.	Pusa	Reared from fallen Bael fruits.
	Argyroploce illepida, But.	S. I. I., pp. 449-450, f. 327.	Plains of India, Ceylon; Surat; Pusa.	Bores into the fleshy portion of the fruit.
		Proc. 2nd Ent. Conf. 1917, p. 230.		
	Euzophera plumbeifasciella, Hmpsn.	Hmpsn. F. I., IV, 73.	Pusa, 4th March 1914, 4th January 1915, Coimbatore.	Larva in pulp of fruit.

Ber (*Zizyphus jujuba*).

Leaves	*Myllocerus discolor*	Mshll. F. I., Curc. I, 348-350, f. 106.	Pusa	Adult on leaves.
	Myllocerus 11-pustulatus, Fst.	Mshll. F. I., Curc. I., 350-352.	Do.	Ditto.
	Peltotrachelus pubes, Fst.	..	Shevaroys	Adult (few only) on trees.
	Platymycterus sjöstedti, Mshll.	..	Daltonganj	Adult on Ber.
	Phytoscaphus triangularis, Ol.	..	Pusa	Adult on leaves.
	Amblyrrhinus poricollis, Boh.	..	Cuttack.	
	Xanthotrachelus faunus, Oliv.	Ento. Note No. 27	Pusa	Adult (many).
	Xanthotrachelus superciliosus, Gyll.	..	Do.	Adult on ber (one only).
	Lixus brachyrrhinus, Boh.	S. I. I., pp. 331-332, f. 189.	Daltonganj ; Mandalay.	
	Platypria andrewesi, Weise	..	Surat ; Pusa	At Pusa larva mines leaves.
	Beara dichromella, Wlk.	Hmpsn. F. I., II, 428.	Pusa	Larva on leaves, but not a pest.
	Euproctis lunata, Wlk.	Hmpsn. F. I., I., 472-473.	Lyallpur.	
	Taragama siva, Lef.	I. I. L., p. 497, t. 41, ff. 8-11. Hmpsn. F. I. I., 405-406.	Pusa.	
	Tarucus theophrastus, Fb.	Bingham F. I., II., 417-419, t. 20, f. 151.	India, Burma, Ceylon.	A minor pest of grafted Ber trees in Central Provinces.
	Ancylis lutescens, Meyr.	Meyr. Exot. Micro. I., 32 (1912).	Pusa	Larva rolls tender leaves fairly commonly at Pusa, once found boring into fruits ; scarcely a pest.
	Porthmologa paraclina, Meyr.	Meyr. Exot. Micro I., 261 (1914).	Ditto.	Larva rolling leaves and boring into the shoots ; not a pest.
	Tischeria ptarmica, Meyr.	Rec. Ind. Mus. II. II, 399 ; I. I. L., p. 540.	Orissa	Larva mines leaves, sometime a minor pest.
	Thiacidas postica	S. S. I., pp. 395-396, I. I. L., p. 459, f. 313; B. J. XVI, 199.	Pusa, Bilaspur, Coimbatore.	Larva on leaves, scarcely a pest.
	Antheræa paphia	Injurious insects of Indian Forest Stebbing, p. 90.	Chota Nagpur, Central India, South India.	
	Cricula trifenestrata	*Vide S njiboni* (a Bengali paper, 2nd April 1912).	Vikrampur, Dacca, Comilla.	Larva on leaves.
	Dilinia capitata	..	Pusa, 8th January 1910.	Larva (looper) on leaves.
	Dilinia medardaria	..	Pusa, 28th September 1907.	Larva on green leaves.

Ber (*Zizyphus jujuba*)—*contd.*

Leaves	*Tarucus theophrastus*	..	Pusa, 10th June 1906, 6th July 1907.	
	Tanymecus hispidus	Mshll. F. I. Curc. I, 98, f. 24.	Pusa	Adult on leaves.
	Myllocerus sabulosus Mshll.	Mshll. F. I. Curc., 336-337.	Do.	Adult in some numbers.
	Myllocerus transmarinus, Hbst.	Mshll. F. I. Curc. I., 337-338, f. 102.	Do.	Adult on leaves.
Shoots	*Anarsia sagittaria*, Meyr.	Meyr. Bom. Jour. XXII, 774-775 (1914).	Do.	Larva in top shoots June-July. Not a pest.
Fruits	*Meridarchis scyrodes* Meyr.	One Hund. Notes, p. 28; Meyr. Exot. Micro. II, 30 (1916).	Surat, Nagpur, Pusa, Coimbatore.	Larva bores into fruits.
	Carpomyia vesuviana	Proc. 2nd Ent. Meeting, p. 11-254, 1917.	Coimbatore, Pusa, Poona, Hadagalli.	Maggots in fruits.
	Curculionid (Gen.? sp.?)	..	Poona, Augt. 1915.	Larva in fruits called Ahmedabad variety. Attacked fruits become round berrylike. R. S. K.'s letter of 25th September 1916.
Stems	*Arbela tetraonis*, Mo.	S. I. I., pp. 453-454, f. 41.	Pusa	Larva boring in stems and branches.
?	*Cœlosterna scabrator*, Fb.	S. I. I., p. 325-326, f. 181. Stebbing Forest Inst., Coleop., p. 358-362, f. 25.	Poona, 1st June 1910.	On *Zizyphus* (It was not stated on what part of plant.)

Berberry.

Leaves	*Anomala dimidiata* Hope.	Arrow, F. I. Rut., pp. 232-233.	Chawai (Kangra)	Appears during June and July every year; found on trees in sunny places, completely defoliating trees.

Cashew (*Anacardium occidentale*).

Leaves	*Cricula trifenestrata*	S. I. I., 405-406	Damper parts of South India.	An occasional pest.

Carissa carandas (*Karonda*).

Leaves	*Agathia visenda*	..	Pusa, 13th May 1914.	Larva on leaves.
	Nephele didyma	..	Pusa	Ditto.

CHERRY.

Leaves	*Serica marginella*, Hope	..	Shillong, May 1905.	Adult on cherry.
	Serica maculosa, Brenske	..	Do.	Ditto.
	Serica clypeata, Brenske	..	Do.	Ditto.
	Anomala transversa, Burm.	Arrow, Rut., pp. 142-143, f. 33; Entl. Note 43.	Do.	Adult on leaves in numbers.
Borers	Buprestidæ (Gen.? sp.?)	..	Simla	These were found on imported five-year old cherry trees. The larva hatched between bark and wood. Pupa was embedded in the hard wood. The outside was riddled with oval holes.
Sucking	*Chionaspis* sp.		Shillong	Fletcher collection, 16th July 1918.
Stems	*Aristobia approximator ?* Thoms.	..	Taung-gyi	Larva boring stems and branches.

CHESTNUT.

Leaves	*Mimastra cyanea*, Hope.	I. M. N., IV, 4, 217.	Jeolikote	Adult on leaves.

Citrus spp.

Leaves	*Peltotrachelus pubes*, Fst.	..	Shevaroys	Adults on orange in some numbers.
	Psychid		Pusa	April 1913—Larva feeds on orange twigs; scarcely a pest.
	Cacœcia epicyrta Meyr.	..	Solan (near Simla)	Larva, orange leaf.
	Papilio demoleus, Lin.	Proc. Sec. Ent. Conf., 1917, p. 210; I. M. N., II, 6, p. 156; I. M. N. I., No. 2, pp. 93-95; S. I. I., p. 412-413, tab. 25; Ent. Mem. Vol. V, pp. 33-38, tab. 6.	South India, North-West Frontier Province. Plains of India, Burma, Ceylon.	Destructive to large plants. Alternative food *Aegle marmelos* and *Psoralea*.
	Papilio polytes	Proc. Sec. Ent. Conf., 1917, p. 210.	India, Burma, Ceylon.	Alternative food *Murraya kœnigi*.
	Papilio memnon, L.	Ditto	Myitkyina (Upper Burma).	Adult ovipositing on orange trees at Myitkyina, Upper Burma, September 1914. A minor pest of orange.
	Papilio helenus daksha	Ditto	South India Hill Districts.	

Citrus spp.

Leaves .	*Papilio polymnestor* . .	Proc. Sec. Ent. Conf., 1917, p. 210	South Coorg .	Serious on orange trees in Coorg.
	Chilades laius . . .	Bingham F. I. I., II, 50-51, t. 12, f. 85 ; Proc. Sec. Ent. Conf., 1917, p. 210.	India, Burma, Ceylon.	Larva on orange, lime and pomelo. Ichneumon. *Dioctes vulgaris* parasitizes.
	Chrysomelid beetle . . .	Proc. Sec. Ent. Conf. 1917, p. 210.	Myitkyina (Upper Burma)	Rolls the leaves ; minor pest of orange and lemon.
	? *Chilades putli* . . .	..	Pusa . .	On leaves ?
	Tonica zizyphi . . .	S. I. I., p. 459. f. 335.	Chapra, Peshawar, Coimbatore, Nagpur, Pusa.	Larva rolling lemon leaves. Also on *Murrya kœnigii*.
	Chilades laius, Cram. . .	Bingham F. I., II, 365-367. I. I. L., p. 426.	Pusa, 12th July 1915.	A minor pest. Larva on orange, lemon, lime, pomelo. Larva attended by ants (*Tapinoma melanocephalum*).
	Hypomeces squamosus, F. .	Mshll. F. I., Curc. I, 116-117, f. 39.	Myitkyina .	Adult on orange.
	(Miners) *Phyllocnistis citrella* .	Proc. Sec. Ent. Conf., 1917, p. 210.	Pusa ; S. India.	Common on rough lemon.
		S. I. I., p. 465, f. 341.	Burma . .	Larva mines leaves, and epidermis of green shoots, doing considerable damage.
Shoots .	(Lamiadæ) Gen.? sp.? . .	..	Latu (Assam), C. No. 1766.	Larva boring orange shoots.
Flowers .	*Prays citri*	Proc. Sec. Ent. Conf., 1917, p. 212. Ent. Note 89.	Plains, Coorg, Pusa, Ceylon.	Larva devours flowers, bores into shoots, tunnels the rind of fruits.
	Oxycetonia albopunctata . .	Ditto .	Pusa . .	Eats lemon flowers at Pusa.
	Colasposoma semicostatum Jac. .	Ditto Ent. Conf. 1917, p. Note 89. F. I. Chrysom, p. 443.	Assam, Chapra, Khasi Hills.	Injures flowers in Assam. Adult destroyed flowers and leaves of orange trees in March and April 1916 in the Khasi Hills ; said to have done considerable damage to oranges. Appear generally in March and April.
Fruits .	*Chætodacus ferrugineus dorsalis* Hendel.	Bezzi. Bull. Ent. Res. VII, 104-105, 1916.	Mandalay, Myitkyina.	Larva in mango and chillies.
	Chætodacus diversus, Coq. .	Bezzi. Bull. Ent. Res. 108-109, 1916.	..	Originally bred from oranges.

Citrus spp.—*contd.*

Fruits—*contd.*	*Ophideres fullonica*	Proc. Sec. Ent. Conf. p. 212; Entl. Note 64, figs. 11-12.	Pusa, Bombay	Larva on *Tinospora cordifolia*. Damages orange fruit at Poona. Attacks pomelo fruits, attacked fruits fall down.
	Rhynchocoris humeralis, Thun.	One Hnd. Notes, p. 35, fig. 18; Fauna, Ind. Rhyn. I, 212-213, fig. 130.	Myitkyina (Upper Burma).	
	Virachola isocrates	Proc. Sec. Ent. Conf., 1917, p. 212. S. I. I, pp. 416-417.	Nagpur; South India.	Occasional borer in orange.
	Heliothis obsoleta	Ditto	Peshawar	Caterpillars gnawed the fruits.
	Anthomyiad fly	Ditto	Nilgiris.	
	Chætodacus ferrugineus	Proc. Sec. Ent. Conf., Pusa, 1917, p. 226. Bull. Ent. Res. VII, 104.	Myitkyina	Pomelo.
	Chætodacus caudatus	Ditto	Do.	Pomelo fruits; also in gourds.
	Vitellus sp. (Pentatomid)	Annual Rept. Dept. of Agri, Madras, 1917-18, p. 75.	Kurnul	Ripening oranges.
	Heliothis obsoleta, Fb.	S. I. I., pp. 373-374, f. 235.	Peshawar	Larva boring into fruits.
	Anthomyiad	..	Toong, Darjiling District.	Larvæ boring into healthy lime and orange fruits. Possibly this is the same as the Tomato fly (Proc. Sec. Ent. Meeting, p. 178, 1917), attacking rotting fruits.
Stems	*Arbela* sp. probably *quadrinotata*	..	Nagpur; May 1914. Bangalore.	Larva boring into green orange branches A serious pest at Nagpur.
	Monohammus versteegi Rits.	..	Haflong, Khowang (Assam).	Larva boring orange stem at Haflong. Boring into pith of young stems of orange trees, the leaves turn yellow and the branch withers.
	Gnatholea eburifera, Thoms.	F. I. Ceram., p. 111	Moulmein; Kyain (Karin Hills).	Larva boring stems and branches of orange.
	Chelidonium cinctum	F. I. Ceram. p. 210	Bangalore	Larva boring into orange branches.

Citrus spp.—*contd.*

Stems—*contd.*	*Stromatium barbatum*, Fb.	F. I. Ceram., pp. 114-115, f. 45; Proc. 2nd Ent. Conf., 1917; S. I. I. 321-322, f. 175; Bomb. Jour. XXIV, 610-612.	Nagpur, Central Provinces.	Boring into dead orange branches after they have been affected by *Arbela*.
	Chloridolum alcmene, Thoms.	Ditto S. S. I., 323, f.177, Ceram., pp. 199-200.	Pollibetta, Virajpet.	Bores into orange stems. Adult May 1917.
	Agrilus grisator	Ditto I. I. L. 331.	..	Lemon trees.
	Arbela tetraonis	Ditto S. S. I., 453-454 t. 41.	Poona, Nagpur, Bangalore.	Bores in stems; very common at Nagpur.
	Sathrophyllia sp. (Phasgonurid)	..	Bangalore	I. R. 176, 24th June 1918. Eats the bark. Moves quickly round the stems when attempts made to catch it.
Roots	*Autoserica* sp.	..	Pusa	Adult, lemon root.
Sucking	*Cappœa taprobanensis*	S. I. I., p. 470, f. 346; Proc. Sec. Ent. Conf., 1917, p. 213.	Hill districts, South India.	Minor pest.
	Rhynchocoris humeralis	Ditto	Ditto Bassein (Burma), Jeolikote.	
	Chrysomphalus (*Aspidiotus*) *aurantii*.	Ditto	Pusa.	
	Chrysomphalus aonidum (*ficus*)	Ditto	Khed (Poona); Calcutta.	Also on palms.
Sucking	*Aspidiotus lataniæ*	S. I. I., p. 470, f. 346; Proc. Sec. Ent. Conf., 1917, p. 213.	Poona, Coonoor, Calcutta.	Also on *Citrus medica*, peach, *Phœnix* (serious).
	Saissetia (*Lecanium*) *hemisphœrica*.	Ditto	Konkan.	
	Aleurocanthus (*Aleyrodes*) *spinifera*.	Ditto	Pusa.	
	Dialeurodes citri	Ditto	Plains.	
	Euphalerus citri	Ditto	Do.	
	Toxoptera aurantii	Ditto	Pusa.	
	Lawana conspersa	..	Do.	In numbers on fruits and stems of *Citrus*, Pusa, August-September 1918.
	White fly (Species ?)	Madras Annual Report, 1917-18, pp. 75-76.	Circars, and ceded districts.	
	Diaspis sp.	..	Pusa	On leaves, 5th September 1918. Leaves very heavily infested and turned pale.
	Antestia cruciata	..	Nagpur	16th June 1906.

COCONUT (*Cocos nucifera*).

Leaves	*Contheyla rotunda*, Hmps.	Madras Dept. Agri. Year Book, 1917, pp. 91-96, fig. 23-24 ; B. J. XIII, 196.	West Coast, Madras. Wynaad.	On the leaves. Adult damaging foliage flower shoots and rinds of young nuts. Pupa in small oval shell-like cocoon.
	Nephantis serinopa, Meyr.	S. I. I., p. 460, f. 336.	Travancore, South India, Bengal, Burma.	Coconut and palmyra. Travancore, 1917-18. Leaves of trees seriously damaged. Sometimes serious.
	Gangara thyrsis, Mo.	S. I. I., p. 417, f. 290-291.	Kasargode	Adult on palms of various species, coconut palms in nurseries. Attacking coconut seedlings (Madras. Monthly Report, August 1918).
	Gangara thyrsis	S. I. I., p. 417 ; I. M. N. I., 4, 204 ; I. M. N. II., 6, 156.	South India, Mandalay.	Larva destructive to nurseries of young coconut palms.
	Parasa lepida	S. I. I., 410-411	South India	Also on palmyra.
	Elymnias caudata	..	Mercara, Coorg, South India.	Adult on coconut, and betel-nut palms as well as arecanut palm.
	Suastus gremius	S. I. I., p. 418-419 ; I. M. N. I., 9 ; I. M. N. II., 6, 156.	Bangalore, Godavari, Coimbatore, Pusa.	Larva on palmyra palms also on coconut and on garden palms.
	Aularches miliaris L.	Kirby F. I. Acrid, pp. 168-169 ; Fletcher, S. I. I., p. 526, f. 418 ; Proc. Sec. Ent. Conf., pp. 28, 77, 200.	Shevaroys, Nilgiris, Vizagapatam, Coimbatore, Veyangoda (Ceylon).	Does little damage as a rule. On arecanut and coconut and various shade trees.
Shoots	*Oryctes rhinoceros*	Proc. Sec. Ent. Meeting, Pusa, 1917, p. 258 ; Arrow F. I., Dynast, pp. 278-281.	Ahmednagar I. R. 120, 7th February 1914. South India, Ceylon, North as far as Pusa Bandra hitherto not recorded from United Provinces.	Leaves and shoots of coconut palms. Larva in Farm-yard manure, coffee pulp, decaying vegetation generally. Adult boring into palm trees, occasionally into sugarcane.
Fruits	*Tirothaba* sp. nov.	An. Rept. 1917-18, p. 99, t. 14, f. 2 (1918).	Pusa	Larva boring young coconut fruits in the branch on the tree and causing the young fruits to fall off.

COCONUT (*Cocos nucifera*)—*contd.*

Stems .	*Eophileurus perforatus* . .	..	Moulmein, 14th September 1918. K. D. Shroff.	This specimen was sent by K. D. Shroff for identification. It was found in dead tops.
	Rhynchophorus ferrugineus Fb. .	S. I. I., p. 343, Plate XIV.	South India, Khasi Hills, Pusa, Assam, Kanara, Bombay, Ceylon.	Palmyra, date and coconut palms. Larva in stem. All over the palm-growing districts.
	Calandra stigmaticollis Gyll. .	An. Rept. Pusa, 1917-18, pp. 98-99, f. 15, f. 1.	Malvan (Ratnagiri district), Tamarasseri, (Malabar).	Larva boring coconut palm.
	Solenopsis geminata . .	..	Ratnagiri .	I. R. No. 944, 18th March 1918.

CUSTARD APPLE (*Anona squamosa*).

Fruits .	*Heterographis bengalella*, Rag. .	Hmpsn. F. I., IV, 70; Bom. Jour. XII, 313.	Pusa . .	Larva tunnels into fruit, September-October but is not common. Scarcely a pest.

DATE-PALM (*Phœnix sylvestris*) (*Khajur*).

Leaves .	*Wallacea* sp.	..	Pusa .	Larva on date palm. Adult on top leaves. Larvæ and adults eat epidermis of young leaflets.

FIG (*Ficus carica*).

Leaves .	*Brahmina coriacea*, Hope. .	One Hundred Notes, p. 3.	Jeolikote .	Defoliating by night.
	Adoretus versutus . . .	One Hundred Notes, p. 5.	Do.	
	Adoretus horticola . . .	F. I. Rut. p. 344, One Hundred Notes, p. 7; Ent. Note, 21.	Do.	
	Adoretus duvauceli, Bl. . .	One Hundred Notes, p. 6.	Pusa, Chapra, Jeolikote.	
	Adoretus duvauceli, Bl. . .	F. I. Rut. pp. 343-344; Ento. Note 21.	Jeolikote .	Leaves by night
	Prodenia litura . . .	..	Pusa.	
	Hypsa ficus	S. I. I., page ? I. I. L., p. 463, t. 39, ff. 1-2.	Coromandel, Trichinopoly, Coimbatore, Pusa.	
	Talanga sexpunctalis . .	..	Pusa (1st August 1909).	Larva on wild fig trees.
	Glyphodes itysalis . . .	..	Pusa (22nd July 1908).	
	Perina nuda	..	Coimbatore (February 1914).	Larva on leaves.

FIG (*Ficus carica*)—*contd.*

Leaves—*contd.*	*Ocinara varians*, Wlk.	S. I. I., p. 407, f. 278.	South India	Larva on leaves. A minor pest of fig.
	Pœcilocerus pictus, Fb.	Kirby. F. I. Acrid, pp. 172-173, f. 113; Fletcher, S. I. I., pp. 526-527, fig. 419; Proc. Sec. Ent. Conf., pp. 136 tab.	Bellary	Has been found to damage young *F. carica* leaves.
Leaves	*Hypsa alciphron*, Cram.	I. I. L., t. 39, ff. 3-4; Hmpsn. F. I. I., 502-503.	Pusa	A minor pest of *F. carica* in Bihar.
	Hypsa ficus, Fb.	S. I. I., p. 400, f. 269.	Do.	
	Phycodes radiata, Ochs.	S. I. I., p. 463, f. 339.	Peshawar, Kulu, Pusa, Gauhati, Nagpur, Hagari.	Larva rolls the leaves and is sometimes a serious pest of young fig trees.
Shoots	*Batocera rubus*, L.	..	Peshawar	Eating shoots of *F. carica*. Larva boring into stems of *F. carica*.
Fruits.	*Stathmopoda sycastis*, Meyr.	..	Peshawar Valley	Larva in figs during May-June; the larvæ are so well known that the local people are chary of eating the fruit.
	Chaætodacus zonatus, Saund.	Bezzi. Bull. Ent. Res., VII, 105-106, 1916.	Pusa	Larva in cultivated figs.
Stems	*Batoeera* sp.	..	Jeolikote, (Kumaon).	Two photos by Mr. Gill. Boring into and ring-young fig trees.
	Aclees sp.	..	Shillong (June-July 1918).	Larva boring into main stem, doing considerable damage. Adult on stems by day.
	Batocera rubus, L.	..	Peshawar, Pusa, Gwalior (Lashkar) Dehra Dun, Khasis.	Rotten Papaya stem. Boring sisoo wood. Larva boring Bombax stem (Pusa). Larva boring into stems of *F. carica* (Peshawar).
	Apriona cinerea, Chev.	Stebbing Forest Ins. Coleop., p. 374.	Jeolikote	Larva boring into trees.
	Epepeotes uncinatus, Gahan	..	Shillong (July 1918).	Larva boring into stems. Adults on twigs.
	Olenecamptus bilobus, Fb.	Stebbing Forest Ins. Coleop., p. 375, f. 250.	Surat, Coimbatore, Kistna District.	
Borers	Gen.? sp.	..	Mandalay, Thaton, (Burma).	Larva boring *Ficus carica*. Also in mango.

GOOSEBERRY (*Physalis peruviana*).

Fruits	*Heliothis obsoleta*, Fb.	..	Pusa.	
	Heliothis (*Chloridea*) *assulta*, Guen.	S. I. I., p. 374, fig. 236.	Do.	*Physalis minima*, and *Ph. peruviana*.

GRAPE-VINE (*Vitis* spp.).

Leaves	*Brahmina coriacea* Hope.	One Hundred Notes, p. 3.	Jeolikote, United Provinces.	
	Adoretus horticola	One Hundred Notes, p. 7. Ento. Note, p. 21.	Ditto.	
	Adoretus lasiopygus	Ditto	Calcutta, Begus erai (Bengal) Daltonganj, Palamau, Chapra, Jorhat, Rewari.	
	Adoretus duvauceli	One Hundred Notes, p. 6, No. 21.	Jeolikote, Pusa, Chapra.	
	Adoretus versutus Har.	F. I. Rut., pp. 350-351.	Jeolikote.	
	Chrysomelid	..	Ramgarh	Fletcher collection August 1918. These were found on wild grapes.
	Euproctis flava	..	Lyallpur, 27th June 1917.	
	Hippotion celerio, Linn.	Destructive Insects of Victoria II, p. 109.	Pusa	Larva on leaves. Alternative food *Vitis trifolia*.
	Sylepta lunalis	..	Shripur, (Bihar), Pusa.	Larva rolling leaves.
	Nodostoma subcostatum, Jac.	Jac. F. I.; p. 334	Assam, Burma, Pusa.	Larva underground near roots of grasses.
	Scelodonta strigicollis, Mots.	Jac. F. I. Chrys., p. 386.	Nasik, Peshawar, Jeolikote, Pusa, Minbu, Nagpur.	In Burma on wild *Vitis*.
	Mimastra cyanea, Hope.	I. M. N., IV, 4, p. 217.	Sambli (Murree Hills).	Defoliating vines.
	Phyllocnistis toparcha, Meyr.	..	Coimbatore	Larva mining leaves.
	Monolepta signata, Oliv.	S. I. I., p. 310, f. 159; Ann. Rept., 1917-18, t. 12, fig. 2.	Jeolikote	Adult on leaf.
	Gonocephalum depressum, F.	..	Bangalore	Adult damaging grape vines by nibbling tender roots and scraping fruits.
	Gonocephalum hoffmannseggi, Steven.	S. I. I., p. 299, f. 143.	Bangalore	March 1910.

GRAPE-VINE (*Vitis* spp.)—*contd.*

Leaves—*contd.*	*Teratodes monticollis*, Gray.	Kirby F. I. Acrid, p. 235; Lefroy I. I. L., p. 88, ff. 28-29; Proc. Sec. Ent. Meeting, p. 235.	Bengal	Sent in from Bengal as attacking grape vines leaves but probably a casual visitor or feeder.
	Theretra gnoma, Fb.	Hmpsn., B. J. XVI, 145.	Jeolikote	Is a regular feeder on vines.
	Theretra alecto, Linn.	Hmpsn., F. I. I., 85; B. J. XVI, 145.	Rae Bareli (United Provinces).	Larva on cultivated vines during October-November.
	Theretra pallicosta, Wlk.	..	Sind	Larva on eaves of which it is a decided pest.
Flowers	*Clysia ambiguella*, Hb.	..	Hills of Assam and Burma.	This insect occurs in Europe on grape vine flower buds. With the extension of cultivation in the Hill tracts, it is possible it may prove to be a pest.
Stems	*Sthenias grisator*, F.	S. I. I., p. 326, f. 182; Stebbing Ind. For. Insects Col. pp. 377-378, f. 252.	Nasik, Palitana State, Coimbatore, Bangalore, Polibetta, Kurnul.	Girdles grape vines, rose bushes, *Erythrina*, mulberry, *Tabernæmontana*, *Bougainvillea*.

GREENGAGE.

Leaves	*Adoretus* sp.	..	Fort Sandeman	Political Agent, Zhob, July 1918.
Fruits	*Anomala polita* Blanch.	Arrow, Rut. F. I., pp. 146-147, t. 2, fig. 24.	Zhob (Baluchistan), July 1918.	Adult attacking fruits.
	Anomala dimidiata, Hope.	Arrow, F. I. Rut., pp. 232-233.	Ditto	Ditto.

Grewia asiatica.

Leaves	*Mimastra cyanea*, Hope.	I. M. N. IV, 4, 217	Dun Forest.	

GUAVA (*Psidium guyava*).

Leaves	*Myllocerus viridanus*, Fb..	Mshll. F. I. Curc. I., 301-303, fig. 93.	Palur	Adult on guava leaves.
	Myllocerus discolor	Mshll, F. I. Curc., I., 348-350, f. 106.	Pusa	Adult.
	Myllocerus 11-pustulatus, Fst.	Mshll. F. I. Curc., I., 350-352.	Pusa	Adult on leaves.
	Chrysomelid (Unidentified)	..	Mandalay, 12th May 1909.	Adult on guava (K. D. Shroff, No. 128).
	Cacœcia micaceana Wlk.	Wlk. Cat. XXVIII, 314 (1863).	Mandalay	Larva on guava; January 1909.

GUAVA (*Psidium guyava*)—*contd.*

Leaves—*contd.*	*Spilonota rhothia* Meyr.	Meyr. T. E. S., 1910, 368.	Pusa, Koilpatti (Madras), Coimbatore, Plains of India.	Larva rolls tender guava leaves.
Fruits	*Chætodacus ferrugineus ferrugineus.*	Proc. Sec. Ent. Conf., 1917, p. 213-226 ; Bezzi Ento. Res. VII-104, October 1916.	Peradeniya, Katihar, Pusa.	See Mango fruit.
	Chætodacus ferrugineus dorsalis, Hendel.	Bezzi Bull. Ento. Res. VII, 104-105, 1916.	Myitkyina	Larva in guava and pomelo.
	Chætodactus ferrugineus incisus, Wlk.	Bezzi Bull. Ento. Res. VII, 105, 1916.	Bangalore	Larva in guava fruit.
	Chætodacus ferrugineus versicolor, Bezz.	Bezzi. Bull. Ento. Res. VII, 105, 1916.	Pusa	Larva also in *Achras Sapota* fruits.
	Agrotis ypsilon	..	Pusa (April 1915).	Caterpillar found in a decomposing guava fruit.
	Virachola isocrates, Fb.	S. I. I., p. 416-417 ; B. J., XXIV, 184.	South India, Pusa.	Larva in fruit.
	Dichocrocis punctiferalis	..	Pusa, Coimbatore.	Larva in fruits.
	Cacœcia epicyrta, Meyr.	..	Pusa	Larva boring in fruit.
Stems	*Æolesthes holosericea*, Fb.	Gahan F. I., pp. 127-128.	Khedut (Baroda), 4th April 1907.	Larva in guava stem. In this case the stem was affected with *Belionota prasina*.
	Belionota prasina, Thunb.	..	Poona	Boring guava stems.

JAMUN (*Eugenia jambolana*).

Leaf (eating).	*Aerocercops telestis*, Meyr.	..	Pusa, Coimbatore.	Leaves of Jamun. Alternative food *Trewia* sp., *Gmelina arborea*.
	Metanastria hyrtaca	One Hundred Notes, No. 66 ; S. I. I., p. 409-410.	Trivandrum	Larva on bark of tree.
	Trabala vishnu, Lef.	I. M. N. V, 107 ; I. I. L., p. 498, t. 46.	India, Burma.	
	Spilonota rhothia, Meyr.	Meyr. T. E. S., 1910, 368.	Pusa, Coimbatore, Koilpatti.	Larva rolls tender leaves but not a pest.
	Ætherastis circulata, Meyr.	..	Trivandrum	Larva on *E. jambolana* ; not known as a pest.
	Acrocercops phæospora, Meyr.		Pusa	Larva mining leaves.
	Acrocercops telestis, Meyr.	Ento. Note 87	Do.	Ditto.

JAMUN (*Eugenia jambolana*)—*contd.*

Fruits .	*Balaninus c-album* . . .	..	Pusa . .	Fallen fruits as well as healthy fruits on trees are affected.
	? *Polychrosis cellifera*, Meyr. .	..	Do.	
	Meridarchis reprobata, Meyr. .	..	Nagpur . .	Larva *Eugenia jambolana*.
			Kashmir .	Larva in olive fruits.
Seeds .	*Balaninus c-album*, Fb. . .	Ann. Rept., Pusa, 1917-18, p. 102, t. 18, f. 1.	Pusa . .	Larva *E. jambolana* seeds and small fruits.
Stems .	*Arbela tetraonis* Mo. . .	S. I. I., pp. 453-454, t. 41.	Do.	

JAK (*Artocarpus integrifolia*).

Leaves .	*Perina nuda*, Fabr. . .	I. M.N., IV, No. 1, p. 14.	Calcutta . .	China, India, Ceylon. Scarcely a pest.
Fruits .	*Chætodacus ferrugineus* . .	Proc. Sec. Ent. Conf., Pusa, 1917, p. 226.	..	See mango fruit.
	Chætodacus incisus, Wlk.	Bezzi. Bull. Ento. Res. VII, 105, 1916.	Pollibetta, (Coorg).	Larva in jak.
	Margaronia cæsalis, Wlk. .	S. I. I., p. 435, t. 311.	South India, Assam.	Larva bores in flower buds and young fruits and feeds on leaves as well.
?	*Olenecamptus bilobus*, Fb. .	Stebbing, Forest Insects, Coleop., p. 375, fig. 250.	Pusa .	Adult on trees.
Sucking .	*Cosmoscarta relata*, Dist. . .	S. I. I., p. 495, f. 383.	Coorg, Mysore .	Serious local pest.

LOQUAT (*Eriobotrya japonica*).

Leaves .	*Myllocerus discolor* . . .	Mshll. F. I. Curc. I, 348-350, f. 106.	Pusa . .	Adult on leaves.
	Galerucella sp. . . .	..	Maymyo.	
Fruits .	*Chætodacus ferrugineus* . .	Proc. Sec. Ent. Conf., 1917, pp. 213-226.	Peradeniya, Katihar, Pusa.	See mango fruits.
	Chætodacus ferrugineus dorsalis, Hendel.	Bezzi Bull. Ento. Res. VII, 104-105, 1916.	Pusa.	
	Virachola isocrates . . .	S. I. I., 416-417; Butterflies III, p. 478 (De Niceville).	South India .	Larva also reared on guava fruits.

LITCHI (*Nephelium litchi*).

Leaves .	Litchi *Eriophyes* . . .	..	Pusa, Sibsagar	Very bad, no fruits formed.
	Cricula trifenestrata . .	..	Vikrampur, Dacca.	*Vide Sanjiban* (Bengali paper 11th April 1912).

Litchi (*Nephelium litchi*)—*contd.*

Leaves—*contd.*	*Thalassodes* sp.	..	Pusa	Larva feeding on leaves.
	Amblyrrhinus poricollis, Boh.	..	Do.	Adult on litchi.
	Lycænesthes emolus, Godt.	Bingham F. I., II, 373-374.	Calcutta, Pusa	On mango leaves.
	Argyroploce aprobola, Meyr.	Meyr. T. E. S., 1886, 275.	Pusa	Larva rolls leaves.
	Argyroploce leucaspis, Meyr.	Meyr. Gardiner's Fauna, Geogr. Maldives I., 126 (1902).	Do.	Larva rolling leaves ; scarcely a pest.
Leaf (eating).	*Selepa* (*Plotheia*) *celtis*	Proc. Sec. Ent. Conf., 1917, pp. 229, 218.	India, Burma	Also on mango, roses, *Terminalia*, Gmelina.
	Thalasssodes veraria	Proc. Sec. Ento. Conf., 1917, p. 229 ; I. I. L., p. 475, f. 325, t. 41, fig. 7.	Pusa, Poona	In small numbers.
	Argyroploce leucaspis	Proc. Sec. Ent. Conf., 1917, p. 229.	India, Burma, Ceylon.	Larvæ roll leaves in small numbers.
	Argyroploce aprobola	Proc. Sec. Ent. Conf., 1917, p. 229.	Pusa, Coimbatore, Poona, Bassein Fort.	Larva rolls leaves also on mango, rose, *Cassia*, *Polyalthia*.
Leaf (miner).	*Acrocercops hierocosma*, Meyr.	One Hundred Notes, p. 31.	Pusa	Larva mining leaves.
Twigs	*Chlumetia transversa*	Proc. Sec. Ent. Conf., Pusa, 1917, p. 220.	Do.	Also on mango.
Fruits	*Argyroploce illepida*	S. I. I., 449-450, fig. 327 ; Proc. Sec. Ent. Conf., 1917, p. 230.	Pusa, 21st June 1911.	Bores in the interior of the stone, also in fleshy substance of *A. marmelos*.
Sucking	*Eriophyes* sp.	Proc. Sec. Ent. Conf., 1917, p. 229 ; Agri. Jour. India, VII, 286-293, figs.	Pusa.	
Other	*Oecophylla smaragdina*	Proc. Sec. Ent. Conf., 1917, p. 230.	..	A general pest Makes nests.

Mango (*Mangifera indica*).

Leaves	*Spilonota rhothia*, Meyr.	Meyr. T. E. S., 1910, 368.	Koilpatti, (Madras).	Larva rolls tender leaves, not a pest.
	Cricula trifenestrata	..	Dacca, 26th March 1917. Chaumahani.	
	Thalassodes veraria	Hmpsn. F. I. Moths III, 508 ; I. I. L., p. 475, f. 325, t. 41, fig. 7.	Pusa	Larva on grafted trees.
	Anomala dussumieri, Bl.	Arrow F. I., Rut. p. 233.	Travancore	Adult on leaves.
	Adoretus lasiopygus, Burm	Arrow F. I., Rut., pp. 348-349.	..	Damage similar to *A. ovalis*.

MANGO (*Mangifera indica*)—*contd.*

Leaves—*contd.*	*Myllocerus sabulosus*, Mshll.	Mshll. F. I. Curc. I., 336-337.	Pusa	Adult damaging leaves.
	Myllocerus discolor	Mshll. F. I., Curc. I, 348-350, f. 106.	Do.	Adult on leaves.
	Myllocerus 11-pustulatus, Fst.	Mshll. F. I. Curc. I, 350-352.	Do.	Ditto.
	Platymycterus sjöstedti, Mshll.	..	Do.	Tender leaves.
	Dasychira mendosa, Hb.	S. I. I., p. 396, f. 264.	Do.	On leaves.
	Euproctis lunata, Wlk.	Hmpsn. F. I. I., 472-473.	Mysore	Defoliating mango and other trees in June 1902.
	Perina nuda, Fb.	I. M. N., IV, 14, Hmpsn. F. I. I., 486, f. 323.	..	Larva also on *Ficus* and jak.
	Lycænesthes emolus Godt.	Bingham F. I., II, 373-374.	Pusa	Larva on leaves.
	Macalla moncusalis, Wlk.	S. I. I., pp. 429-430, f. 306.	Coimbatore, Salem, Madras, Samalkote.	Larva webbing mango leaves and shoots and destroying the young leaves.
	Psyche vitrea, Hmpsn.	Hmpsn. F. I., I, 299.	Bakarganj	Not a pest.
	Amblyrrhinus poricollis	Ditto	Pusa, Cuttack, Pithapuram (Godavari), Hagari.	Eats tender leaves. Not a pest.
	Apoderus tranquebaricus	Ditto S. S. I., p. 335-336, fig. 193.	South India	Not a pest. Rolls the leaves and feeds on them.
	Rhynchænus mangiferæ	Ditto.		
	Œcophylla smaragdina	Proc. Sec. Ent. Conf., Pusa, 1917, p. 220.	Pusa	Leaves tied together.
	Pulvinaria psidii	..	Do.	1914.
	Chrysomphalus trilobitiformis	Green's identification, 1915.	Do.	1914.
	Parlatoria pergandii, Comst.	..	Alwar, Rajputana.	Green's identification, 1915.
	Aspidiotus destructor	..	..	Mango leaves. (Green determ) 1915.
	Dasychira mendosa	..	Pusa, II., 14	Larva on leaves, also twigs of leaf.
	Euproctis flava	..	Lyallpur, 27th June 1917.	
	Euproctis scintillans	S. I. I., p. 399; injurious insects of Indian Forests. Stebbing, p. 111.	South India, Poona.	A minor pest. Larva injurious to young grafted mangoes.
	Parasa lepida	S. I. I., 410-411, fig. 283, 284.	Bankura; South India.	Larva on leaves.
	Mango leaf (Cecidomyiad)	..	Pusa	Galls on leaves. Bad pest in Mauritius, imported from India.

MANGO (*Mangifera indica*)—*contd.*

Leaves—*contd.*	*Argyroploce erotias*, Meyr.	Proc. Sec. Ent. Conf., Pusa, 1917, pp. 217-219 ; One Hundred Notes, p. 28.	India, Ceylon, Pusa, Bombay.	Rolls up tender leaves also bores in shoots. Larvæ feed on tender leaves.
	Chelaria spathota, Meyr.	One Hundred Notes, p. 30 ; Proc., Sec. Ent. Conf., Pusa, 1917, p. 217.	Pusa, Koilpatti	Larva found eating leaves.
	Selepa (Plotheia) celtis	Proc. Sec. Ent. Conf., 1917, pp. 229, 218.	India, Burma, Pusa.	Occasional sporadic though at times serious on mango leaves as well as on litchi.
	Argyroploce aprobola	Meyr. Trans. Ento. Soc., 1886, 275 ; Proc. Ent. Conf., 1917, pp. 230, 217.	Poona, Pusa, Bassein Fort, Coimbatore.	Larva rolls tender leaves.
	Eugnamptus marginatus	Ann. Rept., Pusa, 1917-18, p. 99 ; Proc. Sec. Ent. Conf., 1917, p. 219 ; S. S. I., pp. 329-331, fig. 186-187.	Bombay, Sabour, Pusa, Burma, Dehra Dun, Nagpur, Poona, Maymyo, Madras.	Tender leaves cut off. (On mango shoots Monthly Report, September 1918, Sabour).
	Natada velutina	Proc. Sec. Ent. Conf., Pusa, 1917, p. 217.	Bengal	
	Euthalia garuda	Ditto	Pusa, 9th September 1907.	Not a pest.
	Cricula trifenestrata	Proc. Sec. Ent. Conf., Pusa, 1917, p. 218.	South India, North-East India, Burma, Bengal, Eastern Bengal.	Serious in Bengal.
	Lymantria beatrix	Ditto	India, Ceylon, Poona, Pusa.	Not a pest.
	Euproctis lunata	Ditto	Mysore	Defoliates tree.
	Bombotelia jocosatrix	Ditto S. S. I., pp. 382-383, fig. 245.	South and West India, Bihar.	Occasional pest.
	Thalassodes quadraria	Ditto.	Poona, Pusa	A sporadic pest.
	Macalla moncusalis	Ditto p. 219 ; S. S. I., pp. 382-383, fig. 245.	India, Madras	Webs up leaves and destroys shoots.
	Acrocercops sp.	Ditto Bull. No. 59, Note 84.	..	Not a serious pest.
Leaf-miners.	*Rhynchœnus (Orchestes) mangiferæ*, Mshll.	Proc. Ent. Conf., Pusa, 1917, p. 220.; One Hundred Notes, p. 8 ; S. I. I., p. 334, f. 192.	Pusa, Coimbatore, Godavari district, Paddavadlapudi (Guntur District).	Larva mining tender leaves.
	Acrocercops syngramma, Meyr.	One Hundred Notes, p. 30 ; Meyrick B. J. XXIII, 120.	Saidapet, Pusa, Bankipur, Chitur, Coimbatore.	Larva mines leaves.

MANGO (*Mangifera indica*)—*contd.*

Leaf-miners—*contd.*	*Acrocercops cathedræa*, Meyr.	One Hundred Notes, p. 30.	Pusa, Coimbatore, Rajshahi.	Mines leaves. Alternative food *Achyranthes aspera*.
	Acrocercops isonoma, Meyr.	One Hundred Notes, p. 30; Meyr. Ext. Mycro I, 625.	?	A single specimen reared from mango. Larva mining leaves.
	Acrocercops pentalocha, Meyr.	Bom. Jour. XXIII, 119.	..	Larva mining blotches in leaves.
Shoots	*Alcides frenatus*, Mshll.	Ann. Rept., Pusa, p. 103, t. 19, f. 1; Proc. Sec. Ent. Con., 1917, p. 220; One Hundred Notes, No. 28, p. 9, fig. 4.	Dacca	The grubs bore into the shoots. A bad pest at Dacca.
	Argyroploce erotias, Meyr.	One Hundred Notes, p. 28.	Bombay	Larva bores into the shoots.
	Anarsia melanoplecta	One Hundred Notes, No. 78, p. 29; Proc. Sec. Ent. Conf. Pusa, 1917, p. 220; Meyrick B. J. XXII, 774 (1914).	Nagpur, Pusa	Larvæ bore into the top shoots of young twigs. Scarcely a pest.
	Chlumetia transversa	Proc. Sec. Ent. Conf., 1917, Pusa, 220; Ann. Rept. of A. R. I., 1917-18, p. 103.	United Provinces, Poona, Travancore, Coimbatore, Bombay, Pusa.	Also on litchi boring in shoots and sometime feeding on mango leaves; a bad pest of grafted mango at Poona.
	Apsylla cistellata	I. I. L., p. 742, f. 514-515; Proc. Sec. Ent. Conf., Pusa, 1917, p. 221.	North India.	
	Beetle grubs	Monthly Report Bihar and Orissa, April 1918.	..	Grubs boring in shoots.
	Brachytrypes portentosus, Licht.	Fletcher S. I. I., p. 536, f. 430; Proc. Sec. Ent. Meeting, pp. 79, 93, 98, 132, 270, 278, 281, 290.	Malda	Young mango shoots.
Buds	*Selepa (Plotheia) celtis*.			
	Eublemma sp.	..	Pusa	On bud.
Inflorescence.	*Nanaguna breviuscula*, Wlk.	..	Do.	Larva in dry fallen flowers and feeding on them.
	Eublemma silicula, Swinh.	..	Landhi (Sind) Pusa, Nagpur.	Larva in inflorescence and buds.
	Amblyrrhinus poricollis, Boh.	..	Pusa	Adult on inflorescence.
	Scelodonta strigicollis, Mots.	Jac. F. I. Chryso., p. 386.	Do.	
	Chelaria rhicnota, Meyr.	Meyr. Exot. Micro I, 580-581.	Panapakom (Chittur District), Shevaroy Hills.	Larva on flowers.

MANGO (*Mangifera indica*)—*contd.*

Inflorescence—*contd.*	*Prosintis florivora*, Meyr.	Meyr. Exot. Micro. I., 598.	Pusa.	
	Antestia cruciata, Fb.	S. I. I., p. 472, f. 350.	Chhindwara	Inflorescence was reported to be damaged.
Flowers	*Chelaria rhicnota*, Meyr.	B. J. XXII, 165-166.	Chittur (Madras)	Larva feeding on flowers.
	Mango-hoppers	Ann. Rept. Dept. Agri., Madras, 1917-18, p. 75.	Vizagapatam, Chittur, Salem.	
	Euproctis scintillans	Proc. Sec. Ent. Conf., 1917, Pusa, p. 221. S. S. I., p. 399, f. 268.	Saidapet (Madras).	Found in flowers.
	Dichocrocis punctiferolis	S. S. I., p. 433, t. 34; Proc. Sec. Ent. Conf., Pusa, 1917, p. 221.	Pusa, Nagpur	Minor Pest. In aborted flowers, Pusa, June 1912.
	Eublemma silicula	Proc. Sec. Ent. Conf., 1917, Pusa, pp. 221-222.	Do.	Buds and flowers, Castor fruits and Juar Head. Probably a rubbish feeder.
	Antestia cruciata	Proc. Sec. Ent. Conf., Pusa, 1917, pp. 221-222; S. S. I., p. 472, f. 350.	Central Provinces.	Possibly a mere casual visitor.
	Idiocerus atkinsoni	Proc. Sec. Ent. Conf., 1917, Pusa, pp. 221-222; Agri. Jour., India.	Plains.	
	Idiocerus clypealis	Ditto Philippine Agri. Review, 1917, X, 2, pp. 128-2, 145, Rev. applied Ento. VI A January 1918, p. 25.	Do.	This also attacks mango blossoms in Philippines.
Fruits	*Chætodacus ferrugineus incisus*, Wlk.	Bezzi. Bull. Ento. Res. VII, 105, 1916.	Bangalore, Coimbatore.	Adult on leaves
	Chætodacus ferrugineus versicolor	Ditto	Coimbatore	Larva in fruits.
	Chætodacus zonatus, Saunders	Bezzi. Bull. Ento. Res. VII, 105-106, 1916.	Amraoti, United Provinces (Moradabad).	Ditto.
	Chætodacus diversus, Coq., (*Batrocera diversa*).	Bezzi. Bull. Ento. Res. VII, 108-109, 1916.	Peradeniya	
	Chætodacus correctus (*Bactocera zonata*).	Proc. Sec. Ent. Conf., 1917, pp. 225-226. Bull. Ento. Res. VII, 107, 1916.	Pusa, Coimbatore, Hagari, Guindy.	
	Cryptorrhynchus mangiferæ	Proc. Sec. Ent. Conf., Pusa, 1917, p. 225; S. S. I., p. 341, fig. 200.	Travancore, Coimbatore, Lahore, Palur, India, Ceylon, Java, Chagos Island, Mauritius, Reunion, Madagascar, Zanzibar, Natal, Hawaii, Rangoon.	Larva inside stone.

MANGO (*Mangifera indica*)—*contd.*

Fruits—*contd.*	*Cryptorrhynchus gravis* . .	Ann. Rept., Pusa, 1917-18, pp. 100-101.	Rangpur, Silchar, Maymyo, (Does not occur at Pusa).	Bad in Bengal. Old trees damage serious.
	Cryptorrhynchus poricollis .	Ento. Note, 28 .	Dacca, throughout Eastern Bengal.	
	Dichrocrocis punctiferalis . .	..	Pusa . .	Occasionally.
	Chætodacus ferrugineus dorsalis, Hendel.	Bezzi. Bull. Ent. Res. VII, 104-105, 1916.	Coimbatore, Pusa, Mandalay.	
Borers in Stems, branches, bark.	*Batocera rubus* . . .	One Hundred Note, p. 10 ; Proc. Sec. Ent. Conf., Pusa, 1917, p. 226.	Pusa . .	Life History occupies one year.
	Arbela tetraonis, Mo. . .	Proc. Sec. Ent. Conf., Pusa. 1917, pp. 226-227 ; S. I. I., pp. 453-454, t. 41.	Do.	
	Acanthophorus serraticornis .	Proc. Sec. Ent. Conf., Pusa, 1917, pp. 226-227.		
	Belionota prasina . . .	Proc. Sec. Ent. Conf.. Pusa, 1917, pp. 226-227.	Pusa, Surat.	
	Cerambycid beetle (unnamed)	Proc. Sec. Ent. Conf., Pusa, 1917, pp. 226-227.		
Borers in Stems, branches, bark.	Termites	Proc. Sec. Ent. Conf., Pusa, 1917, pp. 226-227.		
Base of mango trees.	*Eutelia blandiatrix*, Boisd. .	..	Pusa . .	15th March 1916, caterpillars at base of tree.
Mango trunks.	*Parasa lepida*	..	Bankura .	Larva resting in cocoons on trunks.
Stems .	*Belionota prasina*, Thunb. .	..	Baroda, Surat .	Larvæ in numbers at Surat in stem apparently killed by them.
	Stylotermes fletcheri, Holmg. .	Holmg. Ento. Mem. V, 142-143.	Shevaroys .	Burrowing in rotten interior and in sound wood of a mango tree.
	Arbela theivora, Hmpsn. .	Hmpsn. B. J. XX, 97, t. G. f. 1.	Assam . .	Larva borers in the smaller branches feeding under a web.
Sucking insects.	*Aleyrodes* sp.	Proc. Sec. Ent. Conf., Pusa,1917, pp. 227-228.	Pusa . .	Not a pest.
	Monephlebus stebbingi octocaudatus.	Proc. Sec. Ent. Conf., Pusa, 1917.	Pusa, Moradabad.	
	Icerya seychellarum . .	Proc. Sec. Ent. Conf., Pusa, 1917, pp. 227-228.	Poona . .	Not a pest.

MANGO (*Mangifera indica*)—*contd.*

Sucking insects—*contd.*	*Icerya minor*	Proc. Sec. Ent. Conf., Pusa, 1917, pp. 227-228; Mem. Ento. Ser. II, 17-18.	Pusa . .	Not a pest.
	Pseudococcus sp. . . .	Proc. Sec. Ent. Conf.. Pusa, 1917, pp. 227-228.	Madras . .	Ditto.
	Pulvinaria psidii . . .	Proc. Sec. Ent. Conf., Pusa, 1917, p. 228; S. S. I., p. 511, fig. 399.	..	Ditto.
	Ceroplastes floridensis . .	Proc. Sec. Ent. Conf., Pusa, 1917, p. 228.	..	Ditto.
	Vinsonia stellifera . . .	Proc. Sec. Ent. Conf.. Pusa, 1917, p. 228.	Madras . .	Ditto.
	Coccus (*Lecanium*) *mangiferæ* .	Proc. Sec. Ent. Conf., Pusa, 1917, p. 228.	Pusa . .	Ditto.
	Chionaspis dilatata . . .	Proc. Sec. Ent. Conf..Pusa. 1917, p. 228.	Poona, Calcutta.	
	Chionaspis vitis . . .	Ditto .	Madras.	
	Leucaspis indica . . .	Proc. Sec. Ent. Conf.; Pusa 1917, p. 228.	Poona.	
Young seedlings.	*Termites*	Proc. Sec. Ent. Conf.. 1917, p. 216.		
	Gryllodes melanocephalus . .	Proc. Sec. Ent. Conf., Pusa, 1917, p. 216.		

The following mango pests were detected by E. R. Sasscer, Columbia, on mangoes received there from India.

[*Jour. Economic Ento.*, Vol. VII, No. 2 (1914), p. 242].

Phenacaspis dilatata, Green.

Asterolecanium pustulans, Ckll.

Pulvinaria (immature).

Mango weevil (? in mango seed).

MELON (*Cucumis melo*).

Stems .	*Julodes atkinsoni*, Kerr. . .	*Ind. Mus. Notes*, IV—2, 48-49 (1896).	Lieah (Dera Ismail Khan).	Reported as very destructive in June 1895 to melon crops.
Fruits .	*Aulacophora abdominalis* . .	S. I. I., p. 311, fig. 161.	Jallandhar .	Larva and adult boring fruits (underside) lying on ground.
	Dacus brevistylus, Bezzi. . .	Bezzi. Bull. Ent. Res. VII, 101 (October 1916); Proc. Sec. Ent. Meeting, pp. 243, 304.	Siddhout (Cuddapah).	Larva in melons.

MELON (*Cucumis melo*)—*contd.*

Fruits—*contd.*	*Chætodacus cucurbitæ*, Coq.	Bezzi. Bull. Ent. Res. VII, 109-110, 1916.	Coimbatore, Peshawar.	Larva in melon. Larva in melon shoot.
	Myiopardalis carpalina	Proc. Ent. Meeting, 1917, p. 306.	Baluchistan	Larva in melons.

MULBERRY (*Morus* spp.).

Leaves	*Mimastra cyanea*, Hope.	I. M. N., IV-4, 217	Hills near Simla.	Defoliating. (See under apple).
	Euproctis lunata, Wlk.	Hmpsn. F. I. I., 472-473.	Coimbatore.	
	Prodenia litura	I. M. N. I., No. 4, 1890, p. 210. I. M. Notes II-6, p. 160.	Balasore	Eats the leaves.
	Astycus lateralis, Fb.	Mshll. F. I. Curc. I., pp. 139-140.	Rangoon	Defolia[illegible] bushes.
	Sympiezomias cretaceus, Fst.	Mshll. F. I. Curc. I.	Bangalore	On mulberry.
	Deiradolcns (n. g. Mshll. Ms. n.sp.)	..	Shillong, June-July 1918.	Adult nibbling leaves and doing considerable damage.
Shoots	*Monophlebus* sp. (near *tamarindus*, Green.).	..	Kohat (North-West Frontier Province).	Identification by Mr. Green, December 1918.
Fruits	*Anoplomus flexuosus*, Bezzi.	Mem. Ind. Museum Vol ? pp. 100-102, t. VIII, fig. 12.	Jeolikote, (Kumaun, United Provinces).	
	Dichocrocis punctiferalis, Guen.	S.I. I., p. 433, t. 34	Bangalore.	
	Chætodacus caudatus, Fb..	Bezzi. Bull. Ent. Res. VII, 110, 1916.	Jeolikote	On fruits.
Stems	*Cœlosterna* sp.	..	Imphal, 27th April 1914 (Manipur State).	Considerable damage done to mulberry on one plantation. A quantity of dust accumulated round the roots. Holes on the stem. When cut stems contai[illegible] beetle and grubs.
	Sthenias grisator	S. I. I., p. 326, f. 182; Stebbing Ind. For. Insects. Coleop., pp. 377-378, fig. 252.	Coimbatore, Pollibetta, Bangalore, Kurnul, Nasik, Palitana State.	Girdles stems Bad in Madras. Not seen in Mysore. Very bad in grapevine.
	Apriona germari, Hope.	Stebbing For. Ins. Col., pp. 371-372, 374, f. 249.	Shahdera (Lahore).	Larva boring into main trunk, doing considerable damage.
	Apriona cinerea, Chev.	Stebbing Forest Insts. Coll,, p. 374.	Dehra Dun., Jammu.	Larva boring mulberry stem. Adult stripping off bark of leading shoots and young twigs of *Morus indica*.

NECTARINE.

Fruits .	*Calpe ophideroides* . . .	One Hundred Notes, p. 21, Note 64, figs. 9-10.	Jeolikote .	Punctures the fruits at night. Doing considerable damage.
?	*Lagoptera honesta* . . .	..	Jeolikote.	

OLIVE.

Leaves .	*Argynnis hyperbius*, Joh. . .	..	Kashmir (27th November 1918).	Larva on leaves; sent in by F. H. Mitchell.
Fruits .	*Dacus oleæ*, Fb. . . .	..	Cherat (North-West Frontier Province).	A serious pest of cultivated olives in Southern Europe.

PAPAYA (*Carica papaya*).

Stems .	*Dasysès rugosellus*, Stt. . .	Stainton T. E. S. (N. S.) V, 113-114, 1859.	Pusa, Coimbatore.	Larva usually feeds on dead wood, but may bore in below the bark of old living stems. Direct damage slight, but the indirect damage by admission of disease may be serious.

PEACH (*Prunus persica*).

Leaves .	*Anomala aurora*, Arrow. .	One Hundred Notes, p. 4.	Maymyo (Upper Burma).	Attacks leaves.
	Anomala pallidospila, Arrow. .	Ditto .	Ditto.	
	Popillia histeroidea, Gyll. .	One Hundred Notes, p. 7.	Maymyo, May 1909.	Damages leaves.
	Emperorrhinus defoliator . .	Bull. Ent. Res. VI, 366-368, fig. 1; 2nd Hundred Notes 116-117.	Kulu .	Damages leaves.
	Dasychira sp. . .	..	Pusa (3rd March 1911).	
	Dirades theclata . .	..	Pusa (2nd September 1909).	Larva on tender apical leaves.
	Popillia sp.	Arrow, F. I. Rutd. p. 80.	Maymyo, May 1909.	Adult on leaves.
	Anomala decorata, Kirsch. .	Arrow, F. I. Rut., p. 216.	Maymyo .	Adult on leaves (one only).
	Nodina rufipes, Jac. . .	Jac., F. I. Chrys, p. 293.	Moulmein; Maymyo.	Adult on leaves.
	Dasychira mendosa, Hb. .	S. I. I., p. 396, f. 264.	Pusa.	
Sucking .	*Antestia cruciata*, Peach Aphis .	..	Nepal (9th May 1911).	
Affecting fruits.	*Calpe ophideroides* . . .	One Hund. Notes 64, p. 21, figs. 9-10.	Jeolikote .	Punctures fruits at night and these drop down.

PEACH (*Prunus persica*)—*contd.*

Affecting fruits—*contd.*	*Chætodacus ferrugineus* Fb.	Proc. 2nd Ent. Conf. 1917, pp. 213-226. Bezzi. Bull. Ento. Res. VII, 1916.	Myitkyina	See Mango fruits.'
	Dichocrocis punctiferalis	..	Pusa, 6th September 1914.	Larva boring into fruits.
	Chætodaccus zonatus, Saund. (*persicæ, mangiferæ*).	Bezzi. Bull. Ento. Res. VII, 105-106 (1916).	Pusa	Specific pest of peach. Bred from mango.
			Pachmarhi	Larva in peach fruits.
			Taru (North-West Frontier Province).	Larva in fruits,
	Lygæus pandurus, Fb.	..	Punjab	Monthly Report, Lyallpur, July 1918.
	Lucanus lunifer, Hope.	Stebbing Ind. For. Insects, Col., pp. 70-72, ff. 37-38.	Ramgarh (United Provinces); Aug. 1918.	Males found boring into peach fruits about middle of July. The beetles are said to do considerable damage and bore into sound ripe fruit.
	Kallima inachus, Boisd.	Bingham, F. I., I, 395-397, t. 10, f. 76.	Pachmarhi (Central Provinces).	Butterfly reported to suck fruits; record seems doubtful.
	Chætodacus ferrugineus dorsalis, Hendel.	Bezzi., Bull. Ento. Res. VII,104-105, 1916.	Maymyo	Larva in peach.

PEAR (*Pyrus communis*).

Leaves	*Brahmina coriacea* Hope.	One Hundred Notes, p. 3.	Jeolikote, United Provinces.	
	Euproctis flava	..	Lyallpur, 27th June 1917.	Larva on leaves.
	Adoretus duvauceli, Bl.	Arrow, F. I. Rut., pp. 343-344; Ento. Note 21.	Jeolikote.	
	Adoretus horticola, Arr.	Arrow, F. I. Rut., p. 344. Ento., Note 22.	Do.	
	Adoretus versutus, Har.	F. I. Rut., p. 350-351; Ento. Note 20.	Do.	
	Emperorrhinus defoliator, Mshll.	Mshll. F. I., Curc. I, 286-287.	Kulu	Alternative food *Alnus nitida*.
	Phytoscaphus triangularis, Ol.	..	Pusa.	
	Deiradolcus sp.	..	Shillong (June-July 1918).	Adult nibbling holes on leaves. Doing considerable damage; collection by hand.

Pear (*Pyrus communis*)—*contd.*

Leaves—*contd.*	*Mimastra cyanea*, Hope. . .	I. M. N., IV, 4, 217.	Solan; Sambli (Murree Hills).	Defoliating trees.
	Sphingid (Gen.? sp. ?) . .	..	Kulu; Shillong	Also on apple. (See under apple.)
	Belippa laleana, Mo. . . .	I. I. L., p. 501, t. 28, f. 14.	Shillong.	
Fruits .	*Chætodacus ferrugineus dorsalis*, Hendel.	Bezzi. Bull. Ento. Res. VII, 104-105, 1916.	Maymyo.	

Phyllanthus emblica.

Leaves .	*Ophiusa analis* Guen. . .	..	Bazidpur (Muzaffarpur).	Semilooper on leaves. A few only.
	Parallelia analis, Guen. . .	Hmpsn. F. I., II, 501.	Darbhanga District (Bihar), India, Burma, Ceylon.	Defoliating.
Stems .	*Arbela tetraonis*, Mo. . .	S. I. I., pp. 453-454, t. 41.	Pusa.	
Twigs	*Machærota* sp.	..	Pusa, Lucknow.	
	Pyralid	..	Pusa . .	Larva making a gall.
Shoots .	(Aphid)	..	Pusa.	

Phoont (*Cucumis trigonus*).

Fruits .	*Chætodacus cucurbitæ*, Coq. .	Bezzi. Bull. Ent. Res. VII, 107-110, 1916.	Pusa . .	Cultivated large fruits.
	Myiopardalis pardalina, Big. .	Proc. Sec. Ent. Meeting, p. 306.	Pusa (August 1915).	Adults.

Plantain (*Musa sapientum*).

Leaves .	*Stephanitis typicus* Dist. . .	One Hundred Notes, p. 36, fig. 20.	Plains.	
	Pericallia ricini . . .	S. I. I., pp. 370-371.	Throughout South India.	
	Psychid	..	Pusa (11th February 1914).	Larva on leaf.
	Nodostoma subcostatum, Jac. .	Jac. F. I., Chrys., p. 334.	Assam, Burma, Pusa.	Plantain leaves. Larva found underground near roots of grasses.
	Parasa lepida, Cram. . .	S. I. I., pp. 410-411, ff. 283-284.	India, Ceylon, Kumbalengno, (Cochin) Poona, Bankura.	Gregarious round shell-like cocoons on tree trunks.
Fruits .	*Nodostoma subcostatum*, Jac. .	Second Hundred, Notes, No. 147. Jac. F. I. Chry., p. 334.	Assam, Burma, Pusa.	Adult on fruits as well as leaves.
	Chætodacus diversus, Coq. .	Bezzi. Bull. Ento. Res. VII, 108-109, 1916.	Mandalay .	Also bred from oranges.

PLANTAIN (*Musa sapientum*)—*contd.*

Stems .	*Tinda indica*, Wlk. . . .	One Hundred Notes, p. 17.	Pusa, Chapra .	Larva bred in stems.
	A Hispid beetle . . .	..	Hmawbi (Burma), 7th September 1918.	The specimens were sent by Mr. K. D. Shroff as boring into the plantain stem. These could not be identified and were returned.
	Odoiporus longicollis . .	Proc. Sec. Ent. Conf. Pusa, 1917.	Calcutta, Pusa	Larva in stem. Destructive of affected plant.
	Cosmopolites sordidus, Germ. .	S. I. I., p. 342-343, f. 201.	Mahim (Bombay) Wynaad, Poona.	Adult in stem. Occurs as a pest and may be introduced in planting setts.
	Chrysomelid (Hispinæ) (Gen.? sp.?)	..	Hmawbi (Lower Burma).	Bores into plantain flowers (K. D. S.; 7th September 1908).
Roots .	*Pelytus mellerborgii*, Boh. .	..	Pusa . .	Boring roots.

PLUM (*Alu Bokhara*).

Leaves .	*Adoretus horticola*, Arr. . .	Arrow, F. I. Rut., p. 344; Ento. Note 22.	Jeolikote	Damage by night.
	Adoretus versutus, Har. . .	Arrow, F. I. Rut., p. 350.	Ditto.	
	Chrysomelid (Gen.? sp.?) (Galerucinæ).	..	Helem, 29th March 1907.	Adult on plum trees in numbers; attacks leaves and unripe fruits in large numbers.
	Brahmina coriacea, Hope. .	One Hundred Notes, p. 3.	Jeolikote, United Provinces.	
	(Leaf curl)	..	Saharanpur.	
	Myllocerus sabulosus . .	..	Taru-Peshawar	Eats foliage of young plum trees.
	Euproctis flava . . .	...	Lyallpur (27th June 1916).	
	Anomala varicolor, Gyll. . .	Arrow, F. I. Rut., pp. 152-153, f. 41.	Jeolikote (20th May 1915).	Adult on leaf.
	Anomala lineatopennis, Bl. .	Arrow, F. I. Rut., pp. 212-213.	Ditto .	Ditto.
	Adoretus duvauceli, Bl. . .	Arrow, Rut., pp. 343-344; Ent. Note 21.	Jeolikote (1st July 1912).	
Fruits .	*Virachola isocrates*, Fb. . .	S. I. I., p. 416, f. 289: B. J. XXIV, 184.	Pusa . .	Larva in fruit.

POMEGRANATE (*Punica granatum*).

Leaves .	*Euproctis fraterna*, Mo. . .	S. I. I., pp. 398-399, fig. 267.	South India.	

Pomegranate (*Punica granatum*)—*contd.*

Leaves—*contd.*	*Euproctis flava* . . .	..	Lyallpur (27th June 1917).	
	Parasa lepida . . .	S. I. I., p. 410-410.		
	Myllocerus 11-pustulatus, Fst. .	Mshll. F. I., Curc. I, 350-350.	Pusa . .	Adult on leaves.
	Euproctis scintillans, Wlk. .	S. I. I., p. 399, f. 268.	Do.	
Fruits .	*Virachola isocrates*, Fb. . .	S. I. I., 416-417; I. M. N., II, 156.	Shikarpur (Sind), South India, Surat, Samalkota, Samastipur, Bhagalpur, Bangalore.	Also reared from seedless Navel Oranges, Bangalore.
	Deudorix epijarbas, Mo. . .	Lep. Indica IX, 33-34, t. 711, ff. 3, 3-*a*-*c*.	Kumaon .	Larvæ destructive to fruits in June-July, in some years scarcely a fruit escapes.
	Euzophera punicæella, Mo. .	Hmpsn. F. I., IV, 73. I. M. N. II, 28.	Baluchistan .	Larva recorded boring in fruits.
Stems .	*Ophiusa arctotænia*	..	Pusa (31st September 1909).	Caterpillars were found in cracked bark on stem though doing no damage. In the Insectary they ate leaves a little—did not eat bark.

Sapatu; alligator-pear (*Achras sapota*).

Leaves .	*Metanastria hyrtaca*. . .	First Hundred Notes, p. 25, fig. 14.	Pusa, 10th June 1916.	40 caterpillars were found feeding on the leaves. Also found on *Eugenia jambolana* trees, on the bark.
	Nephopteryx eugraphella, Rag. .	Hmpsn. F. I. Moth IV, 77.	Pusa (8th July 1914). Also in Punjab, Calcutta.	Webbing leaves.
	Rhodoneura myrseusalis, Wlk. .	..	Pusa (26th September 1909).	Larva on leaves.
	Acrocercops gemoniella, St. .	..	Pusa . .	Larva mining leaves. Not a pest.
Fruits .	*Chætodacus ferrugineus versicolor*	Bezzi. Bull. Ento. Res. VII, 105, 1916.	Pusa . .	Larva in fruits.
	Chætodacus zonatus, Saunders. .	Bezzi. Bull. Ento. Res. VII, 105-106, 1916.	Do.	

Strawberry.

Leaves .	*Myllocerus blandus*, Fst. . .	Mshll. F. I., Curc. I, pp. 333-334, f. 101.	Pusa . .	Adult damaging leaves.
	Myllocerus 11-pustulatus Fst .	Mshll. F. I., Curc. I, pp. 350-352.	Do. . .	Adult on plants.

TAMARIND (*Tamarindus indica*).

Leaves .	*Stauropus alternus* . . .	S. I. I., p. 408, ff. 279-280.	Coimbatore, Ganjam, South India.	Larva also on *tur*, *Trewia nudifolia* and tea.
Fruits .	*Virachola isocrates* . . .	S. I. I., pp. 416-417	South India.	
Fruits (Stored).	*Calandra linearis*, Hbst. . .	One Hundred Notes, p. 10.	Pusa . .	Breeds in stored fruits.

WALNUT.

Leaves .	*Saturnia* (*Caligula*) *simla* .	..	Simla (13th July 1907).	
	Oxyambulyx sericeipennis, Butl.	..	Shillong . .	Each larva defoliates considerably.
	Belippa laleana, Mo. . .	I. I. L., p. 501, t. 28, f. 14.	Do. . .	Larva does slight damage by feeding on the leaves.

WATER-MELON (*Citrullus vulgaris*).

Fruits .	*Acythopeus citrulli*, Mshll. .	..	Hagari . .	Reported as a bad pest of water-melons in April 1908. Grubs bore into the side on the ground. They tunnel into the fruits filling the passage with excrement and cause decomposition.
	Chætodacus cucurbitæ, Coq. .	Bezzi. Bull. Ento. Res. VII, 109-110, 1916.	Attur . .	Larva in water-melons.
	Dacus brevistylus . . .	Proc. Second Entl. Meeting, p. 305.	Hagari.	

WATERNUT (*Trapa bispinosa*) (Vern. *Singhara*).

Leaves .	*Galerucella Singhara* . .	..	Bhandara (Central Provinces), Shakartala (Central Provinces), Muzaffarpur, Cawnpore.	A bad pest of *Singhara*.

WOOD-APPLE (*Feronia elephantum*).

Leaves .	*Parasa lepida*	S. I. I., 410-411 .	South India.	
Fruits .	*Argyroploce illepida* . .	Proc. Sec. Ent. Conf. 1917, p. 230.	..	Bores into the fruits.
	Euzophera plumbeifasciella, Hmpsn.	Hmpsn. F. I. IV, 73.	..	Scarcely a pest.

Most of these insects have also been discussed in the general list of crop-pests. We have been collecting information on Fruit-pests for some years now and it will be useful to have a list of the various fruit-trees showing what insects we know as attacking each. **Mr. Fletcher.**

23.—LIST OF THE PESTS OF FRUIT-TREES (INCLUDING PALMS) IN BURMA.

By K. D. Shroff, B.A., *Entomological Assistant, Burma.*

Pest	Part of the Plant attacked	REMARKS
1. RUTACEÆ.		
(*a*) *Citrus trees.*		
Brachytrypes portentosus	Seedlings (Orange)	Reported "serious" at Kya-in (Amherst District).
Papilio demoleus	Leaves	Sometimes serious to young plants.
Cacœcia micaceana	Do.	Not serious.
Gnatholea eburifera	Stem and Branches	Proved serious at Kya-in.
Rhynchocoris humeralis	Plant juice	Reported "serious" from Bassein.
Neodurtus acocephaloides	Do.	Not serious.
Coccids (2 species)	Do.	Minor pests; status not known.
(*b*) *Wood apple.*		
Euproctis fraterna	Leaves	Not serious.
2. RHAMNEÆ.		
Zizyphus jujuba.		
Phycita sp.	Leaves	Minor pest.
Dereodus sparsus	Do.	Ditto.
Moth ?	Fruit	Ditto.
3. AMPELIDEÆ.		
Grape vine.		
Theretra gnoma	Leaves	Not serious.
Theretra alecto	Do.	Not common.
Theretra oldenlandiœ	Do.	Ditto.

23.—LIST OF THE PESTS OF FRUIT-TREES (INCLUDING PALMS) IN BURMA—*contd.*

Pest	Part of the Plant attacked	Remarks
4. ANACARDIACEÆ.		
(*a*) *Mango.*		
Eugnamptus marginatus	Leaves	Found once at Maymyo.
Cricula trifenestrata	Do.	Minor pest; sometimes serious; abundant in Rangoon.
Macalla moncusalis (?)	Do.	Found at Mogaung and Hopin.
Weevils ?	Branch-joints	Found at Mogaung; status not known.
Rhytidodera robusta	Branches (Borer)	Minor pest; kills medium-sized trees gradually at Maymyo; also attacks fig trees.
Anomala aurora	Fruit	Once found feeding on semi-ripe fruits at Maymyo.
Cryptorrhynchus gravis	Do.	Very serious.
Chœtodacus ferrugineus	Do.	Ditto.
Idiocerus atkinsoni	Plant-juice	Minor pest but sometimes serious.
Tettigoniella ferruginea	Do. (?)	Found in numbers on the tree but status not known.
Mealy Bugs (3 species)	Do.	Not yet found serious.
(*b*) *Amra* (*Gwe-di*) (*Spondias mangifera*).		
Podontia affinis	Leaves	Once found at Mudon (Amherst).
5. ROSACEÆ.		
(*a*) *Loquat.*		
Beetles	Shoots	Eat up the shoots and two or three trees do not bear fruits at Maymyo.
(*b*) *Apple.*		
Borer	Stem and Branch	Found very serious at Taunggyi; could not be reared.
Woolly Aphid	Roots and Stems	Found pretty serious at Taunggyi.

23.—LIST OF THE PESTS OF FRUIT-TREES (INCLUDING PALMS) IN BURMA—*contd.*

Pest	Part of the Plant attacked	Remarks
(*c*) *Pear.*		
Chætodacus ferrugineus dorsalis	Fruit . . .	Very serious at Maymyo.
Aphids	Shoots . . .	Found once at Taunggyi.
(*d*) *Peach.*		
Anomala pallidospila . .	Fruit . . .	Once found at Maymyo ; not serious.
Popillia feæ	Do. . . .	Ditto.
Popillia histeroidea . .	Do. . . .	Ditto.
Popillia complanata . .	Do. . . .	Ditto
Nodina rufipes . . .	Do. . . .	Ditto.
Beetles ?	Do. . . .	Ditto.
Chætodacus ferrugineus . .	Do. . . .	Very serious.
Chætodacus tuberculatus . .	Do. . . .	Ditto.
Aphids	Leaves (Sucking) .	Sometimes very serious.
6. COMBRETACEÆ.		
Country Almond.		
Trabala vishnu . . .	Leaves . . .	Not serious.
Adoretus nitidus . . .	Do. . . .	Minor pest ; rarely proves serious.
7. MYRTACEÆ.		
(*a*) *Guava.*		
Cacœcia micaceana . . .	Leaves . . .	Not serious.
Chrysomela democratica . .	Do. . . .	Probably not serious.
Chætodacus ferrugineus . .	Fruit . . .	Very serious.
Scale insects (Sucking) . .	Leaves, shoots .	Minor pest.
Mealy Bugs (Sucking) . .	Do. . .	Not yet found serious.

23.—LIST OF THE PESTS OF FRUIT-TREES (INCLUDING PALMS) IN BURMA—*contd.*

Pest	Part of the Plant attacked	REMARKS
8. ANONACEÆ.		
(*a*) *Custard Apple.*		
The Red Borer (*Zeuzera*) . .	Stem and Branch .	Getting serious in the Prome District.
Mealy bugs	Fruits . . .	Minor pest.
(*b*) *Cherrimoya.*		
Aristobia approximator . .	Stem and Branch .	Proved serious at Taunggyi.
9. RUBIACEÆ.		
Coffee.		
Scale insects (sucking) . .	Shoots, leaves .	Minor pest; found at Maymyo.
10. URTICACEÆ.		
(*a*) *Fig.*		
Phycodes minor . . .	Leaves . .	Minor pest.
Rhytidodera robusta . .	Stem and Branch .	Proved serious at Maymyo in one garden; killed all trees.
Borer ?	Do. .	Another species found in the same garden at Maymyo.
(*b*) *Mulberry.*		
Glyphodes pyloalis . . .	Leaves . . .	Found at Maymyo; not serious.
Amsacta caterpillars . .	Do. . . .	Found at Lashio; the pest could not be identified as the caterpillars died at Mandalay.
Borer ?	Stem . . .	Found at Taunggyi; could not be identified as the collected borers died before pupation.

23.—LIST OF THE PESTS OF FRUIT-TREES (INCLUDING PALMS) IN BURMA—*concld.*

Pest	Part of the Plant attacked	Remarks
11. SCITAMINEÆ.		
Plantain.		
Small beetles	Leaves . . .	Minor pest but not serious.
Odoiporus longicollis . .	Stem . . .	Serious in some places.
Borer ?	Do. . . .	Found for the first time at Hmawbi in 1918.
Chætodacus diversus . .	Fruit . . .	Found only once at Mandalay.
12. MALVACEÆ.		
Durian.		
Borer ?	Stem and Branch .	Getting serious at Moulmein.
13. GUTTIFERÆ.		
Mangosteen.		
Minute Beetles . . .	Stem and Branch .	May prove serious in the course of time.
14. PALMEÆ.		
(*a*) *Coconut Palm.*		
Oryctes rhinoceros . . .	Bud, Stem . .	Major pest; also attacks Palmyra.
Rhyncophorus ferrugineus .	Stem . . .	Found for the first time inside the rotten top of a dead tree at Pyinmana in 1918. About 10 grubs and one perfect weevil were collected; they were along with the grubs of *Oryctes rhinoceros.*
Nephantis serinopa . . .	Leaves . . .	Minor pest but sometimes serious to coconut and toddy palms.
Gangara thyrsis . . .	Do. . . .	Reported "serious" in Henzada.
(*b*) *Date Palm.*		
Skipper	Leaves . .	Not serious.

24.—COCCIDS AFFECTING FRUIT-TREES IN SOUTHERN INDIA.

By T. V. Ramakrishna Ayyar, B.A., F.E.S., *Acting Government Entomologist, Madras.*

It is generally recognized that of the different kinds of insects that levy their toll on fruit-trees the members of the group *Coccidæ* or Scale insects play a very important part. This is, of course, not recognized as much in India as it is in the well-known orchard areas of the world. In California, Australia, South Africa and the Mediterranean countries, which are the foremost places where fruit crops are extensively grown, individuals of this family of insects have been known to do very serious damage and bring about appreciable loss to the country. Even a single species such as the "San Jose Scale" or the "Oyster Shell Scale" has been found responsible for the loss of thousands of pounds worth of fruits every year.

In India on the other hand, although conditions of fruit growing and the consequent chances of insect infestation have not advanced to any such remarkable degree, within the last decade very great attention has been paid by land-owners in South India towards the extension of the area under different kinds of fruit crops. It is a common sight now-a-days, as one moves in a railway train, to find numerous young orchards of mango, *Citrus* and other fruit crops in areas which were till recently barren and uncared for. This fairly rapid extension of the area under fruit allows the easy dissemination of the different kinds of insect pests and especially those that belong to the group of Scale-insects. Of all insects which have, in virtue of their peculiar habits and nature, the best chances of easy distribution from place to place the Scale-insects rank very high, and as such I believe it may help prospective fruit-growers to have some idea of the different species of this family that they are likely to meet with, so that they may be in a position to take prompt measures before any of the insects assume serious proportions. I have therefore attempted in this brief paper to note down the species that have so far been found on fruit trees of different kinds in South India, either as important or as minor pests. So far, only a few of those in this paper are really serious pests; but it would be advantageous to have an idea of what are the species found on the plants, so that we might watch the progress of the different species. The species have been arranged under each fruit crop found in South India.

Mango.

Proportionate to its importance in South India the mango tree is subject to the attentions of a good many species of Coccidæ. However, only a few of these have been noted to do appreciable damage now and then.

Chionaspis vitis, Green.

Locality.—Very common in South India especially in the Mysore uplands.

Habits.—Attacks the foliage. Badly infested leaves turn into a sickly yellow colour.

Diaspis barberi, Green.

Locality.—In the Northern Circars, Ceded Districts and Tanjore.

Habits.—Not so common as the previous species. Often found on the tender shoots and leaf stalks. It is found on *Loranthus*, which is a plant parasitic on mango in certain tracts.

Diaspis rosæ, Bouche.

Locality.—In Bangalore. Not noted before from India.

Habits.—On the leaves ; it has also been noted on a wild plant.

Diaspis mangiferæ, Green.

Locality.—Vizagapatam District.

Habits.—Not very common.

Aspidiotus rossi, Msk.

Locality.—Godavari and Coimbatore Districts.

Habits.—The dark common oval scales are generally found in patches on the leaves near the stalk. Has been found on *Carissa Carandas* also.

Aspidiotus ficus, Ashmead.

Locality.—Noted in the Ceded Districts, along the West Coast, the Nilgiris, and Coimbatore.

Habits.—The purplish-black scales are easily made out on the infested leaves. Attacks also *Citrus, Eugenia* and *Pandanus.*

Aspidiotus trilobitiformis, Green.

Locality.—Northern Circars, Coimbatore, Malabar.

Habits.—Though not recorded before from India it has been found on two other plants besides mango—*Ixora* and *Mimusops.*

Pulvinaria psidii, Msk.

Locality.—Found all over the Presidency.

Habits.—This is one of the bad fruit pests of South India (see under guava).

Ceroplastes actiniformis, Green.

Locality.—Godavari, Ceded Districts, Coimbatore and South Kanara.

Habits.—Besides mango, the scale has been noted on coconut, *Canna, Ficus*, and *Calophyllum* in South India.

Ceroplastes rubens, Msk.

Locality.—Ganjam District.

Habits.—Has been noted on jak, *Calophyllum, Cycas*, and cashew elsewhere in South India.

Vinsonia stellifera, Westw.

Locality.—Coimbatore.

Habits.—Of minor importance on mango.

Lecanium adersi, Newst.

Locality.—Coimbatore.

Habits.—Occasionally pretty bad on the foliage.

Lecanium discrepans, Green.

Locality.—Godavari District.

Habits.—This insect is a new record from India. Ants of the genus *Cremastogaster* generally visit the scales in numbers.

Lecanium acutissimum, Green.

Locality.—Coimbatore.

Habits.—Very rare on mango.

Phenacoccus iceryoides, Green.

Locality.—Coimbatore and Northern Circars.

Habits.—It is often bad on mango—the white mealy masses covering the shoots, leaves and fruits.

Phenacoccus ballardi, Newstead.

Locality.—Coimbatore.

Habits.—Very much like *Phenacoccus iceryoides*, Green, but not found in such numbers.

Phenacoccus mangiferæ, Green.

Locality.—Coimbatore.

Habits.—Not very common. This is the first record from India.

Tachardia lacca, Kerr.

Locality.—Saidapet, Madras.

Habits.—Only on one occasion was this noted and that not in large numbers.

GUAVA.

This plant, although subject to the attacks of only a few Coccids, often suffers considerably from one or two species.

Pulvinaria psidii, Msk.

Locality.—This is found all over the country.

Habits—It is very often found doing considerable damage to guava trees. The leaves of badly-infested trees present a dark blighted appearance.

Lecanium hemisphæricum, Targ.

Locality.—Coimbatore District.

Habits.—Though this is a specific bad pest of coffee, I have noted it causing appreciable damage to guava.

Mytilaspis pallida, Green.

Locality.—Godavari District.

Habits.—Very rare. Noted only once and that as a minor insect.

ORANGE, LEMON, POMELO, ETC.

So far as known there are not as many Scale-insects affecting the *Citrus* trees in Southern India as one may be expected to find, judging from the conditions in other Citrus-growing countries. I have not yet come across the well-known " Orange Scale " (*Aspidiotus aurantii*, Msk.) on *Citrus* trees, although the species is not absent in South India.

Aspidiotus ficus, Ash.

Locality.—Malabar and Nilgiris.

Habits.—Occasionally bad.

Parlatoria ziziphus, Lucas.

Locality —Coimbatore.

Habits.—Rarely found. Another species of *Parlatoria* is also found on *Citrus* in the Mysore uplands.

Lecanium viride, Green.

Locality.—On the Nilgiris and the Mysore uplands.

Habits.—This is the notorious " green bug " of coffee, and often it affects *Citrus* foliage badly.

Lecanium hesperidum, L.

Locality.—Godavari District.

Habits.—The long soft scales are found chiefly on the shoots.

Phenacoccus iceryoides, Green.

Locality.—Godavari District.

Habits.—Pretty bad on *Citrus* as it is on mango in the Northern Circars.

Pseudococcus corymbatus, Green.

Locality.—Godavari District.

Habits.—The insect is found in large mealy masses on the shoots of the plant and is as bad as *Phenacoccus iceryoides*, Green.

PLANTAIN.

Only about half a dozen species have been noted on plantain and so far not one of them has appeared in pest form.

Aspidiotus orientalis, Newst.

Locality.—Coimbatore.

Aspidiotus cyanophylli, Sign.

Locality.—Nilgiris, 2,000 feet.

Lecanium signiferum, Green.

Locality.—Vizagapatam District.

Lecanium discrepans, Green.

Locality.—Godavari District, on the plantain fruits and fruit-stalks.

Lecanium depressum, Targ.

Locality.—Coimbatore.

POMEGRANATE.

I have only noted two Coccids so far on this fruit plant and of the two only one of them can to a slight extent be considered as a pest.

Pseudococcus crotonis, Green.

Locality.—Coimbatore.

Habits.—Found on the stalk and crown of the fruits. Often the latter portion is eaten away by the mealy-bugs.

Hemichionaspis theæ, Mask.

Locality.—Coimbatore.

Remarks.—Very unimportant as a pest.

GRAPE.

Aspidiotus cydoniæ, Comst.

Locality.—Bangalore and Coimbatore.

Habits.—Found often bad on the main vines and shoots. Greatly weakens the vigorous growth of the vines. Appears to be an imported Australian species.

Lecanium nigrum, Niet.

Locality.—Coimbatore.

Habits.—Found on young leaves. Not serious.

Pulvinaria sp.

Locality.—Krishnagiri, Salem.

Habits.—Although it was made out to be a *Pulvinaria* the material was not sufficient to identify the correct species.

FIG.

Cultivated fig harbours two Coccids both of which do some damage to the fruits.

Aspidiotus cydoniæ, Comst.

Locality.—Coimbatore.

Habits.—Found on the fruit-stalks as in pomegranate.

Pseudococcus crotonis, Green.

Locality.—Coimbatore.

Habits.—On fruit-stalks and stem and roots just under the soil.

APPLE.

I have not yet noted any Scale on the apple-plant in South India, although it is not unlikely such may be found.

PEAR.

Aspidiotus cydoniæ, Comst.

Locality.—Bangalore.
Habits.—On shoots and fruit-stalks as in fig.

PEACH.

Aspidiotus lataniæ, Sign.

Locality.—Coonoor (Nilgiris 5,000 feet). Noted by Andrewes. have not observed this insect on peach myself.

SAPOTA.

Pseudococcus crotonis ? Green.

Locality.—Coimbatore.
Habits.—The tender shoots are often badly infested by colonies of this mealy-bug and ants visit them in numbers.

JAMBOLAN (*Eugenia jambolana*).

Aspidiotus destructor, Sign.

Locality.—Maddur, Mysore.
Habits.—Sometimes the leaves are badly infested.

Aspidiotus ficus, Ash.

Locality.—Maddur, Mysore.
Habits.—Found along with *Aspidiotus destructor*, Sign.

ROSE APPLE (*Eugenia jambos*).

Vinsonia stellifera, Westw.

Locality.—Godavari District.
Habits.—Pretty common. Found chiefly on the under-surface of the leaves. However, not a serious pest.

CUSTARD APPLE.

Pseudococcus virgatus, Ckll.

Locality.—Coimbatore and other places.
Habits.—A pretty bad pest. It is often found covering the shoots and the surface of the fruits.

Pine-apple.

Pseudococcus bromeliæ, Bouch.

Locality.—Taliparamba, Malabar.

Habits.—Within the leaf sheaths. The species looks like *P. longispinus*, Targ., but I am not certain. The material is with Mr. Green for identification.

Bilwa (*Ægle marmelos*).

Lecanium viride, Green.

Locality.—Coimbatore.

Habits.—I found it pretty bad on young plants.

Cashew (*Anacardium*).

Ceroplastes floridensis, Comst.

Locality.—Bangalore.

Habits.—Not found in numbers.

Country almond (*Terminalia catappa*).

Lecanium nigrum, Niet.

Locality.—Kollegal, Coimbatore.

Habits.—Often bad on the foliage.

Jak.

There are over half-a-dozen species noted on this tree but only one or two of the mealy-bugs often prove destructive.

Hemichionaspis aspidistræ, Sign.

Locality.—Mysore uplands.

Remarks.—Not a pest.

Aspidiotus triglandulosus, Green.

Locality.—Bangalore.

Remarks.—Not very common.

Parlatoria artocarpi, Green.

Locality.—Periaghat, Western Ghats.

Remarks.—Not a pest.

Parlatoria (Websteriella) papillosa, Green.

Locality.—Palghat, Malabar.
Habits.—Not found in numbers.

Ceroplastes rubens, Mask.

Locality.—Ganjam District.
Habits.—Only a few isolated scales found.

Pseudococcus corymbatus, Green.

Locality.—Malabar District.
Habits.—Often bad on the tender shoots and fruits and visited by the red ant in numbers.

Icerya ægyptiaca, Dougl.

Locality.—Kallar, Nilgiris.
Habits.—Bad on the leaves, shoots and tender fruits.

BREAD FRUIT TREE.

Icerya ægyptiaca, Dougl.

Locality.—Vadanapalli, South Malabar.
Habits.—Pretty bad on leaves and shoots.

BER (*Zizyphus*).

Ceroplastodes cajani, Mask.

Locality.—Coimbatore.
Habits.—Found as whitish glassy masses on the distal shoots. Not a serious pest.

MULBERRY.

Lecanium nigrum, Neitn.

Locality.—Coimbatore.
Habits.—Bad on isolated plants occasionally.

Pulvinaria maxima, Green.

Locality.—Coimbatore.
Habits.—Found rarely.

25.—*TUKRA* DISEASE OF MULBERRY.

(Plate 98).

By C. S. Misra, B.A., *First Assistant to the Imperial Entomologist.*

(1) *Dactylopius bromeliæ*, Bouche., Naturgesicht, 1834, p. 20.
(2) *D. bromeliæ*, Signoret, Annales de la Soc. Ent. de France, December, 1874, p. 310.
(3) *D. bromeliæ*, Ind. Mus. Notes, Vol. III, No. 5, p. 51, fig. 52.
(4) *D. bromeliæ*, Bouche ; C. S. Misra—The *Tukra* Disease of Mulberry. A Report on the Silk Industry in India by H. Maxwell-Lefroy (1915).
(5) *Phenacoccus hirsutus*, Green. Mem. Dept. Agric. Ind., Entl. Series, Vol. II, No. 2, April 1908, p. 25, Plate II, fig. 1.

The disease locally known as "*Tukra*" in Bengal is caused by *Phenacoccus hirsutus*, Green. Hitherto it was thought that the cause of the disease was *Dactylopius bromeliæ*, Bouche. But early in July last year (1918) specimens were sent to Mr. E. E. Green and he has now identified the Mealy-bugs causing the *Tukra* disease as *Phenacoccus hirsutus*, Green. The disease was noticed for the first time by me at Pusa early in 1908, but with the pressure of other work further investigations regarding the cause of the disease could not be taken up. In April 1909, when I visited the Babulbona nurseries in the Murshidabad district, my attention was drawn to the damage done to the bush mulberry plantations in the nursery compound. The mealy-bug was so bad that hardly a plant was free from it in the nursery plantations, and Mr. A. C. Ghosh, Superintendent of the Babulbona nurseries, informed me that the disease was very widespread in the interior of the district, and in consequence I visited some of the villages in the neighbourhood of Murshidabad and found the disease very bad in a large number of bush mulberry fields. In some places the disease was so bad that there were hardly any green succulent leaves on the plants. All that was present on them were the hard, compact, malformed shoots in which the leaves had turned distinctly coppery-green or pale-yellow. The apical leaves forming the malformed heads had become so crisp that it was hardly possible to examine them without breaking them. Later on, a large number of stray bush mulberry plants—the remnants of a former roadside plantation at Pusa—were found to be severely affected with the disease and on examination were found to be infested with the nymphs and adults of *P. hirsutus*, Gr., in every stage of development. These plants were kept under observation until, early in 1916, specimens were obtained

PLATE 98.

Shoot of mulberry affected with "Tukra."

from Ramnagar in the Murshidabad district to compare them with those found at Pusa. The two sets of specimens were sent last year for identification and both were declared to be the same species, *Phenacoccus hirsutus*, Gr. The disease is known as *Tukra, Kokra, Thopna* and *Topor* in Bengal (*vide* letter from Mr. A. C. Ghosh, Superintendent of Sericulture, Bengal, dated the 16th December 1918). The local names are symbolic of the malformation caused to the leaves and shoots by the mealy-bugs. The disease has hitherto been noticed by me at Pusa and the silk-growing districts of Bengal, Murshidabad, Malda and Bankura. But it is possible that it is more or less present in some of the other mulberry-silk-producing districts of the country. The disease is so prominent and characteristic, that once seen it cannot soon be forgotten. The shoots of the affected plants first turn coppery-green, then pale-yellow and ultimately become so hard and compact that it is not possible to open them without breaking away the crisp leaves. With the appearance of the malformed shoots the lower lateral leaves become seared and fall off prematurely. In cases of severe attack, there may be seen nothing but the bare stems of plants standing in the field. The apical leaves, if they do not turn pale-yellow, become so crisp and devoid of nutrient constituents, that they become unfit to be served to *Bombyx mori* caterpillars. In some years the disease is very widespread and considerable damage is done to the leaf-crop, and in such years there is heavy loss to the cultivators who take to leaf cultivation and supply. The disease seems to have obtained a permanent footing in mulberry-silk-producing districts in Bengal for the reason that the remedies hitherto adopted for eradicating the pest are to collect the affected shoots and to throw them outside the infested fields, in a ditch or a pool of water close by. The nymphs as well as the mature females crawl over from these and again infest the succeeding crop. In this way the pest runs on its course uninterruptedly. Besides this, the nymphs as well as the gravid females are blown away by the wind with the fallen leaves and these have been found to lie buried in a pit close by the infested fields. As soon as the winter is over, the eggs hatch and the nymphs walk over long distances, ultimately reaching their favourite foodplants, the cotton or the mulberry. The eggs and nymphs have also been observed to be transported to new places by means of the nymphs and females of *Pseudococcus virgatus*, Ckll., as well as other insects. During the winter the matured females move down and establish themselves in leaf-scars, under bark and notches on the stem. There they remain quietly ensconced until the winter is over, when they again move up the plant and establish themselves, preferably on the shoots, thereby producing the characteristic malformation known as *Tukra* or *Kokra* of Mulberry.

The nymphs as well as the females prefer to feed on the tender apical leaves of mulberry plants. In order to determine when and how the malformation of the mulberry shoots was caused a newly-hatched nymph was taken and put on a healthy growing bush-mulberry cutting in a pot. The nymph was transferred on the plant on 4th September 1916 and on 12th September 1916 the place where the nymph had fixed itself to feed in the axil of a leaf had turned deep coppery-green and the stem flattened out laterally. Soon after the presence of the nymph on the plant could be known easily by the presence of the ant, *Monomorium indicum*. The ants attend upon the nymphs and the maturing females for the sake of the honey-dew. They have not been seen to attend upon the full-grown male nymphs prior to their pupation. They have also not been seen to attend upon the gravid females when they have begun laying eggs and are covered with fine, whitish cretaceous threads, especially towards the pygidial end. On the 18th September 1916 the leaves had curled distinctly and had turned deep coppery-green. The characteristic malformed head was formed and the leaves forming these had changed colour and had become firm and crisp. The following day one or two patches of the mulberry mildew, *Phyllactinea corylea*, were visible on the leaves. The plant on to which the nymphs were transferred had remained immune from the attack of the fungus, along with another plant potted at about the same time as this, but now began to show traces of the presence of the mildew. It was just possible, because the vitality of the plant was lowered by the undue draining away of the sap which would have gone ordinarily to the development and maturing of the plant, that the mildew appeared. The other plant was also unfortunately utilized for marking the development of the apical malformation, otherwise if it had been kept separate it would have served well for comparison. On the 23rd September 1916 I talked this over with Dr. E. J. Butler, Imperial Mycologist, Pusa, and he very kindly gave me access to literature* belonging to him, wherein it was recorded that the plants at first immune from the attack of a fungus fell a victim to it as soon as they became infested with Aphididæ. The experience gained by me was very much similar to this. Early in 1909 when the mulberry leaf-mildew was very prominent on a few plants in a small plot of broad-leaved mulberry plants in the compound of the bungalow occupied by Mr. H. Maxwell-Lefroy, I found a large number of grubs and adults of *Thea cincta*, feeding voraciously on the mildew on leaves.

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* 1. On *Erysiphis graminis*, Dc. and its adaptive parasitism within the genus *Bromus*. ....Ernest S. Salmon, F.L.S., (*Annales Mycologi*, Vol. II, Nos. 3 and 4, 1914, pp. 24-25).

2. Cultural experiments with "Biologic Forms" of the Erysiphaceæ......Ernest S. Salmon, F.L.S. (*Phil. Trans. Royal Soc. London, Series B*, Vol. 197, p. 112).

The grubs were specially active in devouring the fruiting bodies (*perithecia*) of the fungus, and were again observed in numbers during December 1912. The adult beetles have been found to devour with avidity the nymphs and adults of the Red Spider, *Tetranychus bioculatus*, especially bad on castor, jute and *Hibiscus abelmoschus* at Pusa. The sequence of observations was :—

4th September 1916.—Nymphs put on two potted bush-mulberry plants. (From cuttings obtained from Malda).

12th September 1916.—Apical leaves turned coppery-green and the stem flattened out laterally (both ways).

14th September 1916.—Leaves became curled, malformation of shoot apparent now.

18th September 1916.—Leaves curled distinctly, malformed apical head became compact.

19th September 1916.—Mildew, *Phyllactinea corylea*, visible on the leaves especially the lower ones.

21st September 1916.—The leaves became dark coppery-green and crisp.

23rd September 1916.—The mildew, *Phyllactinea corylea*, became very prominent and spread to a number of leaves on the plant.

4th October 1916.—The leaves became pale yellow and fell down.

20th October 1916.—The growth of the affected plant from 19th September to 19th October 1916 was only 3¼ inches. Some of the apical, malformed leaves became pale yellow prematurely and fell down. The lower leaves became covered profusely with the white mildew.

31s October 1916.—The total apical growth of the plant from 19th September to 31st October 1916 was 4½ inches

Such leaves, if served to *Bombyx mori* caterpillars, cause Flacherie and Grasserie in the worms (*vide* letter from Mr. A. C. Ghosh, Superintendent of Sericulture, Bengal). The apical leaves become crisp with the presence of the mealy-bugs on the top shoots of plants and contain very little succulent matter in them. It is no wonder if worms fed on such leaves should develop Grasserie and Flacherie.

At Pusa *Phenacoccus hirsutus* has been found by me on *Morus* spp., cotton and on potted *Ficus religiosa* plants kept near the potted mulberry-plants to study the life-history of the White-fly. Close to the potted mulberry-plants were also *Eugenia jambolana*, *Ficus glomerata*, sugarcane, paddy seedling, and *Citrus decumana* plants, but none of these was found affected. During the present winter, fully matured and gravid female *P. hirsutus* have hibernated on *Ficus religiosa* plants in pots and I was able to rear one complete cycle on these plants. Late in October, when *Spalgius epius* caterpillars appeared, they cleared away whole colonies of *P. hirsutus* on the potted mulberry as well as on *Ficus religiosa* plants. On mulberry plants in pots I have found *Pseudococcus virgatus* to occur along with *P. hirsutus*, but the nymphs and females of the former may easily be distinguished from the eggs, nymphs and adults of the latter by the following prominent characteristics :—

Pseudococcus virgatus, Ckll.

Egg, pale yellow, ovoid ; nymph, pale yellow with a pair of whitish caudal setæ ; female stout, thinly covered with white meal, with a pair of whitish setæ at caudal end, the lateral margins as well as the venter covered with small, white hairs, especially so when gravid and about to lay eggs.

Phenacoccus hirsutus, Green.

Egg, cylindrical, bright pink with one end suffused with bright pink; nymph, bright pink, thinly covered dorsally with a thin whitish meal (in some cases when attended by ants the meal wears off) ; adult female bright deep pink with a light fuscus tinge, ovisac of whitish felted threads which envelop the female entirely. The eggs are laid touching each other within the cretaceous white ovisac.

Besides these, the presence of the nymphs and adult females of *Pseudococcus virgatus* does not cause the crumpling of the apical leaves and the subsequent malformation of the apical heads. In a series of experiments conducted with the nymphs of *Pseudococcus virgatus*, along with those of *Phenacoccus hirsutus*, to find the malformation of leaves and shoots caused by the two mealy-bugs, it was found that in one or two instances there was a slight crumpling of the leaves caused by *P. virgatus*, but it was not so striking as the curling of the leaves caused by *Phenacoccus hirsutus* within the same length of time. If, however, the nymphs and females of *P. virgatus* strayed over and got mixed with the nymphs and adult females of *P. hirsutus*, they could be separated easily by their colour differences as well as by the presence of caudal setæ. The case was, however, different when *P. hirsutus* occurred on cotton along with *P. corymbatus* and *P. virgatus*. In such a case as this there was no difficulty in first separating *P. hirsutus* from *P. virgatus*, and then differentiating between *P. hirsutus* and *P. corymbatus*. To do this satisfactorily some experience is however necessary. The two mealy-bugs may, however, be distinguished on the plants by means of the following superficial characteristics. To do the differentiation critically, the specimens must first go through the usual mounting technique and then an examination of their pygidial ends will give characters sufficiently distinct. The eggs of *P. hirsutus* lie loosely within the female ovisac and are bright pink in colour with one end suffused with scarlet. The female is bright pink with an ovisac consisting of white, cottony threads. In the case of *P. corymbatus* the adult female is dark castaneous with a globular cottony ovisac consisting of fine white threads enclosing the eggs which are chocolate-brown in colour, suffused at one end with dark castaneous.

From July to the middle of October 1918 *P. corymbatus* overran the cotton plots to such an extent that the crop was damaged to a very large extent. Like *P. hirsutus*, it also produces malformation of the shoots of cotton plants. The apical leaves, although they do not turn deep coppery green, become brittle and the stems swell up. The heads become hard and compact and the affected plants are thrown back in growth, and in a climate like Pusa (which is not a typically good place for cotton-growing) the initial retarding of growth of plants at a time when their growth should be very vigorous tells prejudicially on the cotton outturn later on. The plants are unable to recoup the loss and as such remain stunted in growth. The flowering is also retarded, and, coupled with the damage done by the bollworms (*Earias fabia* and *E. insulana*) the crop may to all practical purposes be said to be a failure, and the present season's crop (1918-19) is illustrative of the damage done by *P. corymbatus*, *P. hirsutus*, *Machærota planitiæ* and *Eriophyes* sp. (*gossypii ?*). From the middle of October onwards *P. hirsutus* preponderates over *P. corymbatus*, and, if an examination is made, it will be found that gravid females of both the species are to be found side by side of each other on the cotton top-shoots. During July-September both *P. hirsutus* and *P. corymbatus* fall a prey to *Eublemma* sp. (near *quadrilineata*), but the latter is much affected by Drosophilid flies whose cocoons are to be found in the affected top-shoot in numbers.

The females when matured remain on the spot on which they had fixed themselves in the larval stage. Sometimes they change their places and cluster together on a stem, the base of leaf-stalks, or the axils of leaves. When full-grown they are bright pink in colour dorsally as well as laterally, covered with thin, cretaceous, white, flocculent threads. On some portions of the plant a number of females may be seen laying eggs side by side of each other. The ovisac consists of white cottony threads and covers up the female with eggs completely. The ovisac on account of its milk-white colour becomes a prominent object against the greenish background of the leaves, or the russet-brown colour of the stems or the russet-yellow of the leaf-stalks, and as such can be easily spotted and collected. The female lays a large number of eggs and in one instance the number of eggs was found to be 232. The cretaceous white ovisac, if removed from the pygidial end of the female, grows again and the flocculent material covers up the eggs. The female, if disturbed at the time of laying eggs, becomes restive, moves about for a time, settles down and begins laying eggs. If again disturbed it moves about for some time and again begins laying eggs. From close observations made for a full year, it was found that in all the cycles the female lays eggs which take from 5 to 8 days to hatch according to the time of the year.

The female lays bright pinkish eggs which remain covered within the ovisac. Each egg is bright pinkish, suffused at one end with bright scarlet. The eggs lie loosely within the ovisac covered with whitish flocculent threads forming the ovisac. Each egg is 0·36 to 0·39 mm. long and 0·15 to 0·21 mm. broad. It is cylindrical, rounded at both ends. The chorion is covered thinly with meal owing to its being covered with the flocculent material forming the ovisac.

The nymphs on hatching move about the plants. They generally gather together on the apices of branches, the leaf-stalks or the tender stems below shoots. They are gregarious in habits and their presence is known easily by the presence of the ants (*Monomorium indicum*) which attend upon them for the sake of the honey-dew. In this case it was observed that the amount of honey-dew exuded by the nymphs was not so copious as to cause the development of the black fungus on the lower leaves. When full-fed they either remain at the same place of feeding or move about to establish themselves on some other part of the plant, and here too their presence is betrayed by the ants which find them out soon. The male nymphs shift their places and have been observed to collect together on the lower surfaces of leaves, preferably near the midribs, leaf scars on the stems and branches, any cavities or holes on the stem, or the lower surface of malformed leaves. At times they have also been seen to collect together near the gravid females and so near their ovisacs that they might be taken to have pupated under the female ovisacs. Prior to pupation the nymphs become covered with their whitish silken threads and when several puparia coalesce together, the spot looks white with the flocculent material enclosing the puparia.

A fully-developed female before laying eggs is 2·52 mm. long from apex to end of pygidial lobe and 2·70 mm. from apex to end of caudal setæ, greatest breadth over abdomen transversely dorsally is 1·47 to 1·50 mm., greatest breadth over cephalo-thorax dorsally is 1·11 mm. Body deep red, antennæ and legs stramineous, dorsum covered with thin white meal, abdominal segments distinct dorsally, small hairs on the peripheral margin, pygidial lobes prominent, each with a seta, and a pair of thick cretaceous white stump-shaped threads in the middle. (The above description is of a female removed from an affected shoot prior to laying eggs, floated on distilled water and stifled with chloroform. It was not treated with K O H).

From March to October, each complete cycle lasts from 24 to 29 days. Later on, with the advance of cold, the period becomes lengthened.

The bug has hitherto been seen by me at Pusa on mulberry, cotton and *Ficus religiosa*. If a close search be made it will be found to be distributed widely.

The nymphs as well as the females are parasitized by three species of Chalcididæ. Of the three, one species of Chalcidid parasitizes the nymphs very largely, so much so that numbers of parasitized nymphs may be seen on the infested plants. The parasitized nymph swells up, becomes cylindrical with both the ends swollen, its colour turns to dirty yellow and it resembles a cylinder in miniature lying loosely either in the affected shoots or the axils of leaves. During the winter this parasite has been found to hibernate in the pupal stage in the bodies of its host which has segregated itself either in the cracks on the stem or curled-up leaves where a number of females have congregated to pass the winter.

Besides the three species of Chalcididæ which parasitizes the nymphs and the females, a Cecidomyiad fly* is parasitic upon the eggs, the nymphs and the gravid females. The fly lays its eggs loosely on the female ovisac and in some instances eggs were found amongst the eggs in the ovisac. The maggot on hatching sucks the eggs dry and pupates within the ovisac. The empty eggshells remain within the ovisac near the pupæ of the fly. In several cases the predaceous maggots were seen sucking the matured females. The maggot fixes itself on the sternum of the female and inserts its rostral setæ so firmly that the female remains squirming or shaking its legs. Only in a few cases has the maggot been seen attacking the nymphs, whose shrivelled bodies were found interspersed on the pupæ. The adult Cecidomyiad is dark-pinkish with pale-stramineous legs and antennæ which are thinly hairy. The female is more robust than the male and may be distinguished easily from the male on account of her size and genitalia. The wings are clothed with small, black hairs and the first tarsal joint is very small. The claws to tarsal joints are simple, the thorax as well as the abdomen is thinly hairy. The fly is prominent from August to November and thereafter hibernates in the pupal stage amidst the colonies of females on the affected shoots but mostly in the rugosities or deep cavities on the stems.

The caterpillars of *Eublemma* sp. (near *quadrilineata*) are also predaceous on the nymphs and females. They devour these with avidity and their pupæ are found in the midst of colonies of nymphs and females.

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* This fly has since been named by Professor E. P. Felt as *Diadiplosis indica*.—*Editor.*

These, along with the caterpillars of *Spalgius epius* clear away the colonies on mulberry as well as, on *Ficus religiosa.* The latter appears late but is very effective in freeing the plant of its pest. In one instance a single *Spalgius epius* caterpillar was observed to have cleared away the colonies of the mealy-bug on a large-sized mulberry plant. The caterpillar moves about quickly from branch to branch devouring the nymphs as well as the females. When full-fed, it pupates on the leaves of the infested plant. Hitherto no parasite has been found on the eggmasses or on the adult males of *Phenacoccus hirsutus.*

26.—A NOTE ON OUR PRESENT KNOWLEDGE OF INDIAN THYSANOPTERA AND THEIR ECONOMIC IMPORTANCE.

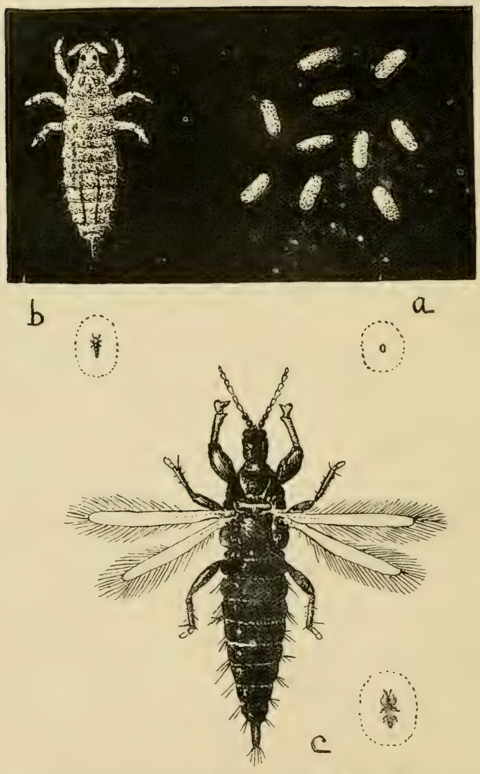
By T. V. Ramakrishna Ayyar, B.A., F.E.S., F.Z.S., *Acting Government Entomologist, Madras.*

Though one of the major sub-divisions into which the great class of insects is divided, the Order Thysanoptera is one which has hardly received any serious attention till now from Entomologists in India. In America and other Western countries the importance of some of the species of this Order has been realized and a good deal of work has been done in this direction. Some of the well-known pests of this group in western countries are the pear thrips, orange thrips, tobacco thrips, wheat thrips and so on. Though many of the forms of this group are found in flowers and are apparently harmless, the group as a whole should not be considered so harmless as we are often led to believe. I have, therefore, attempted in this note briefly to review our knowledge of Indian forms so far known and add a few remarks as to the economic importance of the group as a whole and of some of the species in particular.

So far as I have been able to find out the following appear to be the previous records of Thysanoptera from India. Uzel's Monograph of this group, which was published in 1895 and which unfortunately is in the Bohemian language, according to Lefroy records only two Indian species, *viz.*, *Idolothrips halidayi,* Newm., and *Phtocothrips anacardii,* Newm., both from South India.

The later records of species from India are mostly by Bagnall. This well-known Thysanopterologist has described the following species up-to-date so far as I know :

(1) *Panchætothrips indicus,* p. 257, *Records of the Indian Museum* VII, 1912—on turmeric, Madras.
(2) *Heliothrips indicus,* p. 291, *Annals and Magazine of N. H.* XII, 1913—on onion, brinjal, indigo, etc., Bengal.
(3) *Physothrips lefroyi,* p. 290, *Annals and Magazine of N. H.* XII, 1913, on tea flowers, Bengal.



Arrhenothrips remakrishnae, **Hood, on** *Mimusops elengi* **leaves ;** *a,* **eggs ;** *b,* **young ;** *c,* **winged adult. All figures are magnified (×16), the smailer figures within dotted lines showing the natural sizes.**

(4) *Physothrips usitatus*, p. 291, *Annals and Magazine of N. H.* XII, 1913—on flowers of *Butea frondosa*, Allahabad.
(5) *Phoxothrips breviceps*, p. 380, *Annals and Magazine of N. H.* XIV, 1914—on wild plants, Himalayas.
(6) *Leeuwenia indicus*, p. 377, *Annals and Magazine of N. H.* XIV, 1914—from Burma ; on wild plants.
(7) *Hindsiana apicalis*, p. 323, *Annals and Magazine of N. H.* XV, 1915—Almora (North India) ; on wild plants.
(8) *Physothrips longiceps*, p. 221, *Annals and Magazine of N. H.* XVII, 1916—on Rhododendron, Garhwal (North India).
(9) *Tæniothrips major*, p. 216, *Annals and Magazine of N. H.* XVII 1916—on Rhododendron, Garhwal (Himalayas).
(10) *Aptinothrips ruficornis* var. *connaicornis*, Uz., p. 205, *Annals and Magazine of N. H.*, 1918—on tea flowers, Darjiling.
(11) *Haplothrips tenuipennis*, p. 206, *Annals and Magazine of N. H.* 1918—on tea and rose, Darjiling.
(12) *Physothrips setiventris*, p. 65, *Bulletin of Entomological Research* IX, 1918—on tea ; North India.
(13) *Physothrips brunneicornis*, p. 206, *Annals and Magazine of N. H.* 1918—on rose, Darjiling.
(14) *Physothrips peculiaris*, p. 206, *Annals and Magazine of N. H.*, 1918—on lucerne, Pusa.

In 1915, my specimens of Thrips collected on paddy from Madurantakam (Chingleput) were described by Mr. Williams in the *Bulletin of Entomological Research*, p. 353, to belong to a species of *Thrips* and was named *Thrips (Bagnallia) oryzæ*, being the first record of a species of the genus *Thrips* from India.

Recently I forwarded some of my material to Mr. Hood of the United States and he has so far identified the following new forms from my lot. The descriptions of these have not yet appeared in print. [Since appeared in *Insecutor Inscitiæ Menstruus*, April 1919.]

(1) *Arrhenothrips ramakrishnæ* (Plate 99). On *Mimusops elengi*, Coimbatore.
(2) *Rhipiphorothrips cruentatus*. On grape vine leaf, Coimbatore.
(3) *Scirtothrips dorsalis*. On chillies and castor shoots, Coimbatore.
(4) *Neoheegeria indica*. On *Ailanthus* shoots, Coimbatore.
(5) *Perissothrips parviceps*. On *Ailanthus* shoots, Coimbatore.

The above appear to be the species so far noted from India till now.

Speaking of the economic side of Thysanoptera, there are some species which are really very injurious. *Thrips oryzæ* on young paddy does considerable damage in certain seasons in different parts of South India. There are, I know, one or two species of *Thrips* (*Physothrips*) which often give a good deal of trouble in the tea gardens, as Mr. Andrews will be able to tell us. The turmeric thrips (*Panchætothrips indicus*, Bgl.) is sometimes found bad also. The onion crop in different parts of the country is often seriously injured by Thrips (*Heliothrips indicus*). The one on *Mimusops* (*Arrhenothrips ramakrishnæ*) is very serious on this garden plant in Coimbatore. The leaves are twisted and galled and the plant suffers considerably. The grape-vine Thrips (*Rhipiphorothrips cruentatum*) is also capable of doing appreciable harm to the tender foliage of grape. I have recently noted a species on young pepper leaves, curling up the leaves, and the species appears similar to one noted on pepper in Ceylon (*Gynaikothrips karnyi*, Bgl.).

I have with me material collected on indigo, red gram, *agathi*, ground-nut, etc., some of which have occasionally given trouble. Thrips are generally believed to be harmless although there is no foundation for this belief. In favourable seasons they multiply enormously and give great trouble.

So my idea is to invite your attention to the economic aspect of the several species of Thysanoptera and point out that this is a group which is well worth special study not only from a scientific or systematic aspect, but from the standpoint of Economic Entomology also. There is plenty of literature on foreign species by Haliday, Hood, Moulton, Bagnall, etc., although there is very, very little on Indian forms.

Mr. Ramakrishna Ayyar. I am thinking of specializing in this group and shall be glad if any collectors will send me in material.

Mr. Senior-White. Do you want specimens sent in spirit ?

Mr. Ramakrishna Ayyar. Yes ; that will do.

Mr. Andrews. Do Thrips do damage in the Hills or Plains ?

Mr. Ramakrishna Ayyar. Everywhere, both in the Hills and in the Plains.

Mr. Fletcher. Thrips are very common everywhere in India and probably do much more damage than has been observed so far. We must have a very large number of species but they have not been collected so far. At Pusa we get a very handsome species, bright crimson and green, on *Ficus* about December.

Mr. Senior-White. Some species are aquatic.

Mr. Fletcher. Are they aquatic in the real sense of the word or is it that you have found them sitting on the surface film ?

Mr. Senior-White. Probably they were only sitting on the surface of the water.

Mr. Ramakrishna Ayyar. They are also found under bark and in old posts.

Mr. Senior-White. They cluster on plants.

Mr. Ramakrishna Ayyar. I have tried spraying with plain water and that is quite sufficient to kill them. We have not tried this on a large scale.

Mr. Andrews. Water may work in some cases, but not in all. Thrips on tea make the leaves curl up and are often found in partially opened buds and are therefore protected and in such cases the only spray that can do any good should be very volatile so that the fumes can get inside the buds and curled-up leaves. I have found XEX quite good as a spray. Thrips may occur for years without doing any damage but, if the plants are attacked by another insect or weakened in any way, then the Thrips may cause considerable damage. In one case in Cachar I noticed in one year that the tea was very badly attacked by Red Spider and in this case it did not flush but after some time it started growing slowly but its growth was checked by Thrips. The growth in the Plains is more rapid than in Darjiling and therefore Thrips do not do so much damage in the Plains. I have found four species which I have sent to Mr. Bagnall. Three of these have been named and the fourth is still unidentified. This unidentified species is the one that got into this checked tea and hindered its growth. The first year the attack was severe. The second year it was mild and the third year it did not affect the tea much.

The three named species are *Physothrips lefroyi*, *Ph. setiventris* (referred to in the Report of our Second Meeting as the "Common Thrips" of tea), and *Haplothrips tenuipennis* (referred to as the "Black Thrips" of tea).

In Darjiling, rose, *Hibiscus* and most other flowers are crowded with Thrips. In Jorhat we only get one species of Thrips on flowers of rose.

Thrips do more damage to plants when the growth is slow and, if the growth quickens, they are thrown off.

The life-histories of the Common Thrips [*Physothrips setiventris*] and of the Black Thrips [*Haplothrips tenuipennis*] are different and so we have to use different sprays and different methods for each. The pupæ of the black Thrips are found amongst lichens covering the stems of the bushes and so, by removing these lichens, you kill the Thrips. The pupæ of the common Thrips are found in the soil and are very difficult to get at, as the methods applied in the case of the black Thrips are not suitable. The more you cultivate, the deeper they go. If you cultivate as far down as eighteen inches, they will go further down to pupate. When I suggested different cures to different planters they asked me why I suggested one thing to one man and a different thing to another man, the reason being these differences in habits of distinct species. This proves how essential it is to know the species and its life-history and habits before suggesting remedial measures.

Dr. Butler's experimental plot of *tur* suffered very badly from Thrips last year. **Mr. Misra.**

We made experiments on onion Thrips by forcible spraying with water but found that this was of no use. Crude-oil emulsion and fish-oil soap could not kill them at a strength of one pound in four gallons of water, but one-and-a-half pounds of fish-oil resin soap in four gallons of water kept them in check. We had a species of Thrips on cabbage and we sprayed it with this mixture. **Mr. Ramrao.**

Fish-oil resin soap on edible cabbage? How could you do it? What about the smell? **Mr. Ramakrishna Ayyar.**

In Baroda we had Thrips badly attacking lucerne. We tried a water spray but it was no good. We then applied the following measures:—one man was made to disturb the plants and another following him with **Mr. Patel.**

burning cowdung cakes in a pot; the Thrips jumped into this and more than seventy-five per cent. were thus destroyed by the smoke.

Mr. Ramrao. What about the larval stages? They cannot fly.

Mr. Ghosh. But they can jump away, although without wings.

Mr. Andrews. Thrips can jump backwards and forwards equally easily.

Mr. Ramachandra Rao. There are two or three species of Thrips in *Lantana* flowers. One species is useful in the fertilization of the flowers. I conducted experiments to prove this. I enclosed some flowers in paper bags and removed all the Thrips; there were very few seeds in such flowers. In another lot I enclosed Thrips in the bags and all these flowers formed seeds. I am sure that some Thrips are important in pollination.

Mr. Ramakrishna Ayyar. It has been recorded that Thrips are very useful in pollination.

27.—THE METHODS OF CONTROL OF *AGROTIS YPSILON* IN BIHAR.

By H. L. Dutt, M.Sc. A. (*Cornell*), *Officiating Economic Botanist, Bihar and Orissa.*

(*I*) *Cultural Method.* In order to discuss the cultural method of its control, it will be advisable to consider the character of the soil in the *chaur* land. It is a stiff heavy clay and cultivation can be commenced on it ten days after the flood water has left the land and can be continued from fifteen to twenty days, after which it is so hard that it cannot be ploughed. Ordinarily the cultivation consists in one ploughing followed by dibbling behind the second plough or by a country seed drill, depending on the moisture in the soil. The fact that the land on account of its gradual slope does not all dry simultaneously enables the sowing to be carried on for at least a month, although some land is generally left fallow every year owing to its being too hard to plough.

(*a*) From the habit of the caterpillar it is reasonable to suppose that if the land is properly cultivated, *i.e.*, if ploughed four or five times before sowing, as in high land, the pulverized condition of the soil would, to some extent, check the activities of the pest. But the character of the soil, as noted above, does not allow of any such cultivation unless, of course, the number of ploughs working on the whole area is considerably increased. So, as a general control method for the whole area, it is not practicable, since 15,000 to 20,000 bighas have to be finished within a month.

(*b*) There is another system of sowing common in the lower areas of the *chaur*, *viz.*, broadcasting. It consists in scattering the seed on the land immediately after the water has left it, *i.e.*, when it is still muddy.

It has been seen invariably that the crop on a broadcasted area is less liable to damage than that on a ploughed area. This is on account of the fact that in the former, the surface of the land being smooth (with cracks here and there) does not give as good facilities for locomotion and hiding to the caterpillar, as the ploughed land with its surface composed of blocks of soil of all sizes. Broadcasted areas are by no means immune from attack, as many instances are known of their being damaged as badly as other areas. But its greatest drawback is that the outturn from broadcasted areas is very poor and a cultivator takes to it only when there is no other way of taking a crop on the area. The method cannot therefore be generally adopted.

(*c*) Nothing can be done to prevent *Agrotis* attack by way of changing the crop, as those grown in the *chaur* (peas, gram, wheat, *masur*, *khesari*, mustard, etc.) are all acceptable to the caterpillar, although it has a decided preference for the first three.

(*II*) *Chemical Method.* Considering the enormous extent of the area, chemical methods are out of the question. Poison baiting was tried at Mokameh in 1910 but it proved useless under the conditions prevailing in the area.

(*III*) *Mechanical.* As a result of the last eight years work in Bihar against this pest it has been seen that it can be most satisfactorily controlled by the use of Andres Maire traps against the parent moths supplemented by handpicking the first brood caterpillars on higher land. The result of the work since 1911 is given below.

Year	Locality	Extent of damage during the year	Normal extent of damage	Number of traps used	Number of moths caught in traps	Number of caterpillars collected
		Bighas.	Bighas.			
1911-12	Mokameh	5,000	15,000	2	6,293	62,699
1912-13	Do.	100	15,000	25	152,003	107,439
1913-14	Do.	3,700	15,000	35	833,896	43,005
1914-15	Do.	2,000	15,000	34	434,726	..
1913-14	Ghogha	20	6,000	18	45,465	340,000
1914-15	Do.	200	6,000	24	23,535 (in one area)	143,745
1915-16	Do.	80	6,000	56	437,956	133,443
1916-17	Do.	..	..	..	..	..
1917-18	Do.	400	6,000	54	157,992	470,196
1918-19	Do.	86	6,000	54	47,532	587,084

(*IV*) *Destruction of Weed Food-plants.* It has been noticed at Ghogha that in the absence of any crop on the *chaur* early in the season, the caterpillar feeds on a weed called "*Agra*" (*Xanthium strumarium*). In order to see the effect of the destruction of the weed on the first brood of caterpillars, the whole area in question at Ghogha was completely freed from the weed in 1917-18. But the result of the experiment was not satisfactory. The first-brood caterpillars were found, in the absence of the weed, on tobacco, *kulthi*, etc., on higher lands surrounding the area. Destruction of the weed food-plant does not therefore appear to have any chance of keeping the pest under control.

(*V*) *By Parasites.* Under field conditions the caterpillar has several parasites of which two Braconids are more in evidence than the Tachinids of which there are more than one. Of the Braconids again one is more numerous than the other. These parasites are first observed in the field in October when the percentage of parasitization is very low but this however gradually increases towards the end of the season. Ordinarily it becomes 30 per cent. on an average by the end of December but in 1918 it was 74 per cent. in one plot at Ghogha. With a view to finding out the possibilities of the parasite against *Agrotis* attack in the *chaur* land, its life-history was completely worked out in the Insectary at Sabour in 1917-18. The idea was that if a large number of adult parasites could be liberated in the normally attacked area early in the season, they would by attacking the first brood caterpillar make the second or the destructive brood negligible. As regards its life-history, it has been found out in the Insectary that in January to February the length of its egg and larval stages is 25 days and the pupal stage is 11 days—total 36 days. In March the periods are 17 days and 8 days respectively—total 25 days. In April the length of the egg and larval stages is 12 days only. It goes into æstivation in March or April and remains as a grub inside the cocoon. What is still unknown about its life cycle is the time when it comes out of its æstivation in the *chaur* land. Presumably it does so along with the appearance of the first brood caterpillars in the *chaur* in September or October, when, its numbers being very small, on account of the exigencies of climate and adverse *chaur* conditions during the æstivating period, the percentage of parasitization is very low. With the idea of giving it a fair start against the first brood in the beginning of the season, by increasing their number, large broods of the parasite were reared in the insectary in February and March 1917 and allowed to go into æstivation in April. The grubs inside remained healthy through the summer and the rains and even in the first week of October they were alive, but they failed to pupate and come out as adults. The same experiment was repeated in the Insectary in 1918 with no better results. It is evident that the natural factors controlling their emergence from the æstivating pupæ did not obtain in the Insectary. As it is not definitely known what these factors are, efforts will again be made this year to find these out, so as to be able to have ready a large number of live adults for inoculating the first brood caterpillars in the *chaur* early in the season. The object in view may also be accomplished by work in another line and that is by first ascertaining if the *Agrotis ypsilon* caterpillars, which are reported to be found in the Hills during the rains, are parasitized there and, if so, by introducing a large number of affected caterpillars from the Hills in August and September and rearing them out for use in the *chaur*. Work on this line will be taken up this year along with the trial in the Insectary for carrying through the local parasite during the æstivating period.

28.—CONTROL OF THE MELON-FLY IN HAWAII BY A PARASITE INTRODUCED FROM INDIA.

By David T. Fullaway, Honolulu, H.I.

The Hawaiian Islands are situated in the midst of a vast ocean. They are completely isolated from the continent, so that insects detrimental to agriculture cannot easily reach them. But with the development of trade on the Pacific, the Islands have become a commercial crossroads, a day seldom passing without a steamer putting into our main port, and despite the strict inspection and quarantine of horticultural products a serious pest now and then does slip in. Our equable climate permitting almost continuous breeding, an excessive multiplication and rapid spread of the pest soon result. Thus it was that the melon-fly (*Chætodacus cucurbitae*) gained access to the islands about 1895, and thereafter melons of any sort could not be grown successfully. A somewhat similar experience later with a more destructive insect, the Mediterranean fruit-fly, aroused public interest to the extent of inducing the Government to experiment with the possibility of controlling the injuriousness of the fly by searching out and introducing its parasites, that is to say, other insects that were known or could be ascertained to live at the expense of the first. Parasitism among insects is a very common phenomenon, which even the layman to-day is acquainted with, and the check which this parasitism exerts on the multiplication of insects is also well-known. It should be pointed out here that the same circumstances which prevent the migration of injurious insects to our isolated islands, also prevent beneficial insects from reaching us. Likewise, the same causes which lead to the rapid spread and excessive multiplication of injurious introductions, operate equally on the beneficial ones that prey upon them. In other words, the method of controlling injurious immigrant insects by the introduction of their parasites is particularly applicable to Hawaiian conditions. The experiment that was tried with the Mediterranean fruit-fly was successful to a very large degree and induced the Government to go further and see what could be done to control the ravages of the melon-fly. In this way the writer was engaged in July 1915 to investigate the parasitism of the melon-fly and obtain whatever natural enemies could be discovered.

Before going on to the detailed account of the expedition, it should be stated that when the search for melon-fly parasites was begun, our knowledge of the fly outside of Hawaii was very limited, consisting almost wholly of the probable distribution of the fly gained from the meagre records of Compere and Muir and the publications of the Imperial Entomologist of India. Nothing positive was known of parasites, although Muir's accounts of the relative scarcity of the fly in certain localities gave a measure of confidence to the assumption that parasites existed.

In regard of the facilities offered by the Government laboratories in India, it was considered that *it* would be the country to work first, and on 23rd July I set out with the intention of going directly to Pusa in India. When I reached Manila, however, I went up to Los Baños to have a conference with Muir, and it was largely on his recommendation that I decided to work first around Singapore.

While at Hongkong, 17-20th August, on my way to Singapore, I made a short trip up the river to Macao, where Muir and Kershaw had worked considerably, to determine its suitability as a breeding station on my probable return with parasites.

Leaving Hongkong on the 20th, I arrived at Singapore on the 26th, located a supply of infested fruit in some Chinese vegetable gardens, and set up my laboratory in a room over the hotel garage. Here I worked over a month, rearing melon-flies out of cucumbers and a few *Momoraicas* and *Luffas*. At the end of a week, on opening some of the puparia, I found a single female *Opius*, and shortly after two males, and felt encouraged to go on. However, although more than 6,000 flies were reared, no further parasites were obtained, and I decided to continue on my way to India. I attribute the meagre results obtained in Singapore to the character of the fruit used, and the manner of its cultivation. The only cultivated cucurbit to be obtained in any quantity is the cucumber, which is produced by Chinese market gardeners under conditions which are very favorable to mould—the ground where these gardens are is low, and it is the custom of the Chinese to wet down the beds three or four times a day with liquid manures. I think if wild *Momordicas* could have been obtained, the parasites would have been more abundant, but under the conditions described, the parasites have little chance to multiply.

The method used to ascertain what parasitism existed was very simple. Infested fruit was placed in cages on sand, and as soon as the maggots had emerged and pupated, the sand was screened to separate the puparia, which were then placed in shell vials. After a few days, the flies would emerge from unparasitized material, and these were liberated daily until emergence ceased. The material was then gone over and everything discarded except the sound puparia, which would be suspected of containing parasites. When parasites emerged they were conducted as soon as possible into $6'' \times 1''$ test-tubes containing a fresh leaf holding drops of honey and water. About twenty parasites can be kept in good condition in a single tube and if carefully attended they can be expected to live at least a month. If necessary to hold longer, they can be reared in confinement wherever a good supply of infested fruit can be obtained.

At Singapore I had the misfortune to lose part of my equipment and I utilized the time necessary to have it replaced in investigating melon-fly conditions in Java. It is only a 36-hour run from Singapore to Batavia, and another 3-hour journey on the railroad to Buitenzorg, the seat of Government and location of the scientific laboratories. The director of the scientific work, Dr. Konigsberger, showed sympathetic interest in my mission, and kindly offered me a desk in the Strangers' Laboratory. I spent nearly a month in Java, 10th October to 6th November, and in this time reared between 4,000 and 5,000 flies. In due course the material disclosed the parasite found at Singapore, and I was able to take a small lot of males and females away with me. My time in Java was limited, and the work done there was done too hurriedly to give anything more than an impression of the conditions, but the impression was very favorable. Cultivated fruit was scarce at that season of the year, and *Momordicas* were used very largely in rearing flies. These fruits are not cultivated in fields or gardens, but are grown by the natives around their houses, and are, therefore, very much scattered. The cultivated fields appeared clean, and I was told that two pickings are usually secured before an infestation is noticed. A large ground-beetle was very active here.

On returning to Singapore, I found a letter from Muir giving encouraging information in regard to the Philippines, but I had already made my plans to go to India, and was obliged to defer the investigation of this new field till later.

Leaving Singapore on the 9th of November, we arrived at Negapatam on the 16th, and from there I proceeded by rail to Bangalore, in Mysore State, a locality highly recommended by Compere. I may say that the idea of going to Pusa had to be abandoned on account of the low temperatures prevailing there during the winter months. I found Bangalore suited to my purposes, although it is not, as I had expected it to be, in a rich agricultural or fruit-growing section; it is one of the hill stations of India, in normal times with a garrison of more than 10,000 troops, and on account of its fine climate, has attracted many Indian pensioners. It was natural, therefore, to find on the outskirts of the city extensive gardens, and my first examination of these revealed the melon-fly. I utilized a small room in the hotel as a laboratory, and was soon rearing hundreds of flies. Before I had a chance to breed the parasites brought from Java, the same species appeared in Indian material, and in a very short time I had a flourishing colony. I spent five weeks or more in India, rearing about 10,000 flies. Out of these *Opius fletcheri* came abundantly, and I was also able to cultivate a small lot of *Spalangia*; but nothing further appeared, and after my own extensive work and the assurance of Mr. Fletcher, the Imperial Entomologist, that nothing else had ever been bred by them from *D. cucurbitae*, I decided I had exhausted this field and it was time to move on to the Philippines. All the while in India I was looking closely for *Syntomosphyrum indicum*, the fruit-fly parasite introduced by Compere into Australia, by Lounsbury into the Cape, and by Silvestri into Italy, but I saw nothing of it, and the Indian Entomologist could give me no information about it beyond what I already knew.

Leaving Bangalore on the night of 23rd December for Colombo, I was detained by the Indian police at Dhanushkodi for three days *en route*, but arrived in ample time to catch the Spanish mail (31st December) and after an uneventful voyage of 18 days reached Manila with about 75 living examples of the Indian parasite, *Opius fletcheri*, which I had carried with me on leaving India. While stopping in Singapore I had also secured infested fruit to breed the parasites *en route*, and from this material I subsequently got 64 additional individuals.

In Manila I received very generous assistance from the Bureau of Agriculture and Science, and established a laboratory in a room set aside for me at the latter institution. I found fruit very scarce and practically no cultivated cucurbits. Under the circumstances, I was obliged to depend entirely for rearing and breeding purposes on *Momordicas*. These fruits are dry and do not give the same trouble with regard to mould that cucumbers do; at the same time they contain very few maggots, and are got only with great exertion and loss of time.

As a consequence my stock of parasites dwindled, and I was disappointed in the hope of finding additional species. I spent nearly three months in the Philippines, rearing about 18,000 flies, but nothing new disclosed itself. This seemed strange in view of the rich fruit-fly fauna there, which is known to harbor several species of Opiine parasites. I also lost the small colony of *Spalangia*, one generation running to males.

It was unfortunate that at the time of leaving Manila the steamer connections were such that I was obliged to remain in Hongkong a week. I used this intermission in the voyage to the best advantage, but my fruit-fly parasites had dwindled to very small proportions by the time of my arrival in Honolulu, on 10th May 1916.

From this small stock, however, the parasite was successfully multiplied and in the course of a month or two it was possible to liberate large lots in suitable localities. This artificial propagation has continued to the present date and thousands of the parasites have been sent out to every locality in the islands where melons are grown. By August 1916 the parasite was recovered from fruit gathered in Honolulu gardens, and we were soon assured of the success of the introduction. At the present time the parasite accounts for the destruction of 50 *per cent.* of the melon-fly infesting our fruit, as ascertained from rearing parasites and flies from different localities in the islands, and in some localities it is again possible to grow melons successfully.

Mr. Fletcher. It is very kind of Mr. Fullaway to have sent us this paper in response to a request on my part to give us a short account of his trip to India to collect parasites of *Chaetodacus cucurbitæ*. It is of considerable interest to us and we are very pleased to find how successful this introduction has proved in Hawaii.

29.—INSECT PESTS OF THE TEA-PLANT IN FORMOSA. (Preliminary Report.)

By Dr. T. Shiraki, *Government Entomologist, Formosa.*

Tea-cultivation in Formosa is one of most important items of agriculture, and the annual out-turn totals more than 20,000,000 pounds. The cultivation has improved, year by year, and at the present time is being carried out more scientifically. Slight attention is, however, given by the cultivators to tea-pests, with a few exceptions, such as *Andraca bipunctata, Euproctis conspersa*, and several *Tortricidæ*.

At the Agricultural Experiment Station of the Government of Formosa, the pests of the tea-bush are being studied, especially those which are injurious. Up to the present time about fifty species have been noticed by us, but none of them is completely studied yet. The following brief note on each species is chiefly summarized from several observations and experiments in the fields or laboratory.

Insect pests of the tea-plant in Formosa.

No. 1.—Odontotermes formosanus, Shir. (*Hime Shiroari.*)

This termite is commonly found all over Formosa, while it occurs in Burma,* Siam, Hongkong, Canton, Fokien, Ishigakijima, and Loo-Choo.

The imagines swarm usually in the afternoon from five to seven o'clock from April to August, and they come down to the ground. After a journey on the surface of the soil the couple find a cleft or hole in the ground and enter into it. In about five or eight days the female begins to deposit her eggs (slightly curved elliptical, 2/3 mm. long) in a roughly-formed royal cell, not very many but twenty to thirty daily, and about a week later the female or male carries out the eggs from the royal cell to the other places which are galleries from the cell. The larvæ which first appear are almost always soldiers, but there are rarely found a few workers. Afterwards the female deposits her eggs gradually, but not on every day, and thus the workers increase in number. During this rime the female grows longer and thicker in the abdomen and in about a year her abdomen measures about one inch or more in length. At that time the royal cell is almost completely formed, flat and irregularly ovate (about half an inch in height and about two inches or less in long-diameter), while the nest around (almost always above half of the royal cell) the royal cell consists of numberless small cells containing the round spongy fungus-bed, each of which connect with one other by means of many narrow galleries. The nest is about one inch or more in thickness and about six inches or more in longitudinal diameter, and it is almost always roundish but somewhat flat, especially on the lower side. This nest containing the royal cell gradually grows larger, and in the next year it becomes about twice in height or length and in the following year thrice, and in the fourth year the nest is about three and a half feet or more long and about one and a half feet high. The nest described just above must be a central one, while the other nests connected to it by narrow (about a half inch or less in diameter and about one-fifth inch or more in depth) exceedingly long galleries, which are from about six feet to 500 feet, from the

* We have no information regarding the occurrence of this Termite in Burma.—Editor.

central nest, are accessory ones. There are many accessory nests belonging to each central one, and these are only houses of workers or a few soldiers. The position of the central nest varies in depth from about half a foot deep in the soil to about ten feet or more. Apparently this varies with the nature of the soil, this species building its nest at different depths in different localities. The colony is exceedingly large ; the soldiers are almost always found in the royal cell and about the termination of the outside galleries which are formed on the trunks of trees ; the queen and king are in the royal cell and never come out from there ; the workers live everywhere in the nest and main galleries ; while the nymphs are only found in particular parts of all the nests.

The damage to tea-plants done by this termite is sometimes fairly extensive, and when the attacks are severe the plant is almost entirely plastered over with soil and it is quite withered when the earthing-over is done in the summer season, but not wholly in a plantation.

This termite also attacks stumps, logs, timbers, several living trees (peach-tree, orange-tree, camphor-tree, *Acacia* sp., *Cryptomeria japonica*, mango-tree, *Eugenia malaccensis* L., *Nephelium longan* Camb., pine-tree, etc.), and sugar-cane.

No. 2.—Leucotermes speratus, Kolbe (*Yamatoshiroari.*)

This insect is commonly found in North Formosa, while it is recorded from Botel-tobago, Ishigakijima, Loo-Choo, Amami-Oshima, Kiushiu, Shikoku, Honshiu, Hokkaido, and Korea.

This widely-distributed termite forms irregular cavities under or in rotten boards, timbers, decayed logs, stumps, fallen trees, etc., and constructs outside them narrow fragile galleries. The colony is rather large, generally consisting of numerous workers, fewer nymphs, soldiers and larvæ. The winged insects swarm on a warm day in April or May. There are sometimes neoteinic queens, although the usual mode of reproduction is performed by a king and a queen. We often suffer from the damage done by this termite to wooden buildings, furniture, bridges, telegraph posts, sleepers, etc., and very rarely to the tea-bush and camphor tree. The injuries to the tea-plant are almost always very slight, but, if the attack of this insect occurs at the time that the plant has been cut off near the soil surface for pruning, it often causes the plant to wither.

Remedial measures for these two termites are two up to the present time, one being the crushing of the outside-galleries plastered over the tea-bush, and the other being the destruction of the central nest.

No. 3.—Toxoptera citrifolia, Maki. (*Komikan-Aburamushi.*)

This is one of the most common pests of the orange-tree, and it is also found on several roses, or very rarely on the tea-plant, but its injuries are very slight. This pest usually occurs in the Northern part of Formosa, but it is not recorded from the South.

Only one control-measure is recommended by us, *i.e.*, the spraying of contact poisons, and this is practised at the time that the young leaves are plentiful or that the buds are coming forth.

No. 4.—Ceroplastes ceriferus, Andrs. (*Tsuno-Romushi.*)

This giant Scale-insect is rather common throughout the whole Island, but not so abundant that the plants suffer from it. This injurious insect attacks the twigs or trunks or rarely the leaves of the tea-plant, orange-tree, mulberry-tree, and *Eugenia malaccensis,* L.

No. 5.—Ceroplastes floridensis, Comst. (*Mikan-Rokaigaramushi.*)

This is not common in the Island of Formosa, but we can find it from May to July in Northern Formosa or in September to October in the South. It is one of the rare pests of the tea-plant, and is sometimes found on the twigs of orange, pear and mango.

No. 6.—Ceroplastes rubens, Mask. (*Momoiro-Rokaigaramushi.*)

This species is less common in Formosa than *ceriferus,* but rather more familiar to us than the preceding Scale-insect. We have found several host-plants, of which tea, camphor, orange and *Psidium guyava* are important plants in Formosa. I do not mean to state that these plants are destroyed by this insect.

The three Scale-insects described above are rather resistant to spraying with contact insecticides, but fumigation with cyanide acid gas is recommended. The latter measure is only practised for destruction of the scales attached to the young shoots.

No. 7.—Lecanium hemisphæricum, Targ. (*Mikan-Tamakaigaramushi.*)

This is the rarest species of tea-plant Scale-insects, and its injuries are very slight although the insect attacks the young twigs. Of its other host-plants the orange-tree is well known. The larvæ are usually found in April or May and the imagines in September. The scarcity of *hemisphæricum* is mainly due to the fact that a certain species of Chalcidid occurs on it.

No. 8.—Chionaspis theæ, Mask. (*Cha-no-Nagakaigaramushi.*)

This *Chionaspis* occurs throughout the Island, and is very common and abundant in the Northern parts. It is only found on the upper surface of leaves of tea, *Cleyera ochracea,* and other unknown shrubs, but the female often occurs on the twigs or trunks.

Though occurring rather commonly in Formosa, I have never seen this insect in injurious numbers, but it is believed by the natives that this pest occasionally injures the leaves so severely that there come almost entirely no crops from an area in the Shinko district of Taihoku Cho. In this district the fresh patches of snowy-white male puparia are usually seen twice in a year, one in May and the other in October.

No. 9.—Icerya ægyptiaca, Dougl. (*Egypt-Watakaigaramushi.*)

No. 10.—Icerya seychellarum, West.=*okadae*, Kuwana (*Okada-Watafukikaigaramushi.*)

These two species are sometimes found on the twigs of the tea-plant, but I have never seen these insects in injurious numbers, while orange-trees are sometimes attacked seriously by the latter species so that the growing of the plant is quite retarded or the twigs entirely withered.

All the above four scale insects are fairly easily controlled by means of spraying with resin-mixture or lime-sulphur, whenever the insects are in the stage of larvæ or young imagines.

No. 11.—Icerya purchasi, Mask. (*Watafukikaigaramushi.*)

This Cottony Cushion Scale-insect has been unfortunately imported from probably Australia in the year 1902, and then it gradually increased in number and became distributed to a large extent. In the year 1907 it was distributed all over the districts surrounding the city of Taihoku. Afterwards the insect spread through the other districts of Taihoku-Cho, and its injuries were a very serious matter to orange-cultivators and others, but such an occurrence was naturally controlled with the introduction of *Novius cardinalis* from Honolulu and New Zealand. Up to the present time, it is well known that this pest attacks about sixty kinds of plants and also the tea-plant, but the damage done to the latter is not noticed by anyone.

No. 12.—Empoasca flavescens, Fab. (*Usuba-Himeyokobai*, or *Chano-Midoriyokobai.*)

This small fly is commonly found in the tea-districts in May or June in somewhat injurious numbers, and it always attacks the under surface of the leaves. In every year the damage done by this insect is almost always about thirty or forty *per cent.* of the usual crop in a small area of the plantation, but never through a large area or whole district. It is also injurious to sugar-cane, orange-tree, and mulberry-tree, and this last is sometimes seriously damaged by a swarm of this pest. In the year 1911, some of the mulberry-tree fields in Taihoku-Cho were affected by a great emergence and some serici-culturists suffered from scarcity of leaves.

Only one control-measure, mineral oil spraying, is recommended by us.

No. 13.—Tettigonia ferruginea var. *apicalis*, Walk. (*Oho-Tsumaguroyokobai.*)

This widely-distributed Jassid is commonly found throughout the Island of Formosa, but the emergence is not abundant annually, and I have never seen this in injurious numbers. It is generally known by agriculturists and entomologists that this species attacks sugar-cane, mulberry-tree, orange-tree, *Paulownia* sp., and the tea-plant.

No. 14.—Geisha distinctissima, Walk. (*Ao-Hagoromo.*)

This Fulgorid also very commonly occurs throughout Taiwan Island, but is not very abundant. It attacks orange, tea, etc., but the injuries are, however, very slight, so that the natives almost always take no care of this pest.

No. 15.—Brachytrypes portentosus, Licht. (*Taiwan-O-Korogi.*)

This large brown cricket is our most familiar burrowing species, found commonly through the Island, and its occurrence is rather abundant, especially in sea shore districts or on sandy high-land.

In September the female cricket burrows into the soil, about one or two feet below, until she reaches the hard soil, where she deposits her eggs (about 40) which usually stand in a bunch at intervals of about 9 mm. and never in contact with one another. In one burrow only a single egg-mass is almost always found, but two or three masses may be deposited by a single female. The eggs hatch in about a month after deposition. Newly-hatched larvæ usually live together in a burrow, but soon after they separate and come out of the burrow. Thus each larva burrows under the soil-surface about three to six inches, and lives in its hole. At night, it comes to the surface and seeks its food, the leaves and young shoots of plants, which it eats or draws into its burrow. During its wandering for food, here and there, the young cricket often loses its burrow and is forced to begin to form a new burrow for its dwelling place. This reburrowing is sometimes probably repeated again. The burrow of this species is not straight but generally curved twice or more, and it is rather elliptical, about six to twelve inches in the long-diameter or about from three to six inches in the short-diameter. The outside opening of the burrow is covered with fine sandy-soil, and consequently the middle of the cover is always elliptically depressed. In the early morning, if there is no cover over the exit of the burrow, there is almost always no insect living therein.

During the rainy season we have sometimes found two or more larvæ in a burrow, this depending on the fact that the insect never re-burrows into the soil in this season, but it seeks the old tunnels. This does not, however, continue for long, and one or two days after the weaker larva comes to the surface and then begins to make its own burrow. It is also rarely seen on the surface save when the heavy rains flood it out of its burrow. After the fifth moult the larva comes up as the imago, and the duration of each stage of larva is from forty to eighty days. From May to June of the next year the adult cricket emerges and the male comes to the surface at dusk, and pours forth its strident note, the sustained shrill vibration being very piercing and, as one approaches, beating in the ears with extraordinary intensity. At that time the female comes there to couple with the male, and the ovaries of the female gradually ripen towards September.

This insect is injurious only to the young tea-plant, as it eats or carries down into its burrow a great number of the young leaves or shoots. It also attacks mulberry, cotton, *Cryptomeria japonica*, *Acacia* sp., camphor, orange, rice-plant, *Sesamum indicum*, melons, cucumber, egg-plant, potatoes, tobacco, sweet-potato, sugar-cane, and several vegetables.

The seedlings of the plants mentioned above usually suffer from this insect (especially of the orange-tree) while *Sesamum indicum*, melons and cucumber are very often destroyed nearly throughout the whole field in the sea-coast districts.

In vegetable gardens the flooding of water is the recommended control, but in tea-gardens the application of poisoned bait is the simplest and most effective method. This bait consists of sweet-potatoes, gingelly-oil, and lead arsenate ; sweet potatoes must be cut about 7 mm. cube, and then must be slightly dried in the sun. The dried pieces of sweet-potato are first dipped into the gingelly-oil and then the oil must be rather clearly drained out of them ; afterwards they must be powdered with lead arsenate. These small baits are placed inside the burrows (one or more in each burrow) by means of long chopsticks in the early morning. The buds or small shoots of bamboo are often used by the natives instead of sweet-potato. These are more efficacious as a medium for attracting the insect than sweet-potato, but the collection of bamboo-shoots is a rather laborious matter.

No. 15.—Olegores citrinella, Shir. (*Mikan-no-Hamaki.*)

This Gelechiad is commonly found throughout Taiwan Island, but is not very common. The larva is slender and long, pale greenish, rather smooth but with a few short hairs on each somite, with the head reddish brown, the chitinous plate on the first somite brown, and the somites from the sixth to the end pale yellowish ; the legs are well developed but the prolegs are rather small.

This caterpillar is found throughout the whole year, and it lives in a shelter formed by fastening together two or more leaves of a tea-plant or orange-tree, but sometimes in a transversely-folded leaf, feeding on the top of the somewhat matured leaf. I have never seen the larva feeding on the very young leaf or bud. The pupa is about 12 mm. long, blackish brown, with a few pale-brown anal processes, in a cocoon of transparent white silk spun in the gathered or folded leaves. The moth usually emerges in March or April.

The damage done to the tea-plant by this insect is very slight, and is almost always neglected by the natives. There is only one remedy, which is the hand-picking of the caterpillars in the fastened or folded leaves.

No. 16.—Acria gossypiella, Shir. (*Wata-no-Hamaki.*)

The caterpillar of this insect is usually found in May and December in the district of Taihoku-Cho, living in a web spun almost always rectangularly on the mid-rib of the underside of a leaf of tea, orange, or camphor, but on cotton it folds a leaf at the margin and lives within. The larva is very long and sub-cylindrical, pale greenish with a rather broad greenish yellow dorsal stripe with the head pale yellowish green ; on the anal somite there are two long hairs and a few short bristly hairs. The full-grown caterpillar is about 17 mm. long. When full-grown it turns to a pale brown pupa in a very thin cocoon spun in the web or folded leaf. This pupa is almost always curved below at the anal half, the wing-sheaths reaching to the posterior margin of the fifth segment of the abdomen ; the anal apex bears a ring of minute spines, and in the middle of the dorsal part of the ring there is a stout short conical process ; on the third abdominal segment from the ventral anal end there is a row of minute processes on each side of the middle. It is about 6 mm. long. The moth emerges somewhat abundantly towards the end of June or in the middle ten days of December, but it is rather a minor pest of the plants mentioned above. Only one control measure may be recommended, *viz.*, collecting the caterpillars by hand-picking, whenever this insect appears in injurious numbers.

No. 18.—Lecithocera formosana, Shir. (*Taiwan-Shiro-Hamaki.*)

This Gelechiad may be a rather rare species even in Formosa, and the larva lives in a folded leaf of orange or tea, feeding on the margin of the leaf. The full-grown caterpillar pupates in a whitish cocoon-like shelter in the fold of the leaf, and about a week after the greyish-white moth emerges. Its occurrence is almost always in April in northern Formosa.

No. 19.—Homona menciana, Walk.=*Archips asiaticus*, Shir. [*nec* Wlsm.] (*Taiwan-Atoki-Hamaki*)

This insect in Formosa was first wrongly determined as *Archips asiaticus*, Wals., by Mr. K. Hori, and this was followed by the present writer. After careful study he has found that it was quite a mistake, and now he corrects it as above.

This tortrix is a well-known tea-pest throughout the Island of Formosa. The outbreak is not a regular one occurring annually but is rather spasmodic, the pest giving trouble on some particular gardens for a few months especially during the late winter and then disappearing for a considerable period. But in the Anpeichin-district of Toyen-Cho it is of a rather permanent character, and is responsible for a considerable annual loss of crop, the yield being sometimes only a half or much less. The eggs are laid on the upper side of the mature leaf and, from their pale yellow colour, form conspicuous objects on the deep green surface of the tea-leaf. They are deposited in compact masses, and are flattened disc-shaped objects, overlapping each other like the scales of a fish, the whole mass covered with a film of a gelatinous substance. After the emergence of the young caterpillars, the eggmasses lose their yellow colour and appear white. A single egg-mass is about 8—10 mm. long or about 5—8 mm. wide and contains about 200 eggs on an average from 20 masses. The eggs usually hatch in five to seven days in March to May.

The newly-hatched caterpillar is dull green, with a shining black head, and looks rather hairy. Soon after hatching it begins to wander about in search of suitable food, here and there, scraping the surface of the leaf on which the eggs were laid and from which it sometimes eats the chlorophyll. It is not satisfied to remain on that leaf, and very soon arrives at a young leaf or shoot. It does not stay there long, however, and is soon again on the move after a short interval. If it finds a young leaf which has not been attacked by another larva, it at once fastens two or more leaves together and lives beneath the shelter, either by itself or with others, feeding on the enclosed surfaces of the leaves. Otherwise the caterpillar hangs down by a fine thread which is sent forth from its mouth, and the thread is blown by the wind until another twig or bush is reached. After the first moult the young larvæ completely distribute themselves over the tea bush, and each individual forms a separate shelter for itself by fastening one or two leaves together, very often enclosing a young shoot, and within this they live and feed. The remainder of their larval life shows no distinct variety of habit. As they grow they merely construct larger enclosures for themselves and consume a greater quantity of leaves. They do not eat steadily through a leaf, but nibble it here and there, bite into the base of a growing bud, or gnaw a small hole in the side of a young shoot, after which they will desert that spot and commence operations elsewhere. In a badly infested field, every shoot on the bush may consequently be injured, and every bush in the garden affected. The full-grown caterpillar measures about 20 to 26 mm. in length, and is pale greenish or whitish green, with a shining reddish brown head and a dark brown chitinous plate on the dorsum of the first thoracic somite, the plate surrounding a narrow quite black crescent behind which in the middle is longitudinally interrupted by a narrow paler line. There are almost always twelve minute tubercles on each somite of the body, from each of which springs a fine bristly hair. The legs are blackish, but the prolegs are very short and whitish, while the anal legs are conspicuously developed. The larval stage occupies about three weeks in May or about a month in January, after which the caterpillar almost always folds a leaf longitudinally or transversely at about its middle or its side, and turns to a blackish-brown pupa which when newly formed has a somewhat greenish tinge on the abdomen. On each dorsal abdominal segment of the pupa there are two transverse rows of minute tubercles, the first row, near the anterior margin, consisting of two rows of many large oval-shaped tubercles, which are in contact with one another and are more conspicuous, while the second, near the middle, is composed of very minute dot-like tubercles and is rather inconspicuous. The anal segment is narrowly and flatly produced behind, and bears a few (about six) thin hooks at the extreme apex, and there are another two similar but more narrow hooks at about each lateral end of the anal process. The pupa of the female is about 15—17 mm. long, but that of the male is much shorter, about 11—13 mm. The moth is found throughout the whole year, and the whole life-cycle occupies about a month during the summer, or about one and a half months during the winter.

Control-measures :—(1) Collection of the egg-masses is most effective for preventing the propagation of this pest. The egg-masses can be easily collected in large numbers by the plucking-girls or children. It is most important that the egg-masses be carefully collected during the first half of the winter as the insect usually does great damage to the tea bush in February to March. (2) The next important remedy is plucking off all twisted leaves containing the caterpillars or pupæ. This must be undertaken at the commencement of an attack when only a few shoots on each bush are involved. If an estate is badly affected by this Tortrix throughout, so that there are almost no green leaves or shoots, it is better to cut away all the twigs from near the soil surface (of course the cut-off twigs should be soon destroyed by fire) than to pluck the attacked leaves. This is rather a violent act, but it is often practised by the natives in the districts where the tea bushes are commonly injured by this insect, and this does little harm to the tea-plant growth, its effect being rather a good thing. If the badly affected tea bush is left naturally or only the twisted leaves are plucked off by hand, the after-growth of the bush is rather poor and there come no good crops.

The application of light-traps is recommended by some entomologists as the moths are attracted by it. I cannot, however, recommend it according to my good many experiences. My observations show that the moths attracted by light are rather few, and consequently that the expenses do not bring forth sufficient benefit.

No. 20.—Adoxophyes fasciata, Walsm.=*Archips minor*, Shir. (*Hime-Hamaki.*)

This species was first brought to my notice in the year 1909, when specimens of the insect were received from the district of Koroton in Taichiu-Cho, with a report of serious damage to tea bushes. The outbreaks are rather regular in that district, but annually the damage done by this pest is not very serious throughout the tea districts. When some tea gardens are badly infested by this Tortricid, these are almost always followed by an attack of the preceding species. There are many other plants affected by this caterpillar, of which egg-plants, orange and mulberry are well known to us as the host-plants, but I have never seen this insect on those plants in injurious numbers. When the pest is at its worst, the leaf is sometimes destroyed over a whole garden, resulting in a serious loss of flush.

The eggs are deposited by the female moth on the upper surface of the leaf of a tea-plant, as in *Homona menciana*, but the egg-mass is usually larger than the latter and consequently contains more eggs. The caterpillar is rather cylindrical and is greenish : the head is flat, with a pale yellowish orange tinge but it is rather greenish in the young stages, and bears black or dull brown or sometimes yellowish brown ocelli, the apex of antennæ, and mandibles. The first somite is rather small and is not distinctly chitinized ; each of the other somites has about eight somewhat greenish tubercles which are arranged in two rows and from each of which a long yellowish hair grows right up ; the legs, prolegs, and anal legs are all of the same colour as the body, the anal ones being longer. When full-grown the body-length becomes about 15 mm.

The young caterpillar lives in the rolled-up leaves and eats inside them, but after the second moult it fastens two or three somewhat matured leaves or folds a single leaf irregularly, and nibbles them from inside of the shelter here and there as in the preceding species. The larval stage occupies more than two weeks at any season, after which the caterpillar fastens almost always two leaves firmly together (but on the mulberry tree or egg-plant folds a single leaf at the margin) and turns to the pupa within.

The pupa is small and slender, with a yellowish brown or dull brown tinge. The wing-sheaths, with the rather sharp apex, extend to the posterior margin of the third abdominal segment, and the antennal sheaths do not reach their apical extremities. Each dorsal segment from the third to the eighth bears a blackish transverse carina near the anterior margin and just behind this is a row of many minute very short spine-like tubercles ; after the middle of each segment there is a fine blackish transverse carina. The anal segment is produced behind, and the apical part of that prolongation is depressed and is slightly curved below, tinged with a reddish purple-brown ; the dorsum is concave, bearing two yellow hooks at each side and four in the middle of the apex, while the venter is distinctly transversely furrowed and bears a single hook near the end of its furrow. The pupæ are usually about 7 to 10 mm. long.

In about four to seven days after pupation the moth usually appears, though one of my observations showed that twenty days elapsed before emergence. The moth is commonly found from May to July, and it is attracted by light as are other moths.

Nothing can be added to what was said under the previous species. It works similarly and should be dealt with in like manner. There are a small Ichneumon fly and a small Tachinid fly, which have been reared from the larvæ and the pupæ respectively.

No. 21.—Clania variegata, Cram. (*Ofio-Minoga.*)

This Psychid is a widely distributed species, commonly found throughout the whole year, and it sometimes appears in very injurious numbers but not regularly. This pest is rather attracted to *Acacia* sp., and the tea-plant; on the former it often occurs in great numbers so that there are no green leaves on all the trees in a small area, *e.g.*, in the year 1910 at Pankio in Taihoku-Cho, in 1912 in a certain district of Shinchiku-Cho and Kagi-Cho, and in 1914 at Ako. In those cases *Acacia*-trees were almost always withered by the attack of this insect.

The wingless female is fertilized by the male in the case, the long protrusible abdomen of the male penetrating into the female-case from above. Eggs are laid in the case, the female gradually shrinking up as the eggs fill the lower portion of the case. The number of eggs deposited by a single female is about 40 to 150, each egg being roundish and pale whitish yellow. One to three weeks after the eggs have been laid the caterpillars hatch and soon after they emerge from the parent's case and make their own little cases of vegetable matter and interwoven silk; these cases are extremely tough and durable, and are spindle-shaped. At first the young larvæ spin a rather broad ring formed of small pieces of finely divided under-epidermis of a leaf woven by means of a fine silky thread sent forth from their mouths, and then they place their head in the ring-hole and thus the body becomes covered with the ring cloth. The larvæ, after the first moult, grow to about twice or more in length. Afterwards the larvæ bearing the complete case wander to take more pieces of leaf for their case, here and there, and the cases are gradually formed completely, with small pieces of leaf (or only of the under-epidermis). The caterpillars eat the leaves from the under-side, in an irregular shape, and when fully fed the cases are firmly attached on to the under-side of the mature leaves or young twigs or other suitable places. After a few days the larvæ in such a case moult and then the head and thorax emerge at the upper end of the cases. Again the larvæ wander here and there to seek their food or some covering matter for their cases. After repeating the above, the larvæ become full-grown, and the cases grow very large clothed with several large pieces of leaves and a few leaf-stalks or short (about 12 mm. long or less) pieces of young twigs. At last the full-grown larvæ firmly fasten their cases almost always on the twigs and pupate in them. The larvæ, in the last instar, are blackish brown; the head is rather semicircular, and bears a few fine hairs; the dorsal thoracic somites are pale yellowish, on the middle there is a blackish longitudinal stripe from the first to the second, which is inconspicuously divided into two lateral stripes by a fine whitish middle stripe, while at the side there are irregular blackish brown flecks. The abdominal portion on each somite bears 8—10 shining tubercles from which spring fine hairs. The legs are well-developed and are blackish brown, bearing a claw on each one; prolegs and anal legs grow a little and are like short protuberances. The length of the full-grown larvæ: the male is about 25 mm.; the female is about 40 mm.

The pupæ of the females are cylindrical in shape, with both ends narrowed towards the extremities, and are shining reddish brown; on the anal end there are three fine spines. They measure about 30 mm. long. In the male they are purplish black: the head is slightly produced forwards: wing-sheaths are short, reaching the posterior margin of the second abdominal segment: the abdomen is paler and rather tapers to the anal end, bearing many fine irregular transverse carinæ which do not appear at the posterior border of each segment: each dorsal segment of the abdomen near the anterior margin, bears a row of many small spine-like tubercles; the anal segment is somewhat conical in shape, bearing two rather large hooks at the apical extremity. The length is about 19 mm.

The duration of the larval stage is about from nine to ten months, after which the larvæ turn to pupæ. The moth emerges in about 30—40 days. The whole life-cycle occupies about a year; thus there is only one occurrence in a year, and I have never found that this insect appears twice in a year although the male moth or female adult is found in several months.

The food plants observed in Formosa are as follows: *Acacia* sp., tea, camphor, cotton, grape, vine, orange, pear, *Bischoffia javanica*, rose, *Eriobotrya japonica*, *Psidium Guyava*, *Eugenia jambos*, *Eugenia malaccensis* and mulberry.

The effective remedy is hand-picking of the caterpillars or pupæ or the females living in the cases during the winter time. Two Tachinidæ and one Ichneumonid have been reared from the pupæ, and their destructiveness is rather conspicuous in Formosa.

No. 22.—Clania destructor, Dudg. (*Taiwan-Cha-Minoga.*)

This species is also rather common throughout the island of Formosa. I have formerly mis-identified it as *minuscula*, Butl., but it is easily distinguished from the latter by its large size, and by the two greyish median stripes on the thorax, as well as by the more blackish colouring. This insect usually attacks the tea-plant and *Psidium Guyava*, and the former is often seriously damaged by it, in February to May, so that no crops can be plucked from a small area of a particular district.

The caterpillar is yellowish brown, with the head pale yellowish ornamented with many small irregular blackish brown flecks, and bearing a few hairs; the first thoracic somite in colour is similar to the head, with two distinct rather large longitudinal blackish brown dorsal stripes which are far apart from one another on the anterior border, and with many minute blackish brown dots especially on the side: second and third somites blackish brown, with three narrow yellowish longitudinal stripes on the dorsum. The abdomen bears 18 brown tubercles on each somite, and from each of these tubercles a fine hair springs out: the anal somite is blackish brown. The legs are blackish, bearing a strong dark castaneous claw on each one, while the prolegs are very short and brownish. The full-grown larva measures about 25—35 mm. in length. The larva lives in the case formed of longitudinally arranged twigs and a few small pieces of leaves, these twigs being about 2—27 mm. long. The effect of its attack on the bush is very similar to that of the Variegated Bag-worm, destroying completely every leaf of that and of the next one or two bushes. After it is full-grown, the larva turns to a blackish brown (or brownish in the female) pupa which has a slight purplish tinge, inside the case. Before pupation the larva firmly fastens the case to a twig at its anal end, and the pupa always rests head downwards. The pupa of the male is slender, with short wing-sheaths which extend below to the posterior margin of the third abdominal segment; each dorsal segment of the abdomen from the fourth to the eighth bears a row of many minute blackish spines near the anterior margin, behind that the surface is usually transversely wrinkled except the narrow posterior border; the anal segment is slightly curved below and bears two short but stout downward-directed spines below the anal extremity. The pupa is about 11—13 mm. long. In the female it is much larger but much paler, and is spindle-shaped; the abdomen bears a row of 5—13 minute less conspicuous roundish tubercles on the dorsum of each segment (from the fourth to the eighth), and behind that the side is very finely transversely striolate leaving the rather broad posterior border; the anal segment bears two spines quite similar to those in the male. The length is about 16 mm.

The male moth is commonly found in March and April in the district of Taihoku-Cho, but it can be found nearly throughout the whole year from the North to the South. Owing to the fact that the larva forms its case with many twigs, it is almost always more injurious to the tea bush than is the preceding *Clania*.

The remedy for this insect is to pluck off the cases and destroy them during the winter time, but this is sometimes very heavy work in the case of a bad attack. In such a case the whole affected bushes are cut-off near the soil-surface and the cut-off portions are burnt. When only a few plants are badly attacked, get dry straw and fire them. This is probably the quickest and safest method of dealing with the pest. We must, however, take care for the season of the tea-plant. There is a Tachinid fly reared from the pupa of the female.

No. 23.—Mahasena sp. (*Kuro-Minoga.*)

It has been quite recently noticed by us that this Basket-worm is a rather common insect injurious to tea bushes in the several districts of Toyen-Cho.

The caterpillar commences its career, after emerging from the egg, by covering itself with a few minute pieces of tea leaf, attached by one end to the leaf. They are at first conical little houses standing on a flattened base and not more than 6 mm. in size. At this stage they are very dangerous and spread all over the bushes in such numbers that they may be said ultimately to ruin the entire foliage of a bush, and then take to back. As they grow larger they seem to be less voracious, and the bulk of them disappear by some means or other. The full-grown case is about 40 mm. long and nearly 20 mm. broad, and is clothed with tea leaves each united by its lower extremity, the upper and lower ends being free and spreading outwards from the bag. The full-grown larva is similar to that of the preceding *Clania*, but it is rather paler, and the yellowish stripes on the thorax are rather broad but the middle one is somewhat inconspicuous; the abdomen bears about ten tubercles, which are not much darker than the colour of the body, on each segment: the legs are paler; the length is about 23 mm. The pupa of the male is castaneous brown: the wing-sheaths are short and extend to near the posterior margin of the ventral abdominal segment; the second and fifth segments each bears a row of minute spines which are anteriorly directed at the posterior margin, and on the third and fourth segments there is a row of minute rather inconspicuous tubercles on each dorsum near the posterior margin, while each of the seventh and eighth segments bears a row of rather conspicuous hindwardly-directed spines at the anterior margin; the anterior two-thirds of each abdominal segment is finely transversely striolate; the apical segment is curved below, and bears two sharp distinct spines directed below, and just before their bases there are two very short triangular processes. The length is about 11—13 mm. The female pupa is not known.

The male moth has uniformly dark brown head, thorax, abdomen, and forewings; the antennæ bear rather long branches decreasing towards the tip; the forewing has 12 veins, but the hindwing has 8 veins; the veinlet in the discal cell is forked but in the forewing this is not conspicuous. The fore tibia bears a very long spine. The expanse of the wings is 27—30 mm. The male moth probably appears usually in March and April, according to my investigation last year. Occasionally, when this pest is allowed to spread, it may become exceedingly serious. An attack is on record where on an experiment garden in Anpeichin every leaf on a block of about an acre was destroyed in the manner described above. This may be, however, not a permanent character, and the damage done by this insect is usually inferior to that of *Clania destructor*.

The most convenient control-measure is hand-picking the cases during the early spring. Up to the present time, only two parasites, one being a rather small Tachinid fly, the other a small Ichneumon fly, have been reared from the larval case.

No. 24.—Diabasis (?) sp. (*Taiwan-Chibi-Minoga.*)

This small Psychid is commonly found in May, throughout Taiwan Island, but its occurrence is not abundant; and consequently this is the least serious of the Psychid pests of tea in Formosa.

The larval cases of this species might be described as small thorns about 10—12 mm. long, of a dull grey colour, somewhat pointed at the apex and slightly widened below but not into a circular sucker-like mouth. They are always covered with many small fragments of tea-leaf or thin bark, but never carry pieces of twigs attached to them. The caterpillars attack the lower or sometimes the upper side of the leaf and the twigs, and eat irregular circular spots at the margins, but when they are quite young they eat the lower epidermis in irregular shape. They move from place to place until they reduce the leaf to a mass of veins with some green surface. After the leaves and the buds have all been destroyed, they come down to attack the bark and eat the surface of it. There is a countless multitude of these creatures all over the bush and within a few weeks it is damaged almost beyond repair without very heavy pruning, but this only happened in one case which I met in Koshun in the last year.

The full-grown caterpillar is about 8 mm. long or more, and is brownish except the head and thorax which are dull yellowish; the head and thorax have a few inconspicuous blackish brown flecks, and each segment of the abdomen bears about 8 tubercles from which arise fine hairs.

When full-grown the caterpillars almost always firmly fasten their cases on the twigs, and hang down by means of rather stout, about 5 mm. long, dull-grey prolongations of the case. At that time the shape of the cases almost always become slender but they still retain their conical shape. The pupa of the male is castaneous, and is 7—8 mm long. The wing-sheaths reach just beyond the second segment. On the fourth and fifth abdominal segments there is a row of minute processes near the posterior margin of the dorsum; the seventh and eighth abdominal segments bear a distinct row of tiny spines, which are directed behind, near the anterior margin of the dorsum; each segment is finely transversely striolate on about the anterior half or two-thirds; the anal segment is strongly curved below at the apex which bears two rather inconspicuous short processes below. It is a constant character that the old skin of the last-stage larva projects at right angles for nearly its whole length, the anal end being free and the dorsum being below, but not quite straight.

I have as yet not succeeded in breeding this species throughout the whole life-cycle. Picking off the cases is the only control measure.

No. 25.—There is another small Psychid pest on the tea bush, found in the district of Koshun-prefecture, in October. The larval case is very long and slender, like a long straight spine, and is about 25 mm. long or about 2·5 mm. thick at the base, when probably full-grown. This is greyish brown, and does not carry fragments of leaf, twigs or bark, but is composed of very fine vegetable matter and of silky thread, the numerous very fine rings being connected one with another. These rings cannot be distinctly seen with the naked eye, but through a microscope. I have not reared the moth of this species, and it is not known to occur on any other plants. It is probably one of the most minor pests of the tea-plant.

No. 26.—Zeuzera coffeæ, Nietn. (*Kohii-Gomafu-Bokuto.*)

This species was known as *pyrina*, L., in Formosa for a long time, and the name has been accepted by the author.

This Cossid is found in May throughout the island, especially in mountainous districts, but its occurrence is not abundant. I reared this insect from a tea-trunk only once. This probably shows that it is not a serious pest of tea in our island.

No. 27.—Euproctis conspersa, Butl. (*Cha-Dokuga.*)

This species is very common in Formosa, and we can find it through the whole year on tea-bushes.

There are apparently two distinct forms of the caterpillar, of which the first form is yellow, having a somewhat pale brownish or reddish dorsal stripe and two very narrow yellowish white subdorsal stripes which are margined with a blackish tinge at the thoracic portion, while the second form is rather darker, having two rather broad blackish (not well-defined nor well-continued) subdorsal stripes, which are separated into two (above and below) by a fine yellowish white stripe, and a narrow pale reddish brown dorsal stripe; in this second form what one may describe as the dorsal half is blackish and has a somewhat broad yellowish dorsal stripe and very narrow yellowish white subdorsal stripes. In both the forms, the roundish dorsal tubercles are two on each abdominal somite, and these tubercles on the first and second are rather connected with each other; just below the subdorsal stripe there is a small round black tubercle on each abdominal somite; the first thoracic somite bears a flat and broad tubercle just below each subdorsal stripe near the anterior margin; on the rest there are two small tubercles at the side of each somite, one being just below the blackish brown stigma and other above the base of the leg. The dorsum of the thoracic somites bears two inconspicuous tubercles on each section. All these tubercles bear rather long but rather sparse whitish or brownish erect hairs, but on the large dorsal ones there are short dull orange-yellow scale-like hairs intermixed. The head is pale orange-yellow; all the legs are rather well-developed and coloured as the body. When full-grown the larva measures about 20—25 mm. long.

The caterpillars live together on the underside of the leaf, and eat its epidermis or chlorophyll, but the leaf is not perforated right through. After the third moult the larvæ become rather active and feed from the margin, the entire inter-cellular tissue of the leaf being eaten away, and only a skeleton remains, corresponding to the midrib and veins. The young shoots and tender leaves are very often attacked. Owing to this insect's very irregular occurrence throughout the whole year, the tea-bush very often suffers, as the young shoots and tender leaves one after another, as they come out, are usually attacked by it, and the tea bush is often defoliated by such a depredation. When full-grown the caterpillars almost always separate and come to a suitable shelter, between the twigs or under the fallen leaves or others. Afterwards they begin to spin thin pale brownish somewhat hairy cocoons in which they turn to yellowish-brown or blackish pupæ. The pupa is 7—10 mm. long and 2·8—3·2 mm. wide, and is covered with many long somewhat golden-yellow hairs on the dorsum especially on about the posterior half of the abdomen. The wing-sheaths are large and extend to the fifth abdominal segment: the anal segment is narrowly produced behind and bears several slender hooks at the extremity. The duration of the pupal stage is from 7 to 18 days.

The moths are greyish-brown in both sexes, but there is another form of the male, which is deep smoky-brown, with the head, antennæ, legs, and wing-fringes, yellow. The forewings are orange-yellow at the apex and near the posterior angle, the apex bearing two black spots which are sometimes one or three in the female : the hind wings are orange-yellow at the rather broad outer-margin : antennæ, legs, head, and anal tuft are orange-yellow or yellow or sometimes yellowish white. In the darker form the forewings bear two black spots at the apex and are blackish at the middle of the cilia.

The female is almost always fertilized by the male only one day after emergence, and in three or four or sometimes seven days it usually begins to deposit its eggs on the under-side of the matured leaf in a mass which contains 15—145 eggs, covered by yellowish hairs from the anal tuft. The eggs usually hatch in about ten days after deposition in April or May, and the newly-hatched caterpillars live together near that place and never move from place to place until the first moult.

The whole life-cycle occupies about 55 days, according to only one breeding in our laboratory in Taihoku. This insect is mostly attached to the tea bush ; it is, however, found feeding on orange and *Eriobotrya japonica* sometimes, but its injuries to these are very slight. The tea-farmers generally fear this creature more than some other serious pests of the tea-plant.

Up to the present time nothing has been done but to collect and kill the caterpillars or eggs. It is, however, very dangerous to do it, as the poison of the hairs is rather strong for the skin, and the natives very often suffer from the hairs of the caterpillars. At one time, I used several contact poisons for the caterpillars and this gave rather good effects, but further trials are desirable.

No. 28.—Euproctis varians, Walk. (*Hoshi-ki-Dokuga.*)

This has been first mis-identified by the author as *E. flavinata*, Walk., and I now correct the nomenclature as above.

Although this species is found throughout the island of Formosa, it is a rather rare Lymantriad there, and it attacks the leaf of orange and tea, but its injuries are slight.

The larva is black, with a reddish-yellow lateral stripe just below the stigmata and with a narrow similar coloured dorsal stripe which appears only on the thoracic portion and suddenly widens on the first thoracic somite ; all these stripes have not straight margins but are irregularly and slightly notched ; on each somite there are four oblique narrow reddish-yellow flecks, two on the dorsum in V-shape, and another two on the side from the lateral stripe near the anterior margin, and there is a narrow interrupted reddish-yellow band near the anterior margin ; these flecks and bands are not conspicuous on the thoracic somites but are obsolescent. The venter has two or three or four narrow transverse reddish-yellow flecks on each somite and round the base of each proleg or leg there is an incomplete reddish-yellow ring. The head is brownish-yellow, bearing sparsely fine pale hairs. The first somite has two large conspicuous black protuberances on each side, the tufts on which are very pale brownish and somewhat long, and on the yellowish dorsum there are many white and yellowish hairs intermixed ; the second and third somites each has ten roundish yellowish tubercles which bear short whitish hairs ; the remaining somites have eight large roundish brownish tubercles on each one of which the dorsal four are larger than the rest and covered with rather short pale brownish-yellow hairs with a few whitish ones intermixed, and the others are small and not roundish, and bear longer hairs ; all tubercles are surrounded with a narrow dull orange-yellow ring, except the lowermost one on each side which is dull orange-yellow. Legs, prolegs, and anal legs are dull yellow, slightly infuscate, the legs bearing long pale castaneous claws. The full-grown larva measures about 25 mm. in length.

The caterpillars disperse in all directions in two or three days after hatching, and usually live on the upperside of the leaf, eating from its margin. When full-grown they come between the leaves or twigs, and spin a dark greyish cocoon which is very sparsely interwoven with the larval hairs, and in which they pupate in two or five days. The moth is well attracted by light and the female deposits her eggs on the upper surface of a leaf, in a mass of about 50—250 eggs covered with hairs from the orange-yellow anal tuft. The egg hatches in about six to eight days. The whole life-cycle occupies about forty days in June or July, but it may be longer in early spring.

Nothing for the control can be added at the present time to what has been said under the previous species.

No. 29.—Porthesia montis, Leech. (*Taiwan-ki-Dokuga.*)

This species is almost always found throughout the Island of Formosa, and it is much more common on the tea-plant than the previous species, but its attack is much less than that in *E. conspersa*, Butl. The food-plants, found up to the present in Formosa, are as follows :— several Cruciferæ, egg-plant, potato, *Canavalia ensiformis*, *Phaseolus vulgaris*, *Gardenia florida*, *Ficus carica*, *Bœhmeria nivea*, *Spinacea oleracea*, *Eriobotrya japonica*, pear-tree, *Prunus communis*, peach-tree, *Prunus mume*, rose, orange, *Ricinus communis*, grape, cotton, and tea.

The larva is dark brown, with a broad yellow dorsal stripe, interrupted at first two and eighth abdominal somites, and separated into two by a narrow reddish stripe which becomes blackish on the thoracic segments, and with two narrow pale-yellow lateral stripes composed of longitudinal small flecks, situated below the spiracles. The head is dull yellowish and bears a few short brownish hairs ; the first thoracic somite has two conspicuous tubercles on each side, of which those of the upper pair are long and about twice as long as the lower ones, and bear dark brown hair tufts, while those of the lower pair are yellowish and covered with a few short pale-brownish-yellow hairs ; on each of the following four somites there are ten tubercles of which the dorsal two on the first and second abdominal somites are conspicuously large, touching one another or nearly so ; the remaining somites bear very flat tubercles on each somite. The tufts on all tubercles are brownish and rather sparse, but on the lower ones paler, while the median dorsal two tubercles on each of the first and second abdominal somites are densely covered with short dull-yellowish-brown hairs intermixed with long blackish hairs. These tubercles are pale brown or blackish, but the lower ones are somewhat yellowish, the tubercles just below the spiracle surrounded with an incomplete red ring. The first and second abdominal somites are roundly tinged with brown in the middle of each one, this colour containing two dorsal tubercles and with a yellow margin which is somewhat continuous with the dorsal stripe on the preceding and following segments, and in the yellow side there is a reddish spot. The venter is pale yellow and ornamented with a few transverse brownish and orange-yellow flecks. Legs, prolegs, and anal legs are yellowish irregularly tinged with dark grey. The full-grown larva is about 25 mm. long. The larva before the first moult is yellow with a blackish-brown head.

The eggs are laid by the female on the underside of a leaf, in a mass, covered with hairs from the orange-yellow anal tuft, composed of from a few to 50 eggs. The number of eggmasses deposited by a single female is usually two or three. The eggs hatch from four to twelve days after deposition, and the newly-hatched caterpillars live together on the underside of the leaf, feeding on the lower epidermis, leaving the upper epidermis and chlorophyll. This habit continues for a long time until after the second moult when they separate, and eat the leaf from the margin, often leaving thick veins. The caterpillars sometimes feed upon the flowers and very young fruits. Seven days after they are full-fed the caterpillars pupate in a somewhat loose greyish brown cocoon composed of silky thread and hairs, spun on the leaf or twig. The duration of the pupal stage is short. During the summer months, the moths emerge in four to six days after pupation, and in the winter in from ten to seventeen days. The moths are well attracted by light. The larvæ almost always pass through four moults before becoming full-grown, but rarely five. The caterpillars complete their development in from 17 to 30 days, each instar occupying from two to nine days. The whole life-cycle occupies from 30 days to 70 days, depending on the time of year.

I have no records that tea bushes have been seriously attacked by this pest during the last ten years. The recommended remedy is the collection and destruction of the young caterpillars or pupæ.

No. 30.—Orgyia postica, Walk. (*Koshiromon-Dokuga.*)

This species is commonly found throughout the whole year in Formosa, but its attack on tea-plants is not very serious as it rarely appears abundantly on the bushes. It has been noticed that the food-plants of this caterpillar are Cruciferæ, *Spinacea oleracera*, potato, egg-plant, *Gordonia anomala*, tea, cotton, grape-vine, *Sapium sebiferum*, *Ricinus communis*, rose, orange, peach, *Prunus mume*, *Prunus communis*, pear, *Eriobotrya japonica*, *Bœhmeria nivea;* mulberry, *Ficus carica*, and other several plants.

The eggs are spherical, with the upper side slightly flat, and on the upper surface there is an inconspicuous pale brownish ring, but the rest of the surface is quite smooth. The eggs are white and are 0·7 mm. in diameter. They are almost always laid on the cocoon of the female, in very irregular masses; they hatch in from seven days to twelve days after deposition.

The larva is brownish-yellow with a reddish-brown head and yellowish-brown legs; the first somite bears a long dull blackish tuft projecting forwards on each side near the anterior margin, a similar but paler tuft on each dorsal somite (11th and 12th somites); four very compact whitish-yellow tufts on the back of the first to fourth abdominal somites, while on each side of the first and second abdominal somites there is a similar but very narrow tuft; the tubercles on each somite are eight and bear sparse yellowish bristly hairs except on the tubercles covered with the tufts mentioned already; the sixth and seventh abdominal somites have another conspicuous tubercle which is deep red and is placed between the dorsal tubercles; the subdorsal and lateral stripes are paler but rather conspicuous, and the venter is still paler. The duration of the larval stage is 25—55 days. The full-grown larva measures 30—35 mm. long.

The young yellowish caterpillars live together on the leaf, and eat it. They gradually disperse, here and there, and feed on the matured leaf, leaving the veins. When full-grown they begin to form their very loose dull yellowish-grey cocoons between the leaves or on the twigs, and in these they turn to hairy pale-yellowish-brown pupæ which in the female are very roundish without wing-sheaths or other appendages. The duration of the pupal stage is from nine to fourteen days. The male moths are rather active and are attracted by light. The females are wingless and are very pale brownish white, covered with numerous short soft hairs. They deposit their eggs in two to five days. The whole life-cycle occupies from 42 days to 82 days.

The number of generations annually of this small tussock-moth in Formosa is probably six or seven, as shown in the following table :—

	Eggs deposited	Eggs hatched	Larvæ pupated	Moths emerged	Length of life-cycle
Generation—					Days
1st . . .	30th December 1905.	11th January 1906.	7th March 1906.	21st March 1906.	82
2nd . . .	24th March 1906.	4th April 1906.	25th April 1906.	4th May 1906.	42
3rd . . .	7th May 1906	16th May 1906.	9th June 1906	18th June 1906.	43
4th . . .	20th July 1906.	27th June 1906.	22nd July 1906.	2nd July 1906	44
5th . . .	4th August 1906.	12th August 1906.	9th September 1906.	19th September 1906.	47
6th . . .	24th September 1906.	4th October 1906.	30th October 1906.	11th September 1906.	49
1st . . .		25th February 1911.	1st April 1911	5th April 1911	56
2nd . . .	26th April 1911.	16th April 1911.	13th May 1911.	18th May 1911.	48
3rd . . .	29th May 1911.	4th June 1911	28th June 1911.	2nd July 1911	40
4th . . .	3rd July 1911	10th July 1911.	21st August 1911.	27th August 1911.	61
5th . .	8th September 1911.	17th September 1911.	26th October 1911.	2nd November 1911.	61
6th . . .	4th November 1911.	6th November 1911.	12th December 1911.	21st December 1911.	53
7th . . .	25th December 1911.	13th January 1911.	22nd February 1911.	2nd March 1911.	73

This caterpillar is not active but rather sluggish, and I have never seen this insect in very injurious numbers in any year. Collection and destruction of the cocoons and eggs are the only efficacious control measure.

No. 31.—Dasychira mendosa, Hubn. (*Mikan-Dokuga.*)

The caterpillar of this tussock moth was first found in the Taihoku district, feeding on the leaf of an orange-tree, in December of the year 1911. It is very probable that this caterpillar almost always occurs throughout the whole year in nearly all parts of the Island, and it attacks the leaves of Asparagus, *Phaseolus vulgaris*, *Ficus carica*, *Ficus retusa*, *Acacia* sp., mulberry, orange, and tea. Although very rarely prevalent to such an extent as to occasion much anxiety, it may be regarded as rather abundant and the most widely distributed of all Formosan caterpillar tea-pests. The caterpillars are not usually found by the natives as they feed for the most part during the night and hide below the undersurface of the leaf.

The caterpillar in colour varies to a great extent from pale yellowish to steel-grey, with the head deep black (until the third moult) to reddish. The first thoracic somite is ornamented with five rather distinct flesh-red longitudinal stripes surrounded by yellowish lines, and bears a long greyish black tuft on each side projecting forwards. The short compact dorsal tufts are three and whitish or greyish until the third moult, and afterwards they become four and brownish, yellowish brown or whitish, but on the fourth abdominal somite the tuft is less prominent. The lateral tuft on the first abdominal somite is usually white and conspicuous but when full-grown it becomes less conspicuous ; on the second it is bunch-like and is black. The anal tufts are two, conspicuous and greyish. The tubercles on each somite are eight and red but the lower pair is paler, and the sparse tufts projecting from them are whitish or yellowish. When full-grown it is about 30 to 35 mm. long.

The caterpillars live together on the underside of the leaf until the second moult, and afterwards they gradually disperse here and there. They eat the leaf along the margin and when full-grown they spin their elliptical dirty-white cocoon composed of fine silky thread and hairs. The pupa is blackish brown ; the wing-sheaths reach to the fifth abdominal segment ; each abdominal segment bears short pale-yellowish hairs which become a compact mass on the second, third, and fourth dorsal segments ; the anal segment is triangular and projects hindwards, and bears a few spines. The length of the pupal stage is from about 12 days (male) to about 19 days (female).

Four to twenty-nine days after pupation the moth emerges and the female deposits her eggs (about two or three hundred) on the leaf-surface, not in a cluster but slightly covered with hairs. The duration of the egg-stage is from four days to eleven days, and that of the larval stage is from 22 to 29 days.

This insect probably has five or six generations in a year, and the whole life-cycle occupies 35—54 days. The following table summarizes the actual breeding in the laboratory in Taihoku.

	Eggs deposited	Larvæ emerged	Cocooned	Moths emerged	Duration of life-cycle
Generation—					Days
1st . . .		10th February	9th March	4th April	54
2nd . . .	5th April	16th April	15th May	20th May	46
3rd . . .	22nd May	29th May	20th June	24th June	34
4th . . .	25th June	29th June	25th July	1st August	38
5th . . .	..	..	26th October	2nd November.	..

Control-measures are the same as in the preceding species.

No. 32.—Dasychira dudgeoni, Swinh.=*Orgyia viridescens*, [*nec* Walk.] Shir. (*Momo-Gokuga.*)

This species is commonly found in Formosa throughout the whole year, and it occurs somewhat abundantly on the tea-plant. The other food-plants are peach, *Prunus mume*, *Prunus communis*, orange, rose, and mulberry, and on the last this is the rarest of all the caterpillar mulberry pests.

About two or three hundred eggs are deposited irregularly by the parent on the leaf-surface in a single layer. They are pale yellowish brown and spherical, the free surface being slightly depressed in the middle and the attached surface more or less flat; they measure about 0·6 mm. in diameter. In the winter season about 12 days after eggs have been deposited the larvæ emerge and immediately eat the leaf, gathering on the leaf, but they disperse here and there after a few days. The caterpillars are very active and feed on several leaves along their margins, leaving the midribs, in the daytime or at night. I have never met the fact that this caterpillar defoliates the bush over a large patch of tea-garden, and its injuries may be less than in *Euproctis conspersa*.

The larva, in the first instar, is pale greenish-grey with a dark tinge on the dorsum, with the head black; on each somite there are ten tubercles from which project short blackish hairs, each of the lateral tubercles bearing two long white hairs, and the pair at the apical margin of the first thoracic somite with a long tuft projecting forwards. It grows up to about 3 mm. long. After the first moult, the caterpillar becomes about 6 mm. long, when full-fed, and on each of the first and second abdominal somites there appears a compact black tuft, and on each somite from the third to seventh abdominal somites two black spots appear. When the larva has moulted twice it becomes greyer but the blackish colour still remains on the dorsum especially on the abdominal somites. The first thoracic somite has ten tubercles of which the six at the apical margin of the dorsum bear fine white hairs projecting forwards, and the upper one on each side bears a smoky-coloured very long tuft of narrow feather-like hairs projecting obliquely forwards, the lower one bearing a few white hairs. The three long compact yellowish-brown dorsal tufts become conspicuous and between them there are two large black spots. The fourth and fifth abdominal somites have a red spot on each side near the apical margin ; the sixth and seventh abdominal somites bear a somewhat large conspicuous pale yellow protuberance in the dorsal middle of each somite. On the tubercles of the anal somite there are long pale smoky hairs horizontally projecting hindwards. The three lateral remaining tubercles each bears sparse but numerous long greyish-white hairs but on the upper pair there are a few dark hairs intermixed, and on the eighth and ninth abdominal somites long blackish brown hairs. When full-fed it becomes about 14 mm. long. The caterpillar of the fourth instar is quite similar to that of the third and becomes about 25 mm. long.

The last instar is greyish-white, with numerous scattered very minute inconspicuous darker dots on the dorsum, with the head yellowish brown. The three lateral tubercles bear long whitish tufts projecting slightly forwards and below, of which the upper pair are intermixed with two or three blackish-brown long bristles. The four dorsal tubercles on the thoracic segments bear a few long pale yellowish-grey sparse tufts intermixed with only one black hair and projecting slightly forwards. The dorsal compact pale-yellowish-grey or pale-yellowish-white tufts become four in number, of which the second one is longest and the fourth is shortest. The dorsal tubercles of the remaining abdominal somites bear very few short inconspicuous hairs but on the eighth somite there is a very long dense yellowish brown tuft and on the anal segment there are numerous long white hairs. The two dorsal black spots are the same as in the previous instar. When full-grown the caterpillar measures about 40 mm. long.

The duration of the larval stage is about 50 days in the winter time, but it may be less in other seasons than that.

When full-grown the caterpillar spins a very loose whitish cocoon between two leaves, in which it turns to a blackish-brown pupa. The pupa is from 18 mm. (male) to 22 mm. (female) long, with rather short wing-sheaths which extend down to the posterior margin of the fourth abdominal segment, covered with short whitish hairs ; the hairs on the first to third abdominal segments are very short and form a roundish patch. There are a few blackish hairs on the dorsum of the anal segment which is conical and bears a few short brown spines. After pupation the moth emerges in about five days in the spring, and it is only active at night especially shortly after sunset, being attracted by light. The whole life-cycle occupies about 83 days from December to March, but the number of generations annually is not known yet.

Collection of the egg-masses or newly hatched larvæ or cocoons is the only recommended control-method, up to the present time. We reared two Tachinids from the pupæ, one being larger and yellowish and the other greyish. Both the flies are not identified yet, and they probably serve as a medium of natural control.

No. 33.—Redoa cyanea, Mo. (*Cha-Shiro-Dokuga.*)

This Lymantriad is a rather common pest of the tea-bush throughout the tea districts, but I have never seen the caterpillars in a serious number on tea-plants.

The white-haired blackish caterpillar lives on the leaf, and eats along the margin, leaving the veins, especially the mid-rib. It has six fine interrupted white stripes through the whole length and two narrow reddish-yellow transverse bands on each dorsal somite which do not appear on the first thoracic somite and on the following two are rather inconspicuous, and which become one yellowish-white band on the anal somite; the yellowish tubercles on each somite are twelve, arranged in two ill-defined transverse rows and bearing rather long white hairs which become shorter and sparser on the four dorsal ones; the head is black, with yellowish mouthparts; the legs, prolegs, and anal legs are smoky brown, but at the innerside yellowish; the venter is dark smoky brown throughout.

When full-grown this handsome caterpillar twists one or more leaves, and comes under the shelter, and pupates there without any cocoon. The pupa is yellowish-white, and is very sparsely covered with fine whitish hairs all over the surface; the anal process is reddish-brown, bearing a few short hooks. It is about 12 mm. long.

After pupation the moth emerges in from six to thirteen days, and the female deposits her eggs (about 30 to 60) on the leaf in an irregular mass in a single layer. The eggs are apparently larger than in the other Lymantriadæ described already, and the free surface is slightly depressed in the middle. The tiny caterpillars emerge in about seven days after deposition. Soon after, they disperse here and there, and begin to eat the leaf.

The whole life-cycle occupies about 40 to 85 days. This species is probably one of the minor pests of tea-plant, and destruction of the egg-masses is an easily practised control-measure.

No. 34.—Thosea sinensis, Walk. (*Akahoshi-Iramushiga.*)

In Formosa this species was first described by the author as a new species belonging to the genus *Susica* in the year 1912, but after careful studies he found that it is the same as *Thosea sinensis*, Walk., but there is a little doubt of the genus.

The Nettle-grub is commonly found on the tea bush throughout the Northern belt of Formosa, but it has not been noticed as doing much damage. It also attacks orange and *Acacia* sp.; it is, however, a very minor pest of these.

The larva is one of largest Formosan Limacodidæ, and is a rather active (for this group) fleshy green caterpillar with a white dorsal stripe bordered with a green tinge, and with four pairs of red dot-like spots, and with red spiracles on each side. There are two rows of small tubercles bearing short stinging spines on the back, and on each side a very conspicuous series of spines set the whole length of the body. This caterpillar appears in May or September in the Plains, and the pest is at its height during the next one or two months and often into the cold weather in December and even later.

When full-grown the caterpillar measures about 30 mm. in length, and about 15 mm. in width. The dorsum is broadly longitudinally elevated at the middle throughout the whole length, this elevation being greatest at about one-third. The head is comparatively small and brown; the first somite is almost always hidden below the second somite. The dorsal stripe is yellow, and is bordered with a greenish-white stripe at the side, this greenish-white stripe being curved at each segmentation. On each somite from the second to eleventh there are four tubercles of which the lateral pair are conspicuous and somewhat conical, bearing a long tuft of thick spines from which project the black and yellowish green stinging bristles; the dorsal pair are small and from each tubercle projects eight (on an average) green spines, tipped with a yellowish tinge, which bear tiny black bristles. On the twelfth somite there are two large tubercles which bear spines and bristles similar to the others, and are larger than those at the side. The red dorsal spots are usually seven to eight pairs in number but sometimes only one pair, the third pair being largest and most conspicuous.

The larval stage occupies about 53 days in the summer season, and about 65 or more days in the winter time. The full-grown caterpillar almost always comes down to the ground and begins to make a brownish cocoon which is exactly like a tea-seed both in shape and size but usually greyer, and is buried in the soil about half an inch or more deep under the bushes. It is, however, very rarely formed on the plant, between the leaves, where it remains for about one month (or two or more months in the winter time), after which the moth emerges. So far as we can make out, there are two broods per annum, the whole life-cycle occupying about four (or eight) months. The following table shows one of my actual rearings summarized very briefly :—

Eggs hatched	First moult	Second moult	Third moult	Fourth moult	Cocooned	Moths emerged
13th May	21st May	27th May	21st June	29th June	10th July	10th August

The caterpillar lives solitarily, and is never gregarious even when newly hatched, and eats the leaf from the top margin. I have no record of the serious occurrence of this pest on tea or even on orange.

I reared 28 small greyish-black Tachinid flies from a nearly full-grown caterpillar ; the parasite may be one of the effective natural enemies.

No. 35.—Thosea castanea, Wilem. (*Taiwan-Hime-Iraga.*)

This Limacodid moth is commonly collected in April or May in the districts of Taihoku-Cho, but it is known that this insect very rarely attacks the tea-bush, with only one instance in the field of the Agricultural Experiment Station, Government of Formosa, Taihoku.

No. 36.—Orthocraspeda trima, Mo.=*Thoseoides fasciata*, Shir. (*Obi-Iraga.*)

This Limacodid caterpillar is found from February to October on tea or orange or rarely on mulberry, but its injury is not usually serious to any plants.

The pale yellowish eggs are singly laid by the female moth on the leaf, and are elliptical and slightly flat, covered with a few anal tuft-hairs. The full-grown caterpillar measures about 15 mm. in length, with a broad smoky-black dorsal stripe which becomes very wide from the first somite to the fourth somite, and bears a similar coloured branch on each side of the ninth somite. This broad blackish band separates into lateral two by a narrow interrupted white median dorsal stripe which on the third and fourth somites surrounds the dorsal tubercles. On each somite there are four tubercles of which the dorsal two are small and bear short blunt spines, while the lateral pair are long, project ing laterally, conical, and bear black-tipped spines. The dorsal tubercles on the fifth to the eighth somites are reddish brown, on the third to the fourth, the ninth, and tenth somites white; the lateral tubercles on the fifth to the eighth, tenth, and eleventh somites are pale greenish; the remaining tubercles are black. The first somite is brown and the head is blackish brown.

The caterpillar almost always lives singly on the upperside of the leaf, and eats it from the margin, the trace of the eating being nearly straight. When full-grown it begins to form a hard brown short-elliptical cocoon, between the leaves or on the underside of the leaf, which is usually covered with a very loose blackish brown silky thread.

This insect probably has three generations in a year, as the moths of the first brood appear in February or March, of the second in April to July, and of the third from October to December; the larval stage occupies about 35—45 days.

The one remedy is to collect the caterpillars and the cocoons, especially the latter; during the winter season is the most effective time for this.

No. 37.—Canea bilinea, Walk. (*Futasuji-Iraga.*)

The eggs of this species have not yet been observed, but they are probably laid upon the surface of the leaf. The caterpillar is similar to that of *Thosea sinensis*, but it is smaller and flatter. The dorsum has a very broad white longitudinal band and on that band there is a narrow pale yellowish-red dorsal stripe which becomes wide at the segmentations. The duration of the larval stage is about 30 days in March. The full-grown larva measures from 20 mm. to 25 mm. in length. The cocoon is pale purplish-brown and is covered with a thin white skin; the length is about nine to eleven millimeters, and the width is about 8—10 mm. It is almost always attached to the upperside of the leaf. About 21 days after the cocoon has been formed, the moth emerges from the pupa.

I first noticed this pest on orange in March of the year 1912, at Taihoku-prefecture, and afterwards my assistant found it on tea bushes in March of the year 1915, at Toyen-prefecture. In both cases the damage done was not of a permanent nature; but on the latter the caterpillars ate out almost every vestige of green leaf and five whole bushes were stripped almost bare. This shows that this Limacodid is not a serious pest to orange or even to tea.

The destruction of the cocoons is much the reliable remedy for this pest.

No. 38.—Nagoda nigricans, Mo. (*Mikan-Iraga.*)

This Limacodid moth usually appears in the winter time, throughout the Island of Formosa, and the eggs are probably laid on the surface of the leaf, about four or five at a time.

The young caterpillar lives on the leaf-surface, and eats its epidermis and chlorophyll, leaving the lower epidermis, but soon after it feeds on the leaf from the top-margin or lateral margin, as other Limacodidæ. The growth of the larva is very slow, as the duration of the larval stage is about 120 days; after that it begins to form a white spherical cocoon between two leaves and turns to the brown pupa. This cocoon measures about 7·5 mm. (male) or 13 mm. (female) in length or about 6 mm. (male) or 10 mm. (female) in width. Specimens kept in captivity remained as cocoons for about 230 days throughout the summer season. The pest has only one generation in a year. The actual *data* of the breeding in the laboratory in Taihoku are shown in the following table :—

Eggs hatched	First moult	Second moult	Third moult	Fourth moult	Cocooned	Moths emerged
3rd December 1911.	11th December 1911.	28th December 1911.	14th January 1912.	7th February 1912.	30th March 1912.	20th November 1912.

The full-grown caterpillar is elliptical and strongly convex backwards, without distinct segmentations. This greenish larva is smooth, with five pale whitish stripes and between each stripe there is one wavy white stripe (six in total) throughout the whole length. The venter is pale yellowish-green, with three pairs of tiny conical legs which bear a brown hook and two spines on each apex. The head hides under the first somite and the mouthparts often protrude forwards. The spiracles are pale yellowish-white; the first somite is well-developed and is pale blue. It measures about 15—18 mm. in length.

This pest is almost always neglected by the natives but the damage done is rarely serious to the tea-bush although it is a rather minor pest of the orange-tree. The destruction of the caterpillars in December and the collection of the cocoons in the summer season form the most reasonable remedy.

No. 39.—Narosa nitobei, Shir. (*Kenashi-Shiro-Iramushiga.*)

This species is not commonly found throughout the Island, but its occurrence is restricted to the upper half of the island according to our investigations, and the moth appears from March to May or from October to December.

I have not observed the eggs of this species but they are probably deposited by the female on the upper surface of the leaf of a tea-plant or orange-tree, one or two on each leaf. The newly hatched caterpillar eats out the upper epidermis of the leaf, and after it has grown larger the larva eats out almost every vestige of green leaf from the margin.

We can almost always find one to four caterpillars on a twig and one or sometimes two or more on a leaf. When full-grown the caterpillar begins to form the whitish small cocoon, between the leaves, and this is sometimes greyish and covered with pale brownish thread. The following table shows our actual breeding *data*, but each brood was not continued as the eggs were not deposited by the females in several cases.

Eggs hatched	First moult	Second moult	Third moult	Fourth moult	Formed cocoon	Moths emerged
1st December 1911.	15th December 1911.	28th December 1911.	not observed.	not observed.	16th January 1912.	16th March 1912.
30th March 1912.	4th April 1912.	13th April 1912.	20th April 1912.	27th April 1912.	9th May 1912	28th September 1912.
8th October 1912.	24th October 1912.	5th November 1912.	13th November 1912.	not observed.	10th December 1912.	not observed.

The above table shows that this insect has about two generations per annum, and that the whole life-cycle occupies about 110—180 days.

This insect is probably one of the minor pests of the tea-bush, and the collection of the cocoons, and of the caterpillars, are the recommended remedies.

No. 40.—Amata perixanthia, Hamps. (*Mikan-Kanoko.*)

This species is a widely distributed Amatid throughout the island of Taiwan, and the food plants are only three, orange, tea, and *Psidium Guyava*, as observed by us up to the present time. I think that *Amata lucerna*, Wilem., is probably a synonym of this species.

The eggs are spherical and pale-yellowish, about 0·5 mm. in diameter. They are irregularly deposited by the handsome parent on the underside of the leaf, and about two weeks later the tiny caterpillars emerge from the eggs and begin to eat the leaf from the margin, resting on the underside, but it seems they dislike to live together on a leaf. The full-grown caterpillar is dark greyish, with the head orange-yellow. On each somite there are eight tubercles bearing short pale dirty-yellow hairs but the four ventral tubercles on each of the fourth, fifth, tenth, and eleventh somites do not bear conspicuous hairs. The dorsal stripe is inconspicuous and is dark; all the legs are well-developed. It measures about 21 mm. in length.

When full-grown the caterpillars begin to spin the very loose web-like shelter between the twigs or on the leaf, and turn to pale yellow pupæ in it. The pupa is gradually tapering to an obtuse anal angle, with a row of blackish spots on each segment. The length is about 11 mm.

In about ten or eleven days after pupation the moth emerges and begins to deposit the eggs. The breeding *data* are as in the following table :—

Eggs deposited	Eggs hatched	First moult	Second moult	Third moult	Fourth moult	Pupated	Moths emerged
..	..	1st Feb. 1913.	12th Feb. 1913.	27th Feb. 1913.	6th March 1913.	25th March 1913.	5th April 1913.
5th April 1913.	19th April 1913.	26th April 1913.	3rd May 1913.	16th May 1913.	21st May 1913.	20th June 1913.	1st July 1913.

The eggs of the second brood were not deposited by a female of the first brood, but by a female collected in the orange-tree field.

The above table shows that this insect has probably three or four generations in a year in Formosa.

This very plentiful Formosan moth can hardly be called a pest of the plants already mentioned, although it is usually well-known as a minor pest of them.

No. 41.—Biston marginata, Mats. (*Kurozu-Yedashaku.*)

This Geometrid is commonly found in April in the districts of Kimpori and Tamsui in Taihoku-Cho, and its occurrence is often so abundant that there is no vestige of green on the tea-bushes throughout a large plantation, but it is quite restricted to these two districts according to our past investigations.

The greyish moth usually emerges in March and the female deposits her eggs on the twig or trunk in a large mass (10×5 mm.—35×15 mm.) covered with her pale brownish anal tuft-hairs, immediately after emergence. The eggs are short-elliptical, about 0·8 mm. in length and are pale greenish-yellow but become green towards hatching. The tiny larvæ hatch in two or three days, and begin to hang down by a fine thread sent forth from their mouths, and the thread is blown by the wind until another bush or twig is reached. This method of moving is done by almost all newly hatched larvæ, with the exception of those that find suitable leaves soon after they are hatched. They almost always live singly and eat the leaf irregularly from the margin. The duration of each instar is from about five to ten days.

The larva of the first instar is pale yellow, with a broad black lateral stripe on each side; on this stripe there are two paler spots, on each somite, bearing a bristly hair. The head is large, dark brown, bearing a few white hairs. The ventral side of the abdominal portion is greyish-black: the legs are paler but with a black tinge on the outside and on the claws: the prolegs are only one pair and are paler, with the end yellow. It reaches about 2 mm. in length.

The larva, after the first moult, becomes green, excepting the first and twelfth segments which are somewhat yellowish. The head is yellow with many brown flecks which bear pale brown hairs. The body has about thirteen narrow greenish-white stripes of which the dorsal middle one is rather inconspicuous. On each somite there are two dorsal and a few lateral black spots each bearing a bristly hair. The legs are greyish-black, and the prolegs are deep green. When full-fed it measures about 6 mm. in length.

The third instar larva is much more greenish than in the preceding instar. The head becomes pentagonal with two short triangular upper processes, and it is pale yellowish-brown but all the sutures are blackish brown, and it is scattered over with brown flecks. The body has about eight fine deep-green dorsal stripes of which the middle two are usually darker than the others; at the side there are a few greenish-black stripes which are almost always hardly connected with one another. On each somite there are four dorsal and a few lateral black dots. The first somite bears two somewhat brownish tubercles on the dorsum; the anal somite is conspicuously paler; the ventral surface of the body is black, but the portion between each pair of legs or prolegs is green. The legs are black, with two yellow bands: the prolegs are dark green, and the anal legs are paler. It measures about 27 mm. in length.

The fourth instar is yellowish green, and there are no conspicuous stripes but numerous fine black flecks, and on each somite there are two small quadrate yellow dots on the dorsum. The anal somite is yellow, and is triangular when seen from above with an acute anal angle, and at each side of this triangle there is a small process. The body colour varies to a great extent, according to the colour of the food plant, with large red spiracles. The legs are pale yellowish-green, with each segmentation blackish; the prolegs are pale reddish yellow, and the anal legs are yellow. It is about 34 mm. long.

The fifth instar larva is quite similar to the fourth but the colour becomes deeper and the flecks are larger, the flecks varying to a great extent; in some cases they are formed of 13 rather conspicuous stripes and in others they remain as irregular dots. When full-grown it reaches about 50 mm. in length. The duration of the larval stage is about 45—50 days.

Soon after it is full-grown the looper caterpillar goes down to the ground and turns to a blackish pupa buried in the soil about a half or one inch below the surface. This pupal stage is very long and this species hibernates through the winter (from May to the next March) as a pupa. The pupa is dark castaneous, the anal end being strongly curved. The surface is shining but with numerous fine dot-like sculptures. The head bears two small processes below and two conspicuous transverse processes above, which consist of seven tiny tubercles. The wing-sheaths are rather small, reaching to the fourth abdominal segment, the end being sharp. The anal segment bears many small roundish tubercles of which the middle one is large and conspicuosly long. It is about 18 mm. long.

During the day-time the moth sits with outstretched wings flat against the trunk of any tree which may be around its feeding ground, *Acacia* sp., being apparently preferred. On these the moths congregate in crowds, accompanying the large egg-masses, and thousands can thus, during a serious attack, be killed by simply smiting them while in this position. There is only one brood per annum in Taihoku, the caterpillars being active in April, though of course in March or May some caterpillars can be found.

This insect usually attacks *Acacia* sp., but it seems occasionally to have attacked tea-plants in some tea-districts. In the years, 1910, 1911, and 1912, however, the damage to the tea-plant done by this looper caterpillar was considerable at Kimpori. When a serious attack commences, the whole of the leaves of the bushes are eaten off, and so ravenous are the caterpillars that Mr. N. Onoda wrote saying that he thought " about five caterpillars would strip a medium-sized bush in a couple of days." They can in fact be heard feeding, when one is standing near, when a bad attack is under way.

The destruction of the moths or eggs is easy and a most efficacious remedy.

No. 42.—Heterusiacœdia, Lism. (*Okinawa-Rurichirashi.*)

This handsome moth is commonly found throughout the Island of Formosa, but it was not known that the caterpillar attacks tea-plants for a long time. In the year 1910, it was first found on the tea-bush, by the author, and many moths were successfully bred from the caterpillars in the laboratory.

The caterpillar is brown and is broad and short, like a Limacodid larva, the dorsum being roundish, and the ventral side being flat. The head hides under the first somite. On each somite (except the first and anal somites) there are four small black short tubercles in a transverse row on the dorsum, and at the side there is a red tubercle. The first somite bears two red tubercles on each side and the anal somite has two brown dorsal tubercles and two reddish lateral tubercles. The full-grown caterpillar measures about 23 mm. long.

This caterpillar lives on the upper surface of the leaf singly and eats the leaf from the margin as in a Limacodid larva. The full-grown larva forms a large brownish cocoon which is tough and closely woven, in the fold of a leaf (being on its upper surface).

I have never seen this pest on tea-bushes in serious numbers, and it is probably one of our most minor pests. There is a small black Tachinid which was reared from the full-grown larva. About 10—15 flies usually emerge from a single larva. This is probably one of the effective enemies of this *Heterusia*.

No. 43.—Tiracola plagiata, Walk. (*Mikan-Kuchiba.*)

In the year 1913, it was first known that this larva eats the leaves of tea and orange. According to later investigations its food-plants are cabbage, onion, Agave and others.

The larva is blackish-brown, with the head orange-yellow. The dorsal stripe is black, and is distinct on the thoracic portion and tenth, eleventh, and twelfth somites. At the side there are two bottle-shaped yellowish-white spots, one being between the fourth and sixth somites, and the other between the tenth and eleventh segments. The eleventh somite is produced above on the dorsum, like an anal protuberance, and its side is yellowish-brown. When full-grown it measures about 50 mm. long. This caterpillar lives at the margin of leaf and eats it, but seems rather to prefer a young leaf or shoot. When full-grown the caterpillar comes down to the ground and begins to form an earth-cell under the surface. After this work it turns to a brown pupa in the cell. The pupa is spindle-shaped, with short wing-sheaths which reach the posterior margin of the fourth abdominal segment. The fifth abdominal segment is thickest, and from this the body is gradually narrowed towards the anal apex. On each segment there are many minute roundish dots near the anterior margin; the anal segment bears six yellowish spines, and has a longitudinal furrow in the middle of the ventral surface. It is about 24 mm. long.

The caterpillar is usually found in February or March, and the moth in March or May. This insect is probably not an important pest of the tea-plant.

No. 44.—Andraca bipunctata, Walk. (*Futaten-Kagiba.*)

This is a well-known tea-pest noticed early in this country, attention having been drawn to it by an old Chinese Governor in the year 1820 but my description of its depredations in the *Report of Agricultural Experiment Station of Formosan Government*, Vol. I, under the name *Hypsomadius* sp., as named by Prof. Matsumura, is the first detailed account of its ravages. After careful studies I found that this species belongs to the Family *Bombycidæ* and that it is probably *Andraca bipunctata*. Six (three males and three females) Indian specimens of the latter presented by the Imperial Entomologist quite agree with our species, and I have determined it as the above.

It is a very widespread tea-pest found in practically every garden throughout the tea-districts, and is becoming really most serious in the Northern half of the Island. In Taihoku- and Toyen-Choes it is very common, and recently Mr. J. Sonan has found it at Kusukusu in Ako-Cho, feeding on *Cleyera ochracea*, *Eurya* sp., and *Melastoma candidum*.

The eggs are laid on the underside of the leaf, and these are arranged very methodically in a mass in a single layer (about 15—72). The number of egg-masses deposited by a single female is from about one to three, and the total number of eggs is 50 to 150. In 8—10 days the eggs hatch and the caterpillars take about 21—61 days to reach maturity. This insect has three generations per annum, but it is most prevalent in May, June, and July. The caterpillars almost always live in a compact mass during the day-time, if they are young resting on the underside of leaf, and when they become larger on the twig; they feed at night and very often strip the bushes over a large patch of plantation before the morning (leaving nothing but hard stalks). Although the tea-bushes are severely attacked by this pest through the season, in the next year there come slight crops from such a garden; but if the same garden is damaged by it for two years the bushes almost always begin to wither. The abundant occurrence of this pest is a rather permanent character up to the present time in Formosa, and the natives are generally used to collect and destroy the caterpillars as a remedy.

The actual breeding *data* are briefly summarized in the following table :—

	Moths emerged	Eggs deposited	Eggs hatched	Larvæ pupate	Length of the whole life-cycle
Generation— 3rd . . .	1st August to 13th November 1917.	22nd October 1917.	31st October to 2nd November 1917.	12th December to 15th December 1917.	Over 120 days.
1st . . .	20th February to 27th February 1918.	20th February to 14th February 1918.	5th March to 10th March 1918.	21st April to 23rd April 1918.	Over 100 days.
2nd . . .	11th May to 14th May 1918.	13th-17th May 1918.	21st-27th May 1918.	17th-27th June 1918.	Over 120 days.
3rd . . .	12th August to 21st October 1918.	20th-22nd October 1918.	31st October to 2nd November 1918.	7th-11th December 1918.	Over 120 days.

The above shows that the duration of the pupal stage of the second brood varies to a great extent from 21 days to 110 days, and that the season of deposition of the third lot of eggs is in October. It is a rather curious fact that the moths which emerge in August or September are always fruitless as they die without any deposition of eggs. The multiplication of this insect is rather rapid but the larvæ of the second brood are usually infested by several still unknown Bacteria and die in the fifth instar. The sudden disappearance of this insect, after reaching its climax, is almost always due to the work of these useful Bacteria, though sometimes a Tachinid-fly is still more effectual in the work of extermination. The remainder become full-grown larvæ and begin to form their cocoons below shelters on the ground or below the twigs near the stem or rarely between or on the leaves. The pale brownish cocoons are usually aggregated together in some numbers, the united structure showing a flat face. After pupation the moths emerge in from 18 to 114 days and the females deposit their eggs in five to fourteen days. The newly hatched larvæ remain on the underside of the leaf in a mass, and begin to eat the under epidermis and chlorophyll, leaving the upper epidermis until they first moult ; in this case the caterpillars usually extrude fine silky threads and form a weblike skin on the under surface of the leaf, this serving as a resting place for the delicate larvæ. After the first moult they move from leaf to leaf, and eat it from the margin. The caterpillar is not like that of a Bombycid, but it is densely covered with very fine hairs and the appearance of the skin seems velvety. The duration of each instar is from about three to ten days.

The collecting of the larvæ of the first brood is most effectual and rather an easy control-measure, and this is generally practised by the gardeners in Formosa.

No. 45.—Hypomeces squamosus, Fab. (*Aokofuki-Zomushi.*)

This insect is very commonly found throughout the Island of Formosa and it is generally noticed that it attacks cotton, orange, tea, mulberry, and sugarcane.

This greenish or greyish Curculionid strips the young leaves off the tea-bushes, and the injuries are a rather minor thing though it very rarely occurs in serious numbers on a few bushes.

The beetles should be collected and destroyed whenever seen, and the sooner a pest like this is attacked the better.

No. 46.—Aeolesthes induta, Newm. (*Cha-Kamikiri.*)

The grubs of this longicorn beetle were first found by Mr. M. Maki boring into the stem of a tea-plant, at Horisha in March of the year 1917. They were brought to the laboratory of the Division of Entomology, and afterwards the beetles emerged on April 15th in that year. On 6th May eggs were deposited by a female beetle beneath the epidermis of a trunk near the soil surface. About two weeks after deposition the young grubs hatched and begun to bore into the centre of the stem. In the next year, 1918, I found that the nearly full-grown grubs had all died in the tunnels in December. This probably shows that the whole life-cycle occupies more than one year.

This insect probably attacks only the large bushes, and the injuries are not known yet.

No. 47.—Oscinis theæ, Lef. (*Cha-no-Hamuguribai.*)

This small leaf-mining fly is a widely distributed species through the whole tea-districts, but I have never seen this in serious numbers. Probably it is one of our most minor tea-pests.

No. 48.—An unknown Lepidopterous borer found at Giochi, near Horisha, is a rather serious tea-pest, but its occurrence is quite restricted there.

No. 49.—Tetranychus bioculatus, W. M. ? (*Cha-Akadani.*)

This mite is commonly found throughout the tea-districts, and the damage done by this pest is an annually recognizable thing.

We are much obliged to Dr. Shiraki for sending us a paper for our Meeting. Many of the insect pests of tea in Formosa are identical with ours in North-East India and in other cases they are very similar, and it is of considerable interest to us to learn what damage is done and what control measures are found effective in Formosa. **Mr. Fletcher.**

I may add that Dr. Shiraki expresses a hope that he will be able to take part personally in our Fourth Meeting and that is a hope which I am sure we shall all endorse.

30.—HELOPELTIS THEIVORA, WATERH.

By E. A. Andrews, B.A., *Entomologist to the Indian Tea Association.*

Helopeltis theivora, the Tea Mosquito, is the worst insect pest of tea, and is responsible for enormous losses every year.

The insects suck the young leaves and shoots. At first the portion sucked shows as a round pale area on the leaf, and generally a tiny drop of liquid can be seen at the spot where the proboscis of the insect was inserted. Later, the extreme edge of the area, and the central spot, turn brown, and the brown colour gradually extends all over the area until the patch shows as a light-brown spot. This gradually darkens until it becomes absolutely black, and by then the texture of the patch has become hard and dry. By the coalescence of a large number of such patches on the leaf the whole leaf becomes black and shrivelled, and eventually falls off. But the damage does not stop here. The discoloration extends down the centre of the shoot, and I have known, in severe cases, new shoots twelve inches long to be killed right back. When one shoot has been killed off, the bush attempts to throw out another, which is likewise killed off, and in badly attacked tea there is often a broom-like growth of blackened shoots at the top of the branches, and the bushes look as if they had been scorched by fire.

The life-history of the insect is somewhat as follows :—The insect hatches from the egg as a small amber-coloured spidery-looking larva, which bears a superficial resemblance to the adult, but is wingless and without any trace of the scutellar horn characteristic of the genus. At first the larva is covered with conspicuous hairs, which gradually disappear as the insect becomes older. After the first moult the scutellar horn appears, and after the second moult the wing-buds can be made out. There are two more larval stages, and after the fifth moult the adult insect emerges. Copulation takes place shortly after emergence. The male generally dies after copulation, but I have on several occasions got one male to fertilize two females in captivity, and the female may be fertilized by more than one male. Eggs are laid two days or so after fertilization, the number of eggs laid (in captivity) varying from fifty to more than five hundred. The eggs are laid in the tissues of the plant, and their position can be ascertained owing to the presence of two fine hairs which project externally. They may be laid in the base of a bud, in the mid-rib of a leaf, or in the young shoot, and towards the end of July, when the insects are beginning to attain large numbers, the eggs are often laid in the broken end of a plucked shoot. This habit of laying in the ends of shoots from which leaf has been plucked protects the eggs from any chance of being removed by the pluckers, and is of great importance, as it means that from about the end of July to the end of the season close plucking, to remove the eggs, is of little avail.

The insects are exceedingly active in all stages, and feed principally during the early morning and late afternoon and evening. They attack all varieties of tea, but especially China and hybrid varieties and certain delicate varieties of light-leaved indigenous kinds.

The distribution of the insect I discussed at the last Meeting, and I then also discussed the effect of climate on the pest. The action of insecticides, and their value as a means of control, I discussed in my paper on Insect Control at the first session of this Meeting. There is therefore no need to go over this ground again.

Hand-catching is still largely relied upon as a means of control, and, though by no means a cure, is yet of considerable value in alleviating attacks of the pest.

Our investigations during the past two years have been directed to the problem of the effect of soil conditions on the incidence of the pest. At the last Meeting I spoke of the relationship found to exist between the ratio of available potash to available phosphoric acid in the soil and *Helopeltis* attack. I spoke also of the effect of the attack of the insect on the composition of the leaf, and of experiments carried out with potash manures to see whether the pest could be controlled by increasing the ratio of available potash to available phosphoric acid. I told you then that the experiments made seemed to point to the presence of some factor or factors in the soil which controlled the relative availability of the potash and phosphoric acid. Applications of potash manures were successful in some instances, but not in others. Experiments have since been carried out, by adding, in the one case, sufficient soluble potash manure to raise the ratio $\frac{\text{available potash}}{\text{available phosphoric acid}}$ to the required degree, in the other case, a quantity of potash manure sufficient to allow of enough being present in any available form after a quantity proportional to $\frac{\text{(total potash in the soil)}-\text{(available potash in the soil)}}{\text{total potash in the soil}}$ has been rendered non-available. The plots to which these manures were applied were half shut up by the pest at the time of application. At the end of the season the first plot was almost shut up, while the second plot was certainly no worse, and if anything slightly better.

The estate on which this experiment was carried out contains rather mixed tea, that is to say, China, hybrid, and indigenous bushes are mixed together in any one section. A survey of the garden, in which over 4,000 bushes were examined at intervals, was made, and this survey showed that the intensity of attack was certainly not controlled by the variety of the bush, but by the nature of the soil, for one patch would be better or worse than another, independent of the "jat" of tea.

In addition to the field experiments, however, investigations were carried out in the laboratory to ascertain the nature of the behaviour of the various manures when added to the soil. A grey sandy loam soil and a red clay soil were treated with potash and phosphatic manures, and analysed at intervals to ascertain the behaviour of the manure. It was found that in both cases the potash manures gradually became fixed in the soil, and rendered non-available, this effect increasing with time. In both cases, the phosphatic manures were slightly fixed at first. In the case of the red clay, however, this fixation increased with time while in the case of the grey sandy loam the phosphoric acid, after first being fixed, was subsequently liberated in an available form, until at the end of three months the whole of the phosphoric acid added was found to be present in the soil in an available form. Thus we have been able to detect, in the laboratory, a difference between the two soils which results in the liberation of phosphoric acid in the one and its fixation in the other.

We have gone further into this matter, and endeavoured to find which fractions of the soil contain the bulk of these two constituents in an available form, and have found that in the heavy soil practically all the available potash is present in the clay, while practically all the phosphoric acid is present in the sandy portion. Investigations regarding their distribution in the grey sandy loam are still proceeding.

31.—LANTANA INSECTS IN INDIA.

By Y. Ramachandra Rao, M.A., F.E.S., *Entomological Assistant* (*on Lantana Work*).

Lantana is probably sufficiently familiar to most of you not to need any detailed description. It is a moderate-sized shrub with prickly branches and bunches of pretty little flowers varying greatly in colour and setting into small rounded fruits. It belongs to the Natural Order of Verbenaceæ under which are grouped the following forest trees, Teak and *Callicarpa*, and garden plants like *Clerodendron* and *Verbena*.

The plant under investigation is one of several species of *Lantana*—almost all natives of Mexico and South America— and has been carried to the various parts of the Tropics as a garden plant. There are numerous varieties of *Lantana* found cultivated in India, differing from one another in the colour of the flowers, but all appear to belong to one species, *Lantana camara* (or *aculeata*). There is one species of *Lantana* that is indigenous to India, *L. indica*. It has been recorded throughout India, but so far as I know it occurs in the greatest abundance in the Hill Districts of South India.

The Life-history of Lantana.

Though never attaining the dimensions of a tree it grows into a large-sized shrub attaining to a height of nearly ten or twelve feet and often climbing to a height of thirty feet or more supported by the trunks of trees. When under favourable conditions the plants grow close together in thick masses the branches tend to elongate into runners attaining a length of thirty to fifty feet and interlace with those of the neighbouring bushes so as to lead to the formation of dense thickets which neither man nor beast can penetrate. It is a perennial and is blessed with longevity. It is also possessed of a high vitality which plant-breeders might well yearn for to infuse into their hybrids.

When the climate is favourable the plant flowers throughout the year, but where the summer is very dry, it may completely dry up and put forth shoots again when the rains again set in. It flowers profusely and the quantity of fruits produced is enormous. The fruits as they ripen develop a soft sweetish pulp and turn blue-black in colour. The fruits are freely eaten by birds, chiefly by the bulbul, but the kernels, being hard, are not acted on by the digestive juices and are cast out along with the excreta without the germinating power being impaired.

Its present distribution.

The beauty of the flowers having attracted the attention of man, the plant has travelled step by step from its original home in Mexico into almost all parts of the Tropical and Sub-tropical world. We have reports as to its having become a nuisance in Hawaii, Java, Ceylon, the Malay Peninsula, Fiji and Queensland. In the Indian Empire it is represented in one part or other of all the Provinces, but it is chiefly along the long stretch of country on either flank of the Western Ghats from the latitude of Bombay down to Travancore, that *Lantana* has obtained a firm hold and become a serious pest. In other parts of India, it is only in certain restricted tracts that it has spread injuriously, as for instance, around Maymyo in Burma, around Chikalda in the Central Provinces, around Haldwani in the United Provinces, around Madhupur in the Punjab, and around Shillong in Assam.

The circumstance that the plant is found in numbers only in certain restricted localities is no guarantee that it will not spread into other places. In some places it is certainly only a question of time as to when it will completely overrun the country, though in other places it is probably very unlikely that, owing to adverse conditions, it will ever spread.

History of introduction.

Wherever *Lantana* has run wild it has been invariably reported that it had originally been introduced as a rare plant, later on planted around bungalows and paths to form a live-fence. If left unclipped, the fence in a few years attains huge proportions and grows into unsightly thickets. The fruits are eagerly eaten by birds and are spread broadcast all round and the plant thus escapes out of cultivation and where conditions are favourable spreads like wildfire. Watercourses and channels seem also to play a fairly important part in the spread of this plant, for the ripe fruit, when dry, freely floats in water. The spread of *Lantana* is governed by the presence or absence of certain favourable conditions. Firstly, it needs a fairly heavy rainfall. It does not flourish in a dry climate nor does it relish very heavy rainfall. Secondly, a well-drained soil is very favourable for its spread; it does not thrive in waterlogged situations. Thirdly, it is a lover of sunlight and cannot make headway in dense forests under heavy shade; and fourthly, very low temperature is inimical to its growth. It cannot survive frost and snow. In localities which fulfil the above conditions, as for example, along the flanks of the Western Ghats of South India, the weed grows with extreme luxuriance and covers all available open places.

The Lantana problem.

In the cultivated areas *Lantana* is very easily kept out, for the few weedings even the most careless cultivator has to give to his crop will necessarily keep the interior of his field free from it. In public commons used as general pasture grounds and in wastelands the case is different. Little by little the weed encroaches on the grass-land until the greater part of the pasture is covered over and, owing to the simple reason of its being common property, nobody attends to the removal of *Lantana*.

In forests again it is a great problem. In thick forests it has no chance whatever owing to the heavy shade, but the case is altered when part of it is felled and a clearing made. Before the seedlings of the forest trees have had time to grow and fill up the blanks, introduced by the agency of birds, *Lantana* springs up rapidly and in a short time covers the clearing so densely as to choke the seedlings altogether.

Around villages in the infested areas, it forms dense thickets giving shelter to wild animals, and also conduces by the cover it provides to make the village surroundings extremely insanitary. In the Malnad area of Mysore, it is believed that malaria has increased in virulence ever since *Lantana* occupied the open areas and tended to the conservation of moisture to a much larger degree.

Although owing to the above reasons most people condemn it as an injurious weed, there is also an opposite camp that holds that it is really a blessing in disguise. According to them, the plant has great soil-renovating properties. Under the dense cover of its thickets, the soil-moisture is conserved and by the huge mass of leaves shed by the plant in the course of a decade a rich humus is formed. One has simply to cut the *Lantana*, set fire to it when fairly dry and plough the ashes in and the land is fit for any crop—coffee, tea or orange. It is reported that soils, which before the advent of *Lantana* had been unfit for anything, have since been converted into virgin soils in which anything could be grown. The ashes are reported to be rich in potash and function as a valuable manure. *Lantana* is also believed to be a valuable nurse for sandal.

However, it is only in moist areas where any vegetation will flourish that *Lantana* thrives, and in dry areas where its soil-improving properties would be of the greatest value, it does not grow, so that its much-vaunted qualities do not come into play where they are really needed. In forests, the part it takes in the spread of fires is enough to stamp it as a noxious weed of the worst degree.

Lantana destruction.

When undertaken at the very outset extermination of *Lantana* by mere mechanical means is quite feasible, but when—as is the case in many places—it has become established over extensive areas it becomes a very expensive and almost impossible measure. In the plateau of Chikalda in Berar, the plant had been introduced in 1865 and by 1890 it had not only spread all over the tableland but had extended into the forests along the slopes. Control measures were undertaken in 1893 and, in the course of ten years, more than Rs. 25,000 had been spent in uprooting *Lantana*. As the number of plants had become considerably diminished, operations were stopped in 1903.

When I examined the area recently last month (January 1919) I found masses of *Lantana* yet standing in parts of the forests along the road from Ghatang to Chikalda, and even on the plateau where destruction had been most carefully attended to, numerous plants were noticeable, growing undetected in odd corners. This shows how difficult it is to attempt to exterminate *Lantana* where it has really overrun the land. At present, in Coorg, operations on a very large scale are in progress, for exterminating *Lantana* in the forest areas. *Lantana* stems are first cut and set fire to, in summer when dry. The stumps and roots are dug out when the rains commence. For three or four years in succession, the same area is watched and all *Lantana* seedlings are carefully removed. By the fifth year the seedlings of the forest trees sown by the Department have had time to shoot up and form a leaf-canopy under cover of which *Lantana* cannot flourish.

As may easily be conjectured, destruction by mechanical means is by no means an easy task and would involve the expenditure of enormous sums of money, if the aim be to exterminate *Lantana* throughout the country. Unless the work is done with the thoroughness it demands, it is probable that it will all be labour wasted, for, if a few plants be left unnoticed in odd corners, or if the roots are not removed, there is nothing to prevent the plant from spreading and becoming a nuisance once again.

Lantana in Hawaii.

It is not in India alone that *Lantana* has become a serious pest. The same problem has come into existence in various parts of the Tropics. In Hawaii, it was reported to have been originally imported about 1858. The Indian Mynah which had been imported into Hawaii is reported to have been chiefly instrumental in spreading the plant throughout the island. By the eighties, *Lantana* had increased enormously and become a serious problem for the ranchmen. About 1900, Mr. Koebele, the Entomologist in Hawaii, hit upon the idea of examining *Lantana* in its original home in Mexico and studying the conditions existent there. In 1902 he visited Mexico and found that *Lantana* there was subject to the attacks of various insect enemies, chief among which was the *Lantana* seed-fly, a small Agromyzid, the maggots of which bred in the unripe fruit and destroyed the embryos. There were also a Plume-moth and two butterflies, the larvæ of which bred in the flower-buds and led to a decrease in fruit production. There were in addition a leaf-miner, a Tingidid bug on the leaves and a gall-fly in the shoots. He sent parcels of all these insects to Hawai where they were bred and liberated by Dr. Perkins, another Entomologist

In about three years, it was reported that the spread of *Lantana* in Hawaii had been very greatly checked. In Hawaii this method was however to some extent marred by the introduction by irresponsible persons, private ranchmen, of the *Lantana* bug, *Orthezia insignis,* which, though an extremely effective check on *Lantana,* was found to spread to cultivated plants.

In 1908-1909, a shipment of seed-fly was reported to have been made from Hawaii for New Caledonia and in 1912 we hear of the fly having been successfully introduced there. The seed-fly appears to have been introduced into Fiji in 1915, and a Bulletin was published in 1916 reporting successful results. In February1917, seed-fly was introduced from Hawaii into Queensland.

The successful results reported by the entomologists in Hawaii and Fiji led to the question of the advisability of trying the same method in India also. On the question being referred to them, all the responsible entomologists in India warned the Government of India as to the risks involved in the introduction of foreign insects into a new country, as it was impossible to estimate the potentialities of an introduced insect in its adopted country. They further considered that the indigenous insects attacking *Lantana* in India might first be studied, especially with reference to their efficiency in preventing the spread of *Lantana* in India. Hence my deputation on *Lantana* work.

Lantana work.

I have been engaged on this work since 15th November 1916 and have, under instructions from the Imperial Entomologist, visited Lantana-infested tracts in the various parts of India. Nearly five months were spent in Coorg, which is without question the part worst-affected by *Lantana* in India. After Coorg, parts of the Wynaad, the Nilgiris and the Anamalais, portions of Mysore, the Ramandrug Hills, Dharwar, parts of Burma and Assam, parts of the United Provinces, the Punjab and the Central Provinces were visited, and as far as possible observations as to the occurrence of pests on *Lantana* have been made and specimens of insects collected and reared.

There have, however, been certain factors which have tended to limit the degree of thoroughness of this work. If the best results are to be obtained, it is indisputable that *Lantana* ought to be examined at the right time in each Province in order to observe with accuracy the degree of maximum effectiveness of the chief insects of the particular Province. Owing to the large area to be covered, it was of course impossible to arrange to visit each Province at the really proper time.

For example, I visited Burma during the dry season and it is probable that the time of the visit was one of the reasons why, in a country so teeming with insect-life, so few insect pests were noted on *Lantana.*

Again in some places, people did not know what *Lantana* was and in general I found it rather difficult to get information as to where *Lantana* occurred in abundance. In this connection I beg to acknowledge the great help received from the Officers of the Forest and Agricultural Departments in the various places visited by me.

Furthermore, my examination could not be restricted only to areas where *Lantana* occurred in particular abundance, for those places in which it might be found in small numbers, are of equal and possibly greater importance. Though the paucity in numbers might possibly be due to the unsuitability of the climate, or the texture of the soil, or might be due to the plant having been quite a recent introduction or due to the circumstance of the variety introduced being a sterile one, it might also be due to the activity of insect enemies. Hence a thorough study within a prescribed time of the enemies of this plant in a vast country like India, becomes an impossibility.

However, what we really want to know is whether there is in India any insect that will be capable of readily acting as a check on *Lantana,* especially one of the nature of the Agromyzid of Hawaii. If such an insect really occurred in India, it is very probable that it will have been found breeding during the greater part of the year and traces at least of its occurrence are bound to have been found even during the dry season.

Lantana insects.

Numerous insects have been noted feeding on *Lantana* in India, chiefly in the South. Most of them attack the flowers, the fruits or the leaves, and there were very few found damaging the stems or the roots.

On the flowers, the following are some of the insects noted :—

Platyptilia pusillidactyla, the Plume-moth which is found in Mexico and was one of the insects introduced into Hawaii ; two species of *Lobesia ;* a *Cacoecia ; Homona* sp., etc. ; several hairy caterpillars, such as *Diacrisia eximia, Olene mendosa, Euproctis scintillans,* etc. ; the Noctuid, *Hypena* sp. ; two species of *Eublemma ;* two species of Geometrids ; two Meloids ; three Cetoniads—*Protætia,* etc., which attack the basal part of the flower-bunch ; four species of grasshoppers ; a Cecidomyiad causing galls in flowers ; several Capsids ; and two species of Thrips.

On the fruits.

Platyptilia, *Lobesia* spp., *Eublemma* spp., *Zizera gaika* (a butterfly larva ; taken only once) ; several bugs (*Plautia*, *Halyomorpha*, *Antestia*, *Nezara*, etc., and several Capsids),

On the leaves.

Several species of hairy caterpillars (*Diacrisia*, *Pericallia*, *Creatonotus*, *Trabala*, *Olene*) *Hypena* sp., two or three leaf-rollers (*Adoxophyes*, etc.), two Geometrids, several Grasshoppers, two Scale-insects and an *Aleurodes*.

On the stems.

Arbela sp., attacking the bark, a Shot-hole borer, Scale-insects, etc. (*Orthezia* in an Estate on the Nilgiris), a bark-fungus in South India.

Roots.

Termites in a few instances, and a fungus of the *Polyporus* type. In addition, a species of Dodder has been noted attacking *Lantana* in some of the moist areas as at Kathgodam, Dehra Dun, parts of Burma, etc.

Thus a fairly large number of insects has been noted on *Lantana*, especially in the South. Of these *Platyptilia* (the Plume-moth) is the only one of the Mexican insects that is already found here. It breeds also in *Lantana indica* and *Lippia geminata*, but owing to the occurrence of parasites, its usefulness is considerably minimized. The most important of the Mexican insects is undoubtedly the Agromyzid fly. No insect of that sort has yet been noticed in India breeding in the fruits and it is very unlikely that it will be found in India. Caterpillars of the Plume-moth and *Lobesia* sometimes attack the fruits too, but generally in most of these cases the embryos which are lodged in special pockets of the hard shell are uninjured. The Cecidomyiad, which causes galls in fruits, is, even when it occurs in maximum abundance, of low efficiency and it is probable that it is identical with the gall-fly in *Sesamum*, which renders it a dangerous insect to introduce elsewhere.*

So far as my observations go, there is no insect which is really efficient by itself in acting as a check on *Lantana*. The fly does not seem to occur here. Under these circumstances, the next question probably is whether we can safely import it into India. We know it has been breeding in Hawaii since 1902. If the Agromyzid had been an insect capable of turning its attention to other plants, it has surely

* *Note*. Dr. Felt has since informed us that the gall-flies in *Lantana* and *Sesamum* are quite distinct.—*Editor*.

been in Hawaii sufficiently long to have definitely shown such tendencies. Being a part of the Tropics, the flora in general and the crops in particular in Hawaii are unlikely to be very dissimilar to those in India. If the fly has not become a pest of other plants during a decade and a half in Hawaii, it is not more likely to do so in India. Moreover, unlike Scale-insects, which will adapt themselves to almost any plant, the fly is a type of a specialized insect. The *tur* Agromyzid which we find in India, has, so far as I know, not been reared from any other plant and it is as unlikely that the *Lantana* fly will turn its attention to any other plant than perhaps *L. indica*. I think, therefore, that there will be no special danger in introducing it into India, but before doing so, I am of opinion, that we ought to make sure by writing to the Entomologists in Hawaii and Fiji and New Caledonia, requesting them to let us know their experience in the matter. The behaviour of the fly might also be studied among crops of various kinds, under control in breeding cages, before actual introduction.

It must of course be kept in mind that our aim in introducing this fly is not to exterminate *Lantana* but to check the spread of the plant by minimizing the seed production. If this be accomplished, *Lantana* would settle down into the rank of many a harmless weed whose presence we do not much care about.

In Mexico and in Hawaii there is a Chalcidid parasite that acts as a check on the increase of the seed-fly. In Fiji it appears that the parasite has been introduced along with the fly and has proved a clog on the usefulness of the insect. It will probably be necessary that the factor of the parasite should, if possible, be eliminated, if the seed-fly is to be introduced.

Inquiries might also be made of the Fiji entomologists if the seed-fly, unaided by the other insect enemies of *Lantana* in Mexico, is capable of checking the spread of the plant.

Plant pests.

Lantana and *Opuntia* (Prickly Pear), which are familiar cases of introduced plants spreading injuriously in the countries of introduction, are by no means the only instances of this sort. I have personally met with numerous examples of garden plants escaping into the surrounding area and trying to elbow out the indigenous vegetation, but usually they are mostly annuals and are not sufficiently vigorous. There is however the well-known case of the water hyacinth, and another plant which is at present spreading in alarming numbers and with much greater rapidity than *Lantana* in the forests of Burma and Assam and around Calcutta. I refer to a plant of the Order Compositæ—*Eupatorium odora-*

tum, a West Indian species introduced as a garden plant and known as *Bi-zat* in Burma. It is incomparably a greater nuisance than *Lantana* in Burma and Assam, and measures ought to be taken to prevent it spreading into the moist tracts of Southern India and Ceylon, where it is sure to become a greater nuisance than *Lantana*.

Mr. Fletcher. This is merely a preliminary note on Mr. Ramachandra Rao's work on *Lantana* during the last two years. He is now writing up his results more fully and they will be published in due course.

As regards the introduction of the *Agromyza* into India, the conditions are not so simple as Mr. Ramachandra Rao would lead us to believe. It is true that in Hawaii it has not attacked any plants other than *Lantana* but, as Mr. Fullaway pointed out in his paper, the position in Hawaii is rather a special one. For one thing there are no Verbenaceous plants of any importance other than *Lantana*; this is by no means the case in India. I have had a good deal of correspondence with the Hawaiian entomologists on this question and there does not seem to be a very united body of opinion even in Hawaii regarding the real effectiveness of the *Agromyza*, of which, by the way, I have some specimens if anyone would care to see them.

32.—A NOTE ON CRABS AS PESTS OF RICE.

By C. C. Ghosh, B.A., *Assistant to the Imperial Entomologist.*

Reports have occasionally been received of damage to growing rice plants by freshwater crabs. The question came up for discussion at the Second Entomological Meeting held at Pusa in February 1917 and the information then elicited will be found at pages 155—159 of the published Proceedings of that Meeting. Some observations were afterwards made by the writer in a few villages in Bankura district and in a large rice-growing tract known as Barail in Muzaffarpur district, comprising villages Barail, Munni, Banra, Lobanra and a few others, at a distance of about six miles to the north of Pusa. These observations are briefly described in this paper.

A few broad facts concerning the life-history and habits of freshwater crabs, partly derived from the writer's past experience in his own and neighbouring villages in West Bengal and partly gathered in the course of this inquiry, will not be out of place here.

Crabs are always found in ponds in West Bengal but seldom in large numbers. They live in holes near the edge of the water and although the mouth of the holes may be in dry ground and clear of water there is always water in the holes and the crabs actually live in water. They are also found to live at the bottom of the ponds where they go apparently in search of food and are frequently brought up in the fishermen's nets and sometimes cut the angler's fishing line. Other reservoirs of water such as ditches and burrow-pits dug on either side of high roads also harbour crabs. These crabs are dark brown in colour and are edible.

A yellow-brown crab is very common in rice-fields in the Bankura district in the rainy season. Breeding takes place about July-August when young crabs are extremely common in the shallow water standing in the fields and the larger ones are found to carry the brood in the brood-pouch under the abdominal fold. At the close of the rainy season when the water dries up from the fields, the crabs burrow underground and hibernate and æstivate there, coming up and resuming activity in the next rainy season. The writer remembers to have seen many years ago in his native village in this district, a crab resting in a small chamber just big enough for itself at a depth of about 5 or 6 feet in a field where a well was being dug in the hot weather about April-May. The chamber was moist or rather slightly muddy. The crab was resting and would have come out in the rains. A crab collected from these fields in July 1917 has been identified at the Indian Museum as *Paratelphusa* (*Barytelphusa*) sp. nov ? allied to *P.* (*B.*) *napea*, Alcock. But it is not known how many species actually occur there. Although crabs are so common in these fields no damage is ever reported to be caused by them to the rice crop. It may be noted that these rice-fields, like most of the rice-growing lands in West Bengal, are situated on high land. They are not marshy and do not afford any opportunity to the rainwater to collect in deep pools. In the rainy season water has to be collected in them by means of *bunds* or banks around them. The only trouble from crabs is that they make holes in these *bunds* and allow the water to escape. This is probably the experience of all paddy-growers in high lands. Therefore it is a routine with the cultivators to visit their fields every day during the whole period when the presence of water is essentially necessary for the crop.

In order to be able to see crabs at a place where damage is reported to be caused by them to rice plants, a visit was paid to Barail in Muzaffarpur District on the 25th October 1917. Here there were thousands of acres under rice and the entire area was still under water, at some places several feet deep. Only small portions here and there, situated on higher levels, were free from water. The place is a low land and remains under water from about June to November every year. On the way to Munni, a village situated somewhere about the middle of this tract, numerous crab-holes could be observed near the edges of the water on both sides of the road which was of the form of a high embankment through the rice-fields under water. Crab-holes were similarly present on all mounds and embankments in the midst of the fields. The crab-holes were deep holes underground, each with a large mass of earth thrown out of its mouth, much like, though very much larger than, the casting of earthworms. The local people reported that as it was the end of the season the crabs were taking shelter in these holes where they would remain till the next season.

At Munni, in walking through the plots from which the water had receded but which still had small pools of water here and there, a medium-sized crab was observed in the act of cutting a rice-plant in ear. The plant was sheared off entirely about three-fourths of an inch above the soil across the third internode from the roots. The cut, not exactly transverse or smooth but somewhat lacerated and oblique, extended for about one-third of an inch in length. No portion of the stem was observed to be eaten. The crab was disturbed by our approach and it moved away, thus making the water turbid. It sat buried in the substratum of mud in such a manner that it was altogether hidden from view and to locate and catch it became difficult. This specimen got mixed up in the general lot. But so far as can be remembered it was *Potamon* (*Acanthopotamon*) *martensi*, Wood-Mason. At one place, about a foot or a little more under water, a plot about one-fourth of an acre in area was observed in which the crop in ear seemed to have been thinned and many plants were floating on the surface of the water. The owner of the plot ascribed the damage to crabs. The plants were cut near their bases and the incision seemed to be caused by crabs. At another place which was under about three to four feet of water, floating plants could be collected which were similarly cut by crabs near the base. It was evident that the crabs lived at the bottom of the water and as practically during the whole of the rice-growing season the entire area remained submerged, the greater portion of it under several feet of water, the crabs were quite out of sight and reach. The people ascribed no damage to crabs in the earlier stages of the rice plants and said that grown-up plants were attacked and always in patches here and there.

The children of a class of local people known as *Mushahars* were asked to collect some crabs for specimens. Five of them, two girls and three boys, all about 8 or 9 years old, volunteered at once. It was not easy to locate and find out the crabs in the rice fields. The children resorted to the following *modus operandi*. There were numerous crab-holes by the sides of roads and *bunds* and by the edges of the receding water. The children thrust their whole arm into those situated near the edges of water and pulled out the crabs quickly. Every hole did not yield its tenant which in some cases most probably happened to be beyond the arm's length of the children. On an average one crab was obtained from one hole in every three. Sixty crabs in different stages of growth were thus collected in a very short time. In all about 80 crabs were obtained. They comprised the following three different species as determined in the Indian Museum, Calcutta, afterwards :—

(1) *Potamon* (*Acanthopotamon*) *martensi*, Wood-Mason.
(2) *Paratelphusa* (*Paratelphusa*) *spinigera*, Wood-Mason.
(3) *Potamon* (*Acanthopotamon*) sp. nov. allied to *P.* (*A.*) *woodmasoni*, Alcock.

The majority of them were *P.* (*A.*) *martensi*. *P.* (*P.*) *spinigera* was fewer in number. While there were only a few specimens, probably only one, of the new species of *Potamon* which happened to be sent to the Indian Museum for identification. At the time they were collected no attempt was made at discrimination and they were kept together in the following manner in a shed in the Insectary compound in two zinc cylinders. About six inches of earth was placed in the cylinders and stools of rice plants about three-fourths grown transplanted into it and then water was poured in so that it stood about two inches above the level of the earth. In one cylinder two feet in diameter fifteen crabs were put in with ten stools having 49 plants. In another cylinder three feet in diameter 55 were kept with 80 plants in 17 stools. They seemed to be at ease in both the cylinders. Between 26th October and 15th December only five plants in the smaller cylinder and 6 plants in the larger, were cut and none afterwards. No part of the cut plants was observed to be eaten. The crabs lived in these cylinders up to June 1918. All did not live, many dying at intervals. Thus at the end of April 1918 only three in the larger cylinder were alive and none in the smaller. They did not breed and were not observed to be dormant at any time. There was no food unless of course they derived anything from the mud and water. Mosquitos were breeding in the water but there was nothing to show that the crabs were preying upon the mosquito larvæ. Probably they did not require any food as they are known to hibernate and æstivate underground from about December to June under natural conditions.

On the 13th April 1918 a second visit was paid to the same locality at Munni where the crabs were collected in October 1917. The fields were perfectly dry at this time. A search was made for crabs in two reservoirs of water and they could be found in holes near the edge of the water but their number was by no means large. Several boys took several hours to collect 30 only. Those collected were in different stages of growth as observed in October. They were not dormant, as freshly made holes were observable. Both *P.* (*A.*) *martensi* and *P.* (*P.*) *spinigera* were present, the former being in larger numbers. In the dry fields which were not yet ploughed up the dried castings of crabs were prominently noticeable as small mounds of earth. The holes came to view when these castings were removed. Five such holes were dug out and at a depth of about 10 to 12 feet five crabs were found, one in each hole. These five are shown in the photograph.* The three larger ones are *P.* (*P.*) *spinigera* but the largest of them is only about half the size of large specimens of *spinigera* observed in this locality. The two small ones in the photograph are *P.* (*A.*) *martensi* and they are quite young. The earth at the depth where these crabs were found was soft and muddy but there was no water although a little water was oozing out into the pit. The holes were open throughout their length and not clogged or blocked anywhere. The crabs were not actually dormant but they were certainly less active and less agile than when observed in water in the rice fields in October.

A third collection of crabs from the same locality was made on 20th January 1919 in holes near water where available. Four men took about the whole day to collect 41 specimens which were in different stages of growth but none of them appeared to be full-grown. Out of these 41, only four were *P.* (*P.*) *spinigera* and the rest *P.* (*A.*) *martensi*.

The season of activity of the crabs at Barail lasts throughout the rains. The *Mushahars*, who use these crabs largely as food, said that breeding takes place in *Asar* (June-July), *i.e.*, the early part of the rains, when the mothers are observed to carry the brood in the brood-pouch under the abdominal flap. The crabs live in the fields as long as the latter are under water. When the water recedes or dries they make, and go into, holes underground. The holes are extended downwards with the subsidence of the level of the subsoil water. The winter and summer are passed in these holes. From the size of the hibernating and æstivating specimens collected at different times, it would appear that these crabs take several years, probably three to four or more, to become full-grown. Large numbers of them, probably all which escape from enemies, successfully hibernate and æstivate. In fact it becomes necessary for them to be able to do so when they take such a long period to attain full-growth. Their underground life is a great help in this respect. In order to give a rough idea as to the numbers which hibernate and æstivate, it may be mentioned that in an area of about 50 yards by 40 yards of the plot of land in which the five crabs

* Not reproduced.

mentioned above were dug out, there were 107 dry castings of crabs. It was certain that many more castings had been displaced and removed, this place being the pasture ground, during the hot weather, of hundreds of cattle from even distant villages.

Barail is situated on the north side of the river Gandaki flowing by the Pusa Estate. On the south side there are large rice-growing tracts in which no damage by crabs is reported, though crabs are common at a distance of only about two miles from these fields on the opposite side of the river. These fields do not allow water to accumulate in the way the Barail fields do. The local people explain the presence of crabs in Barail fields and their absence in the others by saying that the Barail fields are flooded every year and many crabs come into these fields with the flood water. This however does not seem to be the actual fact. These crabs do not live in sandy beds of rivers. Moreover they are creeping and not natatory in their locomotion, being structurally incapable of swimming. They cling to the surface of the earth as a rule. Therefore there is hardly any likelihood of their being carried off, at least in large numbers, by a current of water. The real reason appears to be the presence of several feet of water in the Barail fields for about half the year. It is also probable that particular soils afford favourable conditions for excavating holes.

Before proceeding to a discussion of the conditions of damage to growing rice plants by crabs, a few remarks may be made on their enemies. In Burma Mr. Shroff notes that herons, storks, cranes and other wading birds are natural enemies of crabs. While herons, etc., may destroy some of the young ones, it is doubtful whether any birds prey upon crabs as a rule. The greatest of all enemies are human beings. Everywhere the lower classes of people eat these freshwater crabs, while the children of higher classes too indulge in them in some parts of the country. In Western Bengal the pond-living ones are preferred as food to the field-living ones. Marine crabs are of course liked and eaten by various classes of people and form a regular saleable article for food like fish in Calcutta. According to the Ayurvedic system of treatment, crabs are a wholesome diet for patients having pulmonary complaints including consumption. At Barail the *Mushahars* collect the crabs in large numbers and eat them. It is said that in this way cartloads of crabs are disposed of every year. They are also evidently eaten by other classes of people besides the *Mushahars*, as they are brought for sale to the local *hats* and *pettiahs* and the usual price is a quarter of an anna for about a pound containing about 10 to 30 crabs according to size. Jackals are known to eat field crabs in Western Bengal, parts of the hard carapace and limbs of crabs being found in their droppings. There are many folk-tales current in which the crab figures as the aunt of the jackal. It is said that the jackal has a peculiar trick of getting the crab out of the hole. The tail is thrust into the hole and when the crab has caught hold of it with the pincers it is pulled out and the crab with it. It is not known how far it is true. But to anglers in ponds in Western Bengal the crab is known to keep its hold on the fishing line which is being pulled up to the surface of the water. It is not known what other enemies prey upon crabs.

In the writer's experience crabs have not been observed to cause damage on any scale although plants have been observed to be cut and the crop thinned in patches. It could not be made out why plants were cut in this manner. They certainly did not afford food to the crabs. If the crabs had eaten the plants or had been obliged to cut them in order to get their food, it was clear from the enormously large number present in the Barail fields that severe damage would have resulted and probably rice-growing would have been impossible there. No damage was reported at Barail to be caused to the young crop. According to Mr. T. V. Ramakrishna Ayyar, the soft central pulpy parts of young paddy plants are eaten by the crab, *Paratelphusa hydrodromus*, which occurs in Madras. In the grown-up plants observed to be cut at Barail and also in confinement in the Insectary, the part of the plant tackled by the crab was only a hollow tube. In Burma according to Mr. Shroff the principal damage due to crabs is in the form of burrows in the *bunds* between the fields which allow the water to percolate through. This, as noted above, is experienced probably in all high lands under paddy. In Burma some mischief is also reported to be caused to young plants, especially young transplants, which are said to be pinched off. It seems almost certain that the Barail crabs derive hardly any food from paddy plants. To the writer it seems that they cut some plants not by choice but owing to an inherent habit of occasionally pinching with their pincers long and slender substances and probably those which stand vertically. It is a common experience of anglers in ponds of Western Bengal to have their fishing lines cut by crabs a little above the point of attachment of the hooks which are thus lost. In some places a large number of crabs happen to be present and therefore a large number of plants happen to be cut. This is why damage occurs only in patches here and there and such damage may be severe occasionally.

From observations so far made the writer comes to the following conclusions :

1. Crabs occur in all places where water accumulates and stands for long periods. They are therefore likely to and do occur in all

rice-growing fields, whether high or low. The highlands having only a few inches of water for a comparatively short period, the conditions are unfavourable to the crabs and their natural enemies have better chances. Therefore in such lands only a small number of crabs appear. While in low lands, having deep water for the greater part of the year, the conditions are altered both for the crabs and their natural enemies. Therefore a large number of crabs are found in such lands. Of course much will depend on the habits of particular species.

2. In North Bihar crabs cannot be considered a pest of rice in the strict sense of the term. In high lands no damage is reported to be done to the crop itself, although a form of indirect harm to it may be caused by the burrowing of holes in the *bunds* through which the water escapes from the fields. In low submerged lands which afford favourable conditions the number of crabs present is usually large and owing to their habit of cutting across thin long substances some plants may be cut by them. In such lands therefore it would be a gain if some means could be adopted to diminish their number every year as a matter of routine. For this purpose collection by hand is the only feasible and the cheapest method.

Has anyone got any information about the natural enemies of crabs ? **Mr. Fletcher.**

Crows attack crabs. **Mr. Inglis.**

I do not know how far you believe the story about the jackal catching crabs by means of thrusting its tail into the crab's hole but there is rather a curious confirmation of it, in the case of the fox, given by Olaus Magnus, a Scandinavian Bishop who lived in the sixteenth century. He says :—" Sometimes fearing the multitude of wasps, he counterfeits and hides himself, his tail hanging out : and when he sees that they are all busy, and entangled in his thick tail, he comes forth, and rubs them against a stone or tree, and kills them and eats them. The same trick, almost, he useth, when he lyes in wait for crabs and small fish, running about the bank, and he lets down his tail into the water, they admire at it, and run to it, and are taken in his fur, and pull'd out." In this old woodcut [*exhibited*] you see a fox with his tail in the water and a number of cray-fish " admiring at it," to use Olaus Magnus' words. So it seems quite possible that the jackal actually does catch crabs in this way. **Mr. Fletcher.**

The same tale is current in South India and also in Bombay. **Mr. Ramkrisna Ayyar.**

In Mysore the crabs are usually caught by hanging a rope down into the water and, when the crabs get hold of it, they are pulled up. But, as they let go their hold when near the surface, a hand-net is used to net them. **Mr. Kunhi Kannan.**

Mr. Ramakrishna Ayyar. In some places shells of water-snails are tied at the end of a rope, and, by moving the rope, a jingling sound is produced, and this sounds like the noise of water coming in and the crabs come out of their holes and are then hooked. I have seen this done several times.

Mr. Deshpande. In some places they grind together two stones, with sand in between them, and the crabs think it is raining and come out of their holes.

Mr. Ramakrishna Ayyar. Crabs are doing damage in South India. As a rule the crabs are carnivorous but the young ones probably cannot get the desired food and so they take to paddy seedlings. We have actually seen them cutting paddy and after dissection found paddy in their stomachs. The adults live in holes and these holes are not as Mr. Ghosh described. They are winding about and at the bottom of the hole is a little water.

We tried the following bait. We made small balls of Paris Green, molasses and bran and placed them at the mouths of the burrows. At the time there was no crop in the field. This worked very well for two or three days and we killed thirty or forty crabs out of a hundred holes. They did eat the bait as was proved by the examination of their stomachs. But after two days they did not eat any. We do not know why. It is only the seedling that is damaged and if this is protected for a week or ten days there is no more trouble. We used a wire-gauze screen at one place and it kept them out for sometime, but it is not possible to do this over large areas. In lands which are irrigated they are bad. They hibernate as adults and breed in June or July, *i.e.*, in the early Rains.

Mr. Senior-White. How big are the balls you use ?

Mr. Ramakrishna Ayyar. As big as a marble, half an inch or so in diameter.

Mr. Deshpande. Crabs in many parts do not damage the paddy plants directly but are harmful indirectly as they make holes in the *bunds* and let water out. In one field there were five hundred holes in a *bund.*

Mr. Ramakrishna Ayyar. We had a similar complaint from the Salt Department. Holes were made and water drawn off.

Dr. Gough. In Egypt a *Paratelphusa ?* bores holes in dams and lets the water out.

Mr. Ramakrishna Ayyar. We tried crab-pots. They are deep pots and are kept with their mouth just above the water level and we keep in them some fried things. Crabs drop down in them and they are not able to get out.

Mr. Pillay. In our parts crabs do damage to paddy in the following way. During the summer the whole field is under water and then we make *bunds* and draw off the water. The crabs make holes and the water comes in again.

Mr. Ramakrishna Ayyar. Why the damage is not visible is, I believe, due to the fact that in most places handfuls of seedlings are put in one place and if two or three are cut it is not noticed, but when they are put singly the damage is more noticeable. The cultivators therefore do not like this mode of cultivation. The only enemy we have in Madras is *Ardeola grayi*. By draining off the water we noticed some reduction in the number of the young crabs which went to lower fields with the water.

33.—NOTES ON SOME LAND AND MARINE CRABS AND FIELD-SNAILS WHICH ARE PESTS IN BURMA.

By K. D. SHROFF, B.A., *Entomological Assistant, Burma.*

Land Crabs.

The specimens of land-crabs collected from the paddy fields in different districts were identified by Mr. Kemp, Superintendent of the Zoological Survey of India, as the following :—

(*a*) *Potamon dayanum*, Wood-Mason.
(*b*) *Potamon calvum*, Alcock.
(*c*) *Potamon andersonianum* var *rangoonense*, Roth.
(*d*) *Potamon pealianum*, Wood-Mason.

Of these, *Potamon dayanum* is the most common species. The last two species were received from the Southern Shan States.

Experiment with *mahaga* on Land-crabs.

Mahaga (*Linostoma decandrum*, Wall.) is a creeper which grows on and at the foot of the Kachin hills. The roots of this creeper are used for poisoning fish. They are pounded and mixed with mud and water and allowed to stand for four or five days. The mixture, which becomes most offensive in odour, is baled into the water and all fishes and insects living therein are killed.

Eight plots, each eight feet square, were prepared with raised *bunds* and in each plot ten crabs were put after the seedlings were transplanted. Then the *mahaga*-water was poured into these plots. The crabs managed to escape during the night. The plants ought to have been killed by the poison, but they were not, and it is presumed that the *mahaga*-powder, which was two years old, had probably lost its property.

Marine crabs.

The paddy fields of Burma, which are completely flooded in the rains and then communicate with permanent sheets of water like rivers, creeks and the sea, are affected by the inroads of multitudes of certain species of marine crabs and field-snails. The following species are found along the seacoast and the margins of rivers and tidal creeks but very little is, in fact, known, at present, of their habits and life-histories.

(1) *Varuna litterata*, F.	Marine Crabs.
(2) *Metaplax dentipes*, Heller.	
(3) *Sesarma edwardsi*, de Man.	
(4) *Gelasimus acutus*, Stimpson	
(5) *Ampullaria* sp., . . .	Field-snails.

1. *Varuna litterata*, F.

(Vernacular name *Paung-ganan* or *Paung-si-ganan.*)

According to the reports of the District and Settlement officers, the *Varuna* crabs come up from the sea with the high tides and enter the paddy fields. They are, at that time, too small to cause any damage to the crop. The young grow in the soil of paddy fields and small creeks and, when full-grown, migrate to the sea for oviposition at the spring tides of the following year.

The female crab lays her eggs in the sea or on the sea-coast and the young, which hatch out, come up, as already stated, along the creeks and shelter in the fields.

In the Hanthawaddy district it is said that the *yos* (blind water courses) and *chaungs* (streams) are black with them and, while the migration to the stream-banks is going on, cattle cannot go about the fields.

The adult crabs nip and eat up the sprouts ; hence the sowing is delayed and carried on only after they quit the fields and before the young come up from the sea. It is not practicable after the invasion of the young, as the fields stink badly from their presence.

It is said that the whole field, where young plants have just sprouted, is destroyed in a single night. It is usual to ascertain whether the adult crabs have departed or not by scattering a few handfuls of seed in the flooded fields. Should this come up, sowing is continued ; if it does not, fresh experiments are made.

Personal Inquiry and Observation.

The adult crabs go down to the sea, as stated above, with the spring tides in July and August for oviposition, and the young, which hatch out, come up with the high tides in September and October in such great masses that they cover the banks of the creeks which look white whilst they remain there, for a day or two *if the water is low.* They are carried up into the fields over very extensive areas with the tidal water. The tidal water remains on the fields for two or three hours during which time the soil becomes soft and the young penetrate into it on the ebbing of the tide.

Water is not necessary for the existence of these crabs, since they remain in the soil till they migrate to the sea in the following year, nor do they travel in Burma to seek fresh or salt water as stated* by Dr. W. T. Calman, the Carcinologist of the British Museum, London. The habits of the species are *more terrestrial than aquatic* and not *more aquatic than terrestrial* as described in Mr. Kemp's Memoirs of the Indian Museum referred to by Dr. W. T. Calman.

Although it is not exactly known to what depth they go down into the soil after the harvest of the paddy crop and in the hot season, yet from an examination of the infested fields, which was made on the 1st March 1918, it is presumed that it is six to nine inches deep after the harvest and nine to twelve inches deep in the hot season. On the 1st March 1918 a large number of them was found eight or nine inches deep. They live in the *bunds* as well as in the open fields. While digging for the specimens of *Varuna litterata, Metaplax dentipes* was also found along with the *Varuna* in larger numbers. In a space of about 16 square feet, 47 *Varuna* and 150 *Metaplax* were dug out. Both the species remain in the cracks and under the clods where the soil is moist.

The cultivators seem to be ignorant of the fact that the *Varuna* and the *Metaplax* live together in the field and that the number of the *Metaplax* predominates over that of the *Varuna*.

It has yet to be ascertained which of the two species is really more troublesome. The *Metaplax* may also be responsible for the destruction of the paddy sprouts, but the *Varuna* is most probably the chiet cause of the trouble. The cultivators notice the annual migrations of the adult *Varuna* to the sea and the ingress of the young to the fields in masses and they hold this species alone responsible for causing the delay in the agricultural operations which they complain of; they are probably right in this belief, as the sowing is possible after the migration of the *Varuna*, notwithstanding the presence in the field of the *Metaplax, which do not go to the sea like the Varuna.*

In the crab-infested localities, no nurseries are prepared or seedlings transplanted, as is done elsewhere in the Province, but the seeds are steeped in water for four or five days and when they germinate and grow to a length of $\frac{1}{4}$ to $\frac{1}{2}$ inch, they are sown broadcast. If the seeds are sown before the *Varuna* quits the fields and the sprouts are eaten up by it, the cultivators, who can afford to do so, buy seedlings at high rates from uninfested localities and transplant them into their fields.

* He stated this in his report of the Director of the Imperial Bureau to Entomology British Museum, to whom I had referred.

But it is not always possible to get them, as the cultivator generally prepares his nurseries according to the requirements of his own field.

Owing to late sowing on account of the presence of the *Varuna* in the field, the vigour of the plants and consequently the quality and the outturn of the crop are said to be affected. The outturn is believed to suffer to the extent of 15 to 20 baskets (*i.e.*, Rs. 15 to 20 at least) per acre.

In the Amherst, Thaton, Hanthawaddy and Myaungmya districts, the area affected by this species is along the sea coast and the riversides, the approximate length of which is 96, 42, 32 and 20 miles respectively.

2. *Metaplax dentipes*, Heller.

(Vernacular name *Ganan-chi-she.*)

This crab is called the long legged crab (*ganan*-marine crab, *chi*-legs, *she*-long) by the Burmans, as it has long legs.

It is said to climb up the plants and eat them from the top downwards. According to the village headmen of the Ziekre village, Thaton District, it destroys an area of 10 acres in two nights if there is no water in the field. If there is water in the field, it practically causes very little damage. It is said to be very destructive on accretions and virgin forest lands newly brought under cultivation.

The Burmans, Taungthas and Karens boil and fry *Varuna* and *Metaplax* and eat them with *ngapi* (rotted salted fish).

3. *Sesarma edwardsi*, de Man.

(Vernacular names *Thayaw ganan ;* also *Pha-in-ganan* in Moulmein.)

This crab is called *Thayaw ganan* because it is found on or near the *Excœcaria*, which is known as *Thayaw bin* (*bin*-tree), in the vicinity of which it makes its burrows. According to the report from the Amherst District, it is said to pinch or squeeze the tender stalks of young paddy plants with its claws and to eat them up. In the Hanthawaddy District, it is said to live all the year round along the edges of the tidal creeks and *yos* (blind watercourses). It, sometimes, proves very destructive by burrowing into the *bunds* and letting in salt water into the fields.

Some cultivators do not regard this crab as injurious to paddy plants.

The Burmans do not eat this species of crab as it is believed to cause diarrhœa.

4. *Gelasimus acutus*, Stimpson.

(Vernacular names *Phongyi ganan ; shwe-ganan ; Ganan-ni.*)

This crab is of a bright reddish orange colour, hence it is called *Phongyi ganan*, (monk-crab) from the reddish orange colour of the Buddhist monk's robe. It is also known as *Shwe-ganan* (golden-coloured crab) and *Ganan-ni* (red crab).

It is said to cause no damage to paddy but to feed on mud. It makes nearly perpendicular burrows in the soil on the high wet banks of rivers, creeks and streams.

At the Second Entomological Meeting, which was held in February 1917, I read only a few extracts, describing the habits of the *Varuna litterata*, from the Settlement Reports of the crab-infested districts. No discussion was, in fact, then made on the measures of control and the notes, which I read, being meagre, were taken back from the typist and are, therefore, not included in the Proceedings of the Second Entomological Meeting.

Further investigations were carried out in 1918 and the information, collected at that time, is given above for discussion at the present Meeting.

The following experiments were contemplated but were rejected as impracticable over extensive areas.

1. *For the prevention of the infestation of fields*—

   (*a*) Prevention of the ingress of the flood water during the period of the year when the young are known to come up with the high tides from the sea, *e.g.*, by *bunds* constructed with earth and fascines along the face of the area subject to infestation and

   (*b*) cleaning the flood-water by drag-nets and dealing with the young before they enter into the fields with the tidal water.

2. *For the control of the young*, to use—

   (*a*) hot water,
   (*b*) tobacco water,
   (*c*) unslaked lime,
   (*d*) crude earth-oil,
   (*e*) *mahaga*.

3. *For the treatment of the soil*, to use a few days before sowing paddy—

   (*a*) *Mezali* leaves (*Cassia siamia*).
   (*b*) *Tama* leaves (*Melia indica*).
   (*c*) *Adhatoda vasica*.

It was found that these trees are sparse in the crab-infested districts. Even if they were plentiful, the transportation-charges would be prohibitive.

The experiments of dragging with nets in the fields before sowing and importing seedlings for transplanting into the fields after the migration of the *Varuna litterata* to avoid delay in sowing were suggested by the Agricultural Chemist, but they are, says the Director of Agriculture, Burma (in his letter No. 2808-1E-2, dated the 15th June 1918), not hopeful as, even if demonstrated to be effective, the increased cost of cultivation would probably deter cultivators from applying them.

A few experiments with tobacco, *yenan* (crude earth-oil) and *mahaga* might, if possible, be tried in the ensuing season in small plots ; but these, even if they prove successful, would hardly appeal to the cultivators, as the treatment would be expensive on extensive areas.

As the agricultural operations are delayed till the migration of the *Varuna* crabs to the sea, the difficulty might be overcome if any late-growing variety of paddy could be introduced into the localities subject to infestation.

The name of any such variety, if known, and a scheme of cheap practicable experiments on the marine crabs and field-snails, if any recommendable, might be communicated.

Field-Snails.

Ampullaria sp. (?)

(Vernacular name *Le-kayu.*)

As this snail is found in the fields, it is called *Le-kayu* (Field-snail : *Le* field, *kayu* snail) by the cultivators. According to the Talaing cultivators of the Amherst District, these snails eat up the paddy seeds which are sown. The cultivators, therefore, collect and throw them into the creeks before they start sowing. However, it has to be done twice or even sometimes thrice in badly infested fields. Their number is so great that half to one basketful of snails is collected from a plot of ·5 acre. They generally infest swampy places. In the absence of rain, they remain in the soil ; when the monsoon begins and the fields are ploughed, they come out of the soil.

34.—NOTES ON THE RED WORMS FOUND IN THE *NGACHIMA* PADDY AT HMAWBI.

By K. D. Shroff, B.A., *Entomological Assistant, Burma.*

The presence of these worms was first noticed in Lower Burma by the Assistant Botanist, Southern Circle, in a limited area and only in the variety of paddy known as *ngachima*. They appeared again in 1917. In 1918, their attack was almost insignificant. The plots, in which they were found in large numbers, were not manured; but they were also present in the plots which had been treated with nitrogenous manures. The yield of the attacked plots was seriously affected. Probably the same kind of worms was also found in the soil of the plots wherein sickly plants were seen.

The worms are found under the sheaths, in the tissues of the sheaths and among the roots of the rooting paddy transplants which are said to emit a bad smell.

Personal observations in September 1918 showed in many plots plants with the outer leaves rotting and apparently looking like plants infested with red worms, but there was no trace of the worms inside them. Besides, many of these uninfested rotting plants also emitted a bad smell like the infested ones. From this it is presumed that the decay and the bad smell may not be due to the presence of the worms. The plants probably suffer from some disease or something is wrong with the soil. The *ngachima* and a few other varieties of paddy show signs of a fungus disease, under the attack of which the outer leaves are first affected; the upper parts of the leaves dry up and the lower ones in contact with water decay. Manured as well as unmanured plots showed the presence of this disease. It was worse in plots manured with nitrate of soda.

Specimens of the diseased leaves from various plots were collected and sent to the Imperial Mycologist, Pusa, for identification. He says,

> "In the specimens from the field manured with potassium sulphate, fungus hyphæ can be traced in the collar. As there is no fructification, it is not possible to say whether these hyphæ belong to *Rhizoctonia* or *Sclerotium Oryzæ*. Complete plants should be sent for examination, as the trouble is very likely at the roots or at the collar. The dried leaves, that have been sent, do not show the presence of any parasitic organism."

It has not been definitely ascertained whether the worms attack the green tissues of the plants and cause decay or whether they follow the decay brought about by some other cause at present unknown.

The knowledge of the food-habits of the worms and the identification of the fungus disease under suspicion will probably solve the problem, which puzzles us at present.

35.—SOME PROBLEMS IN FOREST INSECT CONTROL.

By C. F. C. Beeson, M.A., I.F.S., *Forest Zoologist, Forest Research Institute, Dehra Dun.*

In order to appreciate the position of forest insect control in relation to the study of forest entomology generally, it is necessary to recognize certain fundamental characteristics in the constitution of the forests of British India, and in the methods by which they are managed.

The first striking character is the absence of epidemics of primary pests, that are capable of killing off healthy, living, trees over large areas. The forests of Central Europe have for the last century suffered considerably from fatal outbreaks of lepidopterous defoliators and boring beetles. The forests of the United States and of Canada have to contend against serious epidemics of caterpillar and saw-fly pests and the depredations of bark-beetles, which accompany fires and lumbering operations.*

In British India, on the contrary, no primary pests are known that are capable of killing healthy trees in natural forest and no secondary pests have increased to epidemic incidence and completely destroyed appreciable areas of pure forest, or even all the individuals of one tree-species in a mixed forest. The factors contributing to the absence of epidemics are complex, but they arise from the existing ecological conditions of the forests, and from the methods by which they have been worked since the time of their reservation.

It is not possible to define the peculiar conditions more precisely in this paper, but, in illustration of the absence of any tendency to epidemic development of pests in natural forests, the following cases may be cited.

1. The *sál*, *Shorea robusta*, is the foodplant of a heartwood borer, *Hoplocerambyx spinicornis*, which normally breeds in dead or diseased trees. Recently a localized endemic outbreak of this borer has occurred in a *sal* forest in the United Provinces, and a large number of trees has been killed annually by direct preliminary attack. The area of the infestation is small, some 7 square miles; the annual death-rate varies from 8,000 to 12,000 trees, but the total mortality represents only a small percentage of the growing stock. The forest has been under close observation for three years and it has been found that the progress of the attack is extremely variable throughout the area. In a given unit area, say 100 acres, the rate of increase of the pest, expressed in the number of trees killed, may rise from three to ten times, and then decrease to a half or a tenth in a period of four years; in other words,

* *Vide* Beeson, C. F. C., "Forest Insect conditions in India." *Agric. Jourl. India*, Special Indian Science Congress Number, 1918, pp. 114-124.

the intensity of attack is constantly shifting its foci, with a general trend from the highly attacked localities to those in which the incidence is lower. The effect of the attack of the insect on the forest approximates to a heavy thinning but never to a clear felling.

One might be tempted to consider this instance as a case of serious damage by an insect pest, but the forest has also received attention from the sylvicultural aspect and has been diagnosed as much over-stocked and in a generally unhealthy condition. Thinnings are being made in accordance with modern sylvicultural principles and a far greater number of trees is being removed by these operations than by the insect.

2. A second instance may be taken from the Sunderbans. In 1909 a cyclone blew down several thousand *sundri* (*Heritiera Fomes*) trees. The normal consequence of such an occurrence in the forests of Central Europe would be an epidemic outbreak of woodborers and bark-beetles. No epidemic occurred in the Sunderbans and attack by shothole borers and bark-beetles was confined entirely to trees with diseased roots along the banks of water channels and islands.

3. A third illustration is found in the *sál* forests of the Duars, where an abnormal mortality of *sál* was reported five or six years ago. On investigation the dead trees were found to contain a mixed fauna of heartwood and sapwood-beetles and shothole borers. Careful enumeration failed to show a preponderance of one species to which the blame for primary attack could be assigned, while the presence of an appreciable proportion of dead trees without insect attack led one to suspect other agents as the primary cause of death. This was eventually discovered in the form of a root fungus, which was itself consequent on unfavourable conditions of soil-aëration.

While emphasizing the immunity of Indian forests from epidemic outbreaks of insects I do not wish to imply that injury from secondary pests is equally negligible. The existence of insects capable of causing technical damage to timber or of producing loss of increment and delayed growth is an indisputable fact. It is becoming annually more evident that these insects will in the future be capable of causing serious loss, and there are also indications that several species now of secondary importance will modify their habits and take on the rôle of primary pests.

But at the present moment the need for the wholesale control of insects injuring forest trees has not yet arrived. Injury due to insects is only one factor causing loss of forest capital. The other factors are more easily and more profitably controlled than the insect factor, and require to be eliminated before the latter can be considered as a practical measure.

This fact does not appear to have been recognized in the early years of Forest Entomology in this country. The Departmental literature of that period is characterized by the output of a large number of incomplete seasonal histories and fragments of life-cycles, with detailed suggestions for the control of the pest thus created. The suggestions were based mainly on the weaklink theory, and faith in the successful application of European methods to the conditions of Indian forests.

As a natural result we find that the control measures recommended have, since the day of their invention, remained recommendations. They have never been tested practically, nor has the demand for control measures been heard from those officers whose duty it is to establish and protect the forest crop

This aspect of the relationship of insects to forest growth may appear strange when viewed from the standpoint of Agricultural Entomology, but it must be remembered that the rotation of the forest crop is one hundred years and more, whereas the rotation of the agricultural crop is annual. We are to-day establishing the forest crop, and in a few cases only have we reached the stage of cleaning and tending operations, while the final harvest is not in sight.

The present policy of forest insect control may be summarized in a few words :—

(1) Where intensive cultivation of forest plants is carried on (*e.g.*, in nurseries, in the establishment of plantations, in artificial regeneration, etc.), intensive methods of control are necessary. Such operations, however, are not forestry but agriculture, and the principles of agricultural pest control are directly applicable.

(2) Where the technical damage to the existing standing crop is sufficiently high to affect the sale value of thinnings and final fellings, special problems arise and special investigations are required.

(3) Where modern sylviculture aims at the removal of the existing natural forest, and the substitution of an artificial type of forest, conditions are created for the evolution of pests which at present are economically negligible or do not exist. It is in connection with the management of such forests that the majority of control problems arises, and the main object of a control policy is to shape the guiding principles of crop-production and crop-protection in a double mould while both are in a state of flux.

The following examples illustrate the types of problems now being investigated.

1. The Beehole Borer of Teak.

The Beehole borer, *Duomitus ceramicus*, Wlk. (Fam. Cossidæ) is the most serious pest we know of teak forests in Burma. It is apparently absent from India. The caterpillar is a heartwood borer, which attacks teak trees of all ages and sizes from the sapling 10 inches in girth to the veteran overdue at the saw mill. The larval gallery or so-called "beehole," which lies more or less vertically in the heartwood, attains a length of nine inches, and the diameter of one's thumb. The life-cycle is annual and the beeholes formed in one year are overgrown by the next season's wood, so that by the end of its life the teak log may be riddled with beeholes from the core to the skin. Such timber is of course useless for constructional purposes.

A rough estimate puts the loss at 20 per cent of the gross value of teak in the natural forests of Burma.

In pure teak plantations in which the borer increases rapidly the loss is likely to be several times greater. No plantations are yet old enough for the final felling, but there is every indication at present that all trees in the final crop will be seriously beeholed.

The problem of the beehole borer is almost unique. Its work is unusually inconspicuous in the forest and the location of infested trees is in consequence extremely difficult,—even to an entomologist. Not only are absolute numbers very small (there are perhaps not more than one hundred individuals per acre each year), but for more than ten months of the year they are hidden inside the trunk of the tree and no wood-dust or gum or discoloration is produced to mark the presence of a single borer. The timber merchant is unable to judge if the trees he purchases are badly beeholed, until he cuts them in the saw-mill.

For an insect of such obscure habits it is impossible to conceive control measures based on direct trapping or destruction. Even if a very attractive bait or lure were devised, its practical utilization would be prohibited by the prolonged emergence period of the moth, a period which extends over three months and represents a daily catch of two moths only. And what sort of trap can one devise to kill two Cossid moths per night in a Burma forest, that will not at the same time destroy thousands of other insects of unknown importance ?

Accepting the premise that we shall not abandon the policy of growing teak pure or in plantations, we have now to devise some methods of tending the crop throughout the rotation of, say, seventy years. An obvious remedy is the use of an alternative food-plant as a trap-crop, but at present none is known. In Java the pest is said to attack *Spathodea campanulata* and *Sesbania grandiflora*, but we have yet to find an alternative host in Burma.

A second possibility of control lies in the conduct of thinnings :—

(1) In order to kill the borers present in infested trees, the most favourable time to fell is in November or December. The felling of trees should therefore be carried out shortly after marking.

(2) We have discovered that the liability to attack is proportional to the girth of the tree and is independent of its state as a dominant, dominated or suppressed tree.

The incidence of the borer can be reduced, therefore, by felling all suppressed trees marked in a sylvicultural thinning instead of leaving them to die.

(3) The more frequently thinnings take place and the greater the proportion of large-girthed trees removed the more marked is the reduction in the absolute numbers of the borer. Beyond a certain point, however, these two factors are adverse to the development of the maximum yield in the crop. We have now to determine the point at which the advantages in one direction balance the disadvantages in the other direction.

A third control measure lies in the isolation of pure stands of teak by belts or blocks of other species in order to delay the introduction of the borer and to restrict its subsequent development. Here again we have methods which favour the control of the borer opposed to sylvicultural and economic principles.

The collection of statistical *data* is at present directed to the elucidation of these points.

The beehole borer is an example of a pest with an annual life-cycle and one known food-plant; the next type to be considered is that of a pest with several generations in the year and several host-plants.

2. The Shoot and Fruit borer of Toon.

The shoot and fruit borer of *toon*, *Hypsipyla robusta*, Moore. (Fam. Pyralidæ), has an annual cycle of five generations. The caterpillars of the first generation feed on the flowers of the tree; those of the second generation on the fruits, and the remaining three generations bore inside the green shoots of the current year's growth. Its importance as a pest lies in the damage done by the broods attacking the shoots. The leading and lateral branches of young trees and saplings are killed off to so complete an extent that the season's growth is entirely nullified, and the development of the sapling is checked for many years. Eventually one or two leaders in the bushy broom-like formation escape attack, and a slight growth in height is obtained, but the resulting tree is so much forked as to be useless for timber.

The weak link in the seasonal history of the insect occurs in the first two broods. In the absence of the flowers or fruit of *toon* or of mahogany and other Meliaceous trees, these generations are very seriously checked. Shoots are not produced during this period by the host-trees except in insufficient quantity and the incidence of the pest suffers a very considerable reduction, which may amount to a complete hiatus.

We have therefore a simple protective remedy. In order to establish a *toon* or mahogany plantation, it is sufficient to remove all flower-bearing host trees in the neighbourhood. If it is necessary for sylvicultural or other reasons to retain these trees, another measure must be adopted. A protective barrage must be established round the site of the plantation or regeneration area, by sack-banding the flowering trees and destroying the *toon* moth larvæ in the forest, just as codling moth larvæ are destroyed in fruit orchards.

Later, when the young trees have grown up and begin to flower the pest may gain a foothold. But, during this period the methods of crop production, which aim at prolonging the height growth and checking the tendency to crown expansion and flowering, are also methods of crop protection. They may be assisted, if vitally necessary, by sack-banding during the first two generations. Towards the end of the life of the crop when it is opened out for diameter increment, and possible natural regeneration, sack-banding will be necessary annually. That particular problem will arise in some fifty or sixty years time and may safely be left to the Entomological Service of the period.

The case of the *toon* shoot borer with its successive generations of different habits is analogous to that of many important lepidopterous defoliators. The notorious teak defoliators, *Pyrausta machœralis*, *Hyblœa puera* and their associates, do not pass the whole of their seasonal history on teak. The times of leaf-flush and leaf-fall vary in different parts of its habitat, and in those localities where teak comes into leaf late the defoliators develop at least one brood on other food-plants. We are now endeavouring to discover the foodplants of these defoliators and their preferences ; but investigations so far have shown that the defoliation of teak is produced by a truly bewildering complex of Noctuids, Pyralids, Arctiads, Curculionids and Melolonthids ; which seems to indicate that we have undertaken to investigate the habits of a large portion of the insect population of the forest.

Leaving the Lepidoptera, an example may be cited of the problems presented by the Coleoptera.

3. Bark-beetles.

I have already mentioned that the forests of India have not suffered appreciably from the epidemic attacks of bark-beetles. We have not been faced with the *Dendroctonus* problem of the coniferous forests in the United States and Canada, or with the *börkenkäferfrage* of the country that used to be Germany. Nevertheless it is inevitable.

The changes in the management of the coniferous forests of the Himalayas, which are accompanying the revision of working plans, will produce fundamental alterations in the composition and aspect of these forests. The existing irregular uneven-aged stock is being converted into uniform forests ; that is to say, into forests of one or very few species arranged in regular blocks in which all the trees are nearly of the same age. These blocks are produced on areas cleared by one felling or by two or three fellings at intervals of a few years. In the first case the area is planted up artificially ; in the second, reliance is placed to a great extent on the natural regeneration by seed-bearers left on the area for that purpose.

Bark-beetles breed in the slash and felling refuse ; and, since most Himalayan species have three or four broods a year, rapid increase is possible.

Ips longifolia, Steb., the large pine bark-beetle, is a species which is beginning to give trouble in *chir* pine forests. Normally it is a secondary species breeding in dead trees ; but, on felling areas of rhe uniform system, a succession of generations develops in the bark of the felled trees, and in the refuse on the coupe area after the logs have been extracted ; and then in the following season, finding no more dead breeding-material, it is forced to attack living trees or migrate. By a series of massed attacks the bark-beetles break down the resistance of the young growth on the regenerated area, and overwhelm it. To adopt a familiar simile, they now consolidate their ground. The broods emerging from the killed pine saplings adopt the same tactics with equal success against the young growth in the vicinity. But mass attacks on any field of battle are costly and the amount of territory gained in each successive onslaught decreases, until the zone of action is reduced to a few centres of resistance, which eventually disappear. The attack is spent, and the trees now have the situation well in hand.

Before this stage is reached the Forest Officer intervenes and nullifies the success of his plant allies by making another felling. This act supplies the bark-beetles with powerful reinforcements. The mass attacks are repeated and each year with each annual coupe a fresh batch of beetle reinforcements is called up and a corresponding number of *chir* trees is killed, These are the tactics now being developed by the large pine bark beetle, with the evident intention of becoming a primary pest.

The counter-attacks possible against this mode of invasion are simple. (1) The removal of the bark of trees as soon as they are felled, (2) the burning of the slash and brushwood on the area at the close of the felling operations, and (3) the early destruction of affected trees. The broader strategy is more complex, but is primarily based on the arrangement of felling areas into series, so that the coupe of any one year is not in the neighbourhood of areas under regeneration or near the coupe of the year before.

In this case the size and location of the felling area as determined by the rules for protection are at variance with those required by the principles of extraction and utilization. The problem to be solved involves not only the entomologist but also the sylviculturist, engineer and utilization officer.

I have tried to indicate that we have roughly three classes of control problems :—(1) the control of pests of intensive cultivation, in which direction Forest Entomology approaches most closely to Agricultural Entomology, (2) the reduction of damage by insects to the standing crop, where the damage is greater than that from other more easily controllable factors, and (3) the prevention of pests which are likely to arise from the new conditions produced by new methods of forest management, and particularly the creation of uniform forests and pure plantations.

In conclusion, I wish to indicate a few of the difficulties attendant on the investigation of problems of the last two classes. The principal difficulty lies in the scale on which an inquiry has to be carried out, both in area and in time.

The sample plots that we are using in observing the seasonal history of *Hoplocerambyx spinicornis* are not small areas ; none is less than 50 acres. These areas represent check plots for a block of forest of several square miles, which is kept under continuous detailed observation for at least 5 years.

In South India, again, we are establishing plots to watch the effect of annual defoliation of teak on the girth increment. The trees will be felled at the end of a ten-years period and the annual increment of defoliated and immune trees compared.

In Burma we have observation areas on the ecology of the beehole borer in several forests of the Pegu Yomas and the Upper Irrawaddy valley, that were started four years ago. We have also discovered a method of obtaining accurate information on the past history of the pest by systematic stem analyses and dating of beeholes. It is thus possible to compare changes in the incidence of the pest with fire protection, climatic and historical records for at least as far back as the period of British occupation extends.

When we worked out the seasonal history of the *toon* shoot borer over 120,000 insects were utilized and in testing the control measures all trees on an area of nearly three square miles were protected by sack-banding.

I have chosen the same pests throughout to illustrate my points but others, if cited, would show equally well that for an investigation to be of practical value it must be carried out over a large area and for a long period.

The time factor in experimental Forest Entomology is very great but not so great as in experimental forestry. The Forest Entomologist has at least the consolation of seeing the results of his own work.

Mr. Fletcher. We are much obliged to Mr. Beeson for coming here and giving us such an interesting paper. We in the Agricultural Department have very little opportunity of seeing anything of Forest Insects or of acquainting ourselves at first hand with the problems of Forest Entomology and therefore we are hardly in a position to discuss this paper. I should, however, imagine that, as the study of Forest Entomology progresses in India, we shall find that we have many very destructive pests—possibly even some primary pests—whose very existence is at present unknown simply because they have never been noticed or reported. Certainly that is the case with many agricultural crop-pests. We are constantly coming across—and that often quite by accident—cases where a large amount of damage has been done to crops over a long period without the facts ever having been brought to entomological notice, and in many of such cases the insects concerned are themselves new and undescribed forms. The damage done by *Agrotis ypsilon* at Mokameh, which totalled several *lakhs* of rupees annually, had been done for many years before it was ever brought to our notice and then it only came to light more or less by accident. And, if this is so in the case of the densely-populated agricultural tracts of India, it is, I think, safe to infer that it is still more the case in many of the areas under forest. The main requirement at present of Forest Entomology—as indeed, of all other branches of Entomology—in India seems to be a large increase of staff for investigation of the numerous insects which are at present levying in the aggregate an enormous toll on the wealth of the country.

36.—THE PRESERVATION OF WOOD AGAINST TERMITES.

By T. Bainbrigge Fletcher and C. C. Ghosh.

During the last eight years we have made numerous tests of various proprietary preservatives advertised for use in India as protective to wood liable to attack by Termites. The following tables show the results :—

Creosote.

No. of Expt.	Wood	Treatment	Date buried	Date found eaten	Period (months)	Remarks
2	Deodar .	Dipped in cold creosote for about five minutes. 18th Aug. 1911.	21st Oct. 1911 .	27th Feb. 1914	28	
3	Jarrah .	Do. .	Do. .	..	..	(16th Sept. 1913, missing.)
4	Deodar .	Dipped in warm mixture of creosote and soap solution.	Do. .	27th Feb. 1914	28	
5	Jarrah ?	Immersed in boiling creosote allowed to cool and soak for 7 days.	Do. .	..	81+	1st August 1918, not attacked.

The great difference in effect of application of an incomplete treatment in cold creosote (28 months) and a complete treatment in hot creosote (more than 81 months) is evident from the above. Wood to be properly treated with creosote should be immersed in a tank or other receptacle heated to 80° to 90° C. and allowed to cool down gradually. The cost of treatment is relatively high, owing to the large amount of creosote absorbed, but it is better to have a large degree of absorption if more than relatively temporary protection is desired. For outdoor purposes, where long endurance is required under underground conditions, thorough impregnation with creosote is likely to yield good results.

Carbolineum.

No. of Expt.	Wood	Treatment	Date buried	Date found eaten	Period (months)	Remarks
33	Jarrah .	Painted with as much cold Carbolineum as could be soaked up by dry wood.	21st Oct. 1911 .	11th April 1916	54	
34	Deodar .	Do. .	Do. .	..	..	11th April 1916. Not eaten but wood decayed.
35	Mango .	Do. .	Do. .	11th April 1916	54	
36	Teak .	Do. .	Do. .	1st Aug. 1918 .	81	
37	Deal .	Do. .	Do. .	16th Sept. 1913	23	
38	Mango, Deodar and Deal.	Dipped half-way into cold Carbolineum and allowed to soak maximum amount.	Do. .	11th Oct. 1912	12	Attacked through untreated ends.
39		Do. .	Do. .	Do. .	12	
40		Do. .	Do. .	Do. .	12	
41		Do. .	Do. .	Do. .	12	

Powell Process.

The first lot of twenty pieces of powellized wood were all attacked within eight months and were stated by the Company not to have been treated properly. A second lot, sent in for trial as properly treated, was placed underground on 17th October 1911, and consisted of twenty pieces of wood, weighing 24·25 lb. on receipt. On 22nd July 1913, after 21 months, three pieces were found to have been eaten into. By 27th February 1914, four other pieces were found to have been attacked, after an interval of 29 months. By 3rd May 1915, seven more pieces were found attacked, 43 months after having been buried. On 1st August 1916, another piece was attacked, after 59 months. On 1st August 1918, another was found eaten into at one end, after 82 months, and only two pieces remained of the original twenty, the others having been lost or eaten without leaving any trace.

Lead Arsenate.

			Months.
1.	50 gr. Sodium Arsenite solution boiled in water, wood immersed and left 2 hrs. to cool; 90 gr. Lead Nitrate boiled in water, wood immersed and allowed to cool, 29th November 1910.	Not attacked on 22nd July 1913. Attacked on 27th February 1914.	39
2. 3. 4. 5. 6. Deal	50 gr. Sodium Arsenite solution boiled in water, wood immersed and left 2 hrs. to cool; 90 gr. Lead Nitrate boiled in water, wood immersed and allowed to cool, 27th August 1912.	(5) (6) Attacked 25th May 1915.	...
7. Deal	50 gr. Sodium Arsenite solution boiled in water, wood immersed and left 2 hrs. to cool; 90 gr. Lead Nitrate boiled in water, wood immersed and allowed to cool, 27th August 1912 [cut in two pieces].	Attacked through cut ends, 22nd July 1913.	11
8 Mango	50 gr. Sodium Arsenite solution boiled in water, wood immersed and left 2 hrs. to cool; 90 gr. Lead Nitrate boiled in water, wood immersed and allowed to cool, 27th August 1912.	......	...
9. ,,	Ditto ditto	Attacked 25th May 1905.	33

Lead Arsenate—contd.

			Months.
10. Mango . .	50 gr. Sodium Arsenite solution boiled in water, wood immersed and left 2 hrs. to cool; 90 gr. Lead Nitrate boiled in water, wood immersed and allowed to cool, 27th August 1912 [cut in two pieces].	Attacked 25th May 1905.	33
11. Deodar . .	50 gr. Sodium Arsenite solution boiled in water, wood immersed and left 2 hrs. to cool; 90 gr. Lead Nitrate boiled in water, wood immersed and allowed to cool, 27th August 1912.	Ditto .	33
12. „ . .	Ditto ditto .	Ditto .	...
13. „ . .	50 gr. Sodium Arsenite solution boiled in water, wood immersed and left 2 hrs. to cool; 90 gr. Lead Nitrate boiled in water, wood immersed and allowed to cool, 27th August 1912 [cut in two].	Attacked 22nd July 1913.	11
14. Bombax . .	50 gr. Sodium Arsenite solution boiled in water, wood immersed and left 2 hrs. to cool; 90 gr. Lead Nitrate boiled in water, wood immersed and allowed to cool, 27th August 1912.	Attacked 27th February 1914.	16
15. „ . .	Ditto ditto .	Attacked 25th May 1915.	33
16. „ . .	50 gr. Sodium Arsenite solution boiled in water, wood immersed and left 2 hrs. to cool; 90 gr. Lead Nitrate boiled in water, wood immersed and allowed to cool, 27th August 1912 [cut in two].	Attacked 27th February 1914.	16
17. Jarrah . .	50 gr. Sodium Arsenite solution boiled in water, wood immersed and left 2 hrs. to cool; 90 gr. Lead Nitrate boiled in water, wood immersed and allowed to cool, 27th August 1912.	......	...
18. „ . .	Ditto ditto .	......	...
19. „ . .	50 gr. Sodium Arsenite solution boiled in water, wood immersed and left 2 hrs. to cool; 90 gr. Lead Nitrate boiled in water, wood immersed and allowed to cool, 27th August 1912 [cut in two].	......	...

Mortant.

No. of Expt.	Wood	Treatment	Date buried	Date found eaten	Period (months)	REMARKS
20	Deodar .	Boiled in Mortant 20 per cent. water 80 per cent. 17th Oct. 1911.	21st Oct. 1911 .	16th Sept. 1913	22	
21	Do. .	Do. .	Do. .	Do. .	22	
22	Do. .	Do. .	Do. .	20th Feb. 1913	15	
42	Jarrah .	Immersed in cold Mortant and allowed to soak as much as possible, 15th Oct. 1911.	Do. .	11th April 1916	54	
43	Deodar .	Do. .	Do. .	20th Feb. 1913	15	
44	Mango .	Do. .	Do. .	Do. .	15	
45	Teak .	Do. .	Do. .	16th Sept. 1913	22	
46	Deal .	Do. .	Do. .	20th Feb. 1913	15	

Sideroleum.

No.	Wood	Treatment	Date buried	Date attacked	Period (months)	REMARKS
1	Deodar .	Well painted and dried in shade.	7th Jan. 1914 .	31st Aug. 1916	32	
2	Mango .	Do. .	Do. .	18th Mar. 1915	14	
3	Jarrah .	Do. .	Do. .	..	(55+)	Not eaten 1st August 1918.
4	Deodar .	Immersed in Sideroleum, heated and allowed to cool in it, dried in shade.	Do. .	18th Mar. 1915	14	
5	Mango .	Do. .	Do. .	Do.	14	
6	Jarrah .	Do. .	Do. .	31st Aug. 1916	32	

Out of the six pieces, three failed within 14 months and five within 32 months. The sixth piece was of Jarrah, which is naturally fairly immune.

Microlineum.

No.	Wood	Treatment	Date buried	Date found attacked	Period in months	REMARKS
1	Deodar .	Given two coatings Dark Oak. (10th-11th Feb.) and dried in shade.	13th Feb. 1915	11th April 1916	14	
2	Sissu .	Do. .	Do. .	22nd June 1917	28	
3	Deodar .	Given two coatings Art Brown (10th-11th Feb.) and dried in shade.	Do. .	11th April 1916	14	
4	Sissu .	Do. .	Do. .	..	(42+)	Not eaten 31st July 1918.
5	Deodar .	Given two coatings Moss Green (10th-11th Feb.) and dried in shade.	Do. .	11th April 1916	14	
6	Sissu .	Do. .	Do. .	22nd June 1917	28	

Of these six pieces, all three of deodar failed within 14 months. Of the three pieces of sissu, two failed within 28 months and the third was unaffected after 42 months.

Solignum.

No. of Expt.	Wood	Treatment	Date buried	Date found eaten	Period (months)	REMARKS
23	Jarrah .	Painted with Solignum heated to 75° C. First coating 17th Oct. 1911. Second coating 18th Oct 1911.	21st Oct. 1911 . Do. .	11th April 1916	54	
24	Deodar .	Do. .	Do. .	Do. .	54	
25	Mango .	Do. .	Do. .	27th Feb. 1914	28	
26	Teak .	Do. .	Do. .	11th April 1916	54	
27	Deal. .	Do. .	Do. .	11th Oct. 1912	12	
28	Deal and mango.	Half only dipped into hot Solignum, 17th Oct. 1911. Dipped again, 18th Oct. 1911.	Do. .	Do. .	12	Attacked through untreated half.
29	Deal and mango.	Do. .	Do. .	Do. .	12	Attacked through untreated half.
30	Deal and mango.	Do. .	Do. .	Do. .	12	Attacked through untreated half.
31	Deal and mango.	Do. .	Do. .	Do. .	12	Attacked through untreated half.
32	Deodar .	Immersed in hot Solignum on two days. Weight dry 165 gms. Weight after second immersion 187 gms.	Do. .	1st Aug. 1918 .	81	

Zinc Chloride.

No. of Expt.	Wood	Treatment	Date buried	Date found eaten	Period (months)	REMARKS
8	Jarrah .	Placed in cold solution and brought to boil for 10 minutes, removed and cooled in air, 25th July 1911.	21st Oct. 1911 .	11th April 1916	54	Surface slightly nibbled.
9	Deodar .	Do. .	Do. .	11th Oct. 1912	12	
10	Mango .	Do. .	Do. .	Do. .	12	
11	Deal .	Do. .	Do. .	Do. .	12	
12	Jarrah .	Placed in boiling solution, boiled 10 minutes, allowed to cool in solution for 22 hours, covered with Zinc Chloride crystals, 25th July 1911.	Do. .	..	(81+)	1st August 1918. Not eaten.
13	Deodar .	Do.	Do. .	20th Feby. 1913	16	
14	Mango .	Do.	Do. .	16th Sept. 1913	23	
15	Deal .	Do.	Do. .	20th Feb. 1913	16	
16	Jarrah .	Placed in cold solution, raised to boiling, and left to cool for 4 days, 25th July 1911.	Do. .	..	?	24th May 1915 missing.
17	Deodar .	Do. .	Do. .	11th Oct. 1912	12	
18	Mango .	Placed in cold solution, raised to boiling, boiled ½ hour, then dipped in creosote till cold.	Do. .	..	(81+)	1st August 1918; not eaten.
19	Deal .	Do. .	Do. .	27th Feb. 1914	28	

Timborite.

Two pieces of Bombax wood were given seven coatings in shade on three days (6th-8th April) and buried on 10th April 1916, and were found untouched up to 1st August 1918, a period of 28 months.

Two pieces of deal were given two coatings (on 6th and 8th April) and buried on 10th April 1916, and of these one was found eaten out on 28th February 1917, after an interval of 11 months. The other piece was wholly eaten by 1st August 1918, a period of 28 months.

Two more pieces of Bombax wood, two of deodar, two of mango and two of sissu were given four coatings in March 1917 and buried on 20th March 1917. By 1st August 1918, one of the pieces of sissu had failed, after 16 months. The rest were reburied.

Lead Chromate.

Two pieces of wood treated with Lead Chromate were buried on 29th November 1910, and were found slightly attacked by 14th June 1911, within a period of seven months.

Siderosthen.

No.	Wood	Treatment]	Date buried	Date found attacked	Period (months)	REMARKS
1	Deodar .	Painted with Ordinary Black.	15th Jan. 1913	..	..	Removed 6th Jan. 1914.
2	Mango .	Do. .	Do. .	6th Jan. 1914 .	12	
3	Deodar .	Painted with Ordinary Chocolate.	Do. .	..	..	Removed 6th Jan. 1914.
4	Mango .	Do. .	Do. .	6th Jan. 1914 .	12	
5	Deodar .	Painted with White Siderosthen.	Do. .	15th May 1913	4	Treated pieces eaten more than untreated checks.
6	Mango .	Do. .	Do. .	22nd July 1913	6	
7	Deodar .	Painted with Siderosthen Stone.	Do. .	15th May 1913	4	
8	Mango .	Do. .	Do. .	Do. .	4	
9	Deodar .	Painted with Siderosthen Red.	Do. .	Do. .	4	
10	Mango .	Do. .	Do. .	6th Jan. 1914 .	12	
11	Deodar	Painted with Siderosthen Green.	Do. .	22nd July 1913	6	Do.
12	Mango .	Do. .	Do. .	15th May 1913	4	

Orr's Wood Preservative.

Three pieces of deal, three of mango, three of teak and three of deodar were painted with four coatings of Orr's Wood Preservative, which is a thin liquid smelling of creosote. They were buried on 31st August 1916 and were untouched up to 31st July 1918, a period of 23 months. They were reburied for further test, and this trial is therefore incomplete.

Placing these various processes in order as regards efficacy, so far as our experiments show this, we obtain the following results :—

	Months
Creosote (hot), more than	81
Creosote (cold), less than	28
Carbolineum, less than	23
Powell Process, less than	21
Lead Arsenate, less than	16
Mortant, less than	15
Sideroleum, less than	14
Microlineum, less than	14
Solignum, less than	12
Zinc Chloride, less than	12
Timborite, less than	11
Lead Chromate, less than	7
Siderosthen, less than	4

There is also Orr's Wood Preservative which had lasted 23 months on last examination (trial incomplete). As this is apparently a form of creosote, it may be expected to do well.

We do not think it necessary to state more than the bare facts, as our conclusions are practically identical with those obtained at Dehra Dun by R. S. Pearson and lately published in " A Further Note on the Antiseptic Treatment of Timber " (*Indian Forest Records*, Vol. VI, pt. IV (1918)). It will be noticed, however, that treated wood at Pusa has a considerably shorter life than at Dehra Dun and this is probably due to a difference in the termite attacking it, the Pusa species being *Microtermes obesi* and that at Dehra Dun (as ascertained by one of us when at Dehra Dun in August 1918) a species of *Odontotermes*, probably *O. obesus*.

Another point which is brought out in the Tables, is the fact that treatment is of little use if the whole surface subject to attack is not treated. If the wood is cut after treatment, so as to expose an untreated interior face, this latter is especially liable to attack, which may then invade the interior of the wood. For examples of this see the Table of experiments with Lead Arsenate, in which treatment was effective in the case of whole pieces for 33 months whilst exactly similar (but cut) pieces failed within 11 months. We have excluded such failures from the above table of durability.

Mr. Higginbottom. Does not the variety of wood make a difference ?

Mr. Fletcher. Certainly it does, and therefore we have tried several different kinds.

Mr. Higginbottom. Do you think there is some difference when the wood is buried entirely underground and when part of it is underground and another part of it outside ?

Mr. Fletcher. Certainly ; the part underground is attacked first.

Mr. Higginbottom. Did you try hot creosote under pressure ?

Mr. Fletcher. No ; we have no pressure plant. Certainly, the more you can get into the wood, the better. Creosote seems to be the best preservative but cannot well be used for indoor purposes ; for outdoor use it is good and well worth using where durability is desired.

Mr. Higginbottom. I have heard, although I have not tried it myself, that corrosive sublimate, mixed with mortar and spread in a layer when the foundations of a house are at a certain height, is useful in keeping off white-ants. Have you tried it ?

Mr. Fletcher. No.

Mr. Kunhi Kannan. In some places they use arsenic mixed with mortar and lay a layer of it in the basement.

Mr. Andrews. Have you tried the White-ant machine in exterminating them from a building ? I once had great trouble from termites in a godown. They came out in numbers from the floor and attacked the boxes. I removed the bricks from the floor and, by means of a wire, cleared the hole through which the white ants were coming up. I then put the nozzle of the machine into the hole and fumigated. It was very successful.

Mr. Fletcher. I have used the machine successfully in a bungalow, but it is generally necessary to break a hole into the galleries with a crow-bar. When termites come up through the floors of the bungalows at Pusa, I generally paint the place with crude creosote and that keeps them down for a long time afterwards.

37.—STORED GRAIN PESTS.

By T. Bainbrigge Fletcher, R.N., F.L.S., F.E.S., F.Z.S., *Imperial Entomologist, and* C. C. Ghosh, B.A., *Assistant to the Imperial Entomologist.*

INTRODUCTORY.

Storing grains in houses and keeping them from being damaged by insects while in the store is a problem which confronts every householder, whether he be a cultivator or not. Different countries have tried to solve this problem in different ways but there is a general agreement as to the results and consequent recommendations regarding the methods to be adopted. This is, that the grains should first of all be fumigated with a poisonous chemical fumigant such as carbon bisulphide, and then stored in insect-proof receptacles. This method is of course the best if it can be adopted. But this is impracticable so far as the Indian cultivators and householders are concerned. Fumigation with carbon bisulphide cannot be recommended to them nor can they practise it for want of facilities. Also the effect of fumigation will be nullified by the receptacles in use among the people for storage.

Of the recent efforts in this country (though none of them made from the view-point of the Indian cultivators and householders) to deal with the pests of stored grain, or rather stored wheat, the most notable are the experiments on the effects of dryness* on weevils and their practical applicarion for storage purposes, especially storage in bulk. The latest efforts are those of Messrs. Barnes and Grove (*Ind. Agric. Dept., Chemical Memoir,* Vol. IV, No. 6. "The insects attacking stored wheat in the Punjab and the methods of combating them," etc.), who also tried the effects of inert gases like carbon dioxide. There was no practical outcome of all these experiments. Messrs. Barnes and Grove took the damage by store-pests as an inevitable evil and suggested a mechanical method of cleaning the grains with a view to separating the insects (and dirt) by means of an air-blast. With regard to this recommendation it may be said that it may not be so successful as expected. It will certainly never be possible to separate all the insects present in the grain, for instance the grubs of *Trogoderma khapra,* which stick to the grains fairly tightly. Then, although the much-eaten and light grains may be blown off, the freshly infected grains will certainly remain behind. Even the second cleaning will not be able to free the

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* Those anxious to know the details about this can refer to the following publications :—

"The Bionomics of grain weevils," *Jl. of Ec. Biology,* Vol. I, 1905-06.

"Indian Trade Journal" 1907 (Several issues from Jan. to Augt.) ; 1909, November 18 ; and 1911, November 23.

"Indian wheat and grain Elevators" by F. Nöel-Paton.

"Agrl. Jl. of India" Vol. VI, pp. 333-343, Weevil and dry wheat by T. Bainbrigge Fletcher.

Chemical Memoir, Pusa, Vol. IV, No. 6, The insects attacking stored wheat in the Punjab, etc., by J. H. Barnes and A. J. Grove (pages 261 *et seq*).

grains from insects. Besides, if it be possible to erect a plant at a high cost, the sure treatment with carbon bisulphide is certainly preferable, there being skilled supervision to guard against accidents. In the case of the Indian cultivators and householders who deal with small lots, for separating insects and dirt from the grain the country sieves and hand-winnows are effective and cheap appliances.

It will be apparent that there was room for experiment aimed at finding means of prevention of damage. Such experiments were undertaken more from the view-point of the Indian householders and cultivators than of dealers in bulk. As a result, a method has been worked out which is inexpensive and can be easily adopted by the former and adapted to the receptacles they use for storage. The method is also applicable to storage in bulk.

THE GRANARY PESTS.

The insect pests of stored grains, etc., are mentioned below under the articles in which they occur.

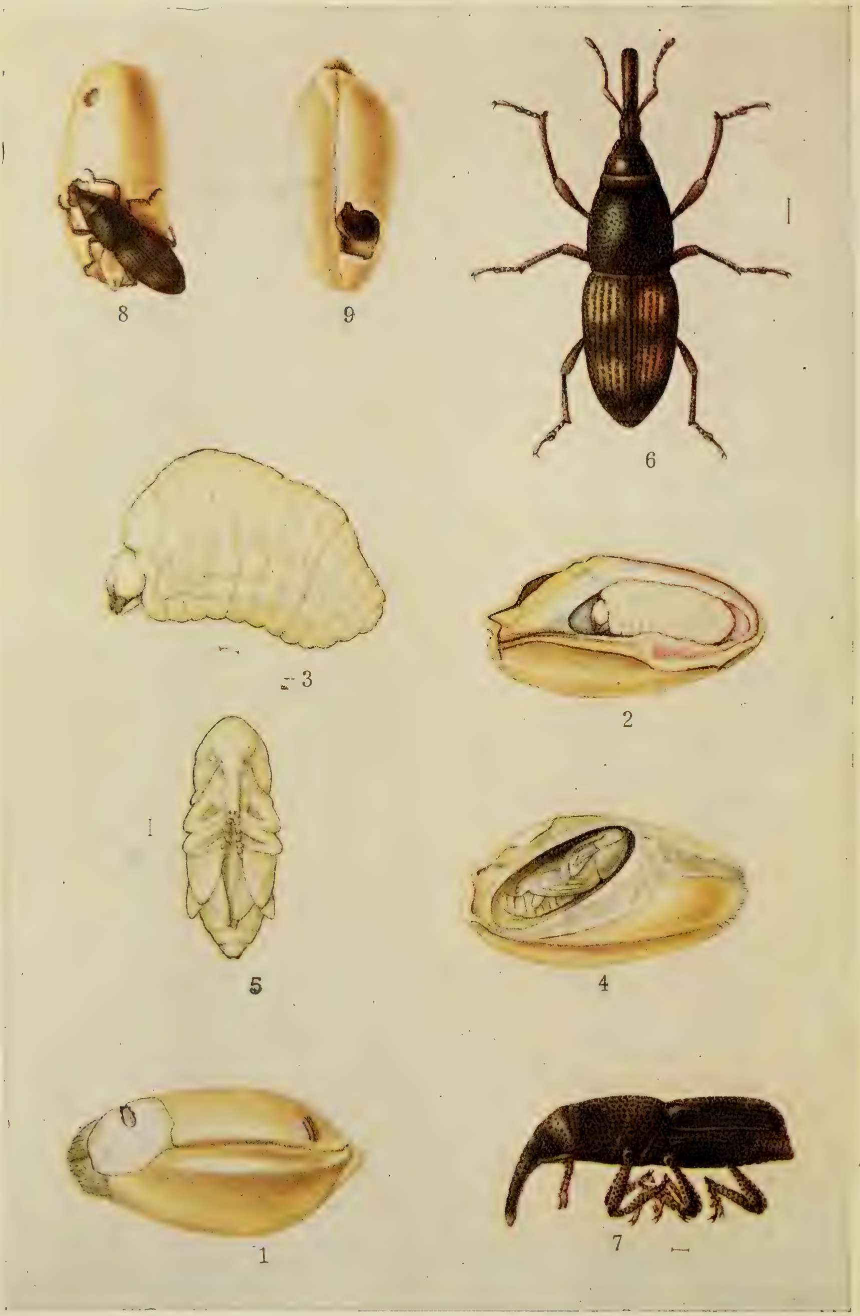
I. *Cereals*—

COLEOPTERA (BEETLES).
Calandra oryzæ (major).
Rhizopertha dominica (major).
Trogoderma khapra (major).
[*Attagenus undulatus*.
Æthriostoma undulata.
Trogoderma versicolor].
Calandra granaria (minor).
Tribolium castaneum (minor).
Latheticus oryzæ (minor).
Læmophlœus pusillus (minor).
Tenebroides mauritanicus (minor).
Gibbium scotias (minor).
Attagenus piceus (minor).
LEPIDOPTERA (Moths).
Sitotroga cerealella (major).

N.B.—In ground wheat, rice, etc., *Tribolium castaneum* is the most injurious major pest.

II. *Pulses*—

The Pulse Beetles—*Bruchus chinensis* and other species of *Bruchus*.
Trogoderma khapra (major).



CALANDRA ORYZÆ.

EXPLANATION OF PLATE 100.

Calandra oryzæ.

Fig. 1. Eggs laid on and in a wheat grain $\times 8$.
Fig. 2. Larva feeding inside a grain $\times 8$.
Fig. 3. Larva removed from grain $\times 16$.
Fig. 4. Pupa in natural position inside grain $\times 8$.
Fig. 5. Pupa removed from grain, ventral view $\times 16$.
Fig. 6. Adult weevil from above $\times 16$.
Fig. 7. ,, ,, ,, side $\times 16$.
Fig. 8. Weevil gnawing into a wheat grain $\times 8$.
Fig. 9. Weevil inside a wheat grain $\times 8$.

III. *Spices*—
Lasioderma serricorne (major).
Anobium sp. (major).

IV. *General.*—The following occur in practically all substances. They are of very minor importance, as they cause very little actual damage and can be kept off with a little care and cleanliness.

Alphitobius piceus.
Ephestia cautella.
Pyralis pictalis.
Pyralis farinalis.

Most of those mentioned under cereals have been dealt with in detail by Messrs. Barnes and Grove (*Chemical Memoirs*, Vol. IV, No. 6). Below short notes, some embodying new facts, are given on these insects as well as on those not mentioned by Messrs. Barnes and Grove.

Calandra oryzæ (Pl. 100).

This is the commonest of the pests in the store and causes serious damage to stored cereals. In some countries it is known to infest the grains in the field. R. I. Smith observed it laying eggs in fields on ripening corn [maize] on 12th September from which weevils emerged in October (*North Carolina Agricultural Experiment Station Bull.* 203). A. L. Quaintance says " it is to be found in the field early in August. But it is when the corn has been gathered and housed however that the rice weevil does the greatest damage " (*Florida Agl. Expt. Stn. Bull.* No. 36, p. 367). In this country also it probably infests the ripe grains in the fields as it is found in the fields at the ripening time. But the real damage is done in the store.

The life-history has been dealt with in various Indian publications. The following obscure points have been recently determined. At Pusa the weevils become really active in August and from this time until about October there are three generations in quick succession, each occupying a period of about a month. From about November to July the development is extremely slow, single generations taking about $1\frac{1}{2}$ to 6 months. During this period, therefore, there are usually two broods, but there may be a third brood for the more forward ones. During the cold part of this period, *viz.*, from about November to about February, the beetles are more active than in the hot months. Eggs laid in February-March did not develop into adults before July-August. In the case of the more forward ones the extra brood occurs between December and March-April. The broods however are highly overlapping and the insect has been observed to emerge as an adult in all the months from July to April.

This seasonal life-history coincides with the amount of damage done by the insect during different periods of the year. The greatest damage occurs between August and November or December. The damage continues though in a slightly smaller degree until about February, and it is the least in the hot weather. Although by about December actual breeding decreases it should be remembered that the adults also damage the grains by boring into them for the purpose of feeding. The enormous number of weevils present in the store about this time more than compensates for the slower rate of breeding.

The number of eggs which the weevil is capable of laying has not been determined very accurately. Hinds and Turner had a maximum number of 417 in Alabama, Barnes and Grove had 60 in the Punjab in October and we had 88 at Pusa in February-March. The seasons are observed to have a great effect on the rate of development of the insect and most probably have some effect on the number of eggs which will be found to be more in August-September.

The adult weevils ordinarily live for about five months and in the course of their whole life they are capable of causing a loss of about 50 per cent. in the weight of wheat grains simply by feeding.

The loss in the weight of wheat grains caused by the grub, which feeds and develops inside until it emerges out of the grains as an adult, is about 30 per cent.

There is a good deal of difference of opinion as regards the amount of loss caused by the rice weevil. In this respect it is not possible to make a general statement. As will appear from the records of experiments given elsewhere in this paper the damage is very serious in small lots of grain and its percentage decreases with the increase in the bulk of the grains concerned. Thus for a given period, say one year, the loss in a lot of one maund of wheat may be more than 75 per cent., while in a lot of 500 maunds it may be as small as 4 or 5 per cent. Small lots suffer most. Therefore the majority of the cultivators who stock only small quantities are the greatest sufferers.

Rhizopertha dominica. (Plate 101.)

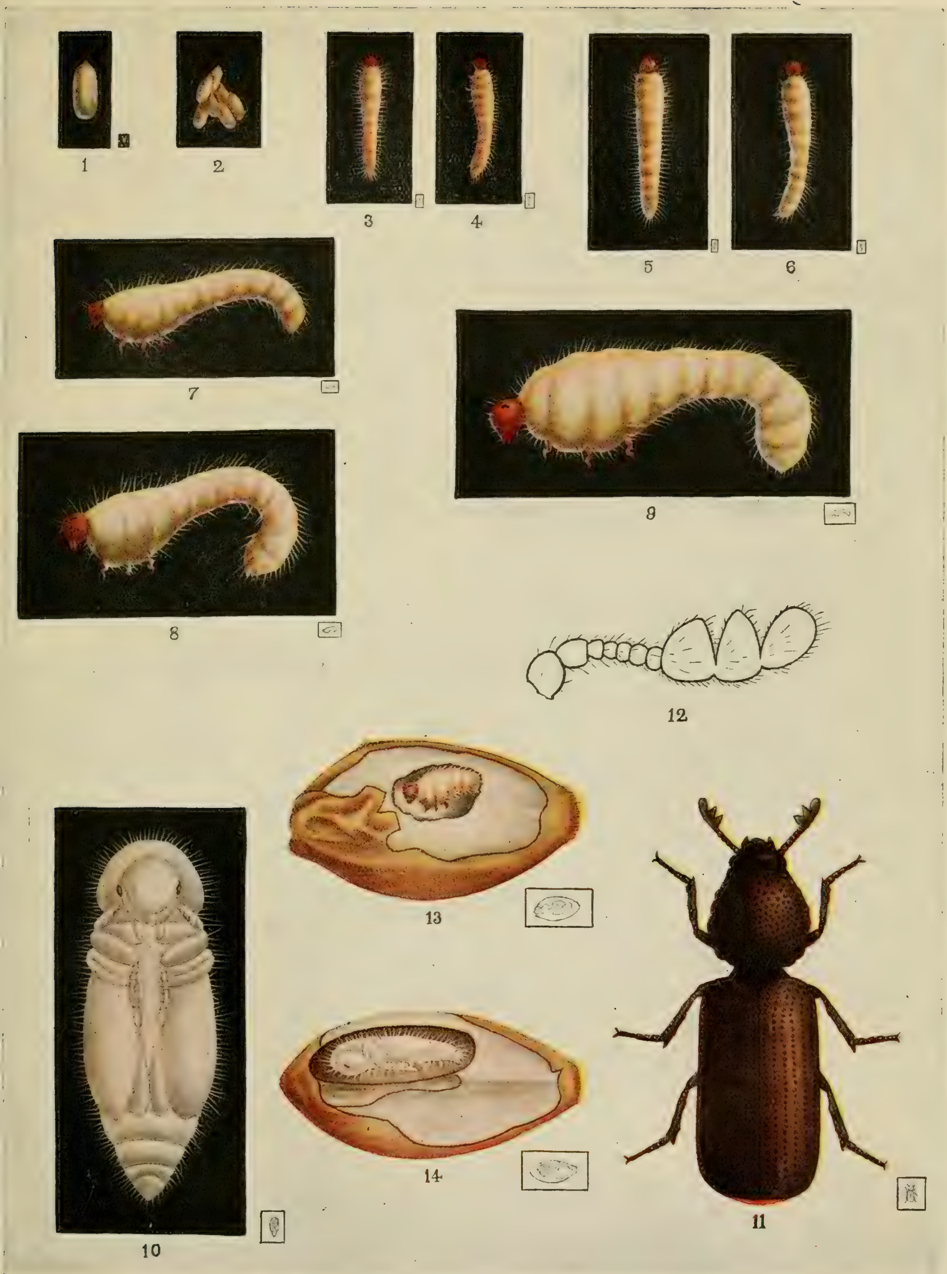
This insect is not observed ordinarily in the store to do as much damage as the rice weevil. But under certain conditions it is capable of doing far greater damage and in a much shorter time than the latter insect. It does not infest the grain if free air finds access into the storage receptable. If however the vessel is made airtight or fairly so it finds the ideal conditions for breeding. The storage experiments

EXPLANATION OF PLATE 101.

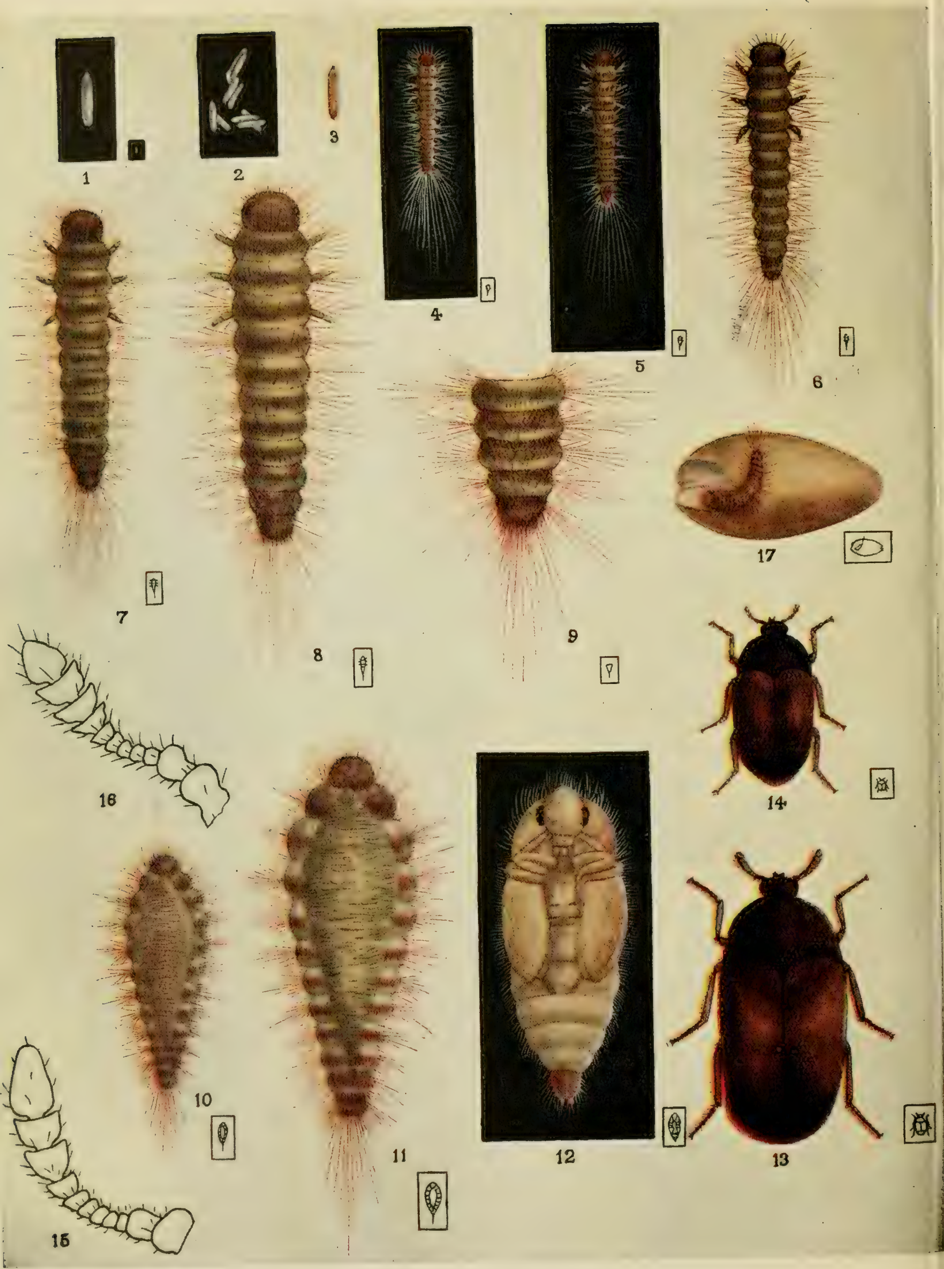
Rhizopertha dominica.

Fig. 1. The egg ($\times 20$).
Fig. 2. A cluster of eggs ($\times 10$).
Fig. 3. A freshly emerged larva, dorsal view ($\times 26$).
Fig. 4. A freshly emerged larva, lateral view ($\times 26$).
Fig. 5. The larva after the first moult, dorsal view ($\times 26$).
Fig. 6. The larva after the first moult, lateral view ($\times 26$).
Fig. 7. The larva after the second moult ($\times 26$).
Fig. 8. The larva after the third moult ($\times 26$).
Fig. 9. The fully developed larva just previous to pupating ($\times 20$).
Fig. 10. The pupa. Ventral view ($\times 20$).
Fig. 11. The adult showing the attitude when actively moving about ($\times 20$).
Fig. 12. The antenna.
Fig. 13. A grain showing the larva inside ($\times 6$).
Fig. 14. A grain showing the pupa in the cavity excavated by the larva ($\times 6$).

The small figures by the side of the larger ones indicate the natural sizes of the insects.



RHIZOPERTHA DOMINICA.



TROGODERMA KHAPRA.

EXPLANATION OF PLATE 102.

Trogoderma khapra.

Fig. 1. The egg ($\times 13$).
Fig. 2. A group of eggs showing the way they are sometimes laid together ($\times 6$).
Fig. 3. An egg a few days' old showing signs of the developing larva inside ($\times 13$).
Fig. 4. A freshly emerged larva ($\times 26$).
Fig. 5. The larva after the first moult ($\times 26$).
Fig. 6. The larva after the second moult ($\times 26$).
Fig. 7. The larva after the third moult ($\times 23$).
Fig. 8. The larva after the fourth moult ($\times 23$).
Fig. 9. The terminal segments of a larva after the fifth moult ($\times 23$).
Fig. 10. The pupa of a male beetle still enclosed in the last larval skin. Dorsal view ($\times 13$).
Fig. 11. The pupa of a female beetle as in Fig. 10 ($\times 13$).
Fig. 12. The female pupa removed from the larval skin, ventral view ($\times 13$).
Fig. 13. *T. khapra* female ($\times 13$).
Fig. 14. *T. khapra* male ($\times 13$).
Fig. 15. Antenna of male beetle.
Fig. 16. Antenna of female beetle.
Fig. 17. A larva attacking a wheat grain.

The small figures by the side of the larger ones indicate the natural sizes of the insects.

were carried on with a number of gunny bags and earthen vessels (as shown in Plate 111) in a godown for two years. This insect never occurred in gunny bags or in earthen vessels kept with their covers loose. It occurred only in those vessels in which the cover was made airtight by being plastered with mud and in kerosine tins similarly treated.

The life-history of this insect is given in detail by Messrs. Barnes and Grove. It hibernates in the cold weather from about October to March. During the rest of the year the generations occur after roughly about four weeks.

Trogoderma khapra. (Plate 102.)

This Dermestid is of importance as a pest of wheat, maize and pulses in the western parts of the United Provinces, the Punjab and Gujarat. Its life-history is given in detail by Messrs. Barnes and Grove. The period of activity coincides with the months of May to August or September, when the generations are passed through in quick succession, each cycle of life occupying about four to five weeks. During this time there is an enormous increase in its number. The fourth generation occupies a long period from about September to April, the cold weather from about October to March being passed by the larvæ in a dormant condition.

In the godowns examined at Cawnpur numerous grubs were observed inside cracks and interspaces between the bricks on the walls. In these places they can live from season to season and feed on the dust and particles of grains which are usually present there.

Messrs. Barnes and Grove remark that the interesting feature of attack of this insect is that it is usually present at the top of the wheat. It certainly can and does penetrate to some depth into the wheat but the greatest amount of damage always occurs in the first six to twelve inches and during the first year. As a matter of fact, the other pests (*Calandra oryzæ* and *Rhizopertha dominica*) also begin at the top and gradually go downwards.

Tribolium castaneum. (Plate 103, figs. 1-5.)

These small red-brown beetles and their slender brownish grubs are frequently found in damaged grain in company with the principal pests, *viz.*, *Calandra oryzæ*, *Rhizopertha dominica* and others. They cannot damage the grains by themselves and simply follow the real pests and breed in the dust produced by the latter. They however occur in profuse numbers and seem to prefer the company of *Rhizopertha* to that of the others. When, however, in want of food they are forced to procure sustenance by nibbling the grains. A number of the beetles confined with wheat grains were observed to nibble the germ of the grains. This was, however, exceptional. Ordinarily they do not attack sound grains.

They are, however, a serious pest of ground wheat (*atta*, *maida*, *suji*), ground rice, oatmeal, etc. In addition to the damage they cause they impart to the stuff a characteristic nauseous smell and taste which lowers its value as food and consequently also its price. In cases of bad infection the attacked material may be uneatable. In the trade, *atta* is stored and sold in gunny bags. A visit to a store-house containing such bags between July and November reveals the presence and working of this insect through the dust which oozes out of all sides of the bags and covers them entirely. *Atta*, *suji*, etc., are found to swarm with these insects, especially their grubs, about September-October. The insect seems to be more active in the rainy season than at other times of the year. Fresh generations occur after about a month.

Tenebroides mauritanicus (Plate 104).

These brown beetles and their large flat white grubs easily attract attention when they are present among the grains. They occur more commonly in rice and wheat than in other grains.

Various opinions have been held regarding the part played by this insect in the store, some being distinctly of the opinion that its presence is beneficial and therefore desirable on the ground that it preys upon other grain pests. It has been ascertained by experiments that the grubs feed only upon the grains and not upon any insect. The adult beetles prey upon adult rice weevils (*Calandra oryzæ*) but feed upon the grains as well even when adult rice weevils are present. Besides, their growth is so slow, as will appear from the short details of life-history given below, that their usefulness as agents of destruction of other pests is negligible. Therefore they are to be ranked among pests. As pests, however, they are not capable of serious injury on account of the very slow rate of their development.

Elongated cigar-shaped white eggs with soft membrane, measuring about 1·5 to 2 mm. in length and about 0·25 mm. in thickness, are deposited in clusters among the grains. In ordinary weather they hatch after about 6 days. The flat white grubs are sluggish in nature and feed by gnawing the grains, consuming the farinaceous matter and sometimes entering the gnawed grains bodily. They can also feed upon the dust produced from the grains by other pests.

They develop very slowly and become full grown in the course of about 10 to 20 months. Pupation takes place either inside the corroded

EXPLANATION OF PLATE 103.

Tribolium castaneum.

Fig. 1. The egg ($\times 13$).
Fig. 2. The freshly emerged larva ($\times 13$).
Fig. 3. The fully grown larva ($\times 10$).
Fig. 4. The pupa. Ventral view ($\times 13$).
Fig. 5. The adult ($\times 13$).

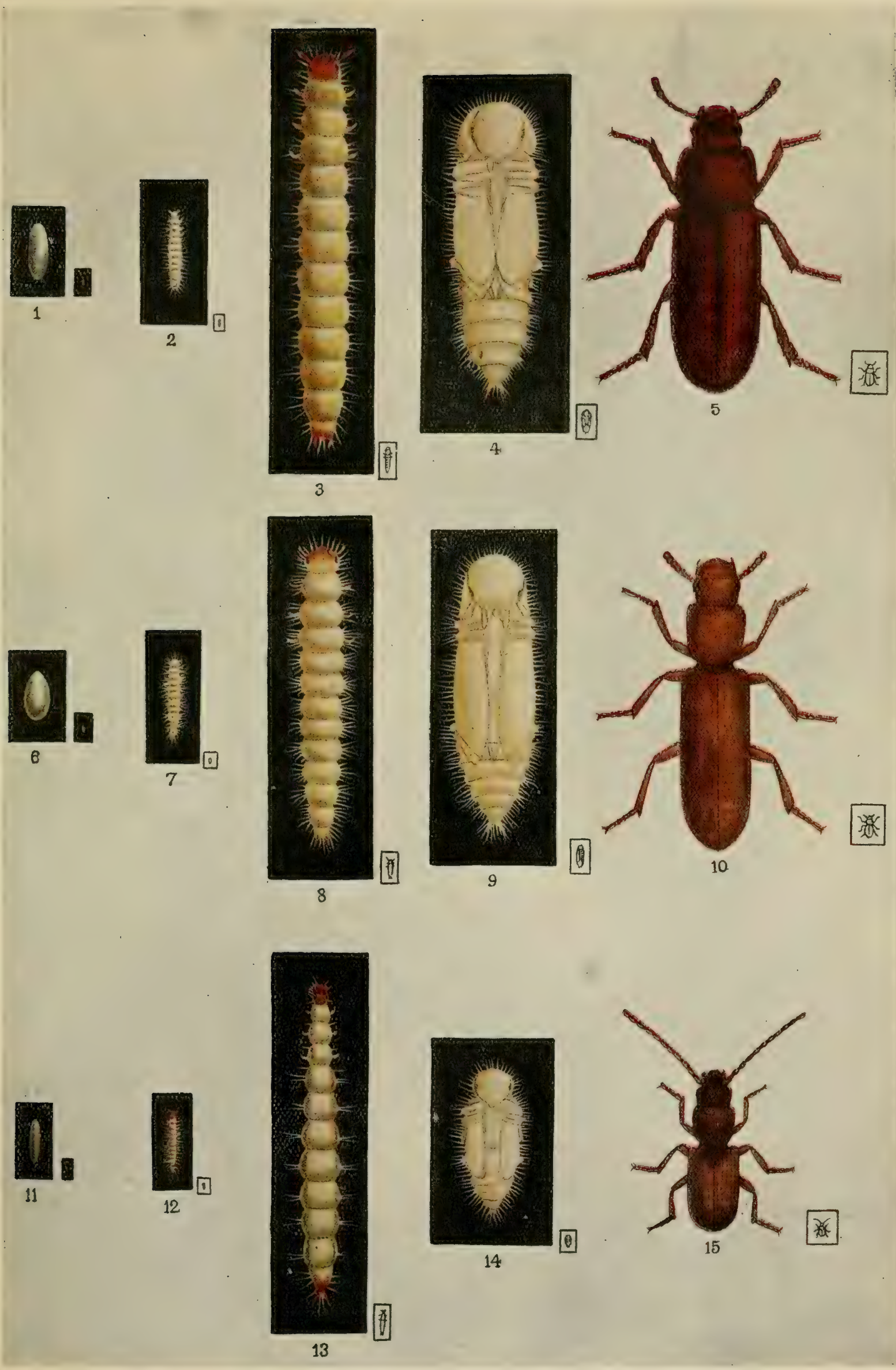
Latheticus oryzæ.

Fig. 6. The egg ($\times 13$).
Fig. 7. The freshly emerged larva ($\times 13$).
Fig. 8. The fully grown larva ($\times 10$).
Fig. 9. The pupa. Ventral view ($\times 13$).
Fig. 10. The adult ($\times 13$).

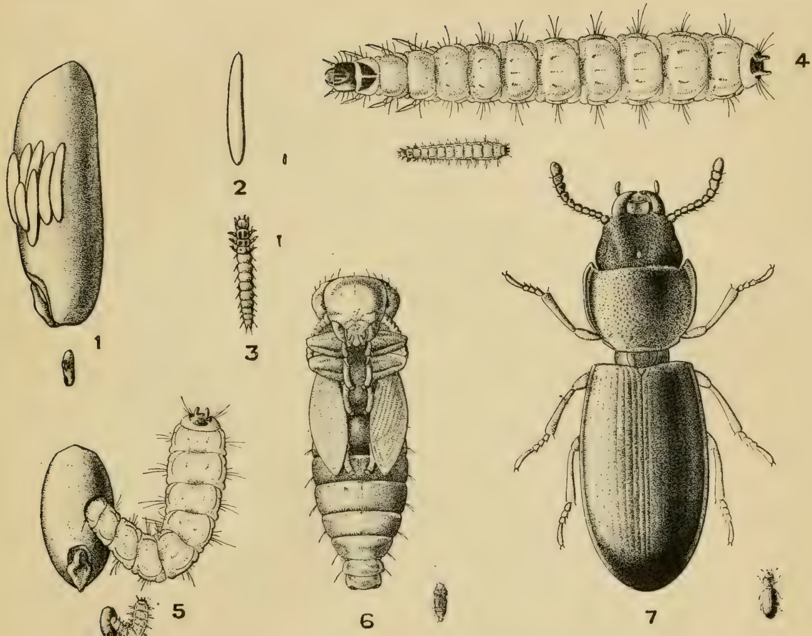
Læmophlœus sp.

Fig. 11. The egg ($\times 13$).
Fig. 12. The freshly emerged larva ($\times 13$).
Fig. 13. The fully grown larva ($\times 13$).
Fig. 14. The pupa. Ventral view ($\times 13$).
Fig. 15. The adult ($\times 13$).

The small figures by the side of the larger ones indicate the natural sizes of the insects.



TRIBOLIUM CASTANEUM, LATHETICUS ORYZÆ, LÆMOPHLŒUS SP.



Tenebroides mauritanicus ; 1, group of eggs on grain ; 2, a single egg ; 3, newly-hatched larva ; 4, full-grown larva ; 5, larva gnawing into grain ; 6, pupa ; 7, beetle. All figures are enlarged, the natural sizes being shown by the smaller outline figures.

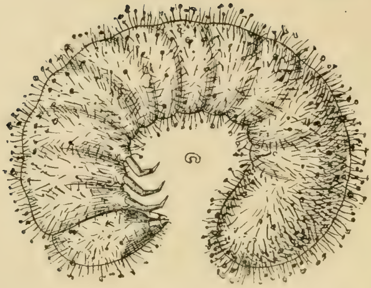


Fig. 1.—Larva of *Gibbium scotias,* magnified (×16). The smaller outline figure shows the natural size.

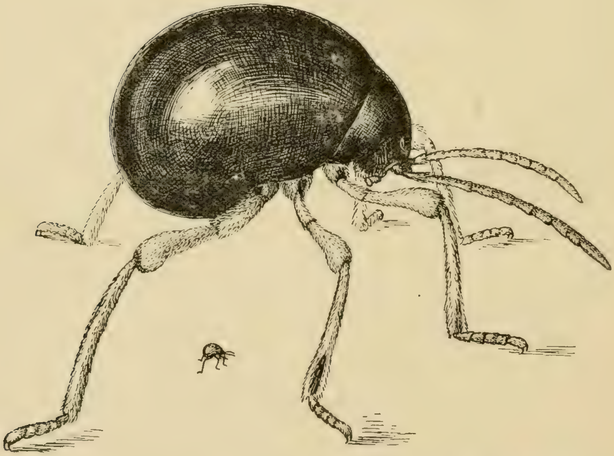


Fig. 2.—*Gibbium scotias* (magnified; the smaller figure shows the natural size).

grain or between a few grains fastened together. The pupal stage at ordinary temperatures is about 8 days. The adult beetles live for about five months. They oviposit and breed any time in the year when they find suitable conditions.

Gibbium scotias (Plate 105).

This has not been recorded before as a pest of stored grain, but it was found by Sardar Harchand Singh feeding upon and breeding among stored wheat grains in a shop in Patiala in July. Living specimens were brought to Pusa where it was observed that they completed a generation in the course of a month. Small white eggs are laid among the grains and both the grubs and adults feed upon the grains, either nibbling their surface or gnawing deeper into them. The grub is white with a yellow head and is clothed with hairs to which particles of grain, dust, etc., stick, bringing about a dust-covered appearance. The adult beetles have a bulging back and long legs and look like spiders of a brown shiny appearance.

This insect has been recorded as boring into the outer parts of opium cakes at Patna and damaging the records in the Dharwar Collectorate. It is a household insect and may prove to be serious as it is capable of breeding rather quickly.

Attagenus piceus (Plate 106, fig. 1).

This Dermestid beetle also has not been recorded as a pest of stored grain. But it was originally received from the Punjab along with other store pests, and actually breeding in wheat chaff. It is capable of feeding and certainly does feed on grains in the store but it is overshadowed by the more numerous and more active *Trogoderma khapra*. It breeds very slowly, fresh generations occurring after one, two or even three years. This is also one reason why it cannot be prominent and it will probably never prove serious.

Beetles emerge in April, May, and June and live at the most for about three weeks, in the course of which they complete oviposition and die. Each female is capable of laying up to about 50 eggs, which are deposited loosely among the stuff in which breeding takes place. The eggs hatch in about 8 days. The grubs from the eggs of the same mother may feed for one to three years, some attaining the adult stage after one year, some after two years and some after three years. As already stated, the beetles appear in April, May and June.

Sitotroga cerealella. (Plate 106, fig. 2.)

The small moth, *Sitotroga cerealella,* (known as *surwi* in the Western parts of Bengal) causes considerable damage to paddy, wheat, barley, maize, and *juar* (*Andropogon sorghum*) grains in the store. It is known as the Angoumois Grain Moth in other countries, or as "fly-weevil" in America. In some countries it is known to infest the grains in the field. R. I. Smith gives two photographs of maize cobs infested by it in the field in October-November (*North Carolina Agricultural Experiment Station Bull.* 203 (1909), pp. 14-17). A. L. Quaintance records the same fact observed in Florida (*Florida Ag. Exp. Stn. Bull.* No. 36, 1896). In this country it has not been observed to attack grains in the fields. Even if it does so, it must be so rarely that no notice is taken. The damage it does is confined to the store. When the grain lies exposed or is kept in receptacles not full it literally swarms with this insect and the damage is very considerable.

The insect is active practically throughout the year, fresh generations occurring in the ordinary season after about a month. In the cold weather its activity is less, December and January being a short period of rest. Each female moth is capable of laying up to about 120 eggs which are deposited in depressions, cracks, crevices, or holes in the grains or among the grains in the heap. The egg hatches in about 6 days. The young caterpillars bore into the grains and consume the farinaceous matter and when full-grown, in the course of about a fortnight, pupate inside the grains, emerging as moths after another week.

The Pulse Beetles (Bruchidæ).

The pulse beetles have not yet been fully worked out. It is not known how many species of them there are in all in this country. Of the known ones again the life-history and habits of only a few have been fully observed. As regards their known habits they can be grouped as follows :—

(*a*) Some work only in the store, attacking and breeding in stored seeds.

(*b*) Some work both in the field and in the store. They infest the seeds while still green in the pods on the plants growing in the fields. With the harvested seeds they find their way into the store where they continue damaging the dry seeds. On account of the altered conditions in the store the damage and consequent loss are considerably more than in the fields. These beetles are, of course, capable of invading fresh stores and attacking fresh seeds which may be harvested in an unaffected condition.

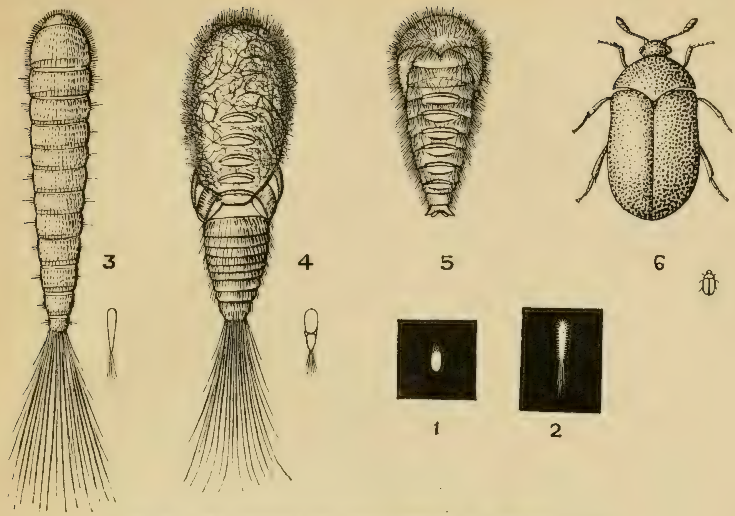


Fig. 1.—*Attagenus piceus*, stages in life-history (×7).

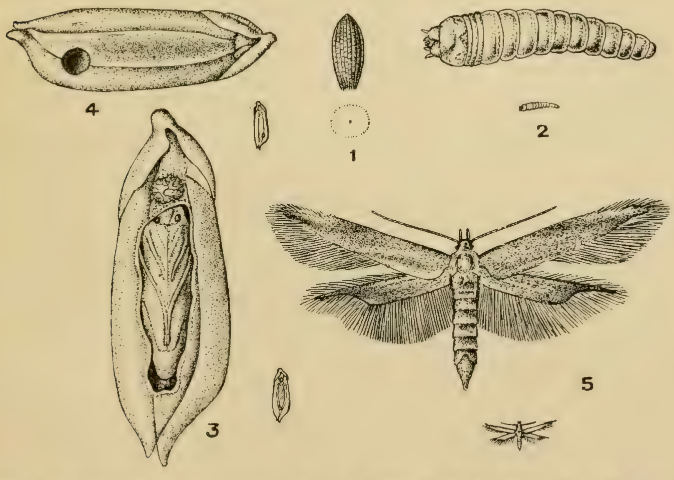


Fig. 2.—*Sitotroga cerealella* ; 1, egg ; 2, larva ; 3, pupa inside attacked grain (cut open) ; 4, attacked grain after emergence of moth ; 5, moth. All figures are considerably magnified, the smaller outline figures indicating the natural sizes.

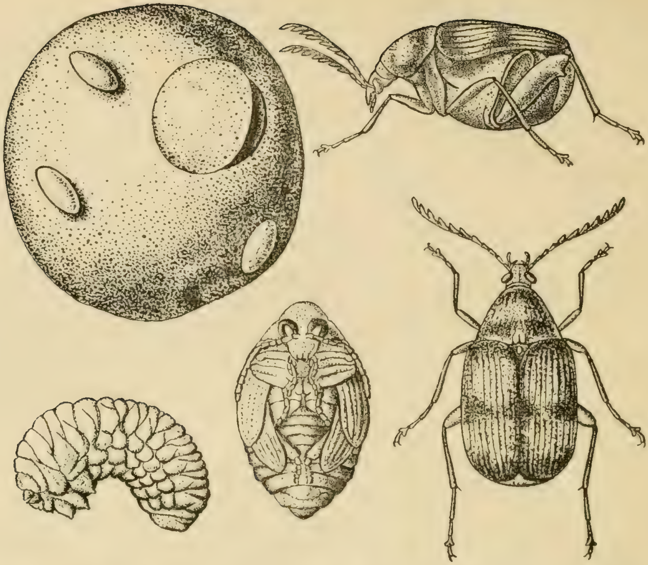


Fig. 1.—*Bruchus chinensis.* **Attacked seed with three eggs and hole of emergence of beetle, larva, pupa, and dorsal and lateral views of beetle (magnified 12 times).**

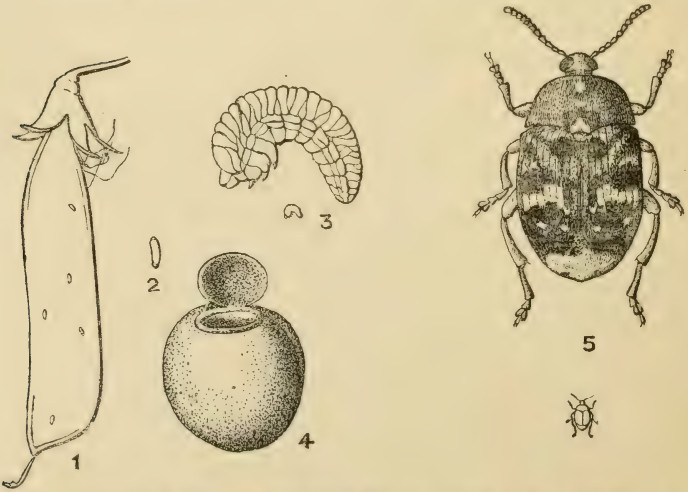


Fig. 2.—*Bruchus affinis.* **1, Eggs laid on pod (×4) ; 2, egg (×16) ; 3, larva (×8) ; 4, seed after emergence of beetle (×4) ; 5, beetle (×8). The small outline figures against nos. 3 and 5 indicate the natural sizes.**

(*c*) Some infest the seeds in the fields and are brought into the store with the harvested seeds but do not breed in the store.

In order to deal with the pulse beetles therefore it is not enough if the seeds are kept in receptacles into which the insects cannot have access; but it is necessary to treat the seeds before storage in such a way that they may be freed from the insects which may be present in them due to infestation in the field.

Below are given the life-history and habits of the common ones occurring in the neighbourhood of Pusa. The names attached to each species are given with reserve, as the identifications require to be corroborated.

Bruchus chinensis (Plate 107, fig. 1).

This is the most common pulse beetle in store. It is found principally in the store, although in some places it has been observed to infest green pods in the field as well. But its activity in the field is small. In the store, however, it causes serious damage and is capable of breeding in almost all kinds of pulses. The following three pulse seeds have so far been found to be immune from its attack, *viz.*, the small field-pea (*Pisum arvense*) and two varieties of *Urid* (*Phaseolus ? radiatus*), known in the neighbourhood of Pusa as *Aghania* and *Mungia urid.*

The oval, convex and whitish eggs, looking like small whitish spots on pulse seeds, must have been observed by all. The grubs on hatching from the eggs gnaw into the seeds and the adult beetles emerge through a hole by pushing open a round piece like a lid. Fresh generations occur in the course of about three weeks and, as each beetle lays several hundred eggs, an enormous amount of damage is caused in the course of a short time. Generation after generation occurs in the seeds until there is hardly anything left of the seeds. Taking lots of 25 seeds which were exposed to these beetles, on the average, 7 beetles have been bred out of each large pea seed, 6 from each gram seed, 5 from each *khesari* (*Lathyrus sativus*) seed, 6 from each *arhar* (*Cajanus indicus*) seed. These facts demonstrate its injurious capacity very well.

Bruchus affinis (Plate 107, fig. 2).

This beetle attacks peas of all sorts, but the small field pea (*Pisum arvense*) more than the other varieties. Eggs are deposited on the surface of the green pods in the fields in January and February. They are elongated oval and cylindrical in shape, measuring 0·66 mm. in length and 0·25 mm. across and are orange yellow in colour. They are held in position by a clear gummy substance exuded with the egg from the ovipositor, this substance covering the egg and spreading to a small distance on the substratum all round the egg. They are deposited singly but there may be several to many eggs on the same pod. On hatching from the egg the young grubs gnaw their way into the pod and ultimately into the seeds inside the pod. They feed and grow inside the pod. They feed and grow inside the seeds which are harvested and brought into the store. They attain the adult stage by about May-June but do not leave the seeds. From July onwards a few beetles may emerge out of the seeds but sit quietly and rest among the grains or under some shelter in the store. All emerge and fly out in December and January and lay eggs.

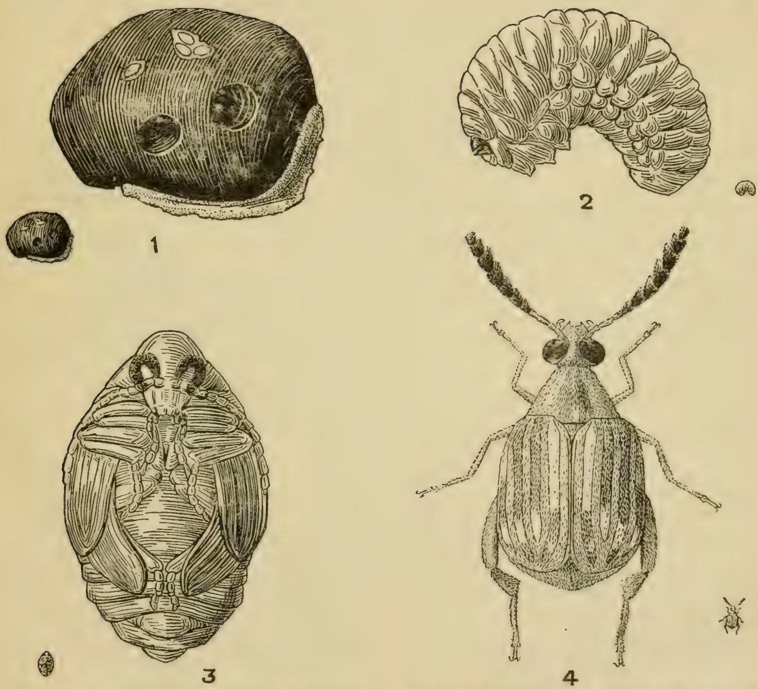
A quantity of the small field-pea pods which had eggs on them was picked out and kept separately and 50 per cent. of the seeds of these pods proved to be damaged. Taking whole fields together the amount of damage normally has been found to vary from about 3 to 7 per cent. A lot of the seeds from the field which showed a damage of 7 per cent. was sunned after harvest consecutively for seven days in the hot sun in March. In the sunned lot with no further treatment the damage was reduced to about $2\frac{1}{2}$ per cent. By storing the seeds in airtight jars with naphthaline in March, or treating them with carbon bisulphide at this time, the damage was entirely prevented. When the seeds are harvested the grubs which have lodged themselves inside them are quite young and, if they are killed at this time, the seeds remain practically undamaged.

Bruchus sp. (Plate 108).

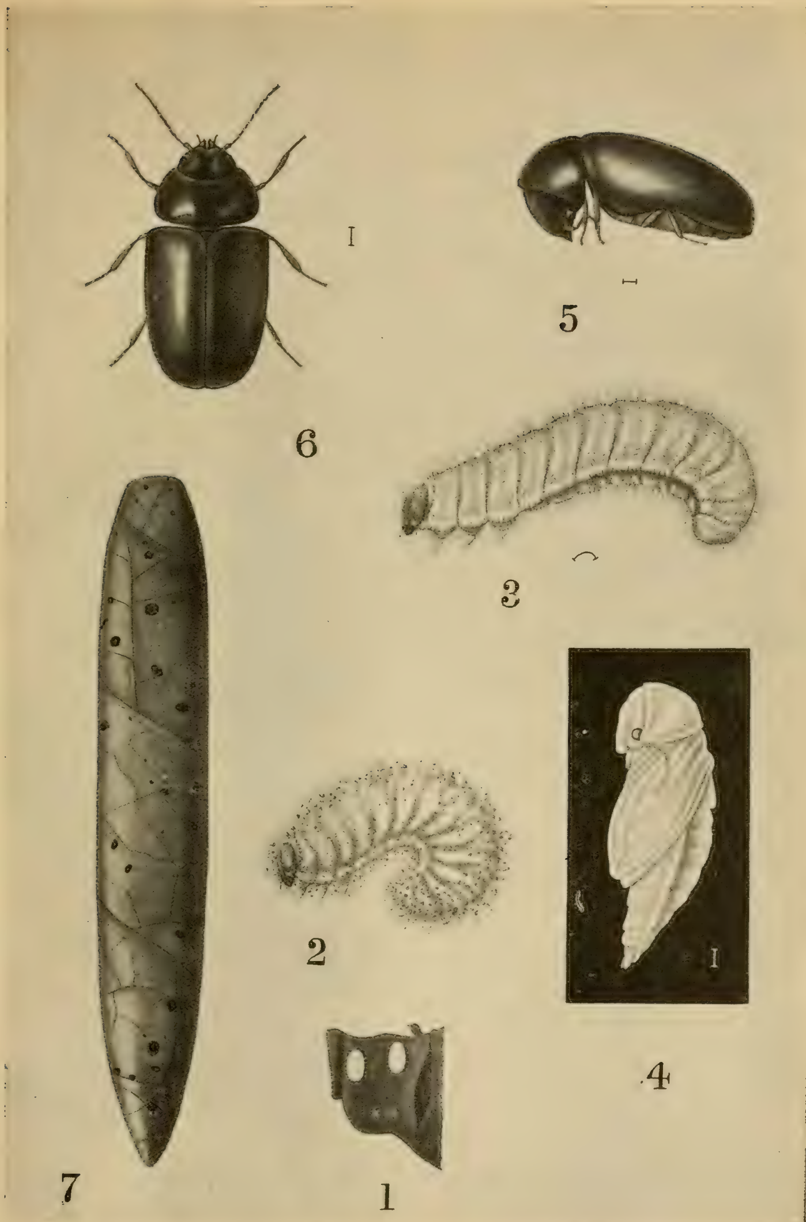
This is an unidentified species of a pulse beetle which has been observed to breed in bean seeds in store. It probably breeds as well in the fields, where eggs are laid on the green pods. In the store the eggs, as usual with this class of beetles, are deposited on the seeds as shown in the figure. Fresh generations occur after about a month. This beetle is therefore also capable of very serious damage.

Lasioderma serricorne (Plate 109).

This small red beetle, commonly known as the cheeroot beetle, bores and breeds in turmeric, dry ginger, black pepper, dry chilli pods and various other things. It is one of the major pests of the store. Its life-history and stages are shown in the figures. Fresh generations occur ordinarily after about a month. It is capable of breeding in the open air and on one occasion was observed to breed in dry pods of *Poinciana regia* still hanging on the plant in August.

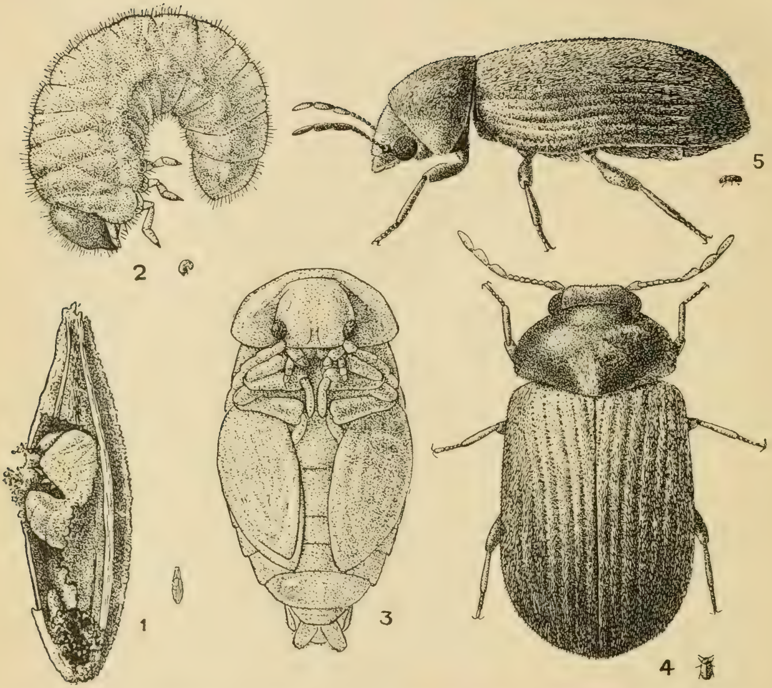


Bruchus sp. (C. S. 1598) in bean seeds in store ; 1, eggs on bean seed which also shows holes of exit of beetles ; 2, larva ; 3, pupa ; 4, beetle. All figures are considerably magnified, the smaller figures showing the natural sizes.



LASIODERMA SERRICORNE.

1, *Eggs ;* 2, young larva ; 3, larva, cleaned of attached particles; 4, pupa ; 5, beetle, side view ; 6, beetle, dorsal view ; 7, cigar riddled by beetles. Figures 1—6 are considerably magnified, the hair-lines indicating the natural sizes.



Anobium sp. in Cumin seed in store. 1, larva in seed ; 2, larva ; 3, pupa ; 4, 5, beetle, magnified.
The small figures indicate the natural sizes.

Anobium sp. (Plate 110).

This small brown beetle causes serious damage to aniseed, coriander seed, cumin seed, *ajwan* (*Carum copticum*), and *banjoan* (*Apium graveolens*). Both the grubs and adults feed on the grains. In affected material all the stages will be found at the same time. The white grubs feed inside the grains and frequently bind several grains together before pupation.

IMMUNITY OR OTHERWISE OF GRAINS, ETC., STORED IN HOUSES.

In order to ascertain the immunity or resistance of the various kinds of seeds which householders ordinarily stock, two pounds of each of the seeds mentioned below were kept in small earthen vessels (Plate 111) without covers in a tiled godown where the storage experiments were carried on and which was full of insects and opened frequently so that any insect could have easy access. The seeds lay in the godown for two years and those which were unaffected by insects after this period are placed in one group and the affected ones in another group.

Unaffected.

I. Cereals—

Oats (*Avena sativa.*)
China (*Panicum miliaceum*).
Shama (*Panicum frumentaceum*).
Kauni (*Setaria italica*).
Kodon (*Paspalum scrobiculatum*).
Gandli (*Panicum miliare*).
Marua (*Eleusine coracana*).
Bajra (*Pennisetum typhoideum*).

II. Pulses—

Urid (*Aghania* and *Mungia*) (*Phaseolus radiatus*, varieties of).
Kirao (The small Field-peas, *Pisum arvense*).

III. Oil-seeds—

Mustard and Rape, (*Brassica spp.*).
Castor, (*Ricinus communis*).
Poppy, (*Papaver somniferum*).
Linseed (*Linum usitatissimum*).
Niger oilseed, (*Guizotia abyssinica*).
Safflower, (*Carthamus tinctorius*).
Groundnuts and groundnut seeds, (*Arachis hypogœa*).
Gingelly, (*Sesamum indicum*).

N.B.—All safflower, groundnuts and groundnut seeds and some of gingelly and niger oilseeds were eaten by rats and mice.

IV. Fibres—
Jute, (*Corchorus* spp.).
Sann hemp, (*Crotalaria juncea*).

V. Spices—
Kalajira, Black cumin, (*Nigella sativa*).
Golmirich, Black pepper (*Piper nigrum*).
Methi (*Trigonella Fœnum-græcum*).

Affected.

I. Cereals—
Wheat (*Triticum vulgare*).
Barley (*Hordeum vulgare*).
Maize (*Zea mays*).
Juar (*Andropogon Sorghum*).
Paddy (*Oryza sativa*).

N.B.—Damaged principally by *Calandra oryzæ* and *Rhizopertha dominica* and to a less extent by *Sitotroga cerealella*.

II. Pulses—
Moth or *Bhringi* (*Phaseolus aconitifolius*).
Khesari (*Lathyrus sativus*).
Bora or *Barbati*, Cowpea, (*Vigna catjang*).
Chhola or Boot Gram, (*Cicer arietinum*).
Kulthi, Horse-gram (*Dolichus biflorus*).
Masur, Lentil (*Ervum lens*).
Mung, Green gram (*Phaseolus mungo*).
Arhar, Redgram or Pigeon-pea (*Cajanus indicus*).
Bakla, (*Vicia faba*.)
Matar, Peas, (*Pisum sativum*).
Bhat or *Gari-kalai*, ? Soy bean, (*Glycine hispida*) partly.

N.B.—All damaged by *Bruchus chinensis*.

V. Spices—
Sonf or *mouri*, aniseed (*Fœniculum vulgare*).
Jira, Cumin seed (*Cuminum cyminum*).
Ajwai or *jwain*, (*Carum copticum*).
Ajmud, (*Carum Roxburghianum*).
Dhaniya, Coriander seed, (*Coriandrum sativum*).
Pipal, Long pepper (*Piper longum*).
Haldi, Turmeric (*Curcuma longa*).
Ada, Ginger, (*Zingiber officinale*).
Lanka, Chillies, (*Capsicum frutescens*).

N.B.—The first five bored by *Anobium* sp. and the last four by *Lasioderma serricorne*.

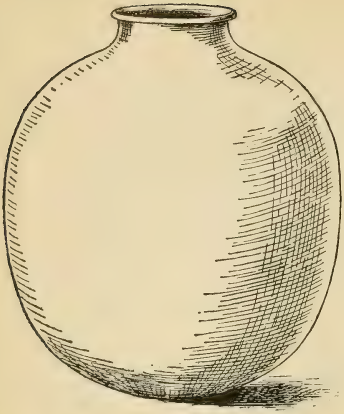


Fig. 1.—Earthenware jar for preservation of grain.

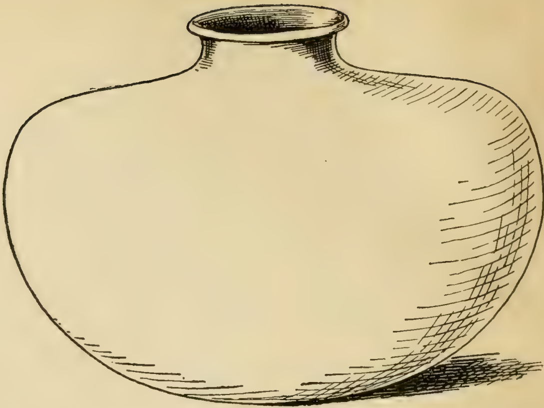


Fig. 2.—Earthenware jar for preservation of grain.

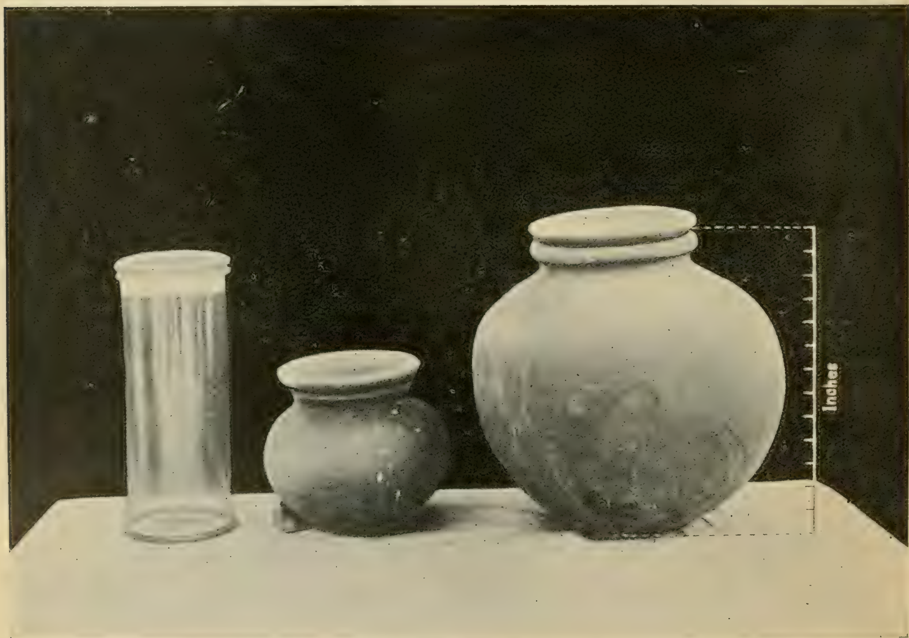
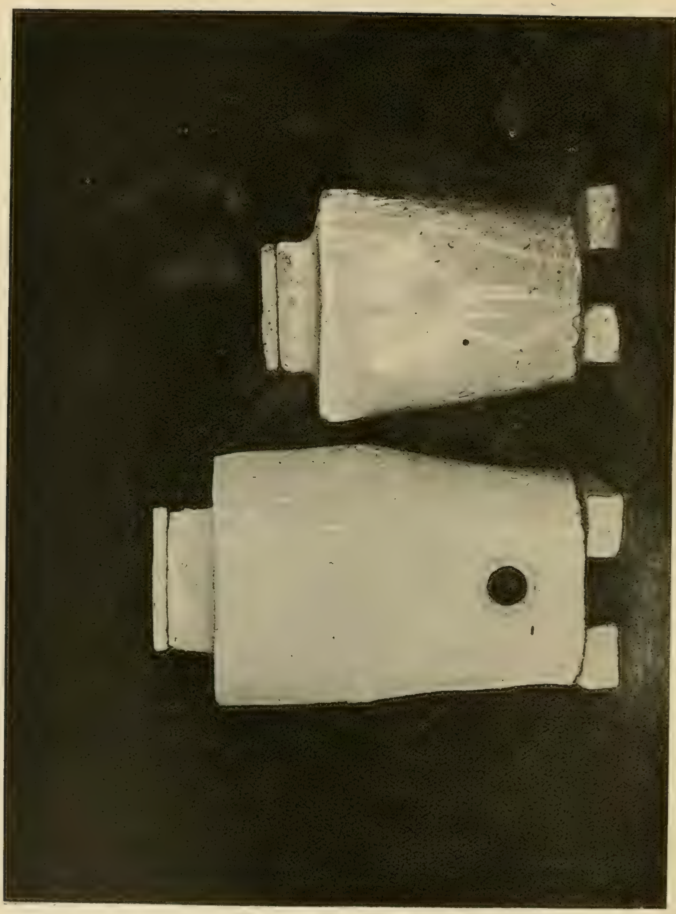
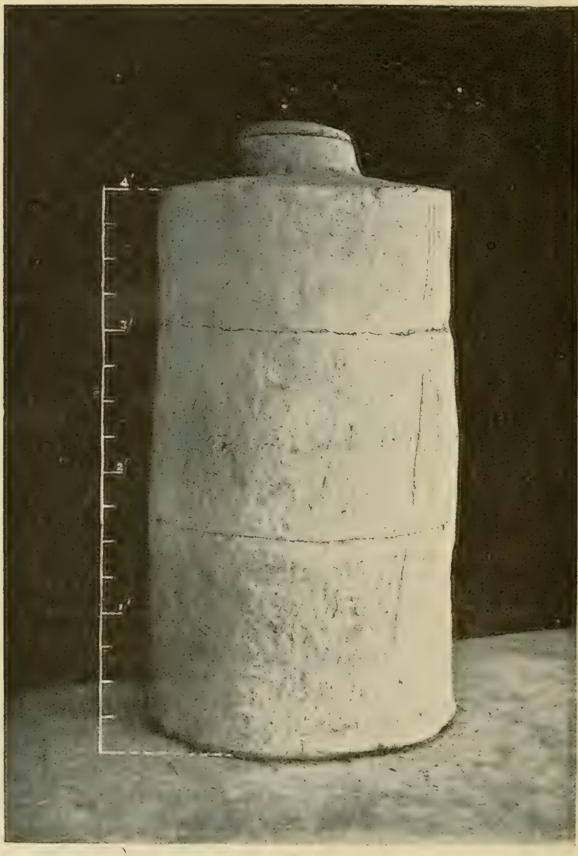


Fig. 3.—A glass jar, 12 inches high and $4\frac{3}{4}$ in diameter, and two earthenware receptacles (called *Harias*) with covers. The larger one is about 13 inches high and about 14 in diameter, the smaller one about 6 inches high and 7 in diameter.



Small storage receptacles, called *Kothis* and made of unburnt clay. The larger one (to left) is about 30 inches high and is made of two pieces, one set over the other, and is provided at the lower part with a hole for taking out the stored grain. The smaller one (to right) is about 20 inches high.



Storage receptacle (*Kothi*) made, in three pieces, of unburnt clay. Inside measurements, 4 feet high and 2 feet in diameter.

VI. Miscellaneous—

Paniphal or *Singhara*, Water-nut (*Trapa bispinosa*).
Bored by *Rhizopertha dominica*.

Tamarind seeds.
Bored by *Caryoborus gonagra*.

STORAGE RECEPTACLES IN USE AMONG THE PEOPLE.

Earthen vessels. Earthenware vessels and pots are in universal use. These are made of various sizes and shapes. Some are shown in Plates 111—113. For storing small quantities earthen pots are probably the only vessels used everywhere. In some localities larger vessels used are specially prepared for storing larger quantities up to about four maunds (81 lb. =1 md.) in single vessels (Plate 111, figs. 1, 2) and these are called *jalas, motkas, nands,* and by various other names. Earthen covers are used for them (Plate 111, fig. 3) and, when it is intended to seal up the store, these covers are plastered with a mixture of cowdung and mud. But this does not make the vessels proof against insects, as will appear from actual experiments detailed later on.

Mud-bins. In Bihar for indoor storage various kinds of vessels, called *kothis,* are made of unburnt clay. The clay is mixed with long bits of straw or grass so as to give a tough consistency to the walls which are about one to one and a half inches thick according to the size of the vessel. The entire wall is not built up all at once but is gradually added to as the lower portions dry. Also high vessels are not built in one piece. The vessel in Plate 112 (right) is a single piece, that in Plate 112 (left) is of two pieces and that in Plate 113 is of three pieces, the pieces being placed one above the other and prevented from slipping off by means of projecting lips which fit on to each other at the points of juncture. The *kothis* shown in Plate 112 are oval in outline and one of them has a hole at the lower part through which the stored article can be taken out without opening the mouth. That shown in Plate 113 is round in outline. Square and oblong *kothis* are also made and frequently they possess several chambers inside with walls between them for storing different kinds of grain. The covers, as shown in the photographs, are made of the same stuff as the *kothis* themselves and are plastered with mud to seal the store. The joints also are similarly plastered (Pl. 112, left). The joints and the mouth of the *kothis* are their weak points and cannot be made proof against insects, which frequently occur in the grains stored in them.

Kerosine tins, being available everywhere at a small cost and being not as brittle as the earthenware pots, are also used extensively for storing purposes, of course on a small scale. The difficulty with them however is that their openings can hardly be made insect-proof.

Gunny bags are in universal use among all cultivators, grain dealers and even big merchants, especially for convenience of handling and transport. Bags filled with grain are piled up in large godowns up to the ceiling. As storage receptacles they are extremely bad as they expose the grain to insects all around their surface.

Bamboo bins, etc. Bins are made of bamboo matting or wattling, of stems of *Saccharum arundinaceum*, of sticks of leguminous plants, etc. These are of the shape of ordinary cylindrical iron bins and of various capacities. Their walls are plastered with cowdung both inside and outside or only inside and usually they have solid bottoms which are also plastered similarly. They are as a rule used for indoor storage and sometimes have conical umbrella-like coverings which can be placed on the top. Rarely they possess no bottom and are pitched on the flat floor and made firm by means of sticks driven into the ground. In such cases they are used for a rather coarse stuff like unhusked paddy grains. Such bins are incapable of keeping off insects. They are not in use all over India. As far as the writers know, they are found in Assam, parts of Bengal and, as Mr. V. G. Deshpande, the Entomological Assistant of the Konkan, informs them, in the Deccan. Even by being well plastered with mud they cannot be made insect-proof.

Straw *pura* (Plate 114). In West Bengal for storing indoors, and at one place, say from about four to about 16 maunds usually of husked rice or unhusked paddy grains, this *pura* is in common use. It is made entirely of paddy straw. In this part paddy straw is in great demand for thatching purposes and therefore all varieties of paddy are harvested in sheaves, the grain being separated by beating the sheaves on sloping planks. For the *Pura* as well as for the *Morai* to be described later on, thick ropes about $1\frac{1}{4}$ to $1\frac{1}{2}$ inches in diameter are prepared with this straw in the manner shown in Plate 115. For this purpose the loose leaf-sheaths of the straw are discarded as far as possible by holding the loosened sheaf at the top and giving downward jerks. The straw is then moistened with water to make it pliable. In this figure (No. 2) about two and a half bundles of such straw are lying in front of the man who is sitting. He is feeding the rope with his hands, giving it a twist at the same time by rolling it in the desired direction by means of his right foot. The man at the other end continually twists the rope. The ropes are usually made in lengths of about 50 yards. One bundled-up rope is lying on the left side of the feeder. Fig. 1 shows how the rope is commenced and Plate 114, fig. 2, how it is fed. Unless the paddy is harvested before the straw becomes too dry and brittle no

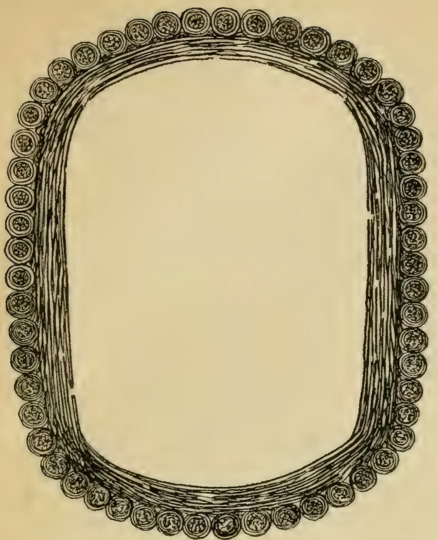


Fig. 1.—Section through straw *Pura*.

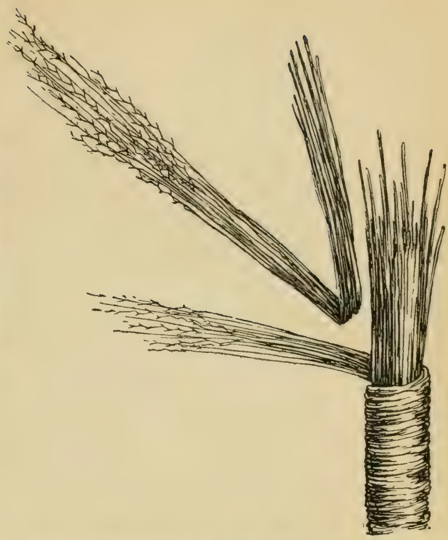


Fig. 2.—Preparation of a straw rope showing how the rope is fed with straw.

Fig. 3.—*Pura* made of straw rope.

Fig. 1.—Commencing a straw rope for the building of a *Morai.*

Fig. 2.—Preparing a straw rope for building a *Morai*. It is fed with the right hand and twisted with the right foot of the feeder, and twisted with the hands of the twister.

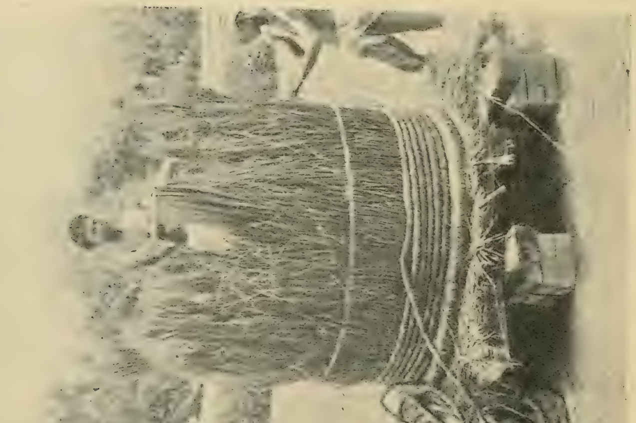


Fig. 1.—A *Morai* in process of building.

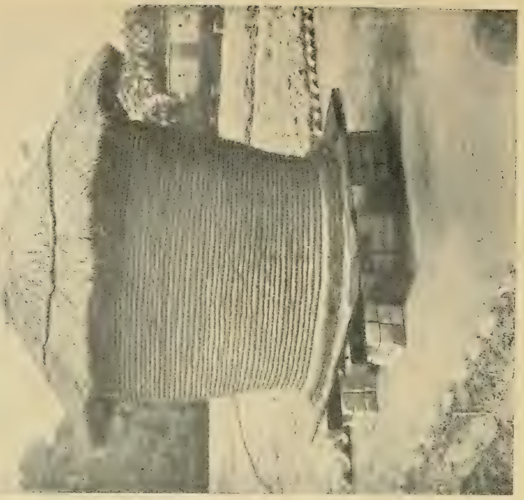


Fig. 2.—A completed *Morai*.

rope can be made out of the straw. Attempts were made to prepare ropes with Bihar straw but without success. Plate 114, fig. 1, is a diagrammatic section through the *Pura*. The hollow space inside is occupied by the grain and there is a thick lining of straw between the grain and the covering of ropes.

Unhusked paddy grains are known to keep well in *Puras* for years. Husked rice is, however, known to be attacked by the Rice Weevil (*Calandra oryzæ*) if kept for two or three years. Much depends on the make of the *Pura* and ability of the insects to penetrate into it.

There is also a method of preserving paddy seeds inside straw bundles. Two such bundles are seen lying on the ground in front of Plate 118, fig. 2. The seeds are placed in loose straw which is then rolled up into a large bale which is secured and made tight by means of ropes passed round it. In Bihar these bundles are known as *Puras*. They are either kept indoors or in the court yard where they are covered with earth. Sometimes several such *puras* are kept outside on a sort of a platform similarly covered with earth, the covering of earth being intended to protect the seeds from rain. Mr. Deshpande says a similar method is followed in the Konkan where the bundles are known as *Mudhas*. About a maund or at the most two maunds of seeds can be preserved in one bundle.

Cavities in walls. In some places for storing small quantities of grain hollow cavities are kept in walls of houses.

Store House : Hamar, Gola, Kotha, Kothi. For storing grains in bulk outdoor methods are adopted. In many places regular store-houses are built with solid walls all round and small doors like trap-doors high up in the wall near the roof. In order to keep the grain as much above the ground as possible sometimes the store-house is built with two storeys, the room or rooms in the first floor being used for storage and the space in the ground floor for other purposes. In such houses no other receptacle is used and the grain is poured into the room through the small door. Rarely such houses are built with wooden walls. These houses, built specially for storage purposes, are variously known as *hamars, golas, kothas, kothis*, etc.

Morai (Plate 116) is a feature of Western Bengal as far as the writers know, being used practically wholly for storing paddy grains in bulk out of doors.

Plate 116 shows the building of the small *morai* which was used for storing wheat at Pusa. It is built practically on the same principle as the straw *pura* described above (Plate 114) with ropes of straw. A large *morai* intended for keeping a large quantity, say several hundred maunds, of grain, is usually built on a solid platform either of earth or masonry, instead of on planks as shown in the figure. On the platform first of all a thick layer of straw is spread, on which the grain is poured and the building commenced. The lowest rope is very thick and made in the form of a ring and distinct from the upper ropes. It helps the straw intended for lining to stand. The grain is poured in and the rope taken round and round. At the top the grain stands in the form of a conical heap and on the top of it there is the thatch which is thick and proof against rain. Plate 116, fig. 2, shows the *morai* after it is complete and Plate 117, fig. 1, shows a diagrammatic vertical section of it.

About 20 to 500 maunds of grain can be stored in each *morai*. Provided the materials are ready it can be built up and completed in the course of a single day by two or three men. In it the cultivator has devised a very cheap, efficient and convenient method of storing paddy. The ropes last for about 7 or 8 years with a little care, even when used frequently. If, however, the *morai* is built and left unopened they are known to last for more than ten years. Paddy grains are known to keep in it perfectly safe from insects.

The *morai* (Plate 116) built at Pusa was about 4½ feet in diameter at the base and about 5 feet high. It accommodated 60 maunds of wheat.

Bakhari.—In Bihar the outdoor granaries take the forms shown in Plates 118-121. These are called *bakharis.* All are built on a platform somewhat raised from the ground in order to avoid damp. The walls of the round *bakharis* (Plate 119, fig. 2) are usually made of the stems of *Saccharum fuscum,* locally known as *Ikri,* and plastered with mud. Plate 119, fig. 1 shows a larger *bakhari* under construction. It has four chambers with a door for each. The walls are of wattled bamboo which will be plastered with mud. On the right-hand side of Plate 121, fig. 1, part of such a *bakhari* in the finished condition is seen. On the left side of this figure there is a *bakhari* with masonry walls, with open arches below for prevention of damp and with three chambers as is evident from the three doors. Wheat, barley, maize, peas, etc., are stored in the *bakharis* with plenty of *bhusa* (usually broken wheat straw, chaff, etc.) all around the grain as shown somewhat diagrammatically in Plate 117, fig. 2. Sometimes gunny bags filled with grain are similarly kept in the midst of *bhusa.* The *bhusa* is well pressed to make it as impervious to insects as possible. In the case of wheat, barley, and maize, which are very liable to be damaged by insects, some people take very great care for storage. The *bakhari* is filled with *bhusa* which is very well pressed down. Then a hole or cavity is scooped out in this *bhusa.* Grain is poured into this cavity and covered with a layer of *bhusa* on the top. Wheat is said to remain immune in this manner for two or three years. On the other hand it has been observed to be

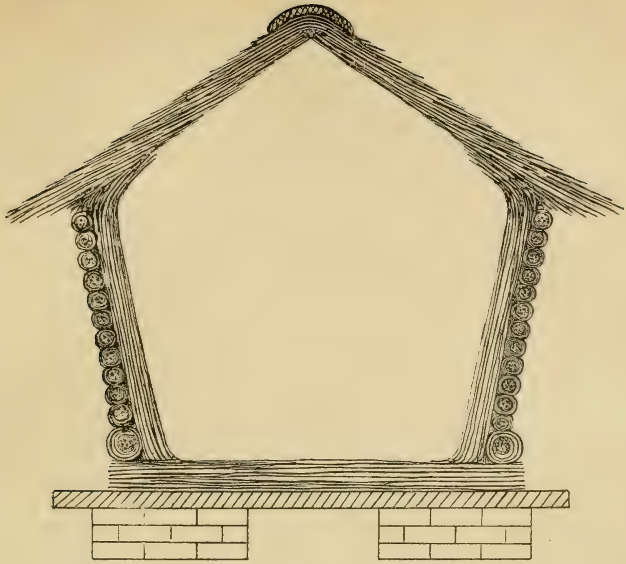


Fig. 1.—Section through a *Morai.*

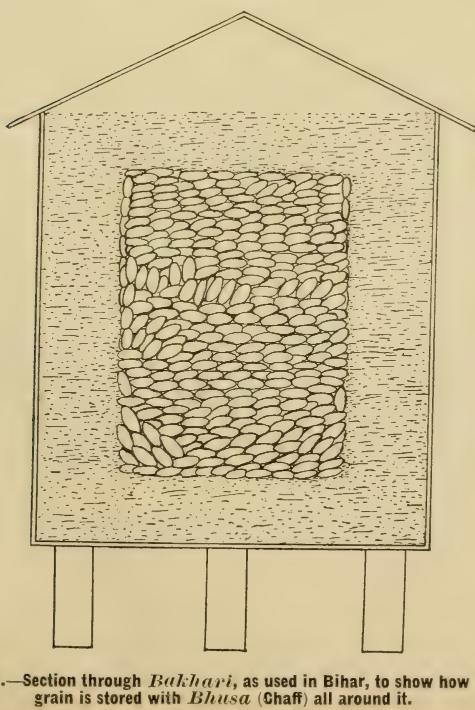


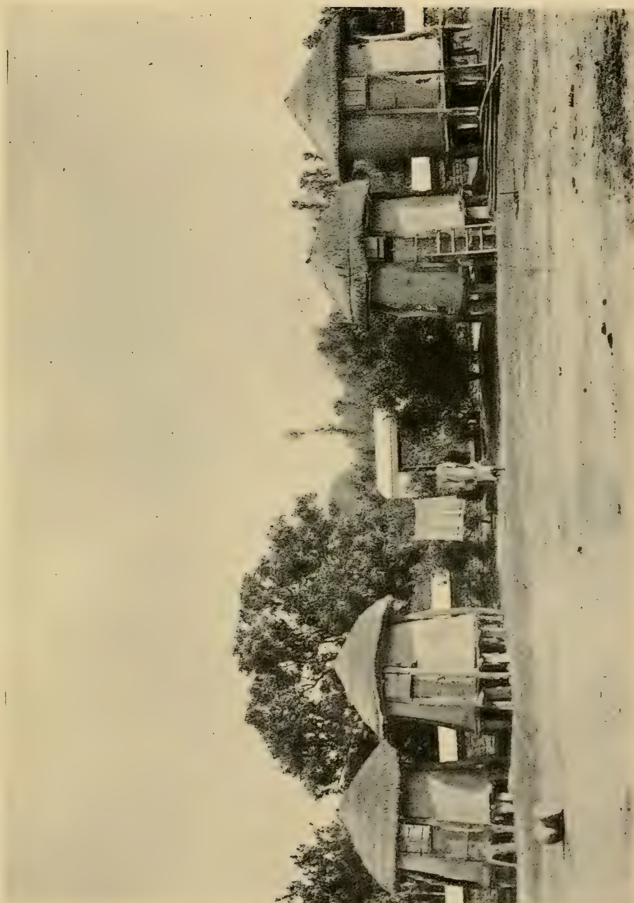
Fig. 2.—Section through *Bakhari*, as used in Bihar, to show how the grain is stored with *Bhusa* (Chaff) all around it.

Fig. 1.—Showing diagrammatically by dots where grain is affected when stored in a *Morai* (left) or *Pura* (right).

Fig. 2.—Two *Bakharis* for storage of grain. Two *puras* of paddy seeds are seen lying on the ground between the *Bakharis*.

Fig. 1.—A *Bakhari* under construction and almost completed. The walls, of bamboo wattling, have not yet been plastered with mud.

Fig. 2.—Two *Bakharis* of a type used in Bihar for storage of grain.



A group of four *Bakharis* (or *Beris*) of the type used in Bihar for the storage of grain.

Fig. 1.—A *Bakhari* with masonry walls. On the right hand is also seen part of another *Bakhari* with walls of bamboo wattling plastered over with mud.

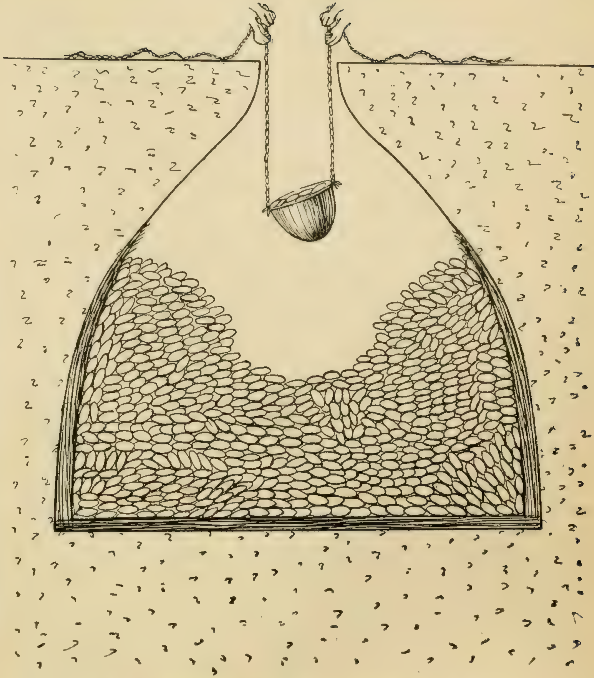


Fig. 2.—Removing grain from a storage-pit (*Khatti*).

attacked by the Rice Weevil (*Calandra oryzæ*) in the course of a year. All depends on the accessibility of the insects into the grain.

On this principle a masonry store-house has been built in the Cawnpur Agricultural Experimental Station especially to preserve the seed for the next season. Bags filled with wheat are piled up to the ceiling. Care is taken to have a thick layer of *bhusa* all round the bags on the floor and against the walls and the ceiling. The door is also similarly closed. But grains are said to be affected by weevils in this store, especially those near the door, through which apparently the insects find access.

Bokhar. From Bihar as we proceed to regions of decreased rainfall of the United Provinces of Agra and Oudh, the precautions against damp in the preparation of store-houses are dispensed with. In some places in the Benares Division ordinary dwelling houses of the cultivators are converted into what they call *Bokhars* in which they store all kinds of grain, such as wheat, maize, pulses, etc. The grain is poured on the floor. Against the walls there is first of all a layer of linseed sticks and then a layer of *bhusa*. The doors and windows also are similarly stopped and the entire room may be filled with grain. In some places the *bokhar* is a room partly underground and partly above ground.

Khatti. Where the level of the subsoil water is low the *bokhar* has been replaced by underground pits known as *Khattis*. Plate 121, fig. 2, shows a diagrammatic section through a *khatti*. It is a hollow pit underground with a narrow round opening at the top about 2½ feet in diameter, through which a man can pass. A layer of leaves and *bhusa* is placed at the bottom before filling in the grains and against the walls a layer of straw is put. When the *khatti* is full the mouth is closed and plastered with earth level with the surface of the ground. In order to empty a *khatti* a man goes in to fill a basket which two men pull up by means of two thick ropes tied at opposite ends on the rim of the basket, as shown in the diagram. Wheat, barley, peas, gram and maize are usually preserved in *khattis* and probably wheat on the largest scale.

Much of the following details regarding *khattis* was supplied by Babu Bhulimal Narayan Das, Merchant, sometime Vice-Chairman of the Ghaziabad Municipal Board, and owner of 20 *khattis*, to one of the writers (C. C. G.), who paid a visit to Ghaziabad in March 1918 to see methods of storage on the *khatti* system. At this place there are 1,200 *khattis*. Their capacity is about 600 to 750 maunds. They are 15 feet to 16½ feet deep and their diameter at the bottom is of the same measurement. The methods of digging *khattis* differ from place to place. At Ghaziabad the diameter of the *khatti* at any point is equal to the depth of this point from the ground-level. In some places, for instance at

Hapur, the diameter at any point is one and a half times or even twice the depth of the point from the ground level. The capacity of the *khatti* is regulated by the level of the subsoil water. At Hapur, where there are 2,000 *khattis*, the capacity is said to be 700 to 800 maunds; at Secunderabad it is 300 to 400 maunds; at Deoband and Dancor 200 maunds; at Meerut and Shamli 300 maunds and at Etawa 1,500 to 2,000 maunds. A *khatti* of a given cubical capacity can accommodate different quantities of different articles. Thus, one capable of holding 600 maunds of wheat, gram or peas can accommodate only 500 maunds of barley.

Storage in *khattis* is extremely cheap. To make one of a capacity of 600 to 750 maunds of wheat at Ghaziabad costs only about Rs. 20 and it lasts for years. Babu Bhulimal has ten which are more than fifty years old. At Ghaziabad there are *khattis* which are more than a hundred years old. They are a source of steady income to their owners who do not as a rule use them themselves but hire out to merchants. At Ghaziabad the hire of the *khattis* for the term (April to April) is Rs. 15, 20 or 25. In some places the hire is fixed according to the capacity. To a merchant who takes, say, a *khatti* for 600 maunds of wheat for Rs. 20 the storage cost works up to a little more than one anna per maund for the whole year.

The greatest defect of the *khatti* system of storage is that the grains absorb moisture and ferment to a small extent, those at the bottom and near the walls being spoilt, turning black and becoming unfit for human consumption. When the grain is taken out it feels moist and hot and possesses a distinct fermentation smell which, however, disappears to a very great extent when the grain becomes dry. For this reason *khatti* grain (*i.e.*, grain preserved in *khattis*) always sells cheaper than *kotha* or *kothi* grains (*i.e.*, that preserved in above-ground storehouses). On the 7th March 1918 at Ghaziabad *khatti* grain was selling at 11 seers per rupee, while *kotha* grain was selling at $10\frac{1}{2}$ seers. The rate for *khatti* wheat was Rs. 4-14-0 per maund and the spoilt wheat from the same *khatti* was selling at Rs. $1\frac{1}{2}$ per maund if moist (*i.e.*, freshly taken out) or Rs. 2 per maund if dry. The spoilt grain is fed to cattle. On account of the absorption of moisture there is always an increase in the weight of the stored grain at Ghaziabad, usually about one maund in every 100 maunds stored. This increase of course varies from place to place or even from *khatti* to *khatti*.

The efficiency of the *khatti* as a storage receptacle depends on (*a*) the kind of soil in which it happens to be dug, (*b*) its age, and (*c*) its size. A high ground is preferred for the *khatti* and one in such ground is always better than one in low ground. A man pointed to a *khatti* in front of his shop in which 10 maunds of grain were spoilt in the first year and, if kept on for the second year, as much as 30 maunds were spoilt, while one equally old behind his shop was reported to spoil only 3 or 4 maunds even if the grain was continuously kept for two years. With age the *khatti* seems to become drier and therefore less grains are spoilt in them but they were reported to be more liable to attack by insects. In some of the *khattis* which were about 100 years old it was said that there was hardly any increase in weight due to moisture, but on the other hand the grain at the top up to a depth of about two to three feet was damaged by insects, leading to a decrease in weight of about 2 or 3 maunds. The insects were reported to work always from the top downwards. In large *khattis* holding, say, 1,500 or 2,000 maunds, on account of the larger bulk of the grain the damage is comparatively small. But, as it is easier to get customers for small quantities, the ordinary dealers prefer *khattis* of smaller capacity. The exporters prefer larger ones. Of course, the longer the grain is kept, the greater is the damage, more in the second year and still more in the third year.

The *khattis* may be said in some respects to occupy the same position as the Country Elevators do in the United States of America and Canada. Sir Thomas Price, in his " Report on the Storage and Handling of Grain in Europe, United States of America and Canada," says :—" The Country Elevators are the buildings [capacity 50 to 20,000 tons and built of wood ; p. 21] studded all over the country adjacent to Railway Stations and usually on Railway ground, to which grain is brought by the farmers to be sold or stored until ordered to be sent forward by rail to a flour mill or to a Terminal Elevator, there to be either further stored till disposed of or shipped by sea, lake, canal, river, railway or other means of communication " (page 6). Also the elevator " is the ware-house for grain, designated by a registered title, inspected and licensed by the State, and under the more particular supervision of the City Board of Trade. Grain must be weighed and classified before going into its bins and once there it is as easy to deal in it in the market as it is to transfer money in a bank from one account to another. The ware-house receipt for it is negotiable ; to all intents and purposes it is the grain itself " (p. 39). The *khattis* are not as systematized as described here. They are situated in large grain centres to which the farmers bring their produce usually for sale. The dealers store the grain in them and the grain stored in them may pass through several hands before being actually emptied out and disposed of. Necessarily some rules and conventions have arisen for the working of the *khattis*. Thus at Ghaziabad there is a special class of men called *Chamars* who do the filling and emptying. The filling charges are 30 *seers* of grain which is taken out of what is stored. The emptying charges are five *maunds* of grain taken out of what is emptied out. These are usually met from the increase in weight and the dealer gets the equivalent of the weight stored. He has to meet them even if there be not so much increase in weight or a shortage.

Questioned about the death of workers in the *khattis* due to the accumulation of poisonous gases, Babu Bhulimal said that in his opinion such accidents happened when the grain was spoilt by water too much and when they were left half-emptied over night. In his experience three deaths occurred in 1910 in a *khatti* which was left about half-full to be emptied wholly the next day. At night three *Chamars* came to steal the grain. They went in one after another and died. Such cases occurred very rarely.

The grain in the *khattis*, at least wheat, does not seem to lose its germinating power entirely. A small quantity of wheat taken out of a *khatti* at Ghaziabad in March was brought to Pusa and 59 per cent. of it germinated when tested in April.

Banda. As described by a literate cultivator of Jabbalpur, this is a modification of the *khatti*, as illustrated in Plate 122, fig. 1. It is of the same diameter (about 10 feet) throughout and about 15 feet deep. It is filled and the grain heaped up at the top and then covered with earth. The convex covering does not allow rain water to get in. *Banda's* are made in high grounds and sometimes with masonry walls and bottom. In these too the grain absorbs moisture and acquires a slight smell due to fermentation.

Pev of the Desh or Up-Ghat Districts (Sholapur, Satara, Poona, Ahmednagar, etc.) of the Deccan is, according to Mr. Deshpande, a huge underground godown usually meant for storing very large quantities (hundreds of tons) of *juar* (*Andropogon Sorghum*) and *bajra* (*Pennisetum typhoideum*) grains. It has small square or circular openings at the top which are at some depth below the ground-level. After filling the godown and closing the openings the earth is filled up and a permanent mark is kept to indicate the position of the openings.

Targhars, or underground cellars of this place, are of the same nature as the underground godowns, except that they are the underground storey of a superstructure and possess vertical doors. The grain in both the above is said to absorb moisture and acquire a slight smell due to fermentation.

Kotha or *Kothi* (literally, a house). The *khatti* or pit system is said to be not prevalent in the Punjab. There the grain when required to

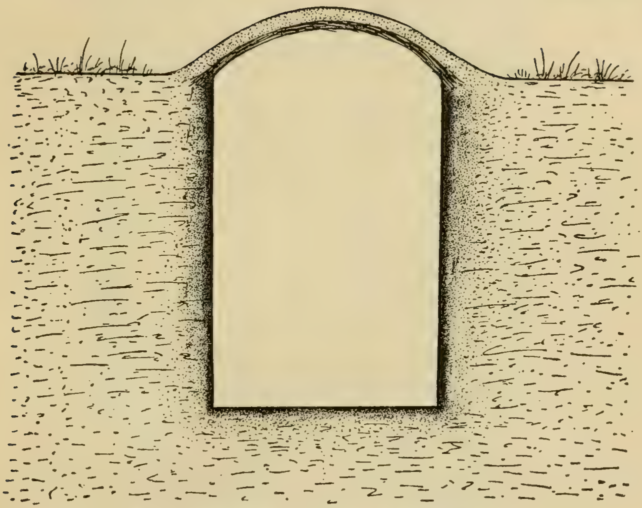


Fig. 1.—Storage-pit (*Banda*) of Jabbalpur.

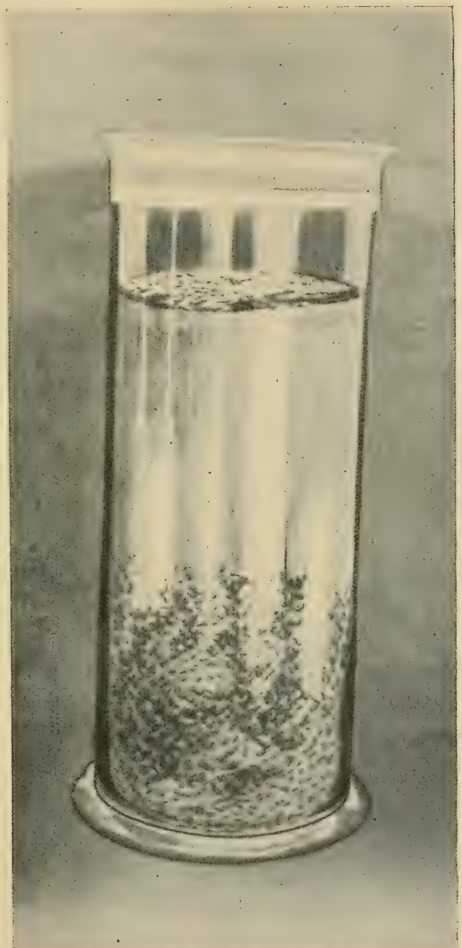


Fig. 2.—Wheat grains in stoppered jar under about seven inches of sand, showing how insect pests leave the grain and come to the top of the sand.

be stored in very large quantities is poured on the floor of ordinary houses or rooms which may be filled to a great depth, the doors and windows being stopped accordingly. Sand is said to be spread over the grain sometimes when the grain thus stored is said to be *Khapra* grain. More frequently *bhusa* is said to be used for this purpose. The upper layers of the grain are always spoilt by insects. Rohtak is said to be the place where the best *kotha* system is practised, and, according to the agent of Messrs. Ralli Brothers at Delhi, with whom one of the writers (C. C. G.) discussed the question in March 1918, the best wheat was available from Rohtak preserved according to the *khapra* system.

Experiments with wheat.

Experiments I, II and III.

The preliminary experiments, *viz.*, I, II and III, were carried on with a kind of hard wheat obtained from the local market. The wheat was cleaned before use but not fumigated. It was apparently infected while lying in the dealer's godown.

Experiment I was carried on with stoppered jars (Plate 111, fig. 3), Experiment II with small earthen vessels with earthen covers (fig. 3) and Experiment III with small gunny bags made by cutting pieces out of ordinary ones. Two pounds of wheat was used in all cases. The oils were rubbed over the grains with the hand. Camphor cakes (50 grains), garlic bulbs, naphthaline balls and *hing* (asafœtida) were placed in the midst of the grains. Lime, *senwar* leaves (*Vitex negundo*), tobacco dust, powdered sulphur and powdered *dacra* stem (a plant said to have insecticidal properties), were mixed with the grains. Sand, ashes and road-dust were placed on the top of the grains. In the gunny bags sand and ashes were used in large quantities and mixed with the grains. Experiment I was started between 1st and 18th June 1915 and the final examination was made on 7th March 1916. Experiments II and III were started on 10th June 1915 and final examinations of the former were made on 10th March 1916 and of the latter on the 23rd March 1916. For the convenience of comparison the results of the three experiments are given together in the form of the weights left on the date of the final examination after sieving out the dirt and insects as much as possible. Fractions of ounces below a half are omitted, half ounces and more being taken as one ounce. In the places left blank nothing was used. In the remarks following this statement some details regarding the various treatments are given :—

Treatment	Stoppered Jars	Earthen Vessels	Gunny Bags	Germination per cent. of Expt. I in March 1916
	Expt. I	Expt. II	Expt. III	
	lb. oz.	lb. oz.	lb. oz.	
Castor oil	1 14	1 4	1 2	25
Mustard oil	1 14	1 5	1 2	67
Sesamum oil . . .	1 15	1 3	1 3	83
Coconut oil	2 0	1 2	1 1	64
Mohwa oil	2 0	1 3	1 2	77
Groundnut oil . . .	1 15	1 0	1 1	84
Linseed oil	(spoilt)	1 1	1 2	...
Camphor	2 0	1 2	1 2	88
Hing	(spoilt)	1 5	1 2	...
Garlic	1 13	1 2	1 0	...
Lime	1 13	1 4	1 5	...
Sand	1 13	1 11	1 5	...
Senwar leaves . . .	1 13	1 3	0 15	...
Tobacco dust . . .	(spoilt)	0 12	0 14	...
Sulphur	1 13	0 15	1 0	4
Naphthaline . . .	...	...	1 8	...
Ashes	(spoilt)	1 4	1 2	...
Dacra stem	(spoilt)	...	...	...
Road-dust	...	1 5	...	...
Check	1 14	1 3	1 3	1

The effect of the storage receptacles on grains treated in the same manner and kept side by side in the same godown is noteworthy in these three experiments. Gunny bags and earthen pots allowed the oils to dry and camphor, etc., to evaporate.

In Experiment I camphor kept the grains in the best and unaffected condition (Naphthaline would have done the same but it was not used as its effects were already known). Next came coconut oil and then *Mohwa* oil in which the weevils apparently could not breed and were found dead. Next came sesamum oil in which a very slight damage had been done. More or less damage was done in all the others and the affected grains, except those with sulphur, were fermenting and emitted a foul smell, the degree of fermentation varying directly with the severity of damage. In those marked "spoilt" in Experiment I the grains were black and rotting. Although the grains were damaged more in the other two experiments none of them fermented or emitted any foul smell. This is a peculiarity of attack by weevils (*Calandra oryzæ*) in closed receptacles. They generate moisture and heat which cause the grains to ferment and rot. In some parts of the country people feel the sides of the storage vessels and, if they feel hot, it is taken as a sure indication of bad weevil attack. *Rhizopertha dominica* has not been observed to behave in this manner even when causing much severer damage in similar receptacles.

As regards the look of the grain, camphor came first and next to it sulphur. The oils made the grains very unsightly.

Lime and ashes seemed to have an injurious effect on the grains, apart from damage by weevils.

In Experiment I the wheat was placed on 10th June 1915. By the 15th June many weevils were observed to have come up to the top of the sand. They could not go down through the sand and were dying (Plate 122, fig. 2). On 7th March 1916 more than 1,800 weevils were dead on the top of the sand. The wheat, however, was not unaffected and its lower part fermented.

All the samples in Experiments II and III were damaged, but that under sand in the earthen pot (Experiment II) kept the best. The sand had settled down, exposing much of the grains at the top, and thus enabling the weevils to infect them.

The damage in these three experiments was due to *Calandra oryzæ*. There were many *Tenebroides mauritanicus* grubs in the sample treated with groundnut oil in Experiment II and in all the samples of Experiment III.

The germination tests were made in all the experiments on sand placed in glass dishes to the depth of about an inch or so and kept wet. This gave better and more uniform results than wet blotting-paper.

Experiment IV.

One pound of wheat, Pusa No. 6, was stored in stoppered glass jars (Plate 111, fig. 3) on 20th May 1916, mixed with the following things, and 20 *Calandra oryzæ* weevils put in.

The first examination was made on the 27th November 1916 when the *juar* seeds, etc., were picked out and the wheat cleaned and stored without these seeds, etc. Blown salt was prepared by thoroughly baking common salt over a fire. *Murhi* is fried rice.

Stored with	Weight on 27th November 1916	Weight on 22nd March 1917	REMARKS
	lb. oz.	lb. oz.	
Juar seed	0 15¾	0 15	
Blown salt	0 14¼	0 13½	
Murhi	0 14¾	0 14	
Nim leaves	0 14½	0 13½	
(Check)	0 14½	0 13¾	

All were damaged by *Rhizopertha dominica.* The salt moistened the grains and caused them to ferment and rot. *Juar* seeds and *Murhi* also were bored.

Experiment V.

Four pounds of Pusa No. 6 wheat were stored in earthen vessels mixed with the following on 20th May 1916. Two examinations were made and the weights taken after sieving out the dirt and insects as far as possible, but with the *juar* seeds, etc., mixed with the grains.

Serial No.	Stored with	Weight on 26th November 1916	Weight on 14th March 1917	REMARKS
		lb. oz.	lb. oz.	
1	*Juar* seeds, 1 lb.	5 5½	2 8	Cover of vessels plastered up with mud.
2	Blown salt	3 13	1 12	Ditto.
3	*Murhi*	3 10	1 11	Ditto.
4	*Nim* leaves	2 9	1 0	Ditto.
5	(Check)	4 4½	1 15	
6	Fumigated with CS_2 for 48 hours.	3 7	1 8	Cover of vessels kept loose.
7	Blown salt	3 11½	1 8	Ditto.

On 26th November 1916 the damage in the samples 2, 3 and 4 was due to *Rhizopertha dominica*, and in the others to *Calandra oryzæ*. On the 14th March 1917 *Rhizopertha* was helped by *Calandra* in samples 2, 3 and 4 and in the others *Calandra* did the work. There were some *Tribolium castaneum*, *Lœmophlœus pusillus* and *Tenebroides mauritanicus* grubs and beetles in all. The salt moistened the grains and caused them to rot.

Experiment VI.

Four pounds of wheat, Pusa No. 6, were stored on 20th May 1916 in gunny bags mixed with the following and were examined on two occasions when weights were taken after sieving out the dirt and insects but not the *juar* seeds, etc.

Mixed with	Weight on 26th November 1916	Weight on 14th March 1917	REMARKS
	lb. oz.	lb. oz.	
Juar seeds, ½ lb.	2 14¾	1 6	
Blown salt, 2 oz.	2 7	1 1	
Murhi	2 8	1 2	
Nim leaves	2 5	1 0	
Fumigated with CS_2 for 48 hours	2 9¾	1 2	
(Check)	2 7	1 1	
(Check)	2 7	1 1	

All damaged by *Calandra oryzæ*. There were some *Tribolium castaneum* and *Tenebroides mauritanicus* grubs and beetles in all.

On the 26th November 1916 in each of these bags there were about 70 to 130 *Tenebroides mauritanicus* grubs. These grubs would not attain the adult stage until the next hot weather. The grubs were feeding on grains and also on the dust produced by *Calandra oryzæ*. It is apparent that *Tenebroides mauritanicus* can be of hardly any help against the other store pests as by the time the beetles (which to some extent prey upon adult *Calandra oryzæ*) would appear there would be nothing left of the grains.

Experiment VII.

A.—Twenty-five pounds of wheat were stored between 14th and 15th May 1916 in earthen vessels with earthen covers (Plate 111, fig. 3) and examined on two occasions and weighed after sieving out the dirt and insects as much as possible, but with eaten grains or corroded shells.

x 2

Serial No.	Cover plastered up with mud or loose.	Treatment	11th-14th December 1916		6th-7th March 1917		Germination per cent.		Remarks
			Weight	Agents of damage	Weight	Agents of damage	Dec. 1916	April 1917, Mar. 1917	
			lb. oz.		lb. oz.				
1	Plastered	Castor oil	20 8	*C. oryzæ*	17 3	*C. oryzæ*	...	...	Vessel found cracked 11th December 1916.
2	Do.	Mustard oil	20 10	Do.	18 7	Do.	...	...	Vessel broke and changed 20th July 1916.
3	Do.	Sesamum oil	20 0	Do.	17 9	Do.	...	...	Do.
4	Do.	Coconut oil	21 0	Do.	19 0	Do.	...	...	Do.
5	Do.	Mohwa oil	25 14	Quite free	26 0	Free	...	1	
6	Do.	Groundnut oil	26 6	Do.	26 5	A few *C. oryzæ*	...	...	Vessel broke and changed 15th July 1916.
7	Do.	Camphor 75 grs.	26 6	Do.	26 8	Free	...	33	
8	Do.	Naphthaline (1 oz.) balls.	25 8	*C. oryzæ*	24 0	*C. oryzæ*	...	11	Vessel broke and changed 24th July 1916.
9	Do.	CS_2	25 14	Quite free	26 1	Free	20	19	

10	Do.	Blown salt	26 14	Do.	26 14	Do.	...	27	No trace of salt.
11	Do.	Sunned	26 0	*C. oryzæ*	25 9	A few *C. oryzæ*	...	41	Vessel broke and changed 2nd July 1916.
12	Do.	(Check)	17 2	*Rhizopertha dominica.*	11 6	*C. oryzæ*	...	...	
13	Do.	(Check)	26 8	Quite free	26 4	Free	...	38	
14	Loose	Fine sand	26 2	Some *C. oryzæ* present.	24 8	*C. oryzæ*	42	4	Vessel broke and changed 2nd July 1916. Grains exposed at top 7th March 1917.
15	Do.	Coarse sand	23 10	*C. oryzæ*	21 4	Do.	19	6	
16	Do.	Dust	8 6	*Rhizopertha dominica*	7 9	*C. oryzæ, R. dominica.*	...	...	
17	Do.	Ashes	19 0	*R. dominica, C. oryzæ.*	17 4	Do.	...	...	Ashes spoilt the grains.
18	Do.	Cotton wool	19 12	*C. oryzæ*	17 15	*C. oryzæ*	...	...	
19	Do.	(Check)	19 8	Do.	16 9	Do.	...	...	
20	Do.	(Check)	20 0	Do.	16 7	Do.	...	...	
21	Plastered	(Check)	3 8	*R. dominica*	...	...	...	...	Removed 14th December 1916, weight after winnowing off the shells.

The grains were smeared with the oils. Camphor and naphthaline were placed inside the grain. Sand, etc., was placed on the top of the grain. The mouth of the vessel was plugged with cotton wool. Carbon bisulphide was placed inside the vessel and the cover plastered up at once. In No. 11 the grains were sunned for three days, then placed while hot in the vessel which was plastered up.

The weights give an idea of the damage. In the germination columns no test was made for samples left blank.

B.—In the first week of May 1916 220 pounds wheat, Pusa No. 6, obtained from the Pusa Farm, were stored in 10 earthen vessels. In the midst of the grain in each vessel ¼ oz. of camphor cakes wrapped in a piece of muslin was placed. The mouth of five of the vessels was plugged with cotton wool which formed a compressed padding about 1 to 1½ inches thick over which a thick plaster, 1½ to 2 inches of mud, was placed. The mud dried and made a hard solid cover. The mouth of the other five vessels was covered with the ordinary earthenware cover (Plate 111, fig. 3), which was very carefully plastered down with mud.

180 lb. of the same wheat were stored in five kerosine tins similarly with camphor cakes, the openings of the tins being plugged with cotton wool and plastered with mud.

The kerosine tins were opened in July-August and the grains in them were observed to be affected by *Rhizopertha dominica* in company with *Tribolium casteneum.* The last tin, opened on the 7th August 1916, had the grain in the top four inches badly damaged by the above insects, the grains below being safe.

The ten earthen vessels were opened on the 8th September 1916. The entire grain was spoilt by the same two insects. There were millions of them and their grubs and *pupæ.* Much of the grain was reduced to a flour-like dust and the whole mass had a very disagreeable nauseating smell due to *Tribolium.* The dust being sieved out weighed more than 40 lb. and the grains about 170 lb. Most of the grains were bored and had insects in them and it was estimated that the *atta* from them would not be more than about one-third this weight. The *atta*, however, would be quite unusable.

The insects bored through the mud plasters.

C.—Pusa No. 6 wheat was harvested and stored in April 1915 in kerosine tins in a private house with camphor cakes, the small holes of the tins being tightly plugged with cloth.

A tin was opened in September 1917. The seeds were free and the percentage of germination obtained in October 1917 was 95.

Experiment VIII.

25 lb. wheat, Black-awn, were put in each of five earthen vessels with 20 live *Calandra oryzæ* weevils on the 15th May 1916 and the covers plastered up with mud.

Serial No.	On 6th December 1916		Agents of damage	Remarks.
	Weight after sieving out dust	Weight after winnowing off chaff		
	lb. oz.	lb. oz.		
1	17 6	...	*C. oryzæ* with some *R. dominica*	
2	18 0	...	Ditto.	
3	6 2	3 8	*R. dominica* with a few *C. oryzæ* and *T. castaneum.*	
4	7 2	4 8	Ditto.	
5	22 0	...	*C. oryzæ* with some *R. dominica*	Vessel broke and changed 10th August 1916.

On 6th December 1916 (3) and (4) were rejected and 24 naphthaline balls (2½ oz.) put in (1), 9 camphor cakes (1 oz.) put in (2), and half an ounce carbon bisulphide put in (5), all being plastered up with mud again.

On 14th December 1916 all insects were living in (1) and (2); some were dead and most living in (5). On this date ½ oz. more of CS_2 was put in (5) and all the three plastered up and left.

On 7th March 1917 all were further damaged by *Calandra oryzæ*, a few *Læmophlœus pusillus* being present. The weights after sieving out the dust were as follows on this date.

In—

(1) 15 lb. 3 oz.

(2) 15 lb. 10 oz.

(5) 19 lb. 4 oz.

Experiment IX.

On 13th May 1916, 160 lb. wheat were placed in each gunny bag and the grain treated as follows. The results of examination and weights after sieving out the dust are given in the same statement.

Serial No.	Variety of wheat	Treatment	Weight on 15th December 1916	Weight on 12th-13th March 1917	REMARKS
			lbs. oz.	lbs. oz.	
1	Pusa No. 6 .	Castor oil, 4 lb. by weight.	160 8	136 6	
2	Do. .	Mustard oil, 4 lb. .	153 14	136 10	
3	Do. .	Sesamum oil, 4 lb. .	153 14	128 0	
4	Do. .	Coconut oil, 3 lb. . .	156 4	122 0	
5	Black-awn .	*Mohwa* oil, 2 lb. . .	160 6	142 12	
6	Pusa No 6 .	Groundnut oil, 4 lb. .	151 0	132 10	
7	Do. .	Camphor, 300 grains .	140 10	119 14	Grain attacked and dust thrown out 21st June 1916.
8	Do. .	Naphthaline, ½ lb. .	137 6	114 0	Do.
9	Do. .	(Check) . . .	146 10	118 0	Do.
10	Do. .	(Check) . . .	133 14	112 0	Do.

The grain was smeared with the oils. The camphor cakes and naphthaline balls were placed in two bundles in the midst of the grain near opposite ends of the bags.

The grain in the external layers was attacked first and the insects gradually proceeded inwards. By 15th December 1916 the camphor had evaporated wholly. The naphthaline balls remained till the end. Their smell did not apparently spread through the grains. The grains round the naphthaline balls and round the camphor as long as it lasted were not attacked. The oils retarded the attack.

The agents of damage were *Calandra oryzæ* and some *Lœmophlœus pusillus*. *Tribolium castaneum* and *Tenebroides mauritanicus* appeared in all the bags.

Experiment X.

To determine if possible the relative immunity of hard and soft wheats this experiment was undertaken. The results are not conclusive. Also a good series of soft and hard wheats was not available. In the samples used Black-awn was harder than the others.

A.—Pusa No. 4, 1 lb. in stoppered glass jar :—

15th May 1916 . .	20 live weevils put in.
6th July 1916 . .	Wt.=1 lb. 40 grains ; not affected. All the 20 weevils dead ; picked out.
4th December 1916 .	Not affected.
15th March 1917 . .	Wheat unaffected ; 20 weevils put in.
21st January 1918 .	837 weevils picked out.
7th November 1918 .	2,100 weevils picked out. Grains decomposed and emitting a bad smell, altogether unfit for use. Weight left after sieving and drying = 13½ oz.

In 10 months 15th March to 21st January the weevils multiplied 41 times and in about 20 months from 15th March 1917 to 7th November 1918 about 147 times.

B.—Pusa No. 6, 1 lb. in stoppered glass jar :—

15th May 1916 . .	20 live weevils put in.
6th July 1916 . .	Unaffected. All the 20 weevils picked out dead. Weight of grains=1 lb. 20 grains.
4th December 1916 .	Unaffected.
15th March 1917 . .	Unaffected ; 20 weevils put in.
22nd January 1918 .	1,389 weevils picked out. Benzine was applied to stupefy the weevils.
7th November 1918 .	28 weevils picked out. Weight after sieving, 14¾ oz. The grains in good condition except that they are bored. They are not decomposed and do not emit any smell. Can be used.

In about 10 months, from 15th March to 22nd January 1918, the weevils multiplied about 69 times.

C.—Pusa No. 12, 1 lb. in stoppered glass jar :—

15th May 1916 . .	20 live weevils put in.
6th July 1916 . .	19 dead weevils picked out, 4 live ones present, evidently 3 bred out from the grains. The 4 living ones left with the wheat. Weight of wheat left=1 lb. less 40 grains.
4th December 1916 .	The wheat is affected. 40 grains dust thrown out. 481 weevils picked out, of which 195 were dead.
15th March 1917 . .	Weight of wheat after sieving 15½ oz. 240 weevils picked out.
22nd January 1918 .	1,257 weevils picked out.
7th November 1918 .	Weight of wheat after sieving and partly drying 13½ oz. The grains decomposing and emitting a bad smell. Altogether unfit for use. To-day only 41 weevils found in it.

In about 7 months, from 15th May to 4th December 1916, the weevils multiplied about 24 times.

In 10 months, from 15th May 1916 to 15th March 1917, they multiplied about 36 times.

In 20 months, from 15th May 1916 to 22nd January 1918, they multiplied about 99 times.

D.—Pusa No. 106, 1 lb. in stoppered glass jar :—

15th May 1916	20 live weevils put in.
6th July 1916	Unaffected ; 20 dead weevils picked out.
4th December 1916	Unaffected.
15th March 1917	Unaffected ; 20 weevils put in.
22nd January 1918	484 weevils picked out. Benzine had been applied to stupefy the weevils.
8th November 1918	58 weevils picked out. Weight left=1 lb. Grains in good condition except that they are bored. They are not decomposed and do not emit any smell. Can be used.

In about 10 months, from 15th March 1917 to 22nd January 1918, the weevils multiplied about 24 times.

E.—Black-awn, 1 lb. in stoppered glass jar :—

15th May 1916	20 live weevils put in.
6th July 1916	Wheat unaffected, 19 dead weevils picked out and 1 not traceable.
4th December 1916	Unaffected.
15th March 1917	Unaffected ; 20 weevils put in.
22nd January 1918	Affected ; 984 weevils picked out.
7th November 1918	36 weevils picked out.
	Grains are in good condition except that they are bored. Not at all decomposed and do not emit any smell. Can be used. Weight after sieving 15¼ oz.
18th February 1919	No weevil found. The above pickings cleared them off and apparently there were none left to breed. Benzine had been applied at the time of the above pickings to stupefy the weevils.

In about 10 months, from 15th March 1917 to 22nd January 1918, the weevils multiplied about 49 times.

Experiment XI.

This experiment was undertaken to see if the grains, when artificially dried, were more liable to be attacked by insects.

A.—Pusa No. 6 :—

13th-14th May 1916	1 lb. dried down to 0° moisture. Weight reduced to 14 oz. 165 grains. 14 oz. kept in stoppered jar which is occasionally opened, thus allowing the grains to absorb moisture from the atmosphere.
15th May 1916	20 weevils put in.
6th July 1916	Unaffected ; all the 20 weevils picked out dead. Weight 14 oz. 100 grains. Grains spread out for 1 hour after which weight=14 oz. 200 grains.
15th March 1917	Unaffected ; 20 weevils put in.
21st January 1918	Unaffected ; 20 dead weevils picked out.
5th May 1918	Unaffected. Weight 14½ oz. Left spread out exposed till morning of 6th May 1918 when weight=15 oz.
	Put back in the stoppered jar with 40 weevils.
8th November 1918	Unaffected ; 37 weevils dead.
18th February 1919	Unaffected. All weevils dead. Weight 15 oz. The germinating power of the grains was lost.

B.—Black-awn :—

13th-14th May 1916 .	1 lb. dried to 0° moisture. Weight reduced to 14 oz. 171 grains; 14 oz. kept in stoppered jar, occasionally opened, thus allowing the grains to absorb moisture from atmosphere.
15th May 1916 . .	20 weevils put in.
6th July 1916 . .	Weight 14 oz. 160 grains. Unaffected. All the weevils dead. Wheat spread out for 1 hour after which weight=14 oz. 200 grains.
15th March 1917 . .	Wheat unaffected. 20 weevils put in.
22nd January 1918 .	Wheat unaffected, the 20 weevils dead.
5th May 1918 . .	Unaffected. Weight 15 oz. less 170 grains. Left exposed till morning of 6th May 1918 when weight =15 oz. Put back in stoppered jar with 40 weevils.
7th November 1918 .	Unaffected, 38 weevils picked out dead.
18th February 1919 .	Unaffected. All weevils dead, weight 15¼ oz. The germinating power of the grains was lost.

C.—Pusa No. 6 ; 1 lb. 1 oz. dried in the sun for full three days. Weight reduced to about 1 lb. ⅛ oz. :—

12th-14th May 1916 .	1 lb. of this kept in stoppered jar which is opened occasionally to allow the grains to absorb moisture from the atmosphere.
15th May 1916 . .	20 weevils put in.
6th July 1916 . .	Weight=1 lb. 155 grains. Wheat unaffected ; the 20 weevils dead. The wheat exposed to ordinary atmosphere as long as it took to pick out the weevils and then put back in the stoppered jar.
15th March 1917 . .	Unaffected ; 20 weevils put in.
21st January 1918 .	Unaffected ; 20 weevils dead.
6th May 1918 . .	Unaffected ; 40 weevils put in.
7th November 1918 .	Weight 1 lb. ¼ oz. ; slightly damaged ; 414 weevils picked out.

92 per cent. of the grains germinated when tested in December 1916.

D.—Black-awn :—

12-14th May 1916 .	1 lb. 1 oz. dried in the sun for full three days. Weight reduced to about 1 lb. ⅛ oz. One pound of this kept in stoppered jar which is opened occasionally to allow the grains to absorb moisture from atmosphere.
15th May 1916 . .	20 weevils put in.
6th July 1916 . .	Unaffected. Weight=1 lb. 115 grains. All the 20 weevils dead. The wheat was spread out to pick the weevils and remained exposed as long as it took to pick out the weevils.
15th March 1917 . .	Unaffected ; 20 weevils put in.
22nd January 1918 .	Unaffected ; 20 weevils dead.
6th May 1918 . .	Unaffected ; 40 weevils put in.
7th November 1918 .	Unaffected ; 38 weevils dead. Weight=1 lb. ¼ oz.
18th February 1919 .	Unaffected.

Cent. per cent. seeds germinated when tested in December 1916.

Experiment XII.

To see if grains sealed with carbon bisulphide lose their germinating power two varieties of wheat, *viz.*, Pusa No. 6 and Black-awn, were used and kept in stoppered glass jars which were further sealed with paraffin wax.

20th May 1916 . .	1. Black-awn, 1 lb. sealed with CS_2.
	2. Pusa No. 6, 1 lb. sealed with CS_2.
	3. Black-awn, 1 lb. sealed without CS_2.
	4. Pusa No. 6, 1 lb. sealed without CS_2.
28th November 1916 .	All the jars opened and the grains aired and sunned. There was profuse smell of CS_2 in the jars treated with it. 100 seeds of each were set out for germination. In (1) and (2) none germinated. All germinated in (3) and 88 in (4).

Experiment XIII.

It will have been observed in the foregoing experiments that in many cases there was an increase in the weight of the grains stored when they were not damaged by insects. This was due to the variations of moisture in the atmosphere. Unless the vessels are airtight or rather impervious to air the grains absorb moisture. In this experiment all the grains were stored with naphthaline, two of them being in air-tight glass stoppered jars and the rest in glass dishes with loose covers which would allow air but no insects to get in. (See Table on page 747.)

Experiment XIV.

Germination had not so far been satisfactory in the case of wheat stored under sand. In order to ascertain definitely whether sand itself had any injurious effect this experiment was made with the variety of wheat known as Black-awn, 8,000 lbs. of which was obtained from the Pusa Farm in April 1917 for carrying on the next experiment. After being harvested the wheat had lain in the Farm godown for a few days when apparently it became infected, as will appear from the records of the experiment. At the time of storing *Tribolium castaneum* beetles could be observed in the wheat. But no attempts were made to clean or fumigate the grain as the aim was to determine the effect of sand both in this and the next experiments. On 4th April 1917, before starting the experiments, two lots of 100 wheat grains each were placed for germination and within a week 93 germinated in one lot and 85 in the other. For this experiment six pounds of wheat were placed in three glass stoppered jars (Plate 122, fig. 2), 2 lbs. in each on 1st May 1917.

Experiment XIII.

Serial No.	Variety of wheat	Vessel airtight or not	Weight on 15th May 1916	Weight on 13th December 1916	Weight on 6th March 1917	Maximum increase in weight per cent.	Germination per cent. in December 1916	Condition of grain at the time of storing
1	Pusa No. 6 . .	Airtight .	8 ounces .	8 ounces .	8 ounces .	...	91	As received from the farm.
2	Black-awn . .	Do. .	8 ,, .	8 ,, .	8 oz. 30 gr. .	...	99	Do.
3	Pusa No. 6 . .	Not Airtight	165 gr. .	190·6 gr. .	187·4 gr. .	...	...	Artificially dried to 0 per cent. moisture
4	Black-awn . .	Do. .	165 ,, .	190·3 ,, .	182·2 ,, .	...	...	Do.
5	Pusa No. 6 . .	Do. .	165 ,, .	178·5 ,, .	175·4 ,, .	8·1	...	Dried in the sun for three days.
6	Black-awn . .	Do. .	165 ,, .	178·9 ,, .	176 ,, .	8·4	...	Do.
7	Pusa No. 4 . .	Do. .	165 ,, .	172·8 ,, .	170·3 ,, .	4·7	...	As received from the Econ. Botanist.
8	Pusa No. 6 . .	Do. .	165 ,, .	171·8 ,, .	168·8 ,, .	4·1	...	Do.
9	Pusa No. 12 .	Do. .	165 ,, .	171·8 ,, .	168·5 ,, .	4·1	...	Do.
10	Pusa No. 106 . .	Do. .	165 ,, .	173·7 ,, .	171 ,, .	5·27	...	Do.
11	Black-awn . .	Do. .	165 ,, .	172·3 ,, .	170·1 ,, .	4·4	...	As received from the farm.

A well-dried sample harvested in April-May may therefore gain about 8 per cent. in weight in the course of the rainy season. This will, of course, vary from place to place according to rainfall and moisture in the air.

(1) This was left as a check.

7th January 1918 .	. 490 *Tribolium castaneum* and 980 *Calandra oryzæ* adults were picked out. Benzine was put inside the jar to stupefy the insects and then the grains were aired and put back. The grains weighed 1 lb. 15¼ oz.
8th November 1918	. 4,315 *Calandra oryzæ* and 17 *Tribolium castaneum* adults were picked out after being stupefied with benzine as before. Many grains were bored ; otherwise the wheat was in good condition.

(2) In the second jar the wheat was covered with a layer of about 7 inches of dry fine sand—

4th June 1917 .	. *Tribolium* and *Calandra* adults came up to the top of the sand.
7th January 1918 .	. On the top of the sand there were 651 dead and 4 living *Tribolium* and 18 dead *Calandra* adults. In the sand and wheat there were 41 dead *Tribolium* and 4 dead *Calandra* adults. Plate 122, fig. 2, gives the photograph of this jar. The wheat was unaffected, though a few grains were bored, and weighed 2 lb. The sand was thrown out and the wheat kept in the jar without sand.
8th November 1918	. Wheat unaffected. There were 4 dead *Tribolium* and 1 dead *Calandra* adults.

(3) The wheat was kept under sand as in (2), but this sand was sterilized by being heated over a fire and cooled before use—

14th June 1917 .	. *Calandra* and *Tribolium* adults came up to the top of the sand.
7th January 1918 .	. On the top of the sand there were 457 dead *Calandra* and 2 dead *Tribolium* adults. From the sand and wheat were picked out 35 living and 1 dead *Tribolium* and 85 living *Calandra* adults. The wheat weighed 2 lb. and was unaffected, though some grains were bored. The wheat kept without sand.
8th November 1918	. 1,936 *Calandra* adults present in the wheat which was distinctly affected and weighed 1 lb. 14 oz.

The percentage of seeds which germinated within a week in January 1918 was 90 in (1), 93 in (2), and 87 in (3). The sand itself has no injurious effect on germination. This was further corroborated in the next experiment. The percentage of germination of seeds in (1), after they were benzined, was 88.

Experiment XV.

In the previous experiments it was observed that *Rhizopertha dominica* was eliminated if closed receptacles were not used. This experiment was made to give extended trials to sand and to see if free air and light (also sun) had any retarding effect on *Calandra oryzæ*. The entire experiment was started in April 1917 with the Black-awn variety of wheat obtained from the Pusa Farm. As observed in Experiment XIV the wheat was already affected before storage. The details of the experiment are given in the statement below.

Serial No.	Where stored	Receptacle used	Treatment	Weight stored in April 1917 in lb.	Weight between 6–12—I—18 after sieving out dust (lbs.)	(oz.)	Agents of damage	Percentage of seeds germinated within a week of being set in January 1918	Percentage of loss in weight	REMARKS.
1	Inside godown	Earthen pot	Cover of pot loose; wheat covered with fine sand.	25	25	4	Free	1	*Nil*	
2	Do.	Do.	Cover of pot loose; wheat covered with fine sand. A piece of cloth below sand.	25	25	0	Do.	3	*Nil*	
3	Do.	Do.	Untreated; cover loose.	30	23	0	*C. oryzæ*			
4	Do.	Do.	Do.	30	23	8	Do.	...		
5	Do.	Do.	Do.	25	17	0	Do.	...		
6	Do.	Do.	Do.	25	18	12	Do.	...	25·4	
7	Do.	Do.	Do.	25	17	4	Do.	...		
8	Do.	Do.	Do.	25	17	12	Do.	...		
9	Do.	Kerosine tin	Do.	36	28	2	Do.	...		
10	Do.	Do.	Do.	36	27	10	Do.	...		
11	Do.	Gunny bag	......	160	136	14	Do.			
12	Do.	Do.	......	160	134	14	Do.	53	17·2	
13	Do.	Do.	......	160	125	8	Do.			
14	Do.	Do.	The wheat mixed with 60 lbs. dry fine sand.	160	143	4	Do.	71	10	

Serial No.	Where stored	Receptacle used	Treatment	Weight stored in April 1917 in lb.	Weight between 6—12—I—18 after sieving out dust	Agents of damage	Percentage of seeds germinated within a week of being set in January 1918	Percentage of loss in weight	REMARKS
					lbs. oz.				
15	In Insectary verandah exposed to free air, light and morning and evening sun.	Earthen pot	Untreated	160	123 0	*C. oryzæ*	...	23	
16	Inside godown	Iron bin	The wheat covered with a layer of fine sand.	800	799 0	Free	88	*Nil.*	
17	Do.	Do.	The wheat covered with a layer of fine sand with a piece of cloth spread below sand.	800	801 0	Do.	79	*Nil.*	
18	In Insectary verandah exposed to free air, light and morning and evening sun.	Straw *Pura* (Plate 114, fig. 3).	Untreated	480	468 2	*C. oryzæ*	80	2·5	
19	In open air	Straw *morai* (Plate 116, fig. 2).	Do.	4,800	4,680 4	Do.	81	Unable to determine, but loss was slight.	A quantity was stolen in December 1917.

The statement is sufficiently self-explanatory.

In No. 18, *i.e.*, the straw *pura* (Plate 114, fig. 3), the places where the grain was affected are the two ends indicated by dots in Plate 118, fig. 1. The ends of the longitudinally arranged straw making up the lining inside converge at the ends but leave enough openings for the insects to creep in. Out of 468 lb. 2 oz. left in January 1918 about 117 lb. was fairly damaged (1 grain in about 8 bored) and the rest was good.

In No. 19, *i.e.*, in the straw *morai* (Plate 116), the places where the grain was affected in the column of the wheat (the column was about 5 feet high, 5 feet in diameter at the top and $4\frac{1}{2}$ feet in diameter at the base) are indicated by dots in Plate 118, fig. 1. At the top the infection spread up to a layer of about one inch all round and at the bottom to a depth of about two inches. Of the total weight obtained in January 1918, about 320 lb. was slightly damaged (about 1 grain bored in every 8) and in about 100 lb. one grain in every 4 was bored. The rest was good. It should be mentioned here that in September 1917 about 320 lb. of affected wheat was cleaned in the Insectary compound at a distance of about 50 yards from the *morai*. Millions of weevils spread all round and many reached the *morai* too over ploughed-up fields.

As noted above, the agents of the damage were *Calandra oryzæ*. There were, however, some *Tenebroides mauritanicus*, *Tribolium castaneum* and *Læmophlœus pusillus* grubs and adults in almost all samples kept inside the godown.

It will be observed that free air, light and sun had no effect on the rice weevil. The sand, of course, gave the best result.

Experiment XVI.

Fumigation with Nitro-benzol.

13th January 1918; 10-30 a.m.	In a wooden fumigating-box measuring 2′ 6″ on all sides a quantity of the affected wheat from the previous experiment was placed to a depth of about 2 feet. On the top of the wheat was kept a flat porcelain dish with 45 cc. of Nitro-benzol and the cover of the box put on and made air-tight by means of water in the water-channel.
14th January 1918; 10-30 a.m.	The box was opened. A strong smell of Nitro-benzol was perceptible. Only about 4 cc. of Nitro-benzol had evaporated. Within about one inch of the surface of the wheat *Calandra oryzæ* and *Tribolium castaneum* adults and *Tenebroides mauritanicus* grubs were quite active.
At 3 p.m.	There was yet sufficient smell of Nitro-benzol present in the wheat, although it was left quite exposed

Experiment XVII.

The experiments in storing grain against insects were carried on at Pusa where *Trogoderma khapra* does not occur. In order to find out the effect of sand on this insect this experiment was made when materials were available.

17th June	100 beetles and 100 grubs about half to three-fourths grown were placed in a glass jar with sound wheat.
19th June ; 10 a.m. .	Fine sand was placed on the top of the wheat. Much of the sand percolated down and a sufficient quantity was added to keep the grains covered.
20th June ; 8 a.m. .	18 grubs and 16 beetles were observed to have come up to the top of the sand, where they were crawling about, apparently not being able to make their way down through the sand. Eleven of the beetles were dead. The insects are left on the top of the sand.
21st June ; 8 a.m. .	29 grubs and 18 beetles are found on the top of the sand. All are left there.
22nd June ; 8 a.m. .	31 grubs and 19 beetles on the top of the sand.
By 26th June . .	58 grubs came up to the top of the sand. No more of the beetles came up, as they were dead.

It will be evident from this experiment that sand will prove as effective a check upon this pest as upon the other pests with which the experiments carried on at Pusa were concerned.

Experiments with rice (husked).

Experiment XVIII.

A parallel series of preliminary experiments was made with *usna* rice (rice prepared after boiling the unhusked paddy grains which are then dried and husked) in small earthen pots with loose covers (Plate 111, fig. 3) and small gunny bags in the same manner and at the same place as wheat in Experiments I to III. Two pounds of rice was used in each receptacle. They were stored between 15th June and 1st July 1915 and the final examination was made on 20th March 1916, the weights left on which date, after sieving out the dust, are shown in the table below. The damage was done by *Calandra oryzæ* and there were *Tenebroides mauritanicus*, *Tribolium castaneum* and *Læmophlœus pusillus* in almost all.

Serial No.	Treatment	In earthen pots	In gunny bags
		lb. oz.	lb. oz.
1	Castor oil	1 14	1 11
2	Mustard oil	1 10	1 12
3	Sesamum oil	1 12	1 12

Serial No.	Treatment	In earthen pots	In gunny bags
		lbs. oz.	lbs. oz.
4	Coconut oil	1 10	1 9
5	*Mohwa* oil	1 8	1 12
6	Groundnut oil	1 10	1 12
7	Linseed oil	1 11	1 11
8	Camphor	2 0	1 8
9	*Hing*	1 12	1 10
10	Garlic bulb	1 14	1 12
11	Lime	1 14	1 14
12	Sand	1 13	1 10
13	*Senwar* leaves	1 12	1 10
14	Tobacco dust	0 12	1 5
15	Sulphur powder	1 4	1 2
16	(Check)	1 11	1 10
17	Naphthaline	...	1 11
18	Husk dust	1 11	1 8
19	Ashes	1 13	1 7

The weights left indicate the damage in each case. Taking both the lots together, the total loss in weight was 15·5 per cent. This, however, does not indicate the real damage. When the eaten shells were removed the loss in weight amounted to 51·3 per cent.

A.—In order to compare the damage to rice with that to wheat, 30 lbs. Black-awn wheat was kept in an earthen vessel with loose cover in the godown by the side of the rice from April 1917 to April 1918, when, on sieving out the dust, the wheat weighed 19 lb. When cleaned in a pestle and mortar the grains which were left and would be fit for making *atta* weighed 8 lb. Therefore there was an actual loss of 73·3 per cent.

Experiments with pulses.

The experiments were made with (1) *bora* or *barbati* seeds (*Vigna catjang*), (2) Lentil seeds (*Ervum lens*), (3) gram seeds (*Cicer arietinum*), (4) *arhar* seeds (*Cajanus indicus*). The receptacles used were earthen pots and gunny bags as in the experiments with wheat and rice.

Experiment XIX.

In the light of the results of Experiment XVIII only lime was selected for trial in this experiment. Both *usna* and *arua* (rice husked out without boiling the paddy grains) rice was used in earthen vessels and gunny bags. The experiment was started on the 18th May 1916, examined at intervals and kept on for two years in the same godown in which the wheat experiments were carried on. All these samples of rice were therefore exposed to the same conditions as the wheat.

Serial No.	*Usna* or *Arua*	Receptacle used	Treatment	Weight of rice stored on 18th May 1916	Weights on 12th December 1916	Weights on 7th March 1917	Weights on 18th January 1918	Weight left of 10 lbs. after cleaning in pestle mortar on 3rd May 1918	Damage per cent. calculated from preceding columns
				lb. oz.	lb. oz.	lb. oz.	lb. oz.	lb. oz.	
1	*Usna*	Earthen pot	Mixed with 12 oz. lime.	25 0	No damage .	25 12	22 14	9 11	11·6
2	Do. .	Do. .	Check . . .	25 0	24 8	24 5	24 0	9 9	8·44
3	*Arua* .	Do. .	Mixed with 12 oz. lime.	25 0	No damage .	25 9	25 4	9 9½	4·0
4	Do. .	Do. .	Check . . .	25 0	24 12	24 14	21 8	9 10¼	17·6
5	*Usna* .	Gunny bag .	Mixed with 4 lb. lime	159 0	No damage .	157 8	154 4	9 8¾	7·0
6	Do. .	Do. .	Check . . .	158 8	158 0	155 8	155 12	9 8¾	6·2
7	*Arua* .	Do. .	Mixed with 4 lb. lime.	160 0	No damage .	159 8	155 4	9 6½	8·9
8	Do. .	Do. .	Do. .	160 0	158 14	157 6	154 14	9 4½	10·4

Taking all together the damage comes to about 9·2 per cent. This may be compared with the damage of the previous experiment.

The seeds were :—

(*a*) Smeared with castor oil, mustard oil, sesamum oil, coconut oil, *mohwa* (*Bassia latifolia*) oil, linseed oil and groundnut oil,

(*b*) mixed with lime, sulphur powder, *murhi* (fried rice) and blown salt,

(*c*) stored with camphor, *hing* (asafœtida) and naphthaline,

(*d*) covered with road dust, sand, and ashes,

(*e*) dipped in salt solution, soda solution and *lye* (solution of plantain ashes).

None of the treatments immunized the seeds, only road-dust, sand and ashes in the earthen pots mechanically prevented the beetles having access to the seeds which thus escaped damage.

The oils retarded the attack. As long as the seeds remained moist with oil they escaped, but were attacked when the oils dried. The seeds were stored in May 1916. By July 1916 those not smeared with oil were attacked, the oiled ones not being attacked until about October 1916.

The affected seeds soon turned black and became unfit for use. The seeds under sand kept their natural colour and appearance even after about two and a half years (26th October 1918). Those under ashes came next but were much inferior. The germination tests, however, gave poor results, varying from 1 to 24 per cent. In the case of wheat also the germination of seeds kept in earthen pots invariably gave poor results.

Kirao (*Pisum arvense*) and *khesari* (*Lathyrus sativus*) seeds, kept from March 1917 to November 1917 under sand in a glass trough, gave cent. per cent. germination.

Conclusion.

The results aimed at in successful storage of grain are (1) that it should remain undamaged by insects, (2) that it should not deteriorate in quality, and (3) that it should not lose its germinating power when required for use as seed. As ascertained by observation and detailed in the section on "immunity or otherwise of stored seeds, etc.", all grains are not liable to be attacked by insects and do not require special precautions in storing. Those liable to be attacked include our principal food-stuffs, *viz.*, rice, wheat, barley, maize, *juar* and the pulses. They require special precautions for storage and in their case the above results are usually recommended to be obtained by fumigating the grains with carbon bisulphide before storing and then storing them in insect-proof receptacles. In the case of Indian house-holders both these conditions are wanting.

Of the receptacles in use among the ordinary house-holders for storage of grain, gunny bags are the worst as they expose the grain to insects all over their surface.

The various types of earthen vessels, mud-bins and bamboo-bins cannot be made insect-proof.

Attempts are often made to make earthen vessels insect-proof by plastering down their covers with mud. They cannot be made insect-proof in this manner, as some of the worst pests (*e.g.*, *Rhizopertha dominica*) can work their way through the mud plaster. As will appear from the records of experiments with wheat given above, the grain (especially the cereals) in vessels closed in this manner is liable to be attacked by two serious pests, *viz.*, *Rhizopertha dominica*, which does the greatest damage in the shortest time of all the store pests, and (2) *Calandra oryzæ*, the ordinary rice weevil, which, in addition to the actual damage by feeding, causes the entire quantity of grain, including the unaffected ones, to ferment and rot owing to the moisture and heat generated by it while breeding in the grain. In vessels which are not thus closed and into which free air can have access the grain (cereals) is liable to be attacked only by the rice weevils with this advantage that no fermentation and rotting are set up, as the moisture and heat generated by the insects escape. Therefore open-mouthed unclosed vessels are preferable.

There is no treatment known which can immunize the grain against insects even for a few months. Safety lies in storing the grain in open-mouthed unclosed receptacles and at the same time adopting such methods as will prevent the insects having access to it. This has been found to be practically possible by keeping the grain in open-mouthed receptacles with solid walls and bottom through which no insects can have access, and by keeping the grain covered at the top with a layer of dry fine sand.

Plate 123, figs. 1 and 3 show how the grain should be stored in earthen pots and kerosine tins or bins. The sand percolates down and exposes the grain at the top. This should be guarded against at the time of storage by making the sand go down as much as possible by shaking or striking the sides of the receptacles. A layer of about 1 to 2 inches of sand should stand at the top covering the grain always.

The sand has an additional advantage. Some of the pests (especially the Pulse Beetles) infect the seeds while still in the field and the insects which remain inside the seeds are brought into the store and afterwards breed there. The sand prevents such insects from breeding and it has been found practically that the insects come up to the top of the sand

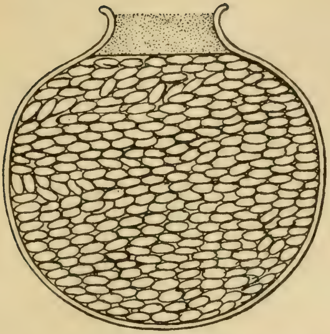


Fig. 1.—Section through earthenware pot, showing how grain should be kept with a layer of sand at the top.

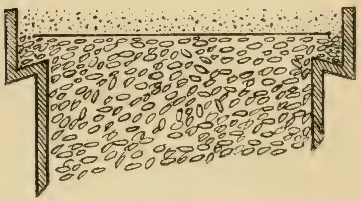


Fig. 2.—Showing how the top of a bin can be modified for the use of sand if it is not intended to allow the grain to be mixed with sand.

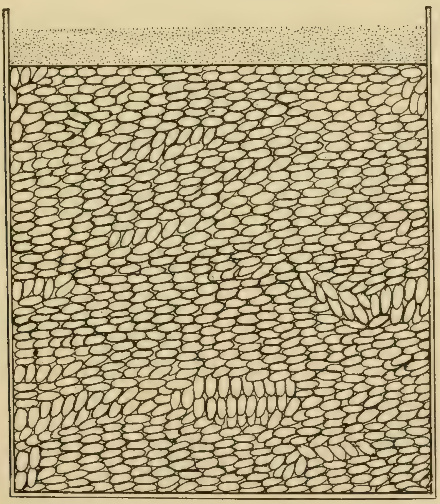


Fig. 3.—Showing how grain should be kept in bins with a layer of sand at the top.

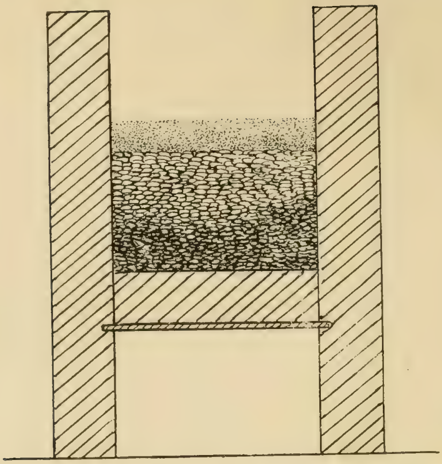


Fig. 1.—Showing how a mud bin can be formed on the floor inside mud-walled houses or huts.

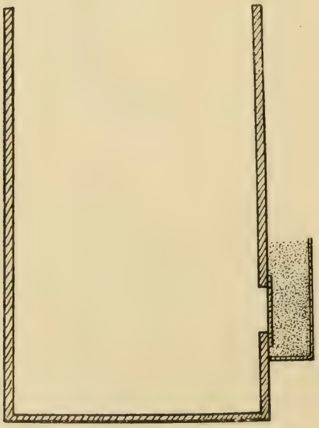


Fig. 2.—How openings, if desired at the lower parts of bins for taking out the stored grain, may be protected with sand.

and cannot go down again. The grain is therefore automatically freed of such insects.

It should be remembered that the principal infection, and in the majority of cases the primary infection, takes place after the grain is harvested and when it is allowed to be exposed either in the threshing yard or in the godown. Storing should be done directly from the threshing yard. Another point to remember is that the sun is a very good insecticide of which all can make use and the grain should be stored while hot after exposing it to the sun, if possible in thin layers so that all the grains may be heated.

If it is not intended to mix the grain with sand, a sheet of cloth can be spread over the grain and the sand placed above the cloth. In actual practice it has been found to be equally effective in the case of wheat, as will appear from Experiment XV, 2 and 17. The insects, at least the rice weevils, somehow crawl out and do not breed in the grain. If the top of the bin is made in the manner shown in Plate 123, fig. 2, the sand will remain in touch with the grain all round the edges while the grain in the bin will remain free from sand. In such bins a sheet of iron or tin or a wooden plank can be used in place of the sheet of cloth. When the grain is stored directly from the threshing floor, as recommended here, cloth for such bins can always be used.

If, however, the grain is already badly infected, sand allowed to percolate down through the grains will force out more insects. It is, however, better not to use sand in the case of badly infected cereals, as sand gets into the holes produced by the insects in the grains and cannot be removed easily. Badly infected cereals cannot be freed of insects entirely by sand and breeding and damage may continue under sand as the insects, especially the weevils, find enough room to move about in the interspaces among the eaten grains. In such cases the grain should first of all be freed of insects either by fumigation where feasible or by breaking up the eaten grains and shells in a pestle and mortar, winnowing off the dirt and chaff and then thoroughly heating the grain in the sun or, better, over a fire. It can then be stored with cloth and sand to prevent re-infection and further damage.

The mud bins of Bihar (Plates 112, 113) and bins made of bamboo or sticks of other plants and the Bihar *Bakharis* are not good for storage purposes, at least for cereals. Whatever be the receptacle used, it should have the bottom and walls in one piece and without cracks or inter-spaces through which insects can creep in. Mud-walled storage bins can be built inside houses as shown in Plate 124, fig. 1. The empty space below is for aeration so that the grain may not be affected by damp. Similar masonry storage bins can be built with arches below as seen in Plate 121, fig. 1. A bin measuring $2\frac{1}{2} \times 2\frac{1}{2} \times 2$ feet can accommodate more than ten *maunds* of grain. It can be made as large and high as one likes. A series of bins can be built side by side. The Bihar *Bakharis* can be replaced in this manner.

If it is intended to have a hole at the bottom for taking out the stored grain whether in mud, masonry or iron bins, the hole should be protected with sand as shown in Plate 124, fig. 2.

The system of storage recommended here is applicable to cereals, pulses and such articles as coriander seed, turmeric, etc., which can be conveniently placed under sand and easily cleaned before use.

Sand keeps the grain practically in the same condition in which it is stored. The germinating power is unaffected. Earthen pots, at least those available from the potters in the neighbourhood of Pusa, have an injurious effect on the germinating power of seeds stored in them. When the grain stored is intended to be used as seed earthen pots should not be used. Kerosine tins or iron bins are good for this purpose.

Storage above ground is always preferable to storage underground such as in pits. But the pit system of storage is so much in vogue and so cheap that it will probably not be given up quickly, although after the initial expenditure has been met for making proper preparations for above-ground storage, the better quality of the stored grain, fetching a higher price, and the absence of loss due to insects, moisture and fermentation, will soon more than make up for the initial expenditure.

Mr. Ramakrishna Ayyar. We tried storing paddy seeds according to this method and the seeds were unaffected by the beetles.

Mr. G. R. Dutt. Mr. Ghosh has said that a cloth should be placed between the layer of sand and the grain ; if so, how would the insects be able to get to the top of the sand ?

Mr. Kunhi Kannan. In Mysore we carried out some investigations along the lines suggested in this paper and we came to the same conclusions. The insects do come to the top layer and this is on account of the instinct of reproduction. In the grain they cannot copulate and for copulation they want a central place where they can come together and so they come to the surface, where they copulate and lay eggs. I have found that the degree of infection is always greater at the top surface, so the insects do come to the top. If there is a layer of sand they cannot get in again. If the layer of sand is not very thick and is only about half an inch deep, then the beetles have been observed to go down and a very interesting thing happens. Sometimes two or three beetles drag a grain to the top and lay eggs there.

In Mysore this practice was very prevalent at one time but now people seem to have forgotten it. Another method employed is that of using a bin with the capacity of six hundred *seers*. This bin has a hole which is closed by a coconut shell fitted with a string arrangement to close the hole, the top of the grain is covered by a layer of sand and the grain can be taken out from the lower hole. In some experiments infected seeds were placed in a jar and covered over with a layer of sand. The insects crawled up but could not come down again. Why they cannot go down is very difficult to say.

Mr. Ghosh. In our experiments several different samples of the grains of wheat were tried.

Mr. Robertson-Brown. In the North-West Frontier Province a cultivator near Tarnab has a grain-store made of *deodar* with a capacity of about 1,500 *maunds*. It is raised from the ground and is simply built of boards and is very airy. I saw it first some seven years ago and the owner tells me that it has been built for thirty years, and that he has never had any trouble with weevils * in it during that time. I have seen the store pretty well filled and also almost empty and without any pests at any time. Other stores which are not airy are always badly affected. My experience is that, if grain is kept in airy stores, it remains safe. It is not a question of storing small quantities, twenty or thirty *maunds* or so, but of thousands of *maunds*. In our district the *banias* mix dust with the grain and it does not get pests. Further, I have found that when local grain is badly affected, "Pusa 4" wheat suffers very little. I have also found that, while grain stored indoors in bins suffers badly, that stored in airy places does not suffer. One year, owing to shortage of bags, we put some of our grain in old snuff-bags and the grain placed in these bags did not suffer from insect attack. Of course, snuff is a very strong-smelling substance. On further inquiries I was told that if the bags were dipped in *polvo* the grain would keep safe. This has not been tried as yet. In some parts cylindrical stores of mud are made and in these the grain keeps well.

Mr. Fletcher. I can corroborate what Mr. Robertson-Brown has told us about the timber-built granary at Peshawar as I saw it when at Peshawar three or four years ago and found it quite free from insect pests, although the ordinary local pattern of granary, built of thick walls of mud, was swarming with pests, mostly *Trogoderma khapra*. It struck me that the difference might be due to the greater variations of temperature in the

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* The term "weevils" here includes *Trogoderma khapra*, which is the worst pest in the ordinary mud stores in the North-West Frontier Province, as well as *Calandra oryzæ*.—*Editor*.

case of the timber-built store as compared with the mud one and it was proposed to test this and compare the efficiency of the two types by building two small granaries, side by side, one of timber and the other of mud, and taking daily temperature-readings in each. These granaries were being built when I was at Tarnab in May 1916 and I left thermometers there for taking the readings but have not heard any more about them.

Mr. Robertson-Brown. Those experimental stores proved a failure as they were not rain-proof.

Mr. Ramrao. Rats do a great deal of damage to stored grains and make holes in granaries.

Mr. Fletcher. If the stores are placed on pillars, off the ground, as these Peshawar timber-built stores are, the damage from rats is eliminated.

Mr. Senior-White. The new rat-proof grain-stores recently erected in Colombo show how the damage done by rats can be nullified.

Mr. Ramrao. In some parts of South Kanara a paste is made of red earth which is mixed with pulses. These are stored in a corner of the house and remain quite exposed. They keep quite well in this way even up to two years. I have seen this myself.

Mr. Kunhi Kannan. This method has been tried in Mysore but was not found successful.

Mr. Ghosh. *Rhizopertha* breeds if the mouth of the bin is plastered over, but, if left unplastered, it does not develop.

Mr. Robertson-Brown. We plastered over the mouths of our *matkas* and the seed was damaged. If kept in air-tight boxes, maize loses its germinating power.

Mr. Harchand Singh. In Patiala and the neighbouring districts *bhusa* [chaff] of gram is placed in a layer below and above the grains and they keep well; but wheat if stored in this way does not keep.

Mr. G. R. Dutt. If the grains are already infested holes are formed in the grains when the adults emerge. In the method of storage under sand, the sand gets into these holes and renders the *atta* made out of such grains uneatable. Also how can insects come out through the cloth ?

Mr. Ghosh. We have experienced the trouble from the sand in the *atta* in the course of our experiments. The first thing is, why should you allow your wheat to be infested ? Take it directly from the threshing yard and store it under sand and there will be no trouble, as the grain will never be infested. The stirring, which the grain receives at the time of storing, causes the weevils, which may be in it, to leave it and the damage is caused by the weevils which gain access to it afterwards. In actual experiments it has been found that the weevils manage to get out through the edges when there is cloth.

Mr. Fletcher. The grain may be infested in the field.

Mr. Ghosh. There is hardly any infestation in the fields.

The reason why it is that the weevils come to the top is that they want free space to mate. **Mr. Kunhi Kannan.**

When a large quantity of grain is stored and small quantities have to be taken out at intervals for use, infestation may take place when the sand is removed from the top. Some arrangement by which the grain can be drawn out from below would be desirable. **Mr. G. R. Dutt.**

Such an arrangement is possible but not necessary. The grain can be taken out from the top and re-covered with sand. The bin of which Mr. Kunhi Kannan has given a description, with a hole at the lower part closed with a coconut shell, affords a weak point at the hole through which weevils will get in. If it is really desired to have such a hole it should have an arrangement which will allow of the hole being covered with sand. **Mr. Ghosh.**

38.—MERCURY AS AN INSECTICIDE. (Abstract.)

By K. Kunhi Kannan, M.A., F.E.S., *Senior Assistant Entomologist, Mysore.*

While investigating the indigenous methods of storing pulses in Mysore, it came to the notice of the Agricultural Department that *raiyats* had great faith in the efficacy of mercury as a protection against the pest. The practice appears to have been to place a drop of mercury in an excavated soap-nut in the receptacle used for storing. Further details could not be obtained, as the practice seems to have died out practically. The poisonous effect of mercury vapour on human beings being well known, it was decided to test the value of the metal as an insecticide and the results have vindicated what has been long regarded as a superstition.

The presence of the metal in very small quantity placed in a dish inside the receptacle prevented the multiplication of the beetles. A series of experiments conducted show that the action is on the eggs of the beetles which are usually laid only on the top surface of the pulses and not on the other stages. The effect is less marked in the case of large store bins of several cubic feet capacity. But in small jars or pots of a couple of cubic feet or so a drop or two absolutely prevent emergence. The same deleterious action has been noticed on the eggs of silkworms also. Detailed results will be published elsewhere.

Where do the *raiyats* get the mercury ? **Mr. Fletcher.**

It is sold in the bazaars. Grocers store it. **Mr. Kunhi Kannan.**

Is it found in India ? **Mr. Fletcher.**

I think so. At one place they had ten pounds of mercury found as metal in one place. **Mr. Kunhi Kannan.**

Mr. Fletcher. It sounds rather unlikely to find free mercury. Possibly it comes from the Kolar mines.

Mr. Kunhi Kannan. I also tried the effect of mercury on silkworm eggs and found that it prevented their hatching. The method of action seems obscure. We weighed the mercury used in our experiments and found that there was no loss of weight.

Mr. Fletcher. The subject seems to require further investigation.

39.—LIST OF THE PESTS OF THE STORED PRODUCTS, SPICES AND DRUGS, IN BURMA.

By K. D. Shroff, B.A., *Entomological Assistant, Burma.*

Pest	Product	Remarks
	Stored Products.	
Sitotroga cerealella	Paddy, *Jua*	Minor pest.
Calandra oryzæ	Rice, wheat, *Juar*, maize, gram, etc.	Major pest.
Tribolium castaneum	Rice, wheat, flour, pulses.	Minor pest.
Corcyra cephalonica	Rice	Do.
Bruchus chinensis	*Mung*, *Urid*, *Tur*, peas.	Major pest.
Bruchus sp.		
Bruchus theobromæ	Beans (*Dolichos lablab*).	Major pest.
Bruchus analis		
Bruchus sp. (3 species)		
Lasioderma testaceum	Peas	Minor pest.
Aphanus sordidus	Sesamum, groundnut	Reported "serious" from Taungtha, Myingyan District.
Beetles looking like *Rhizopertha*	Barley	Found on barley imported from Delhi by the Mandalay Brewery.

SPICES AND DRUGS.

Pest	Part of the Plant Attacked	REMARKS
	Chillies.	
Chaetodacus ferrugineus dorsalis	Fruit . . .	Scarcely a pest.
	Tamarind.	
Weevils (*Calandra* ?) . .	Seeds . . .	Minor pest, sometimes serious especially to stored tamarind if seeds are not removed before storage.
Caryoborus gonagra . .	Do. . . .	Minor pest.
	Mint.	
Syngamia abruptalis . .	Leaves . . .	Not serious.
	Coriander, Cardamom, Betel-nut, Orris root.	
Lasioderma	Do. . . .	Minor pest but causes a large aggregate damage.
Tribolium sp. . . .	Opium seeds . .	Not serious.
	Senna.	
Butterfly caterpillars . .	Leaves . . .	Minor pest.
Aphids (Sucking) . .	Juice . . .	Minor pest but not serious.
	Camphor.	
Beetles	Leaves . . .	Not very serious.

40.—POTATO PRESERVATION IN THE BOMBAY PRESIDENCY.

By RAMRAO S. KASERGODE, *Assistant Professor of Entomology, Poona.*

The potato being an important article of diet should be capable of being preserved from one harvest to another, not only for the purposes of seed but also for consumption. A riddled potato is useless for table purposes and it is equally bad for seed. Almost all attempts at preservation, at least in India, have however been directed to preserve the potatoes for seed. In localities where only one crop a year is the rule it has to be kept for fully eight months or more, but the potato is capable of being grown and is grown in two seasons in a large number of places. In the latter case the period it has to be kept is much less, a matter of four months. On account of the abnormal losses in storage due to diseases and pests the price of the potatoes may rise from one rupee a *maund* in Bengal to even fourteen or twenty rupees a *maund* at the next sowing. In Bombay, although it has not been seen to rise to such a high figure, three to four times the harvest price is realized during the next sowing. The same conditions probably obtain in the Central Provinces and the Punjab. From observations taken of the cultivators' heaps it is found that the loss due to diseases and pests may range from 50 to 75 per cent.

Serial No.*	Weight of Potatoes at the time of storage, in lb.	Percentage loss in storage	REMARKS
1	224,400	31·0	Accurate weights were taken at the time of storage. Potatoes were stored in the last week of March and weighed again in the middle of June.
2	89,600	40·7	
3	108,000	75·0	
4	43,200	80·0	Weights taken at the time of storage and weighed again at the time of disposal. Stored from the end of October and opened in the middle of December.

The way in which the potatoes are stored by the cultivators is briefly this :—A rectangular pit about a foot deep is dug, generally under the shade of a tree. This pit is watered and the soil is pressed down before the potatoes are poured in. These heaps may vary from 3 to 3½ feet in depth. The potatoes are then covered by a layer of *Nîm* leaves or straw. Over the whole heap a roof is constructed of straw and leaves to prevent the heaps being directly exposed to the sun and thereby turn green. No attempt is made to remove the rotten potatoes except when the heap is to be sold off finally at the end of storage. When the potatoes are uncovered at the end of storage practically every potato has the larvæ of the moth boring inside and the potatoes lower down the heap have rotted to a larger extent than in the upper layers of the heap.

The cultivator ascribes all this damage to the easily visible moth and its larvæ and he has no means of discriminating the subtle and

* For all the figures included in this paper I am indebted to S. D. Nagpurker, B.A

invisible bacterial and fungal diseases in the potatoes. An experiment carried out in 1912 showed beyond doubt that even where the moth pest was excluded the rots could continue their destruction. Two lots of 5,000 lb. each were kept under observation. One was fumigated and the other unfumigated, and both were kept in two separate rooms well ventilated and cool. Forty-five per cent. of the potatoes were recovered from the fumigated lot while all the potatoes in the unfumigated lot were lost by rots within a period of three months. This experiment showed conclusively that the presence of moths and their larvæ in the potatoes helped the destruction to a very large extent.

Continued trials have shown that the control of the moth is a comparatively easy task if only the various forms of rots could be eliminated. The larvæ of the moth do not destroy the potato except slightly for seed purposes. It might shrink a little more than when it is kept free from its infection. Only a few eyes will be injured out of the many that the potato possesses capable of sprouting. No cultivator utilizes rotten or even half-rotten potatoes for seed. But he has no objection to utilize wormy ones for seed and actual counts from a number of fields during the planting season have shown that on an average no more than 10 per cent. of the setts have had their eyes injured by the larvæ.

Further observations of the heaps during the period of storage show that the temperature is also a controlling factor which must be taken into account.

Serial No.	Weight of Potatoes in storage in lb.	Percentage loss in storage	Temperature of the heap (degrees Fahrenheit)	Temperature under shade (degrees Fahrenheit)	Depth of the heaps (feet)
1	15,600	7·5	83	87	1½
2	87,600	40·7	87	87	2½
3	1,600	21·0	88	92	2
4	1,08,000	75·0	88	88	3

The moth was equally bad in all the heaps. The percentage loss shown in the above table includes only those thrown away as being rotten and useless. The selected potatoes were pronounced to be quite good for seed purposes even though they contained more than 50 per cent. insect attack. A close scrutiny of the table shows that the depth of the heap bears a close relation to the loss sustained and also to the temperature of the heaps. The deeper the potatoes are stored the higher the loss by rots and this may possibly be accounted for by the higher temperature generated in the depths of the heaps. Ventilation of the heaps must be secured to prevent the rise of temperature so as not to give rots the conditions most favourable for their development.

Out of the five different kinds of rots which have up to this time been discovered in the Bombay potatoes two deserve special attention in connection with this storage. The bacterial rot which is the more important of the two is universally found in practically all potato-growing tracts of Bombay. The next, though a less important one, is the dry *Fusarium* rot. If these two rots are present in any degree in the harvested potatoes the presence of the larvæ of the moth increases the rate of rotting, affording as they do the ready means by which the spores of the two rots effect an entrance into the otherwise healthy potatoes. The larger the number of generations the moth passes through in a potato godown the greater the danger to the heaps. These rots are known to be saprophytic in nature and the infection is carried from the soil along with the harvested potatoes. Any form of external injury either by the larvæ or by other mechanical injuries sustained by the potatoes in their handling during their harvest or subsequent to harvest, exposes the tubers to infection. To control the rots, which are therefore the primary causes of destruction, the moth must first be prevented from breeding in the potatoes intended for storage.

It is also true that under the conditions obtaining in the present methods of storage in heaps, very often as deep as 3½ feet, the moisture given up by the potatoes in the natural process of drying coupled with the high temperature particularly at the bottoms of the heaps favours the spread of the bacterial rot and to a less extent of *Fusarium* rot. If the temperature of the room rises to 86°F. or anything above this, the destruction of the heaps is only a matter of days and not of weeks.

The preservation of the potatoes means therefore the control of the following four factors :—

(1) Thorough fumigation to kill the moth larvæ.

(2) Prevention of injury to the skin of the potatoes incidental to frequent handling.

(3) Thorough selection before storage so as to exclude injured and rotting potatoes and also those which show definite signs of rots.

(4) Ventilation of the potatoes to reduce the temperature.

1. *Fumigation of the Potatoes.*—It is unnecessary for the present purposes of the paper to go into the detailed life-history of this moth.

Suffice it to know that the potatoes are attacked in the field—leaf, stem and tubers alike. In years when the monsoon fails or there are long breaks the cracks in the soil allow the larvæ access to the tubers below. The potatoes in the soil are much less attacked if the rainfall is even and well distributed. Irrigated potatoes escape being attacked in the field on account of the soil receiving regular and timely watering which keeps the soil from cracking. The source of infection may also be from green potatoes which get exposed in the field and so get unwittingly mixed with the sound tubers that go to the store. The moth is known to breed in much the same way as stored grain pests breed in the granary. The larvæ inside the potatoes cannot be killed by any amount of dipping and laboratory experiments show that moths hatch out from such potatoes even by using double the ordinary strength of lead arsenate. Crude-oil emulsion and copper sulphate are equally ineffective for the purpose. Repeated trials with crude-oil emulsion in Bombay have resulted in failures. Experiments of dipping in crude-oil emulsion carried out in Bengal have proved the uselessness of this method. The Central Provinces' experience at Chindwara and Saugor are not reassuring; fifty to seventy-five per cent. were found destroyed even although the potatoes were carefully selected before storage. Experiments by F. Stoward, D.Sc., Government Botanist, Western Australia, show that formalin, mercuric chloride and copper sulphate have had no effect on the larvæ even after six hours of dipping. The eggs and pupæ are more refractory and they are not killed without destroying the germination of the potatoes also. He is positive when he affirms that the dipping is harmful to the germination if continued sufficiently long to kill the live forms of the moth. Dipping in water killed the larvæ by exclusion of air to the galleries in which the larvæ live.

Fumigation by carbon bisulphide was first tried and gave excellent results. It kills the larvæ and pupæ but has no action against the eggs, unless they are exposed to the fumes for 48 hours or longer. Future generations can be prevented from breeding in the potatoes if they are fumigated before the first generation of moths have had the chance of laying their eggs. Experiments with other compounds which evaporate easily have shown that the fumes of benzine and petrol have a lethal effect on the larvæ and pupæ nearly quite as much as carbon-bisulphide. Benzine and carbon-bisulphide have to be discarded on account of their being extremely costly and not easily available except in big cities and towns. Petrol is better on account of its being available even in the nearest *taluqa* places. During normal times petrol is available at one rupee a gallon and there are no restrictions against its transport. From experiments conducted at the College an exposure of 24 hours at the rate of one pint to every 200 cubic feet of space is found sufficient to kill the larvæ and 90 per cent. of the pupæ.

2. *Prevention of Injury to the skin of the Potato.* To protect the potatoes from superficial injuries it is found extremely necessary to desist from handling them until their skin gets hardened. Two weeks must elapse after their harvest before any attempt is made to fumigate them, as this necessarily entails rough handling. It is again possible by waiting two weeks to discard the potatoes which develop signs of bacterial and *Fusarium* rots already noted. Once the potatoes are fumigated they are carefully selected to remove the rotting and injured ones. If this selection is thorough and if it is made by one who understands the signs of rots the potatoes may be kept for four months or more without any danger of rotting and this obviates all further necessity of repeated selections.

3. *Thorough selection before Storage.* Bacterial rots can be avoided to a large extent if the potatoes are examined carefully before storage. The blackening of the eye should always be taken with distrust. Blister-like swellings just under the skin is an evidence which cannot fail to attract attention. They are bound to rot the earliest. Small pinhole-like, black depressions are also signs which ultimately develop into the wet rot and must therefore be looked for. *Fusarium* dry rot can also be identified by concentric depressions on the surface and these are very often found beginning at the stock end of the potato. They may also be found in the eyes or other parts. This rigid selection means the examination of every potato and it has been found that no more than five hundred pounds of potatoes are capable of being selected in one day of eight working hours by one man. Insect-attacked potatoes need not be rejected because of the insects, but if they show any of the two rots they should be discarded.

4. Experiments conducted to determine various methods of subsequent treatment in store have shown that if the potatoes are kept in gunny bags, they remain perfectly sound and that this prevents further infection from moth attack even although there may be moths freely moving about in the *godown*. The *godown* should have as far as possible thick walls and a high roof, so as to secure a cool atmosphere round about the bags. The windows should be opposite to each other to establish free circulation of wind in between the bags. If these precautions are taken and if the bags are not kept one above the other the rots are diminished to the extent that it does not require any further selection for at least three months.

The following figures show that at a cost of Rs. 5-11-0 per ton it is possible to preserve the potatoes in large quantities :—

Serial No.	Fumigated Potatoes. Percentage of rejection	Non-fumigated Potatoes. Percentage of rejection	Weight of potatoes stored after fumigation lb.
1	1·7	19	2,100
2	2·3	27	874
3	1·7	36	1,718
4	1·1	3	1,800
5	Negligible.	3·5	1,729
6	1·6	8	548
7	9·4	51	924
8	·8	3·7	3,059
9	·1	7	2,080
10	1·8	8	995
11	3·5	44	841
AVERAGES	2·5	18·5	16,668

Period of storage $3\frac{1}{2}$ months, end of February to middle of June. Details of cost per ton of potatoes preserved.

	Rs.	A.	P.
Cost of petrol	0	1	0
Labour necessary for lifting the potatoes into the chamber and out of it	0	6	0
Cost of bags	3	0	0
Selection charges	2	4	0
TOTAL .	5	11	0

Calculating that a man has to invest Rs. 5-11-0 over each ton of potatoes he preserves, he can sell these potatoes at enormous profit during the next sowing season. In Bombay the potatoes are sold at Rs. 60 per ton at harvest and Rs. 180 a ton at the next sowing. If he does not sell his produce off soon after harvest, as he most often does for fear of moths and rots, he will be able to realize not less than Rs. 75 behind every ton he preserves (making due allowance for dryage 15 per cent. and rejections 2·5 per cent.). If he tries to preserve them in the methods at present in vogue with him he will realize on the 50 per cent. left about Rs. 90 and this leaves only a small margin of Rs. 30 on the assumption that he does not spend anything on preserving. Fumigation methods may bring him Rs. 45 a ton more than by following his own methods.

Mr. Ramakrishna Ayyar. Can you get the people to fumigate ?

Mr. Ramrao. Fumigation is done in a cemented chamber and the people have also built such chambers. Each costs from 200 to 222 rupees and is all made of cement, with an iron lid. Of course, it is all done on the co-operative system.

Mr. Ghosh. Did you try storage under sand ?

Mr. Ramrao. We did try. It was efficacious against moth but there was more rot.

Mr. Ramkrishna Ayyar. How do you use the petrol ?

Mr. Ramrao. It is poured onto cotton placed in trays at the top of the bags.

Mr. Robertson-Brown. In England the practice is to dig the potatoes early and then to harden them in the sun and then they are stored in a pit. They escape decay to a great extent. I think that storage in trays is also very good ; in trays they do not sprout but remain green. We have no Potato Moth in Peshawar.

Mr. Ramrao. I do not know if the moth is present in England and whether they suffer from the rots we complain of.

Mr. Ghosh. We find that mature tubers keep well [under sand] and therefore they should be dug late.

Mr. Ramrao. That means that the later you dig, the longer the tubers remain in the ground, and the more liable they are to get some disease from the soil.

Mr. Fletcher. Mr. Dutt, have you anything to say ? Have you found any parasite on the Potato Moth ?

Mr. H. L. Dutt. No ; I have nothing to add. We have found no parasite on the moth.

41.—BEE-KEEPING IN INDIA.

By C. C. Ghosh, B.A., *Assistant to the Imperial Entomologist.*

The Usefulness of the Honey-bee.

The honey-bees yield the two very useful products, *viz.*, honey and beeswax. Probably they do more good to agriculture and to plants generally as pollenizing or rather cross-fertilizing agents than as producers of these two substances, although their usefulness in this direction cannot ordinarily be measured by *maunds* and *seers* or valued by rupees and annas. There are plants which do not produce any fruit if their flowers are not visited by bees.

The Natural History of the Honey-bee.

The natural history of the honey-bee is a very fascinating study. Here reference is made to only so much of it as will enable one to understand the drift of this paper.

The bee-colony is made up of the mother-bee called the "queen," a large number of working bees called "workers" and some male bees called "drones." There is a complete differentiation of the work to be performed by the different members. The queen-bee lays eggs from which all bees in the colony develop. She lives for about three years. The workers do all kinds of work, such as building combs, collecting honey and pollen, rearing the brood and every other work necessary for the well-being of the colony. Therefore, the greater the number of workers, the better is the condition of the colony. There may be fifty or sixty thousand of them in a colony, or even more. They however do not live for more than about three to six months. Therefore, in order that the colony may go on, it is necessary for new workers to be born to replace those which die. The queen lays a number of eggs every day and new workers are reared and born every day in the colony. In the daily economy of the bee-hive the drone has no function. In order that the number of bee colonies may increase, nature has provided the bees with instincts which lead the reigning queen to leave the colony at a particular time in the year with about half the number of bees in it and establish a new colony elsewhere. This is called swarming. Before swarming takes place, new queens are reared and are born just after the departure of the old queen with the swarm. The services of the drone are required at this time to fertilize the new queen. The mating of the queen with the drone takes place in the air. The young queen flies out of the hive during the middle of the day for the purpose. A fertilized queen can perform the function required of her in the colony. An unfertilized queen cannot.

In a normal colony there must be a queen and a large body of workers. New colonies can be started with a queen and a few thousand workers. In this manner several colonies can be formed out of one. Old colonies can be carried on for years if they can be provided with new queens when the old queens die or lose vitality. If colonies are re-queened every three years they remain in vigour. In nature colonies requeen themselves at the time of swarming or before old queens die.

In countries where bee-keeping is an established industry there are bee-keepers who make it a profession to rear queens, get them fertilized and sell them to those who want new queens to re-queen their colonies.

The Indigenous Honey-bees of India.

In India three kinds of true honey-bees occur. One is the Rock Bee (*Apis dorsata*), colonies of which build huge single combs, sometimes about 4 or 5 feet in diameter, in open places, on the faces of rocks, on branches of large trees in forests and other localities and sometimes on walls of buildings. Wild tribes or professional honey-gatherers collect their combs, after first of all burning or smoking away the bees. Each comb yields a large quantity of honey (it is said up to about 40 lb.) and wax (up to about $2\frac{1}{2}$ lb.). (Plate 125.)

The second is the Indian Bee (*Apis indica*), colonies of which occupy and build combs in cavities in tree trunks and walls and also in unused boxes. They build several parallel combs side by side and always live in closed covered situations. These are the bees which are kept in the Hill Stations and are capable of being kept in the Plains too.

The third is the Little Bee (*Apis florea*), colonies of which build small single combs in open situations like the Rock Bee, in bushes, under eaves of huts and cornices of buildings, behind doors and windows, in fuel stacks and in various similar situations. The combs are usually small and yield only a few ounces of honey.

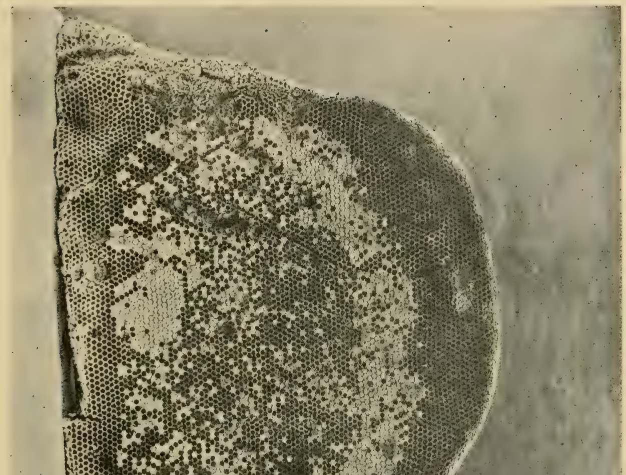
Of all these indigenous honey-bees, practically speaking, only the first two, *viz.*, the Rock Bee and the Indian Bee, produce the whole of the honey and beeswax obtainable in India. Of these two again only the Indian Bee, *Apis indica*, is capable of being kept in hives under domestication.

Bee-keeping as an Industry.

Beekeeping as an industry is carried on principally for honey, beeswax being obtained as a by-product. Let us first of all consider whether it will pay to undertake bee-keeping to produce honey in India.

Uses of Honey in India and how it is obtained.

In India honey forms one of the necessary articles required in most religious ceremonies. Everywhere a little honey is placed in the mouth of the infant at birth. This is considered as a purificatory ceremony, the real usefulness probably being to clear the throat. Honey forms the basis for many preparations and is an important vehicle for almost



Comb of *Apis dorsata* sent from Sabour by Mr. H. L. Dutt. It measured 39 inches in length and 18 inches in depth.

all kinds of medicines in Ayurvedic and Unani *materia medica.* It is very much prized for various medicinal properties of its own. For constipation and colds of suckling infants it is used extensively with good results and is also considered very efficacious against coughs and colds of children generally. For these domestic and sacred uses every family makes it a point always to keep a small stock of this substance. Besides its compulsory use for these purposes, as it is considered to be a very good blood-purifier, when available, some persons sip a little honey every day. A regular use of it is considered to make the system proof against fever and many other ailments. Where procurable it is of course highly appreciated as food. It is used in making "*Gulkand*" or "preserve of rose flowers," in preserving fruits, and for making cakes, sweetmeats, etc., which are intended to keep for some time. In some places vinegar and an alcoholic drink are said to be prepared from it.

Among Europeans honey is used principally as a luxury, being eaten directly with bread or biscuit. It is used by bakers and confectioners on account of its keeping qualities in manufacturing their choicest articles such as honey-gums and various kinds of honey-cakes. It is also used for medicinal purposes in many cough cures and salves and gargles.

The food value of honey lies in its being already digested (in the stomach of the bees) to the extent required for prompt assimilation without taxing the stomach. Cane-sugar cannot be assimilated until changed into grape-sugar by digestion. When sugar is excessively used the stomach sometimes fails to bring about this digestion, the result being sour stomach. The opinion of experts is that this undigested sugar will be removed by the kidneys and it may result in their breakdown, giving rise to what is known as Bright's Disease. Many people who cannot eat sugar, being unable to digest it, can easily digest honey.

As just explained honey is extensively used in India — not usually in large quantities by individual consumers but in small lots by practically every household. The total must be a very large quantity although it is not possible to arrive at any guess which will be near the mark. It is certain that a large quantity of honey is imported into this country although there is no record available about this too. The imported honey, however, is not largely used by the Indian consumers. Enormous quantities of honey are produced in India by the indigenous bees. It is not possible to make an estimate, but the amount will certainly be several million pounds. The defect of this honey is that those who gather it do not know how to take it out from the bees' combs in a pure condition. It therefore ferments soon after being gathered and is reduced to the condition of thin *jaggery* [molasses]. As it does not keep long, in the honey season it is obtainable very cheap, being in many places hawked about and sold at the rate of about eight lb. or even more per rupee.

Besides the hawkers there are dealers in almost all towns who stock large quantities of this thin fermented honey, not for export, but for meeting the demand in the country. The dealers in Calcutta alone sell every year about sixty to seventy thousand pounds of such honey, gathered principally from the combs of the Rock Bee in the Sundarbans. The entire quantity finds its way to the village grocers' shops for retail sale. When good honey is available people are willing to pay and actually pay a very high price. The granulated honey produced in the Hills usually sells at the place of production at the rate of eight to ten annas per pound. The honey produced at the Darjiling Jail sells at the high price of a rupee per pound, because it is guaranteed by the Jail authorities as pure and untouched by hand. The imported honey usually sells at a rupee per pound, although the imported stuff cannot always be taken as pure honey.

Prospects of Bee-keeping in India.

Although the quantity of honey produced by the indigenous bees under existing conditions is considerable, it probably represents but a small proportion of what is secreted by the plants and is possible to be gathered but is wasted because there are not enough and proper bees to gather it. The bee-keeping experiments at Pusa have forcibly demonstrated this. The neighbourhood of Pusa is not apparently very rich in honey, as one would infer from the behaviour of the Indian Bee (*Apis indica*), colonies which never produce more than about six pounds of honey on the average. The maximum quantity yielded by a very large colony worked with very great care was sixteen pounds. But it has been found by keeping Italian Bees that the quantity of honey the locality is capable of yielding is very great.

One year the indigenous bees were allowed to work in the locality and gather honey as they do every year and the approximate number of their colonies would be at least about 500, *viz.*, about 200 colonies of the Indian Bee (*Apis indica*) and about 300 colonies of the Little Bee (*Apis florea*). In addition to what they gathered, two out of three Italian colonies, although worked under certain drawbacks, yielded a surplus of 90 lb. each and the third colony yielded 60 lb. It seemed that if there had been several more colonies they would have gathered similar quantities. Similarly high yields were obtained from the Italian colonies every year during the period they were kept at Pusa. It is probable that every place in the Plains in India, except probably the desert tracts, will prove to be rich in honey. Of the richness in this commodity of all the Hill Stations there cannot be any doubt. Rai Bahadur B. C. Basu, late Deputy Director of Agriculture, Assam, has recorded a yield of 20 to 30 lb. from colonies of the Indian Bee (*Apis indica*) at Shillong. In Hazara, the yield of the same bee is said to be as much as 40 lb. per colony. In India no record is available of the places where large quantities of honey are produced. However, the localities from which the beeswax of the trade (of the annual value of about seven *lakhs* of rupees) is obtained, will give an almost exact idea in this respect. Supplies of Indian Beeswax are chiefly drawn from the following places in the different provinces.*

Bengal.—Sundarbans, Chittagong and Darjiling.

Bihar and Orissa.—Sambalpur, Chota Nagpur and Purnea.

Assam.—Khasi Hills.

The United Provinces.—Eastern Dun Forests and Khari.

The Central Provinces.—Betul, Chanda, Chhindwara, Damoh, Hoshangabad, Jabbalpur, Mandla, Nimar, Raipur and Wardha.

The Punjab.—Bashahr, Chamba, Hazara, Jhelum, Kangra, Kulu and Simla.

Bombay.—Khandesh (Satpura Ranges, etc.) and the Deccan.

Berar—Ellichpur, Mangrul, Melghat and Wum.

Madras.—Bellary, Coimbatore, Cuddapah, Ganjam, Godavari, Kistna, Kurnul, Madura, Malabar, Nellore, Nilgiris, North Arcot, South Kanara, Trichinopoly and Vizagapatam.

Burma.—Bhamo, Chindwin, Katha, Mandalay, Minbu, Pyinmana and Tenasserim.

All of these localities are suitable for bee-keeping and some of them will be found to give large yields of honey. At Pusa the Italian colonies yielded up to 90 lb. Places like Shillong and Hazara will probably yield double this quantity. In Australia in the Basswood forests a yield of 200 lb. per colony is said to be common. Similar yields can be expected in many places in India.

Besides, in India there is a special advantage by which the yield of honey can almost be doubled. In the Hills the principal honey flow s in autumn, in October-November, and in the Plains it is in spring, in March-April. Therefore the bees can be made to gather honey in autumn in the Hills and brought down to the Plains in the spring.

We thus see that bee-keeping in India has a bright prospect before it. There are rich resources of honey and there is a ready market. Profitable bee-keeping will not however be possible until we succeed

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* *Indian Trade Journal*, Vol. XVII, No. 212 (1910).

in introducing and establishing in this country the Italian Bee or a bee of similar quality. Of the indigenous bees, the domesticable Indian Bee is a poor honey-gatherer, is extremely prone to swarming and is unable to protect its hive against the Wax-moth. When the Wax-moth infests a hive, the combs are eaten by the caterpillars and the bees are compelled to run away. The honey-gathering quality of the Italian Bee has already been referred to above and it has been found by actual experiments at Pusa to be able to resist the Wax-moth. To import each colony of the Italian Bee costs about Rs. 100. Importation of colonies on a large scale by intending bee-keepers will therefore not be possible and is not desirable unless through an agency which can check the introduction of diseases. Arrangements have to be made so that colonies may be available at a small cost, say Rs. 10 or 15. For this purpose an apiary with imported colonies should be established in a suitable locality. The colonies can be multiplied and the new colonies which are obtained can be sold to the public. Numerous inquiries are received from the public regarding bee-keeping. If a good honey-gathering bee like the Italian bee can be rendered available in India at a small cost, bee-keeping is expected to make very rapid progress.

In advanced countries various attempts are made to popularize bee-keeping, by teaching apiculture in Agricultural schools and colleges, by distributing popular leaflets, by sending out itinerant lecturers, by holding apicultural shows and through journals and papers devoted to the subject of bee-keeping. In order to contend successfully against bee-diseases (none of which is at present noticeable in India) there are in most countries State agencies backed by acts and regulations. In Australia, in order to provide an outlet for the large quantities of honey produced there, Government has instituted a Co-operative Union in which farmers have shares.

To make a beginning in bee-keeping in this country some persons from different parts may be asked to keep a few colonies after giving them a preliminary instruction at the apiary. Such men will always be forthcoming. They will pay for their appliances as well as for the bees. In this manner the knowledge of modern bee-keeping can be spread without any Government agency.

A small apiary of the kind suggested here was established at Pusa with Italian Bees and worked from 1910 to 1913. At no period of this experiment were more than three colonies available for work and as it was intended first of all to test the yield of honey, there were not sufficient opportunities for multiplying the colonies. As explained above, new colonies can be formed out of existing ones by separating a number of workers with a new fertilized queen. Such a newly-formed small colony is known as a nucleus. Formation of nucleus hives is possible when the colonies become strong in the season of honey flow, which coincides with the hot weather at Pusa in March-April. For nucleus hives the first necessity is a fertilized queen. During the experiment at Pusa 46 attempts were made to form nucleus hives. In 38 cases, *viz.*, 34 between January and May and 4 between August and October, the queens had full opportunities of fertilization but only three of them could mate and come back to the hive, one being in March, one in August and one in October. The loss of so many queens was due to unfavourable climatic conditions principally. The scorching heat and high West winds prevailing during the middle of the day, when the queens went out on their nuptial flight, killed most of them. They did not come back to the hives. Predaceous birds might have snapped up a few but birds are not probably very important. In the hot weather only one queen out of 34 succeeded in mating and returning to the hive, while in autumn two out of four were successful. In autumn however, the honey-flow is very poor at Pusa and queen-rearing operations on a large scale are not possible. All of the three queens reared and fertilized at Pusa were descended from the same mother and mated with the drones of the same colony. Probably on account of inbreeding and, it may be, the enervating influences of the climate, none of them remained prolific for more than a year. But the imported queens remained so for the full periods recorded in other countries. Attempts at importing queens by post from England were not successful. Pusa has proved to be very unsuitable for apicultural operations of the kind necessary for establishing the bee-keeping industry in India. No place in the Plains will probably be suitable. The writer has visited the Hill Stations at Shillong, Darjiling and Naini Tal and to him Shillong seems to be very favourable. An apiary with at least twenty colonies should be started at Shillong, where multiplication of colonies and also rearing of queens for sale can be carried on, both in October-November and in the spring. For imparting instruction to the public an additional apiary in some easily accessible place in the Plains will be necessary later on.

Beeswax.

Beeswax is obtained by melting the honey-combs. The large combs of the Rock Bee and to a less extent the combs of the Indian Bee are the sources of beeswax in India which has an yearly export trade in this substance of the value of about seven *lakhs* of rupees. The wax is gathered from the bees by hill and wild tribes and other professional gatherers. The Forest Department leases out the right to collect the wild combs every year. The small lots of wax are collected from the producers by local agents of firms in big centres like Calcutta. These firms make over the wax to dealers who export the major portion to foreign countries and sell the remainder to meet the demand in the country. The wax trade is almost entirely in the hands of Indians who are mostly the enterprising Marwaris. The export to foreign countries goes through European firms.

The Indian beeswax has acquired a bad reputation for adulteration which can however be prevented. It is not intended to go into thi question in this paper.

Improvements are possible in the method of extracting the wax from the combs. A sample extracted according to improved methods was valued in the Calcutta market at Rs. 85 per *maund* of 82 lb. in 1911, while the best wax extracted according to current methods was selling at Rs. 80.

The supply of beeswax from India will increase with the establishment and progress of bee-keeping as a regular industry. No *data* are available in India to prove this, but a reasonable inference can be made from experience in other countries. The following figures are available to the writer just at present. In 1850 the production of honey and wax in the United States of America was together about 14,800,000 lb. Improved methods in bee-keeping were introduced there in 1853. In 1860 the amount of honey produced was 23,400,000 lb. and that of wax was 1,330,000 lb. In 1900, the amount of honey was 61,200,000 lb. and that of wax was 1,800,000 lb.

Immediate Improvements.

Leaving aside the question of the prospective industry, an immediate improvement in the existing conditions can be effected by the introduction of proper methods in extracting the honey from the wild combs. At present the honey produced in India is not fit to be used as a marketable article. As it does not keep long, it is consumed principally in the localities where it is produced. It can be extracted in a pure condition by the use of "honey extractors" and stocked in vessels, such as properly closed bottles and tins, which will prevent it from absorbing moisture. Then it will not ferment and will fetch its proper price. In this manner several million pounds of a very desirable and highly prized substitute for sugar can be rendered available to the people at large.

Mr. Fletcher. Mr. Ghosh has said that we could not get the queen-bees fertilized at Pusa chiefly on account of the climatic conditions, but I believe this was rather due to the part played by the Bee-eaters.

As regards obtaining better honey-yielders, we must be on our guard in introducing bees from other countries. Most countries outside of India have some bee-disease, and we run at present considerable risk of getting these diseases brought into India by the importation of bees by well-meaning but irresponsible people. I myself know of one case of a man who was keeping bees at Ootacamund and who introduced a colony from abroad. On arrival of the colony he found that it was affected with Foul Brood and, realizing the danger, he burnt the whole lot. But how many people who might send for bees from abroad would do that ? How many would have the knowledge to recognize that the bees were diseased or the public spirit to destroy them ? In England of late years the whole of the South of England has suffered very badly from Isle of Wight Disease, so much so, that I believe that there has been considerable failure in orchards owing to the want of bees to pollinate the flowers. In a country like India, where we have wild honey bees of one or more kinds in every district, a disease, once introduced, would be impossible to deal with. In this connection I think we shall have to consider whether it is not necessary to impose some restrictions on the importation of bees into India. At the time when the Pest Act was under consideration I suggested this, but it was considered that the Act could not be made applicable to bees as they could not be regarded as crops. So we must apparently have another Act to deal specifically with bees and bee-products. In South Africa there are restrictions on the importation of bees and bees-wax. We in India receive honey and probably also wax from Australia and California. Of course, honey does not carry disease unless it comes from infected colonies and is actually eaten by bees.

Dr. Gough. In Egypt the importation of bees is only permitted by license and it is not our intention to get bees from countries where there is disease. Importation from England is not permitted and from Italy only the queens can be imported. Our bee-keeping is conducted principally with *Apis fasciata*, which is a native Egyptian species, smaller than the European bee. It is not a good honey-producer but, when crossed with the Italian bee, gives a very good yield, anything about 60 lb. a year. In the Orient bees suffer from a wasp. To counteract this they produce a large number of queens. The Egyptian bee produces an enormous number, and as many as 365 queens have been taken from one swarm. In Europe six queens, produced by Italian bees, are considered a large number.

When Egyptian bees swarm the first queen goes with the first swarm. This swarm is never large. In the second swarm we get a large number of queens. I have taken as many as 40 unfertilized queens. I remove all except two and so get a fair chance of fertilization. The large number of queens is with a view to accommodate themselves against the attack of birds and wasps. In my opinion an Egyptian hybrid would suit India.

Egyptian bees have another peculiar habit. In honey-bees all the drones are usually slaughtered after the swarming period, but the Egyptian bee keeps the drones right up to the breeding period in the next year. This is a precaution against the loss of the queen by hornet attacks.

In Egypt bees hibernate from September to December. It is then quite warm with us and we have plenty of flowers for them, but the bees go into hibernation on account of the attacks of *Vespa orientalis*. From September onwards this wasp waits in front of the bee-hive and pounces on any bee that comes out. The bees change their daily flight as the result of these attacks. This flight that they make for cleansing purposes takes place at first about midday and it is postponed and postponed till the bees come out after sundown.

The Wax-moth is our other trouble ; it is one of the two great troubles we have in Egypt. It should not occur if the colonies are strong and there is sufficient room for the bees to be able to get about under and above the combs.

Bee keeping is the most important minor industry in Egypt. We have ten thousand apiaries producing an income of £200,000.

Vespa orientalis is probably responsible for the destruction of a half of the colonies. Large sums are spent in catching hornets in front of the hives. I have now invented a trap which is placed in front of the bee-hive with a bait of dates ; the bees can get in and out of it and the hornets can get in but cannot get out.

This year we hope to obtain a credit for Apiary work and we intend starting apiaries in schools. Formerly we used to finance apiary work out of our Experimental Credit.

Mr. Fletcher. What is this Experimental Credit ?

Dr. Gough. It is difficult to estimate in advance the money to be spent on experimental work during the year and we have a system by which a certain sum is allotted to us, not split up into subheads, for labour, purchases, etc. Our Experimental Credit up to last year was £1,000. Research cannot be carried out to a successful issue without experiments and one cannot carry out experiments without Experimental Credit.

Mr. Robertson Brown. How do you kill hornets ?

Dr. Gough. We mark down the nest and pour down carbon bisulphide. The hornets come to the bee-hive along a regular road ; they make a straight line from their nests and we have thus discovered a large number of nests and destroyed them. The nests are built in old walls, *nalla* banks, and vertically down in the desert. The distance that *Vespa* will fly to attack a hive has been found to be as much as five miles in a straight line. *Vespa* makes its nests in a hollow in the wall and the nest projects out. The best way to find it is to look at the foot of the wall and, if you come across a small heap of stones about 1 cm. in diameter, then look above it and you will find a hornet's nest.

Mr. Ramakrishna Ayyar. Anything done to improve the bees at Pusa ?

Mr. Ghosh. We have been trying. But, as I have already said, the greatest yield we have had is 16 lb. and that too from a colony of *Apis indica* which received about three times the care bestowed on the Italian bees here.

Dr. Gough. It will be useful to introduce the Egyptian bastard or the pure Egyptian bee and cross it with the Italian bees. I can guarantee that it is free from disease, and you get a good quantity of honey.

Mr. Ramakrishna Ayyar. Probably there would be increase in yield if we had a cross between the Egyptian bee and the Indian.

Dr. Gough. The Egyptian bastard or Egyptian pure honey-bee gives quite a good yield.

Mr. Ramakrishna Ayyar. Father Newton has done some work on the Indian bee (*Apis indica*) and he has no idea of importing bees from outside. *Apis indica* can be trained to work better.

Mr. Fletcher. He inquired from us lately as to where he could get good bees from outside of India.

Mr. Ghosh. If you read his article you will find that his yield is the same as mine and he is not so hopeful as you think.

Dr. Gough. The Cyprian bee does as well as the Italian. It produces forty to fifty queens and so there is a chance of getting a fertilized queen.

Mr. Kunhi Kannan. We require smaller frames for the Indian than for the European bee.

Dr. Gough. Our bees work on the European foundations and that is an advantage.

Mr. Fletcher. We have our own machine and can make our own foundation-comb to suit *Apis indica.*

Mr. Ghosh. *Apis indica* also produces many queens, about thirty. Unless we import colonies by Government agency we cannot do anything. It should be remembered that, unless this is done by Government, which can check the introduction of disease, diseases are sure to be introduced one day by private people.

Dr. Gough. It is dangerous to introduce honey-bees or honey-food and it is particularly dangerous to feed bees on imported honey owing to the risk of introduction of bee-diseases.

Mr. Fletcher. I think we might have a Resolution to that effect. I therefore propose the following Resolution :—

Resolution 2. **"This Meeting considers that there is considerable danger of the introduction into India of bee-diseases by the unrestricted importation of bees, beeswax and honey from countries infected with such diseases, and that such importation should therefore only be permitted under necessary restrictions."**

Mr. Ghosh. I second that Resolution.

[*The Resolution was thereupon put to the Meeting and carried unanimously.*]

Dr. Gough. As to the loss due to the attacks of Wax-moth, my idea is that the Wax-moth attacks when the colony gets weak; when you have a really strong colony, the Wax-moth larvæ will never feel happy inside the combs. So keep your colony numerically strong. It is always useful to keep one inch space between the bottom of the hive and the lower bar of the comb, so that the bees have enough space to go under. At the bottom of the hive-box there is always some *debris* accumulated in which the Wax-moth caterpillars are sometimes found to live and thrive; if the lower bar of the comb be very near the bottom of the box, the caterpillars will crawl up and attack the comb.

42.—LAC-CULTURE IN INDIA.

By C. S. MISRA, B.A., *First Assistant to the Imperial Entomologist.*

From ancient history it is known that lac has been cultivated in India since very remote times. The very name of Palas (*Butea frondosa*) *Laksha-taru*, shows that the ancient people of India knew the tree to nourish a *Laksha*—one hundred thousand insects. From ancient literature it is also evident that the Rishis of India prohibited the use of such *Laksha-taru* twigs as had small scarlet excrescences on them—possibly the lac encrustations. In the *Mahabharat* in the *Adi-Parva* when the Kauravas meditated destruction of the Pandavas they requisitioned the services of the architect Purochak to construct such a house which would destroy them. Purochak, therefore, decided to build a house of Lac which when once ignited would soon catch fire and prevent the Pandavas from escaping. Early in 250 A.D., Ælian mentioned that there was an insect in India which yielded colouring matter. We also find Lac mentioned in *Ain-i-akbari.* In 1590 Akbar, the Great Moghal Emperor, laid down rules for the proper making of varnish to be applied to the doors of palaces. We have the first descriptive account of the resin from John Huyglen von Linachoten when he was deputed in

1596, by the King of Portugal, on a scientific mission to the East Indies. Abu Hanifa also mentions it and recommends its use as a medicinal thing. In 1781 Dr. Kerr in the *Philosophical Transactions*, Vol. LXX, p. 574, was the first to describe the lac insect. Nine years later in 1790 Dr. Roxburgh in the *Asiatic Researches*, Vol. II, pp. 360-366, gave a detailed account of the life-history of the lac insect. Ten years later Dr. Buchanan-Hamilton was the first to publish a detailed account of the propagation and cultivation of lac in India, and three decades after Dr. Carter in 1861 gave an account of the internal anatomy of the insect and this account was reproduced by Mr. J. E. O'Conor in his Note on Lac Production, Manufacture and Trade. Of late a large amount of literature has appeared, but this relates to lac either grown or collected in the forests. There is very little comprehensive information regarding the industry as pursued in the Plains of India and from what I have seen there are reasons to believe that this aspect of the industry is very widespread in the Plains and provides means of subsistence to thousands, if not millions, of the poor illiterate masses—especially the aborigines who inhabit the outskirts of forests or the interior of districts where the host-plants of the lac insect abound. The information regarding cultivation in the Plains lies scattered in the District Gazetteers or the Revenue Reports which are practically inaccessible to the public. But for all this, the industry is very important to an agricultural country like India, where, I know from personal observations, it forms an important adjunct to agriculture and as such helps the cultivators in such areas to tide over financial stress at a time when rates are low and climatic conditions are against them in disposing of their produce in the market. That the cultivation is widespread and important is evident from the export figures of shellac from the Port of Calcutta alone. As I have already pointed out in my article on "*The Present Condition of Lac Cultivation in the Plains of India*" (*Agri. Jour. India*, Vol. XIII, Part III, July 1918) the exports of shellac from the port of Calcutta only have been as follows during the past twelve years :—

Years	Cases	Weight in Maunds (80 lb.)	Price per Maund	Total value
			Rs. A. P.	Rs. A. P.
1905 . .	157,536	339,840	87 0 0	3,22,64,080 0 0
1906 . .	156,502	391,255	107 0 0	4,18,64,285 0 0
1907 . .	206,789	516,972	102 0 0	5,27,31,144 0 0

Years	Cases	Weight in Maunds (80 lb.)	Price per Maund			Total value		
			Rs.	A.	P.	Rs.	A.	P.
1908 . .	222,112	555,280	57	8	0	3,19,28,600	0	0
1909 . .	322,006	805,015	37	8	0	3,01,88,062	8	0
1910 . .	289,996	724,990	40	8	0	2,93,62,095	0	0
1911 . .	235,339	588,347	37	0	0	2,17,68,839	0	0
1912 . .	254,141	635,352	34	0	0	2,19,19,644	0	0
1913 . .	191,993	479,982	46	0	0	2,20,62,842	0	0
1914 . .	231,831	579,627	35	8	0	2,05,76,658	8	0
1915 . .	243,502	608,755	34	0	0	2,06,97,670	0	0
1916 . .	236,681	591,702	55	0	0	3,25,43,610	0	0

Thus on an average over 550 thousand maunds of shellac worth about 3 crores of rupees are sent out yearly from the port of Calcutta only. The figures of exports from the ports of Bombay and Karachi are not available. If these were available it would have been seen that over 700 thousands maunds of shellac, worth over 4 crores of rupees, are sent out of the country. To produce so much shellac annually at least 140 millions lbs. of stick lac must be utilized. If to this be added the internal consumption, which is by no means small, it would be found that the total yearly produce of stick-lac must be not less than 170 to 200 millions lbs., and if we take the yearly average individual production to be 200 lbs. at least 280,000 persons must be deriving their subsistence from the industries, besides a horde of manufacturers, brokers, salesmen, shippers, wharfmen, etc., the numbers of persons directly or indirectly benefitted by the industry will be found to be very large indeed. But in spite of all this, nothing has been done in the past to resuscitate the industry and put it on a sound basis. There is still an element of uncertainty in the whole business which at the present time is more or less of a speculative nature and thus deters a large number of persons going in for it. There is a very trite Hindi saying "*Lakh nahin to' khak*" apply illustrating the speculative nature of the industry. And the wonder is that with all the uncertainties of a precarious crop and ever-shifting market, the industry has been able to hold its own against various circumventing factors which at various times seemed to engulf the industry and reduce it to the same status as a once-flourishing Indian industry has been reduced to now-a-days. What and in what direction this vitality has lain is known to those who have paid any attention to the industry for some time. The e are years of depression as well as inflation, but with all this the industry has existed and is likely to exist for some time to come. Whether this will continue for ever only futurity can decide. But I am sanguine, if proper measures will be taken to safeguard the industry even so late as now, the possibility of the disturbing factors operating early will at least be avoided or indefinitely postponed. The industry has of late assumed a very precarious aspect. Hundreds are benefitted suddenly, whilst equal numbers, if not more, are more or less affected adversely annually. So great is the element of uncertainty that few dare to risk their money either in cultivation or in manufacture, and the fact is borne out by the low prices prior to the breaking out of the present war when the minimum of Rs. 32 per maund of shellac was touched. During the great war fresh uses were found for the commodity and prices rose by leaps and bounds, so much so, that the maximum of Rs. 135 per maund was touched for a few days. There was a general scramble ; the cultivator as well as the manufacturer was anxious to make the most of the temporary swell in prices. The former went hunting every nook and corner of the lac-producing areas and, I am told, in particular lac-growing tracts so great was the rush that even fairly large-sized trees were cut down for the sake of a few *seers* of lac on them. But from what I have been able to gather, the cultivator was not much better off than he was before. He got some but not the amount commensurate with the labour and risks risked by him. An instance of this I can cite from my own experience while visiting the forests in Singbhum with the late Mr. Charles Macdonald, who had taken a contract in those forests in 1908-1909. We saw the Kols living in very remote corners of the inaccessible forests, looking after a few *kusumb* trees on the banks of a *nalla* frequented by all sorts of wild beasts. We saw a Kol guarding the trees right in the middle of December with hardly any covering over his body, except a miserable thatch constructed from twigs and grasses collected locally. At the present time, as well as in the past, the middleman has benefitted himself the most, doling out a miserable pittance to the all-important cultivator who risks all, even his life, for the sake of a few *seers* of crude lac on the trees. Hitherto the cultivation has been confined to India, Burma and to some extent Indo-China, Annam and Cambodia. But the majority of the world's demand is met with from India. Recently attempts were either made or are being made to grow lac in Formosa by the Japanese on *S. trijuga*, a tree which grows in numbers there as a shade tree to camphor trees, by the Germans at Amani in South-East

Africa and to some extent in Egypt. That the industry is an important one in Indo-China (Tonkin, etc.) is shown by the fact that a detailed account of cultivation, refinement and manufacture of lac is given in *Bulletin Economique de L'Indo Chine*, No. 116, November-December 1915, pp. 872-944. Here the methods of refinement are very much like those adopted in this country, excepting that a wider use is made of the essences obtained from the bye-products of lac. The writer in the bulletin quoted above has summarized the industry in Tonkin and has largely drawn upon the Lac Bulletin issued by me in 1912. The processes of refinement in that country appear to be the same as those adopted in this country and it is rather strange to see that the methods of manufacturing shellac adopted in that country are as antiquated as those adopted in this country and seem to be a copy of those adopted in this country from times remote.

Besides the lac produced in India, there is another kind of resin produced in Madagascar by *Gascardia madagascarensis*, Targioni-Tozzetti (Tar. Tozzetti, p. 425, 1894). This fact was first brought into prominence by M. A. Gascard in 1893 (*Contribution à l'etude des Gommes Laques des Indes et de Madagascar, D'edit. Sci. Paris*, also *Bull. Soc. Ent. Italy*, Vol. XXVI, pp. 457-464, 1894). But the insect producing this differs considerably from that producing lac in structural details.

Lac was first sought after when the prices of cochineal rose high. As is known cochineal is used for dyeing silk and even now, when the prices of the colouring matter are very high, it is still used for giving those delicate shades to silk which cannot be done with synthetic dyes. In the beginning, lac met with the same fate as tea, where the decoction was thrown away and the boiled leaves were used for chewing. In this case the resin was not utilized commercially and was considered a waste product in much the same light as lac dye has come to be considered now-a-days. From 1814 lac-dye began to be exported in increasing quantities. The maximum was reached in the years 1822, 1824 and 1826 when 760,729 lb. were exported. The exports began to decline rapidly from 1882-1883 until it became practically extinct in 1896-1897. In 1900 the total quantity of lac-dye exported was only a ton. Corresponding to this decrease, the resin in the form of shellac has been rising continuously. The figures for the twelve years 1905-1916 have been already given above.

From those figures it will be seen that over 591,702 lb. of shellac worth 3,25,43,610 rupees were exported from the port of Calcutta only. Had such figures been available for the other Indian ports, Bombay, Madras and Karachi, it would be safe to reckon the total production together with the internal consumption to be not less than 60 million lb. of shellac. To produce this quantity of shellac, 160 to 170 million pounds of crude lac must be produced yearly to meet the increasing demand, and as fresh uses are being found every year there is every likelihood of the consumption being increased. But with increased consumption the prices are bound to rise and if these go beyond a certain limit, as was the case with cochineal, the attention of the consumers is bound to be attracted to a cheap substitute. I may here inform you that the greatest danger in this direction was the German exploitation of this old Indian Industry and everyone interested in the Industry was conscious of this possibility, just as has happened in another old Industry, Indigo. But now that the great war is over and schemes are being considered for development within the Empire, I am sanguine, some steps will be taken to resuscitate the industry on thorough scientific and business principles, which will be both profitable to all the parties concerned in the cultivation, production and consumption of the article. Hitherto the lion's share of the profits has gone to the manufacturer and the middlemen, factors which contribute very little to the resuscitation of the industry and amelioration of the condition of the poor, illiterate cultivators who, in some localities, risk their lives for the sake of a few lb. of the crude material, and you would be perhaps astonished to hear that whilst during the war the prices of a maund (82 lb.) of shellac touched their highest watermark of Rs. 135 per maund, the only visible increase obtained by the cultivators in remote corners of regions producing lac was only an increase of two to five annas only. Prior to the breaking out of the great war, the prices had touched their lowest, *i.e.*, Rs. 27 to Rs. 32 per maund and by the end of the war they had gone up as high as Rs. 135 a maund. With an improvement of about 500 per cent. on the manufacturer's side the improvement on the cultivator's side has been less than 50 per cent. even. This is a wide gap to be reconciled and I don't think it is possible to effect any appreciable changes in the near future. The machinery at present operating has been in existence since time immemorial and it will be hard, if not impossible, for any industrial reformer, private or official, to effect any appreciable change within the span of his official life. All that he can do is to touch the remotest fringe and to leave the future for further improvement to be effected by more workers in the cause imbued with fresh energies and ideas to establish the industry on sound economic lines.

As I have already pointed out in my article in the *Agricultural Journal of India* (Vol. XIII, Part III, July 1918, pp. 405-415) the treatment of seedlac with an alkali worth only a few annas practically doubled the prices, and I cannot do better than once more quote here in *verbatim* the report on the samples by Messrs. Parson and Keith, Brokers, London.

—	*Untreated*	*Treated*	REMARKS
Kusumb (*Schleichera trijuga*).	45s. per cwt.= Rs. 24-11-3 a md. (82 lb.) (Good quality, only a limited sale.)	85 s. per cwt.= Rs. 46-10-9 a md. (82 lb.)	Very fine, bold clean seed-lac. We have not seen any as good as this before here. There would be a good ready sale here if the price could compete with fine orange shellac and Karachi seedlac. In Karachi there is a fairly large business done, but this quality would be preferred by buyers.
Palas (*Butea frondosa*).	35s. per cwt.= Rs. 19-3-6 a md. (82 lb.) Small stick-lac not very saleable.	75s. per cwt.= Rs. 42-2-11 a md. (82 lb.)	Good quality, pale seedlac rather small. The same remarks apply to this.

"Before speaking with absolute certainty, we shall have to test the samples...... Shipment of 20 to 25 bags of each quality."

This shows what could be done to effect improvements consonant with the requirements of the consumers, thereby benefitting the producers, whose income from innovations is bound to improve, thereby giving them fresh impetus to improve their hereditary industry instead of congregating in numbers in the already congested towns in search of employment. I think what has been done barely touches the fringe of the present as well as the future requirements, and brings to the fore the question of more workers with fresh ideas to tackle the problem in its varied aspects. The subject, I think, can be taken up for the present in its three broad aspects from (1) biological, (2) chemical and (3) mechanical aspects and I think I should not detain you any longer with minute details of these.

But before coming to a fuller consideration of the three aspects of the industry mentioned above, it would be well to get a glimpse of the industry as it stands at present in the various provinces of India. As regards cultivation and collection of stick-lac, Assam, Bihar and Orissa, and the Central Provinces rank foremost. Thereafter come the other provinces such as the United Provinces, the Punjab, Bengal, Bombay, etc., and I cannot do better than give a short account of each province.

Assam. The districts where lac in quantity is grown or cultivated are :—Sibsagar. Nowgong, Cachar, Kamrup, Garo and Khasi Hills, North Cachar Hills, Sylhet, Darrang, Lakhimpur and the Native State of Manipur. The chief *hâts* are Palasbari, Chhayagaon and Boku. The main host plants of the lac insect are *Cajanus indicus, Grewia, Kydia* and *Ficus* spp.

Bihar and Orissa. The districts where quantities of lac are collected are :—Palamau, Singhbhum, Sonthal Parganas, Manbhum, Gaya, Hazaribagh, Sambalpur and Lohardaga. The chief centres of lac are Daltonganj, Haripur Hat, Purulia, Jhalda, Ranchi, Goilkera and Chaibassa. Fifteen thousand maunds are said to be produced yearly in the Palamau District, 12,000 maunds in Gaya, 2,000 maunds in Hazaribagh, 15,000 maunds in Purulia, and there is great room for expansion in these as well as other adjoining districts.

The chief hosts of the lac insect are *Butea frondosa, Schleichera trijuga* and *Zizyphus jujuba.* During 1917-18, the lac exports from the province were worth Rs. 13,38,000 (*vide Report on Trade of Bihar and Orissa*, 1917-18). In my opinion there are great possibilities of development in this Province alone, provided the host plants of the lac insect are utilized to their utmost, better methods of cultivation and collection are practised, and provided there are better facilities for obtaining healthy brood-lac near at hand and in sufficient quantities at the required time. I know from personal experience that there are vast areas full of *Palas,* and if these are utilized fully the total produce from this Province only will nearly equal the quantity produced throughout the country excepting the Central Provinces, which regarding lac cultivation no doubt occupy the premier position and like this province await development on proper lines.

The Central Provinces. The districts where quantities of lac are collected are :—Raipur ; Bilaspur ; Saugor ; Mandla ; Hoshangabad, Sobhapur, Babai, Barkhari, Futtahpur ; Damoh, Narsingpur, Jabbalpur ; Balaghat ; Bhandara ; Seoni and Betul. The main food-plants are *Zizyphus jujuba* and *Z. xylopyra, Butea frondosa, Schleichera trijuga* and *Acacia catechu.* The south-eastern parts of the province contain a large number of *S. trijuga* trees which produce the finest lac from which pale-yellow or orange shellac is manufactured. The province as a whole could supply from 54 to 60 million lb. of stick lac if properly worked. Nearly the whole of the produce was sent to Mirzapur, but now a great portion finds its way to Calcutta. Besides these, there are considerable areas in Berar where lac is locally cultivated and collected, especially the Nandurbar forests, and as this area abuts on the Hyderabad State, where active steps are now being taken to start lac cultivation, there is every possibility of this area becoming an important lac-growing centre in course of time.

The United Provinces. The cultivation and collection of lac in these Provinces are not so extensive as in the Provinces noted above. Lac is, however, locally collected in the Garhwal Forests, Saharanpur (a part only), Kheri, Pilibhit, Kumaon, Gonda, Bandelkhand, Bahraich, Siwalik range, Rae Bareli and Partabgarh. The host plants are *Butea frondosa, Ficus* spp. and *Zizyphus xylopyra.* Besides these, there are small collections which are utilized locally for the manufacture of toys and bangles. The climatic conditions are in some localities a bar to the further extension of the cultivation, but on the other hand there are places which are quite suitable for cultivation provided good and cheap broodlac is at hand to be put on the *Palas* trees which abound in the plains districts. Mirzapur is an important centre of lac cultivation and manufacture and for nearly a century it was the only centre of shellac manufacture in Northern India. Even now, in almost all the factories in Calcutta, Ranchi, Purulia and other shellac-manufacturing places, the expert labour is wholly drawn from Mirzapur. These people move in families to remote places to earn their livelihood as shellac manufacturers and some of them are so clever that they cannot be displaced easily by local men without jeopardizing the interests of the manufacturer. The hilly, as well as the submontane tracts, as well as those adjoining the Vindhya mountains should suit for the propagation of the lac insect, but actual experiments have to be made to prove this.

The Punjab. As in the United Provinces, there are large tracts wherein regular cultivation and collection are practised. There are local collections in Gujrat, Ambala, Jalandhar, Hoshiarpur, Gurdaspur and the Kapurthala State. In Hoshiarpur, it is said, three to four thousands of maunds are collected locally and the produce finds its way to the shellac factories at Amritsar. Lac is found growing spontaneously on *Ficus* spp., *Butea, Acacia* and *Zizyphus.* On the whole the collections are not very large, but in some tracts the host plants are present in numbers and only experiments can show whether these could be used for the propagation of the lac insect, so as to yield some income.

Bengal. Lac to some extent is grown and collected in the districts of Birbhum, Murshidabad, Bankura, Midnapur and Rangpur. The host plants are *Butea, Zizyphus* and *Schleichera.* There are considerable areas in Birbhum, Midnapur and Bankura districts which could be utilized for lac cultivation as these abound with *Butea frondosa* plants. In the Murshidabad district, *Z. jujuba* plants are grown on field embankments and are annually inoculated with lac which the cultivators purchase in the local *hâts.* The system of cultivation is quite unique and I have not seen anything like this attempted in other parts of India. The plants are pollarded very carefully and inoculated with lac when they have got a number of long, succulent stems. The plants appear very trim, bushy and luxuriant in growth with a good number of healthy stems. The produce from the trees is either reserved for seed or scraped and sold locally. The little extra income that the cultivator gets is used to pay the rents, leaving the produce of the fields for the use of his family. A cultivator having 10 to 20 trees pollards 10 trees during December when they are dormant and utilizes the broodlac from the other trees for inoculating them in June and selling the surplus as broodlac in the local *hât*. In this way, he seldom gets seed from outside and is able to utilize the *Zizyphus* trees fully for the production of lac. When the market rates for stick-lac are high, the cultivator is able to pay off the rents from the sale proceeds of his trees, without having the necessity of obtaining money on loan. In pruning, inoculating, cutting and scraping lac from trees on his field-embankments, the cultivator is assisted by the members of his family and has not to pay for extra labour. This leaves him an ample margin wherewith to continue the cultivation from year to year. An extension of this system widely throughout the districts and the adjoining places is bound to improve the material condition of the cultivators, as with the sale proceeds of the subsidiary produce they will be able to pay off the rent, thereby retaining the produce of the fields entirely to themselves. In doing this not much time or labour is required and the whole work is managed easily by a cultivator assisted by the members of his family. At least I was much struck with the way the whole work was carried on and I wish this system could be adopted in other similar tracts of land where rice is the principal crop.

Bombay. In the Presidency not much lac is either grown or collected, but whatever little is obtained it is collected in Kolaba, Surat, North Thana, Central Thana, South Thana, Panch Mahals, North Khandesh, West Khandesh, East Khandesh, Nasik, Satara, Ali Rajpur, Udaipur, Deogad, Baruja and Hyderabad in Sind. The principal foodplants are *Butea*, *Ficus* spp., *Schleichera*, *Zizyphus jujuba* and *Z. xylopyra*, *Albizzia lebbek*, *Acacia arabica*, *Acacia catechu*, *Xylia dolabriformis*, *Prosopis spicigera* and *Eugenia dalbergioides*.

In Sind lac grows on *Acacia arabica* in the Jerruk forests near Hyderabad. Besides this tract, I have not seen any other tract where lac is found growing by itself on the *Acacia trees.* The reason why the insect should not flourish on the same food-plants, say in the north of Sind, is not known. In the neighbourhood of Hyderabad in Sind the insect is said to flourish well on such trees only as are either low in vitality or are about to die. The reason why the insect should show partiality for such trees only is not known. I think in the first place it has to be ascertained whether such a statement is true. I have heard some such thing repeated very often, but had not the time or opportunities to investigate the truth of the observation. Anyhow, it remains to be tested by actual experiments whether the insect will propagate itself on seedlings raised from seed broadcasted in areas adjoining the present lac-producing areas and whether the broodlac raised on these could be utilized for propagation in the northern parts of the province. In this connection it has also to be determined whether the influence of subsoil water has any effect on the growth of the lac insect on *Acacia* trees, and whether the alkalinity of the soil is in any way connected with the growth or deterioration of the lac insect or not.

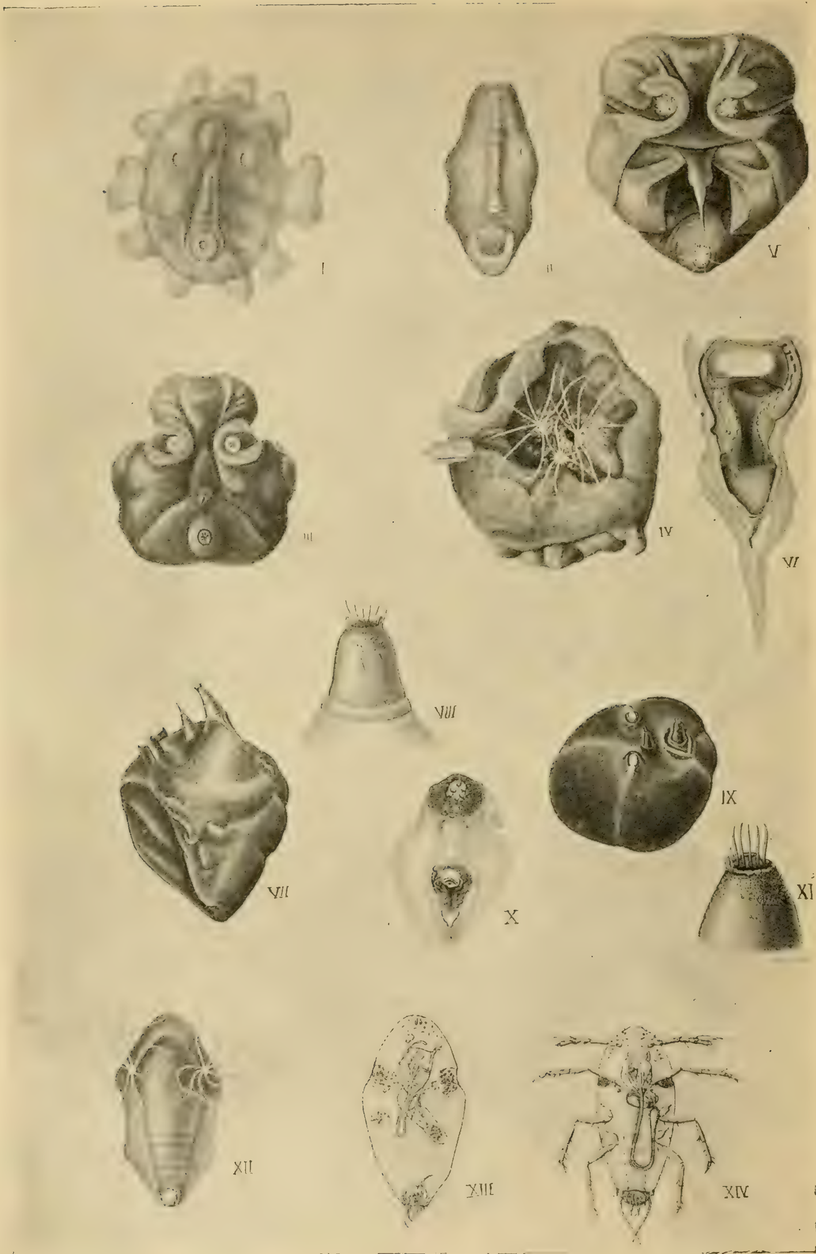
Madras. Local collections only are made in Kanara and Mysore on *Shorea talura.* Some lac is also grown and collected in Ganjam and Jeypur State. There are also local collections in the Omarkote range within an area of 200 sq. miles. The majority of lac used in the Presidency is obtained from Burma and the silk-dyers prefer Burma lac which is richer in colouring matter than the Indian stuff. The lacquer workers at Channapatna utilize the lac grown and collected locally. Some lac is also grown in Nandidrug as well as at Anekal and Closepet in the Mysore State on *Shorea talura.* In Travancore, collections are made in one forest range only, the foodplants being *Odina wodier, Ficus religiosa, Careya arborea, Spatholobus roxburghi.* But with the organization of the Industries Department in the State, considerable attention is being paid now to the cultivation on scientific lines within the State, and it is expected that the suitable portions of the forest may be soon utilized for the production of lac in quantities to meet the local demands as well as those of the neighbouring Presidency.

Ceylon. The Ceylon Agricultural and Horticultural Society sent an Agricultural Inspector for training in lac at Pusa and on his return experimental cultivation was started on *Zizyphus jujuba* (Ceylonese-*Masan*) and *Schleichera trijuga* (Ceylonese-*Kon*) and it was reported that the lac insect had flourished well on the latter foodplant, but later on *Eublemma* sp. did considerable injury to lac on trees.

Burma. Lac in considerable quantities used to be collected and exported in the form of stick-lac which contained more colouring matter than Indian lac. But now the exports have fallen off considerably. It is collected in Thayetmyo, Prome, Tharrawady, Henzada, Arakan, Upper Chindwin and Southern Shan States. In one year a set of villages in the Pakoku Chin Hills produced 100,000 lbs. during a year. Large quantities are collected on the borders of the Shan States and brought into the country to be either exported along with Burma lac or turned into shellac. The produce of the tract bordering on Indo-China finds its way into the interior and is exported chiefly to India along with Burma lac. The country as a whole has great possibilities of development, and if properly worked, is likely to yield large quantities of stick-lac which could be utilized for the manufacture of seed-lac or shellac. Next to Assam, the Central Provinces and Bihar and Orissa, Burma bulks large and is capable of producing half, if not more, of the normal requirements of the country. Lac from Burma is used largely in Madras for dyeing silk and to some extent wool. The foodplants of the lac insect are *Pithecolobium*, *Cassia*, *Zizyphus*, *Dipterocarpus*, *Shorea obtusa*, *Schleichera*, *Albizzia*, *Tamarindus*, *Butea*, *Cæsalpinia*, *Dalbergia ovata* and *Xylia*.

Central India. Lac in some quantity is also collected in the Native States of Rewah, Nagod, Maihar, Chhattarpur and Pannah. Attempts are also being made at Rutlam and Gwalior to grow lac, but how far the experiments have been successful is not known. In Rewah considerable quantities are collected in the forests and worked into shellac in the factory at Umaria. But since last year the out-turn has fallen off considerably, due no doubt to the intensive system of collection practised in the previous years.

From the above it will be seen that lac is found in most of the provinces of India and that in the majority of cases no attempts are made to grow the insect on its foodplants. Whatever quantity is found to grow on the plants is collected and sold to the nearest dealer in stick-lac. In the majority of cases the collection is done by aboriginal tribes who inhabit the outskirts of forests. These people barter lac for salt, cloth or trinkets or such other small luxuries of life. The *bania* or the local dealer collects the local produce and sells it to another merchant who sends it either to Mirzapur or to Calcutta. The actual producer has no dealings with the manufacturer and the result is that the major portion of the profits is appropriated by the middleman. From the above it will also be seen that the greater portion of lac brought for sale is collected as it is found growing on its foodplants and that no attempts have been made to cultivate the insect on scientific and business lines. That the insect can be propagated and its range of distribution extended has been amply demonstrated in various localities and full details for propagating it are given in the Bulletin on the "Cultivation of Lac in the Plains of India," (Revised edition, Agricultural Research Institute, Pusa). If the lines of work laid down therein are followed, it will be found that localities where *Palas* (*Butea frondosa*), *Schleichera trijuga* and *Zizyphus jujuba* plants abound, could be utilized for the production of lac. The result will be that plants which have ceased to be of any economic value now will yield fairly good returns on the amount invested in developing the cultivation. Besides this, there will be the advantage of improving the material condition of the people, especially the aborigines inhabiting the forests, and steadying the market. The present violent oscillations in the prices of the crude material would be avoided if not completely eliminated and the possibility of the introduction of synthetic or other cheap substitutes would be postponed indefinitely. Much could be done to extend the cultivation of lac by starting suitable measures for the distribution of healthy broodlac at proper times and at cheap rates so as to enable even the proprietor of a few trees only to inoculate his trees. At the present time it is practically impossible to obtain good, healthy and cheap broodlac for inoculation purposes. The prices charged are not only exorbitant but prohibitive as well. I know from past experience that when stick-lac was quoted at Rs. 20 per maund in Calcutta, the prices charged for Kusumb broodlac were ranging anywhere between Rs. 40 to 60 per maund, and as it is known that the greater portion of the stuff consists of wood and colouring matter, the actual price of resin obtained by scraping the broodlac sticks works to a prohibitive figure. This to my mind has been mainly responsible for limited cultivation and subsequent production. I know for a fact that a large number of cultivators go long distances from their places in search of healthy broodlac. They sometimes resort to hilly tracts where they think they will be certain of obtaining healthy broodlac at fair rates. In some places the lac cultivators having obtained abnormal prices for their crude material have taken the trouble of exchanging their broodlac with others living in hilly tracts or in localities where the broodlac is considered to reproduce well. With so many obstructions and with an ever-changing market, it is no wonder that the cultivation should have remained in so precarious a condition as is the case at the present time. Thus it seems reasonable that in any scheme of future development of cultivation, the provision of nurseries in suitable localities should not be lost sight of. Besides this, facilities for the transport of broodlac are so cumbrous and the freight charges so heavy that it is not only impossible but risky to import broodlac from other localities. I have personally experienced the trouble of obtaining broodlac from places other than Pusa. The lac cultivators are at first reluctant to undertake the work of packing and sending out parcels of broodlac by rail. The question of despatch by post is prohibitive on account of the heavy postal charges. If, however, they are induced to undertake such work, the transport difficulties are so great that all the efforts end in failure. I have seen instances where crates containing broodlac have been allowed to lie on railway station platforms in the sun for days together before they were despatched to their proper destination and,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EXPLANATION OF PLATE 126.

Lac insects.

Fig. 1. Test of female—150-155 days after inoculation, $\times 32$.

Fig. 2. Male puparium—150-155 days after inoculation, $\times 19$.

Fig. 3. Test of female teased out of resinous cell—151-156 days after inoculation, $\times 32$.

Fig. 4. Test of female—175-182 days after inoculation, $\times 32$.

Fig. 5. Test of female teased out of resinous cell—175-182 days after inoculation, $\times 27$

Fig. 6. Basal portion of anterior stigmatic process of female test—(much enlarged).

Fig. 7. Test of female teased out of resinous cell—207-212 days after inoculation, $\times 27$.

Fig. 8. Anal process of female 207-212 days after inoculation—(much enlarged).

Fig. 9. Test of female teased out of resinous cell—238-243 days after inoculation, $\times 10$.

Fig. 10. Anterior stigmatic process of female—238-243 days after inoculation—(much enlarged).

Fig. 11. Anal process of female—238-243 days after inoculation, $\times 27$.

Fig. 12. Test of female—58 days after inoculation, $\times 32$.

Fig. 13. Test of female teased out of resinous cell—58 days after establishment, $\times 32$.

Fig. 14. Male puparium (ventral view)—58 days after inoculation, $\times 47$.

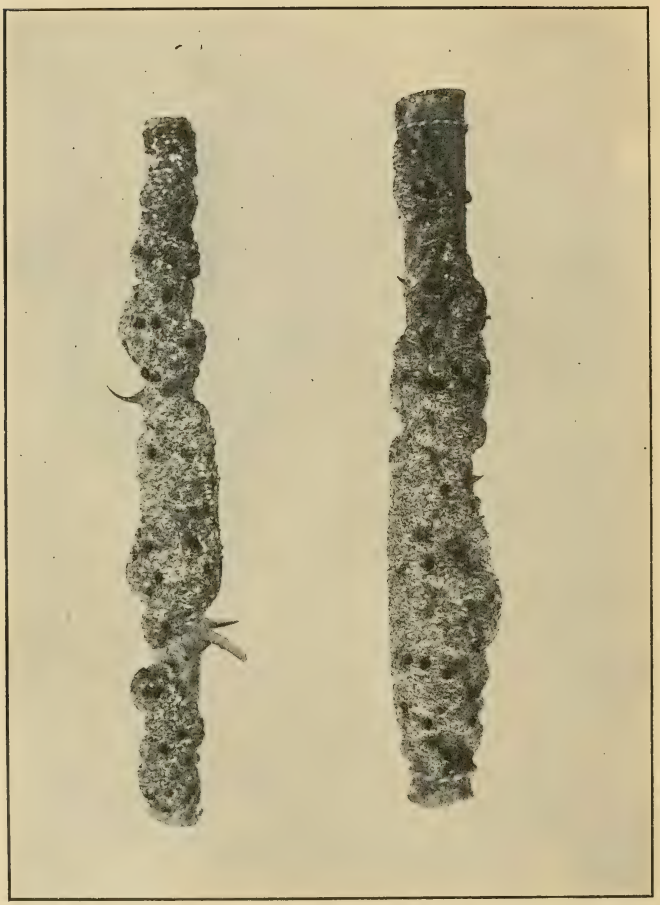
Figs. 1—11 are of lac on Ber (*Zizyphus jujuba*).

Figs. 12—14 are of lac on Kusumb (*Schleichera trijuga*).

as everybody knows, if broodlac is exposed to the sun for a number of hours, the resin melts, the holes of exit for the larvæ are closed and they are unable to emerge. Besides this, with heat fermentation sets in in the body contents of the females and the result is that the nymphs are stifled to death with heat and are unable to emerge. The railway authorities are perhaps unconscious of this fact, otherwise proper precautions would have been adopted by them to ensure safety of the broodlac crates entrusted to them for transport. Because the question has an important bearing on the problem of future development of the lac industry, I have thought it proper to touch upon it here, and I am sure something will be done to remedy the present state of things.

With the question of the establishment of nurseries, the task of establishing the species of the lac insect is of profound interest. A thorough study of the question in all its aspects is bound to yield data of considerable economic importance. With the fixation of species it would be possible to extend the cultivation of the particular species in well-defined areas and therefrom to extend the cultivation. This work was anticipated and collections were made from all parts of lac-producing areas in India with the collaboration of the forest officers. This collection is at Pusa and requires to be worked through. Specimens, both dry and wet, have been collected of cultivated as well as of wild lac and have been preserved. In this way a vast collection has been got together and could soon be worked through. As is well known, with the fixation of species found to occur within the important lac-producing tracts as well as elsewhere, the fixation or knowledge of the swarming of larvæ in both the seasons is very essential to the development of cultivation. With the fixation of species and the periods of swarming of larvæ in particular tracts, the work of expansion would be considerably facilitated and broadened. When this has been done it will be time to look after the details of cultivation. As is well known the introduction of lac into the market came after the price of cochineal—which was used for dyeing silk—had gone very high. It was then that the consumers' attention was drawn to the substitution of a cheaper stuff which would partially, if not wholly, fulfil the requirements of the trade of the times, and the lac-dye was found to meet the exigencies of the situation well. The dye was extracted and used for colouring purposes and the resin was left unutilized. Later on when the special properties of the resin came to be known, it was used along with the dye for various other purposes. From this time onward the exports of resin began to rise until to-day they reach the unprecedented total of £2,314,000. This represents the quantity exported from the port of Calcutta alone. If, however, such statistics were available for the other ports of Karachi, Bombay and

Madras, along with the quantity consumed in the country, which is in no sense a negligible quantity, it will be found that the total annual production of lac in India and Burma is well over 170-200 million lb. This quantity is raised annually, when the insect has been subjected to ill and drastic treatment which, if not effectual in its total extinction, has lowered its vitality to such an extent that it may be said to be the progeny of degenerated parents which are not as yet free from the baneful effects of processes which are antiquated as well as effete. If one looks at the methods adopted for collecting the yearly produce, one is struck with the profound vitality displayed by the insect and I think it is its prolific fecundity which has saved it from total extinction. The cultivators now have recourse to measures of collection such as were adopted by their forefathers centuries ago. But the times have changed considerably. What was once a paying item has ceased to be such. What was once eagerly sought after is now discarded. The introduction of aniline colours has done much to bring about this change. But as the lac cultivator is illiterate, and lives in remote corners where ideas of modern developments do not reach him, he persists in adopting old and antiquated methods of collection. The lac-dye has ceased to be an article of commerce, and attempts are made to obtain resin which is as much free of the colouring matter as is possible to obtain. But the lac cultivator, irrespective of these changes in the commercial world, still continues to collect lac before swarming has taken place, with the result that the larvæ are killed outright by exposure of the lac-bearing branches to the heat of the sun. The result is that the healthiest and most virile larvæ are killed off, leaving behind stragglers which are not so vigorous as they should be. In a count made at Pusa of larvæ of *Zizyphus jujuba* lac, it was found that 52 days after establishment, 25 to 30 per cent. of them had failed to establish themselves and to produce resin. Later on, the percentage was found to increase until barely a fourth of the number had been able to reproduce itself. If material in various places is examined in this light, it will be found that in places even a larger percentage fails every year to establish and subsequently to reproduce itself. This is no doubt one of the causes of the short supplies so much complained of by the shellac-manufacturers from time to time. If, however, the lac cultivators are informed of the mischief they are doing unconsciously, I am sure they will improve their methods and will begin collecting the material after the larvæ have swarmed out. No doubt much could also be done by the manufacturers. If they will adopt the practice of paying the cultivators on the proportion of resin to lac-dye in a sample, the cultivator would soon modify his ways and would adapt himself to changed circumstances.



Holes of exit of *Eublemma amabilis* in introduced lac at Banganapalle, South India, November 1914.

The manufacturers should insist on purchasing stick-lac which contains a smaller proportion of lac-dye than one which has been collected before swarming has taken place and is consequently rich in colouring matter. This will effectively put an end to the unscientific method of gathering lac thereby consigning to death a huge number of larvæ which would otherwise have produced lac. No doubt, to hasten the adoption of the change recommended, active demonstrations would have to be made on an extensive scale before the cultivators could be expected to give up the practice which has rather become engrained in them.

With the establishment of nurseries for the distribution of healthy broodlac, and improvements in the methods of collection, the question of parasites and predators on lac has to be carefully gone through. From what is known now *Eublemma amabilis* is the worst enemy of lac on the trees. The caterpillars devour the females and pupate within silken galleries made in the encrustations. In some places the moth is so bad that it is impossible to grow lac. The predaceous caterpillars appear in hordes and destroy the females with the consequence that no lac is produced. In one place I found that, from a dozen broodlac sticks, each 12″ to 15″ long, as many as 435 *Eublemma amabilis* moths were bred out. (Plate 127) It was from this place that large quantities of broodlac were sent out far and wide and it is no wonder that the place should have been the means of distributing the predator along with the host. In some places the predator forestalled the host with the result that no lac could be grown. This aspect brings to the fore the question or rather the necessity of establishing broodlac nurseries, in any scheme of extension of lac cultivation in India. No doubt before any such scheme is mooted an accurate survey will have to be made of the locality or localities, which if not altogether free from the parasites and predators, are comparatively immune from the attacks of these disturbing factors. Besides *Eublemma amabilis*, the question of parasitic Chalcididæ will have to be studied in greater detail than has been attempted in the past. Species that are parasitic on *Eublemma* caterpillars will have to be differentiated from those which are primarily parasitic on the lac insect. If there are any hyperparasites, these will have to be studied separately and assigned a place in the scheme adopted to check the undue increment of the primary parasites. The rôle of *Holcocera pulverea* will have to be determined specifically as regards the lac on trees as well as stick-lac in storage. The question of storage so as to avoid the stick-lac getting blocky will have to be studied. But what appears to be in keeping with the present conditions, it is advisable to wash the stick-lac and treat it with monohydrated Sodium Carbonate. This will free the resin of the colouring matter adhering to the innermost walls of the cells and will improve the appearance of the washed product. An improvement like this is expected to effect considerable savings and will avoid the possibility of undetected damage brought about by pests to stored produce and will remove the possibility of the material becoming blocky —a thing which no manufacturer would care to buy. (*Vide Agri. Jour. India*, Vol. XIII, Part III, July 1918, p. 410, and *Report on the Progress of Agriculture in India* for 1917-18, pp. 98-99.) If this change will materialize into practice it will then be possible to popularize the use of washed and treated seed-lac more extensively than has been the case in the past. It is a queer anomaly that trades people should give preference to an adulterated product over an unadulterated one. Shellac, however pure it may be, contains from 5 to 10 per cent. of foreign ingredients such as yellow orpiment and colophony—the trade refraction being 4-5 per cent.—and still it is preferred to seed-lac which is pure. But now as lac has come to be extensively used for military purposes, it will be possible to popularize the use of the pure material seed-lac over shellac, I think production of standardized material will obviate the necessity of adopting iodine tests for shellac which the manufacturers have to do before making purchases. Continuous trial shipments of standardised and treated seed-lac will have to be made before the product will be adopted for commercial purposes. Hitherto, as the factories are few and are spread at considerable distances from each other, it has not been possible to effect any changes in this direction. By the new uses that are now being found for lac, it will be possible to restrict the use of the adulterated material.

The uses of shellac are :—

Indian.—Bangles, toys, goldsmiths' work, sealing wax, varnishes, polishes, grinding stones, lacquer ware, hilts to swords.

Foreign.—Insulating material, gramophone records, lithographic inks, varnishes, polishes, paper varnishes, confectionery, top hats, strengthening to steel, shrapnels, for pattern work, shoe blacking, imitation ivory, backs to brushes and combs, tooth brushes, poker-chips, white insulated goods.

The waste, together with other refuse, is utilized within the country for the manufacture of bangles and toys. A great development awaits the toy industry. Hitherto cheap German and Austrian toys have flooded England and America along with the produce of Holland, consisting primarily of compressed paper material. But with the proper organization of the industry it will be possible to popularize the use of light lac toys which will be cheaper and less liable to breakage than the imported ones. In India there is some field for the development of polishes and varnishes. The raw ingredients necessary to manufacture these are present in the country. It requires working them up so as to start an industry which has some prospects before it.

I have touched briefly the salient points concerning cultivation, collection, after-treatment and manufacture into shellac. There are a number of other points which I hope to touch upon hereafter. In conclusion it may be said that the industry is very old and India practically holds the monopoly for the time being. Before other disturbing factors step in, it is essential that a complete survey should be made of the industry as existent at the present time—both in forest areas as well as in the plains—and then to adopt such measures as would resuscitate the industry efficiently as well as financially. It need not be reiterated here that such lines of action would greatly ameliorate the condition of the aboriginal tribes inhabiting the outskirts of forests as well as the Plains, and I think the time has come when necessary steps should be taken to safeguard the interests of the industry which are really very old and important.

Mr. Ramakrishna Ayyar. We have not done so much work on this subject as Mr. Misra has done and it is only recently that the Government of Madras has thought of this industry. The first thing I would like to know is, what are the different species of lac insects ?

Mr. Misra. I believe that there are a number of species and one of these is *Tachardia lacca.*

Mr. Ramakrishna Ayyar. We must know at what time the young ones swarm out. With us they swarm in September and October and we get a poor harvest. Our difficulty is to get broodlac. We do get it from Pusa but we cannot get it just at the time that we require it for inoculation because the times of swarming at Pusa and in Madras are different. The lac-insect found on mango has been identified by Mr. Green as *Tachardia lacca.* We require to know definitely what species is commonly cultivated in India and what species can easily be propagated.

Mr. Beeson. Can Mr. Misra give us some technical details of the work he is going to do and his field-stations and so on ?

Mr. Misra. In order to find out parasites we have to examine twigs, to rear them out in cages and even to dissect out the parasites from their hosts. Another difficulty is the identification of the parasites. *Eublemma* is a serious pest of lac in store-houses.

Mr. Ramakrishna Ayyar. We must first find out the species, because they may differ.

Mr. Misra. We have at Pusa an enormous accumulation of material of lac insects, both dry and in spirit, from various foodplants and collected during every month of the year in almost all the lac-growing districts of India.

All this material requires to be worked over by an expert Coccidologist. Cross-inoculations also require to be tried.

Mr. Kunhi Kannan. Has the host-tree anything to do with the quality of the lac ?

Mr. Misra. Yes ; to a certain extent. *Palas* lac is the best. We find lac-insects on all sorts of all plants and, as far as the host-plants are concerned, they are pests ; but as it produces lac, we call it a useful insect.

Mr. Beeson. To me it seems that the first necessity is the determination of the species concerned before any cultural work is undertaken.

Mr. Fletcher. We have the material for that as soon as we can find someone to undertake the work.

43.—THE PUSA EXPERIMENTS ON THE IMPROVEMENT OF MULBERRY SILKWORMS.

By M. N. De, *Sericultural Assistant, Pusa.*

(Plate 128.)

As a result of the war the silk industry has shown signs of revival, both as regards its value and quantity. New mulberry plantations and rearers have come into existence and they are getting more money by rearing silkworms than by cultivating other crops. It remains to be seen whether the condition of the silk industry in India will improve or revert to its original position.

Multivoltine mulberry silkworm races are cultivated in Bengal, Mysore, Kollegal and Assam. The price of cocoons and the cost of cultivation are less in the above places than in any other country. This advantage is counterbalanced by the inferiority of the yield of silk of the Bengal and Assam races. The yield of the Mysore race, which is reared in Mysore and Kollegal, is superior to the yield of the Bengal and Assam races. The yield of this race as well as that of the races of Bengal and Assam can be improved by careful selection if continued for a long time. We are attaching more importance to hybridization than to selection as our surrounding conditions are not suitable for rearing silkworms throughout the year ; besides, it is the quickest way to modify and renovate a race.

It seems generally admitted that the multivoltine races of India have degenerated. European races of silkworms have been improved by selection and hybridization and are producing about more than double the quantity of their past yield, whereas our races are giving slightly more than three-fourths of their past yield. Long continued in-breeding inadvertently practised by careless rearers and rearing under unhealthy conditions, with leaves of scanty nutritive value, are responsible for the degeneracy of our races. Indiscriminate in-breeding has produced loss of vigour, delicacy of constitution and deterioration of the whole animal system and consequently the silk procured from the Indian races is inferior to that of Europe, Japan and China.

Selection in silkworm rearing means the ability so to choose cocoons and moths for reproducing the progeny, that with proper care a high standard of excellence will be obtained. If the improvement thus secured goes on generation after generation it will result in still further improvement. But when the selection is made carelessly and without judgment the improvement thus obtained is likely to revert to its former level. Judicious selection alone cannot improve a race without suitable nutrition, breeding and environment. The four go hand in hand whenever the improvement made is to be maintained and wherever further improvement is desired. Selection takes a long time to lift a race to a high standard of excellence and requires patience to maintain it.

Cross-breeding has done great service in the formation of new races. The influx of new blood to a weak race is always an advantage. It brings new vigour and renovating power in the constitution of the worms and makes them yield silk superior both in quality and quantity. Crossing gives an immediate increase of productiveness of silk but the result is uncertain in later generations. Time and experience can only tell whether the hybrid races which we have produced will continue to give satisfactory results without degeneration. With univoltine races it is possible to renew crossing every year as there are many univoltine races which yield cocoons of the same colour, shape and size, and so an infusion of new blood is possible in European countries. But this is not the case with the multivoltine races of India. There are only four or five multivoltine races which differ in shape, size and colour and if a cross is effected between any two of them the shape and colour of the cocoons of the mongrel race become different and it takes about six or seven generations to obtain uniformity in colour and shape. Besides, some of the eggs of the mongrel races turn grey and hatch irregularly like univoltine eggs in some later generations and so it is not possible to obtain good results from the race, for, by the time uniformity is obtained, the vigour and renovating powers are gone. If our multivoltine races are combined with the univoltine races, they become univoltine in the second and third generations and it takes about three or four years to establish the multivoltine characteristics. Some hybrid races may turn into pure multivoltine races by accident, but this cannot be depended upon.

Our experience is that all hybrid races are not suitable for all climatic conditions. Again all hybrid races do not necessarily become strong by the cross. Vigour may be imparted to a weak race if it is crossed with a strong one and *vice versâ*. Desirable qualities are imparted to a weak race by crossing it with races possessing the qualities desired. We have produced about ten multivoltine hybrid races. The yield of silk of some of them is about 1½ times more than that of the multivoltine races of Bengal. Our object is to produce two types of multivoltine hybrid races having similarity in size, shape and colour, which would suit a particular climate. When these two types breed true, their eggs or the eggs of the reciprocal cross can be profitably reared if the resulting hybrid keeps the multivoltine characteristics of the races. In this way only we can infuse new blood and vigour whenever we like. It remains to be seen whether the hybrid races can be established without degeneration.

If univoltine races are to be reared they should be annually imported and the progeny should be combined with the Bengal *Boropolu* race which has been acclimatized there. Univoltine races of Japan and China, their crossbreds with the *Boropolu* race and bivoltine races of Japan stand the climate better and hatch more regularly, although the yields of silk of these races are inferior to that of France and Italy.

Superior cocoons are obtained in all seasons by a cross between (1) a univoltine male, or (2) a male of a cross between a univoltine male and multivoltine female, or (3) a male of successive generations of this cross, and a multivoltine female. The crossing will have to be effected in each generation as the eggs of the second generation of this cross will turn univoltine. These univoltine eggs should be sent to cold storage for rearing in spring or in October or November wherever possible. If univoltine eggs are not required then the female cocoons of the hybrid can be rejected by the help of a balance available in France and used for reeling.

Of all the indigenous races, the Mysore race is the best as far as the yield of silk is concerned. The *Nistari* race should be reared in April or May, the Mysore race from July to October and univoltine races from October to March. We do not advise to rear the hybrid races now on a large scale although there is a demand for the eggs of these races. The best test for the suitability of a race in a particular place is by rearing it in the same place. The Mysore race is more susceptible to diseases than the *Nistari* race. Indigenous races are more hardy and can stand diseases better than the foreign univoltine races. An infusion of univoltine blood in the indigenous races makes the latter less hardy. We do not know whether they would be more hardy when they have been acclimatized to the climatic conditions of India for some time. We have produced multivoltine hybrid races by the infusion of univoltine blood into the multivoltine races, the yield of silk of which is like the univoltine races of China and Japan and bivoltine races of Japan for some generations, but they have degenerated later on and do not stand the climate like the indigenous races.

All races of silkworms yield more silk and can stand the diseases better if they are fed with the leaves of tree mulberry than those fed with the leaves of bush mulberry. All the races produce good cocoons if they are fed with bush leaves in the first three or four stages and then with tree leaves. It is always better to have two or three good crops than to have four or five indifferent crops.

In the following Table comparative results of our rearing of univoltine, bivoltine, multivoltine and hybrid races of silkworms of different countries are given, from which an idea of the yield of silk of each race can be obtained.

Race	Date of oviposition	Date of hatching	Date of mounting	Weight of mature worms and raw cocoons in 10 gm.
Shewshing Chinese univoltine	July 1917	3rd March 1918.	29th March 1918.	5 mature worms. 10 raw cocoons.
French race univoltine	1st April 1917.	7th March 1918.	7th April 1918.	4 mature worms. 7 raw cocoons.
Boropolu ♀ and Japanese ♂ univoltine, F_1.	2nd April 1917.	6th March 1918.	6th April 1918.	5 mature worms. 10 raw cocoons.
Wasih Chinese univoltine	July 1917	7th March 1918.	5th April 1918.	6 mature worms. 13 raw cocoons.
Koishimaru Japanese univoltine.	July 1917	9th March 1918.	9th April 1918.	5 mature worms. 9 raw cocoons.
Araya Japanese bivoltine. First generation.	July 1917	9th March 1918.	9th April 1918.	6 mature worms. 12 raw cocoons.
Second generation of the above.	20th April 1918.	29th April 1918.	21st May 1918.	6 mature worms. 12 raw cocoons.
Boropolu univoltine	July 1917	8th February 1918.	18th March 1918.	6 mature worms. 12 raw cocoons.
Pusa multivoltine hybrid No. I.	7th March 1918.	20th March 1918.	15th April 1918.	6 mature worms. 12 raw cocoons.
Mysore race multivoltine	4th July 1918.	16th July 1918.	4th August 1918.	6 mature worms. 13 raw cocoons.
Nistari multivoltine	10th August 1918.	19th August 1918.	7th September 1918.	7 mature worms. 14 raw cocoons.
Madagascar	18th February 1918.	6th March 1918.	2nd April 1918.	7 mature worms. 13 raw cocoons.

Race	Date of oviposition	Date of hatching	Date of mounting	Weight of mature worms and raw cocoons in 10 gm.
Kojikiko. Japanese bivoltine. First generation.	July 1915 .	7th March 1916.	2nd April 1916.	8 mature worms. 13 raw cocoons.
Second generation of the above	12th April 1916.	22nd April 1916.	20th May 1916.	The majority of the worms died on account of abnormal heat of this year.
Japanese ♀ and *Boropolu* ♂ Univoltine F_1.	21st April 1915.	13th March 1916.	11th May 1916.	6 mature worms. 11 raw cocoons.
Japanese ♀ and *Boropolu* ♂ Univoltine F_2.	24th April 1916.	23rd March 1917.	21st April 1917.	6 mature worms. 13 raw cocoons.
Boropolu ♀ and Japanese ♂ Univoltine F_1.	18th April 1915.	5th March 1916.	3rd April 1916.	6 mature worms. 11 raw cocoons.
Boropolu ♀ and Japanese ♂ Univoltine F_2.	15th April 1916.	23rd February 1917.	1st April 1917.	8 mature worms. 13 raw cocoons.
French ♀ and *Boropolu* ♂ Univoltine F_1.	23rd May 1915.	30th January 1916.	9th March 1916.	5 mature worms. 10 raw cocoons.
French ♀ and *Boropolu* ♂ Univoltine F_2.	27th March 1916.	23rd February 1917.	1st April 1917.	6 mature worms. 11 raw cocoons.

In the following Table two races have been combined, leaving the one nearest that which is wanted untouched until a suitable cross between two others have been secured. Then the pure race has been combined with the hybrid with a view to have the influence of the last race. Records of our rearing of the previous generations of this race are given in Bulletins Nos. 48 and 74, on pages 9 and 2 respectively.

Race	Date of oviposition	Date of hatching	Date of mounting	Weight of mature worms and raw cocoons in 10 gm.
Nistari ♀ & French ♂ } & Mysore ♀ ♂ } Mysore ♀ ♂ } F_{14}.	7th July 1916.	14th July 1916.	5th August 1916.	6 mature ; 9 raw.
Do. Do. F_{15} .	14th August 1916.	22nd August 1916.	10th September 1916.	6 mature ; 11 raw.
Do. Do. F_{16} .	20th September 1916.	28th September 1916.	17th October 1916.	6 mature ; 10 raw.
Do. Do. F_{17} .	30th October 1916.	11th November 1916.	20th December 1916.	6 mature ; 11 raw.
Do. Do. F_{18} .	22nd January 1917.	18th February 1917.	24th March 1917.	6 mature ; 11 raw.
Do. Do. F_{19} .	5th April 1917.	14th April 1917.	10th May 1917.	7 mature ; 12 raw.
Do. Do. F_{20} .	22nd May 1917.	30th May 1917.	17th June 1917.	8 mature ; 12 raw.

Race			Date of oviposition	Date of hatching	Date of mounting	Weight of mature worms and raw cocoons in 10 gm.
Nistari ♀ & French ♂	& Mysore ♀ ♀	Mysore ♀ ♂				
Do.	Do.	F_{21}	26th June 1917.	1st March 1918.	1st April 1918.	8 mature, 12 raw.
						Grey eggs were reared in this generation.
Do.	Do.	F_{22}	12th April 1918.	23rd April 1918.	22nd May 1918.	7 mature; 12 raw.
Do.	Do.	F_{23}	22nd May 1918.	30th May 1918.	17th June 1918.	6 mature; 11 raw.
Do.	Do.	F_{24}	28th June 1918.	7th July 1918.	24th July 1918.	6 mature; 10 raw.
Do.	Do.	F_{25}	4th August 1918.	10th August 1918.	28th August 1918.	6 mature; 8 raw.
Do.	Do.	F_{26}	7th September 1918.	15th September 1918.	3rd October 1918.	7 mature; 12 raw.
Do.	Do.	F_{27}	14th October 1918.	24th October 1918.	25th November 1918.	7 mature; 12 raw.
Do.	Do.	F_{28}	23rd December 1918.	..	..	The race is being continued.

The Pasteur system of examination is the best for elimination of pebrine in univoltine, bivoltine and multivoltine races in India. The system is more simple, more economical, and less laborious than all the existing modified methods of Pasteur. For easy and quick detection of pebrine corpuscles from the juice of mother-moths the following precautions should be adopted :—*

(1) Place 50 or 60 mother-moths on a paper after separating the pairs and shake the paper by holding one of its ends. The moths will excrete the contents of the colon so that there will not be much exudation of the colon at the time of crushing them for microscopical examination.

(2) Keep the mother-moths isolated in paper bags on the first night after oviposition at about 80°-95°F. After 4 or 5 days dry them for three or four hours at about 160°-180°F. The number of the bag containing a moth should correspond with the number of the laying oviposited by it so that the eggs laid by each moth can be ascertained. This process will help the multiplication of pebrine corpuscles and dry up the contents of the colon.

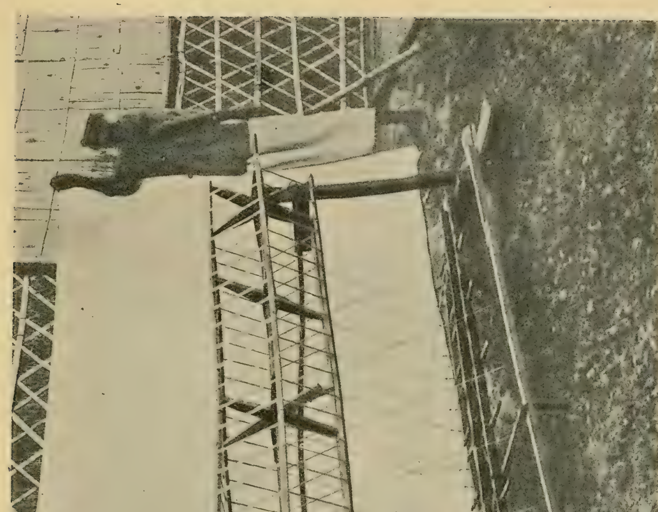
* In Japan multivoltine moths are examined with or without drying. In some countries they are examined without drying.

(3) Remove the wings and examine the juice of the moths on the fifth or sixth day after oviposition after thoroughly crushing them with a few drops of 5 per cent. solution of caustic potash which dissolves the fatty globules. This will help quick detection of pebrine corpuscles.

Our experiments in reeling are given in Bulletin No. 44. Indian reelers find it difficult to dispose of their raw silk. Organized efforts are being made for the sale of raw silk of China, Japan and Europe but there is no such organization for the disposal of Indian raw silk. Imported silk finds a ready market here but there is not sufficient demand for the local produce. Taking all the disadvantages into consideration, our silk can have a good sale in Europe and America and the local market can also be captured if the quality of our silk is improved by the provision of one porcelain button and two small aluminium or glass wheels in the country system of reeling machines, by which 200-350 twists can be given to the reeled thread. In this method the simple country appliance for reeling has been greatly improved and yet its suitability for cottage workers maintained. The first thing required is to produce a standard quality of raw silk for the local market and to place a fairly large quantity of it with merchants to create a market for it. Perhaps it will not be profitable to produce very fine thread for the consumption of France and England.

We have devised a new Twisting Machine on which 24 threads can be twisted at a time (Plate 128). The working of the machine is as follows :—There are 24 spindles with 24 bobbins inserted on one end of each of the spindles. The bobbins should contain double or threefold thread. One wheel rotates all the spindles by means of an endless rope and a swift by means of another cord on which twisted thread is wound up. The cord is passed under the following spindles 1, 3, 5, 6, 8, 9, 11; 12, 14, 15, 17, 18, 20, 21, 23 and 24 and upon the following spindles 2, 4, 7, 10, 13, 16, 19, and 22. The bobbins on the former are inserted in the front of the machine while those on the latter are inserted in the back part. When the wheel is revolved in the righthand direction all the 24 bobbins are turned in the same direction so that a righthanded twist is given to the thread before it is wound upon the swift. It should be noted that the bobbins should always contain wet thread. When the spindles do not revolve properly the cords should be rubbed with a little dust of resin. The hooked guides through which twisted threads are passed to the swift are of glass. As there is no difficulty in unwinding the twisted thread wound upon the swift no mechanism has been provided for cross-winding the thread on the swift. If the weavers

 PLATE 128.



Pusa Twisting Machine.

want to have a lefthanded twist on the machine they should fill the bobbins from the opposite direction (anti-clock way) and the wheel also should rotate in the same direction, so that right-handed and left-handed twists can be given on the machine according to one's requirements. One man can twist about 6 *chattacks* of reeled thread in a day of eight hours. The cost of a machine will be about Rs. 25. Reeled thread of Tasar, Muga and Mulberry, and cotton thread also, can be twisted on the machine.

Pierced cocoons are generally spun into thread in Bengal and Assam on the *Charkha* and *Taku*. Old women and small girls are engaged in this work in cottages at their leisure time. We pay to a boy who spins for us about Rs. 3-4-0 per month and he spins about one *seer* of spun thread in a month. If we get the cocoons spun from outside, we pay at the rate of Rs. 3-8-0 per *seer*. The process of spinning is simple and can be learnt in less than ten days. One *charka* is available for Rs. 2 and a *Taku* for six pies. In Mysore and Kollegal very little spinning is done and the cocoons are sold to the merchants for export. There is a great demand for handspun silk cloth in India and there is no reason why Mysore and Kollegal should not take to handspinning. If this is done, some profitable work can be given to women and some new weavers also will come into existence.

We are carrying on experiments both with vegetable and synthetic dyes. Our experience is that vegetable dyes are extremely fast but dull in appearance. It is difficult to procure all the materials and it takes time to prepare extracts from vegetable dyes. The synthetic dyes are sold on a large scale in the market. The process of dyeing is very easy and the dyed stuffs are bright and glossy but the colour is not very fast.

Silk-weaving is more paying than cotton-weaving. The handlooms which were once used for cotton can be profitably utilized for silk-weaving as the principles of weaving cotton and silk are practically the same. The cotton-weavers who have taken to other occupations can earn more by the change. India imports a large quantity of silk fabrics. Skilled labour and raw materials are available here. The only thing required is capital and organization. We have got three handlooms and three weavers whom we pay Rs. 432 per year. We produce about Rs. 2,000 worth of silk cloth in a year. We make a nett profit of Rs. 500 per annum. If deductions are made for the weaving experiments carried out by us the profit can be raised to Rs. 700. There is a ready sale for our goods and we are not in a position to supply even the Pusa market. Our silk, like all indigenous silk goods, is very durable and the demand for it is gradually increasing. Visitors coming to Pusa take a fancy to our silk and many want to take it as a *souvenir*, but we have to refuse most of them, as our silk is woven for experiments to show what can be done with different kinds of silk thread. Our silk could be sold easily if our production were increased by five times. People can easily invest their capital in a weaving centre and we can show them the way. Many applicants from different provinces as well as from foreign countries want silk from us but we transfer their requisitions to silk merchants of different places.

[*Mr. De exhibited cocoons of the various races and crosses mentioned in his paper.*]

Mr. Ramakrishna Ayyar. Our crying necessity in Madras is disease-free seed. The mulberry cultivated with us is for multivoltine races. Have you any variety, Mr. De, that yields as well as Mysore and that can stand disease ?

Mr. De. I cannot suggest a better variety than Mysore. Your own race is the best, so you need not go in for new races.

Mr. Ramakrishna Ayyar. The silk industry is going down and we badly want a disease-free race. We have no market for reeled silk.

Mr. De. That is because the weavers in China and Japan can produce a standard quality of thread and we in India have no arrangements for producing thread of uniform thickness in large quantities.

Mr. Ramakrishna Ayyar. You sent us a cross between Madagascar and Pusa races. What do you think of that ?

Mr. De. It is superior to the Mysore race so far as disease is concerned. If we breed *Nistari* and Mysore races under similar conditions we find that the *Nistari* race stands the climate better than the Mysore but Mysore gives a good result as regards yield. Many rearers in Bengal want to get the Mysore race, but it is a little delicate. One *maund* of the Mysore cocoons will give three *seers* of thread whilst one *maund* of *Nistari* cocoons will give only two and a half *seers*.

Mr. Ramakrishna Ayyar. We got a quantity of silk well reeled but found no market for it.

Mr. Ghosh. Silk is in such demand in India that large quantities have to be imported. It is strange that you found no market for your silk.

Mr. Hutchinson. Is it better to select or to hybridize to obtain a disease-free race ?

Mr. De. I have not worked on those lines.

44.—PEBRINE IN INDIA.

By C. M. HUTCHINSON, B.A., *Imperial Agricultural Bacteriologist.*

[This paper was given as an evening lecture illustrated by lantern-slides from micro-photographs. This paper will be published separately—*Editor.*]

5.—THE BEST METHOD OF ELIMINATING PEBRINE FROM THE MULTIVOLTINE SILKWORM RACES OF INDIA.

By M. N. De, *Sericultural Assistant, Pusa.*

(Plate 129.)

Introduction.

Pebrine is a disease caused by a species of sporozoa. It is a terrible disease in silkworms. Almost all the domesticated species and varieties of silkworms are attacked with it. The wild silkworm races are generally more immune to this disease than the domesticated ones. It threatened the existence of sericulture in Southern Europe in 1865. A crowd of French and Italian savants began to investigate the inexplicable disease but no one was able to find out the true cause of it and suggest any remedial measures. "Uncertainty was not less great when the disease came to be studied. M. de Quatrefages, after a careful study, had believed to be able to characterize it, through the existence in the interior, but chiefly on the surface of the skin of the worms, of small spots, resembling sprinkling of black pepper and thus had given it the name 'Pebrine.' But experience showed that worms might have these spots without having the disease. By continuing the study of the disease contradictory results began to appear. Thus Messrs. Lebert and Frey had established that in the interior of all the worms and moths stricken with the disease, was a parasite visible only through a microscope, the corpuscle observed first by M. Guerin Meneville, and of which M. Cornalia has shown the pathological importance. But according to M. Filippi these corpuscles existed normally in all butterflies."

A real progress, however, was made when M. Osino discovered the corpuscles in the eggs of silkworms and when M. Vittadini had discovered that their number increased in the eggs when the period of their hatching approached. The means of selection so far obtained too often gave from "good grain" bad results. Very often seed would be condemned on uncertain grounds and rearers could not be blamed for not accepting the advice of science. This was the situation in 1865, when M. Pasteur, at the instance of M. Dumas, began his researches. Next to nothing was known of the nature and cause of the disease and efforts to struggle against it had remained fruitless.

The researches of M. Pasteur have entirely elucidated the problem of the existing malady and led to a practical means sure to arrest it and prevent its return. He clearly pointed out the cause of pebrine and its remedy. Cellular seed and microscopic examination of each mother moth, *i.e.*, the isolation of each mother in a separate cellule and

The Pasteur method.

microscopical examination of its juice after thoroughly crushing it in a mortar and pestle. If pebrine spores are found in the juice then the eggs laid by the moth should be destroyed but if no pebrine spores are seen in the juice the eggs of that moth should be kept for reproduction. This is the "pasteur cellular method." This method is generally practised throughout the world for examination purposes both for univoltine and multivoltine races. The other method recommended is "the double Zero of Italy." In this method both the male and female moths are pounded together for microscopical examination and the eggs laid by the mother-moth are thrown away if the juice contains pebrine corpuscles. It should be noted that the male parent cannot transmit the disease to the embryo and it is considered not advisable to examine the father-moth as the price of the eggs becomes more expensive, because eggs of healthy mothers but pebrinized fathers also are thrown away.

The Italian method.

The Industrial Methods.

Different methods are adopted in different countries as they are less tedious and less expensive than the above two methods.

1. About 500 or more mother-moths are kept on a piece of paper for depositing eggs. Forty or fifty moths out of this whole lot are examined and if less than 5 per cent. of them are pebrinized the eggs are kept for rearing and the cocoons obtained from these eggs are sold for reeling and not used for reproductive purposes.

2. About 100 mother-moths are allowed to oviposit on a paper and the moths are destroyed when the deposition is over. The paper containing the eggs is rubbed off with the fingers when a certain number of loose eggs is dropped from the paper and 50 of these eggs are taken and crushed separately in 10 lots under mortars and pestles. Their juice is then examined under a microscope. If pebrine corpuscles are seen in more than 5 per cent. of these lots then all the eggs of the paper are destroyed but they are kept for rearing if pebrine corpuscles are not found in five or less than five of these lots. The cocoons obtained from these eggs are generally not kept for reproductive purposes.

3. Sometimes eggs laid by moths, the mothers or grand-mothers of which have been found free of pebrine, are distributed for industrial rearing. Industrial eggs contain pebrine spores and they are not always safe to rear.

The Bengal method.

4. In the Government nurseries of Bengal a modified system of Pasteur has been recommended by Mr. N. G. Mukerji. Instead of crushing the mother-moths in mortars and pestles he has advised to crush them in paper as it is "less expensive." Now pebrine corpuscles

may attack the mother-moths in the following parts :—(1) Alimentary canal and its appendages, (2) Muscular system, (3) Adipose tissue, (4) Membrane of the tracheæ, (5) Reproductive organs, (6) Circulatory system and blood, and (7) Nervous system. If pebrine corpuscles remain in any of the above parts and that part is not crushed well then the spores will not be found and the moths will be passed as healthy. I have examined moths of the same lot on many occasions according to the Pasteur method and the modified method of Pasteur as recommended by Mr. Mukerji and I have seen on almost all occasions more pebrinized mother-moths in the former method than in the latter. In Mukerji's method all the parts are not crushed well and a cover glass is not used for examining the juice and so pebrine corpuscles are not found if they remain in the uncrushed part. About 10 per cent. of the mother-moths which have been attacked with pebrine very slightly generally go undetected. If the major portion of the juice is taken from the colon only, as it appears from Bulletin No. 75 of Mr. Hutchinson to be done in Bengal, the chance is that rather more than 20 per cent. of the moths which have been attacked with pebrine will go undetected.

It should be noted that in the nurseries of Bengal seed cocoons are sold instead of eggs. Sometimes a large percentage of the moths coming out of the above seed cocoons contain pebrine corpuscles, which is responsible for the failure of the crops. If disease-free eggs are sold to the rearers after examining each moth separately, as Mysore and all other countries of the world are doing, the failures can be obviated. If the conservative rearers of Bengal, like their *confrères* of Mysore, get good crops from eggs they would certainly prefer to have eggs instead of seed cocoons from the nurseries. The time has perhaps come when we should stop supplying seed cocoons from the nurseries. They should produce as many seed cocoons as the men in charge can examine when the moths come out and not more. The industry will be greatly benefited if responsible overseers are sent to each rearing village to examine the moths of all the rearers and allow them to rear the healthy eggs only. The rearers will gladly bring their moths for examination if an arrangement is made to examine them in a central place.

The rearers of Bengal are supplied with "industrial seeds" and not with healthy eggs and so it cannot be said that the Pasteur system of examination has failed there. Only a modified method of Pasteur as recommended by Mr. Mukerji has been tried there and not the Pasteur system *in toto*. It has not failed in any other country the climatic conditions of which are similar to those of India. If any examiner in Bengal takes it into his head to examine the major portion of the fluid only from the colon for microscopical examination, the examiner must be found fault with and not the system.

Mr. Hutchinson's method.

5. Recently another modified method of Pasteur has been recommended to be practised in India and elsewhere (*vide* Bulletin No. 75, the Pebrine disease of silkworms in India, by Mr. C. M. Hutchinson, Imperial Agricultural Bacteriologist, Agricultural Research Institute, Pusa). In this method " a minute portion of the gut, removed on the needle and rubbed with water on the slide," is examined under the microscope. If it contains pebrine spores the eggs laid by the moth are destroyed but if no pebrine spores are seen the eggs are kept for reproductive purposes. This modified method is said to be superior to all other existing methods. I have made a comparative study of this modified method and the Pasteur method. The number of pebrinized and healthy mother-moths as observed by me are enumerated in the Tables on next page. *The eggs of these consignments were from diseased stocks.*

Thus out of 598 moths examined according to the Pasteur method I found 459 pebrinized moths and 139 healthy ones and out of the same number examined according to the modified method of Pasteur as advised by Mr. Hutchinson, I found 455 pebrinized moths and 143 healthy ones. The latter method takes a longer time than the former but does not appear to be more effective. It should be noted in this connection that one examiner can examine the following number of moths in different countries in one day of eight hours :—

Pasteur method—	
France	1,000-1,200
(*Vide Manuel Pratique du Sericulture* by Alp. Blanchan. Number of working hours per day has not been mentioned)	
Japan	700-900
Kashmir	700-900
Mysore	600
Mukerji's method—	
Bengal	250-300
Hutchinson's method—	
Pusa	200-250
Vide Proceedings of the 37th Regular Meeting of the Bengal Silk Committee held in Calcutta on 5th July 1918.	

I examined 300 moths in 8 hours according to the last method.

System of examination	Race	Date of oviposition	Date of examination	Total number of mother-moths examined	Number of pebrinized moths	Number of healthy moths	Treatment of moths	REMARKS
I. Pasteur	Multivoltine	11th November 1918.	12th November 1918.	50	43	7	*Nil.*	Each number of series (I-X) includes moths from the same lot; the individuals examined by the two methods were however not the same.
Modified method of Hutchinson	Do.	Do.	Do.	50	40	10	*Nil.*	
II. Pasteur	Do.	12th November 1918.	13th November 1918.	100	76	24	..	
Modified method of Hutchinson	Do.	Do.	Do.	100	72	28	*Nil.*	
III. Pasteur	Do.	13th November 1918.	14th November 1918.	100	61	39	*Nil.*	
Modified method of Hutchinson	Do.	Do.	Do.	100	67	33	*Nil.*	
IV. Pasteur	Do.	14th November 1918.	15th November 1918.	40	23	17	*Nil.*	
Modified method of Hutchinson	Do.	Do.	Do.	40	20	20	*Nil.*	
V. Pasteur	Do.	8th November 1918.	Do.	40	32	8	*Nil.*	
Modified method of Hutchinson	Do.	Do.	Do.	40	32	8	*Nil.*	
VI. Pasteur	Do.	12th November 1918.	18th November 1918.	100	76	24	*Nil.*	
Modified method of Hutchinson	Do.	Do.	Do.	100	76	24	*Nil.*	
VII. Pasteur	Do.	Do.	19th November 1918.	50	45	5	*Nil.*	
Modified method of Hutchinson	Do.	Do.	Do.	50	44	6	*Nil.*	
VIII. Pasteur	Do.	14th November 1918.	21st November 1918.	35	29	6	The moths were kept at about 75° F. from 16th to 20th November 1918.	
Modified method of Hutchinson	Do.	Do.	Do.	35	30	5	Do.	
IX. Pasteur	Do.	13th November 1918.	20th November 1918.	44	37	7	Do.	
Modified method of Hutchinson	Do.	Do.	Do.	44	36	8	Do.	
X. Pasteur	Do.	14th November 1918.	21st November 1918.	39	37	2	Do.	
Modified method of Hutchinson	Do.	Do.	Do.	39	38	1	Do.	

In the Table on next page I have given the results of my examination of the gut only according to Hutchinson's method and then the same gut is crushed with the body of the moth and the juice is examined according to the Pasteur method to see in which system more pebrinized moths are detected. *The eggs were from diseased stocks.*

Thus out of 844 moths the gut only of which was first examined and the same gut was crushed with the body of the same moth and examined separately 333 and 334 pebrinized moths respectively were detected.

In about 2 per cent. of the pebrinized moths I have seen more pebrine spores in the body excluding the gut but very few in the gut. In about 13 per cent. of the moths more pebrine corpuscles were seen in the gut than when the whole body including the gut was crushed. In about 85 per cent. the proportion of pebrine was equal. The corpuscles were distributed in the body-juice when the body including the gut was crushed and there was no difficulty in detecting them. In very few cases one or two pebrine corpuscles were detected in the gut but not a single one in the body-juice. In rare cases I have noticed one or two corpuscles in the body-juice but not a single one in the gut. I had to throw away rather more than 5 per cent. of the moths as their guts could not be distinguished on account of decomposition of the moths. I have also noticed that if the entire gut is not crushed well and a minute part of it is taken by a needle and examined as advised by Mr. Hutchinson pebrine spores may escape notice when the infection is very mild; if it is crushed thoroughly it is possible to detect a few spores in about two or three per cent. of the moths where the Pasteur method may fail to detect them if the moths are not treated as stated later on. (*Vide* Bulletin No. 74 also, written by me.)

It has been noticed that when the moths are infected with pebrine acutely or moderately there is no difficulty in detecting pebrine corpuscles by either of the methods; but when the infection is very mild the detection becomes difficult by both the methods and in a few cases it takes more time if examined according to the Pasteur method. This difficulty is obviated if the mother-moths are kept at about 70°-90°F. for about five or six days after oviposition. The contents of the colon are dried up if the moths are kept at about 160° to 180°F. for about three or four hours before examination. The moths in the above table could not be dried well as it would have been difficult to separate the gut from the body. I have noticed that the multiplication of pebrine corpuscles is more rapid from May to October than from November to April. In summer they propagate quickly but their multiplication is

—	Race	Date of oviposition	Date of examination	Total No. of mother moths	No. of pebrinized moths	No. of healthy moths	Treatment of moths	REMARKS
I Gut only	Multivoltine	12th December 1918.	18th December 1918.	33	22	11	Nil	Moths of series I-XIII have been examined according to Hutchinson's method first and then by the Pasteur method.
I Gut only and body of the above					24	9		
II Gut only	Do.	15th December 1918.	19th December 1918.	42	28	14		
II Gut only and body of the above					26	16		
III Gut only	Do.	16th December 1918.	21st December 1918.	28	7	21		
III Gut only and body of the above					7	21		
IV Gut only	Do.	Do.	22nd December 1918.	40	11	29		
IV Gut only and body of the above					12	28		
V Gut only	Do.	18th December 1918.	23rd December 1918.	92	45	47	Kept in the sun from 20th-23rd December.	
V Gut only and body of the above					46	46		
VI Gut only	Do.	19th December 1918.	24th December 1918.	78	55	23	Kept in the sun from 20th-24th December.	
VI Gut only and body of the above					56	22		
VII Gut only	Do.	Do.	25th December 1918.	42	31	11	Do.	
VII Gut only and body of the above					32	10		

—	Race	Date of oviposition	Date of examination	Total No. of mother moths	No. of pebrinized moths	No. of healthy moths	Treatment of moths	REMARKS
VIII Gut only	Multivoltine	20th December 1918.	26th December 1918.	47	22	25	Kept in the sun from 22nd-26th December.	Moths have been kept in paper bags.
VIII Gut only and body of the above					21	26		
IX Gut only	Do.	Do.	27th December 1918.	88	31	57	Do.	
IX Gut only and body of the above					29	59		
X Gut only	Do.	21st December 1918.	28th December 1918.	90	18	72	Kept in the sun from 22nd-27th December.	
X Gut only and body of the above					17	73		
XI Gut only	Do.	22nd December 1918.	29th December 1918.	112	31	81	Kept in the sun from 23rd-27th December.	
XI Gut only and body of the above					30	82		
XII Gut only	Do.	1st January 1919.	6th January 1919.	72	20	52	Kept in the sun in the daytime and at night at about 70F. from 2nd-5th January.	
XII Gut only and body of the above					21	51		
XIII Gut only	Do.	31st December 1918.	7th January 1919.	80	12	68	Do.	
XIII Gut only and body of the above					13	67		

slow in winter. In cold countries they multiply slowly but in hot countries they multiply rapidly. (*Vide* Pusa Bulletins, Nos. 48 and 74.)

We hope that Mr. Hutchinson, by his further researches, will be able to find out a method which is more economical and effective than the Pasteur method.

Comparison and Criticism of the Various Methods.

The Pasteur method. It is simple, effective and economical. The moths are crushed by boys and girls after a week's practice. In France and in some places in Japan crushing machines containing about 100 small mortars and pestles are used for crushing 100 moths at a time.

The double Zero of Italy. It is a simple, effective but does not appear to be as economical as the Pasteur method because the eggs of a healthy mother but a pebrinized father which cannot transmit the disease to the progeny are also thrown away. This method can be found suitable for improving and regenerating a race.

The Industrial methods. All industrial methods are very simple and "economical" but they are not effective at all. Industrial eggs contain pebrine spores and they are not safe to rear as *cocoon crops may fail because it is not known to what extent the eggs are pebrinized.*

The Bengal method as modified by Mr. Mukerji. It is very simple and "economical" but not so effective as the Pasteur system because all the parts of the moths are not crushed well and cover glasses are not used at the time of examining the juice. Pebrine spores escape notice if they are in the uncrushed parts when the infection is very mild. The moths can be crushed by ordinary labourers after a few days' practice and an ordinary microscopist can examine 800—1,200 moths in a day of eight hours if he is supplied with a *microscope which is provided with a "rough adjustment screw."*

The modified method of Pasteur as recommended by Mr. Hutchinson. The method is laborious and is not economical. The system does not seem to be more effective than the Pasteur method. An overseer must be trained to remove the gut. It takes time to take out a minute part of it on the slide with a needle. There will be waste of eggs as about 10 per cent. of the moths are to be thrown away if they are decomposed or dried up because it would not be possible to distinguish their guts. *An irresponsible overseer can take out any part of the body which is free from pebrine, instead of the mid-gut when the infection is very mild there but acute in the ovaries* and pass the diseased moth as healthy. The only advantage in this system is that when the infection is mild in the mid-gut it will take little time and attention for the detection of the spores whereas according to the Pasteur method more time and attention will be required and in a few cases the spores may go unnoticed if the moths are not treated as stated later on. *This " efficiency," secured at the cost of risk and economy, does not appear to be commensurate with the advantage obtained.*

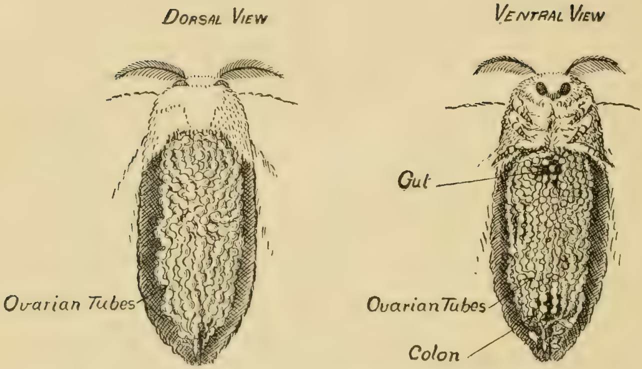
Comparison of the Pasteur Method and the Modified Method of Pasteur as recommended by Mr. Hutchinson.

According to the Pasteur method of examination one microscopist with the help of two labourers to crush the moths can examine about 800-1,200 moths in a day of 8 hours. For examining the same 800 moths according to Mr. Hutchinson's method the same microscopist will require the assistance of at least *two responsible overseers.* In other words, for examining 800 moths according to the Pasteur method the cost will be about one rupee whereas, according to Mr. Hutchinson's method the cost will be two rupees. But time is more valuable when the multivoltine moths are to be examined. If examination is done according to the Pasteur method three trained overseers will examine about 2,400 moths in a day whereas the same men will require about three days to examine the moths according to Mr. Hutchinson's method and, if they cannot examine all of them, the eggs of unexamined moths have to be destroyed as they will hatch on the eighth or ninth day in summer. One advantage of this method is that the examination can be commenced on the first day after oviposition whereas according to the Pasteur method it would be better if the examination is postponed for three or four days. *Pasteur himself advised to wait for a few days instead of examining the gut.*

The gut theory is not a new one. It is as old as Pasteur. All the sericulturists of different countries where multivoltine races are reared and whose climatic conditions are similar to those of India know it but they have preferred the Pasteur method as recommended by him and rejected the method of examining the gut. The following letter, which is a translation of Mr. Lambert's letter in French, corroborates the above statements.

Translation of Mr. Lambert's letter dated the 13th April, 1918. (He is the Director of the Station Sericicole, Montpellier, France.)

" 1. Generally speaking, the surest means for detecting the pebrine germ is in fact to examine the stomach or the mid-intestine of the caterpillar. This is the method advised by Pasteur himself for the examination of pupæ in the bodies of which the abundance of fatty globules render the search more difficult, as the corpuscles are less numerous



Figs. 1 and 2.—Rough dissection of a silkworm moth (*Bombyx mori*).

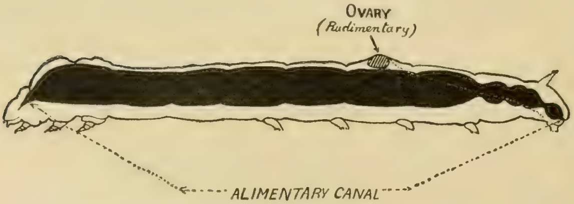


Fig. 3.—Section through full-grown mulberry silkworm.

than in the moths. In the pupæ the corpuscles get mingled up with the globules and so at a cursory examination one is likely to confound the corpuscles with the fatty globules. But that method is a long one and for the moth one prefers to wait a few days after oviposition before proceeding to the examination in order to give to the parasite time enough to multiply itself and to propagate itself sufficiently, thus infecting the entire body of the moth and so simplifying the work. The corpuscles are then very abundant and one can detect them at the first glance without any difficulty. Besides, in the moths, even when taken immediately after the termination of oviposition, the corpuscles are already sufficiently abundant in the cases of pebrinized subjects so that it may be very easy to distinguish them.

2. The examination of the mid-intestine or the stomach is preferable when it is intended to examine the pupæ. Pasteur has in fact advised similarly. For the moth this is not at all necessary and this process will be a very long one.

3. As I have said, the corpuscles since the maturity of the worms (during the time of the formation of the cocoon in the pupal period and during the life of the female moth until after the oviposition) have had time to multiply themselves. They have multiplied in abundance in the body of the animal and one can detect them without difficulty. Thus, by limiting the examination to the stomach of the moth, one would prolong without any utility the duration of the operation for microscopic examination, in which the *graineur* has a great economic interest to curtail and simplify the work as much as possible."

Nature of Pebrine.

This is true in Indian climatic conditions also. Our figures in the Tables corroborate the above statement. *Pebrine spores cannot be transmitted to the embryo if they are confined to the mid-gut.* If egg-cells are free from pebrine then they cannot contain any spores in them when they are developed into eggs as the corpuscles cannot infect the emb yo through the chorion. *If the ovary is infected with pebrine after the formation of the chorion the moths will lay perfectly healthy eggs*; some pebrine spores may adhere on the outer shells but they cannot infect the embryo. These spores are removed by washing the eggs with water. *Pebrine is not hereditary* in this sense. When the infection is very mild in the gut and if we fail to detect pebrine bodies in the ovaries the spores will not be able to transmit them to the progeny. If the egg-cells of pupæ are infested with pebrine then in 99 cases out of 100 the spores will multiply in large numbers and the detection becomes easy when the moths are examined on the fifth or sixth day after oviposition. No one can say definitely that a certain moth is perfectly healthy and is quite free from pebrine spores unless all the body-juice including the gut is examined drop by drop till all the juice is exhausted. This will take about an hour for examining a single moth; but there is no earthly use to have such a strict examination unless especially required for some experimental purposes. Pebrine cannot be eradicated once for all. It is sure to come in the next generation through leaves. The Pasteur system is defective in this sense if any one wants to use the word.

Views expressed by Various Authorities.

Infection may take place through (1) heredity, *i.e.*, from mother-moth to egg-cell which is developed into an embryo, (2) food and so through the alimentary canal, and through (3) wounds in the chitin in the caterpillar stage.

It appears that there is no difference between the organism (pebrine) in the silkworms of India and of other countries. No one in India has found anything which is unlike that of other countries although the European varieties when attacked with pebrine, show pencil marks on the skin, but the worms of India, Siam, China and Japan generally do not show these spots. The life-history of *Nosema bombycis* (pebrine) seems to be the same in all countries and in all stages. The pebrine corpuscles in Indian silkworms are a little smaller than those of Europe.

1. *Heredity Infection through mother.*

"The egg of a pebrinized mother-moth carries the germ of pebrine in consequence of the parasitic growth of the organism in the female generative organ. The spore is often parasitic to the egg-cell and is often enveloped by the shell while the egg develops; otherwise, it attaches itself to the surface of the egg." (*Vide The Silk Industry of Japan* by I. Honda, Director of the Imperial Tokyo Sericultural Institute, 1909, page 120.) According to Dr. C. Sasaki, Professor of Sericulture and Entomology at the Agricultural College, Tokyo Imperial University, in his letter to me of the 25th June 1918, "Pebrine is not hereditary, but only transmitted from mother to the offsprings. The spores are found in any part of the embryo and not confined to a particular part. The spores germinate in every tissue of the silkworms when they are introduced from the infected eggs, but when a non-infected or healthy worm receives the spores in its stomach, then they will germinate in the stomach." But according to Monsieur F. Lambert, Director of the Station Sericicole, Montpellier, in his letter to me of the 23rd April 1918, "L' invahissement du ver par les corpuscles de la pebrine commence toujours par le tube digestif, même dans la transmission par le papillon femelle dont les ovaires sont envahis ; de là le parasite gagne tous les autres organes du ver sans exception."

If we accept the theory of Dr. Sasaki, then a caterpillar which has been infected with pebrine in the embryo, hatches out with pebrine in its organs. If the disease is acute, pebrine spores may be seen only in a part of the tissues of one of its organs, in the whole organ or in all the organs and in the worst case it will die of exhaustion before maturity. If the caterpillar is very mildly infested and if the surrounding conditions are favourable for the growth of the pebrine corpuscles the worm may die of the disease, but if the conditions are not favourable then a case may happen in which pebrine corpuscles may remain in the generative organ only ; so that hereditary elimination of pebrine is not possible in all cases if the mid-gut only is examined. Our experience at Pusa is that we can get perfectly healthy caterpillars and moths from the eggs of a pebrinized mother-moth, whose ovaries have been affected with pebrine, if the worms are carefully attended to.

I have reared eggs of pebrinized moths rather carelessly and examined the body of the caterpillars excluding the alimentary canals and the alimentary canals separately from the third to the fifth stages. In 175 cases I could not see any pebrine spores in either of them. In 11 cases I saw innumerable spores in the alimentary canal but very few in the body. In 89 cases I found innumerable spores in the body but few in the alimentary canal.

If the leaves are smeared with pebrine spores and then fed to the worms of the 5th stage they consume a large quantity of spores and naturally more pebrine corpuscles are found in the gut than in the body cavity when the worms are changed into moths.

25 layings of the Mysore race, laid by moths which were infected with pebrine very mildly (only one spore and sometimes not a single one was visible in a field of the microscope at the time of the examination of the moths), were reared in March. The worms were quite healthy and about 4 per cent. of the moths were found to be pebrinized.

2. *Infection through food.*

Pasteur and other savants observed long ago that silkworms are infected with pebrine by taking the pebrine corpuscles with leaves. The absorption of food takes place in the alimentary canal and naturally the corpuscles at first multiply in that part of the wall of the alimentary canal which has been infested first and then they attack the organs close to it. The multiplication of pebrine will not be necessarily in all the parts of the alimentary canal first and then in other organs. Cases may occur in which infection is very mild in the mid-gut and detection of the spores by Mr. Hutchinson's method is not possible, but acute in the ovaries and egg-cells. *Such cases, which should not be allowed to go undetected, can be easily noticed by the Pasteur method.* As a rule pebrine spores are seen more in the fatty tissues, muscles and membranes of the tracheal branches of silkworms than in the gut, though in *Apis mellifera* pebrine spores are always confined to the gut and malpighian vessels. "Pasteur himself advised to examine the alimentary canal of the caterpillars and pupæ, as it is difficult to detect the pebrine corpuscles when they remain mixed up with the innumerable fatty globules because the multiplication of the spores is limited at the time, but in the case of moths he has advocated the examination of the entire moth and not the alimentary canal only as pebrine bodies would multiply sufficiently in this stage" (*vide* Mr. Lambert's letter, quoted *ante*) If pebrine corpuscles infest only the mid-gut and not the female generative organ they will exercise the same influence over the progeny as the sperm of a pebrinized father-moth, which is generally not examined for elimination of hereditary pebrine. The corpuscles cannot be transferred in the egg-cell if only the mid-gut is affected with them; they can only be transferred in the egg-cell if the female generative organ is affected, and hence that organ must be examined for elimination of hereditary pebrine. The above savants did not think it safe to examine the gut only or any particular part for elimination of hereditary pebrine.

Mr. Honda, in his letter to me of the 17th May 1918, writes "Whether or not there is any other way to infect than the alimentary canal is a question which we cannot yet decide. However, I don't hesitate to assert that the normal way is the alimentary canal."

3. *Infection through wounds in the Chitin.*

Silkworms may be attacked with pebrine (though rarely) through wounds in the chitin and then to the various internal organs.

M. Pasteur observed pebrine bodies through wounds in the skin by infecting pebrine corpuscles with a needle. He says in his *Etudes sur la maladie des vers à soie,* page 130, published in 1870, "Dans le lot temoin, pas un seul des papillons n'a offert la moindre trace de corpuscles. Dans le lot contagioné par la nourriture, tous les papillons, sans exception, furent corpusculeausé de 100 à 200 corpuscles par champ.

"Enfin dans le lot contagionné à l'aide de blessures injectées, sept papillons seulement offrirent des corpuscules, de 50 à 200 par champ.

"Le contagion par piqûres infectées a donc lieu, mais elle est moins sûre que par le canal intestinal, ce à quoi il faillait s'attendre, parceque le sang qui de la blessure ne laisse pas toujours pénétrer les corpuscules qu'on cherche à inoculer."

In all rearings, when a large number of worms is cultivated, they crawl one upon another and scratch the skin with the claws of their legs and in this way wounds are made in the skin. Many worms of a big rearing carry such wounded spots which may not be visible in a small rearing. Regarding this point Pasteur says in the above book :—

" Ces blessures sont faites principalement par l'extremité des six crochets qui terminent les pattes des anneaux anterieurs de la larve. A l'epoque de la montée à la bruyère il est rare de trouver une education industrielle dont tous les vers ne portent pas de ces taches de piqûres. Je ne reviendrai pas ici sur les preuves pèremtoires que j'ai données dans le paragraphe pricité pour démontrer que ces taches sont uniquement produites par le fait de la vie en commun des vers."

If there are pebrinized worms in the rearing their fæces will contain pebrine spores which may enter through these wounds and attack the internal organs where they will multiply. Regarding this point Pasteur goes on in the same book :—

' qu'un ver enfonce les crochets de ses pattes anterieures, ici dans un crottin, là dans un ver corpusculeux qu'il aille ensuite, de ces mêmes crochets, piquer un ver sain, il n'en faudra pas davantage pour que ce dernier soit contagionné. Prenez, dans une education où règne la pebrine, des vers quelconques, et lavez dans une goutte d'eau l'extremité des crochets qui terminent les pattes ; la goutte d'eau vous montrera ensuite au microscope un assez grand nombre de corpuscules."

Mr. P. Vieil in his Sericulture, Edition 1905 (*Encyclopedie agricole*), page 131, says about these wounds :—

" Le plus souvent à la surface de la peau des vers malades on remarque des taches noires disséminées irregulièrement, ce qui a fait donner à la maladie le nom de pebrine. Il ne faut pas confondre ces taches avec les cicatrices des blessures que se font mutuellement les vers avec l'ongle terminal des pattes anterieures."

Mr. I. Honda, Director of the Sericultural College, Tokyo, has written to me the following in his letter of the 8th May 1917, " larvae are attacked by pebrine chiefly through the mouth or rarely wounds of skin."

Mr. Aomori, Professor of Sericulture, in his Japanese book on "Diseases of silkworms" has corroborated the statement of Mr. Honda.

Dr. C. Sasaki has written to me the following in his letter of the 25th June 1918 :—" I do not know whether the spores are introduced into the silkworms from wounds or not ; but if we inject the spores into the body of silkworms they will germinate in the body of the host." According to Mr. Lambert, caterpillars cannot be infected through the skin.

I took 100 healthy worms of the third stage and injected pebrine spores with a hypodermic syringe. About 70 worms died of wounds but six worms showed a very small number of pebrine spores. In another lot 100 healthy worms of the same consignment were reared for control of which two only were attacked with pebrine. I repeated the above experiment with 100 worms. Eighty-nine of them died of wounds but I could not find a single pebrinized worm out of the eleven surviving ones on the fifth day after injection. The failure of contagion in this case is perhaps due to the following causes :—(1) At the time of inoculation blood comes out of the wound and does not allow the pebrine corpuscles to penetrate inside. (2) The lymph cells of the worms could also eat the spores and thus the worms got rid of the corpuscles. (3) When worms get the infection through wounds, their tissues and muscles are attacked and then the ovaries.

Regarding the development of the reproductive organs, P. Vieil in his book on Sericulture, pp. 109-110, says :—

" Les tissus hypodermiques et adipeux, les trachées, les muscles, vont se désogréger et former une sorte de bouillie composée d'une infinité de cellules qui se rapproche de la substance vitelline de l'œuf ....

Aux dépens de cette bouillie, d'autres muscles, d'autres téguments, de nouvelles trachées vont se former et les organes reproducteurs vont s'accroitre."

If the reproductive organ and not the mid-gut is attacked through wounds the new method fails to eliminate the hereditary infection of pebrine corpuscles.

Summary of conclusions.

From what has been said above we come to following conclusions :—

1. Infection can take place in three possible ways,

(1) By heredity,

(2) By eating the pebrine spores with leaves,

(3) By infection through wounds.

2. It is possible that by proper care the progeny of a pebrinized mother, whose ovaries have been infested with pebrine, may be cured of the disease ; but there is always risk of breeding from a diseased stock.

3. In almost all cases of early infection the spores are so abundant in the moth that they can easily be detected by the Pasteur method.

4. If infection takes place through food on the day of spinning (after that the worms cannot be infected through food) the organism gets at least 15 days' time to multiply, which time is sufficient for the multiplication of the spores provided the surrounding conditions are favour-

able for their propagation, and they can be detected easily by the Pasteur method.

5. In cases of very mild attack when the spores are limited to the gut it is certainly true that the corpuscles may escape detection by the Pasteur method when it is possible to detect them by Mr. Hutchinson's method, but it is open to question how far the ovaries are attacked in such cases. If planont, schizont or meront—the undeveloping forms of pebrine—remain in the ovaries it is natural to expect at least some fully-developed forms also which will be detected at once.

6. *As hereditary infection takes place through the ovaries only any method which does not take them into consideration does not seem to be infallible.*

7. The male parent cannot transmit the disease to the progeny; therefore the examination of the male is not essential. The sperm of a pebrinized male will exercise the same influence over the progeny as the spores of a pebrinized mother if they are limited to the gut and other organs excluding the ovaries. Pebrine is not hereditary, but only transmitted from mother to the offspring.

8. Multivoltine mother-moths must be examined within seven or eight days after oviposition. In summer many moths dry up in five or six days and during the rains many are decomposed in about three or four days, when it becomes difficult to find out the mid-gut. About 10 per cent. of the mother-moths and therefore their eggs have to be thrown away as their guts cannot be taken out on account of decomposition and drying up of the moths. If examination is done according to the Pasteur method the above moths can be examined. *If the examiner takes out any tissue from the body of the moth which is immune to Pebrine spores instead of the mid-gut which is mildly infected with pebrine, he will fail to detect the pebrine spores though the ovaries are attacked with them.* The gut must be crushed well. If a minute part of it is taken as advised by Mr. Hutchinson then some pebrinized moths may go undetected. It appears to me that better results would be obtained if the moths are treated and examined as under:—

On the fourth or fifth day after oviposition a mother-moth should be placed on a thick paper. The middle part of the abdomen between the colon and the mid-gut should be held from behind the paper with the thumb and forefinger of the left hand and the thorax should be caught and separated from the abdomen by means of the thumb and forefinger of the right hand. If the middle part is pressed now, then the ovarian tubes and gut will come out of the interior part of the abdomen and the contents of the colon will come out of the anus. (If by chance the fingers are soiled with the juice they should be washed with water at once.) A few drops of 5 per cent. solution of caustic potash should be put on the ovarian tubes and the gut which should be rubbed well with a slide so that the ovarian tubes are crushed and the gut also is mixed up with the solution. This juice should be taken with the same slide and should be examined with the help of a cover-glass. Dry and decomposed moths should be crushed in mortars and pestles. A labourer can learn the work in a day or two. One microscopist will be able to examine 800-1,200 moths in a day of eight hours. I do not advise the examination of the moths before the third or fourth day after oviposition unless eggs are required to be sent to some distant place.

It should be noted that there is some risk in allowing irresponsible men to prepare the slides as described above. If the examiner prepares the slides he will be able to examine about 500 moths in a day of eight hours.

9. If the infection is possible through wounds in the skin the examination of the whole moth or the ovaries can be the only sure test of the disease. In such cases it is probable that the infection may not have reached the stomach or gut.

10. The Pasteur system is not perfect and there is room for improvement. We will gladly accept any system which is more effective and at the same time economical. The modified method of Pasteur as recommended by Mr. Hutchinson is certainly more effective than the Bengal method. It is as effective as the Pasteur method but it is open to question whether it can be adopted commercially, at any rate under the present conditions. In the words of Mr. Lambert (one of the pupils of Mr. Pasteur and who had the advantage of working under him and who is one of the greatest living sericultural authorities), Director of the Station Sericicole, Montpellier, France, in his letter to me of the 13th April, 1918 (*vide* quoted above), " No useful purpose would be served by limiting the examination to the gut. Every one wants to have a method which is simple and economical. The gut theory is not a new one. It is as old as Pasteur himself. He preferred to wait for the examination of the moths for a few days instead of examining the gut." All sericulturists from the time of Pasteur knew that infection takes place through leaves and hence through the alimentary canal but they did not think it advisable to examine only the mid-gut. *The multivoltine mother moths are examined according to the Pasteur method in places like Japan, China, Siam, French Indo-China, Madagascar, etc. If we try the Pasteur method in India the disease will be controlled as it is being done in the above countries.*

11. Taking everything into consideration, the multivoltine mother-moths of India should be crushed in mortars and pestles as recommended by Pasteur. For easy and rapid detection of pebrine corpuscles the moths should be treated in the following way as practised in some countries. In Japan multivoltine moths are examined with or without drying. In many countries the multivoltine moths are examined without drying.

(*a*) Fifty or sixty mother-moths are placed on a paper after separating the pairs. The paper is shaken by holding one of its ends. The moths will excrete liquid so that there will not be much exudation of the colon at the time of crushing them for microscopical examination. Then they are allowed to lay eggs.

(*b*) The mother moths are then isolated in paper bags on the first night after oviposition at about 80°-95°F. for about four or five days and then dried for three or four hours at about 160°-180°F. This will help the multiplication of pebrine corpuscles and the contents of the colon also will be dried up. The number of the bag containing a moth should correspond with the number of the laying oviposited by it so that the eggs laid by each moth can be ascertained.

(*c*) The moths are examined on the fifth or sixth day after oviposition after removing the wings. *They are thoroughly crushed in glass or porcelain mortars and pestles with a few drops of 5 per cent. solution of caustic potash which dissolves the fat-bodies to a great extent.*

12. The nurseries should sell healthy eggs and not seed cocoons. The industry will be greatly benefited if responsible overseers are sent to each rearing village to examine the moths of all the rearers and professional cocoon-sellers and allow them to rear the healthy eggs only. The rearers will gladly bring their moths for examination if an arrangement is made to examine them in a central place. Instead of producing seed-cocoons on a large scale the energy of the overseers should be diverted to this direction.

It must be conceded, as pointed out by Mr. Hutchinson in his Bulletin No. 75, that after fifty years' practice of the Pasteur method the disease has not been eradicated in France. The Pasteur method has so far only succeeded in controlling the disease. If it is possible to eradicate it altogether such scientific methods as that of Mr. Hutchinson would be a great help to the sericulturist. At present we do not know all that we should know about the origin of the disease and of its other possible hosts, which factors are essential for a successful attempt to eradicate the disease. As things are at present in India, an expensive scientific method is not likely to be popular amongst the rearers who would naturally go in for eggs which are cheap and reasonably free from disease. Let us hope that in the near future new methods of detection of pebrine, backed by legislation, may help us in successfully combating this terrible disease. It will be only then that India will regain her former position amongst the great silk-producing countries of the world.

Mr. Chaudhuri. I would like to make a few remarks on the observations made by Mr. De on the pebrine diseases of silkworms in his paper. I had intended to deal with it more in detail as Mr. De had brought forward many observations with which I did not agree. But, as we have already had the advantage of listening to the instructive lecture of Mr. C. M. Hutchinson on the same subject I think it will be unnecessary for me to bring forward again some of those points before you. In the first place I cannot possibly be expected to explain them as the learned speaker had stated. Besides, I think sufficient light has been thrown on most of the important points in connection with the advantages of the gut examination of moths. I would therefore confine myself to pointing out some points which I have observed in the course of my practical experience in the nurseries under my supervision.

Mr. De in his paper has stated that in Bengal we do not follow, strictly speaking, the Pasteur system of the examination of moths. He lays the blame on us on the ground that we use paper for crushing the moths instead of using pestles and mortars for the same purpose. I am not aware that there is any cogent reason for making this assertion, for, if I am not mistaken, what Pasteur stated was that the moths should be sufficiently crushed. In one of his Bulletins Mr. De has clearly stated that the crushing should be done with paper. This again he wrote while describing the Pasteur system. It seems that since the publication of his Bulletin he has changed his opinion. But simply on account of his change in views I cannot see any justification in asserting that in Bengal the system adopted in the nurseries is not the Pasteur system simply because we do happen to have substituted paper for pestles and mortars. So far as my experience goes I have not found that the use of paper has been a great drawback for crushing the moths sufficiently well and I do not think that it will help us in any other way than by introducing a more laborious and uneconomical process. Regarding the opinion expressed by Monsieur Lambert in his letter to Mr. De, I am of opinion that M. Lambert probably did not consider the conditions under which we have to labour in India. M. Lambert expresses the opinion that a moth examined on the day after oviposition will be sufficiently infected to enable one to detect the pebrine corpuscles. I cannot possibly think this to tally with our results. Mr. N. G. Mukerjee in his *Handbook of Sericulture* clearly stated that no examination, excepting that in the winter season, can be said to be perfect, for in other seasons the number of days at our disposal for the examination is too short to enable the development to be sufficiently advanced so as to be detected in the earlier stages of the moths. This is quite true, as we have ourselves noticed that the percentage of pebrine increases—or rather, the detection becomes more efficient—the longer we wait (as long as possible) and have our examinations on the day previous to hatching, or, if we have too many moths to examine, this is done a day or two earlier but seldom before the sixth day. Even with such strict measures we are helpless in combatting this disease to a large extent. Had it not been for the elucidation of this problem by the work of Mr. C. M. Hutchinson we would have been at a loss to account for the reasons. Mr. Hutchinson's experiments have enabled us to ascertain the causes and at the same time have offered an easy solution to this difficult problem.

In our examinations of the pupæ we have not been able to estimate properly the exact nature of the proportion of the disease. For selecting a lot for seed-purposes we generally try a number of pupæ and if the percentage be above two to three per cent. in the pupæ the lot is rejected altogether for seed-purposes and subsequent examination in the moth stage. A fresh lot is selected. In many cases even when the pupæ showed no pebrine, it afterwards turned out that the moths had shown about 10 per cent. disease. There can be no question of the drawbacks for using paper in the case of pupæ. The examination of the guts, however, revealed the existence of pebrine.

In Europe, where univoltine races are reared, there is a lesser accumulation of pebrine germs for infection before the next rearing is commenced. So that the chances of outward infection are very little, whilst in Bengal, where multivoltine races are reared, the germs are constantly being accumulated, as one crop follows another in quick succession. In our May to August crops the larval period is finished in twenty days and the moth emerges out of the cocoon within seven to eight days. There is nothing analogous to such rearings in Europe. Apart from these facts, the conditions in India are not similar to European conditions. I would like also to point out that even in Europe with all such advantages pebrine has not been totally eliminated from scientific grainages. This may not necessitate such strict measures in Europe as they are more favourably circumstanced than what we may expect to be in Bengal. Kashmir may be compared with Europe so far as these advantages are concerned so as to get an instance near at hand. But I understand that even now they have not been able to successfully introduce their own seeds in Kashmir.

In my Hill experiments I had noticed that a diseased lot had shown lesser percentage of disease when reared in the Hills after examination according to the system prevalent in Bengal. But the control reared at Berhampore showed more percentage of disease although reared after similar examination. It may be said that in the Plains the chances for outward infection are greater or it may be that the conditions are not so favourable for the disease to have multiplied rapidly. In any case the conditions are likely to have played a very important part so that the infection of pebrine was higher in one case than in the other.

From what Mr. De has quoted from Monsieur Lambert's letter regarding the examination of the gut in the case of the pupæ as an effective method, I think the conditions under which we have to labour in India are such that we may consider our position, so far as the time available for the development of pebrine is concerned, as practically the same for the pupal stage in Europe and the pupal plus the moth stage in India, owing to the cycles being finished within a very short period.

I have had ample opportunities of closely following the method advocated by Mr. Hutchinson. I have studied the various points in connection with the technique of this problem. So far as practical application is concerned I have tried minutely to examine the relative importance of both the methods by actual trials in the nurseries under me. I submit below some results of my examinations which I had already submitted to the Bengal Silk Committee meetings. I would like however, to point out that in each case I have given the figures of the examination of two overseers who have been helping me in examinations in the nurseries. This has been purposely done so as to test the actual figures according to the average possible for the nursery staff in Bengal. The examinations were done under my supervision and the good moths passed by them again re-checked by me so as to avoid any possibility of error. I might add that in each case the percentage was derived from a number of 250 to 300 moths.

The examination figures of the summer and rainy seasons are shown, as this is the time when the difficulties are more pronounced, as the winter crops are not so unfavourable for a reliable examination.

I am giving only two instances, although we had made a number of tests. In one lot examined on the fourth day after the emergence of the moths, according to Mr. Hutchinson's method we obtained 9 per cent. pebrine against 3 per cent. by the old system. The average number examined by one man in one hour came to 46 whilst in the case of the old system it was 57.

The examination of the second lot on the seventh day after the emergence of the moths showed 21 per cent. for the gut examination and 10 per cent. for the other. The rate of examination per hour was 42 in the case of the gut against 72 of the other.

The percentage of detection is so high as to render the question of time altogether a negligible factor. If for economising time and labour we are ready to leave behind at least 50 per cent. of the diseased specimens in our seeds I doubt whether we can ever expect to combat the ravages caused by this disease.

The figures put forward by Mr. De in his paper are taken from his winter examinations of November-December-January crops, when conditions are favourable for the Pasteur examination, and do not test its efficiency for use in the Rains. My figures are from the May-July crops, which is the period when these difficulties occur. Besides that, in Mr. De's examinations the percentage of disease was so high as 70 to 80 per cent. diseased so that any method of examination would have found pebrine. This high percentage in the Pusa Silk-house does not reflect credit on the method adopted there for eliminating the disease.

It has been stated by Mr. De that in Bengal the rate of examination is very slow. But I think it very necessary that we should not examine at a very high speed. Especially I would be the last to advocate the examination of three moths per minute. It seems that the French authority whom Mr. De has quoted is Monsieur Blachon who states that 1,200 moths can be examined per day. But he does not specify the number of hours per day to be eight hours and he also gives that figure for the best examiners. M. L'Arbousset's figures, if I remember right, are from 400 to 500 per day of eight hours.

From what I have myself examined in my rearings on a large scale—and I doubt whether anywhere else in India rearing is done on such a big scale as in Bengal in the Government nurseries,—I am convinced that the gut system of examination will materially assist us in effecting a great deal of improvement towards the economic condition of the industry. The question of time is a very paltry matter in comparison to the immense advantages this system is calculated to render towards the successful results which will undoubtedly follow the adoption of this method in preference to the old system.

Mr. Harihar Prasad.

With your permission I beg to speak something by way of criticism of Mr. De's valuable paper. As I am connected with sericulture and pebrine for the last about ten years I have had some opportunity of seeing some of the important Sericultural Centres and also meeting with some of those gentlemen who are at present engaged at the seed selection work in India.

Gentlemen, I would endeavour to bring to your notice some of the controversial points mentioned in the learned paper.

I do not like to give the figures I have got in the experimental work at which I am engaged. I do not like to give my own figures in contradiction to what has been said about the different points connected with the methods of examination. From the facts and figures quoted in the paper itself I shall try to explain their value.

Mr. De says that he examined moths in the Bengal method, *i.e.*, crushing the moths in paper and also in the Pasteur method and found more pebrinized moths in the latter method than in the former. He says that in Mukerjee's method (Bengal method) all the parts do not get crushed well and pebrine corpuscles are not found if they remain in uncrushed parts.

About 10 per cent. of the moths attacked mildly go undetected. If the major portion of the juice is taken from the colon only, as it appears to be done in Bengal, the chance is that rather more than 20 per cent. of the moths attacked with pebrine will go undetected.

Now, gentlemen, to my knowledge Mr. De's method, at least prior to the publication of Mr. Hutchinson's Bulletin, was exactly the same as Mukerjee's, as is evident from Mr. De's Bulletin No. 39.

In fact, Mr. Hutchinson's method is responsible for removing the defective method so far practised everywhere in India.

Regarding the figures quoted by Mr. De about the comparative numbers of diseased moths found in the Pasteur and Hutchinson method, practically no difference has been shown. In one or two cases he shows one or two more pebrinized cases in Pasteur's method while in other cases he shows one or two more pebrinized cases in Hutchinson's method. One important point to note in this connection is the highly diseased condition of his experimental lots, because he shows as many as 43 diseased cases out of 50. So it is clear that his experimental broods were from a very highly diseased lot and it may be remembered that in such highly diseased lots any method would show pebrine easily. The superiority of Mr. Hutchinson's method is of very great value inasmuch as it can help detection of pebrine in even mild and earlier stages of the development of the disease such as are usually met with in India in the hot season when the life-cycle of the silkworm is rapidly passed without giving time enough for thorough propagation of the parasite. Mr. De's experiments have been done in the winter season of this year.

My experience shows that there are many cases met with where pebrine would go undetected if the gut is not properly examined. As a matter of fact, Mr. De has admitted this indirectly in the course of his paper. The paper said that in about 95 per cent. of the moths he finds more pebrine in the gut than in the body-juice. He says that in a very few cases one or two pebrine spores were detected in the gut and not a single one in the body-juice.

Then what about these few cases ? Would they not go undetected if Mr. Hutchinson's method was not employed ?

Again, he says that in rare cases he noticed one or two pebrine spores in the body-juice but not in the gut. Can it be explained where did these one or two pebrine spores come from? I do not know whether " few cases " are more than " rare cases."

In order to avoid the colon content Mr. De suggests the use of incubators and caustic potash. Will it not be difficult in practice to incubate the moths keeping the same number on the egg card as also on the bags in which the moths are to be dried ? The use of caustic potash makes the pebrine spores look dull.

However, Mr. De admits that Mr. Hutchinson's method is an efficacious one but he thinks it is a slower method. He also speaks of irresponsible overseers who may not work properly. I think where Governments are anxious to eradicate the disease the question of slowness does not come in, especially in view of the sureness of the method. He admits that this method enables the examination of the moths to begin earlier. He admits that the only advantage in this method is that when infection is mild in the mid-gut it will take little time and attention for the detection of the spores, whereas according to Pasteur's method more time and attention will be required and in a few cases spores may go unnoticed if not treated with caustic potash. My experience shows that in the multivoltine races in India many cases will go undetected if examined by the rough method which is in almost all cases possible in the crushing method.

Professor N. G. Mukerjee, who made a thorough study of the parasite in France and in India, distinctly says on page 57 of his *Handbook of Sericulture* that " if a silkworm gets the pebrine germs the day before it is ready to spin cocoons and if it is examined in the moth stage on the fifth day the germs get only fourteen days to develop themselves. Unless pebrine is associated with Flacherie, corpusculation does not take place in fourteen days and the moth may be passed as disease free, though full of pebrine."

I think for such cases gut examination is the only remedy.

Mr. De says that spores will be found in sufficiently large numbers.

This is, I think, contradictory to his above-quoted statements when he speaks of mild infection.

With regard to infection through wounds Mr. De himself says that he carried out two experiments to see if infection takes place through wounds. He took 100 caterpillars in each of the two experiments. In one 70 caterpillars died of wounds and he got 6 mild cases of pebrine. His control lot also showed 2 cases of pebrine. In the second experiment he got negative results and 89 caterpillars died. I think both his experiments gave negative results as his control lot in the first experiment showed pebrine and it is just possible that there was disease already present in his experimental lots. Mr. De wrote to three or four people in foreign countries for opinions on this point. Two people seem to have given as their opinion that infection does not take place and one man says that rarely it does. Upon this doubtful point Mr. De tries to make a case that, in case infection takes place through wounds, the ovary alone of the moth *may* be infected and not the gut. This to my mind seems to be imaginary for in nature we do not come across any ~~such~~ wounded caterpillars and the caterpillars are so delicate that when they get wounded they die before becoming moths. I do not think Mr. De has ever come across any such moth.

Mr. De says that "the pebrine disease is not a hereditary disease but is only transmitted from a mother to its progeny." I would like to have explained the meaning of this funny sentence.

In conclusion, he admits of mild cases in which the gut is the only affected part and no other tissues.

In my opinion, no case has been made out to criticize Mr. Hutchinson's method, which is based upon scientific work and not upon information gathered from private letters and books.

I thank you, gentlemen, for giving me an opportunity of explaining things and I also thank Mr. De for his efforts in the cause of science.

Mr. Ghosh. I had occasion to visit the Berhampore silk nursery in 1909 and at that time they were throwing off the wings and thorax of the moths and only crushing the abdomen.

Mr. Harihar Prasad. Mr. De recommended the same method in his first Bulletin.

Mr. Ramakrishna Ayyar. It would have been much better if we could have some definite decision regarding the best method to adopt for elimination of pebrine. The man under me does not know which method to follow. One is tedious and the other is inaccurate. As far as I can make out, the methods are the same and do not show any difference in results. The question is, which is the one that can be carried on, on a commercial scale. If Mr. Hutchinson's method is to be followed, then the seed should be distributed by Government agency.

As regards the possibility of developing the method of selection suggested by me, we leave it to the commercial people to judge. Mr. Chaudhuri is engaged in the work on a commercial scale and he has already said what he thinks on the subject. The future elimination of pebrine depends on the examination of the moths and also in raising the resistance of the larvae to the disease. We can do this latter either by hybridization or by selection. Mr. De has done a good deal of hybridizing and I have done some work on pebrine. If we tackle the problem together, it will be very good. I should like to invite Mr. De to co-operate with me in testing the new method and to help with his experience in hybridizing. **Mr. Hutchinson.**

I am quite willing to co-operate with Mr. Hutchinson in the experiments he contemplates. So far I have been working along lines different from those on which Mr. Hutchinson has been working. **Mr. De.**

As regards the criticisms on my paper by Messrs. Chaudhuri and Harihar Prasad, I suggested the paper method for the examination of moths when I was a new-comer and had no experience, although I myself pointed out the defects of that method. As regards the large percentage of pebrine in the worms which I used for testing the different method of examination, this was done purposely for the experiments, and this percentage of infection must not be taken as that normally found in the Pusa Silk-house.

Can the pebrine germs affect other kinds of caterpillars besides silkworms ? We have to do with swarming caterpillars and, if we could use such a disease, we might be able to kill them. **Mr. Ramrao.**

I do not know about other pests, but *Prodenia litura* can be artificially infected. **Dr. Gough.**

46.—EXHIBITION OF SPECIMENS AND DRAWINGS OF INDIAN WILD SILK-MOTHS.

By C. M. Inglis.

[*Mr. Inglis exhibited his collection of wild silk-moths and a number of coloured drawings of various species of the moths.*]

We are much indebted to Mr. Inglis to taking so much trouble in bringing his collection of silk-moths and his excellent drawings for exhibition at this Meeting. **Mr. Fletcher.**

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